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Area Median Income and Metropolitan vs. Non-Metropolitan Location of Care for ACS: A Complex Interaction of Social Determinants

Fabreau, Area-Income and Location of ACS Care

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ABSTRACT

Background: Metropolitan vs. non-metropolitan status and area-median-income may independently affect the care and outcomes of acute coronary syndromes (ACS). We sought to determine whether location of care modifies the association between area-income, receipt of cardiac catheterization and mortality following an ACS in a universal healthcare system.

Methods and Results: We studied a cohort of 14,012 ACS 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 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 to metropolitan and non-metropolitan hospitals.

In models adjusting for area-income, patients who presented to non-metropolitan facilities had a lower adjusted odds of receiving cardiac catheterization within 1 day of admission (OR: 0.22; 95% CI: 0.11, 0.46; p<0.001). Among non-metropolitan patients, when examined by SES, each incremental decrease in income quintile was associated with a 10% lower adjusted odds of receiving cardiac catheterization within 7-days (p<0.001) and a 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 healthcare system the association between area-income and receipt of cardiac catheterization and 30-day mortality differed depending on the location of initial medical care for ACS. Care protocols are required to improve access to care and outcomes in patients from low-income, non-metropolitan communities.

Keywords: Acute Coronary Syndromes, Median income, Angiography, Mortality/Survival, Geography, Rural/Urban, Quality and Outcomes

INTRODUCTION

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 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 in the setting of an ACS for appropriate patients.[10-12]

The geographic location of care for ACS also has been linked to barriers to timely access to evidence-based medical care, cardiac catheterization and increased mortality.[9,13,14] This may be partially due to concentration of specialty services and cardiac catheterization facilities in metropolitan centers.[14] Additionally, 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. Further, the receipt of cardiac catheterization and specialty care for patients presenting to non-metropolitan hospitals without these services often requires transfer to centres located in metropolitan areas. Financial barriers[7,8], intrinsic physician bias[16] and other factors may result in differential receipt of these services based on area median income. Few studies have examined specifically if location of care modifies the association between 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 between metropolitan and non-metropolitan sites — the presence of which may have important implications for health policy and planning.[17,18]

We sought to determine whether the associations between area income and the receipt of cardiac catheterization and mortality following an ACS were modified by initial care in a metropolitan versus non-metropolitan site. Of relevance to health policy, we examined this relationship in Canada where a system of universal healthcare exists for access to physician and hospital services. Thus, 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 two Southern Health Zones of the province of Alberta, Canada, with a catchment population of approximately 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] As APPROACH is a standing cardiac registry, the data used in this study were not collected in a targeted way solely for this this specific research question, but rather were collected in a generic manner for a variety of potential uses. One of the registry's principal strengths 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 previously described.[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, 18 to 99 years of age, admitted to any cardiac service in the two southern health zones between April 18, 2004 and December 31, 2011 with a principal diagnosis of an ACS (ST-segment–elevation myocardial infarction, non–ST-segment–elevation myocardial infarction, and 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 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 two 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 subjects 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 as quintile 5 as per previous studies. [6,9,14,20] We used Canadian census "dissemination areas" (DA), which are the smallest publically available standard geographic units of measure, with populations generally between 400-700 people.[23] In the Canadian census, DAs are designed to represent a smaller subdivisions of census tracts which 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 to any of the 7 urban centers, of which 1 tertiary care facility provides primary cardiac catheterization, were classified as metropolitan; patients presenting to any of the other 26 centers were classified as non-metropolitan. 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™, Mountain View, CA).[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 subjects sent immediately to the catheterization laboratory upon arrival and admitted afterwards. 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 (ST-segment elevation myocardial infarction [STEMI], non-ST-segment elevation myocardial infarction [NSTEMI] or unstable angina [UA]), prior diagnosis of coronary artery disease (CAD), hypertension, dyslipidemia, diabetes, family history of CAD, 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 previously described.[28]

Statistical Analysis

Descriptive statistics were reported according to area median household income quintiles for both metropolitan and non-metropolitan patients. Differences in demographic, clinical characteristics and unadjusted outcomes between metropolitan and non-metropolitan 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 non-metropolitan patients were compared using the Chi square test for trend for categorical variables and ANOVA or the nonparametric Kruskal-Wallis test (where appropriate) for continuous variables.

We first compared the adjusted odds ratio of the outcomes of interest for non-metropolitan 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 odds ratio of catheterization or mortality for each subgroup versus the highest area income patients who presented to metropolitan facilities (reference group) using logistic regression models, adjusting for all clinical and demographic covariates.[29] We used this strategy to examine for 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 (i.e. linear vs. non-linear) 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 for confounding (defined by a change in the β-coefficient for the variables of interest by >20%). Only the variable for 'family history of CAD' was excluded from the adjusted models for collinearity.

To allow for another interpretation of the data and 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 vs. non-metropolitan status on a multiplicative scale (i.e. two-way interaction testing). This dual analysis approach (i.e. interaction analysis on additive and multiplicative scales) allowed us to model the association of each incremental decrease in area income quintile for metropolitan and non-metropolitan 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 (where A is area level income quintile and B is metropolitan vs. non-metropolitan 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., Cary, North Carolina). We reported two-tailed P values (with a predefined threshold for statistical significance of <0.05) or 95% confidence intervals (CIs) when 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. As APPROACH is a provincial cardiac registry, the University of Calgary Conjoint Health Research 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 two Southern Alberta health zones. Among these admissions 5398 episodes were 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 non-metropolitan patients. The final study cohort of 14,012 adult patients included 3165 who presented initially to a non-metropolitan hospital, and 10,847 to a metropolitan hospital.

Baseline demographic and clinical characteristics are presented in Table 1. Median area incomes ranged from $38,587 CAD in the lowest income quintile (quintile 1) to $103,190 CAD in the highest income quintile (quintile 5). Those presenting to non-metropolitan hospitals, on average, were from lower income areas compared to those presenting to metropolitan centers ($49,799 CAD vs. $67,760 CAD; p<0.001). Consistent with this finding, the distribution of metropolitan and non-metropolitan patients by area income quintiles revealed a larger proportion of non-metropolitan versus metropolitan patients in lower income areas (29.9% versus 15.6% in the lowest area income quintile; P<0.001) and alternatively 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, non-metropolitan patients were typically older and had higher rates of hypertension, dyslipidemia, and smoking. In addition, a larger proportion of non-metropolitan 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 non-metropolitan patients and metropolitan patients had similar rates of previously diagnosed ACS, non-metropolitan patients had lower rates of prior percutaneous coronary intervention (17.4% vs. 23%, p<0.001), but similar rates of prior coronary artery bypass grafting (8.3% vs. 7.8%, p=0.41). Non-metropolitan 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 on-site catheterization capability for non-metropolitan patients was 209.1 km and 4.9 km for metropolitan patients (p<0.001).

Across area income quintiles for both metropolitan and non-metropolitan patients, subjects in lower income quintiles compared with those in higher income quintiles were typically older, 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). Also, for both metropolitan and non-metropolitan patients, subjects were similarly likely to present with an STEMI, NSTEMI or unstable angina regardless of their respective area income quintile. There were no differences in the median distance from the initial facility of presentation to a facility with on-site catheterization capability across the area income quintiles for either metropolitan or non-metropolitan patients.

Unadjusted Rates of Cardiac Catheterization and Mortality

Table 2 presents unadjusted rates for cardiac catheterization and mortality for metropolitan and non-metropolitan patients and also for each geographic group stratified by area income quintile. Among both metropolitan and non-metropolitan 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 and 7 days of presentation. However, among metropolitan patients alone, there were no differences 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 to those in higher area income quintiles regardless of location of hospital of presentation (Table 2). On average, non-metropolitan patients had lower rates of receiving cardiac catheterization within 1 day of presentation compared to metropolitan patients (24.5% vs. 41.6%, $p<0.001$) but higher rates of catheterization within 7 days of presentation (67.8% vs. 64.9%, $p=0.003$). Overall mortality rates were higher among non-metropolitan patients than metropolitan patients at 30 days (3.2% vs. 1.9%, $p<0.001$) and at one year (6.6% vs. 5.6%, $p=0.02$).

Non-metropolitan patients had lower unadjusted odds of receiving cardiac catheterization compared to metropolitan patients within 1 day (odds ratio [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, non-metropolitan patients had higher unadjusted odds of 30-day (OR: 1.66; 95% CI: 1.04, 2.65) but not 1-year mortality when compared to metropolitan patients (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 catheterization and mortality. For non-metropolitan subjects, when compared with patients from the highest income areas, each decrease in area income quintile was associated with a 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 a 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 a higher unadjusted odds of both 30-day and 1-year mortality after ACS for all subjects (Table 3).

Adjusted Analysis of Cardiac Catheterization

After adjustment for clinical covariates and area income, non-metropolitan patients had significantly lower odds of receiving cardiac catheterization than metropolitan patients, within 1 day (OR: 0.22; 95% CI: 0.11, 0.46) but not 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. Subjects in each of the area income categories presenting to non-metropolitan facilities, were significantly less likely to receive cardiac catheterization within the first day of presentation (Figure 1, Panel A). 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 to non-metropolitan facilities, only patients from the highest income areas had a higher adjusted odds compared to metropolitan patients from the highest income areas (OR: 1.40; 95% CI: 1.04, 1.88) (Figure 1, Panel B). Moreover, only lowest area income metropolitan patients had a lower adjusted odds of receiving cardiac catheterization within 7 days compared to 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 non-metropolitan 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 to non-metropolitan 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). Similarly, for metropolitan patients a similar but less prominent trend was observed, whereby 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 when compared to metropolitan patients, non-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, respectively). In the adjusted analysis exploring the additive association of location of initial care and area income on mortality, no income category for either non-metropolitan or metropolitan patients were found to have a significantly different odds of 30-day or 1-year mortality compared to metropolitan patients of the highest area income quintile (Figure 2, Panels A and B).

In models investigating the interaction between 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 non-metropolitan 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 on the odds of 30-day mortality by geographic location of initial care. This term was significant (p=0.02), thus 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 non-metropolitan patients had a similar pattern to that of 30-day mortality, but the test of linear trend no longer reached statistical significance (p=0.12). Further, in adjusted interaction models between 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 was not uniform, but was modified by location of initial care. We found that decreasing area income was associated with a lower likelihood of receiving urgent cardiac catheterization within 7 days and higher likelihood of 30-day mortality for ACS patients presenting to non-metropolitan facilities only. In addition, we confirmed that non-metropolitan patients are 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 non-metropolitan and metropolitan patients being similarly likely to receive cardiac catheterization within one week of an ACS, the decreased use of emergent cardiac catheterization and increased short-term mortality appeared closely associated to 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 both 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 repeatedly shown 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 also 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 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 to non-metropolitan 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 non-metropolitan areas. Metropolitan areas have higher concentrations of healthcare 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 one large catheterization facility among 33 health care facilities in the region and this limited procedural capacity may contribute to area income gradients in non-metropolitan 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; whereby, patients from lower income areas are less often referred for urgent cardiac catheterization.[18] This centralized model of specialized cardiac care dependent on a robust referral and transfer system exists over much of Canada[18] and most critical access hospitals in the USA[13] thus our findings may apply to other jurisdictions with low population densities.

Alternatively, non-metropolitan physicians may be privy to unmeasured prognostic information that may affect decisions around referral to a metropolitan facility, or cultural differences among non-metropolitan patients regarding preferences for aggressive care, especially among lower area income patients. Interestingly, non-metropolitan 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 high area-level income patients may be more successful in advocating for urgent referrals to a tertiary care centre for more aggressive care or may be preferentially referred for these procedures even more so than high-income area patients from the metropolitan center. Lastly, equity in metropolitan centres may reflect active quality improvement protocols put in place to improve door to balloon times and cardiac care in metropolitan centres but not in non-metropolitan centres.[39] This may also explain why area income gradients were not seen with emergent angiography use within 1-day of presentation, as this is more likely to be protocol driven for patients with high risk features of myocardial infarction, thus 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 post-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 to non-metropolitan hospitals.[3] This disparity in post-ACS short-term mortality between low area income patients presenting to non-metropolitan 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, while 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, the 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 SES in patients presenting with myocardial infarction.[3,6,20,22] Thus, our findings highlight the contextual associations of area level socioeconomic factors on access to cardiac catheterization and short-term mortality in non-metropolitan 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 between location of hospital, area income, receipt of coronary angiography and post-ACS mortality. Third, although the diagnosis of UA in our cohort was defined using the universally accepted definition, it was primarily dependent on the treating physician's clinical judgment in real time. While this is subject to some variation in judgment across observers, the UA definition used in the APPROACH registry is likely more robust than studies based on administrative or billing data, as it is 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 upon receipt of diagnostic coronary catheterization and thus the importance of first receiving a 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, revealed our findings remained unchanged. Additionally, no major structural changes in the model of cardiac care occurred in our study setting during this time period. Lastly, this study investigates the importance of the location of hospital of presentation and may not be necessarily 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 acute coronary syndromes. Geographic barriers to emergent use of cardiac catheterization likely represent logistical constraints for non-metropolitan patients. However, compared to high income area patients, low income area patients presenting to non-metropolitan hospitals with an ACS are less likely to receive coronary angiography within a week and more likely to die within 30 days of presentation. These findings demonstrate 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 healthcare system that does not have any inpatient user fees, thus suggesting there are factors other than insurance status and ability to pay which are at play. Further investigation of management differences, treatment preferences and referral decisions for patients in non-metropolitan hospitals are needed. In addition, these findings highlight the need for targeted development of ACS care protocols that improve access to care and improve outcomes for non-metropolitan patients, and especially those from low income areas.

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Disclosures or Competing Interests

None

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Figure Legends

Figure 1. The adjusted odds ratios of receiving cardiac catheterization within 1 and 7 days of presentation with an ACS by non-metropolitan and metropolitan status and area income quintile. Panel A. Adjusted odds ratios of receiving a cardiac catheterization within 1 day of presentation

with an ACS compared to metropolitan patients in the highest area income quintile. Panel B. Adjusted odds ratios of receiving a cardiac catheterization within 7 days of presentation with an ACS compared to metropolitan patients in the highest area income quintile.

Figure 2. The adjusted odds ratios of all-cause mortality within 30 days and one year of presentation with an ACS by non-metropolitan and metropolitan status and area income quintile. Panel A. Adjusted odds ratios of 30-day all-cause mortality after presentation with an ACS compared to metropolitan patients in the highest area income quintile. Panel B. Adjusted odds ratios of all-cause mortality within 1 year of presentation with an ACS compared to metropolitan patients in the highest area income quintile.

Table 1. Cohort Characteristics

Variable	Metro / non-Metro	Averages by Metro / Non-Metro	P-value	Area Median Household Income Quintile					
				1 (lowest) (N= 2635)	2 (N= 2766)	3 (N= 2766)	4 (N= 2896)	5 (highest) (N= 2949)	P-value[†]
Area Median Household Income (IQR $CAD)[*]	*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]	-
	Non-Metro	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									
Mean Age, years – (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
	Non-Metro	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
	Non-Metro	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
	Non-Metro	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
	Non-Metro	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

	Non-Metro	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
	Non-Metro	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
	Non-Metro	31		28.6	33.5	30.4	31.1	30.4	0.60
Prior Acute Coronary Syndrome – %	*Metro*	22.5	0.58	26.4	24.5	24.1	20.9	18.9	<0.001
	Non-Metro	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
	Non-Metro	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
	Non-Metro	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
	Non-Metro	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
	Non-Metro	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
	Non-Metro	5.3		7.6	7.6	3.6	7.9	2.5	0.02
Renal Disease – %	*Metro*	4.7	<0.001	5.6	5	5.6	4.4	3.6	<0.001
	Non-Metro	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
	Non-Metro	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
	Non-Metro	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
	Non-Metro	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
	Non-Metro	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
	Non-Metro	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

	Non-Metro	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
	Non-Metro	23.7		23.1	25.2	23.1	23.8	20.6	0.58
Characteristics of Initial Presenting Facility									
Median [IQR]* Distance (km)* of Initial Facility to Catheterization Lab	*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
	Non-Metro	221 [179 – 294]		221 [221 - 268]	221 [191 - 294]	221 [143 - 268]	221 [69.5 - 294]	221 [69.2 - 253]	<0.001

*IQR = Interquartile range, $CAD = Canadian Dollars, PCI = percutaneous coronary intervention, CABG = coronary artery bypass graft, STEMI = ST-segment elevation myocardial infarction, and NSTEMI = Non-ST-segment elevation myocardial infarction, km = kilometers

†P-Value from Chi-Square Trend Test

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/non-Metro	P-Value**	Quintile 1 (lowest) Metro N = 1688 / non-Metro N = 947	Quintile 2 Metro N = 1742 / non-Metro N = 1024	Quintile 3 Metro N = 2204 / non-Metro N = 562	Quintile 4 Metro N = 2468 / non-Metro N = 428	Quintile 5 (highest) Metro N = 2745 / non-Metro N = 204	P-Value for trend†
Catheterization* Within 1 day – %	*Metro*	36.6	0.02	34.3	37.8	37.6	35.9	37	0.53
	non-Metro	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
	non-Metro	66.7		61.6	65.9	69.8	70.1	79.4	<0.001
Mortality 30-day – %	*Metro*	1.9	0.03	2.4	2	2	2	1.5	<0.001
	non-Metro	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
	non-Metro	6.6		7.1	6.1	5.5	5.4	4.5	0.002

Area Income Quintile and Location of Initial Care

*Catheterization indicates cardiac catheterization.

**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.

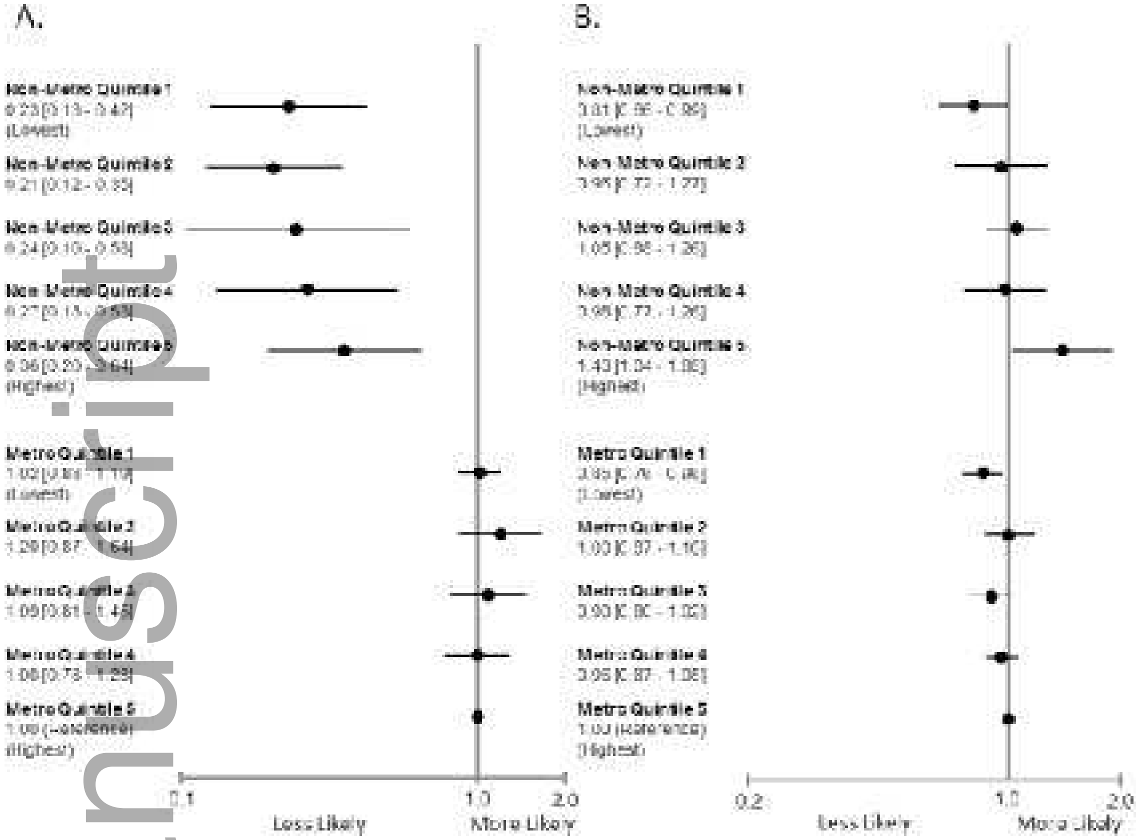
Table 3. Association of Decreasing Area Income Quintile on Outcomes after an Acute Coronary Syndrome for non-Metropolitan and Metropolitan Patients.

Outcomes	**Metropolitan N=10,847**		**non-Metropolitan N= 3165**		**P-Value for Adjusted Interaction**
	Unadjusted OR [CI]	**Adjusted OR† [CI]**	**Unadjusted OR [CI]**	**Adjusted OR† [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

*Catheterization indicates cardiac catheterization; CI, confidence interval; and OR, odds ratio.

†Adjusted models included the following variables: age, sex, metropolitan/non-metropolitan location, area median household income quintile, interaction term for metropolitan/non-metropolitan location × 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 graft surgery, malignancy, congestive heart failure, peripheral vascular disease, cerebrovascular disease, chronic kidney disease, dialysis, chronic lung disease,

liver and gastrointestinal disease.



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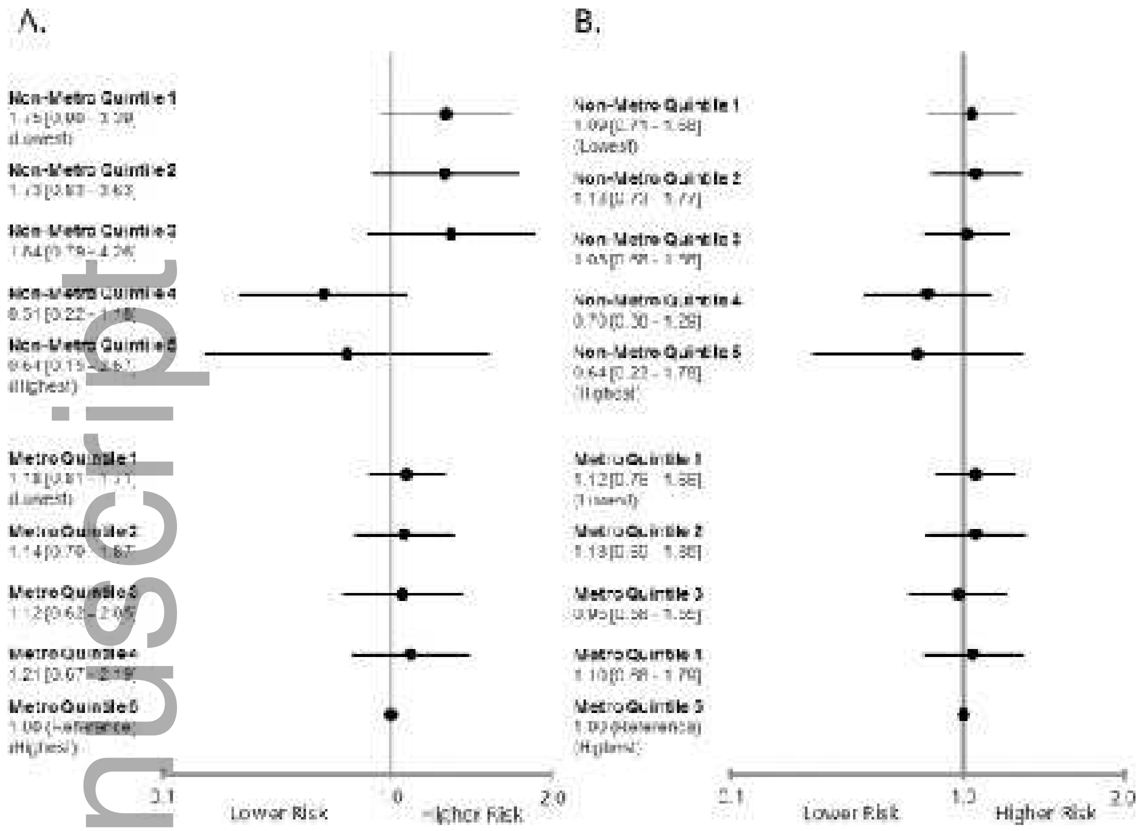

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