Outcomes After Acute Myocardial Infarction in South Asian, Chinese, and White Patients

Nadia A. Khan, MD, MSc; Maja Grubisic, MSc; Brenda Hemmelgarn, MD, PhD; Karen Humphries, PhD; Kathryn M. King, PhD; Hude Quan, PhD

Background—Cardiac mortality rates vary substantially between countries and ethnic groups. It is unclear, however, whether South Asian, Chinese, and white populations have a variable prognosis after acute myocardial infarction (AMI). To clarify this association, we compared mortality, use of revascularization procedures, and risk of recurrent AMI and hospitalization for heart failure between these ethnic groups in a universal-access healthcare system.

Methods and Results—We used a population cohort study design using hospital administrative data linked to cardiac procedure registries from British Columbia and the Calgary Health Region Area in Alberta (1994 to 2003) to identify AMI cases. Patient ethnicity was categorized using validated surname algorithms. There were 2190 South Asian, 946 Chinese, and 38479 white patients with AMI identified. There was no significant difference in use of revascularization procedures between ethnic groups at 30 d and 1 year. Short-term (30-day) mortality was higher among Chinese relative to white patients (odds ratio, 1.23; 95% confidence interval, 1.02 to 1.48). There was no significant difference in 30-day mortality between South Asian and white patients. South Asian patients had a 35% lower relative risk of long-term mortality compared with white patients (hazard ratio, 0.65; 95% confidence interval, 0.57 to 0.72). There was no significant difference in long-term mortality between Chinese and white patients. Among AMI survivors, Chinese patients had a lower risk of recurrent AMI, whereas there was no difference between South Asian and white patients.

Conclusion—The ethnic groups studied have striking differences in outcomes after AMI, with South Asian patients having significantly lower long-term mortality after AMI. (Circulation. 2010;122:1570-1577.)

Key Words: epidemiology ■ ethnicity ■ mortality ■ myocardial infarction ■ patients

Cardiac mortality varies substantially between countries and ethnic groups.1–4 Although part of this variation may be explained by differences in healthcare systems and regional differences, migrants to developed countries also display marked variation in cardiac mortality.5–7 In Canada, compared with patients of European descent, South Asian patients have a 45% to 50% higher proportional mortality from ischemic heart disease, whereas Chinese patients have a 35% to 40% lower proportional mortality.8 The cardiovascular risk factor profile also differs substantially between the South Asian and Chinese populations.9 South Asian patients have a disproportionately higher burden of predisposing cardiac risk factors, including insulin resistance and dyslipidemia, and notably higher incidence rates of acute myocardial infarction (AMI).10 International studies also document a substantially lower incidence of AMI in Chinese populations.1

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Methods

Study Design/Study Sample
This retrospective cohort study design used routinely collected hospital administrative data from the province of British Columbia and the Calgary Health Region Area in the province of Alberta, Canada (April 1994 to March 2003). Hospital administrative data contain details on all hospital admissions including up to 16 diagnosis fields (most responsible diagnosis for admission and comorbid conditions), admission and discharge dates, and demographics.

We identified AMI using a validated algorithm\(^{15}\) based on the most responsible diagnosis code (International Classification of Diseases, ninth revision [ICD 9], 410.x). To enhance comparability and to minimize variations in baseline cardiac stability between ethnic groups, we evaluated the first hospitalization for AMI during and to minimize variations in baseline cardiac stability between ethnic groups, we included demographic and clinical variables from the Tu et al\(^{23}\) AMI mortality prediction rule (age, sex, congestive heart failure, cardiogenic shock, arrhythmia, diabetes mellitus, cerebrovascular disease, cancer, and acute or chronic renal disease). This mortality prediction rule for ICD 9 coding algorithms for hospital administrative data was externally validated for 30-day and 1-year mortality and has reasonable accuracy (ie, areas under the receiver-operating characteristic curve of 0.78 for 30-day mortality and 0.79 for 1-year mortality).\(^{24}\) SES was assessed from area-level median household income (based on residential postal code and the 2001 Canadian Census).\(^{24}\) Ethnic minority patients also tend to reside in urban areas\(^{16}\) and therefore may have increased access to hospitals with revascularization capabilities, a factor associated with lower mortality after AMI.\(^{25}\) To adjust for smaller regional and institutional differences, we determined the distance to the nearest hospital (based on distance between the postal code centroids of the residential area and the nearest hospital) and admission to hospital with and without revascularization services.\(^{26}\) Severity of coronary disease was categorized on the basis of results of the cardiac procedures (percutaneous coronary intervention [PCI] or coronary artery bypass graft [CABG]) and the extent of coronary disease among the ethnic groups were determined on the basis of the coronary anatomy. The likelihood of undergoing revascularization procedures (percutaneous coronary intervention [PCI] or coronary artery bypass graft [CABG]) and the extent of coronary disease among the ethnic groups were determined on the basis of the coronary anatomy. The likelihood of undergoing revascularization procedures (percutaneous coronary intervention [PCI] or coronary artery bypass graft [CABG]) and the extent of coronary disease among the ethnic groups were determined on the basis of the coronary anatomy. The likelihood of undergoing revascularization procedures (percutaneous coronary intervention [PCI] or coronary artery bypass graft [CABG]) and the extent of coronary disease among the ethnic groups were determined on the basis of the coronary anatomy. The likelihood of undergoing revascularization procedures (percutaneous coronary intervention [PCI] or coronary artery bypass graft [CABG]) and the extent of coronary disease among the ethnic groups were determined on the basis of the coronary anatomy. The likelihood of undergoing revascularization procedures (percutaneous coronary intervention [PCI] or coronary artery bypass graft [CABG]) and the extent of coronary disease among the ethnic groups were determined on the basis of the coronary anatomy. The likelihood of undergoing revascularization procedures (percutaneous coronary intervention [PCI] or coronary artery bypass graft [CABG]) and the extent of coronary disease among the ethnic groups were determined on the basis of the coronary anatomy.

Categorizing Patient Ethnicity
Although self-reported ethnicity is the gold standard,\(^{17}\) this information is not documented in administrative data in Canada. We used surname analysis to categorize patients as South Asian (from Pakistan, India, or Bangladesh) or Chinese (ancestry from China, Taiwan, or Hong Kong). Because the remaining population is composed largely of white, nonvisible minority persons (93.2% in British Columbia and 94.6% in Alberta) according to the 2001 Census information, we categorized all non–South Asian and non-Chinese patients as white.\(^{18}\)

Patient surnames are recorded in the provincial population registries, and these registries contain virtually all residents from British Columbia and Alberta. The surnames were merged with the Chinese name list of Quan et al\(^{19}\) and the Nam Pehchan computer program\(^{20}\) to identify Chinese and South Asian ethnicity, respectively. Compared with self-report, the sensitivity for the Quan et al surname algorithm was 78%, specificity was 99.7%, and positive predictive value was 81%.\(^{19}\) Validation studies for the Nam Pehchan surname algorithm report a sensitivity of 90% to 94%, specificity of 99.4%, and positive predictive value of 63% to 96%.\(^{21,22}\)

Other Study Variables
To control for severity of illness on admission between ethnic groups, we included demographic and clinical variables from the Tu et al\(^{23}\) AMI mortality prediction rule (age, sex, congestive heart failure, cardiogenic shock, arrhythmia, diabetes mellitus, cerebrovascular disease, cancer, and acute or chronic renal disease). This mortality prediction rule for ICD 9 coding algorithms for hospital administrative data was externally validated for 30-day and 1-year mortality and has reasonable accuracy (ie, areas under the receiver-operating characteristic curve of 0.78 for 30-day mortality and 0.79 for 1-year mortality).\(^{23}\) SES was assessed from area-level median household income (based on residential postal code and the 2001 Canadian Census).\(^{24}\) Ethnic minority patients also tend to reside in urban areas\(^{16}\) and therefore may have increased access to hospitals with revascularization capabilities, a factor associated with lower mortality after AMI.\(^{25}\) To adjust for smaller regional and institutional differences, we determined the distance to the nearest hospital (based on distance between the postal code centroids of the residential area and the nearest hospital) and admission to hospital with and without revascularization services.\(^{26}\) Severity of coronary disease was categorized on the basis of results of the cardiac procedures (percutaneous coronary intervention [PCI] or coronary artery bypass graft [CABG]) and the extent of coronary disease among the ethnic groups were determined on the basis of the coronary anatomy. 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Table 1. Baseline Characteristics by Patient Ethnic Category

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>South Asian (n=2190), n (%)</th>
<th>Chinese (n=946), n (%)</th>
<th>White (n=38479), n (%)</th>
<th>P</th>
</tr>
</thead>
<tbody>
<tr>
<td>Female</td>
<td>619 (28.3)</td>
<td>319 (33.7)</td>
<td>12 759 (33.2)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Age, y</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&lt;50</td>
<td>282 (12.9)</td>
<td>70 (7.4)</td>
<td>3715 (9.7)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>50–64</td>
<td>780 (35.6)</td>
<td>223 (23.6)</td>
<td>10 513 (27.3)</td>
<td></td>
</tr>
<tr>
<td>65–74</td>
<td>596 (27.2)</td>
<td>282 (29.8)</td>
<td>10 308 (26.8)</td>
<td></td>
</tr>
<tr>
<td>&gt;75</td>
<td>532 (24.3)</td>
<td>371 (39.2)</td>
<td>13 943 (36.2)</td>
<td></td>
</tr>
<tr>
<td>Province</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>British Columbia</td>
<td>1957 (89.4)</td>
<td>821 (86.8)</td>
<td>32 195 (83.7)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Distance ≥50 km</td>
<td>284 (13)</td>
<td>55 (5.8)</td>
<td>12 355 (32.1)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Income quintile*</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1 (low)</td>
<td>517 (23.6)</td>
<td>255 (27)</td>
<td>7798 (20.3)</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>576 (26.3)</td>
<td>211 (22.3)</td>
<td>7311 (19)</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>417 (19.0)</td>
<td>142 (15)</td>
<td>7084 (18.4)</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>338 (15.4)</td>
<td>124 (13.1)</td>
<td>7238 (18.8)</td>
<td></td>
</tr>
<tr>
<td>5 (high)</td>
<td>290 (13.2)</td>
<td>191 (20.2)</td>
<td>7194 (18.7)</td>
<td></td>
</tr>
<tr>
<td>Diabetes mellitus</td>
<td>651 (29.7)</td>
<td>233 (24.6)</td>
<td>6765 (17.6)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Heart failure</td>
<td>441 (20.1)</td>
<td>218 (23)</td>
<td>7057 (18.3)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Hypertension</td>
<td>670 (30.6)</td>
<td>339 (35.8)</td>
<td>9969 (25.9)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Cerebrovascular disease</td>
<td>44 (2)</td>
<td>38 (4)</td>
<td>1120 (2.9)</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>Renal disease</td>
<td>105 (4.8)</td>
<td>69 (7.3)</td>
<td>1194 (3.1)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Cardiac dysrhythmia</td>
<td>280 (12.8)</td>
<td>149 (15.8)</td>
<td>5903 (15.3)</td>
<td>&lt;0.01</td>
</tr>
<tr>
<td>PAD</td>
<td>40 (1.8)</td>
<td>24 (2.5)</td>
<td>1586 (4.1)</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>

PAD indicates peripheral artery disease.

*Data are missing for 1929 patients (4.6%).

Statistical Analysis

Baseline characteristics, diagnostic cardiac catheterization, revascularization (PCI or CABG), mortality, and readmission for AMI and congestive heart failure were compared across groups using 2 df $\chi^2$ testing. There were 4.6% of patients with missing income quintile data. Of those with diagnostic cardiac catheterization, 1.5% of patients were missing data on extent of coronary disease, and 14.9% were missing ejection fraction data. Multivariate models for diagnostic coronary catheterization and separately for short-term mortality (up to 30 days after AMI) were constructed with logistic regression models with adjustment for differences in baseline characteristics: age (≥65 years), sex, SES quintile, distance to the nearest hospital (≥50 km), admission year, admission to a revascularization hospital, province, and presence of comorbid conditions based on the Tu et al prediction rule. Logistic regression models evaluating revascularization were based on the subgroup of patients who received diagnostic coronary catheterization and were additionally adjusted for extent of coronary disease and ejection fraction. Long-term mortality (30 days to a maximum of 8 years after index AMI) was assessed with Cox proportional-hazards modeling adjusted for all baseline characteristics. Separate Cox proportional-hazards models were also constructed for time to the first recurrent AMI and hospitalization for heart failure. Given the potential for survivor bias in which patients who survive are more likely to experience nonfatal complications of AMI, including recurrent AMI and heart failure, we present the Cox models for these end points among AMI survivors only. We used analysis of deviance residuals to test for possible violations of the proportional-hazards assumption for all Cox models. To further evaluate the robustness of these models, multiple sensitivity analyses were performed, including testing for interaction between ethnic category and sex, as well as province, and construction of mortality models that included extent of coronary disease and revascularization among those patients who underwent coronary catheterization. P values were 2 sided. Statistical significance was defined with a criterion of $P<0.05$. All analyses were performed with SAS statistical software version 9.1 (SAS Institute Inc, Cary, NC). This study was approved by the institutional ethics review boards.

Results

Baseline Characteristics

Of the 55 438 patients with a diagnosis of AMI, 13 823 patients were excluded, leaving a final cohort of 41 615 patients (Figure 1). Of these patients, 946 (2.3%) were categorized as Chinese, 2190 (5.3%) as South Asian, and 38 479 (92.5%) as white. As discerned from Table 1, Chinese patients presented with AMI at older ages, whereas South Asian patients were younger than white patients. Both Chinese and South Asian patients were more likely to reside in the low-income neighborhoods and to have diabetes mellitus, hypertension, congestive heart failure, and renal disease compared with white patients.

Cardiac Catheterization, Extent of Coronary Disease, and Revascularization

Chinese patients were significantly more likely to receive emergent diagnostic cardiac catheterization within 1 day of AMI compared with other ethnic groups. After adjustment for baseline factors, compared with white patients, Chinese patients were considerably more likely to undergo emergent diagnostic catheterization (odds ratio [OR], 1.47; 95% confi-
dence interval [CI], 1.17 to 1.85). South Asians were more likely to receive diagnostic cardiac catheterization within 30 days and 1 year after index AMI compared with white patients (Table 2).

In the subset of patients who received diagnostic cardiac catheterization (60.3% of cohort), South Asian patients had a greater proportion of triple-vessel disease compared with white or Chinese patients. The proportion of patients with single-vessel, 2-vessel, and left main disease was similar across all ethnic groups. White patients were also more likely to have “normal” angiograms after index AMI diagnosis.

Ejection fraction was similar across all ethnic groups. Chinese patients were more likely to receive emergent PCI within 1 day of AMI diagnosis compared with other ethnic groups. There was no significant difference in revascularization with either PCI or CAGB surgery at 1 month or 1 year between ethnic groups even after adjustment for baseline factors, including extent of coronary disease and admission to hospitals with and without revascularization capacity.

Mortality
Over a median follow-up of 3.2 years, 29.4% of all AMI patients died. Short-term (30-day) mortality was highest among Chinese, followed by white and then South Asian patients. Short-term (30-day) mortality was highest among Chinese, followed by white and then South Asian patients.

Table 2. Coronary Catheterization Rate, Revascularization Rate, and Extent of Cardiac Disease According to Ethnic Category

<table>
<thead>
<tr>
<th>Procedure</th>
<th>South Asian</th>
<th>Chinese</th>
<th>White</th>
<th>OR (95% CI), South Asian vs White</th>
<th>OR (95% CI), Chinese vs White</th>
</tr>
</thead>
<tbody>
<tr>
<td>Cardiac catheterization*</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>n</td>
<td>1128</td>
<td>526</td>
<td>19 716</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Catheterization at 1 d</td>
<td>16.5</td>
<td>22.8</td>
<td>15.3</td>
<td>&lt;0.001</td>
<td>1.13 (0.94–1.36)</td>
</tr>
<tr>
<td></td>
<td>60.3</td>
<td>55.3</td>
<td>50.4</td>
<td>&lt;0.001</td>
<td>1.32 (1.16–1.52)†</td>
</tr>
<tr>
<td>Catheterization at 1 y</td>
<td>67.9</td>
<td>60.8</td>
<td>57.0</td>
<td>&lt;0.001</td>
<td>1.44 (1.25–1.65)†</td>
</tr>
<tr>
<td>Revascularization*</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>n</td>
<td>796</td>
<td>326</td>
<td>11 765</td>
<td></td>
<td></td>
</tr>
<tr>
<td>PCI at 1 d</td>
<td>17.3</td>
<td>27.6</td>
<td>18.1</td>
<td>&lt;0.001</td>
<td>1.02 (0.82–1.27)</td>
</tr>
<tr>
<td>PCI at 30 d</td>
<td>51.9</td>
<td>53.1</td>
<td>50.9</td>
<td>0.4</td>
<td>1.06 (0.9–1.24)</td>
</tr>
<tr>
<td>PCI at 1 y</td>
<td>58.1</td>
<td>58.6</td>
<td>57.5</td>
<td>0.7</td>
<td>1.06 (0.90–1.24)</td>
</tr>
<tr>
<td>CABG at 30 d</td>
<td>12.8</td>
<td>11.7</td>
<td>11.8</td>
<td>0.9</td>
<td>1.04 (0.82–1.32)</td>
</tr>
<tr>
<td>CABG at 1 y</td>
<td>20.7</td>
<td>18.1</td>
<td>18.3</td>
<td>0.1</td>
<td>1.09 (0.90–1.33)</td>
</tr>
<tr>
<td>Severity of coronary disease, %‡</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Single vessel</td>
<td>25.7</td>
<td>26.7</td>
<td>27.7</td>
<td>0.5</td>
<td></td>
</tr>
<tr>
<td>2 Vessel</td>
<td>24.8</td>
<td>26.7</td>
<td>25.7</td>
<td>0.76</td>
<td></td>
</tr>
<tr>
<td>3 Vessel</td>
<td>38.9</td>
<td>34.0</td>
<td>33.0</td>
<td>0.002</td>
<td></td>
</tr>
<tr>
<td>Left main</td>
<td>6.2</td>
<td>8.6</td>
<td>7.1</td>
<td>0.3</td>
<td></td>
</tr>
<tr>
<td>Normal</td>
<td>4.4</td>
<td>4</td>
<td>6.5</td>
<td>0.02</td>
<td></td>
</tr>
<tr>
<td>Ejection fraction, %§</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>&gt;50</td>
<td>63.9</td>
<td>63.7</td>
<td>63.0</td>
<td>0.14</td>
<td></td>
</tr>
<tr>
<td>30–50</td>
<td>31.0</td>
<td>31.3</td>
<td>31.2</td>
<td>0.68</td>
<td></td>
</tr>
<tr>
<td>&lt;30</td>
<td>5.1</td>
<td>5</td>
<td>5.8</td>
<td>0.69</td>
<td></td>
</tr>
</tbody>
</table>

*ORs were adjusted for age, sex, SES, geographic distance, hospital with revascularization capacity, province, year of AMI, and comorbid conditions. Adjusted ORs for PCI and CAGB are additionally adjusted for severity of coronary disease.
†P<.01.
‡Data on severity of coronary disease were missing for 194 (1.5%) of patients with coronary catheterization.
§Data for ejection fraction were missing for 14.9% of patients with coronary catheterization.

Table 3. Death, Recurrent AMI, and Hospitalization for Heart Failure According to Ethnic Category*

<table>
<thead>
<tr>
<th>Outcome</th>
<th>South Asian</th>
<th>Chinese</th>
<th>White</th>
<th>OR (95% CI), South Asian vs White</th>
<th>OR (95% CI), Chinese vs White</th>
</tr>
</thead>
<tbody>
<tr>
<td>30-d Mortality, n (%)</td>
<td>170 (7.8)</td>
<td>116 (12.3)</td>
<td>3321 (8.6)</td>
<td>0.88 (0.75–1.03) [0.1]</td>
<td>1.23 (1.02–1.48) [0.03]</td>
</tr>
<tr>
<td>Long-term mortality rate, No. events/1000 patient-y</td>
<td>39</td>
<td>65</td>
<td>61</td>
<td>0.65 (0.57–0.72) [&lt;0.001]</td>
<td>0.89 (0.77–1.03) [0.08]</td>
</tr>
<tr>
<td>Recurrent AMI, No. events/1000 patient-y†</td>
<td>95</td>
<td>67</td>
<td>88</td>
<td>1.07 (0.95–1.21) [0.2]</td>
<td>0.80 (0.65–0.98) [0.03]</td>
</tr>
<tr>
<td>Heart failure, No. events/1000 patient-y†</td>
<td>33</td>
<td>35</td>
<td>34</td>
<td>1.09 (0.89–1.34) [0.4]</td>
<td>0.89 (0.64–1.24) [0.49]</td>
</tr>
</tbody>
</table>

*OR (95% CI) [P] for 30-day mortality and HR (95% CI) [P] for long-term mortality (beyond 30 days), recurrent AMI, and heart failure are adjusted for age, sex, SES, geographic distance, hospital with revascularization capacity, province, year of AMI, and comorbid conditions.
†Among survivors only (South Asian, n=2020; Chinese, n=637; white, n=27 046).
patients (12.3% versus 8.6% versus 7.8%, respectively; Table 3). After adjustment for baseline factors, Chinese descent was associated with an increased odds of death compared with white ethnicity (OR, 1.23; 95% CI, 1.02 to 1.48), whereas there was no significant difference in mortality between South Asian and white patients. The long-term, unadjusted mortality was highest among Chinese followed by white patients, with the lowest rate among South Asian groups (Figure 2). After adjustment for demographic and clinical characteristics, there was no significant difference in mortality between Chinese and white patients. However, South Asian ethnicity was associated with 35% lower relative risk of long-term mortality compared with white ethnicity (HR, 0.65; 95%CI, 0.57 to 0.72). In the sensitivity analyses among patients who received cardiac catheterization, even when differences in revascularization and extent of coronary disease were added to the model, the reduced mortality in South Asian patients persisted (HR, 0.85; 95% CI, 0.67 to 0.99; P=0.04). Furthermore, there was no significant interaction for either sex or province on the relationship between ethnicity and mortality.

**Readmission for AMI and Heart Failure**

In total, 22% of patients were readmitted to hospital with AMI during the follow-up period. South Asian patients were more likely to experience recurrent AMI compared with other ethnic groups, whereas Chinese patients were least likely to have recurrent AMI. When the analysis was restricted to survivors and adjusted for baseline covariates, there was no difference in risk of recurrent AMI in South Asian and white patients (Table 3). However, Chinese patients still had a significantly lower risk of recurrent AMI compared with the other ethnic groups (HR, 0.80; 95% CI, 0.65 to 0.98; P=0.03). Only 10% of patients were readmitted to hospital with a diagnosis of heart failure during the follow-up period. There were no significant differences in hospitalization for heart failure between ethnic groups even after the analysis was restricted to survivors. Among only those with recurrent AMI, long-term mortality was lower among South Asian patients relative to white patients (HR, 0.81; 95% CI, 0.67 to 0.99; P=0.04). There was no difference in mortality between Chinese and white patients with recurrent AMI.

**Discussion**

In an equal-access healthcare system, there were striking differences in outcomes in South Asian, Chinese, and white patients after AMI. Although many speculate that South Asian patients would have a higher mortality after AMI given their overall increased rates of death caused by heart disease, in this cohort, South Asian patients had substantially lower long-term mortality after AMI relative to their white counterparts after 2.7 years of follow-up. Yet, other studies revealed no significant difference in long-term mortality between South Asian and white patients. These studies included small numbers of South Asian patients, which may have limited their ability to detect differences. The results of the present analysis are also consistent with findings in peritoneal dialysis patients, another high-cardiovascular-risk population; Hemmelgarn identified a 37% lower long-term mortality among South Asian patients rela-
tive to white patients and in patients hospitalized for heart failure. Moreover, the lower long-term mortality observed among South Asians in our study is not likely due to artifact given the control for numerous confounding factors, including SES, and the sensitivity analyses controlling for revascularization and extent of coronary disease among those with diagnostic coronary catheterization.

Whereas short-term mortality rates for South Asian and white patients were not significantly different, short-term mortality among Chinese-descent patients was significantly higher. South Asian patients also had a higher crude rate of recurrent AMI, which we speculate is due largely to survivor bias. When we limited the analysis to survivors only, there was no difference in recurrent AMI between the South Asian and white groups. Conversely, Chinese patients had a lower risk of recurrent AMI relative to the other groups. Iribaren et al reported no difference in recurrent AMI among Asian patients relative to white patients. However, in the Iribaren et al analysis, no adjustment was made for potential survivor bias.

It is important to speculate on the reasons underlying these differences in outcomes. In our cohort, South Asian patients had a lower SES and a higher prevalence of diabetes mellitus, hypertension, and renal disease, risk factors that accelerate atherosclerotic disease. Other research revealed that South Asian patients are more likely to be sedentary and to have higher ratios of apolipoprotein B to apolipoprotein A-I, greater levels of abdominal visceral fat, and prothrombotic factors. This higher atherosclerotic risk factor burden is consistent with numerous global studies and may explain the finding that South Asian patients were more likely to present at younger ages and with more extensive coronary disease compared with other groups. After adjustment for these factors, short-term mortality was similar between South Asian and white AMI patients, suggesting a similar pathology of AMI. Several studies have demonstrated similar infarct size and type of AMI between these 2 groups.

In our study, South Asian AMI patients had significantly lower long-term mortality. Early revascularization is associated with reduced long-term cardiovascular outcomes after AMI. South Asian patients were more likely to receive diagnostic cardiac catheterization at 30 days and up to 1 year after AMI. Revascularization was similar across all ethnic groups and did not significantly alter our findings when added to the mortality models among patients with cardiac catheterization. Others have also found similar or greater use of cardiac catheterization and revascularization among South Asian patients compared with white patients. Nevertheless, the higher rate of cardiac catheterization may signal that cardiologists are aware of the higher prevalence of coronary disease in this group and may provide more aggressive care.

In a study of elderly AMI survivors in British Columbia, South Asian and Chinese patients were as likely or more likely to be prescribed secondary prevention therapy as their white counterparts. Other differences in long-term cardiac disease management such as changes in health behaviors after AMI, secondary risk factor reduction, greater adherence to evidence-based therapies, and differences in family supports may contribute to the lower mortality observed among South Asian patients. The lower total mortality found among South Asian AMI patients may also partly reflect their lower risk of noncardiac causes of death, including cancer.

Several studies indicate that South Asian patients have a higher age-standardized cardiac mortality compared with the general population. Cardiac mortality for a population is dependent on the prevalence of cardiac disease and mortality from cardiac disease. The higher age-standardized cardiac mortality in the South Asian population is more likely driven by their higher prevalence of coronary disease and AMI rather than a higher AMI case fatality. Furthermore, some of the studies identifying a higher cardiac mortality originate from the United Kingdom, which has a significant Pakistani and Bangladeshi South Asian population. In North America, the South Asian population is composed largely of people from India, who generally have lower rates of coronary disease and cardiac death compared with Pakistani and Bangladeshi patients.

In this analysis, patients of Chinese descent had a significantly higher short-term mortality compared with their white counterparts (12.2% versus 8.6%). To the best of our knowledge, this is the first analysis of short-term mortality among Chinese patients residing in North America after AMI. In China, reports of short-term mortality after AMI range from 8.1% to 18% in hospital-based studies. Our findings are consistent with an international study that identified a higher age-adjusted 28-day case fatality rate among AMI patients from China compared with AMI patients in Canada. Nevertheless, the higher early mortality among Chinese patients cannot be fully explained by increased cardiovascular risk factors and advanced age at the time of presentation. Chinese patients may have delayed presentation to emergency departments from the onset of AMI symptoms. Delays in seeking or accessing medical attention can lead to missed opportunities for thrombolytic therapy and can result in higher mortality. Chinese patients were more likely to undergo cardiac catheterization and PCI within 24 hours of admission, and this higher early mortality may reflect a greater exposure to complications within this ethnic group from early cardiac catheterization or PCI. The higher early mortality and greater use of cardiac catheterization or emergent PCI may also connote that Chinese patients may present with higher-risk infarcts relative to other patients. Although a small retrospective chart review found no difference in ST-elevation versus non-ST-elevation myocardial infarction between Chinese and white AMI patients, the severity of infarct between ethnic groups needs to be explored in a larger, prospective study.

There are limitations to our study given its observational nature. First, we used surname algorithms alone to categorize ethnicity rather than self-report, the gold standard, or in combination with other ethnic identifiers, including country of birth. Although the specificities associated with these algorithms were high, there is potential for some misclassification of ethnic categories. Misclassification would tend to underestimate differences between ethnic categories. Second, by using hospital data, we included only those who were diagnosed and admitted with AMI and may have missed patients who were misdiagnosed or died before hospital...
admission. Third, observational studies are susceptible to bias from residual confounding. There may be residual confounding by age. We were not able to control for differences in tobacco use, fibrinogen levels, abdominal obesity, and lipoprotein(a) level. However, adjusting for these factors would be unlikely to significantly alter the findings of lower mortality observed among South Asians. We also did not have information on year of immigration; differences in mortality may depend on degree of acculturation. However, because the majority of immigration to Canada by these ethnic groups has occurred in the past 25 years, this AMI population would be comprised largely of first-generation immigrants. Finally, our results reflect broad ethnic categories, recognizing that there is some heterogeneity among smaller subgroups within each ethnic category.50

Conclusions
The ethnic groups studied have significantly different risk factor profiles and outcomes after AMI. The higher short-term mortality observed among Chinese patients requires additional examination of severity of infarct and acute care processes in this ethnic population. Although international studies have consistently shown that South Asian patients have a higher cardiovascular mortality compared with other groups, we found no difference in short-term mortality and significantly lower long-term mortality after AMI among South Asians compared with white patients. These findings highlight the importance of comparing ethnic groups within the same equal-access healthcare system. These findings also suggest that the higher global cardiovascular mortality observed among South Asian patients may reflect a higher prevalence of coronary disease, higher rates of out-of-hospital AMI, or regional differences in cardiac care rather than inherently poor outcomes after hospitalization for AMI among South Asians.

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