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Neighborhood Income and Individual Education: Effect on Survival After Myocardial Infarction

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Abstract

OBJECTIVE—To evaluate the association of neighborhood-level income and individual-level education with post-myocardial infarction (MI) mortality in community patients.

PATIENTS AND METHODS—From November 1, 2002, through May 31, 2006, 705 (mean ± SD age, 69±15 years; 44% women) residents of Olmsted County, MN, who experienced an MI meeting standardized criteria were prospectively enrolled and followed up. The neighborhood's median household income was estimated by census tract data; education was self-reported. Demographic and clinical variables were obtained from the medical records.

RESULTS—Living in a less affluent neighborhood and having a low educational level were both associated with older age and more comorbidity. During follow-up (median, 13 months), 155 patients died. Neighborhood income (hazard ratio [HR], 2.10; 95% confidence interval [CI], 1.42-3.12; for lowest [median, $34,205] vs highest [median, $60,652] tertile) and individual education (HR, 2.21; 95% CI, 1.47-3.32; for <12 vs >12 years) were independently associated with mortality risk. Adjustment for demographics and various post-MI prognostic indicators attenuated these estimates, yet excess risk persisted for low neighborhood income (HR, 1.62; 95% CI, 1.08-2.45). Modeled as a continuous variable, each $10,000 increase in annual income was associated with a 10% reduction in mortality risk (adjusted HR, 0.90; 95% CI, 0.82-0.99).

CONCLUSION—In this geographically defined cohort of patients with MI, low individual education and poor neighborhood income were associated with a worse clinical presentation. Poor neighborhood income was a powerful predictor of mortality even after controlling for a variety of potential confounding factors. These data confirm the socioeconomic disparities in health after MI.

Measures of social position have long been associated with post-myocardial infarction (MI) risk.[1,2] However, much of this complex interaction has yet to be elucidated. Socioeconomic status (SES) is a multidimensional construct comprising various factors acting at different levels[3-5] such that both individual-level and area-level measures could affect cardiovascular health through complementary mechanisms.[4,6-8]

In view of this concept, a “double jeopardy” (ie, a multidimensional vulnerability related to SES) theory was formulated but never formally tested.[9,10] Indeed, most previous studies

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examining the interaction between SES and risk after MI were limited to a single indicator or a few indicators measured at a single level.[11-21] Given that the effects of each SES indicator can in part be either explained by or mediated through other indicators,[5] these data are incomplete. Further, most prior studies were conducted in selected populations such as clinical trial participants or women,[2,13,18] took place in different health care systems,[12,14-16,19,21] or used administrative or registry data and lacked essential clinical details.[10,12,15-17,19] These limitations are important because failing to control for key clinical factors leaves substantial potential for residual confounding and thus inconclusive results. Therefore, both the internal and external validity of these results can be challenged, and their applicability to the community is uncertain.[22,23]

Our study was undertaken to address these knowledge gaps by examining the association between primary SES indicators and post-MI mortality in patients from a geographically defined population. Specifically, we evaluated the prognostic importance of individual education and neighborhood-based income in defining risk after MI.

PATIENTS AND METHODS

The study was conducted in Olmsted County, MN, where Mayo Clinic and the Olmsted Medical Center provide medical care for all county residents. Each institution uses a unit medical record in which the details of care for a patient, regardless of setting, are available in one place. The records are easily retrievable because Mayo Clinic maintains extensive indices that, through the Rochester Epidemiology Project, are extended to the records of other health care providers in the county, linking all records from all sources of care through a centralized system.[24]

Olmsted County (2000 census population, 124,277) is 144 km southeast of Minneapolis and St Paul; approximately 70% of its population resides in Rochester. Its population is largely middle class; 91% of adults have graduated from high school, 2.4% are uninsured, and 6.4% have incomes below poverty level.[25] With the exception of a higher proportion working in the health care industry, population characteristics are similar to those of US whites.

The current analysis grew out of an observational parent study that prospectively investigated the effect of the new definition of MI on case ascertainment. Details of the enrollment procedures have been described previously.[26] Between November 1, 2002, and May 31, 2006, 705 patients were enrolled. The mean ± SD age of the cohort was 69±15 years; 44% were women. All residents presenting to an Olmsted County facility with a cardiac troponin T level of 0.03 ng/mL or greater (to convert to μg/L, multiply by 1.0), the cutoff value used at Mayo Clinic and the value at which the coefficient of variation for the assay is 10% or less,[27] were prospectively identified within 12 hours of the blood draw through the electronic files of the Department of Laboratory Medicine. Nurse coordinators sought written consent from all patients to measure cardiac biomarkers in unused blood samples initially stored for additional clinical need. If a blood sample was unavailable, an additional sample was drawn, in conjunction with a clinically indicated draw when possible.

Standardized criteria were used to determine MI status,[28] on the basis of cardiac pain, electrocardiographic data (using Minnesota coding), and biomarker levels.

The participation rate was 82% for the overall study and was higher among patients with confirmed MI.[29] The Mayo Clinic and Olmsted Medical Center institutional review boards approved all aspects of the study.

Socioeconomic Indicators and Risk Factors

Education (ie, years of school completed) was self-reported by a demographic questionnaire. Neighborhood-level SES was obtained by linking the patients' addresses (at the time of the index date) to 2000 census data (US Census Bureau).[25] A total of 33 census tracts were included (Table 1). The census tract's median household income was chosen for analysis, on the basis of recommendations by Geronimus and Bound.[30]

Inpatient and outpatient medical records were used to ascertain cardiovascular risk factors, comorbidity, MI characteristics and severity, and medical treatment given during the index hospitalization. Smoking was categorized as current vs non-current smoking. Diabetes, hypertension, and dyslipidemia were defined clinically. Comorbidity was assessed by the Charlson index[31] and analyzed categorically. Revascularization included percutaneous transluminal coronary angioplasty and coronary artery bypass grafting performed during the index hospitalization.

Mortality Follow-up

Follow-up was completed by surveillance of medical records. The comprehensive approach in place under the auspices of the Rochester Epidemiology Project ensures complete ascertainment of deaths, as it incorporates several sources of information. First, all death certificates for Olmsted County residents are obtained every year from the county office. Second, the Mayo Clinic registration office monitors the obituaries and notices of death in the local newspapers to update the record. Finally, electronic files of death certificates are obtained from the State of Minnesota Department of Vital and Health Statistics.[24,32]

Statistical Analyses

Analyses were performed using the statistical software package SAS, version 9.1 (SAS Institute, Cary, NC). For comparisons of baseline characteristics, participants were divided into neighborhood income tertiles and 3 education categories (defined as fewer than, equal to, and greater than 12 years of schooling). Income tertiles were defined as median (25th-75th percentile): (1) $34,205 ($28,732-$44,665); (2) $50,091 ($49,435-$53,561); and (3) $60,652 ($56,992-$74,034).

Survival across income and education categories, estimated using the Kaplan-Meier method with right censoring at the time of last follow-up, was compared by the log-rank test. Cox proportional hazards models were constructed to evaluate the unadjusted and covariate-adjusted hazard ratios (HRs) and 95% confidence intervals (CIs) for death in income and education categories. No missing values in the variables were used in the regression analyses, except for ejection fraction (19%), for which an indicator variable reflecting a missing value was included when appropriate. The proportional hazards assumption was tested using the Schoenfeld residuals, with no violations detected. All *P* values were 2-tailed.

RESULTS

The baseline characteristics across income tertiles and education categories are presented in Table 2. On average, patients living in less affluent areas were older and more likely to be female and of races other than white. They also presented with more comorbidity and included a higher proportion of smokers than their more affluent counterparts. No other differences were observed after adjustment for age and sex. The percentages of patients with fewer than, equal to, and greater than 12 years of education were 15% (n=105), 36% (n=252), and 49% (n=338), respectively. Lower education was associated with older age, races other than white, higher prevalence of smoking and diabetes, more comorbidity, and a lower ejection fraction.

Over a median follow-up of 13 months (25th-75th percentile, 7-19 months), 155 patients died. The 1-year survival estimates across income tertiles (lowest to highest) were 75%, 83%, and 86%, respectively (*P*<.001). Similarly, for education the survival estimates at 1 year were 67%, 81%, and 85% for patients with fewer than, equal to, and greater than 12 years, respectively (*P*<.001). Modeled as mutually exclusive groups containing income and education categories, both socioeconomic measures showed a dose-response pattern with mortality after adjustment for age and sex (Figure). For example, compared with high-income patients (upper tertile) who had 13 years of education or more (reference category), the adjusted HRs (95% CIs) for death were 2.86 (1.40-5.84) for low-income (bottom tertile) patients with fewer than 12 years of education, 2.33 (1.19-4.57) for low-income patients with 13 years of education or more, 2.23 (1.01-4.95) for high-income patients not completing high school, and 2.12 (1.07-4.22) for average-income patients with 12 years of education.

Evaluated simultaneously, both neighborhood income for lowest vs highest tertile (HR, 2.10; 95% CI, 1.42-3.12) and individual education for 11 years or fewer vs 13 years or more (HR, 2.21; 95% CI, 1.47-3.32) were independently associated with mortality. After adjustment for age, sex, and race, these estimates were reduced by approximately half; further adjustment for comorbidity, cardiovascular risk factors, MI severity indicators, and medical treatment given during the index hospitalization accounted for most of the remaining effect of education but did not alter the association with neighborhood income appreciably (Table 3). Further adjustment for the time from symptom onset to hospital arrival and from presentation to percutaneous transluminal coronary angioplasty and coronary artery bypass grafting resulted in an HR of 1.66 (95% CI, 1.09-2.52) associated with the lowest vs highest income tertile. Additional analysis adjusting for the individual components of the Charlson index separately (rather than lumping components into categories) did not attenuate the income-mortality association for the lowest vs highest tertile (adjusted HR, 1.73; 95% CI, 1.13-2.65). Modeled as a continuous variable, the HRs (95% CIs) for death associated with each $10,000 increment in the annual neighborhood's median household income were 0.82 (0.75-0.90) before adjustment and 0.90 (0.82-0.99) after adjustment for demographics, education, comorbidity, cardiovascular risk factors, MI severity indicators, and medical treatment given during the index hospitalization. All possible 2-way interactions between age, sex, income, and education were examined, as well as the quadratic term of age. None reached statistical significance.

DISCUSSION

Measures of SES are well-established determinants of overall health, quality of life, and life expectancy.[33,34] However, because SES is a complex multidimensional construct, the mechanisms by which it affects health are still incompletely understood. Although SES has traditionally been treated as an intrinsic characteristic of individuals, contextual effects of SES on health are theoretically important. Indeed, growing evidence suggests that a person's health can be influenced by the socioeconomic characteristics of the neighborhood in which he or she lives, above and beyond that person's individual SES. This influence might be related to several factors, including the availability and accessibility of health services, infrastructure features (eg, recreational facilities, high-quality schools, stores selling healthy foods), prevailing attitudes toward health and health-related behavior (such as smoking, diet, and physical activity), stress, and degree of social support.[4,6,9] Despite this, few health studies measure neighborhood features along with, rather than as proxies for, individual-level SES measures.[3,4]

With regard to cardiovascular disease, a few primary prevention studies have evaluated the combined effects on disease incidence of SES indicators measured at both individual and area levels. These studies generally found an increased risk associated with area-level SES measures, even after controlling for individual-level measures.[7,35,36] However, to our knowledge, our study is the first to present such data for patients after MI.

Studies Using Individual-Level SES Measures

Several studies have examined the association between individual-level measures of SES and post-MI outcomes.[13-16,20] Patients with low SES who were hospitalized with MI were generally observed to exhibit a worse clinical profile and receive inferior treatment. Nearly all studies have demonstrated increased risk associated with low SES. For example, Alter et al,[14] studying 3407 patients with MI hospitalized in 53 hospitals in Canada, found a strong inverse relationship between income and 2-year mortality rate (HR, 0.45 for highest vs lowest tertile). However, the association was markedly attenuated after controlling for age, preexisting cardiovascular events, and risk factors (adjusted HR, 0.77). Similarly, in the Platelet Glycoprotein IIb/IIIa in Unstable Angina: Receptor Suppression Using Integrilin Therapy (PURSUIT) trial,[13] low income was strongly associated with worse outcome in unadjusted analysis, but the association was reduced after adjustment (adjusted HR, 1.4 for low- vs high-income patients). Thus, although individual-level SES measures are associated with adverse outcome after MI, the extent to which this relationship is accounted for by differences in baseline characteristics and post-MI management remains uncertain.

Studies Using Area-Level SES Measures

Similar to findings on individual-level SES indicators, increasing evidence suggests that patients with MI living in low-SES neighborhoods are older, are more likely to be female, and have more cardiovascular risk factors and comorbidity. Yet, despite their higher risk, these patients are less likely to receive evidence-based medical therapies (ie, aspirin, statins, and β-blockers) or to be treated aggressively with invasive cardiac procedures.[11,12,17,19,21,37,38] Further, previous studies uniformly revealed an association between low SES and mortality. For instance, Tonne et al[11] studied the relationship of several area-level SES measures to mortality in 3423 community patients with MI from Worcester, MA. A 43% higher death rate was found among patients living in census tracts with the highest percentage of residents living below the poverty line, compared with the wealthiest tracts (top vs bottom quintile). Adjustment for demographic and clinical characteristics yielded a relative risk of 1.30 (95% CI, 1.08-1.56). Similar associations were observed for other SES measures. Alter et al,[12] studying 51,591 patients with MI in Ontario, reported that for each $10,000 increase in the neighborhood median income, there was an approximately 10% reduction in the adjusted risk of death within 1 year. Associations of the same magnitude have been observed in other studies,[17,19] including ours. Thus, data linking area-level SES measures to mortality after MI are consistent, although the estimated effects are generally modest relative to individual-level measures.

What This Study Adds

To the best of our knowledge, this study is the first to evaluate the combined effects of individual-level and area-level SES measures after MI. Moreover, although most previous studies were conducted in selected populations, our study reports on the comprehensive experience of community-dwelling persons, and so its findings can be generalized more readily.

Our findings of older age, female sex, excess comorbidity, and increased mortality associated with low SES are consistent with prior studies. However, unlike previous reports, our study found no strong evidence of treatment disparities related to SES, either for evidence-based medical therapies or for invasive cardiac procedures. This could be related to the fact that few patients were uninsured in this community, which is characterized by easy access to high-quality care.

Interestingly, despite the higher-than-average SES of this population, the associations of individual education and neighborhood income with death after MI were stronger than those reported in many previous studies. We think our approach of evaluating 2 different and complementary indicators of SES allowed us to capture a wider spectrum of this complex construct. As such, our results are commensurate with the double-jeopardy theory,[9,10] whereby patients carrying multiple adverse SES characteristics are particularly vulnerable. Although the risk associated with education was markedly attenuated after controlling for multiple demographic and clinical variables, this attenuation could represent an overadjustment, because many of the variables adjusted for are likely to be intermediate factors on the education-mortality pathway.

Possible Mechanisms

The strong association shown between neighborhood income and death suggests a contextual effect. Alternatively, neighborhood income could merely act as a proxy for unmeasured dimensions of individual-level SES. We think both mechanisms are likely to have a role. The association observed for education could be related to its indirect positive effect on job opportunities, income, housing, access to nutritious foods, health insurance, and more. Higher levels of education could also directly affect health through greater knowledge acquired during schooling and greater empowerment and self-efficacy. As recently reported, education is strongly associated with health literacy, which in turn affects one's ability to obtain, process, and understand basic health information and services needed to make appropriate health decisions.[39]

More specific mechanisms linking low SES to worse MI prognosis could include its substantial adverse influences on functional recovery from MI,[40] attendance at cardiac rehabilitation programs,[20,41] and adherence to postdischarge medications and lifestyle recommendations.[2,42]

Potential Limitations

Several issues should be considered in the interpretation of these data. Our sample size is relatively modest, and although Olmsted County is becoming more diverse, the study population consists primarily of US whites. However, the mean census tract percentage of residents living below the poverty line in this cohort was 8%, which does not greatly differ from the US average of 12%. Further, it was previously shown that, even among populations with relatively high SES, the most advantaged have better health status than the less advantaged.[6] Individual-level SES was assessed solely by education; consequently, the risk associated with neighborhood income might be overestimated because it could also have acted as a proxy for unmeasured individual socioeconomic characteristics.

CONCLUSION

In this community-based cohort of MI, low neighborhood income and lower levels of individual education were associated with a worse clinical presentation. Further, both measures showed a dose-response relationship with mortality. The association between low neighborhood income and increased mortality risk persisted even after controlling for a variety of potential confounders. These findings indicate the importance of SES in determining prognosis after MI.

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Glossary

CI, confidence interval; HR, hazard ratio; MI, myocardial infarction; SES, socioeconomic status.

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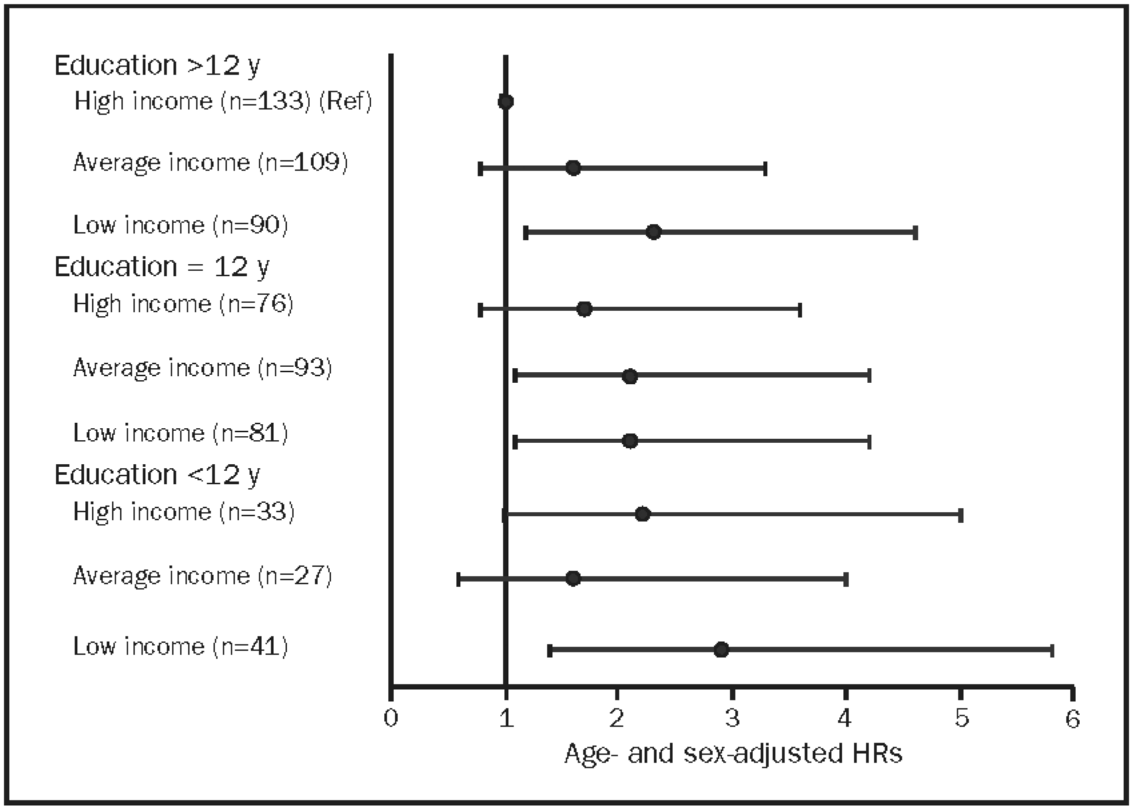

FIGURE.

Age- and sex-adjusted hazard ratios (HRs) (95% confidence intervals) for mortality after myocardial infarction in mutually exclusive groups defined by income tertiles (census tract-derived) and education level. Ref = reference group.

TABLE 1

Residents in Each Census Tract

Census tract No.	No. of residents (%)	Median household income ($)
1	40 (5.7)	14,668
2	25 (3.5)	34,205
3	20 (2.8)	37,460
4	24 (3.4)	53,561
5	13 (1.8)	33,107
6	43 (6.1)	28,732
7	14 (2.0)	49,435
9.01	11 (1.6)	48,750
9.02	14 (2.0)	48,125
9.03	13 (1.8)	74,034
10	33 (4.7)	50,091
11	15 (2.1)	58,143
12.01	17 (2.4)	83,494
12.02	15 (2.1)	56,006
12.03	10 (1.4)	110,820
13.01	20 (2.8)	55,625
13.02	15 (2.1)	68,021
14.01	28 (4.0)	45,318
14.02	21 (3.0)	77,391
15.01	21 (3.0)	59,635
15.02	17 (2.4)	54,865
15.03	14 (2.0)	60,652
16.01	32 (4.5)	47,400
16.02	13 (1.8)	71,125
16.03	18 (2.6)	70,048
17.01	23 (3.3)	51,343
17.02	16 (2.3)	40,417
17.03	5 (0.7)	86,766
18	18 (2.6)	58,672
19	32 (4.5)	56,992
20	37 (5.2)	49,509
21	32 (4.5)	44,665
22	29 (4.1)	55,492
Others[a]	7 (1.0)	
Total	705	

[a]Census tract unknown (neighborhood income estimated by zip code).

TABLE 2

Baseline Characteristics by Neighborhood Income and Individual Education[a]

Characteristic	Income tertiles			Education categories		
	First (n=219)	Second (n=238)	Third (n=248)	<12y (n=105)	12 y (n=252)	>12y (n=338)
Median	$34,205	$50,091	$60,652	8y	12 y	16 y
Demographics						
Age (y), mean ± SD	73±15	67±15	67±14[b]	77±13	69±14	66±15[b]
Female	120 (55)	89 (37)	100 (40)[c]	54 (51)	124 (49)	133 (39)
White	204 (93)	231 (97)	239 (96)[c]	97 (92)	244 (97)	326 (96)[c]
Cardiovascular risk factors						
Prior MI	17 (8)	7 (3)	11 (4)	9 (9)	15 (6)	13 (4)
Hypertension	167 (76)	152 (64)	179 (72)	84 (80)	182 (72)	234 (69)
Diabetes	55 (25)	55 (23)	58 (23)	38 (36)	64 (25)	68 (20)[b]
Hyperlipidemia	133 (61)	148 (62)	148 (60)	58 (55)	159 (63)	206 (61)
Current smoking	39 (18)	55 (23)	44 (18)[c]	16 (15)	69 (27)	49 (15)[b]
BMI, mean ± SD[d]	27.8±6.0	29.0±6.4	28.8±6.4	27.9±6.0	28.5±6.5	28.7±6.1
MI characteristics and comorbidity						
ST elevation	35 (16)	45 (19)	62 (25)	19 (18)	48 (19)	75 (22)
Ejection fraction						
≥50	116 (68)	137 (68)	139 (70)	45 (56)	146 (70)	196 (71)[b]
35-49	37 (22)	40 (20)	47 (24)	21 (26)	43 (21)	58 (21)
<35	18 (11)	25 (12)	13 (7)	15 (19)	18 (9)	22 (8)
Comorbidity index, points						
0	44 (20)	84 (35)	99 (40)[a]	13 (12)	74 (29)	130 (39)[a]
1-2	81 (37)	80 (34)	73 (29)	41 (39)	73 (29)	117 (35)
≥3	94 (43)	74 (31)	76 (31)	51 (49)	104 (41)	91 (27)
Treatment[e]						
PTCA	88 (40)	119 (50)	124 (50)	39 (37)	115 (46)	170 (50)
CABG	13 (6)	15 (6)	23 (9)	8 (8)	17 (7)	26 (8)
Statins	139 (64)	174 (73)	165 (67)	65 (62)	173 (69)	235 (70)
β-Blockers	201 (92)	215 (90)	215 (90)	92 (88)	225 (89)	312 (92)

Characteristic	Income tertiles			Education categories		
	First (n=219)	Second (n=238)	Third (n=248)	<12y (n=105)	12 y (n=252)	>12y (n=338)
Aspirin	198 (90)	219 (92)	232 (94)	94 (90)	231 (92)	314 (93)

[a]Data are presented as number (percentage) unless otherwise specified. BMI = body mass index; CABG = coronary artery bypass grafting; MI = myocardial infarction; PTCA = percutaneous transluminal coronary angioplasty.

[b]Age- and sex-adjusted *P* for trend ≤.05.

[c] Age- and sex-adjusted *P* for trend ≤.01.

[d]Calculated as weight in kilograms divided by the square of height in meters.

[e]During the index hospitalization.

TABLE 3

Association Between Death After Myocardial Infarction and Neighborhood Income and Individual Education[a]

	Median household income tertiles				Education categories			
Adjustment	**First**	**Second**	**Third**[b]	***P* value for trend**	**<12y**	**12 y**	**>12y**[b]	***P* value for trend**
Income and education	2.10 (1.42-3.12)	1.33 (0.87-2.04)	1	<.001	2.21 (1.47-3.32)	1.25 (0.87-1.81)	1	<.001
Age, sex, and race added	1.60 (1.07-2.40)	1.21 (0.78-1.85)	1	.02	1.43 (0.94-2.17)	1.21 (0.84-1.75)	1	.09
Full model[c]	1.62 (1.08-2.45)	1.10 (0.69-1.75)	1	.02	1.01 (0.65-1.56)	0.92 (0.63-1.36)	1	.95

[a]All data are presented as hazard ratio (95% confidence interval), unless otherwise indicated.

[b]Reference value.

[c]Adjusted for income and education, age, sex, race, comorbidity, ejection fraction, hypertension, hyperlipidemia, smoking, body mass index, STelevation myocardial infarction, coronary artery bypass grafting, percutaneous transluminal coronary angioplasty, statins, β-blockers, and aspirin.