Socioeconomic Status, Hospital Volume, and Stroke Fatality in Canada

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Background and Purpose—Low socioeconomic status is associated with stroke fatality; however, the mechanism behind this association is uncertain. We sought to determine whether residence in a low-income neighborhood was associated with admission to low-volume facilities and whether this contributed to differences in fatality after stroke.

Methods—All hospitalizations for ischemic stroke from April 2003 to March 2004 were identified from a national administrative database containing patient-level sociodemographic, diagnostic, procedural, and administrative information. Patients were assigned to income quintiles based on the median income of their primary neighborhood of residence and then categorized as low income (quintiles 1 and 2) or high income (quintiles 3 through 5). Hospitals were categorized as low or high volume on the basis of their annual number of stroke admissions. Multivariable analyses were performed to compare stroke fatality at 7 days and at discharge in patients in low- and high-income groups seen at low- and high-volume facilities.

Results—Overall, 25,228 patients with ischemic stroke were included in the analysis. Those from high-income areas were more likely to be admitted to high-volume hospitals. Fatality at 7 days was 8.4%, 8.2%, 7.7%, 7.1%, and 6.6% ($\chi^2=0.002$) for income quintiles 1 (lowest) to 5 (highest), respectively. Low-income patients admitted to low-volume hospitals had the highest risk-adjusted stroke fatality.

Conclusions—Patients from low-income areas presenting with acute stroke are more likely to be seen in low-volume facilities. This subgroup of patients had a higher risk-adjusted fatality than those from high-income areas seen at high-volume facilities. Understanding the pathways through which socioeconomic status affects health care may lead to strategies for quality improvement. (Stroke. 2008;39:3360-3366.)

Key Words: stroke ■ socioeconomic status ■ mortality ■ hospital volume ■ outcomes research ■ health services research ■ health policy

Socioeconomic disparities in health care have been documented for several medical conditions in many countries, even in those with universal health insurance.1–3 Lower socioeconomic status has been associated with a higher incidence of stroke, a greater prevalence of chronic diseases, and reduced access to care for a variety of conditions.4–6 A few studies have shown a higher stroke case fatality with lower socioeconomic status.2,7,8 However, the underlying reasons for this association are not well understood, and it is not known whether this is explained by individual patient factors (comorbid illness, response to therapy) or by health system factors (available resources, access to care).

For many surgical conditions, increasing hospital patient volumes are associated with reduced morbidity and mortality.9–11 Recently, similar findings have been reported for acute ischemic stroke, with superior outcomes seen in patients with stroke treated in higher-volume facilities.12 To date, however, there has been little exploration of the relation between socioeconomic status and patient volume when explaining differences in outcomes and fatality between hospitals. Furthermore, whether stroke case fatality is differ-
ent in academic versus nonacademic hospitals after account-
ing for volume is unclear. Along the same lines, it is not
known whether rural residence modifies any effect of socio-
economic status on stroke case fatality.

Using a population-based national database, we sought to
determine whether patients from low-income neighborhoods
were more likely than those from high-income neighborhoods
to receive care at low-volume institutions. In addition, we
examined the association between neighborhood income and
hospital volume on stroke fatality. In stratified analyses, we
examined whether mortality was different between academic
hospitals and nonacademic hospitals of similar volume and
whether rural residence affected death in different socioeco-
nomic groups.

Methods

Data Sources and Patient Sample
The Hospital Morbidity and Mortality Database (HMDB) is a
national database managed by the Canadian Institute for Health
Information that contains patient-level sociodemographic, diagno-
sic, procedural, and administrative information on all hospital dis-
charges in Canada. Canada’s health care system includes
government-funded universal public provision of physician and
hospital services and the absence of copayments and other patient
charges. Reporting to the HMDB is mandatory in Canada. Diagnoses
are recorded according to the International Classification of Dis-
eas, either the ninth (ICD 9-CM) or 10th (ICD 10) revision.
Reabstraction studies have shown 92% agreement between the
HMDB and the chart for stroke diagnoses and agreement rates of
97% for date of admission, 99% for death, and 96% to 100% for
sociodemographic data elements.13,14 There are 680 acute-care facil-
ities across the country reporting to the HMDB, which covers 99.8%
of all acute-care hospitals and includes academic and community
hospitals and rural and urban facilities from all provinces and
territories.

For the present study, we identified all patients with ischemic
stroke admitted to acute-care hospitals in Canada between April 1,
2003 and March 31, 2004 with a principal diagnosis of ischemic
stroke (ICD-9-CM codes 433.0, 433.1, 433.2, 433.3, 433.8, 433.9,
434.0, 434.1, and 434.9 and ICD-10 codes I63 and I64).15 Because of
major prognostic differences, patients with transient ischemic attack,
intracerebral hemorrhage, and subarachnoid hemorrhage were ex-
cluded. Records containing unknown socioeconomic status were also
excluded (n = 1448, 5.3%).

Comorbid Illnesses and Complications
We used the Charlson-Deyo comorbidity index to quantify patients’
comorbid conditions.16 This index is a weighted summary score
based on the presence or absence of 17 medical conditions. A score
of zero implies no comorbid illness, and higher scores indicate a
greater burden of comorbidity. For the purpose of this study,
Charlson-Deyo index scores were categorized into none, 1, 2, or 3 or
more comorbid conditions.17 Serious medical complications during
hospitalization (intracerebral hemorrhage, pneumonia, decubitus ul-
cer, and urinary tract infection) were also identified. In the HMDB,
no data are available on stroke severity (such as the National
Institutes of Health Stroke Scale) or functional status (such as the
Barthel Index or modified Rankin scale). Admission to an intensive
care unit (ICU) was used as a surrogate for severe stroke.

Socioeconomic Status
Socioeconomic status was estimated through an approach developed
by Statistics Canada that assigns neighborhoods to quintiles based on
income data reported on the 2001 census. Within each large
neighborhood (census area), smaller areas (dissemination areas,
which contain, on average, 400 persons) were ranked by median
household income (adjusted for household size) and divided into
approximate quintiles, thus creating community-specific income
quintiles, with 1 representing the lowest and 5 representing the
highest income quintile. Each quintile contained 274 or 275 dissemi-
ation areas.18 For our analyses, neighborhoods were dichotomized
a priori into low-income (quintiles 1 and 2) and high-income
(quintiles 3 through 5). The estimation of socioeconomic status
from neighborhood income has been previously reported by different
authors.19,20

Hospital and Physician Characteristics
Academic status was defined as an institution affiliated with a
university that provides health/clinical education programs and
physical facilities necessary for research and education according to
the Association of Canadian Academic Healthcare Organizations.21
Rural location was defined according to the hospital postal code. We
defined hospital volume as the annual number of stroke patients
admitted to an individual hospital in the 2003 to 2004 fiscal year.
Facilities were divided into quartiles based on annual patient
volumes (quartile 1, 1 to 62 cases per year; quartile 2, 63 to 141;
quartile 3, 142 to 197; and quartile 4, >198). We defined high-
volume hospitals as being in the top 2 quartiles and low-volume
hospitals as being in the bottom 2 quartiles. The HMDB defines a
“most responsible physician” as the physician caring for a patient for
the majority of days during an inpatient stay. In our analyses, the
most responsible physician was classified as either a general practi-
tioner or a specialist (including neurologists, general internists, and
other specialists). An interfacility transfer was defined as transfer
between 1 acute-care facility and another. The main outcome
measure was stroke fatality. Stroke 7-day inhospital fatality was
defined as death at or before 7 days after admission. Stroke fatality
at discharge was defined as death by the time of discharge from
hospital.

Statistical Analysis
To examine the effect of the combination of neighborhood income
and hospital volume on stroke fatality, we created 4 groups: high
income/high hospital volume; high income/low hospital volume;
low income/high hospital volume; and low income/low hospital volume.

To determine differences in baseline demographics among income
quintiles and low/high income-volume groups, we conducted a
1-way ANOVA for continuous variables and χ² tests for categorical
variables. The primary outcome was risk-adjusted stroke fatality at 7
days; risk-adjusted stroke fatality at discharge was a secondary
outcome. We used the ADJUST command in STATA to calculate
case-fatality rates with adjustment for age, sex, comorbid conditions,
ICU admission, and hospital type.

We used generalized estimating equations22 to evaluate the asso-
ciation between income and hospital volume and 7-day inhospital
stroke fatality with adjustment for the following variables: patient
age, Charlson-Deyo comorbidity index score, facility type by loca-
tion (rural/urban), facility teaching status (academic/nonacademic),
and most responsible provider (general practitioner/specialist).
Generalized estimating equations account for clustering of patients
within institutions and provide more accurate CIs than would be
provided by simple logistic regression. Compound symmetry (ex-
changeable) was selected as the correlation structure.21 The associ-
ation between hospital volume and stroke fatality was expressed as the
odds ratio and 95% CI. In developing the models, a statistical
significance level of P < 0.25 in the univariate analysis was used as a
screening cutoff for inclusion of factors in the multivariable
analysis. Only variables that achieved a statistical significance of
P < 0.05 were left in the final multivariable model. We used
STRATA and ADJUST commands in STATA to calculate risk-
adjusted fatality.23,24 Because interfacility transfers can “contami-
nate” the classification of high- versus low-volume institutions, we
performed a sensitivity analysis by excluding individuals transferred
from one to another acute-care facility.

Stratified analyses compared stroke fatality in the following groups:
(1) large-volume teaching versus large-volume nonteaching institu-
tions; (2) high-volume teaching versus low-volume teaching institu-

Downloaded from http://stroke.ahajournals.org/ by guest on June 26, 2017
Our study sample included 26,676 patients with ischemic stroke admitted to 606 hospitals across Canada from April 1, 2003 to March 31, 2004. The mean age of patients was 74 years; 5440 (20%) were younger than 65 years, and 5283 (20.2%) were older than 85 years. Socioeconomic status could not be determined in 1448 (5.3%) patients. Of the remaining 25,228 patients, 5752 (22.8%) were in the lowest income quintile, whereas 4019 (16%) were in the highest income quintile. Overall, 44.5% of stroke patients were admitted to low-volume hospitals and nonteaching hospitals, and were more likely to have a general practitioner rather than a specialist as their physician during hospitalization (Table 3). They also had a higher rate of medical complications despite similar Charlson-Deyo index scores.

Inhospital 7-day stroke fatality was 7.6%. Stroke fatality was inversely associated with neighborhood income (8.4%, 8.2%, 7.7%, 7.1, and 6.6% for income quintiles 1 [lowest] to 5 [highest], respectively; \( \chi^2 \) test for trend, \( P = 0.001 \)) and with hospital volume (9.4%, 7.3%, 7.7%, and 5.9% for hospital stroke volume quartiles 1, 2, 3, and 4, respectively; \( \chi^2 \) test for trend, \( P < 0.001 \)).

Risk-adjusted 7-day inhospital stroke fatality was higher in the low-income/low-volume group compared with the high-income/high-volume group (7.8% vs 6.2%, \( P < 0.001 \); the Figure). Using generalized estimating equations, after adjustment for age, sex, Charlson-Deyo score, facility location and teaching status, and physician characteristics, we found that patients in the low-income/low-volume group had higher 7-day inhospital stroke fatality than did those in the high-income/high-volume group (adjusted odds ratio = 1.26; 95% CI, 1.07 to 1.49; Table 4). Similar results were obtained when interfacility transfers were excluded from the analysis.

In the stratified analyses, there were no differences in 7-day inhospital case fatality between high-volume teaching and high-volume nonteaching hospitals or between patients from low-income areas seen at rural versus urban institutions (data not shown). However, when the analysis was limited to teaching facilities, stroke fatality at discharge was lower at high-volume than at low-volume facilities (12% vs 23%,...
Hospital location

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>1 (Lowest), n=5752</th>
<th>2, n=5473</th>
<th>3, n=5245</th>
<th>4, n=4659</th>
<th>5 (Highest), n=4099</th>
<th>P Value†</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hospital stroke volume, quartiles (Q)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Q1 (lowest)</td>
<td>1746 (30.4)</td>
<td>1631 (29.8)</td>
<td>1387 (26.4)</td>
<td>963 (20.7)</td>
<td>425 (10.3)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Q2</td>
<td>1542 (26.8)</td>
<td>1497 (27.4)</td>
<td>1301 (24.8)</td>
<td>1139 (24.4)</td>
<td>997 (24.3)</td>
<td></td>
</tr>
<tr>
<td>Q3</td>
<td>1360 (23.6)</td>
<td>1258 (23.0)</td>
<td>1342 (25.6)</td>
<td>1196 (25.7)</td>
<td>1207 (29.5)</td>
<td></td>
</tr>
<tr>
<td>Q4 (highest)</td>
<td>1104 (19.2)</td>
<td>1087 (19.8)</td>
<td>1215 (23.2)</td>
<td>1361 (29.2)</td>
<td>1470 (35.9)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Teaching hospital</td>
<td>963 (16.7)</td>
<td>896 (16.4)</td>
<td>956 (18.2)</td>
<td>963 (20.7)</td>
<td>1104 (26.9)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Hospital location=urban</td>
<td>3928 (68.3)</td>
<td>3807 (69.6)</td>
<td>4012 (76.5)</td>
<td>3942 (84.6)</td>
<td>3896 (95.0)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Most responsible physician</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.005</td>
</tr>
<tr>
<td>General practitioner</td>
<td>1103 (19.2)</td>
<td>951 (17.4)</td>
<td>848 (16.2)</td>
<td>719 (15.4)</td>
<td>643 (15.7)</td>
<td></td>
</tr>
<tr>
<td>Specialist</td>
<td>4649 (80.8)</td>
<td>4522 (82.6)</td>
<td>4397 (83.8)</td>
<td>3940 (84.6)</td>
<td>3456 (84.3)</td>
<td></td>
</tr>
<tr>
<td>Medical complications overall</td>
<td>489 (8.5)</td>
<td>480 (8.7)</td>
<td>384 (7.3)</td>
<td>313 (7.1)</td>
<td>301 (7.3)</td>
<td>0.12</td>
</tr>
<tr>
<td>Pneumonia</td>
<td>211 (3.7)</td>
<td>208 (3.8)</td>
<td>180 (3.4)</td>
<td>133 (2.9)</td>
<td>139 (3.4)</td>
<td>0.12</td>
</tr>
<tr>
<td>Urinary tract infection</td>
<td>214 (3.7)</td>
<td>183 (3.3)</td>
<td>153 (2.9)</td>
<td>135 (3.3)</td>
<td>137 (3.4)</td>
<td>0.16</td>
</tr>
<tr>
<td>Intracerebral hemorrhage</td>
<td>15 (0.26)</td>
<td>11 (0.20)</td>
<td>9 (0.17)</td>
<td>11 (0.24)</td>
<td>5 (0.12)</td>
<td>0.11</td>
</tr>
<tr>
<td>Pulmonary embolism</td>
<td>35 (0.61)</td>
<td>34 (0.62)</td>
<td>33 (0.63)</td>
<td>24 (0.52)</td>
<td>12 (0.29)</td>
<td>0.12</td>
</tr>
<tr>
<td>Decubitus ulcer</td>
<td>14 (0.24)</td>
<td>11 (0.20)</td>
<td>9 (0.17)</td>
<td>10 (0.21)</td>
<td>8 (0.20)</td>
<td>0.96</td>
</tr>
<tr>
<td>ICU admission</td>
<td>707 (12.3)</td>
<td>714 (13.1)</td>
<td>630 (12.0)</td>
<td>580 (12.5)</td>
<td>824 (12.8)</td>
<td>0.53</td>
</tr>
<tr>
<td>Length of stay in days, median (interquartile range)</td>
<td>8 (4–19)</td>
<td>8 (4–18)</td>
<td>8 (4–17)</td>
<td>8 (4–18)</td>
<td>8 (4–18)</td>
<td>0.19</td>
</tr>
<tr>
<td>7-Day stroke fatality</td>
<td>481 (8.4)</td>
<td>448 (8.2)</td>
<td>383 (7.3)</td>
<td>332 (7.1)</td>
<td>267 (6.5)</td>
<td>0.002</td>
</tr>
<tr>
<td>Stroke fatality at discharge</td>
<td>934 (16.2)</td>
<td>924 (16.9)</td>
<td>782 (14.9)</td>
<td>671 (14.4)</td>
<td>586 (14.3)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Age-adjusted fatality at discharge (95% CI)</td>
<td>14.4 (13.5–15.3)</td>
<td>14.7 (13.8–15.6)</td>
<td>13.2 (12.3–14.2)</td>
<td>12.8 (11.9–13.8)</td>
<td>12.2 (11.3–13.2)</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>

*Socioeconomic status was estimated through an approach developed by Statistics Canada that assigns neighborhoods to equally sized quintiles based on income data reported on the 2001 census. A higher quintile value of a residential area is associated with higher median income of residents in that area. The quintiles in our dataset are not equal in size because median neighborhood income assigned by Statistics Canada at the time of census was missing from the HMDB for 1448 subjects.

†The P values refer to comparisons among groups by χ² tests for trend for categorical variables and by ANOVA for continuous values.

Numbers in parentheses represent percentages, unless otherwise specified.

P<0.001. When the analysis was limited to those seen at rural institutions, stroke case fatality at discharge was lower in those from high-income compared with low-income areas (14% vs 17%, P=0.003).

Discussion

In this large, country-wide study, we found that patients from low-income areas admitted to low-volume hospitals had more medical complications and were more likely to be admitted to rural, nonteaching facilities and to receive nonspecialist care than high-income patients admitted to high-volume hospitals. Death after stroke was higher in low-income than in high-income patients and in low-volume than in high-volume institutions. Case fatality increased by >25% for the compound association of low-income area/low-volume hospitals when compared with high-income area/high-volume hospitals after adjusting for covariates. Our study provides some insight on the route followed by individuals residing in low-income areas and the potential underlying mechanisms. Our findings showed an association between low income, low hospital volume, and poorer stroke outcome, suggesting that Canadians of different socioeconomic groups may have theoretical equal access to health care but practical access to unequal facilities. In other words, in Canada’s universal health care system, all patients have access to hospitals, but those residing in higher income neighborhoods may have greater access to high-volume, urban and teaching hospitals, which are facilities associated with better stroke outcomes.

The finding of an inverse association between hospital volume and fatality is consistent with previous studies of stroke as well as other medical conditions. Increased resources, access to specialists or organized care, and lower complication rates in high-volume hospitals may explain this phenomenon. Similarly, the finding of an inverse association between income and stroke fatality is consistent with previous studies. However, our study suggests that it is the combination of low socioeconomic status and low-volume hospitalization that is most detrimental. It is unclear whether the admission of low-income patients to low-volume hospitals occurs from self-selection or whether it is explained by the geographic catchment area of the closest facility.

Major advances have been made during the past several decades in stroke prevention, acute treatment, and rehabilitation, but less attention has been given to the influence of variations in the delivery of services and the impact on stroke outcomes. In addition, there have been few changes made to health care systems to improve access to care for those of low socioeconomic status despite evidence of poorer out-
comes. Understanding the mechanisms of how socioeconomic status influences health outcomes in different individuals and medical conditions is complex and not unique to cerebrovascular disease. In the Atherosclerosis Risk in Communities Study study, characteristics reflecting poorer neighborhoods were associated with an increased prevalence of vascular risk factors and coronary heart disease. Strategies to modify individual (behavior-dependent) risk factors, such as arterial hypertension, diabetes, and smoking cessation, have been implemented in different countries to target specific low-income groups. However, those strategies that focused on individuals disregard the role and the impact of health system variables, such as hospital stroke volume, facility type (community versus academic, teaching versus nonteaching), and location (rural versus urban). The understanding of health system determinants of stroke outcome may allow governments to adapt a public health intervention to local/regional needs.

Our study has limitations that deserve comment. First, we used administrative health data, which lack information on stroke severity and other clinical factors needed for a detailed case-mix adjustment. Individual comorbid conditions that might explain some of the differences in death by income quintile may have been miscoded or undercoded. In addition, we have little information on differences in the processes of stroke care delivery between low- and high-volume institutions. However, the advantages of the administrative database are its near-population-based case ascertainment (every stroke hospitalization in Canada is included), a large sample size, and valid information on hospital volumes and death after stroke. Second, although we have a shown clear association between socioeconomic status, hospital volume, and stroke fatality, this observational study does not identify the pathway through which patients from low-income areas are more likely to be admitted to hospitals with lower stroke volume. Neighborhood income tends to be lower in rural communities. Understanding the mechanisms of how socioeconomic status influences health outcomes in different individuals and medical conditions is complex and not unique to cerebrovascular disease. In the Atherosclerosis Risk in Communities Study study, characteristics reflecting poorer neighborhoods were associated with an increased prevalence of vascular risk factors and coronary heart disease.

### Table 3. Univariable Analysis by Income-Hospital Volume Group

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Low Income/Low Volume, n=6416</th>
<th>Low Income/High Volume, n=4809</th>
<th>High Income/Low Volume, n=6212</th>
<th>High Income/High Volume, n=7791</th>
<th>P Value*</th>
</tr>
</thead>
<tbody>
<tr>
<td>Age, y, mean±SD</td>
<td>75.4±12</td>
<td>74.5±13</td>
<td>72.6±13</td>
<td>73.3±13</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Age, categories</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Age &lt;65</td>
<td>1102 (17.2)</td>
<td>1135 (23.6)</td>
<td>1169 (18.8)</td>
<td>1730 (22.2)</td>
<td></td>
</tr>
<tr>
<td>Age 65–74</td>
<td>1494 (23.3)</td>
<td>1204 (25.0)</td>
<td>1410 (22.7)</td>
<td>1838 (23.6)</td>
<td></td>
</tr>
<tr>
<td>Age 75–84</td>
<td>2358 (36.7)</td>
<td>1661 (34.6)</td>
<td>2362 (38.0)</td>
<td>2811 (36.1)</td>
<td></td>
</tr>
<tr>
<td>Age ≥85</td>
<td>1492 (22.8)</td>
<td>809 (16.8)</td>
<td>1271 (20.5)</td>
<td>1412 (18.1)</td>
<td></td>
</tr>
<tr>
<td>Sex</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.002</td>
</tr>
<tr>
<td>Female</td>
<td>3233 (50.4)</td>
<td>2394 (49.8)</td>
<td>2996 (48.2)</td>
<td>3701 (47.5)</td>
<td></td>
</tr>
<tr>
<td>Charlson-Deyo comorbidity index score</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>0.22</td>
</tr>
<tr>
<td>0–1</td>
<td>5240 (81.7)</td>
<td>3947 (81.1)</td>
<td>5099 (81.1)</td>
<td>6464 (83.0)</td>
<td></td>
</tr>
<tr>
<td>≥2</td>
<td>1176 (18.3)</td>
<td>862 (17.9)</td>
<td>1113 (17.9)</td>
<td>1327 (17.0)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Facility type</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Teaching</td>
<td>335 (5.2)</td>
<td>1526 (31.7)</td>
<td>538 (8.7)</td>
<td>2485 (31.9)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Nonteaching</td>
<td>6081 (94.8)</td>
<td>3283 (68.3)</td>
<td>5674 (91.3)</td>
<td>5306 (68.1)</td>
<td></td>
</tr>
<tr>
<td>Hospital location</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Rural</td>
<td>2744 (42.8)</td>
<td>746 (15.5)</td>
<td>1622 (26.1)</td>
<td>531 (6.8)</td>
<td></td>
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<tr>
<td>Urban</td>
<td>3672 (57.2)</td>
<td>4063 (84.5)</td>
<td>4590 (73.9)</td>
<td>7260 (93.2)</td>
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</tr>
<tr>
<td>Most responsible physician</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>General practitioner</td>
<td>1279 (19.9)</td>
<td>775 (16.1)</td>
<td>1022 (16.5)</td>
<td>1188 (15.2)</td>
<td></td>
</tr>
<tr>
<td>Specialist</td>
<td>5137 (80.1)</td>
<td>4034 (83.9)</td>
<td>5190 (83.5)</td>
<td>6603 (84.8)</td>
<td></td>
</tr>
<tr>
<td>Medical complications overall</td>
<td>513 (8.0)</td>
<td>306 (6.4)</td>
<td>409 (6.6)</td>
<td>472 (6.0)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Pneumonia</td>
<td>262 (4.1)</td>
<td>157 (3.3)</td>
<td>198 (3.2)</td>
<td>254 (3.2)</td>
<td>0.016</td>
</tr>
<tr>
<td>Urinary tract infection</td>
<td>246 (3.8)</td>
<td>151 (3.1)</td>
<td>207 (3.3)</td>
<td>218 (2.8)</td>
<td>0.006</td>
</tr>
<tr>
<td>Intracerebral hemorrhage</td>
<td>16 (0.25)</td>
<td>10 (0.21)</td>
<td>15 (0.24)</td>
<td>10 (0.13)</td>
<td>0.35</td>
</tr>
<tr>
<td>Pulmonary embolism</td>
<td>43 (0.67)</td>
<td>26 (0.54)</td>
<td>38 (0.61)</td>
<td>31 (0.40)</td>
<td>0.14</td>
</tr>
<tr>
<td>Decubitus ulcer</td>
<td>16 (0.25)</td>
<td>9 (0.19)</td>
<td>17 (0.27)</td>
<td>10 (0.13)</td>
<td>0.23</td>
</tr>
<tr>
<td>ICU admission</td>
<td>782 (12.2)</td>
<td>639 (13.3)</td>
<td>718 (11.6)</td>
<td>1016 (13.0)</td>
<td>0.015</td>
</tr>
<tr>
<td>Length of stay in days, median</td>
<td>8 (4–19)</td>
<td>8 (4–18)</td>
<td>8 (4–18)</td>
<td>8 (4–18)</td>
<td>0.19</td>
</tr>
</tbody>
</table>

*P value refers to chi square tests for trend for categorical variables and ANOVA for continuous variables. Numbers in parentheses represent percentages, unless otherwise specified.
areas, where large-volume hospitals are less likely to be situated. In addition, patients seen at high-volume institutions may be more likely to undergo neuroimaging, permitting the diagnosis of milder strokes associated with lower fatality.

Third, we used an ecologic measure of socioeconomic status, and therefore, we have no information available on individual or household income and level of education. The imperfect correlation between individual- and neighborhood-level income may have contributed to an underestimate of the association between socioeconomic status and stroke outcome.\textsuperscript{19,20} In addition, our dataset included only stroke hospitalizations; therefore, patients who died before reaching a hospital or immediately after arrival to the Emergency Department were not included. This may not be a major limitation, because preadmission death is more likely to occur in subarachnoid hemorrhage and intracranial hemorrhage, and this study was limited to ischemic stroke. Finally, it is possible that other unmeasured variables, not included in the analysis (eg, medication adherence, social isolation, distance to the closest facility, hospital resources), may be important determinants of survival after acute stroke.

Despite these limitations, our national, population-based study provides evidence that both neighborhood income and hospital volume are inversely associated with stroke case fatality. Our results suggest that efforts should be directed toward identifying high-risk subsets of populations as well as institutions with higher-than-expected fatality rates. Public education campaigns could improve the control of vascular risk factors in low-income segments of the population. Small group training sessions could be used to target health care providers at low-volume institutions. In addition, telestroke initiatives could be used to target rural areas, and high-risk patients could be transferred from low-volume to more specialized institutions for care. Our study encourages further research to identify potentially remediable factors related to the delivery of care to reduce stroke fatality, particularly in low-income areas.

**Acknowledgments**

We thank the Canadian Institute for Health Information for providing the data. The authors appreciate the support of Drs Paul O’Connor, Robert Hyland, and Arthur Slutsky. We appreciate the support of the Research Department and members of the Stroke Team at the South Eastern Toronto Region at St. Michael’s Hospital, Toronto.

**Sources of Funding**

This research was supported in part by a grant from the Heart Stroke Foundation of Canada (HSFC) and the Canadian Institutes for Health Research (CIHR) given to Dr Gustavo Saposnik. Dr Moira Kapral was supported by a New Investigator Award from the CIHR and also received support from the Canadian Stroke Network (CSN) and the University Health Network Women’s Health Program. These grants

**Table 4. Multivariable Analysis: Variables Associated With Stroke Fatality**

<table>
<thead>
<tr>
<th></th>
<th>7-Day in Hospital Fatality</th>
<th>Stroke Fatality at Discharge</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Adjusted OR</td>
<td>95% CI</td>
</tr>
<tr>
<td><strong>Age</strong>, for every year</td>
<td>1.04‡</td>
<td>1.03 1.04</td>
</tr>
<tr>
<td>Gender, male</td>
<td>0.99</td>
<td>0.90 1.08</td>
</tr>
<tr>
<td>Charlson index score (\geq2)</td>
<td>1.10</td>
<td>0.96 1.25</td>
</tr>
<tr>
<td>Facility location, urban (reference)</td>
<td>1.00</td>
<td>... ...</td>
</tr>
<tr>
<td>Rural</td>
<td>1.14‡</td>
<td>1.00 1.28</td>
</tr>
<tr>
<td>Hospital status, non-teaching</td>
<td>1.12</td>
<td>0.93 1.36</td>
</tr>
<tr>
<td>Most responsible physician, specialist (reference)</td>
<td>1.00</td>
<td>... ...</td>
</tr>
<tr>
<td>GP</td>
<td>1.03</td>
<td>0.91 1.17</td>
</tr>
<tr>
<td><strong>Income &amp; hospital volume</strong> High income–High volume (Ref)</td>
<td>1.00</td>
<td>... ...</td>
</tr>
<tr>
<td>High income–Low volume</td>
<td>1.11</td>
<td>0.95 1.31</td>
</tr>
<tr>
<td>Low income–High volume</td>
<td>1.16</td>
<td>0.99 1.34</td>
</tr>
<tr>
<td>Low income–Low volume</td>
<td>1.26‡</td>
<td>1.07 1.49</td>
</tr>
</tbody>
</table>

Abbreviations: CI = confidence interval; OR = odds ratio.

*Adjusted for age, sex, hospital location, most responsible provider, Charlson index, income, and hospital volume; accounting for clustering by hospital using generalized estimating equations.

\(\dagger\)Hospital stroke volume defined as quartiles of volume by facility.

\(\ddagger\)Indicates significant at \(P<0.05\).
Disclosures

None.

References

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for the Stroke Outcome Research Canada (SORCan) Working Group

Stroke. 2008;39:3360-3366; originally published online September 4, 2008;
doi: 10.1161/STROKEAHA.108.521344
Stroke is published by the American Heart Association, 7272 Greenville Avenue, Dallas, TX 75231
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Print ISSN: 0039-2499. Online ISSN: 1524-4628

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