Published in final edited form as:
Circulation. 2012 May 8; 125(18): 2197–2203. doi:10.1161/CIRCULATIONAHA.111.085811.

Residential Proximity to Major Roadway and Ten-Year All-Cause Mortality after Myocardial Infarction

Joshua I. Rosenbloom, MPH[1,2], **Elissa H. Wilker, ScD**[2], **Kenneth J. Mukamal, MD, MPH**[1,3], **Joel Schwartz, PhD**[4], and **Murray A. Mittleman, MD, DrPH**[1,2,3,4]

[1]Harvard Medical School, Boston, MA

[2]Cardiovascular Epidemiology Research Unit, Beth Israel Deaconess Medical Center, Boston MA

[3]Division of General Medicine and Primary Care, Beth Israel Deaconess Medical Center, Boston, MA

[4]Harvard School of Public Health, Boston, MA

Abstract

Background—The relationship between residential proximity to roadway and long-term survival after acute myocardial infarction (AMI) is unknown. We investigated the association between distance from residence and major roadway and 10-year all-cause mortality after AMI in the Determinants of MI Onset Study (Onset Study), hypothesizing that living closer to a major roadway at the time of AMI would be associated with increased risk of mortality.

Methods and Results—The Onset Study enrolled 3,886 individuals hospitalized for AMI in 64 centers across the United States from 1989-1996. Institutionalized patients, those providing only Post Office Boxes, and those whose addresses could not be geocoded were excluded, leaving 3,547 patients eligible for analysis. Addresses were geocoded and distance to the nearest major roadway was assigned. Cox regression was used to calculate hazard ratios (HRs), adjusting for personal characteristics (age, sex, race, education, marital status, distance to nearest acute-care hospital), clinical characteristics (smoking, body mass index, comorbidities, medications), and neighborhood-level characteristics derived from US Census block group data (household income, education, urbanicity). There were 1,071 deaths after 10 years of follow-up. In the fully adjusted model, compared to living >1000 km, HRs (95%CI) for living ≤100 m were 1.27 (1.01, 1.60), for 100 m to ≤200 m 1.19 (0.93, 1.60), for 200 m to ≤1000m 1.13 (0.99, 1.30), ptrend=0.015.

Conclusions—In this multi-center study, living close to a major roadway at the time of AMI was associated with increased risk of all-cause 10-year mortality; this relationship persisted after adjusting for individual and neighborhood-level covariates.

Keywords

Acute Myocardial Infarction; Mortality; Roadway; Epidemiology

Correspondence: Murray A. Mittleman, MD, DrPH Beth Israel Deaconess Medical Center 375 Longwood Avenue Room 441 Boston, MA 02215 Phone: 617.632.7653 Fax: 617.632.7698 mmittlem@bidmc.harvard.edu.

Conflict of Interest Disclosures: None

Introduction

Living close to a major roadway has been associated with adverse cardiovascular health including acute myocardial infarction (AMI), coronary artery disease, stroke, and deep vein thrombosis.[1-4] Proximity to roadway is a complex, multi-faceted exposure that includes increased exposure to traffic-related air pollution, traffic noise, and other factors.[5-9]

Long-term exposure to air pollution is associated with increased cardiovascular mortality in the general population,[10-16] and there are a number of possible mediators of this association, including progression of atherosclerosis,[17, 18] autonomic dysfunction as manifested by reduced heart rate variability[19] or repolarization abnormalities,[20] increased inflammation,[21] and increased oxidative stress.[22] Evidence about the relationship between traffic noise exposure and cardiovascular disease is more mixed, with some studies showing an association with hypertension,[23-25] although evidence regarding ischemic heart disease is less clear.[26, 27]

To date, however, there have been few studies specifically focusing on mortality associated with living close to a major roadway,[28-30] and none of these have examined the relationship between living near major roadways and mortality among those with confirmed coronary disease, such as survivors of AMI.[31-33]

We therefore examined the association between distance from residence to major roadway at the time of AMI and 10-year all cause mortality in an inception cohort of survivors of AMI, the Determinants of Myocardial Infarction Onset Study (the Onset study).[34] This multicenter, prospective cohort study included chart reviews and face-to-face interviews with patients who were hospitalized with confirmed AMI.

Methods

Enrollment and Data Collection

The first phase of the Onset Study was conducted in 45 community hospitals and tertiary care medical centers in the United States between August 1989 and September 1994. In the second phase that lasted through September 1996, the Onset Study was expanded to 64 medical centers. Altogether there were 3,886 patients enrolled in the study. The institutional review board of each center approved this protocol and all participants provided informed consent. For the analyses in this paper, approval was obtained from the Beth Israel Deaconess Medical Center Committee on Clinical Investigations.

Trained research interviewers identified eligible patients by reviewing coronary care unit admission logs and patient charts. For inclusion, patients were required to have a creatine kinase level above the upper limit of normal for the clinical laboratory at each center, positive MB isoenzymes, an identifiable onset of pain or other symptoms typical of AMI, and the ability to complete a structured interview. Interviewers used a structured data abstraction and questionnaire form.

Participants reported their residential address at the time of AMI. Addresses were geocoded using ArcGIS 10 (ESRI, Redlands, CA), using StreetMap USA 2006 (ESRI, Redlands, CA). For addresses that could not be automatically matched by the software, manual geocoding, including the use of the phone book and Google Maps, was used. Distance to the nearest major roadway (defined as US Census Feature Class Code (CFCC) A1 or A2) was computed using the “near” tool in ArcGIS. Next, each geocoded address was assigned the appropriate census block group from the 1990 US Census with the spatial join tool. We used this information to derive median household income as well as the percentage of those aged

25 or older without high school diplomas. We also determined the distance to the nearest acute care hospital, as distance to hospital has been associated with socioeconomic position as well as survival after AMI. Other information collected included age, sex, medical history, and prescription and nonprescription medication use. We defined current aspirin use as the reported use of any aspirin or aspirin-containing product in the 4 days prior to the index AMI, based on previous Onset Study analyses and the duration of its physiologic effect.[35] We defined noncardiac comorbidity as any diagnosis of cancer, respiratory disease, renal failure, or stroke recorded in medical records. We derived body-mass index based upon self-reported height and weight. Patients were asked their usual frequency of heavy physical activity (leisure-time and work-related), using a validated instrument.[34] Consistent with previous Onset Study analyses, [34] we defined physical activity as activity ≥6 MET, and categorized participants into sedentary (<1 time/week) or active (≥1 time/week).

All participants were administratively censored 10 years after their enrollment or death, whichever came first. Thus, the median and upper quartile of follow-up time was 10 years. We searched the National Death Index (NDI) for deaths of Onset study participants, and requested death certificates from state offices of vital statistics records for all probable matches using a previously validated algorithm.[36] Three investigators independently verified the determination of each death. Disagreements among raters were resolved by discussion. The outcome measure in all analyses was all-cause mortality after 10 years of follow-up.

For most patients, we also obtained information on cause of death from the NDI and categorized deaths into cardiovascular or non-cardiovascular based on International Classification of Diseases (ICD) 9 or ICD10 codes. The NDI provided ICD 9 codes for deaths through 1998, and ICD 10 codes for deaths from 1999 and beyond. For the ICD 9 codes, we used the 72 category recodes which collapses the ICD 9 codes into 72 categories, and we considered codes 300-490 to represent cardiovascular death. For the ICD 10, we used the 113 category recodes (which is considered the same level of detail as the 72 category ICD 9 recodes), and considered codes 53-75 to represent cardiovascular death. For 292 individuals from the initial phase of the Onset Study, causes of death had previously been abstracted from death certificates and categorized as cardiovascular or non-cardiovascular only, and no further information on specific cause of death was available. As proximity to roadway might be associated with a higher incidence of traffic accidents, we also categorized deaths into non-traffic accident or traffic-accident (n=3) (this information was not available for the 292 individuals referenced above). We considered cardiovascular death as a secondary outcome measure.

Statistical Analysis

We performed univariate comparisons of continuous and categorical variables using ANOVA and χ^2 tests respectively, comparing four exposure groups (≤100 m, 100 to ≤200 m, 200 m to ≤1000 m, and >1000 m from a major roadway). We used Cox proportional hazards models to examine the independent association between distance from residence to roadway,10-year all cause mortality, and 10-year cardiovascular mortality. We treated distance to roadway as both a continuous and a categorical variable for these analyses. In order to graphically assess a potential exposure-response, we used a penalized spline with 3 degrees of freedom for distance to roadway as a continuous variable, based on our *a priori* assumption that the relationship between distance and mortality would be nonlinear. In order to obtain an estimate for the continuous analysis, we examined the shape of the spline, which was found to be similar to ln(distance to roadway), and then used this function for our model. For categorical analysis, we classified distance to roadway as ≤100 m, 100 to ≤200 m, 200 m to ≤1000 m, and >1000 m, based on prior studies showing an association between living within 100 m of a major roadway and adverse cardiac outcomes,[1] living within 200 m and having increased coronary artery calcification,[37] as well as on the results of our continuous graphical analysis. In addition, prior studies have shown that ultrafine particles and black carbon are elevated near roadways but decline to the local urban background rapidly, generally within 100 m.[8] To assess trends, we assigned each exposure category the natural log of the median distance within each category. The p-value obtained represents the linear component of trend on the log scale, consistent with the overall shape of the association. As exploratory analyses, we examined the potential for effect modification by sex, smoking status, diabetic status, marital status, individual education, neighborhood income, and age groups (<65, ≥65), and used interaction terms to assess whether the trends were significantly different across the characteristics.[38, 39]

We present age-adjusted models followed by models adjusting for other potential personal, clinical, and sociodemographic confounders. Individual-level demographic variables included age, sex, marital status (married/not married), race, individual education (<12 years of school, 12 to <16 years of school, 16 or more years of school), and distance to nearest acute-care hospital. Individual clinical characteristics included body mass index (as linear and quadratic terms), smoking (current/previous/never), previous MI (yes, no, uncertain), previous congestive heart failure, previous angina, diabetes mellitus, hypertension, noncardiac comorbidity, previous medication use (aspirin, β-blockers, calcium channel blockers, digoxin, and angiotensin-converting enzyme inhibitors individually), and frequency of physical activity (sedentary vs. active). Neighborhood-level characteristics derived from US Census block group data included median household income (in quartiles), neighborhood education (percent of residents aged 25 or older without high school diplomas, in tertiles), and urbanicity (defined as percent of residents living in urban area and then dichotomized as <50% or ≥50%).

We conducted sensitivity analyses to assess the robustness of our findings. First we restricted our analysis to the northeast region of the country (n=2,909) since components of roadway exposure, including pollution, may differ regionally. Secondly, we excluded patients who died in traffic accidents.

We used indicator variables for missing education (n=74) and marital status (n=51). For patients missing BMI (n=33), we assigned the mean value, and for those missing categorical neighborhood variables (n=6), we assigned the mode value.

We tested hazard ratios (HRs) for linear trend across categories of distance to roadway. We tested the proportionality of hazards using time-varying covariates and found no significant violations, and we also examined Schoenfeld residuals. Analyses were done with SAS 9.2 (SAS Institute, Cary, NC), and the PSpline and Survival packages in R 2.9 (R Foundation, Vienna). We present HRs from Cox models with 95% confidence intervals (CIs). All probability values presented are 2-sided, and we considered values <0.05 to be statistically significant.

Results

There were 3,886 enrollees in the study. For the 20 patients who enrolled in the study twice (after two separate AMIs), only the first enrollment was used. Patients who provided no address (n=59), only a post-office box address (n=153), who were incarcerated or living in a homeless shelter (n=6), or who did not reside in the United States (n=3) were excluded. After excluding participants whose residential addresses could not be geocoded (n=98), we were left with 3,547 (92%) patients for analysis, comparable to results obtained in other large retrospective geocoding efforts.[40]

Characteristics of the patients according to distance from residence to major roadway are shown in Table 1. There were 243 patients (7%) living within 100 m of a major roadway, 230 (6%) living from 100-200 m, 1,311 (37%) living from 200 m to 1000 m, and 1,763 (50%) living >1000 m from a major roadway. Those living close to a major roadway tended live in areas of lower socioeconomic position as noted by lower block group income and lower neighborhood education, although their demographic and clinical characteristics were similar to those living further from a major roadway, with the exception that fewer were of white race.

There were 1,071 deaths at 10 years of follow-up. Of these 672 (63%) were due to a primary cardiovascular cause, and 3 (0.4%) were due to traffic accidents. For the 779 patients for whom complete cause of death information was available, other major causes of death included cancer (n=131) and respiratory disease (n=45).

In both continuous and categorical analyses, living closer to a major roadway was associated with an increased risk of mortality. In the age-adjusted continuous analysis, a reduction in distance to roadway by 50% was associated with a 3.2% higher risk of mortality (95% CI 0.6%, 5.8%), p=0.014. In the fully adjusted model, the risk was 2.3% higher (95% CI -0.3%, 5.1%), p=0.086, which did not reach statistical significance.

Results of the categorical analysis are shown in Table 2. Overall, living closer to a major roadway was associated with an increased risk of mortality in both age adjusted (ptrend=0.004) and fully adjusted models (ptrend=0.015), with a linear component of trend on the log scale. The estimated effect of living close to a major roadway was similar in the age-adjusted and fully adjusted model. In the fully adjusted model, living within 100 m of a major roadway was associated with a 27% higher mortality rate (95% confidence interval: 1% to 60%) compared with subjects living further than 1000 m from a major roadway.

Table 3 presents mortality rates, age-adjusted, and fully adjusted hazard ratios for 10-year cardiovascular mortality according to distance from residence to major roadway in categories. Here too, living closer to a major roadway was associated with an increased risk of mortality with a statistically significant linear component of trend on the log scale. However, although this trend was statistically significant, the three exposure groups had approximately the same magnitude of association with cardiovascular mortality compared to the referent group. These results are different from those for all-cause mortality (Table 2), where the risks more clearly differed across the groups.

Table 4 shows the association between living within 100 m of a major roadway and 10-year all-cause mortality, stratified by clinical characteristics. Although qualitatively it can be seen that effects were larger in non-smokers, women, and diabetic patients, there were no statistically significant interactions.

As a sensitivity analysis we stratified on region of the country (northeast vs. rest of the country) which had no appreciable effect on the estimates. Furthermore, results excluding those patients who died in traffic accidents were unchanged.

Discussion

In this prospective multi-center cohort study of early survivors of AMI, living closer to a major roadway at the time of AMI was associated with an increased risk of 10-year all cause mortality, with a statistically significant risk up to 1000 m. Adjustment for key personal, clinical, and neighborhood-level socioeconomic covariates did not substantially alter the results after age adjustment. Furthermore, the association persisted in the highest socioeconomic stratum in the fully adjusted analysis. Similar results were seen with the outcome of cardiovascular deaths, although there was a less prominent linear trend. This difference between the all-cause mortality and the cardiovascular mortality results may demonstrate that the risk of cardiovascular death persists at further distances than the risk of all cause mortality. Alternatively, the CIs for cardiovascular death are wider due to the smaller number of events and thus the estimates are consistent with a wider range of values.

There are no prior studies about proximity of residence to roadway and survival after AMI. However, there has been some research into the relationship between certain components of roadway proximity, such as air pollution, and post-MI survival. Our findings support those of Zanobetti and Schwartz, who found that in a national study, exposure to particulate air pollution was associated with increased risk of mortality after myocardial infarction, with an HR of 1.3 per increase in 10 $\mu g/m^3$ of particulate matter < 10μm in diameter (PM_{10}) over the three years prior to failure/censoring.[31] They are also similar to those of von Klot, et al. who in a single-city study found that higher levels of exposure to traffic-related pollutants were associated with higher long-term mortality in hospital survivors of AMI.[32] Additionally, our results are similar to those of Medina-Ramón, et al., who found that in Worcester, Massachusetts, the HR for 5-year mortality after hospitalization for heart failure was 1.3 for those living within 100 m of a major roadway; supporting the finding that living close to a major roadway is associated with adverse cardiovascular outcomes in those with underlying cardiac disease.[41]

Besides air pollution, exposure to noise could be a possible mechanism underlying this association. Although there are no studies specifically on noise exposure and survival after AMI, there is some evidence that noise exposure may be associated with risk of AMI and ischemic heart disease.[26]

Consistent with prior studies, we observed a statistically non-significant trend toward stronger associations between living near a major roadway and morality among women, diabetic patients, and non-smokers. Other studies suggest that diabetic patients and women are more susceptible to air pollution,[42, 43] although there is no previous work on these groups and proximity to roadway specifically. Interestingly, while associations between air pollution exposures and cardiovascular outcomes have been found in women in the Nurses' Health Study and the Women's Health Initiative,[13, 16] no association was found among men in the Health Professionals Follow-Up Study,[38] findings which are similar to our stratified results. In terms of the null association seen among current and former smokers, it is possible that any health effects of roadway exposure were overwhelmed by the negative effects of smoking on CVD risk.

Our study has distinct advantages as well as limitations. In particular, the study is based on a multi-center, prospectively assembled cohort with extensive clinical and demographic data, and we were able to follow patients for 10 years. Additionally, our geocoding success rate was comparable to that of other retrospectively geocoded cohorts such as the Jackson Heart Study.[40] However, as with any observational study, the associations we observed could be accounted for, at least in part, by differences between those living closer to roadways and those living farther away. To address this, we incorporated a wealth of socioeconomic data at both the personal and neighborhood level. This is important because it has been shown that survival after myocardial infarction is worse in more deprived areas,[44, 45] and in our cohort, living close to a major roadway was associated with lower economic status (Table 1).

We do not know if patients moved after their AMI and thus if their exposure changed, or alternatively if new roads were built close to patients' homes. It is likely that the inevitable exposure misclassification may have biased our results towards the null. However, older people (such as those in this cohort) are less likely to move house than younger people. For instance in 2008-2009, the overall annual moving rate of Americans aged 1+ was 12%, but for those aged 60+ it was only 3.4%.[46] Furthermore, among those who died in our study, over 90% died in the same state that they lived in at the time of their AMI.

We do not have information on secondary prevention measures or access to care, which could be important determinants of survival. To address the issue of access to care, we included distance to nearest acute care hospital as a covariate. Overall, a majority of patients in all exposure categories were on medications at baseline (prior to their AMI), which suggests that patients in the study received secondary prevention measures as well, in a non-differential fashion. The BMI measurements are based on self-reported height and weight, which has been shown in some studies to be highly reliable, while in others, reliability is less.[47-49] However the relative rank order of BMI should be preserved if there was systematic underreporting of weight. Finally, a number of the individual estimates did not attain statistical significance, perhaps due to the small number of people living closest to the major roadways.

In this cohort of survivors of AMI, living close to a major roadway at the time of AMI was associated with an increased rate of all cause mortality after 10 years of follow-up. This study provides new evidence that long-term exposure to roadways is associated with increased risk for mortality, including in patients with underlying cardiovascular disease. A recent observational study in Vancouver showed that moving away from a major roadway was associated with a decreased risk of cardiovascular mortality, suggesting that interventions to avoid traffic exposure may be beneficial.[30] If in fact the associations found in this study are causal in nature, there are a number of public health implications. The AHA Scientific Statement on Particulate Matter Air Pollution and Cardiovascular Disease from 2010 suggests that clinicians educate their patients on the risks posed by particulate matter pollution and encourage patients with CVD to avoid unnecessary exposure to traffic. [50] On a public policy level, city planners should consider locating housing developments away from the most heavily trafficked roadways. Further studies should continue to examine this association and understand which components of near-road exposure may be most harmful.

Acknowledgments

Thanks to Hannah Buettner for assistance with data collection and processing.

Funding Sources: This publication was made possible by United States Environmental Protection Agency (USEPA) grant RD 83479801. Its contents are solely the responsibility of the grantee and do not necessarily represent the official views of the USEPA. Further, USEPA does not endorse the purchase of any commercial products or services mentioned in the publication. Further supported by NIH grant P01-ES009825. EHW additionally supported by NIH grant T32-HL007374. JIR supported by Harvard Medical School Scholars in Medicine Office.

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Clinical Perspective

Living close to a major roadway has been associated with adverse cardiovascular health including acute myocardial infarction (AMI), coronary artery disease, stroke, and deep vein thrombosis. Proximity to roadway is a complex, multi-faceted exposure that includes increased exposure to traffic-related air pollution, traffic noise, and other factors. However, the relationship between residential proximity to roadway and long-term survival after AMI is unknown. We investigated the association between distance from residence to the nearest major roadway and 10-year all-cause mortality after AMI in an inception cohort of 3,547 patients enrolled in the multi-center Determinants of MI Onset Study. After adjusting for clinical and socioeconomic characteristics, the rate of all-cause mortality in the first 10 years after AMI was highest for those living within 100 m and the risk declined steadily and reached background levels beyond 1000 m. For clinicians, these results suggest that exposure to traffic may be harmful for AMI survivors. Clinicians should consider advising patients to avoid unnecessary traffic exposure if possible and should counsel patients on the risks associated with traffic exposure. On a public policy level, city planners should consider building housing complexes away from major roadways.

Table 1

Patient Characteristics at Baseline*

Characteristics	Distance from Residence to Major Roadway ≤100 m (n=243)	100m-≤200m (n=230)	200m-≤1000m (n=1,311)	>1000m (n=1,763)	p†
Age, mean (SD), y	62.1 (13.9)	62.8 (12.4)	61.3 (12.5)	61.3 (12.8)	0.32
Woman (%)	86 (35)	81 (35)	434 (33)	547 (31)	0.30
White race (%)	194 (80)	193 (84)	1,097 (84)	1,630 (92)	<0.001
Married (%)	131 (54)	137 (60)	808 (62)	1,216 (69)	<0.001
Years of school (%) ‡					0.0004
<**12**	71 (30)	55 (24)	303 (24)	323 (19)	
12− <**16**	119 (50)	117 (52)	719 (56)	1,034 (60)	
≥ **16**	50 (20)	54 (24)	257 (20)	371 (21)	
Distance to nearest acute care hospital, mean (SD), km	4.4 (5.0)	3.7 (4.0)	4.3 (4.5)	6.3 (5.1)	<0.001
BMI, mean (SD), kg/m^2	27.3 (5.5)	27.4 (5.5)	27.4 (5.0)	27.6 (5.0)	0.53
Smoking status (%)					0.30
Never	63 (26)	68 (30)	348 (27)	472 (27)	
Former	93 (38)	100 (43)	508 (39)	724 (41)	
Current	87 (36)	62 (27)	455 (34)	567 (32)	
Morbidity (%)					
Hypertension	103 (42)	94 (41)	589 (45)	755 (43)	0.54
Diabetes	56 (23)	49 (21)	258 (20)	317 (18)	0.18
Previous MI	76 (31)	55 (24)	337 (26)	471 (27)	0.63
Angina	78 (32)	57 (25)	308 (23)	422 (24)	0.035
Congestive heart failure	8 (3)	10 (4)	48 (4)	78 (4)	0.67
Non-cardiac	41 (17)	37 (16)	214 (16)	232 (13)	0.063
Use of medications (%)					
Aspirin	91 (37)	78 (34)	522 (40)	706 (40)	0.30
Beta-blocker	53 (22)	42 (18)	280 (21)	383 (22)	0.69

Characteristics	Distance from Residence to Major Roadway ≤100 m (n=243)	100m-≤200m (n=230)	200m-≤1000m (n=1,311)	>1000m (n=1,763)	p[†]
Calcium-channel blocker	66 (27)	59 (26)	299 (23)	427 (24)	0.43
Digoxin	10 (4)	17 (8)	91 (7)	121 (7)	0.40
Angiotensin-converting enzyme inhibitors	24 (10)	37 (16)	167 (13)	227 (13)	0.25
Sedentary (<1 episode of physical activity/week)	217 (89)	204 (89)	1,132 (86)	1,508 (86)	0.28
Urban dwellers (%) [§]	193 (79)	199 (87)	1,108 (85)	1,318 (75)	<0.001
Low Neighborhood education (%) [//]	95 (39)	98 (43)	552 (42)	435 (25)	<0.001
Neighborhood Income, mean (SD), Yr1990$	35,451 (19,320)	36,235 (19,650)	36,082 (15,883)	42,205 (16,560)	<0.001

[*] SD: standard deviation, MI: myocardial infarction

[†] p-value is from ANOVA for continuous variables and χ^2 tests for categorical variables.

[‡] Numbers do not add to the entire study population due to missingness. Although those missing personal education status were incorporated into the analyses as outlined in the methods section, they are not included in this section of the table.

[§] Defined as living in a block group that was more that 50% urban according to the US Census.

[//] Defined as living in a block group in the highest tertile of percentage of neighborhood residents aged 25 or older without high school diplomas.

Table 2

HRs for all-cause mortality after 10 years of follow up according to Distance to Major Roadway*

	Distance to Major Roadway				
	≤100m (n=243)	**100m - ≤200m (n=230)**	**200m- ≤1000m (n=1,311)**	**>1000m (n=1,763)**	**p-trend**
All-cause mortality No. (%)	90 (37)	76 (33)	410 (31)	495 (28)	—
Mortality rate per 100 person-years	4.6	4.2	3.8	3.3	—
Age-adjusted model HR (95%CI)	1.31 (1.05, 1.64)	1.21 (0.95, 1.54)	1.16 (1.02, 1.32)	1.00	0.0040
Fully adjusted model † HR (95%CI)	1.27 (1.01, 1.60)	1.19 (0.93, 1.60)	1.13 (0.99, 1.30)	1.00	0.016

* HR: hazard ratio, CI: confidence interval

† Model adjusted for age, sex, marital status, race, individual education, distance to hospital, BMI, smoking, previous MI, previous congestive heart failure, previous angina, diabetes mellitus, hypertension, noncardiac comorbidity, previous cardiac medication use, frequency of physical activity, neighborhood household income, neighborhood education, and urbanicity.

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Table 3

HRs for cardiovascular mortality after 10 years of follow up according to Distance to Major Roadway*

	Distance to Major Roadway				
	≤100m (n=243)	**100m - ≤200m (n=230)**	**200m- ≤1000m (n=1,311)**	**>1000m (n=1,763)**	**p-trend**
Cardiovascular mortality No. (%)	51 (21)	51 (22)	266 (20)	304 (17)	—
Mortality rate per 100 person-years	2.6	2.8	2.5	2.0	—
Age-adjusted model HR (95%CI)	1.19 (0.88, 1.60)	1.31 (0.97, 1.76)	1.23 (1.04, 1.45)	1.00	0.030
Fully adjusted model † HR (95%CI)	1.19 (0.88, 1.61)	1.33 (0.98, 1.80)	1.22 (1.02, 1.44)	1.00	0.044

*HR: hazard ratio, CI: confidence interval

†Model adjusted for age, sex, marital status, race, individual education, distance to hospital, BMI, smoking, previous MI, previous congestive heart failure, previous angina, diabetes mellitus, hypertension, noncardiac comorbidity, previous cardiac medication use, frequency of physical activity, neighborhood household income, neighborhood education, and urbanicity.

Table 4

HRs for residence within 100 m of a major roadway and 10-year all cause mortality by group*

Analysis	Group (n)	HR †	95% CI	p-interaction
Age				0.67
	<65 (2,030)	1.30	0.88, 1.92	
	≥65 (1,517)	1.23	0.92, 1.64	
Sex				0.29
	Men (2,399)	1.07	0.78, 1.46	
	Women (1,148)	1.62	1.14, 2.31	
Marital Status				0.96
	Married (2,292)	1.25	0.90, 1.75	
	Unmarried or	1.32	0.95, 1.84	
Individual				0.84
	<12 y (752)	1.08	0.71, 1.64	
	12- <16 y (1,989)	1.25	0.89, 1.75	
	≥16 (732)	1.65	0.87, 3.13	
Smoking				0.14
	Never smoked	2.22	1.47, 3.36	
	Former (1,425)	1.05	0.74, 1.51	
	Current (1,171)	0.95	0.59, 1.57	
Diabetes				0.22
	Diabetic (680)	1.52	1.02, 2.25	
	Non-diabetic	1.14	0.85, 1.53	
Neighborhood				0.89
	Lowest (887)	1.34	0.90, 1.99	
	Second (887)	1.24	0.76, 2.03	
	Third (887)	1.33	0.79, 2.22	
	Highest (886)	1.10	0.60, 2.02	

*HR: hazard ratio CI: confidence interval

†Model adjusted for the following variables, except that each stratified model is not adjusted for the stratification variable: age, sex, marital status, race, individual education, distance to hospital, BMI, smoking, previous MI, previous congestive heart failure, previous angina, diabetes mellitus, hypertension, noncardiac comorbidity, previous cardiac medication use, frequency of physical activity, neighborhood household income, neighborhood education, and urbanicity.