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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% (χ^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;39:000-000.)**

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-

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ent in academic versus nonacademic hospitals after accounting for volume is unclear. Along the same lines, it is not known whether rural residence modifies any effect of socioeconomic 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 socioeconomic 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, diagnostic, procedural, and administrative information on all hospital discharges 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 Diseases, 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 facilities 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 excluded. 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 ulcer, 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 dissemination areas.[18] For our analyses, neighborhoods were dichotomized a priori into low-income (quintiles 1 and 2) and high-income (quintiles 3 through 5) areas. 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 practitioner 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 χ^2 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 equations[22] to evaluate the association 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 location (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 (exchangeable) was selected as the correlation structure.[11] The association 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 "contaminate" 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 institutions; (2) high-volume teaching versus low-volume teaching institu-

Table 1. Baseline Characteristics by Quintiles of Neighborhood Income (N=25 228)

Characteristic	Income Quintile*					*P* Value†
	1 (Lowest), n=5752	2, n=5473	3, n=5245	4, n=4659	5 (Highest), n=4099	
Age, y, mean±SD	73.9±13	74.5±12	73.7±13	73.6±13	74.4±13	0.87
Age categories, y						0.43
Age <65	1183 (20.6)	1054 (19.3)	1099 (21.0)	1008 (21.6)	792 (19.3)	
Age 65–74	1433 (24.9)	1255 (23.1)	1243 (23.7)	1075 (23.7)	930 (22.7)	
Age 75–84	1967 (34.2)	2052 (37.5)	1904 (36.3)	1733 (37.2)	1536 (37.5)	
Age ≥85	1167 (20.3)	1102 (20.1)	999 (19.1)	841 (18.1)	841 (20.5)	
Sex						0.17
Female	2763 (48)	2620 (47.9)	2565 (48.9)	2321 (49.8)	2036 (49.7)	
Charlson-Deyo comorbidity index score						0.07
0	3914 (68.0)	3733 (68.2)	3656 (69.7)	3300 (70.8)	2849 (69.4)	
1	787 (13.7)	753 (13.8)	665 (12.7)	578 (12.4)	515 (12.6)	
2	568 (9.9)	5066 (9.2)	478 (9.1)	387 (8.3)	401 (9.8)	
≥3	483 (8.4)	481 (8.8)	446 (8.5)	394 (8.5)	334 (8.2)	
Charlson-Deyo comorbidity index score ≥1	1838 (32.0)	1740 (31.8)	1589 (30.3)	1359 (29.2)	1250 (30.6)	0.013

*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 χ^2 tests for trend for categorical variables and by ANOVA for continuous values.

Numbers in parentheses represent percentages, unless otherwise specified.

tions; (3) patients from low-income areas seen at rural versus urban institutions; and (4) at rural institutions, patients from low-income areas versus those from high-income areas. All statistical analyses were performed with a commercially available software package (SAS Statistical Software 1999, version 8, from SAS Institute Inc, Cary, NC, and STATA, version 7.0, from Stata Corp LP, College Station, Tex).

Ethics

The study protocol was approved by the ethics review board at St. Michael's Hospital, University of Toronto. Because the identity of the patients was kept completely anonymous, no specific informed consent was required. The data pooling center was blinded to hospital identity.

Results

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 (19.8%) 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 4099 (16%) were in the highest income quintile. Overall, 44.5% of stroke patients were categorized as belonging to low-income neighborhoods (quintiles 1 and 2). Baseline characteristics by income quintile are summarized in Table 1. Patients from lower-income quintiles were more likely than those from higher quintiles to be admitted to low-volume hospitals and nonteaching hospitals and to have a general practitioner rather than a specialist as the most responsible physician during their hospitalization (Table 2).

Compared with high-income patients admitted to high-volume hospitals, low-income patients admitted to low-volume hospitals were slightly older, were more likely to be female, were more likely to receive care in rural 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; χ^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; χ^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%,

Table 2. Stroke Care by Quintiles of Neighborhood Income

Characteristic	Income Quintile* 1 (Lowest), n=5752	2, n=5473	3, n=5245	4, n=4659	5 (Highest), n=4099	*P* Value†
Hospital stroke volume, quartiles (Q)						<0.001
Q1 (lowest)	1746 (30.4)	1631 (29.8)	1387 (26.4)	963 (20.7)	425 (10.3)	
Q2	1542 (26.8)	1497 (27.4)	1301 (24.8)	1139 (24.4)	997 (24.3)	
Q3	1360 (23.6)	1258 (23.0)	1342 (25.6)	1196 (25.7)	1207 (29.5)	
Q4 (highest)	1104 (19.2)	1087 (19.8)	1215 (23.2)	1361 (29.2)	1470 (35.9)	
Teaching hospital	963 (16.7)	898 (16.4)	956 (18.2)	963 (20.7)	1104 (26.9)	<0.001
Hospital location=urban	3928 (68.3)	3807 (69.6)	4012 (76.5)	3942 (84.6)	3896 (95.0)	<0.001
Most responsible physician						0.005
General practitioner	1103 (19.2)	951 (17.4)	848 (16.2)	719 (15.4)	643 (15.7)	
Specialist	4649 (80.8)	4522 (82.6)	4397 (83.8)	3940 (84.6)	3456 (84.3)	
Medical complications overall	489 (8.5)	480 (8.7)	384 (7.3)	313 (6.7)	301 (7.3)	0.012
Pneumonia	211 (3.7)	208 (3.8)	180 (3.4)	133 (2.9)	139 (3.4)	0.12
Urinary tract infection	214 (3.7)	183 (3.3)	153 (2.9)	135 (3.3)	137 (3.4)	0.16
Intracerebral hemorrhage	15 (0.26)	11 (0.20)	9 (0.17)	11 (0.24)	5 (0.12)	0.11
Pulmonary embolism	35 (0.61)	34 (0.62)	33 (0.63)	24 (0.52)	12 (0.29)	0.12
Decubitus ulcer	14 (0.24)	11 (0.20)	9 (0.17)	10 (0.21)	8 (0.20)	0.96
ICU admission	707 (12.3)	714 (13.1)	630 (12.0)	580 (12.5)	824 (12.8)	0.53
Length of stay in days, median (interquartile range)	8 (4–19)	8 (4–18)	8 (4–17)	8 (4–18)	8 (4–18)	0.19
7-Day stroke fatality	481 (8.4)	448 (8.2)	383 (7.3)	332 (7.1)	267 (6.5)	0.002
Stroke fatality at discharge	934 (16.2)	924 (16.9)	782 (14.9)	671 (14.4)	586 (14.3)	<0.001
Age-adjusted fatality at discharge (95% CI)	14.4 (13.5–15.3)	14.7 (13.8–15.6)	13.2 (12.3–14.2)	12.8 (11.9–13.8)	12.2 (11.3–13.2)	<0.001

*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 χ^2 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.[10,12] 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.[2,8,25,26] 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.[27–29] 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-

Table 3. Univariable Analysis by Income-Hospital Volume Group

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

*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.

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.[1,30,31] 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.[32]

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

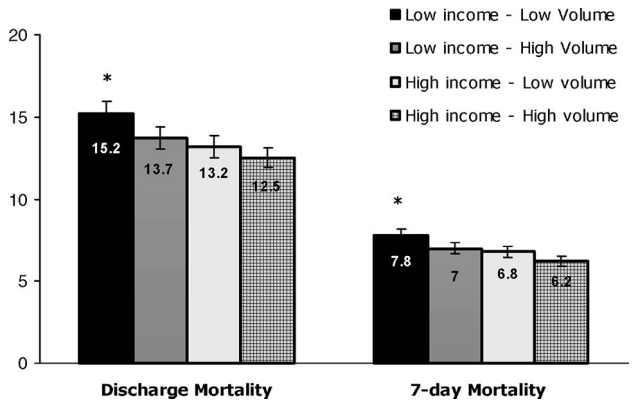

Figure. Figure shows risk-adjusted fatality rates by income and facility volume group. Numbers inside the bars indicate the fatality rate for each group. *$P<0.001$ when stroke fatality at low income/low volume is compared with other income-volume groups. I indicates 95% CI. For the adjusted death rates, stroke fatality was adjusted by age, sex, comorbid conditions, teaching status, most responsible provider, and facility localization.

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.[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.

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

	7-Day in Hospital Fatality			Stroke Fatality at Discharge		
	Adjusted OR	95% CI		Adjusted OR	95% CI	
Age, for every year	1.04‡	1.03	1.04	1.05‡	1.05	1.06
Gender, male	0.99	0.90	1.08	0.99	0.92	1.07
Charlson index score ≥2	1.10	0.96	1.25	1.02	0.93	1.13
Facility location, urban (reference)	1.00	...	...	1.00	...	...
Rural	1.14‡	1.00	1.28	0.99	0.89	1.09
Hospital status, non-teaching	1.12	0.93	1.36	1.16	0.98	1.37
Most responsible physician, specialist (reference)	1.00	...	...	1.00	...	...
GP	1.03	0.91	1.17	1.06	0.96	1.18
Income & hospital volume High income–High volume (Ref)	1.00	...	...	1.00	...	...
High income–Low volume	1.11	0.95	1.31	1.09	0.95	1.25
Low income–High volume	1.16	0.99	1.34	1.10	0.98	1.23
Low income–Low volume	1.26‡	1.07	1.49	1.27‡	1.11	1.45

Abbreviations: CI=confidence interval; OR=odd's 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.

†Hospital stroke volume defined as quartiles of volume by facility.

‡Indicates significant at $P<0.05$.

were obtained on the basis of competitive applications after publication of grant advertisements. The investigators acted as the sponsors of the study. None of the supporting agencies (HSFC, CSN, CIHR) had input on the design, access to the data, analyses, interpretation, or publication of the study.

Disclosures

None.

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