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Area Median Income and Metropolitan Versus Nonmetropolitan Location of Care for Acute Coronary Syndromes: A Complex Interaction of Social Determinants

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Background—Metropolitan versus nonmetropolitan status and area median income may independently affect care for and outcomes of acute coronary syndromes. We sought to determine whether location of care modifies the association among area income, receipt of cardiac catheterization, and mortality following an acute coronary syndrome in a universal health care system.

Methods and Results—We studied a cohort of 14 012 acute coronary syndrome patients admitted to cardiology services between April 18, 2004, and December 31, 2011, in southern Alberta, Canada. We used multivariable logistic regression to determine the odds of cardiac catheterization within 1 day and 7 days of admission and the odds of 30-day and 1-year mortality according to area median household income quintile for patients presenting at metropolitan and nonmetropolitan hospitals. In models adjusting for area income, patients who presented at nonmetropolitan facilities had lower adjusted odds of receiving cardiac catheterization within 1 day of admission (odds ratio 0.22, 95% CI 0.11–0.46, $P<0.001$). Among nonmetropolitan patients, when examined by socioeconomic status, each incremental decrease in income quintile was associated with 10% lower adjusted odds of receiving cardiac catheterization within 7 days ($P<0.001$) and 24% higher adjusted odds of 30-day mortality ($P=0.008$) but no significant difference for 1-year mortality ($P=0.12$). There were no differences in adjusted mortality among metropolitan patients.

Conclusion—Within a universal health care system, the association among area income and receipt of cardiac catheterization and 30-day mortality differed depending on the location of initial medical care for acute coronary syndromes. Care protocols are required to improve access to care and outcomes in patients from low-income nonmetropolitan communities. (*J Am Heart Assoc*. 2016;5:e002447 doi: 10.1161/JAHA.115.002447)

Key Words: acute coronary syndromes • angiography • geography • median income • mortality/survival • quality and outcomes • rural/urban

Cardiovascular disease is a leading cause of morbidity and mortality in North America.[1,2] An excess risk of death has been linked to lower neighborhood income and area median household income in the setting of acute coronary syndromes (ACS),[3–6] in part because of barriers to timely medical care and proven evidence-based interventions.[7,8] Several studies have shown income-related disparities in the use of evidence-based therapies such as invasive cardiac procedures.[3,6,9] These disparities may lead to worse outcomes because timely receipt of these procedures improves outcomes for appropriate patients in the setting of ACS.[10–12]

The geographic location of care for ACS also has been linked to barriers to timely access to evidence-based medical care, to cardiac catheterization, and to increased mortality.[9,13,14] This may be caused in part by concentration of specialty services and cardiac catheterization facilities in metropolitan centers.[14] In addition, with wealth concentrated in metropolitan areas,[15] the association of area median income with access to care and outcome of ACS may be modified by geographic location. Furthermore, the receipt of cardiac catheterization and specialty care for patients presenting at nonmetropolitan hospitals without these services often requires transfer to centers located in metropolitan areas. Financial barriers,[7,8] intrinsic physician

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bias,[16] and other factors may result in differential receipt of these services based on area median income. Few studies have examined specifically whether location of care modifies the association among area median income and access to cardiac catheterization and outcomes of ACS.[9] It remains unclear whether differences exist in the association of area income and cardiac outcomes for metropolitan and non-metropolitan sites; such differences may have important implications for health policy and planning.[17,18]

We sought to determine whether the associations among area income and the receipt of cardiac catheterization and mortality following an ACS were modified by initial care in a metropolitan versus nonmetropolitan site. Of relevance to health policy, we examined this relationship in Canada, where a system of universal health care exists for access to physician and hospital services. Consequently, health insurance status is not an explanatory variable in our evaluation of area median income and geographic factors as determinants of care and outcomes.

Methods

Study Setting and Data Sources

This cohort study was conducted in the 2 southern health zones of the province of Alberta, Canada, with a catchment population of ≈1.7 million people. Data were obtained through the Alberta Provincial Project for Outcome Assessment in Coronary Heart Disease (APPROACH) database, a provincial clinical registry that continuously collects data with complete capture of all patients admitted to a cardiac service or receiving coronary angiography since 2004.[19] Because APPROACH is a standing cardiac registry, the data used in this study were collected not in a targeted way solely for this specific research question but rather in a generic manner for a variety of potential uses. A principal strength of the registry is that demographic, clinical, and procedural data are prospectively collected using standardized definitions, with trained data abstractors and validated methodology to ensure a rich collection of accurate clinical data.[19] For area income and mortality data, we performed linkages with the 2006 Canadian Census and the Alberta Bureau of Vital Statistics, as described previously.[20,21] In total, 33 acute care facilities (including hospitals, cardiology facilities, and urgent care centers) were included in our study. Facility address location information was obtained from Alberta Health Services (http://www.albertahealthservices.ca).

Study Population

Our cohort included Alberta residents aged 18 to 99 years who were admitted to any cardiac service in the 2 southern

health zones between April 18, 2004, and December 31, 2011, with a principal diagnosis of ACS (ST-segment elevation myocardial infarction [STEMI], non–ST-segment elevation myocardial infarction [NSTEMI], or unstable angina) at the time of discharge or admission (if discharge diagnosis was missing). Vital statistics and catheterization data were complete for patients from Alberta, thus patients were followed from admission until death or for a maximum of 1 year, with a study end date of December 31, 2012. To maintain the independence of individual patient observations, only the first admission was included for patients with multiple ACS admissions during the study period. We excluded patients if census data were unavailable (n=1618). Patients residing outside of the 2 southern Alberta health zones were also excluded (n=1449).

Study Variables

Area-level median household income was determined using postal code information linked to the 2006 Canadian census, as in previous studies.[6,20–22] Study participants were then divided evenly into area-level median income quintiles, with the lowest income quintile coded as quintile 1 and the highest area income quintile coded as quintile 5, as in previous studies.[6,9,14,20] We used Canadian census "dissemination areas," which are the smallest publically available standard geographic units of measure, with populations generally between 400 and 700 people.[23] In the Canadian census, dissemination areas are designed to represent smaller subdivisions of census tracts and are designed to be as homogenous as possible in terms of socioeconomic characteristics, such as similar economic status and social living conditions.[23] Patients' geographic location of the medical facility of presentation was determined by the location of first recorded contact for ACS admission. Patients presenting at any of the 7 urban centers, of which 1 tertiary care facility provides primary cardiac catheterization, were classified as *metropolitan*; patients presenting at any of the other 26 centers were classified as *nonmetropolitan*. Metropolitan status was determined using the Statistics Canada definition.[23] Overland distances to the cardiac catheterization facility were calculated in kilometers by geocoding medical facility addresses using Google Maps, an online geographic information systems program (Google).[24,25]

Our study outcomes included the receipt of cardiac catheterization immediately before admission to 1 day after (defined as *emergent*) and within 7 days of presentation (defined as *urgent*). Patients who received cardiac catheterization in the 12 hours immediately prior to admission were considered to have received emergent angiography to allow for participants sent immediately to the catheterization laboratory on arrival and admitted afterward. We defined urgent cardiac

catheterizations as those received within 7 days of admission because the majority of primary catheterizations performed during index admissions were performed within 7 days of admission. The other outcomes of interest were all-cause mortality within 30 days and 1 year of admission.

Data were collected for age, sex, type of ACS (STEMI, NSTEMI, or unstable angina), prior diagnosis of coronary artery disease, hypertension, dyslipidemia, diabetes, family history of coronary artery disease, current and former smoking status, prior ACS, prior coronary revascularization, congestive heart failure, chronic lung disease, peripheral vascular disease, chronic renal disease, dialysis, cerebrovascular disease, cancer, gastrointestinal disease, and liver disease.[26,27] Missing data on comorbidities were filled in using a validated data-merging method that draws on the Canadian national Discharge Abstract Database, as described previously.[28]

Statistical Analysis

Descriptive statistics were reported according to area median household income quintiles for both metropolitan and non-metropolitan patients. Differences in demographics, clinical characteristics, and unadjusted outcomes between metropolitan and nonmetropolitan patients were compared using the chi-square test for categorical variables and the Student *t* test for continuous variables. Likewise, differences across area income quintiles for metropolitan and nonmetropolitan patients were compared using the chi-square test for trend for categorical variables and ANOVA or the nonparametric Kruskal–Wallis test (as appropriate) for continuous variables.

We first compared the adjusted odds ratios (ORs) of the outcomes of interest for nonmetropolitan versus metropolitan patients by using logistic regression models, with area income and all demographic and clinical characteristics included as covariates in the models (Table 1). To examine the interaction between geographic location of initial care and area income, we adopted an additive interaction modeling framework in our primary analysis and categorized patients into 1 of 10 mutually exclusive subgroups defined by initial facility location and area income quintile. We compared the adjusted OR of catheterization or mortality for each subgroup versus the patients with the highest area income who presented at metropolitan facilities (reference group), using logistic regression models and adjusting for all clinical and demographic covariates.[29] We used this strategy to examine interactions between geographic location of presentation and area-level income quintile on an additive scale in our models without making any a priori assumptions about how risk would be distributed across income quintiles (ie, linear versus nonlinear) and care location on the predefined outcomes of interest. We assessed for collinearity (defined as a change in the SE by >10%); when present, these variables were excluded from the

final model unless there was statistical evidence of confounding (defined by a change in the β-coefficient for the variables of interest by >20%). Only the variable of family history of coronary artery disease was excluded from the adjusted models for collinearity.

To allow for another interpretation of the data and to formally test for effect modification by location of care on the outcomes of interest, we used area income quintile modeled linearly as a continuous predictor and tested for effect modification by metropolitan versus nonmetropolitan status on a multiplicative scale (ie, 2-way interaction testing). This dual-analysis approach (ie, interaction analysis on additive and multiplicative scales) allowed us to model the association of each incremental decrease in area income quintile for metropolitan and nonmetropolitan patients compared with metropolitan patients of the corresponding highest area income quintile on the receipt of catheterization and mortality. This approach allowed us to formally test for effect modification by location of care in two complementary ways. In the multiplicative interaction analysis, the two variables of interest were modeled as A×B in the model specification (in which A is area-level income quintile and B is metropolitan versus nonmetropolitan location). This approach of dually presenting interactions on both additive and multiplicative scales allows the reader more complete information to draw conclusions about the size and significance of relationships in question between the two exposures of interest.[29,30] We accounted for clustering at the facility level in our logistic regression models and unadjusted comparisons of the outcomes of interest using generalized estimating equations with a working correlation matrix initially assuming independence. In addition, we accounted for temporal trends by adding indicator variables to our models for each calendar year of the study from 2004 to 2011 inclusively.

All analyses were performed using SAS statistical software, version 9.3 (SAS Institute, Inc). We reported 2-tailed *P* values (with a predefined threshold for statistical significance of <0.05) or 95% CIs, if appropriate. Approval for this study was received from both the University of Calgary Conjoint Health Research Ethics Board and the Harvard Medical School institutional review board. Because APPROACH is a provincial cardiac registry, the University of Calgary Conjoint Health Research Ethics Board granted a waiver of individual patient consent for this study.

Results

Baseline Characteristics

During the study period, we identified 21 028 admissions for ACS among adult patients in the 2 southern Alberta health zones. Among these admissions, 5398 episodes were

Table 1. Cohort Characteristics

Variable	Metro/Nonmetro	Averages by Metro/Nonmetro	P Value	Area Median Household Income Quintile					P Value*
				1 (Lowest) (n=2635)	2 (n=2766)	3 (n=2766)	4 (n=2896)	5 (Highest) (n=2949)	
Area median household income† (IQR)	Metro	67 760 (50 977–88 431)	<0.001	38 959 (34 220–42 368)	50 299 (47 583–52 623)	61 131 (57 919–65 227)	75 757 (72 446–81 668)	103 473 (95 873–119 292)	—
	Nonmetro	49 799 (43 448–63 895)		37 878 (31 831–42 425)	48 960 (46 273–51 228)	60 336 (57 646–64 756)	75 692 (71 978–80 785)	96 980 (92 947–107 547)	—
Clinical characteristics									
Age, y, mean (SD)	Metro	64.4 (12.8)	0.003	65.7 (13.0)	64.7 (12.9)	65.0 (12.8)	63.9 (12.9)	63.3 (12.4)	<0.001
	Nonmetro	65.2 (13.3)		66.9 (13.5)	65.9 (12.8)	64.6 (13.1)	62.1 (13.0)	61.1 (13.2)	<0.001
Male, %	Metro	71.5	0.31	65.8	68.3	72.0	73.1	75.5	<0.001
	Nonmetro	70.6		67.8	68.9	70.6	73.8	85.8	<0.001
Hypertension, %	Metro	68.5	<0.001	71.1	68.9	69.2	67.7	66.7	0.002
	Nonmetro	71.9		73.1	73.5	70.5	69.4	67.2	0.02
Dyslipidemia, %	Metro	72.8	<0.001	72.3	73.5	74.6	71.8	72	0.32
	Nonmetro	78.4		77	78.3	81.3	77.8	78.9	0.33
Diabetes mellitus, %	Metro	25.4	0.58	27.1	28.4	26.8	25.6	21	<0.001
	Nonmetro	25.9		27.7	26.8	24	24.8	20.1	0.02
Current smoker, %	Metro	26.1	<0.001	32.5	32.2	27.5	23.7	19.2	<0.001
	Nonmetro	30.1		31.3	28	33.1	31.8	24	0.58
Ex-smoker, %	Metro	32.2	0.20	32.5	29.3	33.5	33.7	31.3	0.64
	Nonmetro	31		28.6	33.5	30.4	31.1	30.4	0.60
Prior ACS, %	Metro	22.5	0.58	26.4	24.5	24.1	20.9	18.9	<0.001
	Nonmetro	22.9		24.4	25	22.1	18.2	18.1	0.002
Prior PCI, %	Metro	23	<0.001	25.2	23.3	23.9	22.7	20.9	0.001
	Nonmetro	17.4		18.1	17.8	18	15.9	13.7	0.14
Prior CABG, %	Metro	8.3	0.41	8.8	8.7	9.3	7.5	7.7	0.05
	Nonmetro	7.8		7.8	7.9	7.5	10.3	3.4	0.67
Congestive heart failure, %	Metro	12.1	<0.001	14.7	13.6	13.3	10.6	9.9	<0.001
	Nonmetro	15.8		20.1	14.5	14.6	13.8	10.3	<0.001
Cerebrovascular disease, %	Metro	7.8	0.34	9.6	8.3	8.5	7.9	5.8	<0.001
	Nonmetro	8.3		9.2	9.3	6.1	8.6	5.4	0.05
Peripheral vascular disease, %	Metro	6.5	0.004	7.8	5.7	6.4	4.5	3.5	<0.001
	Nonmetro	5.3		7.6	7.6	3.6	7.9	2.5	0.02

Continued

Table 1. Continued

Variable	Metro/Nonmetro	Averages by Metro/Nonmetro	P Value	Area Median Household Income Quintile					P Value*
				1 (Lowest) (n=2635)	2 (n=2766)	3 (n=2766)	4 (n=2896)	5 (Highest) (n=2949)	
Renal disease, %	Metro	4.7	<0.001	5.6	5	5.6	4.4	3.6	<0.001
	Nonmetro	6.4		7.2	6.9	7.1	3.5	3.4	0.006
Dialysis, %	Metro	1.3	0.55	2	0.9	1.6	1.1	1.2	0.07
	Nonmetro	1.2		1.2	1.6	1.1	0.5	1.5	0.5
Chronic lung disease, %	Metro	14.1	0.05	19.6	15.9	14.4	12.4	11	<0.001
	Nonmetro	15.5		17.2	15.1	17.8	12.4	9.3	0.006
Liver or gastrointestinal disease, %	Metro	8.5	0.003	11.1	9	8.8	7.5	7.2	<0.001
	Nonmetro	10.2		11.1	10.3	11.2	7.7	8.8	0.11
Malignancy, %	Metro	4.8	0.48	5.1	4.7	4.7	4.7	4.7	0.61
	Nonmetro	5.1		5.5	5.5	4.3	3.7	5.9	0.33
ACS type									
STEMI, %	Metro	29	<0.001	28.6	28.9	30.9	28	28.9	0.84
	Nonmetro	35.5		34	34.6	37.2	37.2	38.7	0.08
NSTEMI, %	Metro	32.9	<0.001	33.9	33.7	32.9	33	31.7	0.11
	Nonmetro	40.8		42.9	40.2	39.7	39	40.7	0.21
Unstable angina, %	Metro	38.1	<0.001	37.6	37.4	36.3	39.1	39.3	0.08
	Nonmetro	23.7		23.1	25.2	23.1	23.8	20.6	0.58
Characteristics of initial presenting facility									
Distance of initial facility to catheterization laboratory, km, median (IQR)	Metro	0 (0–11.8)	<0.001	0 (0–11.8)	0 (0–11.8)	0 (0–11.8)	0 (0–11.8)	0 (0–11.8)	<0.001
	Nonmetro	221 (179–294)		221 (221–268)	221 (191–294)	221 (143–268)	221 (69.5–294)	221 (69.2–253)	<0.001

ACS indicates acute coronary syndromes; CABG, coronary artery bypass grafting; IQR, interquartile range; metro, metropolitan; nonmetro, nonmetropolitan; NSTEMI, non–ST-segment elevation myocardial infarction; PCI, percutaneous coronary intervention; STEMI, ST-segment elevation myocardial infarction.

*P value from chi-square trend test.
†Dollar amounts are in Canadian dollars.

Table 2. Percentage of Patients Who Achieved Outcomes by Area Income Quintile and Location of Initial Care

Outcomes	Location of Initial Care	Average by Metro/ Nonmetro	P Value*	Area Income Quintile and Location of Initial Care					P Value for Trend†
				Quintile 1 (Lowest)	Quintile 2	Quintile 3	Quintile 4	Quintile 5 (Highest)	
				Metro (n=1688)	Metro (n=1742)	Metro (n=2204)	Metro (n=2468)	Metro (n=2745)	
				Nonmetro (n=947)	Nonmetro (n=1024)	Nonmetro (n=562)	Nonmetro (n=428)	Nonmetro (n=204)	
Catheterization within 1 day, %	Metro	36.6	0.02	34.3	37.8	37.6	35.9	37	0.53
	Nonmetro	18.7		17.1	16.3	19.9	22.2	27.9	0.012
Catheterization within 7 days, %	Metro	64	0.42	59.4	64	62.7	64.5	66.9	<0.001
	Nonmetro	66.7		61.6	65.9	69.8	70.1	79.4	<0.001
Mortality, 30 days, %	Metro	1.9	0.03	2.4	2	2	2	1.5	<0.001
	Nonmetro	3.2		4.1	3.6	3.2	0.9	1	<0.001
Mortality, 1 year, %	Metro	5.6	0.2	7.5	6.5	5.6	5.2	4.4	0.002
	Nonmetro	6.6		7.1	6.1	5.5	5.4	4.5	0.002

Metro indicates metropolitan; nonmetro, nonmetropolitan.
*P value for unadjusted comparison accounting for facility clustering using generalized estimating equations.
†P value from trend test accounting for facility clustering using generalized estimating equations.

excluded as repeat ACS admissions. A further 1618 (10.3%) patients were excluded because of missing area income data, of which 384 (23.7%) were nonmetropolitan patients. The final study cohort of 14 012 adult patients included 3165 patients who presented initially at a nonmetropolitan hospital and 10 847 who presented at a metropolitan hospital.

Baseline demographic and clinical characteristics are presented in Table 1. Dollar amounts shown are in Canadian dollars. Median area incomes ranged from $38 587 in the lowest income quintile (quintile 1) to $103 190 in the highest income quintile (quintile 5). Those presenting at nonmetropolitan hospitals, on average, were from lower income areas compared with those presenting at metropolitan centers ($49 799 versus $67 760; P<0.001). Consistent with this finding, the distribution of metropolitan and nonmetropolitan patients by area income quintiles revealed a larger proportion of nonmetropolitan versus metropolitan patients in lower income areas (29.9% versus 15.6% in the lowest area income quintile; P<0.001) and correspondingly more metropolitan patients in higher income areas (25.3% versus 6.4% in the highest area income quintile; P<0.001).

Compared with metropolitan patients, nonmetropolitan patients were typically older and had higher rates of hypertension, dyslipidemia, and smoking. In addition, a larger proportion of nonmetropolitan patients had a history of common medical comorbidities such as congestive heart failure, chronic kidney disease, peripheral vascular disease, and liver or gastrointestinal disease (Table 1). Moreover, although nonmetropolitan and metropolitan patients had similar rates of previously diagnosed ACS, nonmetropolitan patients had lower rates of prior percutaneous coronary intervention (17.4% versus 23%,

P<0.001) but similar rates of prior coronary artery bypass grafting (8.3% versus 7.8%, P=0.41). Nonmetropolitan patients were more likely to present with STEMI and NSTEMI, whereas unstable angina was most common among metropolitan patients. The mean distance from the initial facility of presentation to a major academic facility with onsite catheterization capability was 209.1 km for nonmetropolitan patients and 4.9 km for metropolitan patients (P<0.001).

Across area income quintiles for both metropolitan and nonmetropolitan patients, participants in lower income quintiles compared with those in higher income quintiles were typically older, were more likely to be male, and had higher rates of medical comorbidities such as hypertension, diabetes mellitus, congestive heart failure, cerebrovascular disease, peripheral vascular disease, and chronic lung disease; a larger proportion of these patients had a history of previous ACS (Table 1). In addition, for both metropolitan and nonmetropolitan patients, participants were similarly likely to present with STEMI, NSTEMI or unstable angina, regardless of their respective area income quintiles. There were no differences in the median distance from the initial facility of presentation to a facility with onsite catheterization capability across the area income quintiles for either metropolitan or nonmetropolitan patients.

Unadjusted Rates of Cardiac Catheterization and Mortality

Table 2 presents unadjusted rates for cardiac catheterization and mortality for metropolitan and nonmetropolitan patients and for each geographic group stratified by area income

Table 3. Association of Decreasing Area Income Quintile on Outcomes After an Acute Coronary Syndrome for Nonmetropolitan and Metropolitan Patients

Outcomes	Metropolitan (n=10 847)		Nonmetropolitan (n=3165)		P Value for Adjusted Interaction
	Unadjusted OR (95% CI)	Adjusted OR* (95% CI)	Unadjusted OR (95% CI)	Adjusted OR* (95% CI)	
Catheterization[†] within 1 day	0.98 (0.95–1.03)	1.03 (0.98–1.07)	0.86 (0.77–0.97)	0.91 (0.82–1.02)	0.07
Catheterization[†] within 7 days	0.93 (0.91–0.96)	0.97 (0.95–1.00)	0.84 (0.79–0.89)	0.90 (0.85–0.95)	0.03
30-day mortality	1.10 (1.06–1.14)	1.03 (0.97–1.09)	1.39 (1.16–1.67)	1.24 (1.06–1.46)	0.02
1-year mortality	1.11 (1.04–1.19)	1.02 (0.95–1.11)	1.28 (1.10–1.50)	1.13 (0.97–1.31)	0.28

OR indicates odds ratio.
*Adjusted models included the following variables: age, sex, metropolitan/nonmetropolitan location, area median household income quintile, interaction term for metropolitan/nonmetropolitan location by area income quintile, calendar year of presentation (2004–2011), acute coronary syndrome type, hypertension, dyslipidemia, diabetes mellitus, prior acute coronary syndrome, smoking, ex-smoking status, previous percutaneous coronary intervention, previous coronary artery bypass grafting, malignancy, congestive heart failure, peripheral vascular disease, cerebrovascular disease, chronic kidney disease, dialysis, chronic lung disease, liver and gastrointestinal disease.
[†]Catheterization indicates cardiac catheterization.

quintile. Among both metropolitan and nonmetropolitan patients, those from lower income areas had higher rates of 30-day mortality (tests for trend: $P<0.001$ and $P<0.001$, respectively) (Table 2) and 1-year mortality (tests for trend: $P=0.002$ and $P=0.002$, respectively) (Table 2) than patients residing in higher income areas. In general, regardless of location of presentation, patients residing in lower area income quintiles had lower rates of receiving cardiac catheterization both within 1 day and 7 days of presentation. Among metropolitan patients alone, however, no differences were detected across area income quintiles for receipt of cardiac catheterization within 1 day of presentation (Table 2).

Patients from lower income areas also had higher mortality at both 30 days and 1 year of presentation compared with those in higher area income quintiles regardless of location of hospital of presentation (Table 2). On average, nonmetropolitan patients had lower rates of receiving cardiac catheterization within 1 day of presentation compared with metropolitan patients (24.5% versus 41.6%, $P<0.001$) but higher rates of catheterization within 7 days of presentation (67.8% versus 64.9%, $P=0.003$). Overall mortality rates were higher among nonmetropolitan than metropolitan patients at 30 days (3.2% versus 1.9%, $P<0.001$) and at 1 year (6.6% versus 5.6%, $P=0.02$).

Compared with metropolitan patients, nonmetropolitan patients had lower unadjusted odds of receiving cardiac catheterization within 1 day (OR 0.40, 95% CI 0.19–0.86) but not within 7 days of presentation with an ACS (OR 1.13, 95% CI 0.84–1.53). In addition, nonmetropolitan patients had higher unadjusted odds of 30-day mortality than metropolitan patients (OR 1.66, 95% CI 1.04–2.65) but not of 1-year mortality (OR 1.21, 95% CI, 0.90–1.61).

Table 3 summarizes the unadjusted and adjusted interaction analyses that describe the relationship between area income quintile and the odds of receiving cardiac catheter-

ization and mortality. For nonmetropolitan participants compared with patients from the highest income areas, each decrease in area income quintile was associated with lower unadjusted odds of receiving both emergent (within 1 day) and urgent (within 7 days) cardiac catheterization (Table 3). For metropolitan patients, however, each decrease in area income quintile was associated with lower unadjusted odds of receiving cardiac catheterization within 7 days only (Table 3). Regardless of the geographic location of first presentation, each incremental decrease in area income quintile was associated with higher unadjusted odds of both 30-day and 1-year mortality after ACS for all participants (Table 3).

Adjusted Analysis of Cardiac Catheterization

After adjustment for clinical covariates and area income, nonmetropolitan patients had significantly lower odds than metropolitan patients of receiving cardiac catheterization within 1 day (OR 0.22, 95% CI 0.11–0.46) but not within 7 days of presentation (OR 1.04, 95% CI 0.84–1.29). In adjusted analyses of catheterization and mortality stratified by area income quintile and location of initial care, metropolitan patients in the highest area income quintile (quintile 5) served as the reference group. Participants in each of the area income categories presenting at nonmetropolitan facilities were significantly less likely to receive cardiac catheterization within the first day of presentation (Figure 1A). Alternatively, among metropolitan patients, no differences were detected between any of the area income categories in the receipt of catheterization within 1 day. Alternatively, for the receipt of cardiac catheterization within 7 days of presentation among patients presenting at nonmetropolitan facilities, only patients from the highest income areas had higher adjusted odds compared with metropolitan patients from the highest income areas (OR 1.40, 95% CI 1.04–1.88) (Figure 1B). Moreover,
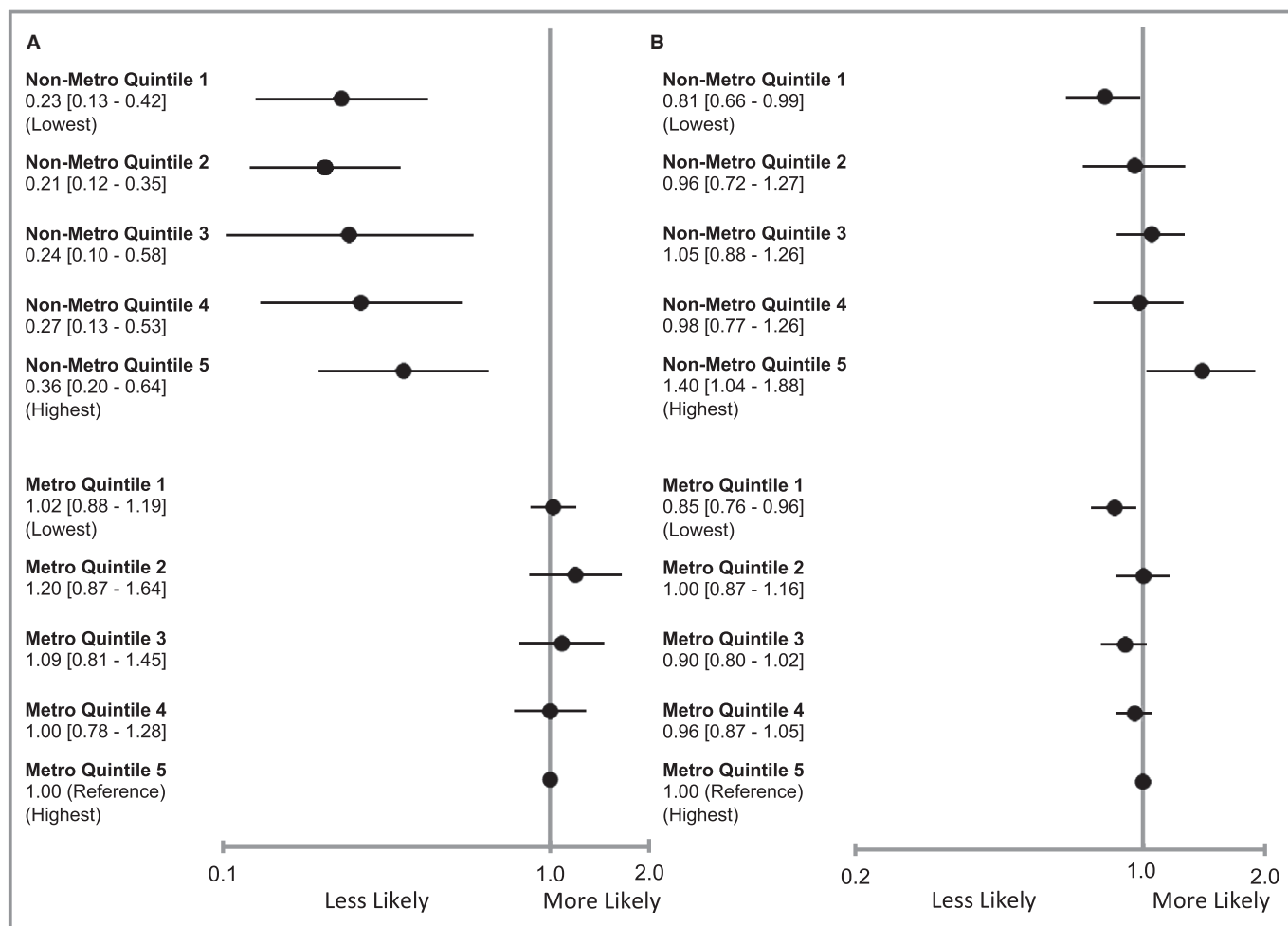
Figure 1. The adjusted odds ratios of receiving cardiac catheterization within 1 day and 7 days of presentation with ACS by nonmetropolitan and metropolitan status and area income quintile. A, Adjusted odds ratios of receiving a cardiac catheterization within 1 day of presentation with ACS compared with metropolitan patients in the highest area income quintile. B, Adjusted odds ratios of receiving a cardiac catheterization within 7 days of presentation with ACS compared with metropolitan patients in the highest area income quintile. ACS indicates acute coronary syndromes; metro, metropolitan; nonmetro, nonmetropolitan.

only non metropolitan patients from the lowest income area had lower adjusted odds of receiving cardiac catheterization within 7 days compared with metropolitan patients from the highest income areas (OR 0.81, 95% CI 0.66–0.99).

Table 3 summarizes the adjusted interaction analyses between area income quintile, the initial location of care, and the odds of receiving cardiac catheterization. There was no observable linear trend across area income quintiles in the odds of receipt of cardiac catheterization within 1 day for either nonmetropolitan or metropolitan patients (Table 3). Moreover, we found the relationship between the receipt of cardiac catheterization within 1 day and area income was not modified by the initial location of care (P=0.07 for interaction term). Conversely, we observed that among patients presenting at nonmetropolitan sites, there was an incremental decrease in the odds of catheterization within 7 days of presentation with lower area income quintiles; with each decrease in area income quintile, the odds of receiving

catheterization by 7 days likewise decreased by 10% (OR 0.90, 95% CI 0.85–0.95). For metropolitan patients, a similar but less prominent trend was observed in which each incremental decrease in area income quintile was associated with a 3% decrease in the odds of receiving catheterization by 7 days (OR 0.97, 95% CI 0.95–1.00). When we tested for the presence of effect modification on the odds of receipt of cardiac catheterization within 7 days by location of care, a significant interaction was detected (P=0.03). This indicated that the association between area income and 7-day catheterization was modified by the initial location of care (Table 3).

Adjusted Analysis of Mortality

In models adjusting for clinical covariates and area income, on average, nonmetropolitan patients compared with metropolitan patients did not experience higher adjusted odds of

mortality at 30 days (OR 1.28, 95% CI 0.93–1.78) or 1 year (OR 0.94, 95% CI 0.77–1.14). In the adjusted analysis exploring the additive association of location of initial care and area income on mortality, no income category for either nonmetropolitan or metropolitan patients was found to have significantly different odds of 30-day or 1-year mortality compared with metropolitan patients of the highest area income quintile (Figure 2A and 2B).

In models investigating the interaction among area income, location of initial presentation, and mortality (summarized in Table 3), each decrease in area income quintile was associated with a 24% (P=0.008) increase in the odds of 30-day mortality for nonmetropolitan patients. In contrast, area income was not a significant predictor of 30-day mortality for metropolitan patients. An interaction term was used to test for effect modification of the odds of 30-day mortality by geographic location of initial care. This term was significant

(P=0.02), indicating a differential association of area income and 30-day mortality by location of care. The relationship between area income quintile and 1-year mortality for nonmetropolitan patients had a pattern similar to that of 30-day mortality, but the test of linear trend no longer reached statistical significance (P=0.12). Furthermore, in adjusted interaction models among area income, location of care, and mortality, area income was not a significant predictor of 1-year mortality for metropolitan patients (Table 3).

Discussion

In our cohort study, we found that the relationships of area income with receipt of cardiac catheterization and mortality after ACS were not uniform but were modified by location of initial care. We found that decreasing area income was
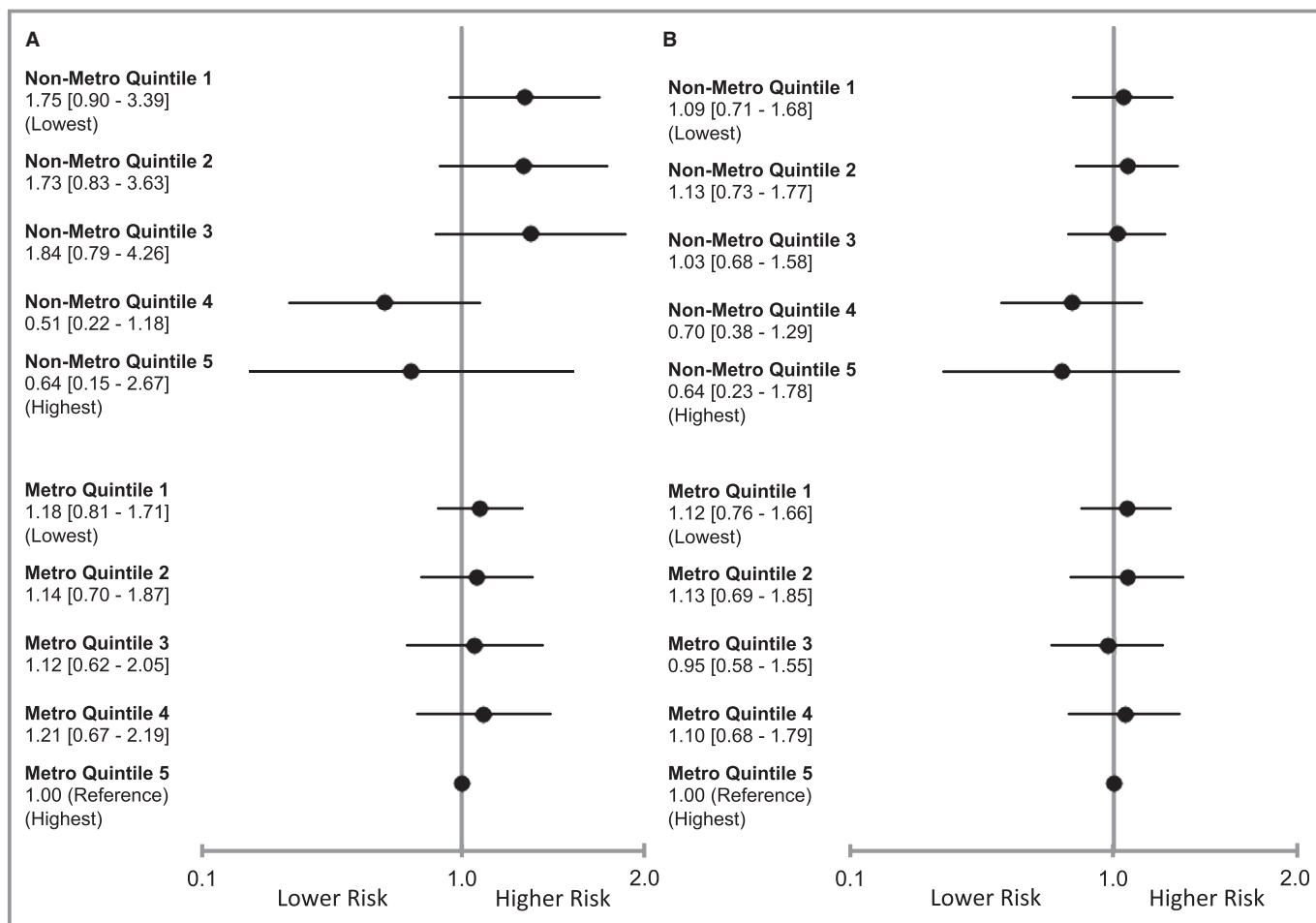
Figure 2. The adjusted odds ratios of all-cause mortality within 30 days and 1 year of presentation with an ACS by nonmetropolitan and metropolitan status and area income quintile. A, Adjusted odds ratios of 30-day all-cause mortality after presentation with ACS compared with metropolitan patients in the highest area income quintile. B, Adjusted odds ratios of all-cause mortality within 1 year of presentation with ACS compared with metropolitan patients in the highest area income quintile. ACS indicates acute coronary syndromes; metro, metropolitan; nonmetro, nonmetropolitan.

associated with lower likelihood of receiving urgent cardiac catheterization within 7 days and higher likelihood of 30-day mortality for ACS patients presenting at nonmetropolitan facilities only. In addition, we confirmed that nonmetropolitan patients were less likely than metropolitan patients to undergo emergent cardiac catheterization in the setting of ACS despite having higher rates of both STEMI and NSTEMI than metropolitan patients, even after adjusting for ACS type and clinical characteristics. Moreover, despite nonmetropolitan and metropolitan patients being similarly likely to receive cardiac catheterization within 1 week of an ACS, the decreased use of emergent cardiac catheterization and increased short-term mortality appeared closely associated with decreasing median area household income for non-metropolitan patients. These findings were evident in a universal health insurance system designed to eliminate cost barriers to medical care, especially in the setting of acute medical conditions such as ACS.

Our study is novel in its exploration of the interplay between geographic location of initial care for ACS and area income. Previous studies in the context of universal health insurance have produced conflicting findings with respect to equitable access to cardiac catheterization and revascularization procedures after an ACS. Earlier studies showed that area income predicted receipt of cardiac catheterization, wait times for angiography, and mortality after acute myocardial infarction.[31,32] In addition, hospital characteristics such as location, teaching status, and catheterization capabilities have been shown repeatedly to be independently predictive of use of advanced cardiac procedures.[3,14,32,33] Subsequent studies, however, did not show income gradients in access to cardiac catheterization or mortality for patients presenting with acute myocardial infarctions.[5,34] Similar to other studies, we did not find significant adjusted differences in long-term mortality by income after presentation with ACS, likely because this outcome is driven primarily by age and medical comorbidities that were accounted for in our analyses[5,14,34–36] rather than by area income or location of care.

Our study provides evidence of a differential association of area income on receipt of urgent coronary angiography and short-term mortality for patients presenting at nonmetropolitan versus metropolitan hospitals. In contrast to previous studies that have shown equitable access to advanced procedures by area income during a period of increasing utilization of these cardiac procedures, our study found area income–based disparities primarily in nonmetropolitan areas. Metropolitan areas have higher concentrations of health care resources and specialist services that may allow for more equitable use of health resources.[17,37,38] Furthermore, unlike other jurisdictions that have greater availability of cardiac catheterization facilities, southern Alberta has only 1 large catheterization facility among 33 health care facilities in the region, and this limited procedural capacity may contribute to area income gradients in nonmetropolitan areas. Our findings may point to a threshold effect with respect to the limited supply capacity of invasive cardiac procedures, below which area income–based disparities begin to emerge and patients from lower income areas are less often referred for urgent cardiac catheterization.[18] This centralized model of specialized cardiac care that is dependent on a robust referral and transfer system exists in much of Canada[18] and in most critical-access hospitals in the United States[13]; therefore, our findings may apply to other jurisdictions with low population densities.

Alternatively, nonmetropolitan physicians may be privy to unmeasured prognostic information that may affect decisions about referral to a metropolitan facility or cultural differences among nonmetropolitan patients regarding preferences for aggressive care, especially among patients from lower income areas. Interestingly, nonmetropolitan patients from high-income areas were found to have an even higher likelihood of receiving urgent cardiac catheterizations after ACS than metropolitan patients from high-income areas. These patients from high income areas may be more successful in advocating for urgent referrals to a tertiary care center for more aggressive care or may be preferentially referred for these procedures, even more so than high-income area patients from the metropolitan center. Last, equity in metropolitan centers may reflect active quality improvement protocols put in place to improve door-to-balloon times and cardiac care in metropolitan centers but not in nonmetropolitan centers.[39] This may also explain why area income gradients were not seen with emergent angiography use within 1 day of presentation; this choice is more likely to be protocol driven for patients with high-risk features of myocardial infarction, allowing less potential for referral bias.

Consistent with previous studies, we found that adjusting for age, other demographic factors, clinical comorbidities, and cardiovascular risk factors largely explained the area income gradient in long-term mortality after ACS.[5,34,36] In contrast to these studies and in keeping with another study in Alberta, we found that the effect of area income on post-ACS 30-day mortality was restricted to patients presenting at non-metropolitan hospitals.[3] This disparity in post-ACS short-term mortality between patients from low income areas presenting at nonmetropolitan and metropolitan hospitals may represent differences in hospital management of ACS patients, availability of cardiologists and specialized cardiac services, or short-term follow-up care.

It is important to highlight that use of area median household income as an approximation of socioeconomic status, although commonplace, may not be indicative of individual socioeconomic position.[20,22,40] The use of area-level socioeconomic exposures likely represent contextual

factors of the physical and social environment such as social position, physical environment, and crime associated with health as opposed to individual-level characteristics. Reassuringly, however, many previous studies (including some in the jurisdiction that we studied) have shown the prognostic relevance of this area-level estimation of socioeconomic status in patients presenting with myocardial infarction.[3,6,20,22] Consequently, our findings highlight the contextual associations of area-level socioeconomic factors on access to cardiac catheterization and short-term mortality in nonmetropolitan ACS patients.

Our study has some caveats and limitations. First, we lack information regarding physician or patient preferences around treatment decisions. Such information would shed light on the role of patient and provider preferences in clinical decision making. Second, despite adjustment for several important clinical variables, there may be important unmeasured confounders or residual confounding of the relationship among hospital location, area income, receipt of coronary angiography, and post-ACS mortality. Third, although the diagnosis of unstable angina in our cohort was defined using the universally accepted definition, it was primarily dependent on the treating physician's clinical judgment in real time. Although this approach is subject to some variation in judgment across observers, the definition of unstable angina used in the APPROACH registry is likely more robust than in studies based on administrative or billing data because it was specified prospectively by care providers in the clinical setting. Fourth, we investigated the outcome of receiving cardiac catheterization, not the receipt of revascularization procedures that provide the therapeutic benefit after an ACS. Despite this, previous research has shown equity in revascularization on receipt of diagnostic coronary catheterization; therefore, the importance of first receiving catheterization is likely an important marker of access to invasive medical care for cardiac disease.[26] Fifth, the study period from 2004 to 2011 may be subject to secular trends and not reflective of current practice; however, adjustment for year of presentation in our analyses to account for this did not change our findings. In addition, no major structural changes in the model of cardiac care occurred in our study setting during this time period. Last, this study investigated the importance of the location of hospital of presentation and may not necessarily be indicative of individual place of residence.

These limitations not withstanding, our study sheds light on important interactions between geographic location of care and area income that are associated with disparities in access to cardiac catheterization and short-term mortality in patients presenting with ACS. Geographic barriers to emergent use of cardiac catheterization likely represent logistical constraints for nonmetropolitan patients; however, compared with patients from high income areas, patients from low income areas who present with ACS at nonmetropolitan hospitals are less likely to receive coronary angiography within 1 week and are more likely to die within 30 days of presentation. These findings demonstrate that area income–related equity for ACS patients is confined to metropolitan centers and that a significant area-income gradient remains outside of these metropolitan centers. These findings were observed despite a universal health care system that does not have any inpatient user fees, suggesting that factors other than insurance status and ability to pay are at play. Further investigation of management differences, treatment preferences, and referral decisions for patients in nonmetropolitan hospitals are needed. In addition, these findings highlight the need for targeted development of ACS care protocols that improve access to care and that improve outcomes for nonmetropolitan patients, especially those from low-income areas.

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Disclosures

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