ORIGINAL ARTICLE

Ten-year trends in stroke admissions and outcomes in Canada

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ABSTRACT: ***Background:*** We analyzed a 10-year stroke administrative dataset to examine trends in admissions, mortality, and discharge destination in Canada. ***Methods:*** We conducted an analysis of hospital administrative data from April 1st 2003 to March 31st 2013 from the Canadian Institute of Health Information's Discharge Abstract Database. Ten-year trends for population-based age- and sex-standardized admission rates were calculated. We reviewed 10-year trends in absolute stroke admissions for differences between provinces and age groups. Stroke 30-day in-hospital mortality rates were calculated and adjusted for sex, age, stroke type and comorbidities. We documented changes in discharge location for ischemic and hemorrhagic stroke patients discharged from acute care. ***Results:*** The rate of hospital admissions has declined from 140.2 to 117.5 (per 100,000 people). The number of absolute stroke admissions within provinces increased in Alberta and British Columbia (21.7% and 16.2% respectively). The proportion of stroke patients aged 40-69 years old increased by 4.8% ($p < 0.0001$) over the 10 years, whereas the proportion aged over 70 decreased by 4.9% ($p < 0.0001$). Risk-adjusted 30-day in-hospital mortality decreased from: 18.5% to 14.9% for all strokes; 15.2% to 12.1% for ischemic strokes; 35.6% to 29.7% for intracerebral hemorrhage; and 25.1% to 18.0% for subarachnoid hemorrhage. The absolute increase in patients requiring inpatient and outpatient support increased by 4% ($p < 0.0001$). ***Conclusion:*** The rate of admissions for stroke is decreasing but there is an increase in stroke admissions for younger patients. In-hospital mortality is decreasing; fewer patients are going directly home without services and more are requiring support services.

RÉSUMÉ: Tendances décennales des hospitalisations et des résultats concernant les accidents vasculaires cérébraux au Canada. ***Contexte:*** Nous avons analysé les données administratives décennales des hospitalisations, de la mortalité et de la destination au moment du congé hospitalier des patients atteints d'accidents vasculaires cérébraux (AVC) au Canada. ***Méthode:*** Nous avons analysé les données administratives hospitalières du 1er avril 2003 au 31 mars 2013 contenues dans la base de données de l'Institut canadien d'information sur la santé. Nous avons calculé les tendances décennales pour les taux d'admission selon la population, standardisés pour l'âge et le sexe. Nous avons revu les tendances des taux d'hospitalisation pour AVC pour détecter des différences entre les provinces et les groupes d'âges. Les taux de mortalité hospitalière due à l'AVC dans les 30 premiers jours ont été calculés et ajustés pour le sexe, l'âge, le type d'AVC et les comorbidités. Nous avons documenté les changements dans la destination au congé hospitalier pour les patients atteints d'un AVC ischémique et d'un AVC hémorragique. ***Résultats:*** Le taux d'hospitalisation a diminué, passant de 140,2 à 117,5 (par 100,000 habitants). Le nombre absolu d'hospitalisations pour AVC dans chaque province a augmenté en Alberta et en Colombie Britannique (21,7% et 16,2% respectivement). La proportion de patients de 40 à 69 ans atteints d'un AVC a augmenté de 4,8% ($p < 0,0001$) au cours de ces 10 ans alors que la proportion de ceux de plus de 70 ans a diminué de 4,9% ($p < 0,0001$). La mortalité hospitalière dans les 30 jours de l'admission, ajustée pour le risque, a diminuée de 18,5% à 14,9% pour tous les AVC ; de 15,2% à 12,1% pour les AVC ischémiques; de 35,6% à 29,7% pour les hémorragies intracérébrales et de 25,1% à 18,0% pour les hémorragies sous-arachnoïdiennes. L'augmentation absolue du nombre de patients nécessitant un soutien hospitalier et extrahospitalier a augmenté de 4% ($p < 0,0001$). ***Conclusion:*** Le taux d'hospitalisation pour AVC est en décroissance, mais il y a une augmentation des admissions pour un AVC de patients plus jeunes. La mortalité hospitalière diminue; moins de patients retournent directement à leur domicile sans services d'appoint et un plus grand nombre de patients a besoin de tels services.

Keywords: Epidemiology, stroke, trends, patient admission, quality of care, mortality

doi:10.1017/cjn.2015.20 Can J Neurol Sci. 2015; 42: 168-175

Stroke mortality is decreasing in Western European countries,[1-4] the United States of America (USA)[4] and globally.[1] The incidence of stroke is also declining or stable in the USA,[6] China,[8] Japan,[9,10] Denmark,[11] Finland,[3] France,[4] England[12] and New Zealand.[13] Conversely, stroke mortality is increasing in Eastern European and Central Asian countries.[14] Stroke demographics are

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Received September 3, 2014. Final Revisions Submitted December 23, 2014.

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Table 1: ICD-10 Codes Used

Acute Stroke Main Category[+]	ICD-10 codes	Definition
Acute Ischemic stroke	163.x[a]	Cerebral infarction
	164.x	Stroke, not specified as hemorrhage or infarction
	H34.1	Central retina artery occlusion
Subarachnoid hemorrhage	160.x[b]	Subarachnoid hemorrhage
Intracerebral hemorrhage	161.x	Intracerebral hemorrhage

[+]Includes all patients where there is a Prefix Q for query or suspected diagnosis
[a]Excludes I63.6, cerebral infarction due to cerebral venous thrombosis, nonpyogenic
[b]Excludes I60.8, other subarachnoid hemorrhage (Meningeal hemorrhage and rupture of cerebral arteriovenous malformation)

changing with the aging of western populations.[15,16] Yet, stroke continues to be a significant burden, as the second leading cause of death worldwide.[17] Not all stroke mortality data from these studies are equivalent, as some used all-cause mortality per 100,000,[1,5,6] others 28-day mortality after first stroke,[3,4] and others used 30-day, 1-year and 5-year mortality for first stroke hospitalization.[2] Where trends in mortality were reviewed by stroke types, reductions in both ischemic and hemorrhagic stroke mortality were observed.

Reduced rates of stroke in-hospital mortality may have an effect on discharge destination, and consequently the need for support services. For example, more patients may require inpatient rehabilitation or long-term care as more stroke patients are surviving. Factors such as hospital type, patient demographics, and stroke type have been shown to affect discharge destination.[18,19] Trends in discharge destination reflect improvement in acute stroke care but suggest that rehabilitative services and long-term care will require ongoing improvement to respond to an increase in demand.

Table 2: Absolute hospital admissions for stroke for Canada by Province

Province	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
All Strokes										
Newfoundland	718	641	715	708	715	701	643	691	652	658
Prince Edward Island	227	192	183	160	183	177	189	187	179	218
Nova Scotia	1157	1211	1284	1042	1141	1198	1167	1286	1262	1253
New Brunswick	1153	1062	1131	1036	1028	998	959	1014	1003	1091
Quebec	–	–	–	–	–	9007	8837	9194	9070	–
Ontario	14514	14408	14591	14221	14208	14241	14456	14779	14522	14873
Manitoba	–	1503	1528	1408	1508	1463	1399	1474	1439	1523
Saskatchewan	1439	1428	1384	1483	1334	1376	1339	1330	1372	1358
Alberta	2966	2984	3071	3068	3037	3154	3158	3262	3565	3609
British Columbia	4857	5042	5014	4964	4828	5090	5049	5480	5570	5646
All Territories	43	50	65	48	60	68	78	68	48	66
Ischemic Stroke										
Newfoundland	579	532	596	600	600	575	552	585	512	507
Prince Edward Island	203	176	155	137	166	158	160	171	167	195
Nova Scotia	980	1037	1087	862	965	995	975	1063	1055	1054
New Brunswick	998	913	938	849	832	822	786	831	789	887
Quebec	–	–	–	–	–	7020	6812	7196	7052	–
Ontario	11806	11732	11809	11463	11421	11458	11530	11869	11658	11940
Manitoba	–	1231	1273	1131	1221	1204	1130	1195	1161	1248
Saskatchewan	1257	1215	1170	1236	1150	1152	1128	1107	1145	1155
Alberta	2428	2417	2503	2482	2524	2518	2588	2695	2911	2966
British Columbia	3881	4016	3935	3938	3758	4024	4016	4345	4419	4479
All Territories	39	42	52	37	48	57	69	56	44	56

Table 2. *Continued*

Province	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012
Intracerebral Hemorrhagic Stroke (ICH)										
Newfoundland	98	77	83	75	78	87	66	72	92	114
Prince Edward Island	21	15	26	19	15	16	27	14	9	22
Nova Scotia	95	103	136	117	122	139	135	150	131	146
New Brunswick	98	107	140	131	140	122	129	139	155	147
Quebec	–	–	–	–	–	1345	1413	1390	1405	–
Ontario	1982	1891	1902	1887	1940	1883	2047	1978	1971	2060
Manitoba	–	180	172	179	204	166	169	181	183	182
Saskatchewan	126	141	163	172	129	153	144	159	158	141
Alberta	347	347	369	383	310	429	385	354	460	428
British Columbia	654	699	719	694	702	716	699	732	792	822
All Territories	1	2	7	6	8	5	3	8	1	4
Subarachnoid Hemorrhagic Stroke (SAH)										
Newfoundland	41	32	36	33	37	39	25	34	48	37
Prince Edward Island	3	1	2	4	2	3	2	2	3	1
Nova Scotia	82	71	61	63	54	64	57	73	76	53
New Brunswick	57	42	53	56	56	54	44	44	59	57
Quebec	–	–	–	–	–	642	612	608	613	–
Ontario	726	785	880	871	847	900	879	932	893	873
Manitoba	–	92	83	98	83	93	100	98	95	93
Saskatchewan	56	72	51	75	55	71	67	64	69	62
Alberta	191	220	199	203	203	207	185	213	194	215
British Columbia	322	327	360	332	368	350	334	403	359	345
All Territories	3	6	6	5	4	6	6	4	3	6

We reviewed 10-year trends in stroke occurrence and mortality for Canada. Specifically, we looked at stroke admissions across Canada by province and age group and stroke admission rates for all stroke types. We also separately reviewed 30-day in-hospital mortality for all strokes, ischemic strokes, intracerebral hemorrhagic strokes, and subarachnoid hemorrhagic strokes. We reviewed discharge destination for all strokes, ischemic strokes and hemorrhagic strokes discharged alive from acute care.

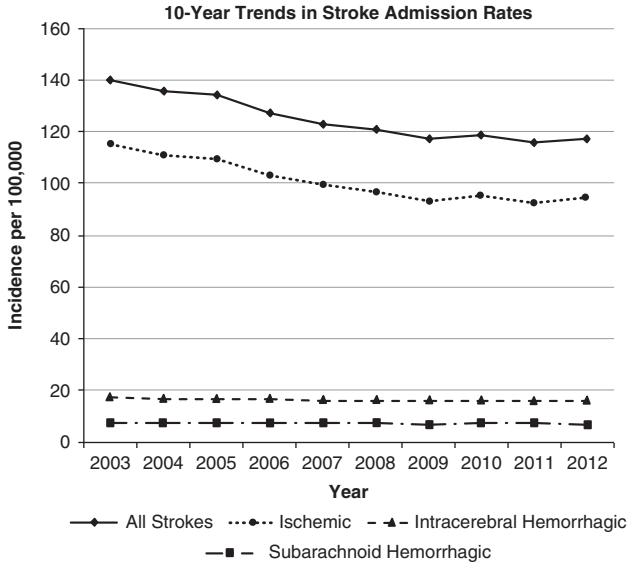

Figure 1: *10-year trends stroke admission risk adjusted rates (incidence per 100,000 population) for all stroke, ischemic stroke, intracerebral hemorrhagic stroke, and subarachnoid hemorrhagic stroke*

Methods

We conducted an analysis of all stroke patients admitted to a hospital for acute care in Canada. Data are from the Canadian Institutes for Health Information (CIHI). The population of Canada in 2013 was 35,158,304 compared to 31,641,630 in 2003.[20] Canada has a universal healthcare system, where all Canadian citizens and permanent residents have access to hospital and physician care. Health services are administered by each of its ten provinces and three territories. The CIHI's Discharge Abstract Database (DAD) contains demographic, administrative and clinical data (including deaths, sign-outs and transfers) on all inpatient hospital discharges. All hospitals in Canada (with the exception of Quebec) are required to report to the DAD; Quebec reports their data through a different process.[21] Analysis of hospital chart coding in teaching and community hospitals in Canada showed excellent positive predictive value (85% for ischemic stroke, 98% for intracerebral hemorrhagic stroke, and 91% for subarachnoid hemorrhagic stroke) with a Kappa statistic (as a measure of agreement between coder and researcher) of 0.89 for International

Table 3: Number (Percent) of Stroke Admissions per Age Group

AGE	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	
00 to 01	20 (0.1%)	32 (0.1%)	34 (0.1%)	34 (0.1%)	32 (0.1%)	28 (0.1%)	38 (0.1%)	28 (0.1%)	15 (0%)	8 (0%)	
01 to 19	80 (0.3%)	82 (0.3%)	94 (0.3%)	80 (0.3%)	88 (0.3%)	118 (0.3%)	107 (0.3%)	105 (0.3%)	92 (0.2%)	63 (0.2%)	
20 to 29	108 (0.4%)	137 (0.5%)	138 (0.5%)	144 (0.5%)	181 (0.6%)	229 (0.6%)	191 (0.5%)	185 (0.5%)	200 (0.5%)	176 (0.6%)	
30 to 39	372 (1.4%)	406 (1.4%)	481 (1.7%)	392 (1.4%)	375 (1.3%)	558 (1.5%)	517 (1.4%)	527 (1.4%)	541 (1.4%)	430 (1.4%)	
40 to 49	1172 (4.3%)	1374 (4.8%)	1476 (5.1%)	1441 (5.1%)	1470 (5.2%)	1866 (5%)	1918 (5.1%)	1988 (5.1%)	1912 (4.9%)	1387 (4.6%)	
50 to 59	2557 (9.4%)	2766 (9.7%)	2994 (10.3%)	2850 (10.1%)	2974 (10.6%)	4086 (10.9%)	4174 (11.2%)	4445 (11.5%)	4459 (11.5%)	3595 (11.9%)	
60 to 69	4380 (16.2%)	4467 (15.7%)	4516 (15.6%)	4626 (16.4%)	4768 (17%)	6620 (17.7%)	6545 (17.6%)	6992 (18%)	7133 (18.4%)	5563 (18.4%)	
70 to 79	8134 (30%)	8447 (29.6%)	8191 (28.3%)	7661 (27.2%)	7598 (27.1%)	10066 (26.9%)	9700 (26%)	9948 (25.7%)	9771 (25.3%)	7499 (24.8%)	
80 to 89	8222 (30.4%)	8704 (30.5%)	8833 (30.5%)	8714 (31%)	8383 (29.9%)	11003 (29.4%)	11135 (29.9%)	11304 (29.2%)	11243 (29.1%)	8852 (29.2%)	
90 +	2029 (7.5%)	2106 (7.4%)	2209 (7.6%)	2196 (7.8%)	2173 (7.7%)	2899 (7.7%)	2949 (7.9%)	3243 (8.4%)	3316 (8.6%)	2722 (9%)	
Total	27074	28521	28966	28138	28042	37473	37274	38765	38682	30295	
All Stroke											**p**
00 to 39	580 (2.1%)	657 (2.3%)	747 (2.6%)	650 (2.3%)	676 (2.4%)	933 (2.5%)	853 (2.3%)	845 (2.2%)	848 (2.2%)	677 (2.2%)	0.128
40 to 69	8109 (30%)	8607 (30.2%)	8986 (31%)	8917 (31.7%)	9212 (32.9%)	12572 (33.5%)	12637 (33.9%)	13425 (34.6%)	13504 (34.9%)	10545 (34.8%)	< 0.0001
Over 70	18385 (67.9%)	19257 (67.5%)	19233 (66.4%)	18571 (66%)	18154 (64.7%)	23968 (64%)	23784 (63.8%)	24495 (63.2%)	24330 (62.9%)	19073 (63%)	<0.0001
Ischemic Stroke											**p**
00 to 39	321 (1.4%)	384 (1.6%)	408 (1.7%)	395 (1.7%)	382 (1.7%)	529 (1.8%)	503 (1.7%)	486 (1.6%)	498 (1.6%)	419 (1.7%)	0.563
40 to 69	5967 (26.9%)	6272 (26.9%)	6582 (28%)	6524 (28.7%)	6814 (30%)	9235 (30.8%)	9229 (31%)	9963 (32%)	10048 (32.5%)	7906 (32.3%)	<0.0001
Over 70	15883 (71.6%)	16655 (71.4%)	16528 (70.3%)	15816 (69.6%)	15489 (68.3%)	20219 (67.4%)	20014 (67.3%)	20664 (66.4%)	20367 (65.9%)	16162 (66%)	<0.0001
Intracerebral hemorrhagic Stroke											**p**
00 to 39	122 (3.6%)	130 (3.6%)	170 (4.6%)	131 (3.6%)	136 (3.7%)	165 (3.3%)	176 (3.4%)	186 (3.6%)	157 (2.9%)	124 (3%)	0.002
40 to 69	1158 (33.8%)	1211 (34%)	1264 (34%)	1212 (33.1%)	1253 (34.3%)	1739 (34.4%)	1831 (35.1%)	1792 (34.6%)	1862 (34.8%)	1497 (36.8%)	0.003
Over 70	2142 (62.6%)	2221 (62.4%)	2283 (61.4%)	2320 (63.3%)	2259 (61.9%)	3157 (62.4%)	3210 (61.5%)	3199 (61.8%)	3338 (62.3%)	2445 (60.1%)	0.084
Subarachnoid hemorrhagic Stroke											**p**
00 to 39	137 (9.3%)	143 (8.7%)	169 (9.8%)	124 (7.1%)	158 (9.2%)	239 (9.8%)	174 (7.5%)	173 (7%)	193 (8%)	134 (7.7%)	0.006
40 to 69	984 (66.4%)	1124 (68.2%)	1140 (65.9%)	1181 (67.9%)	1145 (67%)	1598 (65.8%)	1577 (68.2%)	1670 (67.5%)	1594 (66.1%)	1142 (65.6%)	0.481
Over 70	360 (24.3%)	381 (23.1%)	422 (24.4%)	435 (25%)	406 (23.8%)	592 (24.4%)	560 (24.2%)	632 (25.5%)	625 (25.9%)	466 (26.8%)	0.012

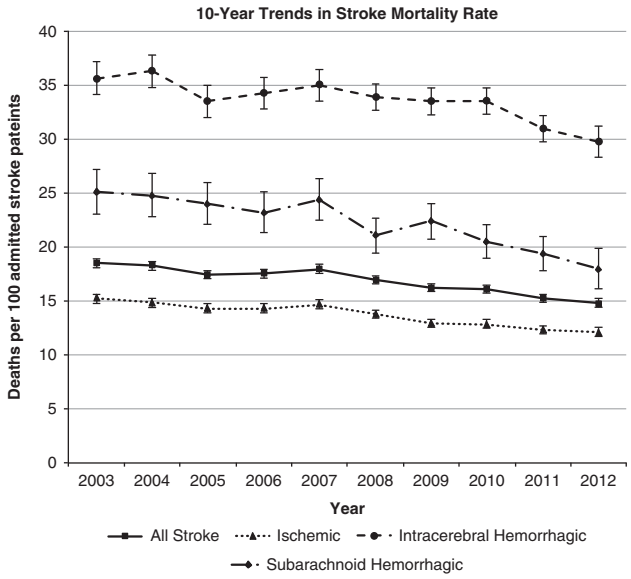

Figure 2: *10-year trends for 30-day in-hospital risk adjusted mortality rate (death per 100 admitted stroke patients) for all stroke, ischemic stroke, intracerebral hemorrhage, and subarachnoid hemorrhage. Error bars represent 95% Confidence Interval.*

Statistical Classification of Diseases and Related Health Problems, 10th Revision (ICD-10) coding.[22]

We used hospital administrative data from April 1st 2003 to March 31st 2013 from the DAD. All acute care facilities in all Canadian provinces contributed to the DAD with the exception of Manitoba (began in April 1st 2004) and Quebec (began in fiscal year 2008/09, ended in 2011/12). Therefore, all stroke patients admitted to hospital for acute care in Canada from April 1st 2003 to March 31st 2013 were included except for Manitoba and Quebec, who contributed only partially based on the above participation periods. Stroke patients were identified in our analysis using standardized case definitions based on ICD-10 codes for acute stroke, acute stroke plus transient ischemic attach (TIA), ischemic stroke, aneurysmal subarachnoid hemorrhage, and intracerebral hemorrhage. [Table 1]

Stroke admission rates were calculated and standardized using the direct method to the Canadian census. Ten-year trends were assessed using standardized rates. We used the Canadian census data (2001, 2006 and 2011) to estimate the population of 2003-2005, 2007-2010, and 2012; and adjusted 2011 data as the standard population. Stroke in-hospital mortality was defined as the risk-adjusted rate of all-cause in-hospital death occurring within 30 days of first admission to an acute care hospital with a diagnosis of stroke. Specifically, the numerator is the number of deaths from all causes occurring in hospital within 30 days of admission for stroke and the denominator is the total number of stroke episodes.[23] We included stroke that occurred during hospitalization as a complication of hospital admission for another reason. Risk-adjusted rates were adjusted for age, sex, stroke type (ischemic vs. hemorrhagic) and comorbid illness defined by the Charlson-Deyo index (0-1 vs. 2+). Discharge location categories are: home without services; home with services; inpatient rehabilitation or other acute care facility; complex continuing care; long term care; and other. All statistical comparisons were done using Cochran-Armitage Trend Test via SAS 9.3 (SAS Institute Inc., Cary, NC, USA).

Results

Stroke Admissions

We identified 323 230 stroke hospital admissions in Canada from April 2003 to March 2013. Table 2 shows the absolute stroke (all), ischemic stroke, intracerebral hemorrhage, and subarachnoid hemorrhage admissions in Canada over 10 years for each province. We note that absolute numbers of stroke admissions were stable or declining in most provinces except Alberta (AB) and British Columbia (BC), where an increase in stroke numbers was observed. In relative terms, there was an increase in stroke admissions in those provinces of 21.7% (AB) and 16.2% (BC). Similar trends were observed for ischemic stroke admissions with an increase of 23.3% in AB and 15.4% in BC. For intracerebral hemorrhage, increases over the 10-year period were present for all provinces with increases ranging from 50% (New Brunswick) to 4% (Ontario). For subarachnoid hemorrhage, increases were present in Ontario (20.2%), Saskatchewan (10.7%), AB (12.6%), and BC (7.1%).

Figure 1 shows the standardized risk-adjusted rates of stroke admissions over the 10-year period. The standardized rate of ischemic stroke admissions has dropped by 17.7%. However, the rate of intracerebral hemorrhage and subarachnoid hemorrhage has dropped much less dramatically (10.0% and 7.9% respectively).

A higher proportion of admitted stroke patients were in younger age groups in 2012 compared to 2003 (Table 3). Stroke (all) and ischemic stroke in patients aged less than 40 years old has been stable. For patients aged between 40 and 69, the absolute increase for all strokes was 4.8% ($p < 0.0001$) and for ischemic strokes, 5.4% ($p < 0.0001$). For patients 70 years old and older, the absolute decrease for all strokes was 4.9% ($p < 0.0001$) and for ischemic strokes, 5.6% ($p < 0.0001$). The changes for intracerebral hemorrhage and subarachnoid hemorrhage were less dramatic.

In-hospital Mortality

We observed a decline for in-hospital 30-day mortality for all stroke patients (Figure 2). For all stroke patients, mortality fell between 2003 to 2012 from 18.5% (95% CI: 18.1%-18.9%) to 14.9% (95% CI: 14.4%-15.2%). For ischemic stroke, it went down from 15.2% (95% CI: 14.8%-15.7%) to 12.1% (95% CI: 11.7%-12.5%). For intracerebral hemorrhage, mortality fell from 35.6% (95% CI: 34.1%-37.1%) to 29.7% (95% CI: 28.3%-31.1%). For subarachnoid hemorrhage, mortality dropped from 25.1% (95% CI: 23.0%-27.2%) to 18.0% (95% CI: 16.1%-19.8%).

Discharge Destination

The discharge destination for all stroke patients discharged alive from acute care is shown in Table 4. For ischemic stroke patients, the following changes were observed: an absolute decrease in the percent of patients discharged home without services by 3.2% ($p = 0.0463$); an absolute increase in the percent discharged home with services by 2.6% ($p < 0.0001$); an absolute increase in the percent of patients discharged to another inpatient acute care facility including inpatient rehabilitation by 5.6% (both $p < 0.0001$), an absolute decrease in the percent being discharged to complex continuing care by 0.9% ($p < 0.0001$) and long term care by 1.9% ($p < 0.0001$). For hemorrhagic strokes, the following

Table 4: Number (percent) of Stroke patients discharged alive to a specific destination from an acute care hospital

Year	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	p
ALL STROKE											
Home without Services	9002 (41.8%)	9390 (41.1%)	9267 (39.5%)	8643 (38.2%)	8905 (39.6%)	12758 (42.1%)	12844 (42.2%)	13357 (42%)	13581 (42.3%)	9810 (38.7%)	<0.0001
Home with Services	2129 (9.9%)	2340 (10.2%)	2707 (11.5%)	2651 (11.7%)	2641 (11.8%)	3553 (11.7%)	3645 (12%)	3696 (11.6%)	3707 (11.6%)	3092 (12.2%)	<0.0001
Inpatient Rehabilitation & other acute facility	5990 (28.8%)	6815 (29.9%)	7004 (29.8%)	6960 (30.8%)	6961 (30.9%)	8982 (29.6%)	9028 (29.7%)	9832 (30.9%)	10046 (31.5%)	8578 (33.9%)	<0.0001
Complex Contin. Care	1444 (6.7%)	1496 (6.5%)	1659 (7.1%)	1636 (7.2%)	1540 (6.9%)	1604 (5.3%)	1673 (5.5%)	1630 (5.1%)	1537 (4.8%)	1543 (6.1%)	<0.0001
Long Term Care	1857 (8.6%)	1955 (8.6%)	1960 (8.4%)	1879 (8.3%)	1725 (7.7%)	2722 (9%)	2584 (8.5%)	2653 (8.3%)	2604 (8.1%)	1681 (6.6%)	<0.0001
Other	915 (4.2%)	857 (3.7%)	852 (3.7%)	806 (3.7%)	704 (3.2%)	721 (2.3%)	630 (1.7%)	606 (1.9%)	613 (2.0%)	615 (2.5%)	<0.0001
ISCHEMIC STROKE											
Home without Services	7795 (42.6%)	8151 (42%)	7916 (40.1%)	7345 (38.8%)	7524 (39.9%)	10766 (42.7%)	10881 (43.1%)	11306 (42.7%)	11435 (43%)	8322 (39.4%)	0.0463
Home with Services	1909 (10.4%)	2079 (10.7%)	2416 (12.2%)	2393 (12.6%)	2370 (12.6%)	3159 (12.5%)	3231 (12.8%)	3290 (12.4%)	3274 (12.3%)	2741 (13%)	<0.0001
Inpatient Rehabilitation & other acute facility	4890 (26.7%)	5449 (28.1%)	5521 (28%)	5450 (28.8%)	5547 (29.4%)	7001 (27.8%)	6962 (27.6%)	7719 (29.2%)	7837 (29.5%)	6825 (32.3%)	<0.0001
Complex Contin. Care	1288 (7%)	1295 (6.7%)	1436 (7.3%)	1398 (7.4%)	1318 (7%)	1331 (5.3%)	1404 (5.6%)	1373 (5.2%)	1293 (4.9%)	1284 (6.1%)	<0.0001
Long Term Care	1661 (9.1%)	1738 (9%)	1754 (8.9%)	1661 (8.8%)	1525 (8.1%)	2350 (9.3%)	2249 (8.9%)	2273 (8.6%)	2204 (8.3%)	1475 (7%)	<0.0001
Other	764 (4.2%)	705 (3.6%)	683 (3.5%)	689 (3.6%)	591 (3.1%)	594 (2.4%)	522 (2.1%)	505 (1.9%)	523 (2%)	494 (2.3%)	<0.0001
HEMORRHAGIC STROKE (ICH and SAH)											
Home without Services	1207 (37.4%)	1239 (36.1%)	1351 (36.3%)	1298 (35.4%)	1381 (38.4%)	1992 (38.8%)	1963 (38.1%)	2051 (38.6%)	2174 (39.1%)	1512 (35.9%)	0.0249
Home with Services	220 (6.8%)	261 (7.6%)	291 (7.8%)	258 (7%)	271 (7.5%)	394 (7.7%)	414 (8%)	406 (7.6%)	436 (7.8%)	354 (8.4%)	0.0214
Inpatient Rehabilitation & other acute facility	1300 (40.2%)	1366 (39.8%)	1483 (39.8%)	1510 (41.2%)	1414 (39.3%)	1981 (38.5%)	2066 (40.1%)	2113 (39.8%)	2220 (39.9%)	1758 (41.7%)	0.4496
Complex Contin. Care	156 (4.8%)	201 (5.8%)	223 (6%)	238 (6.5%)	222 (6.2%)	273 (5.3%)	269 (5.2%)	257 (4.8%)	244 (4.4%)	260 (6.2%)	0.056
Long Term Care	196 (6.1%)	217 (6.3%)	206 (5.5%)	218 (5.9%)	200 (5.6%)	372 (7.2%)	335 (6.5%)	380 (7.2%)	400 (7.2%)	206 (4.9%)	0.1809
Other	151 (4.7%)	152 (4.4%)	169 (4.5%)	147 (4%)	113 (3.1%)	127 (2.5%)	108 (2.1%)	101 (1.9%)	90 (1.6%)	122 (2.9%)	<0.0001

Contin. = Continuing

changes were observed: an absolute decrease in the percent discharged home without services by 1.7% ($p = 0.0249$), and an absolute increase in the percent discharged home with services of 1.6% ($p = 0.0214$).

Discussion

Ten-year trends for hospitalized stroke patients in Canada show that absolute stroke admissions are not equal across provinces. When looking at absolute numbers, those provinces that have had large increases in population are shouldering a stark increase in ischemic stroke admissions; this has implications if funding for stroke services does not match the demands of population increases. When taking population increases into account, standardized risk adjusted admission rates have been decreasing for ischemic stroke but the decrease is much less dramatic for intracerebral and subarachnoid hemorrhage. This finding is somewhat similar to an earlier Quebec study (trends from 1990-2005) where ischemic stroke admissions in Quebec were declining but hemorrhagic stroke admissions were increasing[24] - in contrast we saw a very slight decline in hemorrhagic stroke admissions. This decrease in stroke admission rates may be due to better hypertension control,[25] improved stroke prevention strategies, more proactive secondary prevention through the implementation of stroke prevention clinics across Canada or other unmeasured factors. The decline in stroke rates and case fatality and the relative increase in younger strokes can be explained in part by Ontario data on trends in risk factors and stroke subtypes,[26] which showed a relative increase in cardioembolic stroke due to a decrease in large artery stroke and small vessel disease.

The distribution of age groups of stroke admissions is changing and is likely associated with the increasing age of the baby boomer cohort. The proportion of ischemic stroke patients aged 40-69 years old is increasing, and the proportion aged 70 and older is decreasing. A shift to a younger age group was also observed for intracerebral hemorrhagic stroke, where the proportion of patients in age groups under 40 and between 40 and 69 years old is increasing. An increase in the younger stroke victims, who are at the peak of their career and active role in society, will have greater indirect socioeconomic consequences in lost wages and increased costs of caring for younger disabled adults, despite a declining age-adjusted rate overall.

Similar to the findings from the USA and Western European countries,[1-4] stroke mortality was lower in Canada in 2012 compared to 2003. This holds true for ischemic stroke, intracerebral hemorrhage, and subarachnoid hemorrhage. The decrease in mortality can be attributed to better specialized medical care, prevention of secondary complications, and the implementation of in-hospital stroke units. However, the decline in mortality may translate into an overall increase in the number of patients with substantial functional deficits. When we reviewed trends in discharge destinations for stroke patients discharged alive from acute care, we observed a decrease in the percentage of ischemic and hemorrhagic stroke patients going home without services. There is an increase in ischemic stroke patients going to inpatient rehabilitation or other acute facilities, and ischemic and hemorrhagic stroke patients going home with services. However, there is a slight decrease observed in ischemic stroke patients going to complex continuing care and long-term care. The increase in patients going home with services (outpatient) and to inpatient rehabilitation or another acute care institutions is proportionate to the drop in in-hospital mortality, possibly suggesting that a decline in in-hospital mortality is contributing to the increased need for post-acute stroke services. Therefore, although more patients are surviving their stroke, the need for rehabilitation services is increasing.

Limitations

Our data uses only hospital administrative data, so it excludes patients who were never admitted to hospital, (mostly patients with milder strokes), as the number of stroke patients that die before they reach the hospital is small.[27] Hospital administrative data is subject to differences in reporting, and despite rigorous abstraction processes, variation in reporting may still be present. Data from Quebec and Manitoba do not include the entire 10-year study period, so we are not reporting the entire 10-year period occurrence across Canada. The use of hospital administrative data requires that we include strokes that were coded as *Stroke, not specified as hemorrhage or infarction* with acute ischemic strokes. We acknowledge that this does present some error; however, over 80% of all strokes are ischemic strokes and, typically, an ischemic stroke is most often referred to as *stroke* generally for the small fraction that were coded as *not specified*.

Conclusions

Ten-year stroke trends in Canada show that admission rates and in-hospital mortality are declining. However, those provinces that are experiencing the largest population growths are shouldering a greater proportion of stroke admissions. This is observed for the two western provinces: Alberta and British Columbia. Furthermore, the proportion of stroke admissions by age groups is showing a significant increase for those patients aged 40-69 and a significant decrease for those patients aged over 70. The decrease in mortality may also be contributing to more patients requiring inpatient and outpatient services.

Acknowledgements and Funding

The authors acknowledge HSF Stroke Quality Advisory Committee members 2013–2015. Funding for this study was received from Heart and Stroke Foundation and the Canadian Stroke Network. Moira Kapral is supported by a Career Investigator Award from the Heart and Stroke Foundation, Ontario Provincial Office.

Disclosures

RC has the following disclosures: Pfizer, Consultant, Honoraria; Bayer, Consultant, Honoraria; BMS, Speaker, Honoraria; Sanofi, Speaker, Honoraria. MH, JF, PL, MK, AND NK do not have anything to disclose.

References

1. Kunst AE, Amiri M, Janssen F. The Decline in Stroke Mortality Exploration of Future Trends in 7 Western European Countries. Stroke. 2011;42:2126-30.
2. Schmidt M, Jacobsen JB, Johnsen SP, Bøtker HE, Sørensen HT. Eighteen-year trends in stroke mortality and the prognostic influence of comorbidity. Neurology. 2014;82:340-50.

3. Sivenius J, Tuomilehto J, Immonen-Räihä P, et al. Continuous 15-Year Decrease in Incidence and Mortality of Stroke in Finland The FINSTROKE Study. Stroke. 2004;35:420-5.
4. Benatru I, Rouaud O, Durier J, et al. Stable stroke incidence rates but improved case-fatality in Dijon, France, from 1985 to 2004. Stroke. 2006;37:1674-9.
5. Carandang R, Seshadri S, Beiser A, et al. Trends in incidence, lifetime risk, severity, and 30-day mortality of stroke over the past 50 years. JAMA. 2006;296:2939-46.
6. Broderick JP. Stroke trends in Rochester, Minnesota, during 1945 to 1984. Annals of Epidemiol. 1993;3:476-9.
7. Broderick JP, Phillips SJ, Whisnant JP, O'Fallon WM, Bergstralh EJ. Incidence rates of stroke in the eighties: the end of the decline in stroke? Stroke. 1989;20:577-82.
8. Cheng XM, Ziegler DK, Lai YHC, et al. Stroke in China, 1986 through 1990. Stroke. 1995;26:1990-4.
9. Kubo M, Kiyohara Y, Ninomiya T, et al. Decreasing incidence of lacunar vs other types of cerebral infarction in a Japanese population. Neurology. 2006;66:1539-44.
10. Morikawa Y, Nakagawa H, Naruse Y, et al. Trends in Stroke Incidence and Acute Case Fatality in a Japanese Rural Area The Oyabe Study. Stroke. 2000;31:1583-7.
11. Thorvaldsen P, Davidsen M, Brønnum-Hansen H, Schroll M. Stable stroke occurrence despite incidence reduction in an aging population stroke trends in the Danish monitoring trends and determinants in cardiovascular disease (MONICA) population. Stroke. 1999;30:2529-34.
12. Rothwell PM, Coull AJ, Giles MF, et al. Change in stroke incidence, mortality, case-fatality, severity, and risk factors in Oxfordshire, UK from 1981 to 2004 (Oxford Vascular Study). Lancet. 2004;363:1925-33.
13. Anderson CS, Carter KN, Hackett ML, et al. Trends in stroke incidence in Auckland, New Zealand, during 1981 to 2003. Stroke. 2005;36:2087-93.
14. Redon J, Olsen MH, Cooper RS, et al. Stroke mortality and trends from 1990 to 2006 in 39 countries from Europe and Central Asia: implications for control of high blood pressure. Eur Heart J. 2011;32:1424-31.
15. Niessen LW, Barendregt JJ, Bonneux L, Koudstaal PJ. Stroke trends in an aging population. The Technology Assessment Methods Project Team. Stroke. 1993;24:931-9.
16. Börsch-Supan A, Chiappori PA. Aging population: Problems and policy options in the US and Germany. Econ Policy. 1991; 104-39.
17. Lozano R, Naghavi M, Foreman K, et al. Global and regional mortality from 235 causes of death for 20 age groups in 1990 and 2010: a systematic analysis for the Global Burden of Disease Study 2010. Lancet. 2013;380:2095-128.
18. Mayo NE, Hendlisz J, Goldberg MS, Korner-Bitensky N, Becker R, Coopersmith H. Destinations of stroke patients from the Montreal area acute-care hospitals. Stroke. 1989;20:351-6.
19. Fonarow GC, Reeves MJ, Smith EE, et al. Characteristics, Performance Measures, and In-Hospital Outcomes of the First One Million Stroke and Transient Ischemic Attack Admissions in Get With The Guidelines-Stroke. Circ Cardiovasc Qual Outcomes. 2010;3:291-302.
20. Statistics Canada. *Table 051-0001 - Estimates of population, by age group and sex for July 1, Canada, provinces and territories, annual (persons unless otherwise noted)*, CANSIM (database). (accessed: 2014-04-10).
21. Canadian Institute for Health Information. DAD Metadata. http://www.cihi.ca/CIHI-ext-portal/internet/en/document/types+of+care/hospital+care/acute+care/dad_metadata (accessed: 2014-04-30).
22. Kokotailo RA, Hill MD. Coding of stroke and stroke risk factors using international classification of diseases, revisions 9 and 10. Stroke. 2005;36:1776-81.
23. Canadian Institute for Health Information. *Health Indicators 2011: Definitions, Data Sources and Rationale*, June 2011 http://www.cihi.ca/CIHI-ext-portal/pdf/internet/DEFINITIONS_062011_EN.
24. Mayo NE, Nadeau L, Daskalapoulou SS, Côté R. The evolution of stroke in Quebec: a 15-year perspective. Neurology. 2007;68: 1122-1127.
25. Campbell NR, McKay DW. Accurate blood pressure measurement: Why does it matter? Can Med Assoc J. 1999;161:277-8.
26. Bogiatzi C, Hackam DG, McLeod AI, Spence JD. Secular trends in ischemic stroke subtypes and stroke risk factors. Stroke. 2014;45: 3208-13.
27. Morgenstern LB, Smith MA, Lisabeth LD, et al. Excess stroke in Mexican Americans compared with non-Hispanic whites. The Brain Attack Surveillance in Corpus Christi Project. Am J Epidemiol. 2004;160:376-83.