

Trends in Hospital Admission for Stroke in Calgary

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ABSTRACT: Background: Stroke incidence has fallen since 1950. Recent trends suggest that stroke incidence may be stabilizing or increasing. We investigated time trends in stroke occurrence and in-hospital morbidity and mortality in the Calgary Health Region. **Methods:** All patients admitted to hospitals in the Calgary Health Region between 1994 and 2002 with a primary discharge diagnosis code (ICD-9 or ICD-10) of stroke were included. In-hospital strokes were also included. Stroke type, date of admission, age, gender, discharge disposition (died, discharged) and in-hospital complications (pneumonia, pulmonary embolism, deep venous thrombosis) were recorded. Poisson and simple linear regression was used to model time trends of occurrence by stroke type and age-group and to extrapolate future time trends. **Results:** From 1994 to 2002, 11642 stroke events were observed. Of these, 9879 patients (84.8%) were discharged from hospital, 1763 (15.1%) died in hospital, and 591 (5.1%) developed in-hospital complications from pneumonia, pulmonary embolism or deep venous thrombosis. Both in-hospital mortality and complication rates were highest for hemorrhages. Over the period of study, the rate of stroke admission has remained stable. However, total numbers of stroke admission to hospital have faced a significant increase ($p=0.012$) due to the combination of increases in intracerebral hemorrhage ($p=0.021$) and ischemic stroke admissions ($p=0.011$). Sub-arachnoid hemorrhage rates have declined. In-hospital stroke mortality has experienced an overall decline due to a decrease in deaths from ischemic stroke, intracerebral hemorrhage and sub-arachnoid hemorrhage. **Conclusions:** Although age-adjusted stroke occurrence rates were stable from 1994 to 2002, this is associated with both a sharp increase in the absolute number of stroke admissions and decline in proportional in-hospital mortality. Further research is needed into changes in stroke severity over time to understand the causes of declining in-hospital stroke mortality rates.

RÉSUMÉ: Étude des tendances dans les admissions hospitalières pour accident vasculaire cérébral à Calgary. Introduction: L'incidence de l'accident vasculaire cérébral (AVC) a baissé depuis 1950. Les tendances récentes suggèrent que l'incidence de l'AVC se stabilise ou est à la hausse. Nous avons étudié les tendances séculaires de l'incidence de l'AVC ainsi que la morbidité et la mortalité hospitalière dans la région sanitaire de Calgary. **Méthodes:** Tous les patients admis à l'hôpital dans la région sanitaire de Calgary entre 1994 et 2002 et dont le dossier fait mention d'un diagnostic d'AVC (code ICD-9 ou ICD-10) à la sortie de l'hôpital ont été inclus dans l'étude. Les patients ayant subi un AVC en milieu hospitalier ont également été inclus. Des données sur le type d'AVC, la date d'admission, l'âge, le genre, le statut à la sortie (décès, congé), et les complications hospitalières (pneumonie, embolie pulmonaire, thrombose veineuse profonde) ont été colligées. L'équation de Poisson et l'analyse de régression linéaire simple ont été utilisées pour modéliser les tendances séculaires par type d'AVC et groupe d'âge et pour extrapoler les tendances futures. **Résultats:** De 1994 à 2002, 11 642 AVC ont été observés. 9 879 patients (84,8 %) sont sortis de l'hôpital vivant, 1 763 (15,1 %) sont morts à l'hôpital et 591 (5,1 %) ont présenté des complications pendant leur hospitalisation, soit une pneumonie, une embolie pulmonaire ou une thrombose veineuse profonde. La mortalité hospitalière et le taux de complications étaient plus élevés dans l'AVC hémorragique. Pendant l'étude, le taux d'admission est demeuré stable. Cependant le nombre total d'admissions pour AVC a augmenté significativement ($p = 0,012$) à cause de l'augmentation des admissions pour hémorragie intracérébrale ($p = 0,021$) et pour AVC ischémique ($p = 0,011$). Les taux d'hémorragie sous-arachnoïdienne ont diminué. La mortalité hospitalière due à l'AVC en général a diminué à cause d'une diminution de la mortalité due à l'AVC ischémique, à l'hémorragie intracérébrale et à l'hémorragie sous-arachnoïdienne. **Conclusions:** Bien que l'incidence de l'AVC ajustée pour l'âge ait été stable de 1994 à 2002, on a observé une augmentation importante du nombre absolu d'admissions pour AVC et une diminution de la mortalité hospitalière proportionnelle. Des recherches sur les changements temporels dans la sévérité de l'AVC pourront aider à comprendre les causes de la diminution des taux de mortalité hospitalière due à l'AVC.

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The Calgary Health Region provides tertiary care to all of southern Alberta. Over the past ten years, the region has experienced rapid population growth. During this time, treatment of stroke has undergone a number of improvements, including centralization of stroke services, the introduction of stroke thrombolysis in Calgary in 1996, and the opening of a designated in-patient stroke unit at the Foothills hospital in 2001.

Epidemiological evidence since 1950 suggests that the age-adjusted incidence of stroke is declining over time.¹ However,

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stroke incidence rates may have stabilized²⁻⁴ or even increased^{5,6} over the last two decades and the rising proportion of elderly in western societies suggests that a larger number of overall strokes will occur despite declining or stable incidence.⁷

Although rates of morbidity and mortality from ischemic heart disease have declined in Canada⁸⁻¹⁰ and other industrialized nations,¹¹⁻¹⁴ these trends have not been consistently reported for stroke.^{15,16} A recent World Health Organisation study among nine countries confirms that increasing or decreasing stroke mortality is directly attributable to changes in the case fatality rate rather than changing event rates.¹⁷ Population-based data suggest that a decline in stroke mortality, also beginning in the 1950s,¹⁸ has stabilized over the last two decades.¹⁹ In-hospital morbidity from stroke, however, is less well-quantified and patterns over time are not known.

The purpose of this study was to examine time trends in stroke occurrence and in-hospital morbidity and mortality in Calgary.

Methods

Administration in the Calgary Health Region is coordinated such that hospital discharge data on all patients admitted to hospitals in the region is amassed centrally. Administrative data from a nine-year period beginning January 1, 1994 and ending December 31, 2002 were examined. This period was chosen because data were centralized from this time forward for the Calgary Health Region. Only administrative records from adult facilities were used in this analysis. All patients with a discharge diagnosis code (International Classification of Diseases, 9th Revision—Clinical Modification and [ICD-9-CM]) of 36231, 430, 431, 43300 to 43391, 43400 to 43491, 4350 to 4359, 436, or 4376 or an ICD-10 code of G450, G451, G452, G453, G458, G459, H341, I600 to I609, I610 to I619, I630 to I639 or I64 were included. Consistent with our previous work, the first diagnosis position was chosen to increase the probability that the patient had suffered a stroke on the date of admission.^{20,21} In-hospital strokes were also included. Date of admission, date of inpatient discharge, hospital, age, gender, discharge disposition (died, discharged, signed out), and in-hospital complications (pneumonia, pulmonary embolism (PE) and deep venous thrombosis (DVT)) were recorded. Complications were

identified using the ICD coding flags for in-hospital complications. Gender differences were not evaluated in this analysis.

Population in the Calgary Health Region is recorded by Statistics Canada every five years using national census data. Yearly population changes were estimated using the exponential growth formula and recorded population values from 1996 and 2001 census data for the Calgary Health Region. We assumed that hospital separations for stroke were a reasonable estimate of stroke occurrence rates on a population basis and therefore calculated rates compared to the Calgary population. Stroke occurrence rates were age-standardized to the 2001 Canadian population using the direct method and expressed in terms of events per 100 000 person-years. Poisson regression was used to assess rate changes over time. However, because modeling was not substantially different using simple linear regression, the latter method was used to test and plot time trends of stroke occurrence by stroke type and age-group and to extrapolate future time trends when possible. Venous sinus/cortical vein thrombosis (VS/CVT) rates were so rare that year over year rates were not examined.

RESULTS

Over the nine years from 1994 to 2002, a total of 11642 admitted strokes were observed. Of these, 9879 patients were discharged or signed out (84.8%) and 1763 died in hospital (15.1%). There were 541 patients who developed complications in hospital from pneumonia (4.7%) and 50 patients suffered complications from PE or DVT (0.4%). There were 739 subarachnoid hemorrhages (SAH) (6.4% of all strokes), 8088 ischemic strokes (69.5%), 1717 transient ischemic attacks (TIA) (14.8%), 1084 intracerebral hemorrhages (ICH) (9.3%), and 14 VS/CVT (0.1%). 50.3% of patients were male. Age-adjusted stroke rates are shown in Table 1.

The average yearly in-hospital mortality rate for all strokes was 15.3%. The average yearly mortality for all ischemic strokes was 14.0%; TIA, 1.2%; ICH, 37.3%; SAH, 30.2%; VS/CVT, 7.4%. Both in-hospital mortality and complication rates were highest for hemorrhages. Mean rates of pneumonia and PE or deep-vein thrombosis were 8.4% and 1.0% for ICH, and 9.3%

Table 1: Age-Adjusted Stroke Admissions per 100,000 population

Year	ALL	AIS	VS/CVT	ICH	SAH	TIA
1994	156.6 (146.5-166.7)	104.9 (96.6-113.3)	0	11.1 (8.4-13.8)	9.8 (7.4-12.1)	30.9 (26.3-35.4)
1995	210.3 (199.0-221.7)	145.8 (136.3-155.4)	0.3 (0-0.7)	17.6 (14.3-20.9)	12.5 (9.8-15.1)	34.2 (29.5-38.8)
1996	186.9 (176.5-197.3)	130.6 (121.8-139.3)	0	18.5 (15.2-21.7)	11.7 (9.2-14.2)	26.2 (22.2-30.1)
1997	170.3 (160.7-180.0)	116.5 (108.5-124.5)	0	18.6 (15.4-21.8)	9.1 (7.1-11.2)	26.1 (22.3-29.9)
1998	167.8 (158.5-177.1)	119.2 (111.4-127.1)	0.1 (0-0.3)	16.4 (13.4-19.3)	10.2 (8.0-12.4)	21.9 (18.5-25.3)
1999	179.4 (170.1-188.8)	125.1 (117.3-132.9)	0.1 (0-0.4)	16.1 (13.3-19.0)	12.1 (9.8-14.5)	25.9 (22.4-29.5)
2000	162.5 (153.9-171.0)	117.6 (110.3-124.9)	0.2 (0-0.5)	14.8 (12.3-17.4)	8.8 (6.9-10.8)	21 (17.9-24.1)
2001	162.1 (153.8-170.4)	118.9 (111.7-126.1)	0.6 (0.1-1.0)	14.8 (12.3-17.3)	7.9 (6.1-9.7)	19.9 (17.0-22.9)
2002	145.5 (137.9-153.2)	100 (93.6-106.4)	0.2 (0-0.4)	14 (11.6-16.4)	6.0 (4.5-7.5)	25.3 (22.1-28.5)

ALL = all stroke; AIS = acute ischemic stroke; VS/CVT = venous sinus/cortical vein thrombosis; ICH = intracerebral hemorrhage; SAH = subarachnoid hemorrhage; TIA = transient ischemic attack.

Rates are standardized using the direct method to the 2001 Canadian population.

Table 2: Trends in In-hospital Stroke Complications

PE/DVT	Stroke type	1994	1995	1996	1997	1998	1999	2000	2001	2002
		% (95%CI)	% (95%CI)	% (95%CI)	% (95%CI)	% (95%CI)	% (95%CI)	% (95%CI)	% (95%CI)	% (95%CI)
	all	0 (0-0.4)	0 (0-0.3)	0.6 (0.2-1.2)	0.4 (0.1-1.0)	0.3 (0.09-0.8)	0.3 (0.08-0.7)	0.6 (0.2-1.1)	0.6 (0.3-1.2)	0.9 (0.5-1.6)
	AIS	0 (0.0-0.6)	0 (0-0.4)	0.6 (0.2-1.4)	0.2 (0.02-0.09)	0.3 (0.07-1.0)	0.1 (0.03-0.6)	0.4 (0.1-1.0)	0.3 (0.06-0.8)	0.7 (0.3-1.5)
	TIA	0 (0-2.0)	0 (0-1.7)	0 (0-2.1)	0 (0-2.0)	0 (0-2.25)	0 (0-1.8)	0.6 (0.01-3.1)	0 (0-2.1)	0.8 (0.1-3.0)
	ICH	0 (0-5.4)	0 (0-3.2)	0.8 (0.02-4.3)	0.8 (0.02-4.1)	0.8 (0.02-4.6)	1.6 (0.2-5.6)	0 (0-2.8)	2.2 (0.5-6.3)	2.9 (0.8-7.4)
	SAH	0 (0-5.3)	0 (0-4.0)	1.1 (0.02-6.1)	2.6 (0.03-0.09)	0 (0-4.2)	0.9 (0.02-5.1)	3.7 (0.8-10.3)	3.9 (0.8-10.8)	0 (0-5.6)
	VS/CVT	0	0	0	0	0	0	0	0	0
Pneumonia	all	4.5 (3.3-6.1)	4.8 (3.7-6.1)	4.8 (3.7-6.2)	4.3 (3.2-5.6)	4.5 (3.4-5.8)	5.0 (3.9-6.2)	4.6 (3.6-5.8)	4.7 (3.7-5.9)	4.5 (3.5-5.7)
	AIS	4.2 (2.8-6.1)	4.4 (3.2-6.0)	5.0 (3.7-6.7)	4.9 (3.5-6.6)	4.6 (3.3-6.2)	4.6 (3.3-6.0)	4.5 (3.3-6.0)	4.3 (3.2-5.7)	4.8 (3.6-6.4)
	TIA	0 (0-2.0)	0 (0-1.7)	0.6 (0.01-3.2)	0.6 (0.01-3.0)	0.6 (0.02-3.3)	0.5 (0.01-2.7)	0.6 (0.01-3.1)	1.7 (0.3-4.8)	0.8 (0.1-3.0)
	ICH	7.6 (2.5-16.8)	10.7 (5.7-18.0)	6.3 (2.8-12.1)	6.1 (2.7-11.7)	7.5 (3.5-13.8)	13.4 (8.0-20.6)	10.0 (5.4-16.5)	6.6 (3.1-12.2)	7.4 (3.6-13.1)
	SAH	16.4 (8.5-27.4)	12.2 (6.3-20.8)	9.1 (4.0-17.1)	3.9 (0.8-11.0)	7.0 (2.6-14.6)	7.5 (3.3-14.2)	6.1 (2.0-13.7)	14.1 (7.3-23.8)	7.8 (2.6-17.3)
	VS/CVT	0	0	0	0	0	0	0	0	0
In-hospital death	All	16.7 (14.3-19.2)	15.0 (12.3-17.1)	17.2 (15.2-19.4)	18.0 (15.9-20.3)	16.6 (14.6-18.8)	13.6 (11.8-15.5)	13.8 (12.0-15.7)	13.9 (12.2-15.8)	12.9 (11.1-14.8)
	AIS	17.4 (14.5-20.7)	14.4 (12.1-16.8)	15.2 (12.8-17.7)	13.1 (12.7-17.7)	13.6 (12.4-17.1)	11.6 (9.7-13.8)	12.2 (10.2-14.4)	12.5 (10.6-14.6)	12.9 (10.9-15.2)
	TIA	0.6 (0.01-3.0)	1.9 (0.5-4.7)	1.2 (0.1-4.2)	1.7 (0.3-4.7)	1.2 (0.1-4.4)	1.5 (0.3-4.2)	0.6 (0.01-3.1)	1.7 (0.3-4.8)	0.4 (0.01-2.3)
	ICH	34.9 (2.4-47.6)	33.0 (24.4-42.6)	40.5 (31.8-49.6)	48.1 (39.3-57.0)	44.2 (35.1-53.5)	35.4 (27.2-44.4)	35.4 (27.2-44.2)	34.6 (26.6-43.2)	29.4 (21.9-37.8)
	SAH	35.8 (24.5-48.5)	35.8 (20.8-40.6)	30.0 (25.3-46.1)	35.2 (25.7-48.1)	36.4 (18.8-38.6)	27.9 (20.6-38.5)	29.0 (18.7-39.1)	28.1 (15.3-35.4)	24.4 (15.0-37.4)
	VS/CVT	0	50.0 (1.2-98.7)	0	0	0	0	0	16.7 (0.4-64.1)	0

PE/DVT = pulmonary embolus/deep venous thrombosis; AIS = acute ischemic stroke; TIA = transient ischemic attack; ICH = intracerebral hemorrhage; SAH = subarachnoid hemorrhage; VS/CVT = venous sinus/cortical vein thrombosis

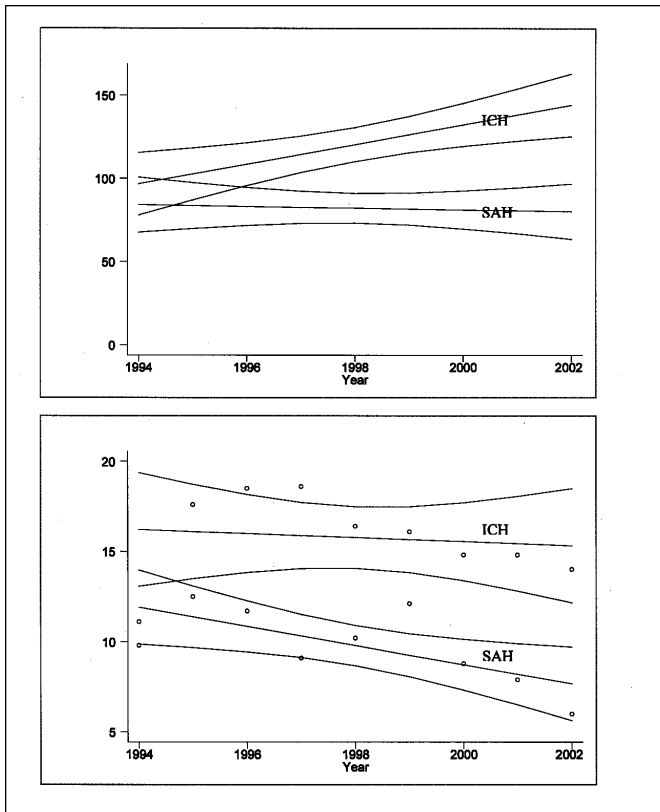


Figure 1: Trends in Hemorrhage

Panel A shows absolute numbers of stroke admissions by hemorrhage type. The curved lines represent 95% confidence bands around the regression lines. The rising absolute numbers of ICH is statistically different from 0 ($p=0.021$).

Panel B shows age-adjusted stroke occurrence rates per 100 000 population. Only the age adjusted SAH rate is statistically significantly declining over time ($p=0.042$).

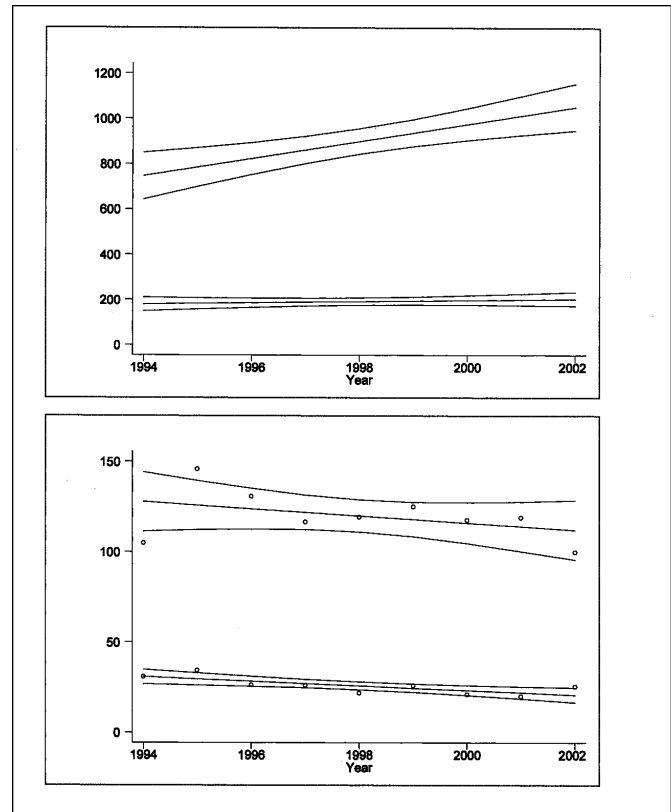


Figure 2: Trends in Ischemic Stroke and TIA

Panel A: The top line represents the sharply rising number of ischemic strokes admitted to hospital annually. The rising slope is significantly different from 0 ($p=0.011$). The lower line represents the number of TIAs admitted to hospital.

Panel B: The top line represents the age-adjusted rate of ischemic stroke admissions per 100000 population. The rate is unchanged over time ($p=0.288$). The bottom line represents the age-adjusted rate of TIA admissions per 100000 population. The rate shows decreasing TIA admissions ($p=0.020$).

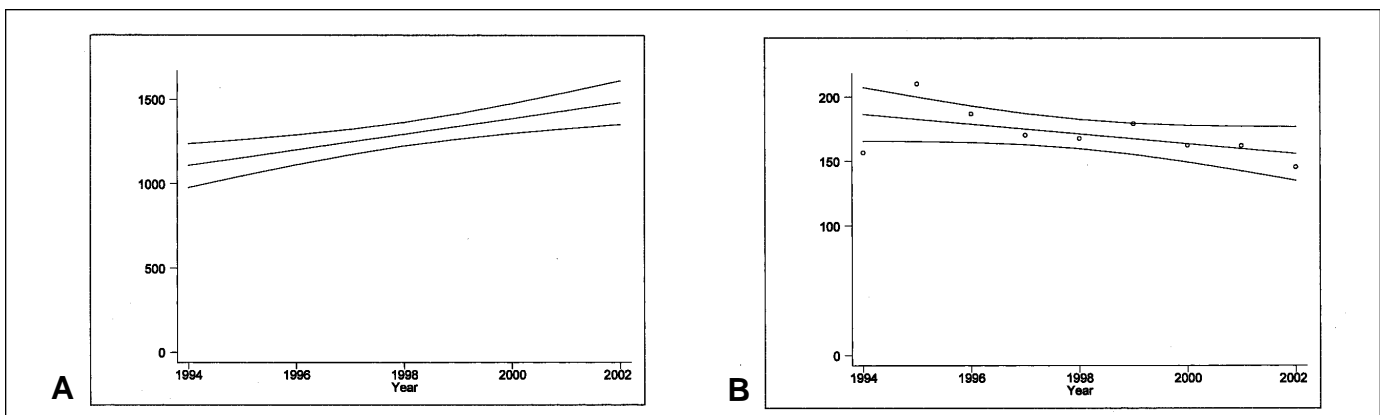


Figure 3: Trends in All Stroke

Panel A shows the total numbers of stroke admissions sharply rising over time ($p=0.012$) due to the combined increases in the ICH and acute ischemic stroke, while TIA, SAH remain stable.

Panel B shows the age-adjusted stroke admissions rates. These are stable over time ($p=0.125$).

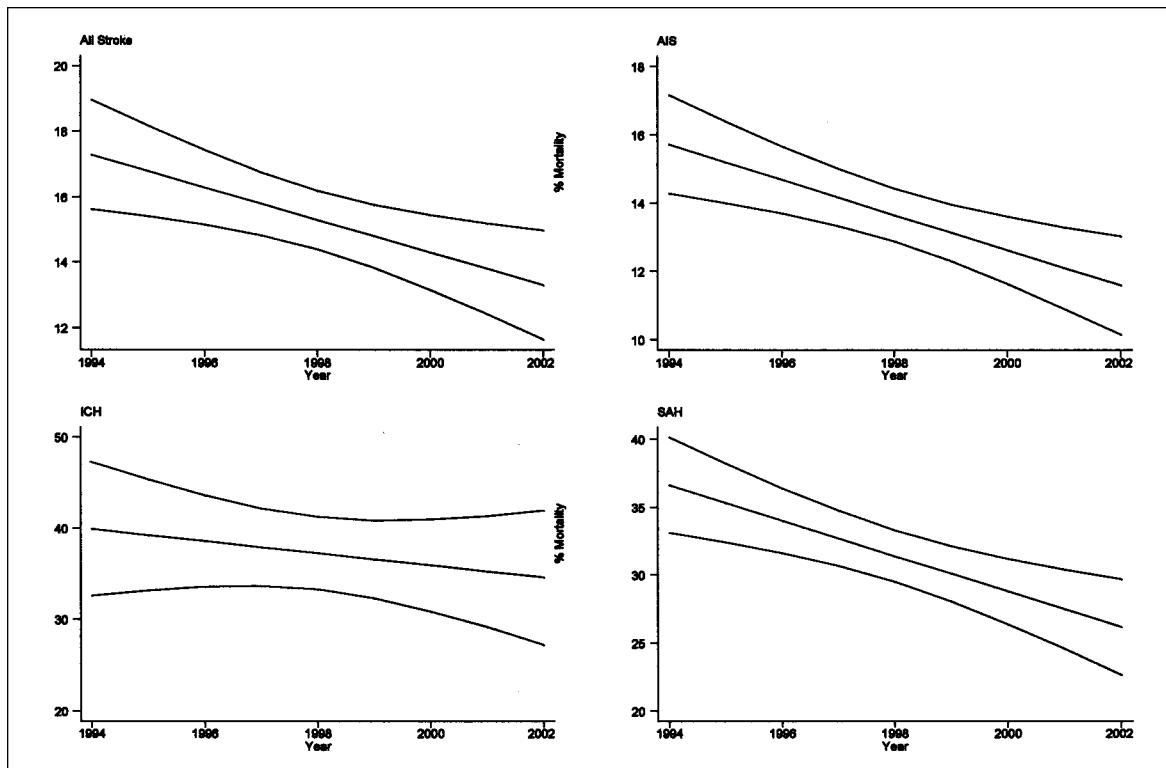


Figure 4: Trends in Stroke Percent In-hospital Mortality
Declining in-hospital mortality by stroke type. Clockwise from the top left are: All stroke, AIS, SAH, ICH.

and 1.4% for SAH. Corresponding rates for ischemic stroke were 4.6% and 0.3%; 0.6% and 0.2% for TIA. There were no instances of pulmonary thromboembolism/DVT or pneumonia associated with VS/CVT.

Age-adjusted rates of ICH admissions remained stable while SAH rates declined ($p=0.042$) (Figure 1, panel B). The absolute number of ICH admitted, however, increased overall ($p=0.021$) while numbers of SAH remained stable from year to year (Figure 1, Panel A).

Over the last nine years, age-adjusted admission rates for ischemic stroke have remained stable (Figure 2, Panel B). However, the absolute number of ischemic strokes admitted has increased sharply ($p=0.011$) (Figure 2, Panel A). Age-adjusted TIA admission rates have remained stable as well (Figure 2, Panel B), while the absolute number of TIA admissions to hospital has decreased slightly ($p=0.063$) (Figure 2, Panel A).

Overall, the rate of stroke admissions in the Calgary Health Region has remained stable over the past nine years ($p=0.125$) (Figure 3, Panel B). However, total numbers of stroke admissions to hospital have faced a significant increase ($p=0.012$), due to the combination of increases in ICH and ischemic stroke admissions. Linear projections of this rate into the future imply an average increase of 47 strokes per year (95%CI 14.0-79.6). With a conservatively estimated average length of stay of seven days per stroke event, every year an additional inpatient bed-day will be required to accommodate the increasing number of strokes in Calgary.

Although stroke admission rates remain constant, in-hospital stroke mortality has experienced an overall decline (Table 2, Figure 4). This is due to a decline in mortality from ischemic stroke, ICH and SAH (Figure 4). Intracerebral hemorrhages experienced a marked decline after 1997 and, overall, the decline is not statistically significant, while ischemic stroke mortality has increased slightly since 1999. Transient ischemic attack mortality has remained stable over the period of study.

In-hospital complication rates from DVT/PE have increased overall, with slight increases in hemorrhage cases and no change in rates seen amongst cases of ischemic stroke and TIA. Overall complication rates from pneumonia have remained stable, with an increase seen in TIA and a decline in SAH.

DISCUSSION

Our data support corresponding data from western countries showing a declining stroke rate per population. However, an aging baby boomer demographic overwhelms this trend resulting in rapidly increasing utilization for stroke. This is expected and predicted. Because stroke is the leading cause of adult acquired disability and costs the Canadian economy over \$3 billion dollars annually,²² this observation has significant implications for Canadian hospitals and health systems.

In a previous study two decades ago using similar methodology to examine the entire Canadian population, age-adjusted rates of total stroke and stroke by each type were higher

than our current numbers, particularly for ICH.²³ The magnitude of decline was much less for acute ischemic stroke. This suggests that declines in stroke rates are actually occurring over time and that these declines are stroke type specific. One less well-explained phenomenon is the declining rate of SAH. This was also observed in a previous 10-year Canadian study where the age-adjusted incidence of SAH declined over time and was nearly double what we report from Calgary.²⁴ Absolute numbers of SAH may have remained stable over time in Calgary due to migration of working-age adults to the Calgary region. Subarachnoid hemorrhage peaks in the fifth decade of life and its most modifiable risk factor is smoking.²⁵ Perhaps, as the baby boomer generation ages beyond the peak incidence, the number of SAH seen in Canadian hospitals will decline. Equally, declining rates of cigarette use in the population, particularly in the working adult population, may be contributing.²⁶ Finally, neurosurgeons and endovascular neuroradiologists are able to discover and treat intracranial aneurysms before they rupture, potentially also leading to a declining rate of SAH.²⁷⁻²⁹ Since 1995, endovascular coiling for treatment of ruptured and unruptured intracranial aneurysm has become a widely used technique with 12000 patients treated worldwide with Guglielmi detachable coil in 1998;³⁰ these numbers will likely increase following the recent publication of positive results from the International Subarachnoid Aneurysm Trial (ISAT).³¹

The decline in in-hospital deaths over time is a particularly encouraging observation. This is true for all stroke types but is most relevant for the most fatal stroke types – SAH and ICH. This trend has been previously observed in Quebec.³² Ongoing improvements in pre-hospital care, emergency and neurocritical care are likely reasons for this observation, since no major therapeutic advances have been made in the specific surgical or medical care of ICH despite promising ongoing trials.

The fall in acute ischemic stroke mortality corresponds with development of active stroke intervention services in Calgary. While stroke thrombolysis was introduced in 1996 in Calgary, it has been applied to approximately 10% of patients annually and is, therefore, unlikely to be the major cause in the continuing fall in stroke mortality. Further, thrombolysis is a treatment that has not been shown to reduce stroke-related mortality but, instead, to reduce morbidity.^{33,34} More importantly, stroke services have been organized culminating in the opening of a 14-bed stroke unit in the city. Stroke unit care results in one less death for every 16 patients treated on a stroke unit.³⁵ It is this organization of stroke care that may be the key factor in the falling death rates.

Neurological morbidity cannot be measured from administrative data. It is, nevertheless, probably more important than mortality. While declining mortality is assumed to imply declining morbidity, this is not necessarily true. If mortality is falling only to leave an increasing proportion of patients badly disabled, few would argue that this is a success because a majority of stroke survivors will report that they would prefer to be dead than badly disabled.^{36,37} This is an important future question for stroke epidemiological research.

Complication rates for DVT/PE and pneumonia have been static. Pneumonia rates remain high, particularly in hemorrhagic forms of stroke and this may be due to the higher rate of intubation and acute intensive care required for these patients. Symptomatic DVT/PE rates are very low, making it difficult to

anticipate cases. Many DVTs may go undetected after stroke; however, PE accounts for a substantial minority of early deaths after stroke and may not be associated with clinically evident DVT antemortem.³⁸⁻⁴²

Our analysis has limitations. Because almost all patients with stroke are admitted to the hospital in Calgary,⁴³ we assumed that hospital-based administrative data provide a good approximation of stroke occurrence. Nevertheless, although stroke tends to be well-coded compared to other medical conditions, the use of administrative data may have some limitations in diagnostic accuracy. Given that no distinction was made during the collection of administrative data, we considered both recurrent and first-ever stroke and we included in-hospital stroke. Changes in admission rates for stroke may also have been affected by changing thresholds for admission. While this is unlikely to have affected ICH, SAH or disabling ischemic stroke, it may well be important for minor ischemic stroke and TIA. It is interesting to note that the rate of admission for TIA has been slowly falling.

It is possible that our assessment of in-hospital complications may be biased by underreporting due to the reduced sensitivity of ICD-9 diagnosis of cardiovascular and pulmonary complications.⁴⁴⁻⁴⁶ Most importantly, stroke severity is an important unmeasured confounder and we could not measure it from administrative data. Because stroke severity is the most important predictor of outcome, our observation of declining mortality could be entirely or partly explained by a fall in the average severity of stroke. There is evidence to support biological reasons why stroke severity may be declining, including suggestive evidence for improving blood pressure control and treatment,⁴⁷ declining cigarette use,^{26,48} and increased use of statin agents.⁴⁹ Further investigation of trends in stroke severity as an explanation for declining stroke mortality is warranted.

Age-adjusted stroke incidence is falling but the absolute number of strokes is increasing in Calgary. This will result in increased utilization of health care resources over time. The increasing absolute numbers of stroke patients in Calgary are a model that can be used in administrative planning.

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