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Background and Purpose—Limited information is available on the effect of age on stroke management and care delivery. Our aim was to determine whether access to stroke care, delivery of health services, and clinical outcomes after stroke are affected by age.

Methods—This was a prospective cohort study of patients with acute ischemic stroke in the province of Ontario, Canada, admitted to stroke centers participating in the Registry of the Canadian Stroke Network between July 1, 2003 and March 31, 2005. Primary outcomes were the following selected indicators of quality stroke care: (1) use of thrombolysis; (2) dysphagia screening; (3) admission to a stroke unit; (4) carotid imaging; (5) antithrombotic therapy; and (6) warfarin for atrial fibrillation at discharge. Secondary outcomes were risk-adjusted stroke fatality, discharge disposition, pneumonia, and length of hospital stay.

Results—Among 3631 patients with ischemic stroke, 1219 (33.6%) were older than 80 years. There were no significant differences in stroke care delivery by age group. Stroke fatality increased with age, with a 30-day risk adjusted fatality of 7.1%, 6.5%, 8.8%, and 14.8% for those aged 59 or younger, 60 to 69, 70 to 79, and 80 years or older, respectively. Those aged older than 80 years had a longer length of hospitalization, increased risk of pneumonia, and higher disability at discharge compared to those younger than 80. This group was also less likely to be discharged home.

Conclusions—In the context of a province-wide coordinated stroke care system, stroke care delivery was similar across all age groups with the exception of slightly lower rates of investigations in the very elderly. Increasing age was associated with stroke severity and stroke case-fatality. **(*Stroke*. 2009;40:00-00.)**

Key Words: access to care ■ health policy ■ health services research ■ medicine ■ mortality ■ occupational therapy ■ organized care ■ outcome research ■ physiotherapy ■ stroke team ■ stroke unit

Population aging is one of the most dramatic demographic trends in the world today. Projections in Canada estimate a 75% increase in the proportion of those aged 80 years or older by 2026.[1] Recent trials have supported the effectiveness of stroke units and organized care, use of thrombolysis, and early treatment with antiplatelet therapy in reducing stroke morbidity and mortality.[2,3] Despite these advances in acute stroke management, prevention, and rehabilitation, studies have demonstrated significant variations in the provision of quality stroke care by gender, region, and socioeconomic status.[4–6] Although the prevalence of stroke, risk factors, comorbid illness, and underlying stroke mechanisms vary dramatically with age,[7,8] limited information is available on age differences in access to care, stroke care delivery, and clinical outcomes.

We used data from the Registry of the Canadian Stroke Network to evaluate the association between age and stroke management and outcomes in patients seen at stroke centers in the province of Ontario, Canada. We hypothesized that compared to their younger counterparts, those aged older than 80 years would have: (1) reduced receipt of stroke care interventions, including thrombolysis, stroke unit admission,

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carotid imaging, and antithrombotic therapy; and (2) poorer stroke outcomes (increased risk of pneumonia, institutionalization, or death after stroke).

Materials and Methods

Study Design and Data Sources

The Registry of the Canadian Stroke Network (RCSN) was established in 2001, with several iterations.[9] In phase 3 of the RCSN, now with >35 000 patients accrued, data are collected for all consecutive patients seen in the emergency department or admitted to hospital at 11 participating regional stroke centers. Data are collected without patient consent, because the goal of the RCSN is to measure and monitor the quality of hospital stroke care delivery across the province for purposes of quality improvement.[10] Chart abstraction is performed by trained neurology research nurses using laptop computers and customized software. The database is housed at the Institute for Clinical Evaluative Sciences in Ontario. Validation through repeat chart abstraction has shown excellent agreement (κ scores of >0.8) for key variables, including age, gender, stroke type (ischemic vs hemorrhagic), thrombolysis use, and comorbid conditions.

From the RCSN, we identified all consecutive patients with ischemic stroke admitted to all designated stroke centers (11) in Ontario between July 1, 2003 and March 31, 2005. Patients with incomplete or missing clinical data, nonstroke diagnoses, hemorrhagic strokes, and transient ischemic attacks were excluded. Using unique encrypted identifiers, patients in the RCSN were linked to the Ontario Registered Person database, which contains vital statistics, and is maintained by the Ontario Ministry of Health and Long-Term Care.

Age was categorized a priori into 4 groups: age younger than 60 years, age 60 to 69, age 70 to 79, and age 80 years and older. We used the Charlson-Deyo index to quantify patients' comorbid conditions.[11] This index is a summary score based on the presence or absence of 17 medical conditions. A score of zero indicates that no comorbid conditions are present, and higher scores indicate a greater burden of comorbidity. Based on their Charlson-Deyo index score, patients were categorized as having 0, 1, 2, or >3 comorbid illnesses.[12] Stroke severity was assessed using the Canadian Neurological Scale (CNS).[13] The CNS is a simple, reliable, and validated scale that gives a score for estimating the stroke severity on admission; lower scores indicate greater stroke severity. Stroke severity was categorized a priori as mild (CNS ≥8), moderate (CNS 5-7), and severe stroke (CNS ≤4) on the basis of previous studies.[14] A stroke unit was defined as a geographically located hospital unit with a dedicated stroke team and stroke resources (eg, care pathway, educational materials, and monitored beds). This unit did not need to have all of these resources, nor did it have to be exclusively for stroke patients, but it must have been in 1 location in the hospital. A stroke team was defined as a multidisciplinary group of stroke specialists including physicians, nurses, occupational therapists, physiotherapists, dieticians, pharmacists, speech language pathologists, and social workers. Use of antithrombotic drugs was defined as exposure to any of the following medications: aspirin, clopidogrel, combination aspirin, and dipyridamole. The use of warfarin for patients with atrial fibrillation was considered in the absence of contraindications (active liver disease, active bleeding, or terminal illness, patients receiving palliative care). Use of antihypertensive was defined as exposure to any of the following medications: angiotensin-converting enzyme inhibitors, angiotensin receptor blockers, diuretics, β-blockers, or calcium channel blockers. Similarly, the exposure to any HMG-CoA reductase inhibitor (statin) was analyzed at the time of hospital discharge. Pneumonia was included as a medical complication if it occurred within the first 30 days of the hospital stay and was confirmed radiographically. Length of stay was defined as the number of days in the acute care facility from admission to discharge or death. The modified Rankin scale was used to assess disability at discharge, and moderate/severe disability (a functionally dependent state) was defined as modified Rankin scale ≥3.

Approval for the RCSN was obtained from the Research Ethics Board at each participating institution. The design of this study was also approved by the Ethics Review Boards at St. Michael's Hospital, by the RCSN publications committee, and by the Sunnybrook Hospital Research Ethics Board.

Outcome Measures: Performance Indicators of Quality of Stroke Care

We selected key performance indicators as proposed by the Canadian Stroke Quality of Care Study Expert Panel, and the American Heart Association/American College of Cardiologists Quality of Care and Outcomes Research in Cardiovascular Disease and Stroke Working Groups.[15,16] (Table 1). The following key indicators were our primary outcome measures: (1) use of thrombolysis; (2) dysphagia screening; (3) admission to a stroke unit or management by a stroke team; (4) carotid imaging during hospital stay; (5) antithrombotic therapy at discharge; and (6) warfarin for atrial fibrillation.

Secondary Outcome Measures

Secondary outcomes included stroke fatality at 7 days, 30 days, and 1 year after stroke, with adjustment for gender, Charlson-Deyo comorbidity index score, and stroke severity. Other secondary outcome measures included disability at discharge, pneumonia within the first 30 days after stroke, discharge disposition, and length of hospital stay.

Statistical Analysis

Age was categorized as younger than 59, 60 to 69, 70 to 79, and 80 years or older, and baseline characteristics, the use of stroke quality indicators, and stroke outcomes were compared in patients of different age groups using χ^2 tests for categorical variables and ANOVA or Kruskal-Wallis tests for continuous variables. For patients aged older than 80 years, logistic regression models with backward selection were developed to determine the association of gender, stroke severity as measure by the CNS, clinical presentation (weakness, neglect, aphasia, dysphasia, visual field defects, level of consciousness), Charlson comorbidity index, stroke team, and major medical complications (pneumonia, deep venous thrombosis, urinary tract infection, pulmonary embolism), with stroke fatality at 7, 30, and 364 days of any cause. Kaplan–Meier failure curves were used to represent the cumulative mortality rate by age group in the first year. All tests were 2-tailed, and $P<0.05$ were considered significant. Statistical analysis was performed using a commercially available software package (SAS statistical software 1999, Version 9.1.3; SAS Institute Inc).

Results

During the study period (July 1, 2003–March 31, 2005), 3756 patients were admitted to participating institutions with an acute ischemic stroke. One hundred twenty-five patients (3%) were excluded because of either lack of a valid unique identifier or missing clinical data, leaving 3631 patients who met the inclusion criteria for this study. Baseline patient characteristics are summarized in Table 2. The mean age was 72.0 years; 655 (18%) were younger than 60 years, and 1219 (33.6%) were older than 80 years. The median (interquartile range) CNS score was 8.5 (6.0 to 10.5). Stroke severity increased with age, with the proportion of those having a severe stroke (CSN ≤4) 8.0%, 8.6%, 13.6%, and 16.4% in those aged 59 or younger, 60 to 69, 70 to 79, and 80 or older, respectively ($P<0.001$). Those aged 80 years or older were more likely to present with aphasia and neglect, both features often associated with larger strokes. The prevalence of

Table 1. Definitions and Domains of Selected Indicators of Quality and Processes of Stroke Care

Indicator	Definition
Acute treatment	
1. Thrombolytic therapy	Patients treated with recombinant tissue plasminogen activator/patients admitted for an ischemic stroke
2. Onset to door time <180 min (150 mi)	Ischemic stroke patients arriving to the hospital within 180 min (150 min) from symptoms onset/patients admitted for an ischemic stroke
3. Arrival by ambulance	Ischemic stroke patients arriving by ambulance/patients admitted for an ischemic stroke
4. Blood glucose levels checked on arrival	Ischemic stroke patients whom blood glucose levels were checked on arrival to the emergency department/patients admitted for an ischemic stroke
5. Dysphagia screening	Dysphagia screening performed/patients admitted for an ischemic stroke
Organization of stroke evaluation and access to specialized care	
6. Admission to designated stroke units	Ischemic stroke patients admitted to a designated stroke unit/patients admitted for an ischemic stroke
7. Management by the stroke team	Ischemic stroke patients assessed by the stroke team/patients admitted for an ischemic stroke
8. Physiotherapy	Ischemic stroke patients receiving physiotherapy/patients admitted for an ischemic stroke
9. Carotid imaging	Carotid imaging completed during hospital stay
Secondary stroke prevention	
10. Antithrombotics at discharge	Ischemic stroke patients prescribed aspirin, clopidogrel, dipyridamole, or oral anticoagulants at discharge/patients admitted for an ischemic stroke, not dead at discharge
11. Antihypertensive agents at discharge	Ischemic stroke patients in whom antihypertensive drugs were prescribed at discharge/patients admitted for an ischemic stroke, not dead at discharge
12. Statins at discharge	Ischemic stroke survivors in whom statins were prescribed at discharge/patients admitted for an ischemic stroke, not dead at discharge
13. Warfarin use in patients with atrial fibrillation	Ischemic stroke survivors with atrial fibrillation discharged on warfarin/ischemic stroke survivors with atrial fibrillation

previous stroke, atrial fibrillation, preadmission dementia, and dependency increased with age (Table 2).

Stroke Care Delivery

Stroke care was similar across age groups for the primary outcome measures of thrombolysis, admission to a stroke unit, screening for dysphagia, management by a stroke team, discharge on antiplatelet therapy, or discharge on warfarin for patients with atrial fibrillation (Table 3). Overall, 510 (14%) of patients received thrombolytic therapy. Those in the older age groups were more likely than their younger counterparts to have a formal screening for dysphagia or to be discharged with antihypertensive treatment (Table 3). Those aged older than 80 years were less likely than their younger counterparts to undergo carotid imaging [85.3% (age ≤59), 83.1% (age 60–69), 81.8% (age 70–79), and 68.7% (age ≥80; $P<0.0001$).

Disability, Fatality, and Disposition After Stroke

The risk of disability after stroke increased with age, with modified Rankin scores ≥3 seen in 46.3%, 54.4%, 63.2%, and 72.7% of those aged 59 or younger, 60 to 69, 70 to 79, and 80 or older, respectively ($P<0.001$). The cumulative mortality by age group in the first year is represented in Figure 1. Stroke fatality at 7 days, 30 days, and 1 year was higher among those aged 80 years and older compared to their younger counterparts, even after adjustment for gender, comorbidity, and stroke severity (Table 4 and Figure 2). Older individuals were also more likely than their younger counterparts to have pneumonia, to be treated with "comfort measures" only during hospitalization, to be discharged to a long-term care facility, and to have a longer length of stay (Table 4 and Figure 3).

In the multivariable analyses, lower stroke severity, lack of neurological deterioration, management by a multidisciplinary stroke team, and use of antithrombotics were common variables associated with better survival at different points in time (supplemental Appendix and Table I, available online at http://stroke.ahajournals.org). Comorbid illness as measured by the Charlson comorbidity score was only associated with stroke fatality at 1 year. There were no significant differences in the variables associated with stroke fatality for younger vs older age groups (data not shown).

Discussion

Population aging is a worldwide phenomenon that will likely modify our clinical practice and challenge the health care system by increasing the demands for acute care and rehabilitation beds and utilization of resources. Different paradigms of care (comprehensive vs limited assessment) for elderly patients with cardiovascular disease have been undergoing intense debate.[17,18]

We found no association between patient age and the quality of stroke care delivery. Even the very elderly (those aged older than 80 years) received thrombolysis, stroke unit care, and other interventions at a similar rate to those seen in younger individuals. Increasing age was associated with greater stroke severity and a higher frequency of symptoms such as dysphagia, aphasia, weakness, and neglect.

Limited information is available on the impact of age on stroke care delivery in other countries. In the 2004 National Stroke Audit in England, Wales, and Northern Ireland, the authors found that those 85 years and older were less likely to be admitted to stroke units when compared to those younger than 65 (risk ratio [RR], 0.82; 95% CI, 0.75–0.90). Neuroimaging was performed in 71% of patients under 65 years within 24 hours compared to 51% among those aged older

Table 2. Baseline Characteristics

	Age Group					
Variable Demographic (%)	Overall n=3631	<59 n=655 (18.0)	60–69 n=627 (17.3)	70–79 n=1130 (31.1)	80+ n=1219 (33.6)	*P*
Gender, Female	47.8	37.6	32.7	46.4	62.3	<0.0001
Charlson index= 0–1	65.8	82.3	64.4	62.1	61.0	<0.0001
2	16.4	9.5	17.4	17.7	18.5	
3	17.8	8.2	18.2	20.2	20.5	
Clinical presentation						
Mean CNS score±SE	8.0±0.1	8.6±0.1	8.2±0.1	8.0±0.1	7.6±0.1	<0.0001
CNS score group <4	12.6	8.0	8.6	13.6	16.4	<0.0001
5–7	31.7	27.0	34.5	31.1	33.4	
>8	55.7	64.9	57.0	55.3	50.2	
LOC on arrival, alert	86.7	90.2	88.8	87.4	83.2	<0.0001
Dysphagia	11.5	7.2	10.7	11.3	14.4	<0.0001
Aphasia	32.9	27.0	30.8	31.5	38.5	<0.0001
Weakness	82.5	77.1	81.3	82.7	85.6	<0.0001
Neglect	19.8	15.4	16.1	20.3	23.5	<0.0001
Visual field defect	18.4	17.3	18.3	20.5	17.1	<0.0001
Neurological deterioration	16.0	13.1	11.3	15.1	20.8	<0.0001
Medical history						
Hypertension	66.6	46.3	69.2	72.4	70.8	<0.0001
Diabetes	25	20.9	32.2	29.1	19.8	<0.0001
Hyperlipidemia	33.1	28.9	41.3	40.2	24.7	<0.0001
Atrial Fibrillation	17	4.3	10.5	17.1	27.0	<0.0001
Stroke or TIA	34.3	22.6	34.8	35.0	39.5	<0.0001
CHF	9.3	2.4	6.9	9.3	14.2	<0.0001
Cancer	6.1	3.4	7.6	6.0	7.1	0.007
Dementia	8.8	<0.01	2.7	8.2	17.1	<0.0001
Premorbid functional status, independent	79.8	95.6	86.1	81.4	66.6	<0.0001
Arrived from						
Home	75.4	62.7	77.7	79.6	77.1	
Nursing home	5.6	0	1.8	3.3	12.8	
Another facility	10.7	23.3	12.2	8.8	5.0	
Doctor office	2.5	4.4	2.1	2.7	1.3	
Other	5.8	9.6	6.2	5.6	3.8	<0.0001
Oxfordshire Stroke Classification						
LACS	19	19.9	22.1	19.8	16.1	
PACS	37.1	32.6	35.4	36.0	41.4	
TACS	12.6	8.6	9.6	13.5	15.4	
POCS	23.6	29.3	24.6	23.1	20.4	
Other	1.7	3.1	2.4	1.1	1.2	<0.0001

Numbers in columns represent percentages unless otherwise specified.

CHF indicates cardiac heart failure; CNS, Canadian Neurological Scale score; IQR represents interquartile range; LACI, lacunar stroke; PACS, partial anterior circulation stroke; POCS, posterior circulation stroke; TACS, total anterior circulation stroke.

Stroke subtype defined according to the Oxfordshire Community Stroke Project classification, ie, TACS, PACS, POCS, and LACI.

than 85 years. The authors also found that older patients were less likely to receive secondary prevention and rehabilitation interventions.[19] In a study of patients with symptomatic carotid stenosis, patients older than the age of 80 years were less likely than their younger counterparts to be investigated (RR, 0.36; 95% CI, 0.28–0.46; $P<0.0001$) and to receive carotid endarterectomy (RR, 0.19; 95% CI, 0.06–0.63; $P=0.007$).[20] We also found lower use of carotid imaging at discharge in the oldest age group. Lower access to specialized care with increasing age has also been reported in other medical conditions such as acute myocardial infarction and lung cancer.[21,22]

Table 3. Quality and Processes of Stroke Care by Age Group

Domains & Indicators	Overall (n=3631)	Age Group <59 (n=655)	60–69 (n=627)	70–79 (n=1130)	80+ (n=1219)	*P*
Acute treatment of ischemic stroke						
1. Thrombolytic therapy	14.0	14.0	14.7	14.7	13.1	0.69
2. Onset to door <180 min (<150 min)	38.6 (35.4)	34.9 (30.3)	36.2 (33.6)	38.5 (35.8)	41.8 (38.6)	0.014
3. Arrival by ambulance	69.8	57.7	64.3	68.3	80.5	<0.0001
4. Glucose level obtained on arrival	96.6	94.6	96.5	97.4	97.0	0.21
5. Swallowing assessment	56.0	45.7	52.9	59.2	60.3	<0.0001
Organization of stroke evaluation and access to specialized care						
6. Admission to designated stroke units	47.9	43.7	48.3	48.8	49.1	0.11
7. Management by stroke team	58.7	62.0	55.7	57.6	59.5	0.10
8. Physiotherapy	82.5	79.4	82.1	83.6	83.3	0.12
9. Carotid imaging before discharge	78.3	85.3	83.1	81.8	68.7	<0.0001
Secondary stroke prevention (among patients discharged alive)						
10. Antithrombotics at discharge	92.7	93.5	93.5	92.7	91.8	0.48
11. Antihypertensive therapy at discharge (any)	75.9	56.6	80.6	80.5	80.5	<0.001
ACE inhibitor	48.0	39.3	53.8	49.2	48.7	<0.001
ARB	9.3	6.3	10.7	11.2	8.4	0.005
Diuretics	26.3	17.1	26.8	26.6	31.3	<0.001
12. Statins at discharge	61.9	57.4	70.8	65.5	55.6	<0.001
13. Patients with atrial fibrillation discharged on warfarin*	80.0	87.2	81.5	82.7	76.8	0.26

Numbers in columns represent percentages unless otherwise specified. Symptoms onset defined according to the "last seen well" criteria.
Use of antithrombotic therapy includes antiplatelet or anticoagulant agents.
*The % of patients with atrial fibrillation discharged with anticoagulation therapy (warfarin/coumadin, heparin) in the absence of contraindications (active liver disease, active bleeding, or terminal illness, patients receiving palliative care).
ACE indicates angiotensin-converting enzyme; ARB, angiotensin receptor blockers.

Our findings of similar care across all age groups (and of an overall high quality of care) may be explained, at least in part, by the higher level of care provided in stroke centers, and the implementation of a comprehensive coordinated stroke program at the National and Provincial levels involving multiple disciplines in an integrated interprofessional care model. For example, in the province of Ontario, the Ontario Stroke System developed in conjunction with the Ontario

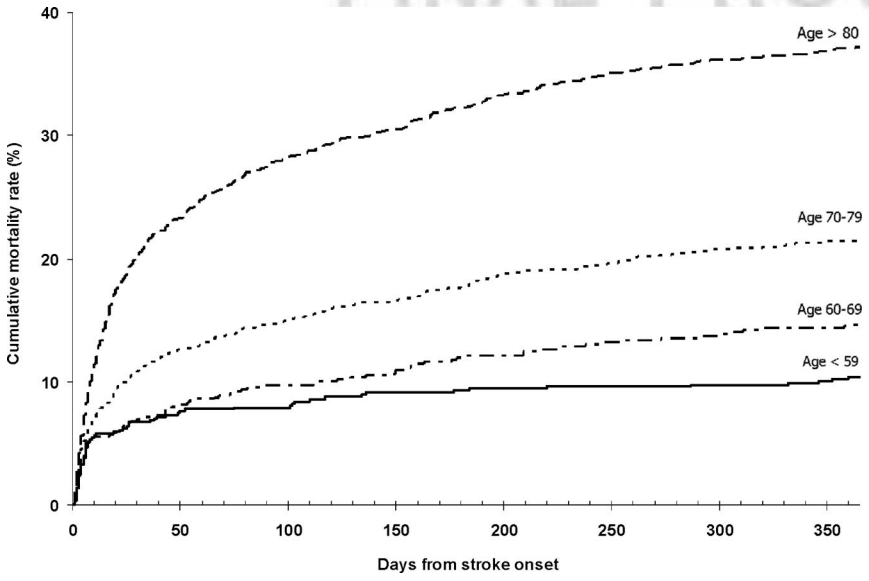

Figure 1. Cumulative mortality by age group. This figure represents the cumulative mortality (Kaplan–Meier failure curves) by age group in the first year. Note a significant difference in mortality for each age group when compared with those 59 years and younger (log-rank $P<0.001$).

Table 4. Outcome Measures by Age Group

Outcome Measure	Overall (n=3631)	Age Group <59 (n=655)	60–69 (n=627)	70–79 (n=1130)	80+ (n=1219)	*P**
Stroke fatality						
Unadjusted stroke fatality at discharge	12.0	6.1	6.1	10.8	19.4	<0.0001
7-day risk-adjusted fatality (95% CI)	5.0	4.8 (3.0–6.6)	4.5 (2.8–6.3)	4.5 (3.2–5.8)	5.9 (4.7–7.0)	0.37
30-day risk-adjusted fatality (95% CI)	10.4	7.1 (4.5–9.7)	6.5 (4.1–8.8)	8.8 (7.1–10.5)	14.8 (13.2–16.3)	<0.0001
1-year risk-adjusted fatality (95% CI)	21.1	11.9 (8.4–15.4)	14.6 (11.7–17.4)	18.9 (16.7–21.2)	29.4 (27.4–31.4)	<0.0001
Disability at discharge (modified Rankin Scale score ≥3)	61.8	46.3	54.4	63.2	72.7	<0.0001
Pneumonia	6.6	2.0	4.3	6.4	10.4	<0.0001
Discharge disposition						<0.0001
Home	47.5	61.3	52.0	46.0	37.8	<0.0001
Long-term care facility	12.3	<1	5.4	12.1	23.9	<0.0001
Rehabilitation institution	33.2	31.9	34.6	35.4	30.9	0.67
Transfer to an acute care facility	5.3	5.2	6.5	5.0	5.1	1.0
Other	1.6	<1	1.5	1.5	2.2	0.83
Home care†	30.5	19.6	22.9	34.5	43.0	<0.0001
Palliative care‡	9.9	4.7	5.4	9.0	15.8	<0.0001
Length of hospital stay (days), median (IQR) 25%, 75%, d	9 (5–19)	8 (4–13)	8 (5–17)	10 (5–20)	11 (6–22)	<0.0001

Numbers in columns represent percentages unless otherwise specified.
Stroke fatality were adjusted for gender, Charlson index, and stroke severity.
**P* for trend.
†Home care defined when special assistance is administered in the home.
‡Palliative care defined when a decision to provide comfort or palliative care rather than active medical management was made at any time during hospitalization.

Ministry of Health and Long-Term Care the creation of Regional Stroke centers (the scope of our study) and established 19 stroke prevention clinics to also facilitate timely access to organize inpatient and outpatient care, respectively.

It is worth noting that appropriate care is not necessarily identical care for patients in all age groups. Antihypertensive therapy or warfarin use in patients with atrial fibrillation may be greater in older groups, whereas lipid-lowering therapy may be lower in younger individuals. The prevalence of risk factors (for example, hypertension and atrial fibrillation), potential contraindications to therapy (comorbid conditions such as cancer and dementia), and factors that influence management (such as stroke severity and etiology) all vary with age. This may explain the higher rates of antihypertensive therapy and dysphagia screening in the older age groups in our study. In addition, the expected benefits of therapeutic interventions may vary with age. For example, evidence suggests that benefit from carotid endarterectomy is greatest in older men with symptomatic and severe carotid stenosis with no evidence of organ failure or cancer likely to cause death within 5 years.[23] In contrast, many of the trials of thrombolysis excluded patients aged older than 80 years, and thus thrombolysis rates may be lower in the very elderly based on appropriate selection of patients based on clinical

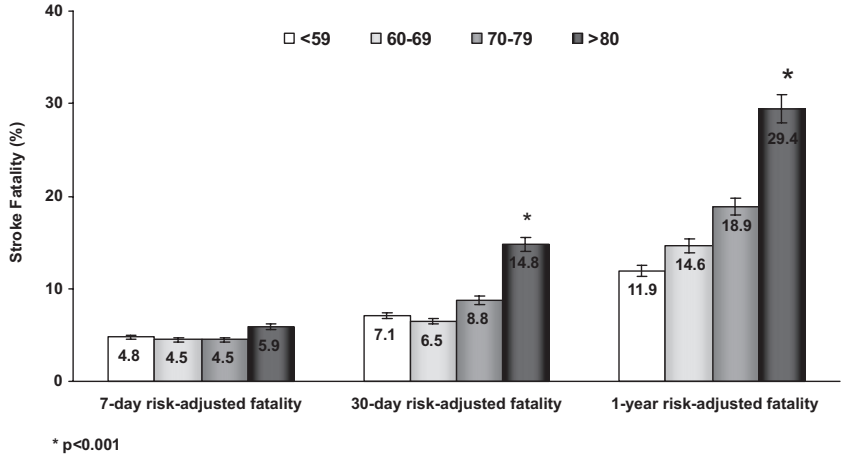

Figure 2. Risk-adjusted stroke fatality by age group. This figure represents risk-adjusted stroke fatality by age group. Error bars represent 95% CI. Stroke fatality was adjusted for gender, Charlson index, and stroke severity. **P*<0.001 when comparing stroke fatality in the oldest age group.

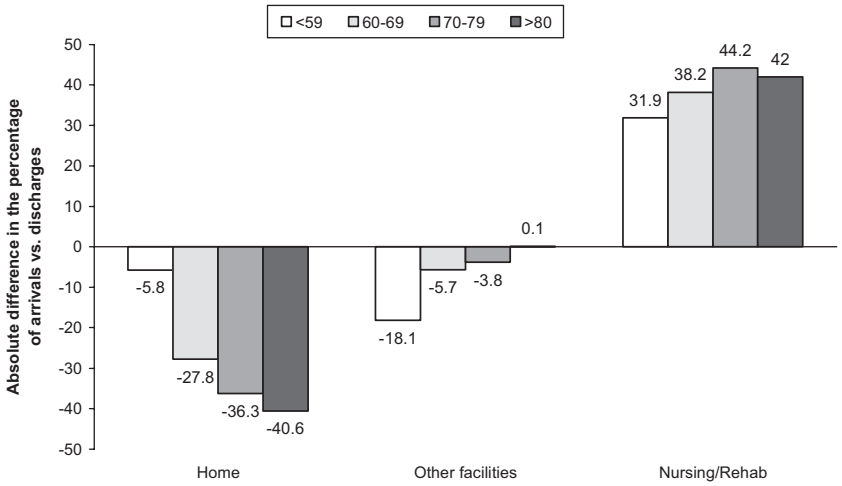

Figure 3. Absolute difference between place of arrival and discharge disposition by age group. This figure represents the absolute difference between the percentage of individuals arriving from and discharged to a nursing/rehabilitation institution, home, or transfer to other facilities (repatriation) by age group. For example, for patients 80 years and older, there was a 40.6 absolute reduction between the percentage of patients arriving from and discharged home. Contrarily, there was a 42 absolute increase in the percentage of patients discharged to a nursing/rehabilitation facility.

trials data. It is important to consider that the treatment rates for intravenous thrombolysis, across all age groups, are among the highest in any jurisdiction previously reported.[19,20]

Although there is certainly room for improvement, the performance on various quality indicators compare favorably with the limited data available in other countries.[24,25] Poorer outcomes in the older age segment have been shown in previous studies.[8,26,27] We found that older age was associated with worse outcomes after stroke, including longer length of stay and an increased risk of disability, institutionalization, and death. As expected, our study found that elderly patients with stroke were more likely to be female and to have comorbid conditions such as hypertension, atrial fibrillation, cancer, and dementia, and were less likely to be independent before stroke.

Our study also emphasizes the tremendous burden of illness from stroke in the elderly. Overall, 65% of the stroke patients in our sample were older than 70 years of age and one-third were aged older than 80 years. Among stroke patients aged older than 80 years, more than two-thirds were dead or disabled at the time of discharge from hospital after stroke, and 1 in 4 required placement in a long-term care facility. Despite the high-quality stroke care seen in all age groups, it would be unexpected that this could mitigate the biological effects of age, comorbidity, and stroke severity on stroke outcome.

Some study limitations deserve comment. First, our study includes only patients admitted to designated stroke centers in Ontario, and may not be representative of the care and outcomes seen in different types of facilities across the country. It is possible that age disparities may be either more noticeable or of a greater magnitude in community hospitals or facilities not specialized in stroke care. Second, although the RCSN contains detailed clinical information, it is possible that unmeasured confounders (such as time to physiotherapy or speech therapy, nurse-to-bed ratio) may have influenced the results. Third, we have no reliable information on the cause of death (stroke-related or attributable to unrelated medical problems).

Despite these limitations, our results provide relevant and robust information on some processes, delivery, and quality of stroke care in the studied population. Treating physicians are responsible for writing medical orders and making decisions regarding consultations, therapeutic interventions, and place of admission. It is encouraging that we found no significant age disparities in relevant indicators of quality of care among stroke centers in Ontario, suggesting that physicians at those institutions do not discriminate by age.

Our study serves as the first step in the understanding of the association between processes of care in stroke centers and outcomes by age. Stroke management should be guided by best clinical evidence and guidelines irrespective of age. Our efforts should be directed to improve the adherence to the recommended guidelines postdischarge considering that antihypertensive, lipid-lowering, and antithrombotic therapies are the best way to reduce the burden of stroke.[28,29]

Implementing organized stroke care is a challenging process that requires the involvement of multiple parties, a comprehensive stroke registry that covers the whole country and all patients, a surveillance system, and the leadership to make the required changes. This is not the task for a group of individuals, a hospital, or a scientific organization. National efforts, worldwide, are required to plan the necessary resources to advocate for and optimize stroke care delivery in the elderly.

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Supplemental Appendix

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Table I. Multivariable Analysis Stroke Fatality in Patients Aged 80 Years and Older

	7-Day Stroke Fatality		30-Day Stroke Fatality		1-Year Stroke Fatality	
Variables	OR	95% CI	OR	95% CI	OR	95% CI
Stroke severity	1.33	1.19–1.48	1.41	1.30–1.53	1.27	1.20–1.34
Neurological deterioration	8.1	4.46–14.8	12.2	7.66–18.9	4.93	3.33–7.31
Management by the stroke team	0.34	0.19–0.63	0.49	0.32–0.77	NS	NS
Use of antithrombotic therapy	0.10	0.05–0.20	0.12	0.06–0.24	0.21	0.11–0.40
Pneumonia	2.25	1.11–4.58	2.17	1.24–3.81	2.35	1.42–3.87

NS indicates nonsignificant.

Neurological deterioration was determined by the local attending physician based on deterioration of the neurological deficit from admission or deterioration in the level of consciousness during hospitalization. Use of antithrombotic therapy includes antiplatelet or anticoagulant agents.

Multivariable analyses for 7-day, 30-day, and 1-year stroke mortality were adjusted for gender, stroke severity as measured by the CNS, clinical presentation, Charlson index, stroke team, medical complications, and antithrombotic use.