Sex, Socioeconomic Status, Access to Cardiac Catheterization, and Outcomes for Acute Coronary Syndromes in the Context of Universal Healthcare Coverage

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Background—Sex and neighborhood socioeconomic status (nSES) may independently affect the care and outcomes of acute coronary syndrome, partly through barriers in timely access to cardiac catheterization. We sought to determine whether sex modifies the association between nSES and the receipt of cardiac catheterization and mortality after an acute coronary syndrome in a universal healthcare system.

Methods and Results—We studied 14012 patients with acute coronary syndrome admitted to cardiology services between April 18, 2004, and December 31, 2011, in Southern Alberta, Canada. We used multivariable logistic regression to compare the odds of cardiac catheterization within 2 and 30 days of admission and the odds of 30-day and 1-year mortality for men and women by quintile of neighborhood median household income. Significant relationships between nSES and the receipt of cardiac catheterization and mortality after acute coronary syndrome were detected for women but not men. When examined by nSES, each incremental decrease in neighborhood income quintile for women was associated with a 6% lower odds of receiving cardiac catheterization within 30 days (P=0.01) and a 14% higher odds of 30-day mortality (P=0.03). For men, each decrease in neighborhood income quintile was associated with a 2% lower odds of receiving catheterization within 30 days (P=0.10) and a 5% higher odds of 30-day mortality (P=0.36).

Conclusions—Associations between nSES and receipt of cardiac catheterization and 30-day mortality were noted for women but not men in a universal healthcare system. Care protocols designed to improve equity of access to care and outcomes are required, especially for low-income women. (Circ Cardiovasc Qual Outcomes. 2014;7:540-549.)

Key Words: angiography ◼ gender identity ◼ mortality ◼ myocardial infarction ◼ neighborhood ◼ sex ◼ social class

Cardiovascular disease is a leading cause of morbidity and mortality for women. Although the overall prevalence of coronary artery disease (CAD) is higher in men, increased attention has been devoted to the clinical impact and outcomes of CAD among women. This focus has been partly fueled by reports highlighting lower receipt of evidence-based care for women, such as access to cardiac catheterization and percutaneous coronary interventions in the setting of acute coronary syndrome (ACS). Moreover, higher mortality and complication rates described in the setting of ACS for women, particularly younger women, may in part be attributable to disparities in care, given that timely receipt of these procedures improves outcomes in the setting of an ACS for appropriate patients. Lower neighborhood socioeconomic status (nSES) has also been linked to barriers to timely medical care and evidence-based therapies, as well as excess risk of death in the setting of ACS. Moreover, many women still face an economic disadvantage in society, with income differentially distributed among men and women. In addition, recent evidence among patients with premature ACS has shown increased clustering of traditional and nontraditional cardiovascular risk factors such as depression and chronic stress in low-income women that may contribute to income gradients in care and outcomes for women but not men. Despite differential distribution of nSES and cardiovascular risk factors, as well as ACS-related mortality and complication rates, by sex, few studies have examined whether sex modifies how nSES...
WHAT IS KNOWN

- Sex and socioeconomic status have been studied independently as factors influencing the care and outcomes after acute coronary syndromes.
- The interplay between sex and socioeconomic status in cardiac disease has not been fully characterized.

WHAT THE STUDY ADDS

- Our findings demonstrate that the association between neighborhood socioeconomic status and both care and outcomes in acute coronary syndrome differs in men versus women.
- Low-income women seem to be particularly vulnerable in terms of access to cardiac catheterization and short-term mortality after acute coronary syndrome.
- These findings highlight the need for cardiac care protocols designed to improve equity of access to care and outcomes for women, especially for low-income women.

Factors are associated with access to cardiac catheterization and outcomes of ACS. Furthermore, it is unknown whether the previously described income gradients in access to cardiac catheterization and mortality in the setting of ACS persist in a universal healthcare system and whether they are differentially present among women relative to men.

We hypothesized that sex and nSES disparities in access to catheterization and mortality after ACS persist and that sex modifies the association of nSES with these outcomes such that income gradients are more pronounced among women. We examined this relationship in Canada where the universal healthcare system aims to provide equitable care with prioritization based on medical necessity. As such, health insurance status is not an explanatory variable in our evaluation of sex and SES factors as determinants of care and outcomes.

Methods

Study Setting and Data Sources

This cohort study was conducted in 2 southern health zones of the province of Alberta, Canada, with an approximate 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 registry with essentially complete ascertainment of all patients admitted to a cardiac service in Southern Alberta since 2004, and all patients receiving coronary angiography in Alberta since 1995. One of the main strengths of this registry is that demographic, clinical, and procedural information are prospectively collected using standardized definitions with trained data abstractors and validated methods to ensure a rich collection of accurate clinical data. For income and mortality data, we performed linkages with the 2006 Canadian Census and the Alberta Bureau of Vital Statistics as previously described.

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, admitted to any cardiac service in the 2 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 essentially complete for patients from Alberta, as such patients were followed from admission until death or a maximum of 1 year with a study end date of December 31, 2012. To avoid confounding of the outcomes of interest by different admissions, only the first admission was included for patients with multiple admissions for an ACS during the study period. We excluded patients if census data were unavailable. Patients residing outside of the 2 Southern Alberta health zones were also excluded.

Study Variables

Patient sex was accurately determined from the APPROACH database, with no missing values. Throughout the article, we refer to a combination of sex factors, recognizing that constructs of sex and gender are biological and sociological constructs, respectively, that define men and women. Both sex and gender may underlie differences between men and women in access to catheterization and outcomes after ACS. As such, we intentionally refer to sex in a manner recognizing that differences between men and women described in our results likely arise from a combination of both sex (biological) and gender (psychosocial) factors. The other main construct of interest in our study, nSES, was described using the validated nSES dimension of neighborhood-level median household income, determined using postal code information as in previous studies.

We assessed the receipt of cardiac catheterization immediately before admission to 2 days after presentation (defined as emergent) and within 30 days of presentation (defined as urgent), based on the current evidence and guidelines for use of these procedures in the setting of ACS. We assessed 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, non–ST-segment–elevation myocardial infarction, and unstable angina), prior diagnosis of CAD, hypertension, dyslipidemia, diabetes mellitus, current and former smoking status, prior ACS, prior coronary revascularization procedure, family history of CAD, congestive heart failure, chronic lung disease, peripheral vascular disease, chronic renal disease, dialysis, cerebrovascular disease, cancer, gastrointestinal disease, and liver disease. In addition, the geographic location of the medical facility of presentation was determined by the location of the first recorded presentation for ACS admission. Overland distances to the cardiac catheterization facility were calculated in kilometers by geocoding medical facility addresses using Google Maps, an online geographic information systems mapping program maintained by Google (Mountain View, CA).

Missing data on comorbidities were obtained using a validated data merging method that draws on the Canadian national Discharge Abstract Database, as previously described.

Statistical Analysis

Descriptive statistics were reported according to neighborhood median household income quintiles for both men and women. Differences in demographic, clinical characteristics, and unadjusted outcomes between men and women were compared using the $\chi^2$ test for categorical variables and the Student $t$ test for continuous variables. Differences across neighborhood income quintiles for each sex were compared using the $\chi^2$ 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 of the outcomes of interest for women versus men by using logistic regression models, with nSES and all demographic and clinical characteristics included as covariates in the models (Table 1). To examine the combined effects of sex and nSES, we then categorized patients into 1 of 10 subgroups defined by sex and neighborhood income quintile. We compared the adjusted odds of catheterization or mortality for each subgroup versus the highest neighborhood income men (reference group) using logistic regression models, adjusting for all clinical and demographic covariates.
Table 1. Cohort Characteristics by Sex and Income Quintile

<table>
<thead>
<tr>
<th>Variable</th>
<th>Sex</th>
<th>Averages by Sex</th>
<th>P Value*</th>
<th>Neighborhood Median Household Income Quintile</th>
<th>P Value for Trend†</th>
</tr>
</thead>
<tbody>
<tr>
<td>Median household income (IQR), Canadian dollars</td>
<td></td>
<td></td>
<td></td>
<td>1 (Lowest) (n=2635)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Men</td>
<td>63.878 (48.779–84.174)</td>
<td>&lt;0.001</td>
<td>38.701 (34.061–42.425)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Women</td>
<td>58.570 (45.865–77.690)</td>
<td></td>
<td>38.581 (33.168–42.310)</td>
<td></td>
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<tr>
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<td></td>
<td>2 (n=2766)</td>
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</tr>
<tr>
<td></td>
<td>Men</td>
<td>64.1 (12.8) (IQR 70.3 (13.1)</td>
<td>&lt;0.001</td>
<td>63.6 (12.5)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Women</td>
<td>68.4 (12.9) (IQR 68.6 (13.1)</td>
<td></td>
<td>63.6 (12.9)</td>
<td></td>
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<tr>
<td>Clinical characteristics</td>
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<td>3 (n=2766)</td>
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<tr>
<td></td>
<td>Men</td>
<td>66.3 (12.9) (IQR 68.3 (12.0)</td>
<td>&lt;0.001</td>
<td>63.6 (12.9)</td>
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</tr>
<tr>
<td></td>
<td>Women</td>
<td>67.4 (13.2) (IQR 66.9 (13.2)</td>
<td></td>
<td>61.9 (11.9)</td>
<td>&lt;0.001</td>
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<tr>
<td></td>
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<td></td>
<td>4 (n=2896)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Men</td>
<td>62.2 (12.6) (IQR 67.4 (13.2)</td>
<td>&lt;0.001</td>
<td>61.9 (11.9)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Women</td>
<td>66.3 (13.2) (IQR 66.9 (13.2)</td>
<td></td>
<td>61.9 (11.9)</td>
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<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>5 (Highest) (n=2949)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Men</td>
<td>75.846 (72.562–81.667)</td>
<td></td>
<td>103.190 (94.901–117.628)</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Women</td>
<td>103.326 (95.675–118.630)</td>
<td></td>
<td>103.326 (95.675–118.630)</td>
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</table>

(Continued)
<table>
<thead>
<tr>
<th>Variable</th>
<th>Sex</th>
<th>Averages by Sex</th>
<th>P Value*</th>
<th>1 (Lowest) (n=2635)</th>
<th>2 (n=2766)</th>
<th>3 (n=2766)</th>
<th>4 (n=2896)</th>
<th>5 (Highest) (n=2949)</th>
<th>P Value for Trend†</th>
</tr>
</thead>
<tbody>
<tr>
<td>Chronic lung disease, %</td>
<td>Men</td>
<td>13.3</td>
<td>&lt;0.001</td>
<td>17.8</td>
<td>14.8</td>
<td>14.3</td>
<td>10.9</td>
<td>10.1</td>
<td>&lt;0.001</td>
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<td></td>
<td>Woman</td>
<td>17.2</td>
<td></td>
<td>20.5</td>
<td>17.5</td>
<td>17.1</td>
<td>16.5</td>
<td>13.3</td>
<td>&lt;0.001</td>
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<td>Liver or gastrointestinal disease, %</td>
<td>Men</td>
<td>8.2</td>
<td>&lt;0.001</td>
<td>10.0</td>
<td>7.9</td>
<td>9.1</td>
<td>7.0</td>
<td>7.2</td>
<td>&lt;0.001</td>
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<td></td>
<td>Woman</td>
<td>10.7</td>
<td></td>
<td>13.3</td>
<td>12.9</td>
<td>9.7</td>
<td>9.2</td>
<td>7.7</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Malignancy, %</td>
<td>Men</td>
<td>4.7</td>
<td>0.18</td>
<td>5.1</td>
<td>4.9</td>
<td>4.8</td>
<td>3.9</td>
<td>4.8</td>
<td>0.31</td>
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<td></td>
<td>Woman</td>
<td>5.2</td>
<td></td>
<td>5.5</td>
<td>5.2</td>
<td>4.2</td>
<td>6.3</td>
<td>4.7</td>
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<td>ACS type</td>
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<td></td>
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</tr>
<tr>
<td>STEMI, %</td>
<td>Men</td>
<td>32.5</td>
<td>&lt;0.001</td>
<td>32.3</td>
<td>33.4</td>
<td>33.9</td>
<td>31.0</td>
<td>32.0</td>
<td>0.35</td>
</tr>
<tr>
<td></td>
<td>Woman</td>
<td>25.6</td>
<td></td>
<td>27.1</td>
<td>25.7</td>
<td>27.8</td>
<td>24.6</td>
<td>22.0</td>
<td>0.03</td>
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<tr>
<td>NSTEMI, %</td>
<td>Men</td>
<td>34</td>
<td>0.005</td>
<td>36.3</td>
<td>35.8</td>
<td>33.8</td>
<td>32.8</td>
<td>31.9</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td></td>
<td>Woman</td>
<td>36.5</td>
<td></td>
<td>38.7</td>
<td>36.9</td>
<td>35.4</td>
<td>36.7</td>
<td>34.0</td>
<td>0.07</td>
</tr>
<tr>
<td>Unstable angina, %</td>
<td>Men</td>
<td>33.6</td>
<td>&lt;0.001</td>
<td>31.5</td>
<td>30.8</td>
<td>32.3</td>
<td>36.1</td>
<td>36.2</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td></td>
<td>Woman</td>
<td>38</td>
<td></td>
<td>34.2</td>
<td>37.4</td>
<td>36.8</td>
<td>38.7</td>
<td>44.1</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Characteristics of initial presenting facility</td>
<td></td>
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<td></td>
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<tr>
<td>Teaching hospital, %</td>
<td>Men</td>
<td>76.3</td>
<td>0.95</td>
<td>61.9</td>
<td>61.9</td>
<td>79.1</td>
<td>83.6</td>
<td>90.2</td>
<td>&lt;0.001</td>
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<tr>
<td></td>
<td>Woman</td>
<td>76.3</td>
<td></td>
<td>65.1</td>
<td>63.0</td>
<td>78.4</td>
<td>84.8</td>
<td>95.3</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Median (IQR) distance of initial facility to catheterization laboratory, km</td>
<td>Men</td>
<td>11.8 (0–12.2)</td>
<td>0.01</td>
<td>11.8 (0–221)</td>
<td>12.2 (0–221)</td>
<td>11.8 (0–12.2)</td>
<td>7.3 (0–12.2)</td>
<td>0 (0–11.8)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td></td>
<td>Woman</td>
<td>11.8 (0–12.2)</td>
<td></td>
<td>11.8 (0–221)</td>
<td>12.2 (0–221)</td>
<td>11.8 (0–12.2)</td>
<td>11.8 (0–12.2)</td>
<td>0 (0–11.8)</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>

ACS indicates acute coronary syndrome; CABG, coronary artery bypass graft; IQR, interquartile range; NSTEMI, non-ST-segment–elevation myocardial infarction; PCI, percutaneous coronary intervention; and STEMI, ST-segment–elevation myocardial infarction.

*P value from χ² or t test.
†P value from χ² trend test.
We used this strategy to examine for additive associations of sex and nSES in our models without making any other a priori assumptions about the distributional relationship between sex and income on the predefined outcomes of interest. We then 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%). From our exploration of collinearity, the variables for family history of CAD, nonmetropolitan status, and teaching hospital were excluded from the adjusted models.

Given the visual appearance of the additive associations of sex and nSES on the outcomes of interest and to estimate sex-specific neighborhood income gradients, we chose to respectively neighborhood income quintile as a continuous predictor, assuming a linear relationship between income and the outcomes of interest for both men and women. We modeled the association of each incremental decrease in neighborhood income quintile for each sex compared with men and women of the corresponding highest neighborhood income quintile on the receipt of catheterization and mortality. We then formally tested for effect modification by sex by including an interaction term between neighborhood income and sex. 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, NC). We reported 2-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 the University of Calgary Conjoint Health Research Ethics Board and the Harvard Medical School Institutional Review Board.

**Results**

**Baseline Characteristics**

We identified 21,028 admissions for ACS among adult patients in the 2 Southern Alberta health zones. Among these admissions, 5,398 episodes were excluded as repeat admissions for ACS. A further 1618 (10.3%) admissions were excluded because of missing neighborhood income data, of which 372 (23%) were women. The final study cohort of 14,012 adult patients included 4017 women and 9995 men.

Baseline demographic and clinical characteristics are presented in Table 1. Median neighborhood household incomes ranged from 38,701 Canadian dollars in the lowest neighborhood income quintile (quintile 1) to 103,190 Canadian dollars in the highest neighborhood income quintile (quintile 5). Women, on average, were from lower income areas than men (58,570 versus 63,878 Canadian dollars; P<0.001). Consistent with this finding, the distribution of men and women patients by neighborhood income quintiles revealed a larger proportion of women versus men in lower income areas (22.1% versus 17.5% in the lowest neighborhood income quintile; P<0.001) and alternatively more men in higher income areas (22.5% versus 17.5% in the highest neighborhood income quintile; P<0.001).

Compared with men, women were typically older by 5 years (63 versus 68.4 years; P<0.001), less likely to be current smokers or have dyslipidemia, and more likely to have common medical comorbidities such as hypertension, congestive heart failure, cerebrovascular disease, renal disease, and chronic lung disease (Table 1). In addition, women were more likely than men to present with non–ST-segment–elevation myocardial infarction and unstable angina and less likely to present with ST-segment–elevation myocardial infarction. Men were more likely than women to have been previously diagnosed with ACS and receive a prior percutaneous coronary intervention (23.4% versus 17.4%; P<0.001) or coronary artery bypass grafting (9.2% versus 5.8%; P<0.001).

Across neighborhood income quintiles for both men and women, subjects in lower income quintiles compared with those in higher income quintiles were typically older, more likely to present initially to a nonmetropolitan facility, and had higher rates of medical comorbidities such as diabetes mellitus, smoking, congestive heart failure, cerebrovascular disease, and chronic lung disease; a larger proportion of these patients had a history of previous ACS (Table 1). For both men and women, patients in the highest neighborhood income quintile were more likely to present with unstable angina, whereas non–ST-segment–elevation myocardial infarction was more common among those from lower income neighborhoods. Both men and women in the lowest neighborhood income quintiles were more likely to present to a medical facility further from the academic facility with on-site catheterization capability (median distance, 11.8 versus 0 km; P<0.001).

**Unadjusted Rates of Cardiac Catheterization and Mortality**

Table 2 presents unadjusted rates for cardiac catheterization and mortality for men and women and also for each sex stratified by neighborhood income quintile. Among women, those from lower income areas had higher rates of 30-day but not 1-year mortality than women from higher income areas (tests for trend: P=0.01 and P=0.06, respectively; Table 2). Among men, significant mortality differences were detected at 30 days (test for trend: P=0.04) and 1 year (test for trend: P<0.001), whereas men from lower income areas were observed to have excess mortality compared with those residing in higher income areas (Table 2).

Women had lower unadjusted odds of receiving cardiac catheterization compared with men both within 2 (odds ratio [OR], 0.66; 95% CI, 0.57–0.75) and 30 days (OR, 0.65; 95% CI, 0.52–0.80) of presentation and higher unadjusted odds of 30-day and 1-year mortality (OR, 1.41; 95% CI, 1.13–1.76 and OR, 1.46; 95% CI, 1.36–1.55, respectively). Table 3 summarizes the unadjusted and adjusted analyses that assume a linear relationship between neighborhood income quintile and the odds of receiving cardiac catheterization. For both sexes, when compared with patients from the highest income areas, each decrease in neighborhood income quintile was associated with a lower unadjusted odds of receiving urgent but not emergency cardiac catheterization (Table 3).

**Adjusted Analysis of Cardiac Catheterization**

In models adjusting for clinical covariates and nSES, women had significantly lower odds of receiving cardiac catheterization than men, within 2 (OR, 0.80; 95% CI, 0.72–0.88) or 30 days of presentation (OR, 0.74; 95% CI, 0.63–0.87). In adjusted analyses of catheterization and mortality stratified by neighborhood income quintile and sex, men in the highest neighborhood income quintile (quintile 5) served as the reference group. Women in both the lowest and the highest
neighborhood income quintiles were significantly less likely to receive cardiac catheterization within 2 days of presentation with ACS (Figure 1A). Men in the second neighborhood income quintile were significantly more likely than the highest neighborhood income quintile men to receive catheterization emergently within 2 days of presentation (Figure 1A). In contrast, women in each of the 5 area income categories were significantly less likely to receive cardiac catheterization within 30 days of presentation compared with high neighborhood income men, with women in the lowest neighborhood income quintile particularly so (OR, 0.58; 95% CI, 0.43–0.77; Figure 1B). Among men, only those in the lowest neighborhood income quintile were significantly less likely to receive catheterization within 30 days of presentation (Figure 1B).

Table 3 summarizes the adjusted analyses that assume a linear relationship between neighborhood income quintile and the odds of receiving cardiac catheterization. We observed that for men there was a slight incremental increase in the odds of catheterization within 2 days of presentation with lower neighborhood income; with each decrease in neighborhood income quintile, the odds of receiving emergent catheterization increased by 3% (OR, 1.03; 95% CI, 1.02–1.05; p=0.01) decrease in the odds of catheterization within 30 days of presentation (OR, 0.94; 95% CI, 0.89–0.98; Table 3). This association was not found among women, and there was no evidence of statistically significant effect modification by sex of the neighborhood income–catheterization relationship (p=0.21). For women, each incremental decrease in neighborhood income quintile was associated with a 6% (p=0.01) decrease in the odds of catheterization within 30 days of presentation (OR, 0.94; 95% CI, 0.89–1.05; Table 3). This association was not evident among men; however, the interaction term between sex and income was not statistically significant (p=0.21).

### Adjusted Analysis of Mortality

In models adjusting for clinical covariates and nSES, when compared with men on average, women did not experience higher adjusted odds of 30-day or 1-year mortality (OR, 0.92; 95% CI, 0.73–1.16 and OR, 0.99; 95% CI, 0.92–1.05, respectively). In the adjusted analysis exploring the additive association of sex and nSES on mortality, only women in the highest neighborhood income quintile approached a significantly lower odds of 30-day mortality compared with high neighborhood income men (OR, 0.81; 95% CI, 0.65–1.00; p=0.05; Figure 2A). Otherwise, there were no significant differences

### Table 3. Unadjusted and Adjusted Association of Decreasing Neighborhood Income Quintile on Outcomes by Sex

<table>
<thead>
<tr>
<th>Outcomes</th>
<th>Unadjusted OR (95% CI)</th>
<th>Adjusted OR* (95% CI)</th>
<th>Unadjusted OR (95% CI)</th>
<th>Adjusted OR* (95% CI)</th>
<th>p Value for Adjusted Interaction</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Men (n=9995)</td>
<td>Women (n=4017)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Catheterization within 2 d</td>
<td>0.92 (0.85–1.00)</td>
<td>1.03 (1.02–1.05)</td>
<td>0.91 (0.91–1.02)</td>
<td>0.99 (0.93–1.06)</td>
<td>0.21</td>
</tr>
<tr>
<td>Catheterization within 30 d</td>
<td>0.96 (0.93–0.98)</td>
<td>0.98 (0.95–1.00)</td>
<td>0.93 (0.98–0.98)</td>
<td>0.99 (0.90–0.98)</td>
<td>0.21</td>
</tr>
<tr>
<td>30-d Mortality</td>
<td>1.14 (1.01–1.30)</td>
<td>1.05 (0.95–1.15)</td>
<td>1.27 (1.05–1.53)</td>
<td>1.14 (1.01–1.28)</td>
<td>0.003</td>
</tr>
<tr>
<td>1-y Mortality</td>
<td>1.16 (1.07–1.25)</td>
<td>1.05 (0.98–1.14)</td>
<td>1.11 (1.00–1.23)</td>
<td>1.01 (0.93–1.09)</td>
<td>0.02</td>
</tr>
</tbody>
</table>

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

*Adjusted models included the following variables: age, sex, neighborhood median household income quintile, interaction term for sex×neighborhood income quintile, distance from facility of presentation to facility with catheterization laboratory, 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.
among the sex and neighborhood income groups for the adjusted odds of either 30-day or 1-year mortality (Figure 2).

In models assuming a linear relationship between neighborhood income and mortality (summarized in Table 3), each decrease in neighborhood income quintile was associated with a 14% (P=0.03) increase in the adjusted odds of 30-day mortality for women. In contrast, for men, neighborhood income was not a significant predictor of 30-day mortality (Table 3). We used an interaction term to test for effect modification on the odds of 30-day mortality by nSES. This term was significant (P=0.003), thus confirming that the association of nSES and 30-day mortality was modified by sex (Table 3).

Discussion

Our findings indicate significant relationships between nSES and the receipt of cardiac catheterization and mortality after ACS for women but not men. We found that decreasing neighborhood income was associated with a lower a likelihood of receiving urgent catheterization within 30 days only for women. In addition, we confirmed that women are less likely than men to undergo emergent or urgent cardiac catheterization in the setting of ACS even after adjusting for clinical characteristics and that this was particularly apparent among women of lower neighborhood income. These findings were evident despite a universal health insurance system designed to eliminate cost barriers to medical care, especially in the setting of acute medical conditions such as ACS.

Furthermore, we found that sex modified the association between nSES and short-term mortality after presentation with ACS, whereby neighborhood income was predictive of 30-day mortality post-ACS for women but not for men. This differential association of nSES and short-term mortality in women seemed to be largely driven by a lower risk of 30-day mortality in women from high-income neighborhoods compared with men from these neighborhoods.

Our study is novel in its exploration of the interplay between patient sex and nSES. Previous studies have shown that women are less likely to receive invasive cardiac procedures than men, and women also experience higher short-term mortality and complications rates after an ACS. Differences in access to emergent catheterization between sexes may be attributable in part to previously described differences in symptom presentation or delays in seeking medical care among women. Alternatively, it is plausible that women presenting with lower

Figure 1. The adjusted odds ratios of receiving cardiac catheterization within 2 and 30 days of presentation with an acute coronary syndrome (ACS) by sex and neighborhood income quintile. A, Adjusted odds ratios of receiving a cardiac catheterization within 2 days of presentation with an ACS compared with men in the highest neighborhood income quintile. B, Adjusted odds ratios of receiving a cardiac catheterization within 30 days of presentation with an ACS compared with men in the highest neighborhood income quintile.
risk ACS (ie, those with negative biomarkers) are appropriately treated without catheterization, and by extension, men presenting with ACS with low-risk features may be alternatively subject to more overuse of cardiac catheterization and may explain some of the sex disparity observed in receipt of catheterization.7,20,41 For receipt of urgent coronary angiography in contrast, where more practice variation may exist, both men and women from low-income areas received urgent cardiac catheterization less often than men from high-income neighborhoods.19 This seemed to be particularly true for women from low-income neighborhoods and may represent the additive disadvantage of a gender bias and socioeconomic status may be predictive of how women relate to the healthcare system, thus leading to lower access to evidence-based therapies such as catheterization and worse outcomes for lower nSES women. We suspect that it is a combination of gender (ie, psychosocial) and sex (ie, biological) factors that lead to differences in cardiac care and outcomes between men and women in the setting of ACS. Future research is needed to disentangle these factors and their contributions to male/female disparities and the differential associations of nSES and sex with care and outcomes for ACS.

Our study has several limitations. First, we do not have information on physician or patient preferences about 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 effects of estrogen and other physiological differences may lead to lower short-term mortality for women after an ACS.45,46 Interestingly, lower mortality for women was not seen for women in lower income neighborhoods, thus indicating that these benefits are negated by the detrimental associations of low nSES status for women but not men. Recent literature describes increased clustering of traditional and nontraditional risk factors such as depression and chronic stress among low-income women in particular.28 The differential clustering of these important risk factors may indicate how women experience the detrimental associations of low nSES differently than men and may also play an important role in modifying short-term mortality after ACS for women. Alternatively, lower nSES status may be predictive of how women relate to the healthcare system by progressively magnifying pre-existing gender biases within the healthcare system, thus leading to lower access to evidence-based therapies such as catheterization and worse outcomes for lower nSES women. We suspect that it is a combination of gender (ie, psychosocial) and sex (ie, biological) factors that lead to differences in cardiac care and outcomes between men and women in the setting of ACS. Future research is needed to disentangle these factors and their contributions to male/female disparities and the differential associations of nSES and sex with care and outcomes for ACS.

Our study has several limitations. First, we do not have information on physician or patient preferences about 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

Figure 2. The adjusted odds ratios of all-cause mortality within 30 days and 1 year of presentation with an acute coronary syndrome (ACS) by sex and neighborhood income quintile. A, Adjusted odds ratios of 30-day all-cause mortality after presentation with an ACS compared with men in the highest neighborhood income quintile. B, Adjusted odds ratios of all-cause mortality within 1 year of presentation with an ACS compared with men in the highest neighborhood income quintile.
or residual confounding of the relationship among sex, nSES, receipt of coronary angiography, and post-ACS mortality. Third, although we found a strong neighborhood income gradient among women alone for the receipt of urgent cardiac catheterization, our power was limited to determine whether the gradient was distinct from the experience of men. Fourth, we investigated the outcome of receiving cardiac catheterization, not the receipt of revascularization procedures that provide the therapeutic benefit after an ACS. We did this intentionally, recognizing that previous research has shown that women have higher rates of nonobstructive CAD in which revascularization may not be appropriate.47 Last, we remind readers that the use of neighborhood median household income is an approximation of SES. Although commonly used as a proxy for individual income, neighborhood income does not always reflect individual income.30,40–42 Reassuringly, however, previous studies have shown the prognostic relevance of this area-level estimation of SES in patients presenting with myocardial infarction.19,23,30

These limitations notwithstanding, our study sheds light on the relationship between sex and nSES factors in cardiac care. The associations between neighborhood income and use of cardiac catheterization and mortality after ACS differ for men and women, with women seemingly more vulnerable to the detrimental associations of low area income. These findings occurred despite a universal healthcare system that does not have any inpatient user fees. These findings suggest that factors other than insurance status and ability to pay are at play. Care protocols designed to improve access to care and improve outcomes in women, especially low SES women, are required.

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Disclosures
None.

References


Sex, Socioeconomic Status, Access to Cardiac Catheterization, and Outcomes for Acute Coronary Syndromes in the Context of Universal Healthcare Coverage

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