Original Investigation

Geographic Variation in Trends and Disparities in Acute Myocardial Infarction Hospitalization and Mortality by Income Levels, 1999-2013

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IMPORTANCE During the past decade, the incidence and mortality associated with acute myocardial infarction (AMI) in the United States have decreased substantially. However, it is unknown whether these improvements were consistent across communities of different economic status and geographic regions since efforts to improve cardiovascular disease prevention and management may have had variable impact.

OBJECTIVE To determine whether trends in US county-level, risk-standardized AMI hospitalization and mortality rates varied by county-based median income level.

DESIGN, SETTING, AND PARTICIPANTS In this observational study, county-level risk-standardized (age, sex, and race) hospitalization and 1-year mortality rates for AMI from January 1, 1999, to December 31, 2013, were measured for Medicare beneficiaries 65 years or older. Data analysis was performed from June 2 through December 1, 2015. Counties were stratified by median income percentile using 1999 US Census Bureau data adjusted for inflation: low- (<25th), average- (25th-75th), or high- (>75th) income groups.

MAIN OUTCOMES AND MEASURES The effect of income on the slope of AMI hospitalizations and mortality, measured as differences in the rate of change in AMI hospitalizations and mortality by county income and by the 4 US geographic regions, and a possible lag effect among low-income counties.

RESULTS In the 15-year study period, AMI risk-standardized hospitalization and mortality rates decreased significantly for all 3 county income groups. Mean hospitalization rates were significantly higher among low-income counties compared with high-income counties in 1999 (1353 vs 1123 per 100 000 person-years, respectively) and in 2013 (853 vs 648 per 100 000 person-years, respectively). One-year mortality rates after hospitalization for AMI were similar across county income groups, decreasing from 1999 (31.5%, 31.4%, and 31.1%, for high-, average-, and low-income counties, respectively) to 2013 (26.2%, 26.1%, and 25.4%, respectively). Income was associated with county-level, risk-standardized AMI hospitalization rates but not mortality rates. Increasing 1 interquartile range of median county consumer price index–adjusted income ($12 000) was associated with a decline in 46 and 37 hospitalizations per 100 000 person-years for 1999 and 2013, respectively; interaction between income and time was 0.56. The rate of decline in AMI hospitalizations was similar for all county income groups; however, low-income counties lagged behind high-income counties by 4.3 (95% CI, 3.1-5.9) years. There were no significant differences in trends across geographic regions.

CONCLUSIONS AND RELEVANCE Hospitalization and mortality rates of AMI declined among counties of all income levels, although hospitalization rates among low-income counties lag behind those of the higher income groups. These findings lend support for a more targeted, community-based approach to AMI prevention.

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There are long-standing disparities in cardiovascular disease prevalence and outcomes based on a neighborhood's or region's income.[1-6] In many low-income areas, there are several challenges to improving cardiovascular outcomes, including inadequate physician supply,[7-9] poor health care quality,[10-12] and limited resources to implement policies and programs designed to prevent and manage cardiovascular disease.[13-16] Concurrently, populations living in these communities tend to have fewer opportunities to engage in healthy behaviors, greater exposure to stress, and higher rates of cardiovascular risk factors. Thus, it is generally accepted that living in a disadvantaged area puts people at higher risk for cardiovascular events.[17,18]

However, during the past 15 years, there have been significant population health initiatives to improve cardiovascular health and reduce health disparities.[19] Campaigns such as Healthy People 2010,[20] the American Heart Association's 2010 and 2020 Impact Goal,[21] and Million Hearts[22] set forth national agendas of policy- and system-level reforms to affect community and clinical care environments. There has been greater attention to ambulatory care access, evidence-based practice, quality measurement and reporting, and implementation of policies and programs to support healthy lifestyle behaviors. During this period (1999-2011), the national hospitalization rate for acute myocardial infarction (AMI) declined by 38% and the 1-year mortality rate for AMI decreased by 23%.[23] Nevertheless, it is unknown whether these trends were consistent across communities of different economic status and geographic regions in which efforts to improve cardiovascular disease prevention and management may have had variable penetration and impact. Specifically, we lack data on trends in AMI incidence and outcomes among low-income communities compared with high-income communities; such data are important for reducing health disparities.

Accordingly, we examined disparities in trends in AMI hospitalization and 1-year mortality rates among US counties of low, average, and high income. The median income was selected as an indicator of a county's socioeconomic status because it is sensitive to economic trends[24] and may serve as a proxy of unmeasured environmental contextual factors associated with geographic communities.[25-27] Our aims were to describe the association between county-level median income and AMI hospitalization and mortality rates, assess trends in AMI hospitalization and mortality rates by county-level median income and across geographic regions, and perform a lag analysis to determine the additional years needed, if any, for low-income counties to achieve outcomes similar to those of high-income communities. We hypothesized that low-income counties would follow different trends than high-income counties, with greater hospitalization and mortality rates for AMI at all time periods; we also hypothesized that these effects would be most pronounced in the South, a region with the highest county-level rates of cardiovascular risk factors and disease as well as the deepest socioeconomic challenges.[28,29] This national perspective on trends in AMI incidence and mortality by county-level income can help to interpret the effectiveness of past campaigns to improve cardiovascular health and can inform whether future efforts should target the most vulnerable communities.

Key Points

Question Amid US national declines in acute myocardial infarction (AMI) hospitalizations and mortality, are there disparities in trends between communities of different income levels?

Findings In this study, similar rates of decline in AMI hospitalizations and mortality among Medicare beneficiaries residing in high-, average-, and low-income counties between 1999 and 2013 were found. However, low-income counties still had persistently higher hospitalization rates compared with high-income counties, although similar mortality rates, throughout the study period.

Meaning Successes in decreasing AMI hospitalizations and mortality have reached communities of different income levels, yet disparities persist, suggesting the need for more targeted research and investment in low-income counties.

Methods

Study Population

We used the Medicare denominator files to identify Medicare beneficiaries 65 years or older who were enrolled in the fee-for-service plan for at least 1 month from January 1, 1999, to December 31, 2013. To account for new enrollment, disenrollment, and death, we calculated the person-years contributed by each beneficiary during the study period. We linked the person-years beneficiary data to the Medicare inpatient claims data and identified beneficiaries discharged from an acute care hospital with a principal discharge diagnosis of 410.xx based on the *International Classification of Diseases, Ninth Revision, Clinical Modification* codes. We assessed demographic characteristics of patients hospitalized with AMI, including age, sex, race (white, black, or other), and Medicare-Medicaid dual eligibility from the denominator file. Clinical comorbidities were identified by using secondary diagnoses of inpatient claims data from the incident hospitalization and the primary and secondary diagnoses from hospitalizations that occurred in the preceding 12 months.[30] We assigned beneficiaries to counties based on the zip code of their residence at the time of hospitalization for AMI. The Yale University Human Investigation Committee approved the study and waived the requirement for informed consent.

County Characteristics

Using data from the US Census Bureau,[31] we determined the median income and percentage of people living below the federal poverty level by county for each year from 1999 through 2013. We compared county-level income with county-level poverty rates and found a high correlation (eTable 1 and eTable 2 in the Supplement). Thus, consistent with prior studies,[32-37] we used median income to characterize the socioeconomic status of the county in each year. County-level median income was adjusted for the consumer price index, with 2013 as the

index year, to account for inflation.[38] We stratified counties into 3 mutually exclusive categories based on each county's annual median income level: low income if the median income was less than the 25th percentile of the national level, high income if greater than the 75th percentile, and average income if otherwise. We obtained county-level covariates from the US Census Bureau, including the estimated population size, proportion of residents 65 years or older, percent female, and percent white/non-Hispanic, black/non-Hispanic, other race/non-Hispanic, and Hispanic. For each county, we also calculated the proportion of Medicare-Medicaid dual-eligible individuals based on Medicare data.

Outcomes

Our primary outcomes were risk-standardized AMI hospitalizations and 1-year mortality following AMI. We calculated the observed AMI hospitalization rates by dividing the total numbers of AMI hospitalizations in each year by the corresponding person-years of fee-for-service beneficiaries for that year for each county by each age group (65-74, 75-84, and ≥85 years), race group (white, black, and other), and sex group (male and female). For hospitalizations, if a beneficiary had more than 1 AMI hospitalization in a given year, we counted them all. We determined 1-year mortality following AMI by using the death information in the denominator files regardless of the cause of death. The 2014 denominator file was used to obtain mortality information for beneficiaries discharged in 2013. We calculated the mortality by dividing the total number of all-cause deaths following AMI in each year by the corresponding total number of fee-for-service beneficiaries who were hospitalized for AMI for that year. For mortality, if a beneficiary had more than 1 AMI hospitalization in a given year, we randomly selected 1 of those. This decision was based on the rationale of minimizing sample selection bias, in which selecting the first hospitalization would result in a relatively low mortality rate and selecting the last hospitalization would result in a relatively high mortality rate.

To obtain the risk-standardized AMI hospitalization rate for each county or county equivalent and for each year from 1999 to 2013, we extended the Centers for Medicare & Medicaid Services hierarchical model[29] used for profiling hospital performance on outcomes with a Poisson link function and county-specific random intercepts to model the number of AMI hospitalizations as a function of beneficiaries' age, sex, and race and accounting for spatial differences between counties. We repeated this hierarchical model with a logit link function, adjusting for patient comorbidities, to calculate the risk-standardized, 1-year, all-cause mortality following AMI.

Statistical Analysis

We examined trends in patient characteristics, hospitalization rates, and 1-year mortality rates for each county during the study period, stratified by the 3 income categories. Hospitalization estimates were expressed as the number of events per 100 000 person-years, and 1-year mortality rates were expressed as percentages. We evaluated the association between income and county-level, risk-standardized AMI hospitalizations by fitting a mixed-effects model with the county-specific, risk-standardized AMI hospitalization rate as a function of change in median income, defined as 1 interquartile range of median income, adjusted for county-specific covariates described above. Time was modeled as a continuous variable corresponding to years 1999 (time, 0) to 2013 (time, 14); an interaction term between time and change in median income was included in the model. We repeated the model for the 1-year mortality outcome.

To assess the difference in the rates of change in AMI hospitalization rates among the 3 county income groups during the study period, we fitted a random intercept (county) and coefficient (time) model with the risk-standardized AMI hospitalization rate as a function of 2 binary income group indicators (low income and average income, with high income serving as the reference group), a time variable, and interaction terms between income group and time, adjusted for the county-specific proportion of residents 65 years or older and percentage of women. We repeated this model for the 1-year AMI mortality rate. We estimated the lag effects by using the method described in the eAppendix in the Supplement to obtain the number of additional years needed for low- and average-income counties to achieve the hospitalization rates of high-income counties in 2013.

To assess geographic differences in changes of AMI hospitalization and mortality rates, we mapped county-specific, risk-standardized AMI hospitalization separately for 1999 and 2013 by using the 1999 distribution of AMI hospitalization rates as the gradient reference. We also divided counties into 4 regions: Northeast, West, Midwest, and South based on US census regional definitions. For each region, we reclassified counties into region-specific income categories based on regional distributions of median income. As a result, the thresholds for defining low-, average-, and high-income counties vary by region, which considers regional differences in cost of living and standardizes comparisons among and between regions. Analyses were conducted using SAS, version 9.3, 64-bit (SAS Institute Inc). Data analysis was performed from June 2 through December 1, 2015.

Results

Study Population

We identified 60 056 069 unique Medicare beneficiaries aged 65 years or older who were enrolled in the Medicare fee-for-service program for 1 month or longer from 1999 to 2013 (**Table**), contributing 416 667 038 person-years. There were a total of 4 290 784 hospitalizations for AMI contributed by 3 294 700 unique patients during this period. After excluding 13 counties or county equivalents with invalid or incomplete data for income during the study period, 3131 counties or county equivalents were included in the analysis. Between 1999 and 2013, the consumer price index–adjusted median (interquartile range) incomes decreased among all county income groups from $37 271 ($4912) to $34 593 ($4329), $46 344 ($6230) to $43 966 ($6253), and $60 495 ($11 455) to $57 559 ($11 948) for low-, average-, and high-income groups (eFigure 1 in the Supplement). Between 1999 and 2013, 79.1% of low-income,

Table. Characteristics of US Counties and Medicare Fee-for-Service Beneficiaries

	County Income Group[a]								
	1999[b]			2006			2013		
Characteristic	Low	Average	High	Low	Average	High	Low	Average	High
County									
Total population, million	21.8	85.8	180.8	20.2	100.3	187.5	23.2	121.6	176.6
Age ≥65 y, mean (SD), %	13.4 (3.5)	14.2 (3.9)	11.4 (3.0)	14.0 (3.6)	13.8 (3.5)	11.5 (2.8)	14.9 (3.8)	14.4 (3.9)	12.2 (2.7)
Female sex, mean (SD), %	52.0 (2.0)	51.1 (1.5)	50.1 (1.0)	51.1 (2.2)	50.9 (1.5)	51.0 (0.9)	51.0 (2.1)	50.8 (1.4)	50.8 (8.4)
CPI-adjusted income, median (IQR), $ in thousands	38.1 (3.9)	48.2 (6.2)	61.4 (15.9)	36.5 (4.3)	47.8 (4.8)	61.1 (14.6)	34.8 (3.7)	45.4 (6.1)	59.1 (17.0)
Race, mean (SD), %									
Non-Hispanic black	22.8 (22.0)	12.7 (13.7)	11.0 (10.3)	20.9 (21.1)	13.9 (14.4)	10.2 (9.7)	21.7 (21.3)	13.8 (13.5)	9.8 (9.1)
Non-Hispanic white	55.4 (29.5)	74.6 (20.9)	68.7 (20.3)	56.0 (30.2)	70.0 (21.5)	63.0 (21.0)	58.0 (29.0)	66.3 (21.9)	60.1 (21.4)
Hispanic	17.6 (27.0)	9.8 (14.7)	14.3 (14.0)	18.6 (28.8)	12.0 (16.3)	17.8 (14.6)	14.3 (24.9)	14.9 (17.6)	19.8 (15.4)
Medicare fee-for-service beneficiaries[c]									
Total, No. in millions	2.5	9.8	14.2	2.3	10.9	15.5	2.5	12.0	14.7
Proportion of total population	11.5	11.4	7.9	11.4	10.9	8.3	10.8	9.9	8.3
Dual eligibility for Medicaid, mean (SD), %	24.6 (9.4)	14.6 (8.0)	12.1 (9.0)	25.6 (10.2)	14.5 (8.9)	13.1 (10.1)	22.5 (9.5)	14.0 (8.4)	12.7 (9.3)
Beneficiaries hospitalized for AMI, No. in thousands	28.8	109.3	140.9	22.3	95.7	119.1	21.5	87.3	89.9
Age, mean (SD), y	77.9 (1.6)	78.2 (1.3)	78.6 (1.1)	77.8 (1.7)	78.5 (1.5)	79.3 (1.2)	77.4 (1.8)	78.2 (1.6)	78.8 (1.3)
Male sex, mean (SD), %	48.5 (9.3)	50.0 (7.2)	49.5 (4.7)	51.0 (10.1)	50.5 (7.5)	49.8 (5.3)	53.6 (9.7)	53.7 (7.6)	53.6 (5.6)
Common comorbidities, mean (SD), %									
History of CHF	18.2 (6.9)	16.1 (5.2)	16.1 (3.8)	18.3 (8.2)	16.5 (6.2)	16.8 (4.2)	16.4 (8.1)	15.3 (5.8)	15.7 (4.5)
Prior MI	7.8 (4.4)	7.3 (3.3)	7.1 (2.2)	7.1 (4.8)	6.9 (3.5)	6.8 (2.2)	7.6 (5.1)	7.3 (3.6)	7.2 (2.6)
Unstable angina	7.2 (4.3)	6.4 (3.2)	6.2 (2.0)	4.6 (4.1)	3.9 (2.5)	3.8 (1.6)	3.3 (3.4)	3.1 (2.3)	3.4 (1.9)
Hypertension	52.3 (9.7)	51.5 (7.3)	52.2 (5.2)	60.0 (10.0)	58.2 (7.6)	58.1 (5.2)	70.0 (9.8)	68.3 (7.0)	67.4 (5.5)
Stroke	2.3 (2.4)	2.1 (1.7)	2.1 (1.1)	2.0 (2.4)	2.0 (1.7)	1.9 (1.2)	2.0 (2.5)	1.7 (1.5)	2.0 (1.2)
Pneumonia	14.1 (6.3)	12.0 (4.6)	12.0 (3.3)	15.4 (7.7)	14.1 (5.3)	14.9 (3.7)	16.7 (8.1)	15.2 (5.5)	15.3 (4.4)
Cancer	5.9 (3.7)	5.7 (2.7)	6.3 (1.9)	6.1 (4.4)	6.4 (3.2)	6.9 (2.2)	5.4 (4.1)	6.1 (3.1)	6.8 (2.5)
Depression	3.7 (3.2)	3.9 (2.6)	4.1 (1.7)	5.2 (4.2)	5.5 (3.0)	5.3 (2.1)	5.9 (4.6)	6.0 (3.2)	5.9 (2.5)
Diabetes mellitus	31.9 (8.9)	30.3 (6.3)	29.5 (4.3)	34.7 (10.4)	31.5 (6.8)	30.6 (4.8)	37.6 (10.4)	35.0 (7.5)	34.0 (5.8)
Observed AMI hospitalization rate per 100 000 person-years, mean (SD)	1452.8 (521.1)	1375.1 (279.1)	1183.7 (284.1)	1140.7 (405.7)	1009.7 (290.9)	890.9 (219.0)	942.0 (341.3)	798.2 (243.5)	681.4 (176.9)
Risk-standardized AMI hospitalization rate per 100 000 person-years, mean (SD)	1352.7 (362.2)	1286.5 (282.4)	1122.5 (233.8)	1085.3 (281.7)	984.0 (226.5)	874.0 (189.7)	852.9 (228.5)	744.0 (182.7)	648.3 (147.2)
AMI 1-y mortality, mean (SD), %									
Observed	32.7 (8.5)	31.0 (6.1)	31.1 (4.1)	28.9 (9.0)	27.9 (6.5)	28.2 (4.5)	26.3 (8.9)	26.1 (6.4)	25.8 (4.7)
Risk standardized	31.5 (1.0)	31.4 (1.2)	31.1 (1.2)	28.3 (1.0)	28.3 (1.1)	27.8 (1.4)	26.2 (0.9)	26.1 (1.1)	25.4 (1.3)

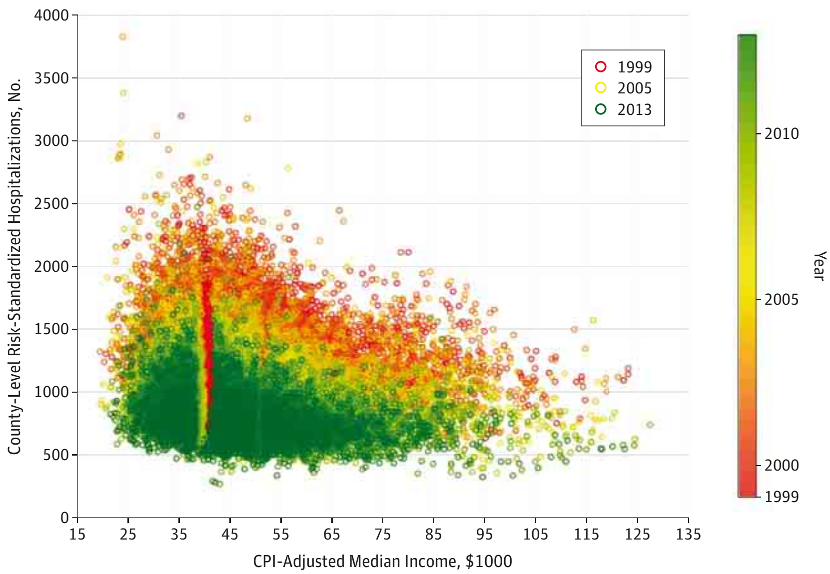
Abbreviations: AMI, acute myocardial infarction; CHF, congestive heart failure; CPI, consumer price index; IQR, interquartile range; MI, myocardial infarction.

[a] Method for classifying counties as low, average, or high income is described in the Methods section.

[b] Adjusted for CPI.

[c] Refers to Medicare fee-for-service beneficiaries residing in the relevant county group.

Figure 1. Association Between County-Level, Risk-Standardized Hospitalization Rates for Acute Myocardial Infarction (AMI) and Income Between 1999 and 2013



County-level, risk-standardized AMI hospitalization rates per 100 000 person-years are plotted. The x-axis represents county-level consumer price index (CPI)–adjusted median income in 1999 ($1000).

78.3% of average-income, and 76.6% of high-income counties remained unchanged in their income classification (eFigure 2 in the Supplement). In 1999, there were 2 512 262 person-years of fee-for-service beneficiaries in 783 low-income counties, 9 812 513 person-years of beneficiaries in 1565 average-income counties, and 14 248 657 person-years of beneficiaries in 783 high-income counties. Comparison of counties by income status across 3 time periods (1999, 2006, and 2013) revealed that, for all years, low-income counties had smaller populations and more residents 65 years or older compared with high-income counties (Table). The greatest proportion of white residents lived in high-income counties, although this decreased over time, offset by increasing proportions of Hispanic residents living in high-income counties. The greatest proportion of black residents lived in low-income communities, and this proportion did not change over time. The prevalence of comorbidities among Medicare beneficiaries did not differ substantially among county income groups (Table).

Association Between Income and AMI Hospitalization and Mortality Rates

Income was associated with county-level, risk-standardized AMI hospitalization rates but not mortality rates; this association persisted during the study period (**Figure 1** and eFigure 3 and eFigure 4 in the Supplement). Increasing 1 interquartile range of median county consumer price index–adjusted income ($12 000) was associated with a decline in 46 and 37 hospitalizations per 100 000 person-years for 1999 and 2013, respectively. Although there was an interaction between income and time for the hospitalization rate, the effect was small (0.56). The association between income and AMI hospitalizations varied by income groups. For low-, average-, and high-income groups, each interquartile range increase was associated with a decrease in hospitalization rates of 74, 47, and 32 per 100 000 person-years, respectively.

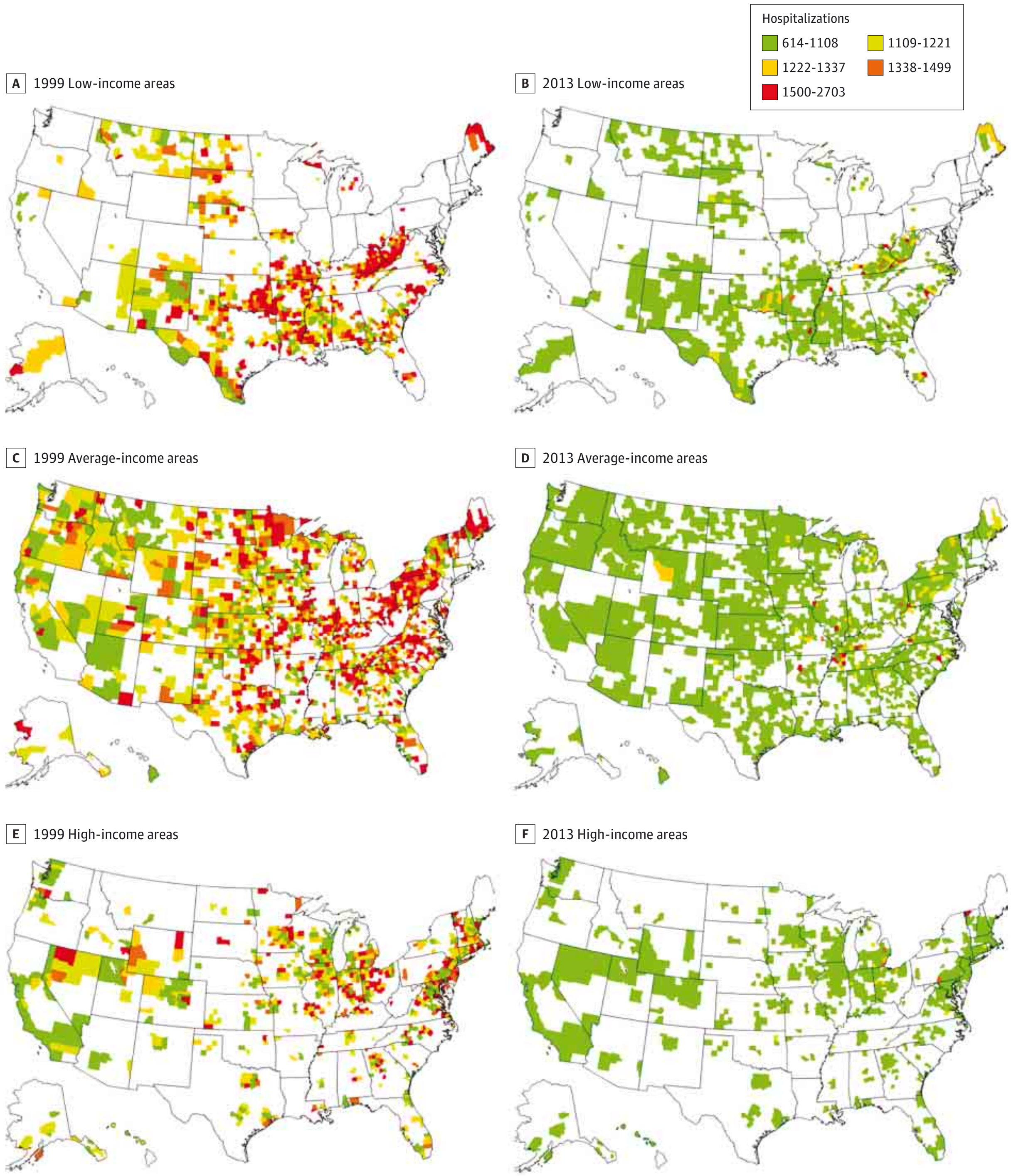
Trends in Hospitalizations and Mortality by County Income Groups

County-level, risk-standardized AMI hospitalization rates decreased significantly from 1999 to 2013 for all counties (eFigure 5 in the Supplement). However, hospitalization rates varied by income groups (**Figure 2**). The mean hospitalization rates among low-income counties compared with high-income counties in 1999 were 1353 vs 1123 per 100 000 person-years, respectively, and in 2013 were 853 vs 648 per 100 000 person-years, respectively. The greatest number of AMI hospitalizations occurred in low-income counties (140 922 in 1999, 119 125 in 2006, and 89 893 in 2013), and the lowest number of AMI hospitalizations occurred in high-income counties (28 756 in 1999, 22 289 in 2006, and 21 502 in 2013). The rate of decline in hospitalizations was consistent across all county income groups (**Figure 3**). There was an interaction between time and the average-income group but no interaction between time and the low-income group, indicating that the slope of decline in the low-income group was similar to the slope of decline in the high-income group. Low- and average-income counties lagged behind high-income counties. To achieve the 2013 hospitalization rate of the high-income counties, assuming a continuing trend, low-income counties would require an additional 4.3 years (95% CI, 3.1-5.9) and average-income counties would require an additional 1.9 years (95% CI, 1.6-2.3). One-year, risk-standardized AMI mortality decreased for counties of all levels of income, with small differences between counties. The 1-year mortality rates for counties of low-, average-, and high-income county groups in 1999 was 31.5%, 31.4%, and 31.1%, respectively, compared with 26.2%, 26.1%, and 25.4% in 2013. The maximum difference between counties at any 1 time point was 2% (eFigure 6 in the Supplement).

Geographic Variation

The mean (SD) consumer price index–adjusted median income in 2013 differed by region: Northeast, $45 580

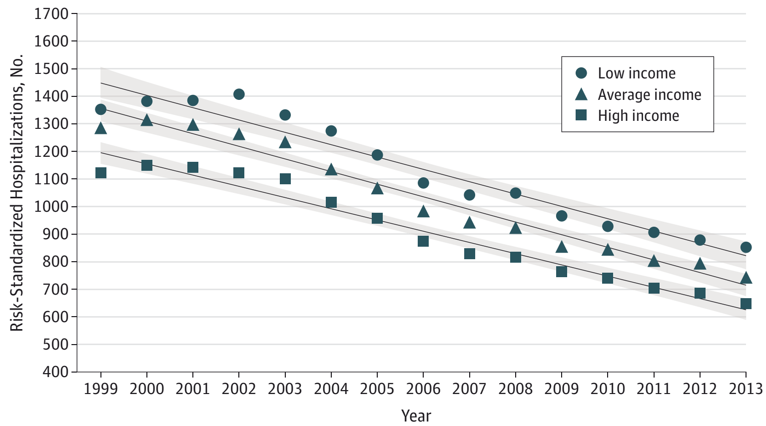
Figure 2. Geographic Variation in County-Level, Risk-Standardized Hospitalization Rates for Acute Myocardial Infarction (AMI) Between 1999 and 2013



County-level hospitalization rates per 100 000 person-years are shown for 1999 vs 2013 for low- (A and B), average- (C and D), and high- (E and F) income levels. The rates are color-coded based on quintiles of observed, risk-standardized hospitalization rates for AMI in 1999.

($14 011); West, $49 064 ($12 193); Midwest, $49 114 ($10 632); and South, $43 949 ($10 122). The densest proportion of low-income counties was in the South. The AMI hospitalization rates for each income county group were similar across regions. In addition, trends in decline in risk-standardized AMI hospitalizations (**Figure 4**) and mortality rates (eFigure 7 in the Supplement) were similar across the 4 geographic regions.

Figure 3. Trends in County-Level, Risk-Standardized Hospitalization Rates for Acute Myocardial Infarction (AMI) by Income Group



Observed income-level, risk-standardized AMI hospitalization rates per 100 000 person-years are plotted. The lines represent linear trends over time; the shaded area indicates the 95% CI.

Discussion

In this national study assessing trends in AMI hospitalization rates and outcomes by county-level income, we found significant declines among low-, average-, and high-income communities in all regions of the United States. The rate of decline was similar across low-, average-, and high-income county groups; however, low-income counties had persistently higher AMI hospitalizations, although not mortality, compared with high-income counties. For example, AMI hospitalization rates in low-income counties in 2013 were similar to the rates for high-income counties in 2008. This estimated 4-year lag time was observed across the entire study period, suggesting that efforts to reduce AMI burden have reached diverse income areas throughout the United States, although disparities persist.

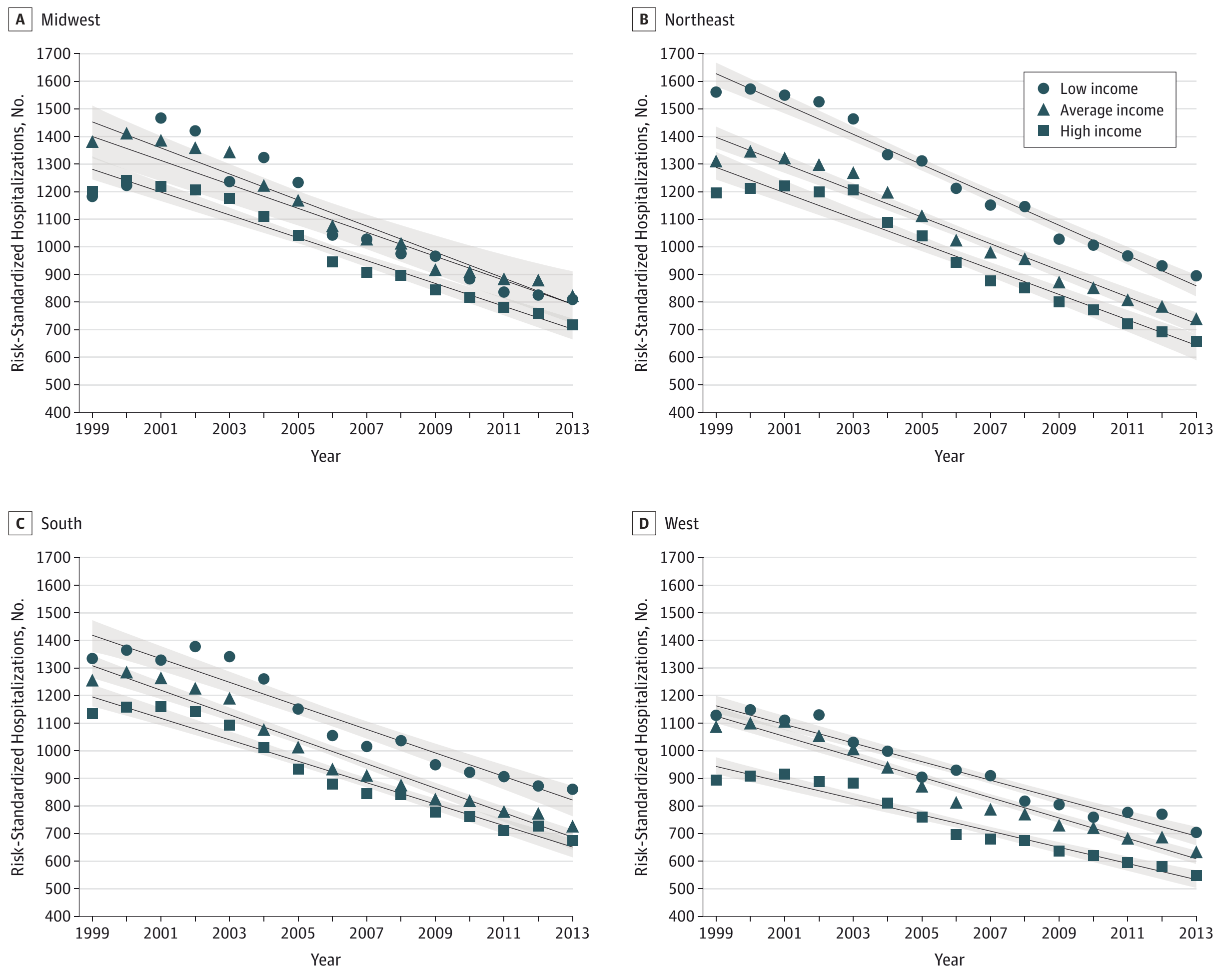
Previous work[23] conducted at the individual level demonstrated significant nationwide declines in AMI hospitalization and mortality rates that were consistent across demographic groups of age, sex, and race. We expand on this work, showing that trends in AMI were similar across communities of different income levels. This finding is important since differences in the physical and social environment can affect cardiovascular outcomes of a population, leading to health disparities.[39-41] Areas with poor access to healthy foods, recreational activities, and health care are limited in their capacity to promote healthy lifestyle behaviors as well as primary and secondary prevention.[26] Also in these areas, exposure to stress, unemployment, and inadequate social support may attenuate the effects of efforts to improve cardiovascular health.[42-44]

However, during the past 2 decades, there have been several broad cardiovascular health initiatives aimed to improve outcomes among all communities. These initiatives include nationwide quality improvement campaigns for better cardiovascular risk factor screening, prevention, and control[16,45,46]; smoking bans[47]; and process and outcome measures assessing adherence to guideline-based risk factor modification[48-50] and cardiovascular events and mortality.[30,49,51,52] The Agency for Healthcare Research and Quality developed prevention quality indicators intended for use by communities as a screening tool to assess quality of care outside of the hospital.[53] The emphasis on measurement and transparency of outcomes, as well as the use of evidence-based practices, may have affected communities of different economic status. In addition, secular (ie, not specific to AMI prevention) trends in the health care system may have contributed to declines, such as greater integration, coordination, and access to care during this period. Thus, a national assessment of AMI trends across communities of different income levels is important for understanding whether these efforts had similar reach.

Our study focused on income level as a means of assessing health disparities across diverse communities. Low-income communities tend to be chronically underresourced, as demonstrated by the stagnant income levels we observed among most counties across the United States.[54,55] Median income can serve as a proxy for other socioeconomic indicators (eg, poverty, educational levels, and employment), which have been associated with health outcomes.[2,17,25,43] In the present study, we found highly significant correlations between county-level median income, poverty rates, and eligibility for Medicaid. In addition, income level can be associated with other community-level factors (eg, health behaviors, health care access and quality, and the physical environment) that can contribute to higher AMI event rates.[1,34] These contextual factors may mediate the association between area income and population rates of AMI or may have independent effects. Understanding these associations is critical for identifying strategies to reduce disparities in AMI and is an important area for future research.

The higher hospitalization rates among low-income communities, along with the lagged decline in hospitalization rates compared with high-income counties, have several explanations. High-income counties may have a greater capacity to quickly adopt new models of care delivery, join campaigns to reduce AMI, and implement evidence-based primary and secondary treatment recommendations.[37] In addition, high-income communities may have greater resources to invest in

Figure 4. Trends in County-Level, Risk-Standardized Hospitalization Rates for Acute Myocardial Infarction by Income Group in 4 US Regions



Observed values for income groups in the Midwest (A), Northeast (B), South (C), and West (D) are plotted. The lines represent linear trends over time; the shaded area represents 95% CI.

the physical and social health environment.[56-58] Conversely, low-income communities may face unique challenges (eg, closure of health centers during economic depression) or disorganized health services that could attenuate the success of new primary and secondary prevention efforts to reduce AMI.[59,60] The AMI hospitalization and mortality rates declined at a similar pace across low- and high-income communities, suggesting that a single factor or intervention was not responsible for the decline. If so, one might have expected admission rates in low-income counties to drop more rapidly since they started with higher rates. In the present study, we found that income had a greater effect on AMI hospitalizations in low-income counties in later years compared with earlier years, suggesting that AMI rates among low-income counties may be particularly vulnerable to economic trends, mitigating efforts to eliminate disparities.

The lack of association of county income with AMI mortality is compelling. We hypothesized that the community factors contributing to AMI incidence would also affect AMI recovery. Prior studies[1,25,61] of coronary heart disease mortality from 1990 to 1999 showed 2-fold and 3-fold differences by state and county, respectively. One explanation for the difference in findings is that having an AMI today activates a robust medical system that may be comparably responsive in different socioeconomic settings. Another explanation for the difference is that county-level income becomes less important following a major life-threatening event. Future studies should examine whether other recovery outcomes, such as recurrent AMI, rehospitalization, patient-reported symptoms and health status, and long-term life expectancy following AMI, are associated with county-level income.

Although more low-income counties were clustered in the South, we did not find a difference in the rate of decline between regions. Aggregating counties into 4 regions may have obscured differences, highlighting the importance of analyses of smaller population units.[62]

Our study has some limitations. First, median county household income is only 1 marker for socioeconomic status, and an index of other variables (eg, educational level, employment, and household crowding) may provide a more

holistic indicator of socioeconomic status.[63] In prior studies,[63,64] median income, when combined with other socioeconomic variables, was the principal component explaining the greatest variance. Moreover, median income is strongly associated with health outcomes, and small differences in income have been associated with large changes in health status, especially among poor communities.[24,65] Second, this study describes AMI risk-standardized hospitalization rates among Medicare fee-for-service beneficiaries who may not be representative of the entire population. Younger uninsured/underinsured populations with AMI may be more affected by county-level income; thus, we suspect that focusing on the Medicare population would have biased our results to the null. Third, heterogeneity in annual household income is present within each county. However, we chose to study counties rather than a smaller geographic area (eg, 5-digit zip code or US census tracts or blocks) because the area is more relevant to policy action steps. County-level data on the contextual environment are increasingly available through the Robert Wood Johnson Foundation[40] and the Centers for Disease Control and Prevention[66] and can help to identify gaps in opportunities for cardiovascular health between counties. Moreover, county-level data on the contextual environment can drive leaders in government, health care, business, and community organizations to consider community efforts to improve cardiovascular health. As the final limitation, this study focused on hospitalization and mortality rates associated with a single condition: AMI. These rates do not take into account prehospital sudden cardiac death due to AMI. Further studies are needed to determine whether trends by county-level income are consistent for sudden cardiac death due to AMI, as well as for non-AMI conditions.

In 1999, the National Conference on Cardiovascular Disease Prevention, convened by the US Congress, was charged to "enhance efforts to remove differences in risk behaviors, preventive care, and morbidity and mortality in the disadvantaged."[1(p3145)] The findings of the present study indicate that the cardiovascular health of people residing in high-, average-, and low-income communities has improved since that time. However, disparities continue to persist. Although significant improvements have been achieved, low-income communities continue to lag behind. Future policies, programs, and nationwide campaigns should consider more focused efforts in low-income communities, potentially targeting health factors in the community that may contribute to the differences in outcomes.

Conclusions

In this national study of disparities and trends in AMI between 1999 and 2013, we observed similar rates of decline in AMI hospitalizations and 1-year mortality between communities of different income levels. However, low-income counties had persistently higher hospitalizations, although not mortality, than high-income counties in all years of the study, with an estimated 4-year lag time for low-income counties. The declines in AMI hospitalization and mortality rates across socioeconomic groups is commendable, although disparities persist in AMI event rates; these disparities present a topic for future research and action.

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