Influence of Socioeconomic Status on Distance Traveled and Care After Stroke

Christopher Ahuja, MD(c); Muhammad Mamdani, PharmD, MPH, MA; Gustavo Saposnik, MD, MSc, FAHA; for the Stroke Outcomes Research Canada (SORCan—www.sorcan.ca) working group

Background and Purpose—Vital to maintaining an efficient delivery of services is an understanding of patient travel patterns during an acute ischemic stroke. Socioeconomic status may influence access to stroke care, including transportation and admission to different facility types.

Methods—We analyzed all acute ischemic stroke admissions between 2003 and 2007 through the Discharge Abstract Database, a national database containing patient-level sociodemographic, diagnostic, procedural, and administrative information across Canada. Socioeconomic status was defined in neighborhood quintiles according to Statistics Canada. Distances between patients and facilities were derived from postal codes. A principal diagnosis of ischemic stroke was identified using the International Classification of Diseases (versions 9 and 10). Analysis of variance and regression analyses were performed with adjustment for demographic characteristics.

Results—Admitted to acute care institutions were 243,410 patients with ischemic stroke. Mean patient age was 72.8 and 49.5% were male; 44.2% traveled beyond their closest center, amounting to an average 7.2 km additional distance traveled. Socioeconomic status quintile had minimal effect on travel patterns, with the lowest socioeconomic status accessing the closest center most frequently (odds ratio, 1.19; 95% confidence interval [CI], 1.13–1.16). Increased utilization of the closest hospital occurred with academic (odds ratio, 6.90; 95% CI, 6.69–7.11) or high-volume (odds ratio, 1.93; 95% CI, 1.88–1.98) facilities. Older patients (β=0.28; 95% CI, 0.27–0.28), expert destination facility (β=0.13; 95% CI, 0.12–0.14), and ambulance use increased travel beyond the closest center.

Conclusions—Patients tend to choose care facilities based on hospital expertise; investment promoting improved regional facilities may be of greatest benefit to patients. Socioeconomic status has little bearing on travel patterns associated with stroke in Canada. These findings may assist in allocating funding to centers and improving patient care. (Stroke. 2012; 43:00-00.)

Key Words: accessibility ■ health services ■ stroke

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Characteristics including demographics, comorbidities, ambulance use, length of stay, and special care unit admission were extracted and are further defined (Supplemental Methods).

Definition of Distances and SES
The forward sorting area (first 3 postal code characters) was used to identify unique census dissemination areas for analysis. Discharge Abstract Database patient and hospital forward sorting areas were linked with Statistics Canada’s 2006 Census data. Median household income for each forward sorting area was divided into quintiles and used as a marker of patient SES. “Crow flies” distances were calculated between patient forward sorting areas, discharging hospital, and closest hospital (see Supplemental Materials for further details).

Outcome Measures
The primary outcome measure was travel distance in kilometers. Secondary outcomes include length of hospital stay, admission to specialized care unit, and mortality at discharge.

Statistical Analysis
The Cochran-Armitage test was used to compare categorical variable levels and trends in proportions across SES quintiles. Linear-contrast analysis of variance was used for continuous variable means across quintiles. For those traveling beyond their closest center, median extra distance traveled was determined. Logistic regression was used to examine both factors associated with presentation to the closest stroke center and factors associated with presentation beyond the closest center (see http://stroke.ahajournals.org for details).

Results
During the study period (January 1, 2003–December 31, 2007), 243 410 patients presented to participating institutions with a diagnosis of cerebral infarction or stroke (not otherwise specified). Descriptive statistics are summarized in Supplemental Table I. Mean age was 72.8 years and 120 415 (49.5%) patients were male; 145 072 (59.6%) patients arrived by ambulance. Secondary outcome measures are summarized in Supplemental Table II. Mean hospital length of stay was 12.7 days; 44 215 (18.1%) patients were admitted to a special care unit. In-hospital mortality was 41 623 (17.1%).

Proximity
Half of patients presented to their closest acute care center. A Cochran-Armitage test verified a linearly decreasing trend from lowest to highest SES quintiles (P<0.001; Table 1). The absolute difference between the lowest and highest quintiles was 4.0%. Of patients traveling to more distant centers, the median additional distance traveled was 7.2 km (interquartile range, 2.0–43.7 km) and was similar among all SES strata.

Factors Associated With Presentation to the Closest or More Distant Centers
The most important factors associated with presentation to the closest stroke care center included admission to an academic hospital (odds ratio, 6.90; 95% confidence interval [CI], 6.69–7.11) and high-volume destination hospital (odds ratio, 1.93; 95% CI,1.88–1.98) for those arriving by ambulance. The same factors were found for patients arriving by other means (Table 2).

Of those traveling to more distant centers, the most important factors associated with greater travel distance were older age (β=0.28; 95% CI, 0.27–0.28), high-volume hospital (β=0.13; 95% CI, 0.12–0.14), and academic hospital status (β=0.08; 95% CI, 0.07–0.08; Table 3).
Discussion

Increased life expectancy, population aging, and limited resources are serious challenges to health care systems. Selecting the correct paradigm of stroke care resource management (centralized versus global investment) is important to efficiently and effectively deliver care. Understanding patient travel patterns and choice of stroke care centers aids in this decision. Any investment should promote equal access to care across all SES strata.

We found that half of patients accessed their closest center and half traveled to more distant centers. All SES quintiles tended to seek specialized stroke care at academic or high-volume centers, both perceived to provide greater quality of care and better outcomes. Rural residents were more likely to choose the closest center, likely because of greater distances to larger centers than for urban residents. These findings were increased further when traveling by ambulance.

Median additional travel for stroke patients receiving care at more distant hospitals was 7.2 km, creating delay in initial assessment and care. SES had minimal effect on additional travel distance, suggesting stroke patients have equal access to acute care facilities.

Expert hospitals (high-volume and academic) were associated with greater travel distances, likely because of increased complexity of offered services and presumed higher quality of care, encouraging longer travel. Older patients may travel farther because of need for expert (often more distant) care because of a greater number of comorbidities (see Supplemental Materials for interpretation of results).

Together, these results suggest the need for investment in greater numbers of regional stroke care centers providing the expertise patients seek with reduced travel distances. Currently, resources are well-distributed to limit major disparities between SES quintiles.

Limitations of the study, use of postal code areas, and SES surrogates are discussed in detail in the supplemental file (Supplemental Methods). Despite these limitations, our study presents a novel analysis looking into the relationship between SES, stroke patient travel patterns, and associated outcomes.

Acknowledgments

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Disclosures

None.

References


Table 3. Multivariable Analysis of Factors Associated With Greater Travel Distance

<table>
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<tr>
<th>Factor</th>
<th>Ambulance Arrival</th>
<th>Other Arrival</th>
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</thead>
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<tr>
<td></td>
<td>Standardized Coefficient (b)</td>
<td>95% CI</td>
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<tr>
<td>Older patient</td>
<td>0.28</td>
<td>0.27–0.28</td>
</tr>
<tr>
<td>High-volume destination</td>
<td>0.13</td>
<td>0.12–0.14</td>
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<tr>
<td>Academic destination</td>
<td>0.08</td>
<td>0.07–0.08</td>
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<tr>
<td>Urban destination</td>
<td>0.04</td>
<td>0.04–0.05</td>
</tr>
<tr>
<td>Longer hospital stay</td>
<td>0.02</td>
<td>0.02–0.03</td>
</tr>
<tr>
<td>Female</td>
<td>0.02</td>
<td>0.01–0.03</td>
</tr>
<tr>
<td>Lower SES*</td>
<td>0.01</td>
<td>0.00–0.02</td>
</tr>
<tr>
<td>Higher Charlson Index†</td>
<td>0.01</td>
<td>0.00–0.02</td>
</tr>
</tbody>
</table>

Standardized coefficients represent influence of factor on dependent, controlling for units.
CI indicates confidence interval; SES, socioeconomic status.
*SES quintile 1 vs SES quintiles 2 through 5.
†Higher Charlson-Deyo Index corresponding to greater comorbidity.
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SUPPLEMENTAL MATERIAL
Influence of Socioeconomic Status on Distance Traveled and Care after Stroke

Introduction

Projections estimate an 80% increase in the proportion of those 80 years or older in the next 20 years. The most effective acute interventions in stroke care include admission to a stroke unit and thrombolytic therapy. Thus, it is important to identify whether patients’ selection of stroke care facilities is based on proximity or level of expertise and resources. Importantly, arrival via ambulance or other means (car, taxi, public transit) must be assessed separately. In Canada, patients not arriving by ambulance may choose to present to any centre. If travelling by ambulance, patients are transported to the nearest hospital emergency department, or to the regional stroke centre according to the ‘by pass stroke protocol’ (i.e. < 4 hours from symptoms onset with deficit affecting face or extremity, no evidence of hypoglycemia, etc). A patient’s home province covers all costs of acute stroke care. If travelling by ambulance, patients are transported to the nearest hospital emergency department, to the regional centre supplying the required specialized services, or to a centre requested by the patient which provides medically necessary services.

Disparities in access have been found across socioeconomic status (SES) levels. Lower SES is associated with poorer access to specialized care, and increased mortality following a stroke after adjusting for stroke severity, age and sex. Moreover, hospitals in low SES regions of Canada are more likely to have indicators associated with lower quality of care.

We examined the association between SES and travel patterns during a stroke. Secondarily, we examined the association between patient demographics, ambulance use, hospital expertise and community type on travel patterns. We hypothesized that patients with low SES receive care at the nearest and less specialized hospital.
Methods & Technical notes

Data Sources

The Discharge Abstract Database (DAD) is maintained by the Canadian Institute for Health Information (CIHI), an independent, not-for-profit organization funded by the provincial and federal governments of Canada. Data are abstracted automatically from electronic hospital records using third party abstracting software designated by CIHI. Participating institutions are mandated by law to submit separation information to the DAD which includes between 555 (2003) and 637 (2007) acute care centres in Canada. Incorrectly formatted or missing elements are flagged at CIHI and corrected by submitting institutions. Patients with invalid health card number were excluded.

Baseline Characteristics: Demographic information was extracted from DAD records. Length of stay was defined as the number of days in the acute care facility from admission to discharge or death. Special care unit (SCU) admission was defined as any intensive care unit, stroke unit, or step-down medical unit admission. Ambulance arrival was defined as air or ground ambulance for any partial or complete trip ending with presentation to hospital. Comorbidities were defined as all conditions co-existing at the time of admission or developing subsequently and either: (1) significantly affecting treatment received, (2) requiring treatment beyond maintenance of the pre-existing condition or (3) increasing length of stay by at least 24 hours. Specifically, myocardial infarction (MI), congestive heart failure (CHF) and Diabetes were analyzed. As an estimate of total comorbidity load, the Charlson-Deyo Index (CDI) was calculated from ICD-10 patient diagnosis codes in the DAD using the method described in Quan et al., 2005. The CDI is a summed-score based on the presence or absence of 17 medical conditions including MI, CHF and Diabetes. A score of zero represents none of the evaluated comorbidities being present while a higher score indicates greater disease burden.
Hospital characteristics were also evaluated including hospital volume, academic affiliation and urban/rural location. Hospital expertise was approximated by annual stroke-patient volume with higher volumes indicating greater expertise. Based on previous studies completed by our and other groups, hospital volume was divided into four categories: low (1-49/yr), medium (50-99/yr), high (100-199/yr) and very high (200+/yr) hospital volumes. Institutions were defined as academic if they were members of The Association of Canadian Academic Healthcare Organizations (ACAHO). An urban centre was defined, according to Statistics Canada, as being situated in a dissemination area with population >1,000 persons and density > 400 persons/km$^2$.

**Definition of Distances and Socioeconomic Status:** The effects of SES on patients’ transit were assessed as part of the overall model and individually. Statistics Canada is the federally-funded central statistical agency for Canada, legislated to produce accurate and complete statistics on the population, resources, economy, society and culture of Canada. The national census is completed every 5 years with the most recent being the 2006 Canadian Census. Questionnaire completion is mandated by law in Canada. Linkages between the DAD and 2006 Canadian Census used the Postal Code Conversion File, a Statistics Canada utility for linking postal codes between databases. Distance travelled was defined as the ‘crow flies’ distance between the patient’s FSA and the healthcare centre presented to. The closest centre was identified as having the shortest ‘crow flies’ distance to the patient’s FSA. SES was estimated by assigning neighborhoods to quintiles based on income data reported on the 2006 Canadian Census. Within each large neighborhood (census area), smaller areas (dissemination areas) were ranked by median household income (adjusted for household size) and divided into approximate quintiles. This created five community-specific income quintiles as described in Wilkins, 2004. Such an estimation of SES from neighborhood income has been previously reported by different authors.

Approval for the DAD was obtained from the Research Ethics Board at each participating institution. The design of this study was approved by the Ethics Review Boards at St. Michael’s Hospital, Toronto, ON.
**Data Quality:** According to a re-abstraction study performed by CIHI for quality assurance, after the implementation of ICD-10, diagnoses in the database agree with diagnoses in the charts in 92% of stroke cases. The agreement of the coding of data collected for day of admission was 97% and for death was greater than 99%. Non-medical and socio-demographic data elements in this study had agreement rates ranging from 96 to 100%.6,9

Other Canadian studies on hospital coding of stroke and vascular risk factors using ICD-9 and ICD-10 have shown a similarly high agreement rate.10,13,20 In one study, ICD-9 coding was excellent with 90% (95% CI:86%-92%) and ICD-10 was similarly good with 92% (95% CI:88%-95%) of strokes correctly coded.9

**Statistical Analysis**

Logistic regression analysis was conducted to examine factors associated with presentation to the closest stroke center. When travelling beyond the closest stroke center, the following factors increasing extra travel distance were examined by linear regression: patient age, patient sex, SES, Charlson-Deyo Index, hospital volume, academic centre status and urban/rural hospital. Both regression analyses were stratified by ambulance arrival or non-ambulance arrival (i.e. car, taxi, public transit).

Residual diagnostics confirmed normal distribution of residuals when using a Box-Cox transformation of the dependent ‘extra distance travelled’ variable. Box-Cox transformation used on the dependent variable (Extra Distance Travelled) was used to alleviate heteroscedasticity. The formula, T(Y)=(Y^λ–1)/λ, was used where Y was ‘Extra Distance Travelled’ and λ was 0.05 increment values from -2.0 to 1.0. A normality plot of post-transformation correlation coefficients and λ found the ‘Extra Distance Travelled’ normality assumption to be reasonable at λ=-0.25.22
Statistical analysis was performed using commercially available software packages (PASW statistical software, 2009, version 18.0.1; SPSS Inc., Chicago, IL). All tests were 2-tailed, and probability values <.05 were considered significant.

**Results**

Descriptive statistics are summarized in Table 1. The overall mean age was 72.8 years, 120,415 (49.5%) patients were male. Mean household before-tax income was $13,880, $31,960, $51,520, $78,280, and $154,020 for SES quintiles 1 through 5, respectively. Comorbidities included myocardial infarction (MI) in 13,388 (5.5%), congestive heart failure (CHF) in 15,822 (6.5%) and Diabetes in 52,090 (21.4%). Charlson-Deyo scores of 0 to 1, 2 and >3 were found in 180,123 (74.0%), 43,814 (18.0%) and 19,716 (8.1%), of patients respectively. Overall, 145,072 (59.6%) patients arrived by ambulance. Secondary outcome measures are summarized in Table 2. Mean hospital length of stay was 12.7 days and decreased over SES quintiles from 13.0 days (lowest SES) to 12.3 days (highest SES) (p<0.001). 44,215 (18.1%) patients were admitted to SCU, this proportion ranged from 17.3% to 18.6% (p<0.001) over SES quintiles. In-hospital mortality ranged from 16.5% to 17.7% over SES quintiles (p<0.001). Mortality was 17.8% for those accessing the closest centre and 16.2% for those accessing more distant centres (p=0.642).

**Proximity**

Presentation to the closest centre was 57.8%, 55.5%, 56.2%, 55.1% and 53.8% for SES quintiles 1 (low) through 5 (high), respectively (p<.001).

**Interpretation of Results**

Population aging is a worldwide phenomenon that would likely challenge the health care system. Similar to other developed countries, the proportion of Canada’s population over age 80 is expected to increase
75% by 2026. SES has been associated with lower access to stroke care and poorer stroke outcomes. These staggering findings underline the need for an efficient and effective healthcare delivery, especially in the realm of stroke-care. The correct paradigm of resource management (centralized vs. global investment) has been under debate. While some argue in favor of a centralized, highly-specialized system; others suggest that reasonable investments in community hospitals would allow local facilities to provide more immediate stroke care. Understanding the effect of SES on patient flow during the acute event helps to distribute resources between SES divides. Identifying other patient factors influencing this decision will also help to streamline future patient transit and choice of stroke care center. Ultimately, any investment should provide equal access to care across all socioeconomic strata to avoid disparities. These decisions have been a source of ongoing debate as the need for age-related disease care comes to the forefront.

This large country-wide study provided significant power to analyses. Patients from the lowest SES quintile were more likely to present to the closest centre than those from other SES quintiles. This effect was not found between other SES levels and was significantly lower in magnitude than the effect of destination academic or high-volume status. The median additional travel for stroke patients receiving care at more distant hospitals was 7.2 km creating delay in initiating care. Depending on the area and time of the day, an additional km may represent 2-10 minutes delay in receiving treatment. Considering that each minute delay in receiving treatment (especially for those candidates for thrombolytic therapy) may decrease the likelihood of a good functional outcome, each extra kilometer may amount to several minutes of additional ischemic time.

Patients living in neighborhoods at higher SES tended to travel beyond their closest hospital (compared to those living in lower SES) to seek care in stroke centres. Since patients with lower SES patients have greater comorbidities (Charlson-Deyo Index, MI, CHF, Diabetes), longer hospital stays and higher mortality rates than their higher SES counterparts (Table 1), it may be that low SES local facilities have patient populations with poorer pre-intervention prognoses. These hospitals may then have poorer
outcomes and be perceived as providing lower quality care changing patient movement patterns. Some of the observed absolute differences are relatively small.

Some limitations of this study should be addressed when interpreting results. First, Canada has a universal healthcare system where travel patterns are less likely to be affected by insurance coverage than other nations. Second, patients and hospitals were represented by the centre of their respective postal code areas. Exact physical location and travel routes may lead to different ‘closest hospital’ results and distance calculations. Third, we have limited information on the occurrence of the stroke for patients who are not home or within their postal code area (e.g. at work, on vacation). These patients may be admitted to the closest location but still appear to be many kilometers from their closest hospital in the data. However, this occurs in a minority of patients, which unlikely would affect our results. Fourth, all comorbidities are likely underreported in administrative databases. Despite a re-abstraction study showed 75.5% agreement on comorbid conditions in the DAD\textsuperscript{27,28}, this could affect the relationship between comorbid conditions and the outcomes of interest. Finally, an approximation of the median income does not account for variations within a postal code area, nor can it account for discrepancies between SES and individual income. The use of quintiles, however, mitigates much of this error by broadly grouping areas to average discrepancies. As education and awareness of the presentations and outcomes of stroke increases, we may see a shift in travel patterns in the future. Patients and emergency medical services may reevaluate the risks and benefits of greater travel distance and the need for specialized stroke care versus time delays. The healthcare system will need to adapt accordingly to meet the needs of patients.

As assistance to practically apply this work in creating a regionalized stroke care network, some investigators have created a model to assist policymakers determine appropriate catchment areas for essential health services.\textsuperscript{29} Emphasis was placed on the need for access in rural and remote regions where economies of scale are not possible and SES may have greater impact. The work used road network analysis to determine appropriate travel times and hospital service areas. Such models can be employed for stroke care in other regions or countries to define allowable travel distances and help select regions
where localized stroke care would be of greatest benefit. Even small decreases in ischemic time and increases in tissue plasminogen activator (tPA) would result in a cost-effective intervention and taxpayer savings.\textsuperscript{30}

Further research comparing countries or provinces with and without universal healthcare would help identify additional factors affecting travel such as transportation costs, hospital costs, insurance coverage and referral systems. SES is expected to reemerge as an important predictor of travel patterns in regions without universal healthcare.

These results may assist policymakers, hospital administrators and health authorities to better allocate resources.

**Sources of Funding**

The investigators acted as the sponsors of the study. None of the supporting agencies had input on the design, access to the data, analyses, interpretation, or publication of the study. The opinions expressed in this paper are those of the authors and should not be attributed to any sponsoring institution.
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6. Canadian Institute for Health Information - profile. Canadian Institute for Health Information.

   Canadian Institute for Health Information; 2008.


Table 1. Demographics and Patient Characteristics

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<th>Overall</th>
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<th>Q2</th>
<th>Q3</th>
<th>Q4</th>
<th>Q5(Highest)</th>
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<td>Number(%)</td>
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<td>52,407(21.5)</td>
<td>48,374(19.9)</td>
<td>43,232(17.8)</td>
<td>38,272(15.7)</td>
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*aMean household before-tax income for each SES quintile
Numbers in columns represent percentages unless otherwise specified.
Charlson Index is a sum score of 17 medical comorbidities. A score of zero indicates no comorbidities present and higher scores indicated greater comorbidity burden. Categorization is 0-1, 2 or ≥3 comorbidities. 

P-values for age ranges, sex, Charlson Index, MI, CHF, Diabetes and ambulance arrival are derived from Cochran-Armitage tests for trend, excluding the unknown SES group. P-value for mean age is derived from linear trend ANOVA, excluding the unknown SES group.
Table 1. Secondary Outcome Measures

<table>
<thead>
<tr>
<th>Variable</th>
<th>Overall</th>
<th>Q1 (Lowest)</th>
<th>Q2</th>
<th>Q3</th>
<th>Q4</th>
<th>Q5 (Highest)</th>
<th>Unknown</th>
<th>P Value **</th>
</tr>
</thead>
<tbody>
<tr>
<td>Length of hospital stay, mean (days)</td>
<td>12.7</td>
<td>13.0</td>
<td>12.9</td>
<td>12.7</td>
<td>12.3</td>
<td>12.3</td>
<td>10.9</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Admission to Specialized Unit (Stroke Unit/ ICU)</td>
<td>18.0</td>
<td>17.8</td>
<td>17.3</td>
<td>17.5</td>
<td>18.6</td>
<td>18.6</td>
<td>26.9</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>In-hospital mortality</td>
<td>17.1</td>
<td>17.7</td>
<td>17.2</td>
<td>16.5</td>
<td>17.3</td>
<td>16.7</td>
<td>18.4</td>
<td>&lt;0.001</td>
</tr>
</tbody>
</table>

* Mean household before-tax income for each SES quintile. Numbers in columns represent percentages unless otherwise specified.

P-values for admission to specialized units and in-hospital mortality are derived from Cochran-Armitage tests for trend, excluding the unknown SES group. P-value for length of hospital stay is derived from linear trend ANOVA, excluding the unknown SES group.