Stroke Outcome in Those Over 80

A Multicenter Cohort Study Across Canada

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Background and Purpose**—**The prevalence of stroke in elderly patients has been increasing in recent years. However, limited information is available about the burden of stroke in individuals over 80. We sought to evaluate differences in clinical outcomes in Canadians over 80 years old hospitalized for an acute ischemic stroke.

Methods**—**The authors conducted a multicenter cohort study including all hospital admissions for ischemic stroke identified from the Canadian Hospital Morbidity and Mortality Database from April 2003 to March 2004. The Hospital Morbidity and Mortality Database contains a national database that contains patient-level sociodemographic, diagnostic, procedural, and administrative information from across Canada. Multivariable analysis was performed using logistic regression. The primary outcome was 7-day case fatality and fatality at discharge. Secondary end points included intensive care unit admissions, medical complications, gender differences, length of hospital stay, and discharge disposition.

Results**—**We analyzed 26 676 patients with ischemic stroke admitted to 606 hospitals across Canada. Mean age (SD) was 74±13 years. Overall, 10 171 (38%) were aged 80 years or older. Case fatality at discharge was 5.7% (age <59), 8.6% (age 60 to 69), 13.4% (age 70 to 79), and 24.2% (age ≥80; $P<0.001$). Patients aged 80 and over were less likely to be admitted to the intensive care unit (7.7% versus 15.3%; $P<0.001$) and discharged to their prestroke residence (47.2% for those over 80 versus 61.6% for patients younger than 80; $P<0.001$). Median length of stay was longer in those over 80 (10 days versus 7 days; $P<0.0001$). In the multivariable analysis for the older group, admission to the intensive care unit, low socioeconomic status, and admission to a nonacademic institution were associated with increased fatality after adjusting for covariates.

Conclusions**—**Aging of the population is a growing reality in Western societies and this translates into an increasing demand on healthcare systems. In our study, patients with stroke over 80 had higher risk-adjusted fatality, longer hospitalization, and were less likely to be discharged to their original place of residence. Strategies need to be implemented to facilitate equal access to specialized stroke care for the elderly. **(*Stroke*. 2008;39:000-000.)**

Key Words: stroke ■ socioeconomic status ■ mortality ■ hospital volume ■ outcome research ■ health services research ■ health policy ■ population aging

Population aging is a summary term to describe shifts in the age distribution of a population toward older ages, most marked in highly developed countries. This rapidly progressing and worldwide phenomenon has been referred to as the "silver tsunami." In Canada in 1956, there were 180 000 people aged 80 or over compared with 1 167 310 in that age group based on the 2006 population census. Demographic projections estimate a more than 75% increase in the proportion of 80-year-old or greater group by 2026 (Figure 1).[1] As life expectancy and number of individuals in the older population increase, their demographic and medical characteristics are also changing.

For instance, at the global level, the most rapidly growing age group is the one aged 80 and over. Although the oldest-old still constitute a small proportion of the total population, their numbers are becoming increasingly impor-

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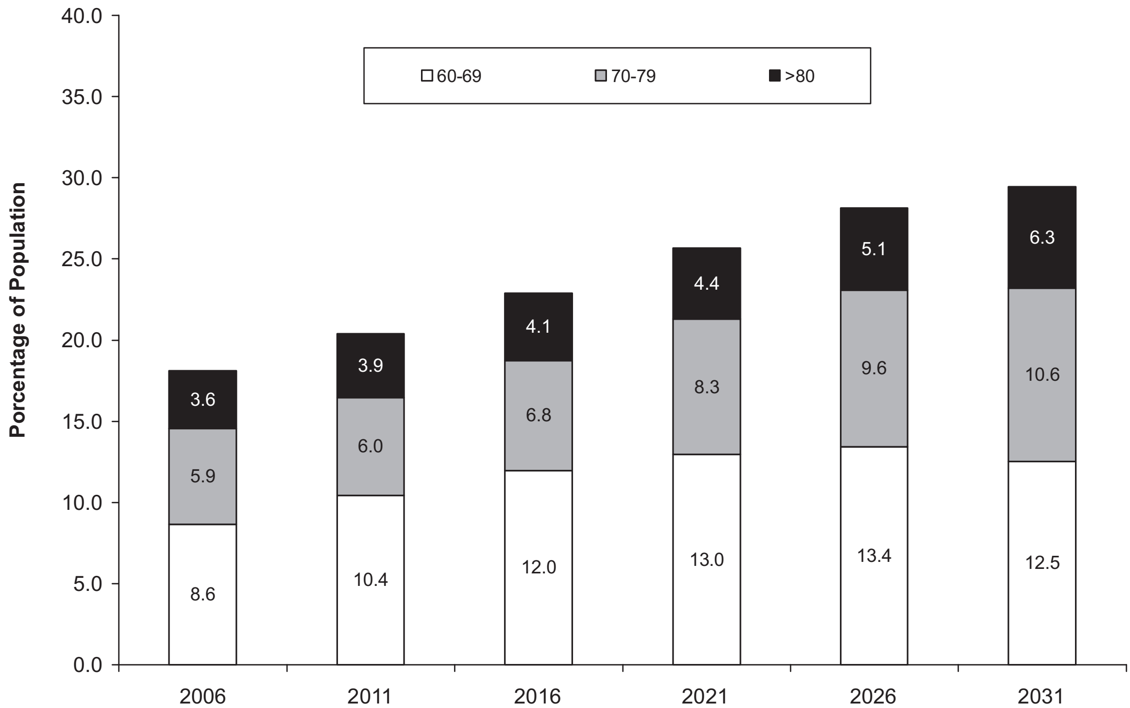

Figure 1. Projected Canadian population growth by age groups (in percentages). Canadian population growth by age groups (in percentages) for 2006, 2011, 2016, 2021, 2026, and 2031 based on population estimates at July 1, 2005. Catalog number 91 to 520-X, Statistics Canada, CANSIM.

tant, largely attributable to 2 factors. First, the fertility rate, which has averaged 1.6 children per woman over the last 30 years, is below the replacement level. Second, there has been a dramatic increase in life expectancy in the 20th century. For example, life expectancy at birth in the United States in 1900 was 47 years, whereas at the end of the century, it was 77 years (representing an extra 30 years, an increase of 64%). Life expectancies in India and China were around 32 and 35 years in 1950, whereas at the close of the century, they had reached 64 and 71 years, respectively. Similar gains have occurred in Canada (presently at 82.5 years for women and 77.7 years for men) as elsewhere around the world.[1–3] As a result, an increasing number of Canadians are reaching the age of 80 years old, and once they attain this age, their expected survival is longer as well.

Stroke incidence rates increase steeply with age.[4,5] Therefore, we would also expect a rise in the number of elderly patients with stroke in the future. Unfortunately, limited information is available on stroke care in patients over age 80. In part, this is due to a paucity of publications on stroke in the elderly and low participation of the elderly in clinical trials.[6]

Our aim was to evaluate the extent of differences (gender, length of stay, complications and discharge disposition, and stroke fatality) in patients 80 years and older and to understand the incidence of stroke in the very elderly as measured by hospital admissions.

We hypothesized that they would have lower survival, longer length of stay (LOS), and more intensive care unit (ICU) admissions than younger patients with stroke and that they would be less likely to be discharged to their original place of residence before their stroke. A better understanding of the outcomes associated with stroke in the older segments of our population may have important and practical implications not only for clinical management, but also for initiating preventive strategies and health policy implementation.

Methods

We identified all patients with ischemic stroke admitted to acute care hospitals in Canada between April 1, 2003, and March 31, 2004, through the Hospital Morbidity and Mortality Database managed by the Canadian Institute for Health Information. The Hospital Morbidity and Mortality Database is a national database that contains patient-level sociodemographic, diagnostic, procedural, and administrative information across Canada. Canada's healthcare system includes government-funded universal public provision of physician and hospital services and the absence of copayments and other patient charges.[7] There are 680 acute care facilities across the country reporting to the Hospital Morbidity and Mortality Database, which covers 99.8% of all acute care hospitals. Reporting to the Hospital Morbidity and Mortality Database is mandatory in Canada. Patients with stroke were admitted to acute care facilities, including academic and community hospitals and rural and urban institutions, from all provinces and territories. For patients transferred between hospitals, the day of admission was defined as the day of presentation at the initial acute care facility.

For the present analysis, the major inclusion criterion was an admission to an acute care facility with a principal diagnosis of ischemic stroke as identified through the patient's principal discharge diagnosis recorded using the International Classification of Diseases, either the Ninth (ICD-9) or Tenth (ICD-10) Revision (ICD-9 codes 433.01, 433.11, 433.21, 433.31, 433.81, 433.91, 434.01, 434.11, and 434.91 and ICD-10 codes I63 and I64).[8,9] All provinces and territories use ICD-10 codes, except Manitoba and Quebec, which use ICD-9 codes.

Because of major prognostic differences, patients with transient ischemic attack, intracerebral hemorrhage, and subarachnoid hemorrhage were excluded from this analysis.

We used the Charlson-Deyo comorbidity index to quantify patients' comorbid conditions.[10] This index is a summary score based

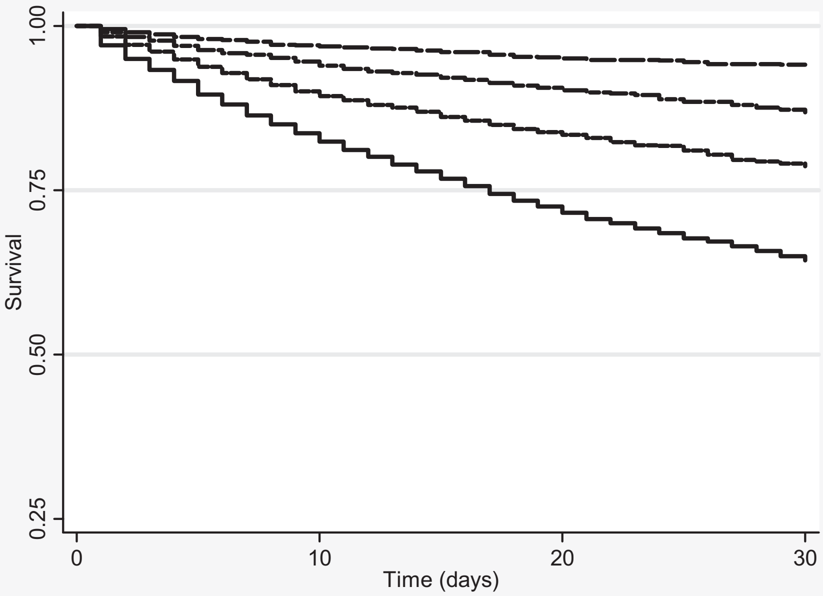

Figure 2. Adjusted survival curves for 30-day stroke fatality by age group. This figure shows the adjusted stroke survival curves at 30 days to compare age groups. The difference between survival curves for those over 80 to any other age groups was significant (log rank $P<0.001$ for those over 80 versus age <59, those over 80 versus age 60 to 69, and those over 80 versus age 70 to 79). ___ represents adjusted stroke survival for those over age 80 group (n=10 171). - - - represents adjusted stroke survival for the age 70 to 79 group (n=8419). _-_represents adjusted stroke survival for the age 60 to 69 group (n=4505). _ _ _ represents adjusted stroke survival for younger than age 60 group (n=3581). Adjusted survival by gender, comorbidities, most responsible provider, hospital location, and ICU admission.

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.[11,12] Serious medical complications during hospitalization (intracerebral hemorrhage, pneumonia, decubitus ulcer, deep venous thrombosis, pulmonary embolism, and urinary tract infection) were also identified. Socioeconomic status was estimated through an approach developed by Statistics Canada that assigns neighborhoods to equally sized quintiles based on socioeconomic status data reported on the 2001 Census.[13] A higher quintile value of a residential area is associated with higher median socioeconomic status of residents in that area.

Rural location was defined according to the hospital postal code. Hospital academic status was defined according to the Association of Canadian Academic Healthcare Organizations.[14]

Each hospital in the Hospital Morbidity and Mortality Database is assigned a unique, encrypted identifier. This identifier was used to determine the annual acute ischemic stroke volume for each hospital that contributed to the database. As expected in administrative–clinical databases, no specific data were available for acute neurological status (such as the National Institutes of Health Stroke Scale) or measures of functional disability (such as the Barthel index and modified Rankin scale).

Statistical Analysis

Chi square or Fisher exact tests were used to compare categorical variables, whereas Student *t* tests and analysis of variance were used to compare continuous variables. Mann-Whitney test was used to compare median LOS. In developing the models, a statistical significance level of $P<0.25$ on univariate analysis was used as a screening cutoff. Those factors achieving this level of significance were then included in a multivariable analysis for the outcomes of interest (7-day fatality and stroke fatality at discharge). Only variables achieving statistical significance of $P<0.05$ were left in the final multivariable model. The association between individuals over

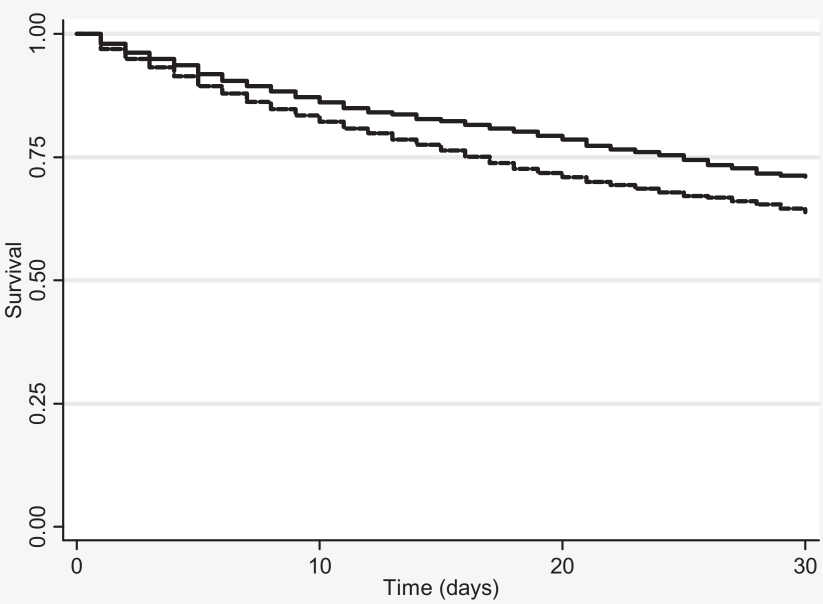

Figure 3. Adjusted survival curves for 30-day stroke fatality for those over age 80 by institutional academic status. This figure shows the adjusted stroke survival curves at 30 days for those over 80 admitted to academic and nonacademic institutions. Survival for those over 80 admitted to nonacademic institutions was significantly lower than for those admitted to academic (log rank $P<0.001$). ___ represents adjusted stroke survival for admissions to academic institutions (n=5179). - - - represents adjusted stroke survival for admissions to nonacademic institutions (n=21 497). Adjusted survival by gender, comorbidities, most responsible provider, ICU admission, and hospital location (urban/rural).

Table 1. Baseline Characteristics by Age Groups

Characteristic	Age Group				P Value
	<59 Years (N=3581)	60–69 Years (N=4505)	70–79 Years (N=8419)	>80 Years (N=10 171)	
Gender, %					<0.001
Male	2233 (62.4)	2875 (63.8)	4573 (54.3)	3997 (39.3)	
Female	1348 (37.6)	1630 (36.2)	3847 (45.7)	6174 (60.7)	
Charlson comorbidity index score, %					0.77
0–1	2486 (69.4)	3146 (69.8)	5814 (69.1)	6981 (68.6)	
2	788 (22.0)	972 (21.6)	1884 (22.4)	2324 (22.9)	
≥3	307 (8.6)	387 (8.6)	721 (8.6)	866 (8.5)	
Facility type					<0.001
Academic	934 (26.1)	911 (20.2)	1576 (18.7)	1758 (17.3)	
Nonacademic	2647 (73.9)	3594 (79.8)	6843 (81.3)	8413 (82.7)	
Hospital location					0.23
Rural	829 (23.2)	1123 (24.9)	2000 (23.8)	2395 (23.6)	
Urban	2752 (76.8)	3382 (75.1)	6419 (76.2)	7776 (76.4)	
Most responsible physician					<0.001
General practitioners	582 (16.2)	750 (16.7)	1371 (16.3)	1808 (17.8)	
Specialist	2999 (83.8)	3755 (83.3)	7048 (83.7)	8363 (82.2)	
Socioeconomic status, quintiles*					0.001
1 (lowest)	778 (22.9)	1024 (24.2)	1820 (22.8)	2130 (22.2)	
2	666 (19.6)	928 (21.9)	1720 (21.5)	2159 (22.5)	
3	730 (21.5)	890 (21.0)	1669 (20.8)	1956 (20.4)	
4	680 (20.0)	741 (17.5)	1518 (19.0)	1720 (17.9)	
5 (highest)	544 (16.0)	651 (15.4)	1270 (15.9)	1634 (17.0)	

*Socioeconomic status was estimated through an approach developed by Statistics Canada that assigns neighborhoods to equally sized quintiles based on socioeconomic status data reported on the 2001 Census. A higher quintile value of a residential area is associated with higher median socioeconomic status of residents in that area. Socioeconomic status could not be determined in 1448 (5.4%) of individuals. *P* values represent differences among age groups.

80 and outcome measures was expressed as the OR and 95% CI. The Hosmer-Lemeshow test for goodness of fit was performed to assess the calibration of the models. We used the ADJUST command in STATA, to calculate risk-adjusted case-fatality rates as reported by other authors.[15,16] For the multivariable and risk-adjusted models, we dichotomized a priori quintiles of socioeconomic status (Q1+Q2 versus Q3+Q4+Q5). Admission to the ICU was used as a surrogate of stroke severity in the models.

Stroke survival at 3 months (Figures 2 and 3) was derived from Cox regression models. We used STS GRAPH, STRATA, and ADJUST commands in STATA to perform the adjustment by fitting a stratified Cox regression model.

We used STS GRAPH, STRATA, and ADJUST commands in STATA to represent adjusted survival at 30 days (Figures 2 and 3) derived from Cox regression models.

Differences in the survival between groups were assessed by the log rank test. All statistical analyses were performed using a commercially available software package (SAS statistical software 1999, Version 8; SAS Institute Inc, Cary NC; and STATA version 8.0; StataCorp LP, College Station, Texas).

Outcome Measures

The primary outcome was stroke case-fatality (at 7-day, at discharge, and risk-adjusted case-fatality). Seven-day stroke fatality was defined as the proportion of ischemic stroke events that are fatal within 7 days after stroke admission. The rationale for using the 7-day case-fatality is based on a higher case-ascertainment and, most important, cost-related decisions are generally achieved within the first week of admission.[17] The 7-day fatality indicator has been previously used by the Organization for Economic Co-operation and Development for comparing stroke and acute myocardial infarction outcomes among different countries as well as in other studies.[18,19] Case-fatality at discharge was defined as the proportion of ischemic stroke events that are fatal before discharge. Gender, comorbidities, most responsible provider, ICU admission, hospital academic status and location, and socioeconomic profile were considered to calculate risk-adjusted stroke fatality at discharge. Secondary end points included ICU admissions, medical complications, length of hospital stay, and discharge disposition (prestroke place of residence, long-term care facility, death).

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.

Data Quality

According to a reabstraction study performed by the Canadian Institute for Health Information for quality assurance, after the implementation of ICD-10, diagnoses in the database were in agreement with diagnoses in the charts in 92% of stroke cases. The agreement for the coding of data collected on the day of admission was 97% and for death was greater than 99%. Nonmedical and sociodemographic data elements in this study had agreement rates ranging from 96% to 100%.[20]

Table 2. Primary and Secondary Outcome Measures

Characteristic	Age Group <59 Years (N=3581)	60–69 Years (N=4505)	70–79 Years (N=8419)	>80 Years (N=10 171)	*P* Value
Primary outcome measures					
7-day case-fatality	118 (3.3)	207 (4.6)	578 (6.9)	1136 (11.2)	<0.001
Case fatality at discharge	191 (5.3)	389 (8.6)	1125 (13.4)	2460 (24.2)	<0.001
Risk-adjusted fatality rate, (95% CI)	3.9 (3.6–4.4)	7.5 (7.1–8.0)	13.8 (13.4–14.3)	24.0 (23.2–24.8)	<0.001
Secondary outcome measures					
Medical complications					
Pneumonia	133 (3.7)	151 (3.4)	290 (3.4)	340 (3.3)	0.75
Urinary tract infection	114 (3.2)	133 (3.0)	275 (3.3)	349 (3.4)	0.50
Intracerebral hemorrhage	7 (0.20)	7 (0.16)	18 (0.21)	27 (0.27)	0.59
Pulmonary embolism	18 (0.5)	26 (0.6)	40 (0.5)	58 (0.6)	0.80
Decubitus ulcer	7 (0.20)	8 (0.18)	16 (0.19)	23 (0.23)	0.92
ICU admission	650 (18.2)	734 (16.3)	1139 (13.5)	781 (7.7)	<0.001
Discharge to prestroke residence*	2263 (66.8)	2620 (63.7)	4429 (58.0)	3627 (47.2)	<0.001
Length of stay in days, median (interquartile range)	6 (3–12)	7 (3–14)	8 (4–18)	10 (5–23)	<0.001

*Discharge to the place of residence before the ischemic stroke excludes death.

Other Canadian studies using hospital coding for stroke and vascular risk factors from ICD-9 and ICD-10 have shown a similar high rate of agreement.[21,22] In one particular study, ICD-9 coding was excellent with 90% agreement (95% CI, 86% to 92%) and ICD-10 was similarly good with 92% (95% CI, 88% to 95%) of strokes correctly coded.[9]

Role of the Funding Source

The sponsor of the study had no role in study design, data collection, data analysis, data interpretation, or writing of the report. The corresponding author had full access to all the data in the study and had final responsibility for the decision to submit for publication.

Results

We analyzed 26 676 patients with an ischemic stroke admitted to 606 hospitals across Canada from April 1, 2003, to March 31, 2004. Mean age (±SD) was 74±13 years and mean (median) length of hospital stay was 16.1 (8) days. Of these, 10 171 (38%) were aged 80 years or older. Baseline characteristics are summarized in Table 1. Minor differences in gender, socioeconomic status, and care facility type were observed in the over 80 age group compared with younger age groups.

Outcomes Measures

Overall, 7-day and discharge stroke fatality rates were higher among those over age 80 when compared with the younger age groups. Table 2 summarizes the main outcome measures by age groups. Stroke fatality at discharge was 5.7% (age <59), 8.6% (age 60 to 69), 13.4% (age 70 to 79) and 24.2% (age >80; $P<0.001$). Patients over age 80 had also higher risk-adjusted stroke fatality when compared with patients younger than 80 years old.

The adjusted survival curves for 3-month mortality demonstrate a significantly lower survival rate for patients over age 80 and for those admitted to nonacademic institutions (log rank <0.0001; Figures 2 and 3).

For the secondary outcome measures, elders had a longer length of hospital stay (median 7 days for younger versus 10 days for older than age 80; $P<0.0001$). Contrary to our expectations, those over 80 years old were less likely to be admitted to the ICU. As expected, they were also less likely to be discharged to their prestroke residence (47.2% for those over age 80 versus 61.6% for younger patients; $P<0.001$). There were no significant differences in the medical complication rates between the older and younger groups.

When analyzing gender differences, women either younger or older than 80 years old had longer LOS, were less likely to be admitted to the ICU, and less likely to be discharged to the prestroke place of residence when compared with men (Table 3). There were no significant differences between men and women in comorbidities, medical complications, and stroke fatality rates. These results indicate minor differences in fatality rates but longer hospitalization and higher discharge to long-term care institutions in women after stroke.

In the multivariable analysis focusing on those over age 80, admission to the ICU, low socioeconomic status, and admission to a nonacademic institution were associated with higher 7-day stroke fatality after adjusting for covariates. Similar results were found for stroke fatality at discharge, including nonspecialist care (Table 4). A goodness of fit test demonstrated no significant departure of model prediction from observed data (Hosmer and Lemeshow test; $P=0.91$ for case fatality at 7-day and $P=0.38$ for stroke fatality at discharge).

Discussion

In this comprehensive study across Canada, we found that 38% of hospitalized patients with an ischemic stroke occurred in individuals aged 80 or older. These individuals had a higher fatality rate (at 7-day, at discharge, and risk-adjusted), longer length of hospital stay, and were less likely to be admitted to the ICU and discharged to their original prestroke residence. Women had a longer length of hospitalization and

Table 3. Gender Differences and Outcome Measures

Characteristic	Overall (N=26 676)	Gender Group: Men (N=13 677)	Gender Group: Women (N=12 999)	*P* Value
7-day stroke-fatality				
<79 years	903 (5.5)	504 (5.2)	399 (5.9)	0.08
>80 years	1136 (11.2)	450 (11.3)	683 (11.1)	0.82
Stroke fatality at discharge				
<79 years	1705 (10.3)	968 (10.0)	737 (10.8)	0.10
>80 years	2460 (24.2)	981 (24.5)	1479 (24.0)	0.5
Risk-adjusted fatality rate (95% CI)				
<79 years	9.4 (8.9–9.9)	8.6 (8.1–9.2)	9.6 (8.9–10.4)	0.19
>80 years	24.4 (23.4–25.2)	24.5 (23.4–25.8)	24.2 (23.2–25.2)	0.71
Medical complications				
Pneumonia				
<79 years	574 (3.5)	351 (3.6)	223 (3.3)	0.22
>80 years	340 (3.3)	125 (3.1)	215 (3.5)	0.33
Urinary tract infection				
<79 years	522 (3.2)	312 (3.2)	1210 (3.1)	0.59
>80 years	349 (3.4)	136 (3.4)	213 (3.4)	0.89
ICU admission				
<79 years	2523 (15.3)	1571 (16.2)	952 (14.0)	<0.001
>80 years	781 (7.7)	377 (9.4)	404 (6.5)	<0.001
Discharge to prestroke residence*				
<79 years	9112 (61.6)	5500 (63.1)	3612 (59.3)	<0.001
>80 years	3637 (47.2)	1579 (51.7)	2078 (44.3)	<0.001
Length of stay in days, median (interquartile range)				
<79 years	7 (3–15)	7 (3–14)	8 (4–17)	<0.001
>80 years	10 (5–23)	9 (5–21)	11 (7–24)	<0.001

*Discharge to the place of residence before the ischemic stroke excludes death.

were more likely to be discharged to long-term care institutions than their male counterparts. Stroke fatality among the over 80s was higher in nonacademic (Figure 3) and rural institutions after adjusting for covariates. Case fatality increased by 15% for those over age 80 with low socioeconomic status. More importantly, nonspecialist care was also associated with a 14% higher case fatality rate at discharge among stroke patients aged 80 or older.

The older segments of our population are growing at a considerably faster rate than that of the world's total population.[3] In absolute terms, the number of older persons has tripled over the last 50 years and will more than triple again over the next 50 years. Despite high immigration rates (usually younger individuals), Canada has had a dramatic increase in the proportion of elderly people with an increasing impact on the demand for healthcare services.[1]

Unfortunately, we know very little about stroke in persons over age 80. The prevalence of arterial hypertension, atrial fibrillation, dyslipidemia, comordid conditions, and case fatality all increase with age.[23–26] Recently published data on stroke trends have also confirmed both an increase in the median age of patients with stroke and of comorbidities.[5,27] In addition to the aforementioned, altered metabolism, lower medication compliance, and higher drug interactions due to polypharmacy make the elderly a unique and higher-risk group.[6] This probably explains why individuals aged 80 and older are usually not included in most of the clinical trials. Despite recent information about the feasibility and safety of the administration of thrombolytic therapy,[28] limited information is available regarding the epidemiology, prevention, and management of stroke in those over age 80.[29,30]

The finding of poorer outcomes in elderly patients with stroke is consistent with previous studies on stroke as well as other medical conditions.[27,31–34] A group of investigators has recently created and validated a "clinical frailty score" to measure the "vulnerability" of elderly people to explain poorer outcomes.[35] From the health system perspective, limited access to specialists or organized stroke care in some institutions may explain this phenomenon. Similarly, the finding of an inverse association between socioeconomic status and stroke fatality is consistent with previous studies.[24,36] In Canada, because of the universal funded healthcare system, everybody gets access to care independently of their socioeconomic status. However, unequal access to specialized stroke care may exist among different subgroups (elderly, individuals living in rural areas, and so on).

Table 4. Multivariable Analysis for Stroke Fatality in Those Older Than 80*

	7-Day Stroke Fatality			Stroke Fatality at Discharge		
	Adjusted OR	95% CI		Adjusted OR	95% CI	
Gender, male	1.006	0.88	1.14	1.02	0.93	1.12
Charlson index score ≥2	1.12	0.96	1.32	1.0	0.88	1.13
Facility location, urban (reference)	1.00	...	...	1.00	...	...
rural	1.12	0.97	1.31	1.02	0.91	1.14
Most responsible physician,						
Specialist (reference)	1.00	...	...	1.00	...	...
General practitioner	1.13	0.96	1.33	1.14	1.01	1.29
Hospital status, nonacademic	1.27	1.06	1.52	1.21	1.06	1.38
Low socioeconomic status†	1.17	1.02	1.33	1.15	1.04	1.27
ICU admission	1.93	1.58	2.36	1.93	1.65	2.26

*Adjusted for sex, Charlson index, socioeconomic status, ICU admission, hospital location, academic status, and most responsible provider.

†Socioeconomic status was estimated through an approach developed by Statistics Canada that assigns neighborhoods to equally sized quintiles based on socioeconomic status data reported on the 2001 Census. For the multivariable analysis, socioeconomic status was dichotomized as low (Q1+Q2) or high (Q3+Q4+Q5).

A retrospective study based on data acquired during the period 1967 to 1985 in a metropolitan area in Portland included patients with stroke aged 65 or older (not broken down by decade) enrolled in the Kaiser Permanente health plan. They found a decrease in 7-day fatality from 17% (period 1967 to 1971) to 6% (period 1980 to 1985).[37] However, death for those over age 85 did not decrease. In a recent Canadian study comparing stroke outcomes from 1988 to 2002 in the province of Quebec, the authors found an increase in median age and prevalence of comorbidities in hospitalized patients with stroke with a stable 7-day case-fatality rate of 14% for those aged 85 and older.[27] In another study that included Medicare beneficiaries aged 65 and older, in-hospital death was 6.8% for patients with ischemic stroke.[38] Similar to our study, gender and comorbid conditions were not associated with stroke fatality in the multivariable analysis.[29,37] In agreement with previous studies, we found that women and those over 80 years had longer LOS and were discharged more often to long-term care institutions.[39,40] Differences in comorbidities, type of care, and the lack of family and social support could explain, at least in part, the longer LOS and differences in discharge disposition.[27,39]

Our study has limitations that deserve comment. First, we used administrative health data, which lack detailed information about stroke severity and other clinical indicators needed for case-mix adjustment and also provide limited information about differences in the processes of stroke care among different facilities. However, the advantages of the administrative database are the large sample size, its population-based case ascertainment, including most stroke separation data in Canada, and valid information on stroke outcome. Second, although we identified a clear association among type of care facility, socioeconomic status, and stroke fatality in more elderly individuals, this observational study cannot establish a cause–effect relationship. Third, inconsistencies in coding comorbidities and medical complications in the Hospital Morbidity and Mortality Database could have masked any true association. Finally, it is possible that other unmeasured variables, not included in the analysis (eg, medication adherence, social isolation, physician expertise, hospital resources), could affect the association between age and stroke outcome.

Despite these limitations, our national, population-based study provides relevant and robust data on stroke fatality, disposition, and hospital care for most individuals aged 80 and over across Canada.

Surprisingly, given our aging demography, very little is known about the fastest growing age group. Considering the increasing number of strokes in the more elderly segment of the population (38% of strokes occurring in those 80 or over), longer LOS and higher use of resources (over 50% of them are discharged to a long-term care institution), our results constitute a first step in the understanding of stroke outcomes in those over age 80 and the approaching burden and challenges faced by the healthcare system. The increased fatality observed in patients older than 80 receiving nonspecialist care supports the findings of the stroke trialist meta-analysis that the benefit of stroke care unit is seen in this older group.[41] These findings have important and practical implications not only for clinical management, but also for initiating preventive strategies and health policy implementation. For example, we can anticipate a "domino effect" associated with the aging impact on stroke, causing longer LOS and more disabled stroke survivors, thus increasing the demand for acute and long-term care beds and need for more complex acute care (specialized care, stroke units, ICU, and so on). Moreover, stroke specialists and teams will need to develop specific skills in the care of older people if they are to provide appropriate stroke services. This approaching phenomenon is recognized by government healthcare planners as the "Stroke Silver Tsunami" to capture a sense of urgency that will likely modify the demands and delivery of heath services.

Our study should encourage further research to identify potentially remediable factors related to delivery of care to reduce morbidity and mortality in more elderly patients with stroke. The recognition of this growing problem may help to implement strategies aimed at involving more elderly subjects in clinical trials and other research, facilitating access to specialized stroke care and improving survival and quality of life in the elderly.

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Disclosures

None.

References

1. Statistics Canada. *Portrait of the Canadian Population in 2006, 2006 Census Population and Dwelling Counts, 2006 Census.* Ottawa: Statistics Canada; 2007.
2. Kuhn P. *Effects of Population Aging on Labor Market Flows in Canada: Analytical Issues and Research Priorities.* Social Sciences and Humanities Research Council of Canada, Canada; Human Resources Development Canada, Canada; Industry Canada. Micro-Economic Policy Analysis Branch. Kingston; 2003.
3. Gavrilov LA, Heuveline P. Aging of Population. In: Demeny P, McNicoll G, eds. *The Encyclopedia of Population.* New York: Macmillan Reference USA; 2003.
4. Goldstein LB, Adams R, Alberts MJ, Appel LJ, Brass LM, Bushnell CD, Culebras A, Degraba TJ, Gorelick PB, Guyton JR, Hart RG, Howard G, Kelly-Hayes M, Nixon JV, Sacco RL. Primary prevention of ischemic stroke: a guideline from the American Heart Association/American Stroke Association Stroke Council: cosponsored by the Atherosclerotic Peripheral Vascular Disease Interdisciplinary Working Group; Cardiovascular Nursing Council; Clinical Cardiology Council; Nutrition, Physical Activity, and Metabolism Council; and the Quality of Care and Outcomes Research Interdisciplinary Working Group: the American Academy of Neurology affirms the value of this guideline. *Stroke*. 2006;37:1583–1633.
5. Rothwell PM, Coull AJ, Silver LE, Fairhead JF, Giles MF, Lovelock CE, Redgrave JN, Bull LM, Welch SJ, Cuthbertson FC, Binney LE, Gutnikov SA, Anslow P, Banning AP, Mant D, Mehta Z. Population-based study of event-rate, incidence, case fatality, and mortality for all acute vascular events in all arterial territories (Oxford Vascular Study). *Lancet*. 2005; 366:1773–1783.
6. Wenger NK. Enrollment and maintenance of elderly patients in cardiovascular clinical trials. *Am J Geriatr Cardiol*. 2006;15:352–356.
7. Detsky AS, Naylor CD. Canada's health care system—reform delayed. *N Engl J Med*. 2003;349:804–810.
8. Goldstein LB. Accuracy of ICD-9-CM coding for the identification of patients with acute ischemic stroke: effect of modifier codes. *Stroke*. 1998;29:1602–1604.
9. Kokotailo RA, Hill MD. Coding of stroke and stroke risk factors using International Classification of Diseases, Revisions 9 and 10. *Stroke*. 2005;36:1776–1781.
10. Deyo RA, Cherkin DC, Ciol MA. Adapting a clinical comorbidity index for use with ICD-9-CM administrative databases. *J Clin Epidemiol*. 1992;45:613–619.
11. Charlson ME, Pompei P, Ales KL, MacKenzie CR. A new method of classifying prognostic comorbidity in longitudinal studies: development and validation. *J Chronic Dis*. 1987;40:373–383.
12. Goldstein LB, Samsa GP, Matchar DB, Horner RD. Charlson Index comorbidity adjustment for ischemic stroke outcome studies. *Stroke*. 2004;35:1941–1945.
13. Wilkins R. *Automated Geographic Coding Based on the Statistics Canada Postal Code Conversion Files*. Ottawa, Canada: Health Analysis and Measurement Group; 2004.
14. Lozon JC, Fox RM. Academic health sciences centres laid bare. *Healthc Pap*. 2002;2:10–36.
15. Lynch AI, Arnett DK, Davis BR, Boerwinkle E, Ford CE, Eckfeldt JH, Leiendecker-Foster C. Sex-specific effects of AGT-6 and ACE I/D on pulse pressure after 6 months on antihypertensive treatment: the GENHAT study. *Ann Hum Genet*. 2007;71:735–745.
16. Skinner J, Chandra A, Staiger D, Lee J, McClellan M. Mortality after acute myocardial infarction in hospitals that disproportionately treat black patients. *Circulation*. 2005;112:2634–2641.
17. Saposnik G, Webster F, O'Callaghan C, Hachinski V. Optimizing discharge planning: clinical predictors of longer stay after recombinant tissue plasminogen activator for acute stroke. *Stroke*. 2005;36:147–150.
18. Moon LPM, Jacobzone S; the ARD-Stroke Experts Group. Stroke care in OECD countries: a comparison of treatment, costs and outcomes in 17 countries. The OECD Health Working Papers 2003:1–103. Paris, France: OECD; 2003.
19. Silver FL, Norris JW, Lewis AJ, Hachinski VC. Early mortality following stroke: a prospective review. *Stroke*. 1984;15:492–496.
20. Data quality of the discharge abstract database following the first-year implementation of ICD-10-CA/CCI. Final report. September 2004:1–81. Ottawa, Canada: Canadian Institute for Health Information.
21. Williams JI, Young W. *Inventory of Studies on the Accuracy of Canadian Health Administrative Databases.* Technical report. Ottawa, Canada: Institute for Clinical Evaluative Sciences; 1996.
22. Williams JI, Young W. A Summary of Studies on the Quality of Health Care Administrative Databases in Canada. Goel V, et al, eds. *Patterns of Healthcare in Ontario: the ICES Practice Atlas* (1996). Ottawa, Canada: Canadian Medical Association; 339–345.
23. Garcia D, Hylek E. Stroke prevention in elderly patients with atrial fibrillation. *Lancet*. 2007;370:460–461.
24. Avendano M, Kawachi I, Van Lenthe F, Boshuizen HC, Mackenbach JP, Van den Bos GA, Fay ME, Berkman LF. Socioeconomic status and stroke incidence in the US elderly: the role of risk factors in the EPESE study. *Stroke*. 2006;37:1368–1373.
25. Browner WS, Lui LY, Cummings SR. Associations of serum osteoprotegerin levels with diabetes, stroke, bone density, fractures, and mortality in elderly women. *J Clin Endocrinol Metab*. 2001;86:631–637.
26. Ellekjaer H, Holmen J, Vatten L. Blood pressure, smoking and body mass in relation to mortality from stroke and coronary heart disease in the elderly. A 10-year follow-up in Norway. *Blood Press*. 2001;10:156–163.
27. Mayo NE, Nadeau L, Daskalopoulou SS, Cote R. The evolution of stroke in Quebec: a 15-year perspective. *Neurology*. 2007;68:1122–1127.
28. Sylaja PN, Cote R, Buchan AM, Hill MD. Thrombolysis in patients older than 80 years with acute ischaemic stroke: Canadian Alteplase for Stroke Effectiveness Study. *J Neurol Neurosurg Psychiatry*. 2006;77:826–829.
29. Kaplan RC, Tirschwell DL, Longstreth WT Jr, Manolio TA, Heckbert SR, Lefkowitz D, El-Saed A, Psaty BM. Vascular events, mortality, and preventive therapy following ischemic stroke in the elderly. *Neurology*. 2005;65:835–842.
30. Rothwell PM, Coull AJ, Giles MF, Howard SC, Silver LE, Bull LM, Gutnikov SA, Edwards P, Mant D, Sackley CM, Farmer A, Sandercock PA, Dennis MS, Warlow CP, Bamford JM, Anslow P. Change in stroke incidence, mortality, case-fatality, severity, and risk factors in Oxfordshire, UK from 1981 to 2004 (Oxford Vascular Study). *Lancet*. 2004;363:1925–1933.
31. Altieri M. Spase-I: a multicenter observational study on pharmacological treatment of acute stroke in the elderly. The Italian Study of Pharmacological Treatment of Acute Stroke in the Elderly Group. *Neurol Sci*. 2002;23:23–28.
32. Casiglia E, Spolaore P, Ginocchio G, Colangeli G, Di Menza G, Marchioro M, Mazza A, Ambrosio GB. Predictors of mortality in very old subjects aged 80 years or over. *Eur J Epidemiol*. 1993;9:577–586.
33. Avery GJ II, Ley SJ, Hill JD, Hershon JJ, Dick SE. Cardiac surgery in the octogenarian: evaluation of risk, cost, and outcome. *Ann Thorac Surg*. 2001;71:591–596.
34. Fairhead JF, Rothwell PM. Underinvestigation and undertreatment of carotid disease in elderly patients with transient ischaemic attack and stroke: comparative population based study. *BMJ*. 2006;333:525–527.
35. Rockwood K, Song X, MacKnight C, Bergman H, Hogan DB, McDowell I, Mitnitski A. A global clinical measure of fitness and frailty in elderly people. *CMAJ*. 2005;173:489–495.
36. Kapral MK, Wang H, Mamdani M, Tu JV. Effect of socioeconomic status on treatment and mortality after stroke. *Stroke*. 2002;33:268–273.
37. Barker WH, Mullooly JP. Stroke in a defined elderly population, 1967–1985. A less lethal and disabling but no less common disease. *Stroke*. 1997;28:284–290.
38. Lee WC, Joshi AV, Wang Q, Pashos CL, Christensen MC. Morbidity and mortality among elderly Americans with different stroke subtypes. *Adv Ther*. 2007;24:258–268.
39. Kapral MK, Fang J, Hill MD, Silver F, Richards J, Jaigobin C, Cheung AM. Sex differences in stroke care and outcomes: results from the registry of the Canadian Stroke Network. *Stroke*. 2005;36:809–814.
40. Roquer J, Campello AR, Gomis M. Sex differences in first-ever acute stroke. *Stroke*. 2003;34:1581–1585.
41. Collaborative systematic review of the randomized trials of organized inpatient (stroke unit) care after stroke. Stroke Unit Trialists' Collaboration. *BMJ*. 1997;314:1151–1159.