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Original Article

Estimating the Number of Hospital or Emergency Department Presentations for Stroke in Canada

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ABSTRACT: ***Background:*** Although age-standardized stroke occurrence has been decreasing, the absolute number of stroke events globally, and in Canada, is increasing. Stroke surveillance is necessary for health services planning, informing research design, and public health messaging. We used administrative data to estimate the number of stroke events resulting in hospital or emergency department presentation across Canada in the 2017–18 fiscal year. ***Methods:*** Hospitalization data were obtained from the Canadian Institute for Health Information (CIHI) Discharge Abstract Database and the Ministry of Health and Social Services in Quebec. Emergency department data were obtained from the CIHI National Ambulatory Care Reporting System (Alberta and Ontario). Stroke events were identified using ICD-10 coding. Data were linked into episodes of care to account for readmissions and interfacility transfers. Projections for emergency department visits for provinces/territories outside of Alberta and Ontario were generated based upon age and sex-standardized estimates from Alberta and Ontario. ***Results:*** In the 2017–18 fiscal year, there were 108,707 stroke events resulting in hospital or emergency department presentation across the country. This was made up of 54,357 events resulting in hospital admission and 54,350 events resulting in only emergency department presentation. The events resulting in only emergency department presentation consisted of 25,941 events observed in Alberta and Ontario and a projection of 28,409 events across the rest of the country. ***Conclusions:*** We estimate a stroke event resulting in hospital or emergency department presentation occurs every 5 minutes in Canada.

RÉSUMÉ : Estimation au Canada du nombre de présentations à l'hôpital ou aux urgences pour un AVC. ***Contexte :*** Bien que la fréquence, normalisée selon l'âge, des AVC ait diminué, le nombre absolu d'AVC augmente néanmoins dans le monde ainsi qu'au Canada. Leur surveillance est ainsi nécessaire pour planifier les services de santé, pour favoriser une conception éclairée de la recherche et pour diffuser des messages de santé publique. Nous avons donc utilisé des données administratives pour estimer le nombre d'événements caractérisés comme AVC qui ont entraîné une présentation à l'hôpital ou aux urgences partout au Canada, et ce, au cours de l'année 2017-2018. ***Méthodes :*** Ces données sur les hospitalisations ont été obtenues auprès de la Base de données sur les congés des patients (BDCP) de l'Institut canadien d'information sur la santé (ICIS) et du ministère de la Santé et des Services sociaux du Québec (MSSSQ). Les données sur les services d'urgence ont été quant à elles obtenues auprès du Système national d'information sur les soins ambulatoires de l'ICIS (Alberta et Ontario). À noter que les AVC, eux, ont été identifiés à l'aide du codage CIM-10. Ces données ont été reliées aux épisodes de soins afin de tenir compte des réadmissions et des transferts entre établissements. Les projections des visites aux services d'urgence pour les provinces et territoires autres que l'Alberta et l'Ontario ont été générées à partir d'estimations normalisées selon l'âge et le sexe de l'Alberta et de l'Ontario. ***Résultats :*** Au cours de l'année 2017-2018, 108 707 événements caractérisés comme AVC ont entraîné une présentation à l'hôpital ou aux urgences dans tout le pays. Ce chiffre se répartit en 54 357 événements entraînant une admission à l'hôpital et 54 350 événements entraînant uniquement une présentation aux urgences. Les événements entraînant uniquement une présentation aux urgences se composaient de 25 941 événements observés en Alberta et en Ontario et d'une projection de 28 409 événements dans le reste du pays. ***Conclusions :*** En somme, nous estimons qu'un AVC entraînant une visite à l'hôpital ou aux urgences se produit toutes les 5 minutes au Canada.

Keywords: Stroke; Epidemiology

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Introduction

Stroke is a leading cause of death and disability globally and places a large burden on the healthcare system.[1] In Canada, the overall direct healthcare costs, in the first year after ischemic stroke or intracerebral hemorrhage, are estimated at $53,001 ($60,658 inflation adjusted for 2022).[2] These costs include acute hospitalizations and lengthy rehabilitation stays but do not take into consideration lost productivity and other economic impacts of stroke.

Although the occurrence rates for stroke in specific age groups (age-standardized stroke occurrence rates) have decreased over the past 3 decades, the absolute (total) number of annual stroke events globally has been increasing, including in Canada.[3] This is likely reflective of the aging global population; meaning that although stroke rates per 100,000 are decreasing, the total number of individuals entering the age demographics most at risk for stroke is increasing, leading to an increasing number of stokes. Recent data from Ontario, Canada, report that the age- and sex-standardized incidence of hospitalized first-ever ischemic stroke and intracerebral hemorrhage in adults decreased between 2003 and 2011 (109.4 to 85.8 per 100,000) but then increased to 96.8 per 100,000 in 2017.[4] Between 2007 and 2016, a national study (which excluded the province of Quebec) reported that the age- and sex-standardized hospitalization rates for all stroke including transient ischemic attack (TIA), without age restriction, declined from 151.8 to 144.7 per 100,000.[5] The Public Health Agency of Canada (PHAC) reports that the age-standardized incidence of stroke in adults, 20 years of age and older, decreased from 384 to 288 per 100,000 between the years 2003–2017. In the 2016 fiscal year in adults, 20 years of age and older, there were 134 hospitalized stroke events per 100,000.[6]

Stroke surveillance is necessary for health services planning, informing research design (e.g., for sample size estimation or study feasibility), and public health messaging. Active surveillance is highly resource-intensive, resulting in the use of passive surveillance via administrative data. However, this is challenging, due to the regionalization of healthcare administration and differences in administrative data reporting requirements. Recent stroke surveillance studies have greatly varied in methodology with some excluding different stroke types or TIAs, individuals less than 20 years of age, the province of Quebec (~22% of Canada's population), and events which only present to an emergency department (ED). None provide a full assessment of the number of stroke events which present to hospital or ED for acute medical attention. We developed a comprehensive methodology to estimate the number of stroke events which result in acute medical attention in the hospital or ED, by stroke type, in Canada, using administrative data records.

Methods

Data Sources

Hospital discharge information was obtained from the Canadian Institute for Health Information (CIHI) Discharge Abstract Database (DAD). The DAD captures administrative, demographic, and clinical information on all health encounters at acute care facilities. All facilities across Canada with the exception of those in the province of Quebec are required to report to the DAD. For the province of Quebec, data on admissions to inpatient care were obtained from Ministry of Health and Social Services. ED data were obtained from the CIHI National Ambulatory Care Reporting System (NACRS) which captures administrative, demographic, and clinical information from all ED visits. Submission of ED data to NACRS is variable by province but is fully mandated in Alberta, Ontario, and The Yukon Territory. However, NACRS data from The Yukon Territory were released in aggregate form with the Northwest Territories and Nunavut, due to small numbers. Thus, we only used NACRS data from Alberta and Ontario in this study. Both DAD and NACRS identify patients through a scrambled Meaningless But Unique Number (MBUN) to allow deterministic linkage between the two databases. Population data were obtained from Statistics Canada population estimates for the year 2017.

Definition of a Stroke Event

We identified all hospital and ED visits during the 2017–18 fiscal year (April 1, 2017–March 31, 2018) across Canada (excluding Quebec) using data from the DAD and NACRS. We used validated International Classification of Diseases – Canadian 10th iteration (ICD-10-CA) case definitions to identify visits for ischemic stroke (I63.x, I64, I67.5, I67.6, H34.x, and G08), intracerebral hemorrhage: (I61.x), subarachnoid hemorrhage (SAH: I60.x), and TIA (G45.x excluding G45.4). An ED visit for a stroke was defined as a NACRS record with one of these codes in the main diagnosis position. A hospitalization for a stroke event was defined as a relevant code in the most responsible diagnosis position. Admissions with a most responsible diagnosis of rehabilitation (Z50.0, Z50.1, Z50.5–Z50.9), palliative care (Z51.5), or convalescence following treatment (Z54.8 or Z54.9) with a stroke code in the 2nd diagnostic position were also classified as stroke hospitalizations. In Canada, the most responsible diagnosis is that which is responsible for the greatest portion of the patient's length of stay.

Data Linkage

There were two important considerations made in linking the identified stroke events into episodes of care: First, inter-hospital transfers are very common in routine care of patients with stroke, and this could lead to multiple DAD and/or NACRS records for a single event, and second, to recognize the clinical phenomenon of vascular events presenting with repeated symptoms over time. As an example, a patient may suffer a TIA or minor stroke as a precursor to a major ischemic stroke, related to the same underlying cause such as carotid stenosis. Pathophysiologically, these events are all linked. Another scenario is a patient discharged to home and then re-presenting to acute care, due to complications from their initial stroke event. As such, linkage into episodes of care was necessary to correctly reflect that a single event may result in multiple hospital encounters and avoid overestimation. For data linkage, stroke types were categorized as either ischemic (ischemic stroke or TIA) or hemorrhagic (ICH or SAH).

After discharge from hospital for a stroke event, any hospital admission or ED visit within 28 days, with a diagnosis in the same category (ischemic or hemorrhagic) of stroke, was considered part of the same episode of care and not counted as a new event. After discharge from ED for a stroke event, any hospital admission or ED visit within 48 hours with a diagnosis in the same category (ischemic or hemorrhagic) of stroke was considered part of the same episode of care and not a new event. In the event that the patient's diagnosis changed within the episode of care, but remained within the same category of ischemic vs hemorrhagic event, the last hospital discharge diagnosis was taken as final for categorizing the event. Clinical uncertainty in the ED is common, and this approach allowed us to address diagnostic revisions (e.g., a diagnosis of TIA

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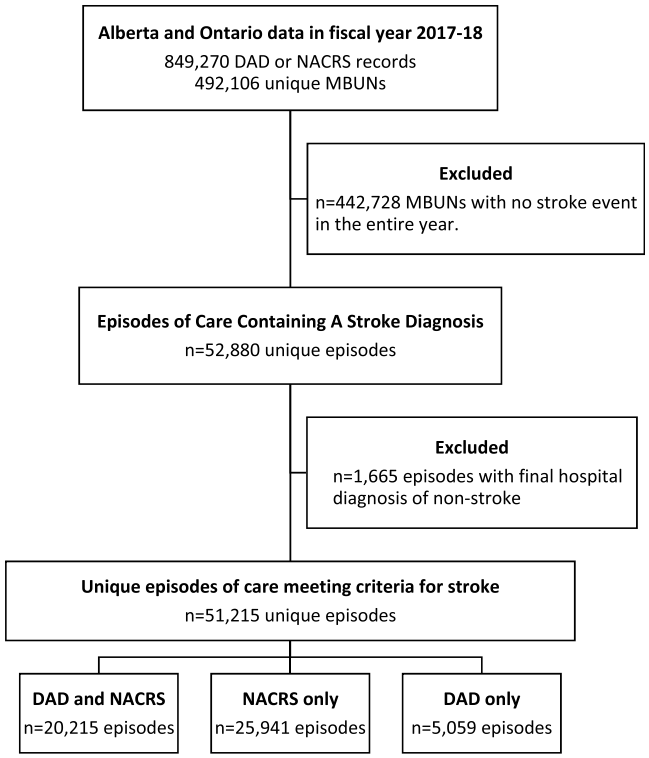

Figure 1: Workflow for organizing NACRS and DAD records from Alberta and Ontario into episodes of care containing stroke events.

in the ED revised as ischemic stroke after hospitalization) without double-counting events. Due to diagnostic uncertainty in the ED, special consideration was given to events where a patient moved from the ED to hospital to avoid misclassification. If an ED visit was classified as a stroke, but the linked hospital admission was not classified as a stroke, this hospital discharge diagnosis was taken as final, and this was not counted as a stroke event. In the opposite scenario, where a patient had a non-stroke diagnosis in the ED, but in a linked hospital admission was classified as a stroke, the hospital discharge diagnosis was taken as final, and this was counted as a stroke event. Final classifications were checked with contingency tables to examine for outliers in classification logic.

Data from Quebec

Hospital admission numbers, but not individual patient records, were obtained directly from the Ministry of Health and Social Services in Quebec. To generate admission numbers, the same ICD-10-CA definition of stroke as the most responsible diagnosis and the same 28-day linkage window were utilized.

Projections

Through the DAD, and hospitalization data obtained from Quebec, all hospitalizations across the country were captured, and no projections were required for hospitalization data. However, due to complete NACRS data only being usable from Alberta and Ontario, projections for ED-only visits from the rest of the country needed to be made. After data linkage and episode of care creation, estimates for the number of stroke events which only presented to the ED (and never to the hospital) in Alberta and Ontario were generated. Using population estimates obtained from Statistics Canada for these provinces, age (5-year age groups) and sex-standardized rates per 100,000 were generated for each stroke type (IS, SAH, ICH, and TIA). Using data from Statistics Canada, age (5-year age groups) and sex-specific population estimates were generated for the rest of the country. Then, the age, sex, and stroke type-specific rates per 100,000 generated from Alberta and Ontario were projected onto the rest of the Canadian population. We used this to estimate the number of strokes only presenting to the ED in regions of Canada which do not have complete reporting to NACRS. Two sets of projections were made, one based on all ED presentations and one excluding ED presentations where the final ED diagnosis contained a query prefix, indicating the final diagnosis is uncertain or unconfirmed.

Sensitivity Analyses

Sensitivity analyses were performed varying the administrative data definitions used. In the first two sensitivity analyses, the definition of stroke varied as (1) stroke as the most responsible diagnosis (DAD) or main problem (NACRS) only; and (2) stroke in the first two diagnostic positions (but not coded as a pre-existing comorbidity). In the third sensitivity analysis, the time frames used for record linkage into episodes of care were shortened to 24 hours from an ED discharge and 14 days from a hospital discharge. As hospitalization record level data from Quebec were not available, these hospitalization numbers were adjusted proportionally to the hospitalization changes observed in other provinces.

All data handling and analyses were performed using Stata17 (Stata Corp., College Station, TX). The analyses, conclusions, opinions, and statements expressed herein are those of the authors and not those of CIHI.

Results

In the 2017–18 fiscal year, there was a total of 489,538 records in the DAD and 578,791 records in NACRS for all diagnoses. Among the NACRS records, 24,164 were from outside of Alberta or Ontario and were removed from analysis. In Alberta and Ontario, there were a total of 294,643 DAD records and 554,627 NACRS records (Figure 1). Among these, approximately 1% (2492 in DAD and 5464 in NACRS) were missing a unique ID; these were all assigned unique identifiers and assumed to be unique individuals and events. These two datasets were merged, and records never containing a stroke diagnosis in the fiscal year (442,728 unique persons identified by their MBUN consisting of 748,184 records) were removed from analysis.

There were 49,378 unique IDs (which contained a total of 101,086 records) identifying at least one stroke event. These records had varying complexity, ranging from a single NACRS or DAD record per person to a maximum of 65 records per person. After organization into episodes of care, by date and diagnosis, there were 52,880 episodes of care containing a stroke diagnosis. There were 1665 episodes of care where the ED diagnosis was stroke but the corresponding hospital diagnosis was non-stroke which were removed from the analysis. This left 51,215 episodes of care related to a stroke event. Among these, 5059 only contained a hospital (DAD) record and had no interaction with an ED (e.g., directly admitted from long-term care or ambulatory care) (Table 1). A further 25,941 only contained an ED (NACRS) record and were never admitted to hospital (Table 1). Among these ED-only episodes of care, 12,053 left the ED with a query final diagnosis (4085 IS, 190 SAH, 158 ICH, and 7620 TIAs, Table S1). The remaining episodes of care (20,215) involved both ED (NACRS) and hospital (DAD) interactions (Table 1). Among

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Table 1: Estimated number of stroke events resulting in hospital or emergency department presentation in the 2017 fiscal year broken down by information source and stroke type

Record source	Ischemic stroke	Subarachnoid hemorrhage	Intracerebral hemorrhage	Transient ischemic attack	Total
Events resulting in hospital admission					
DAD (outside of Alberta & Ontario)	10,493	672	1705	2710	15,580
DAD only (Alberta & Ontario)	3419	250	965	425	5059
DAD & NACRS (Alberta & Ontario)	14,505	869	1916	2925	20,215
Quebec hospitalization volumes	9199	689	1396	2219	13,503
Events with an ED visit only					
NACRS only (Alberta & Ontario)	8801	522	836	15,782	25,941
NACRS only projections for the remainder of the country	9629	555	911	17,314	28,409
Grand total	56,046	3557	7729	41,375	108,707

Table 2: Estimated number of stroke events resulting in hospital admission in the 2017 fiscal year broken down by province/territory

Province	Ischemic stroke	Subarachnoid hemorrhage	Intracerebral hemorrhage	Transient ischemic attack	Total
British Columbia	5157	334	879	1226	7596
Alberta	3436	226	498	663	4823
Saskatchewan	1090	89	162	336	1677
Manitoba	1223	98	210	174	1701
Ontario	14,488	893	2383	2687	20,451
Quebec	9199	689	1396	2219	13,503
New Brunswick	906	45	167	359	1477
Nova Scotia	1188	68	148	168	1572
Prince Edward Island	215	4	19	66	304
Newfoundland and Labrador	653	35	103	342	1133
Territories	61	3	17	39	120
Total	37,616	2484	5982	8279	54,357

these, 2099 had a non-stroke diagnosis in the ED but a stroke diagnosis in a corresponding hospital admission.

Outside of Alberta and Ontario, there were 194,895 DAD records, of which 17,052 records met the definition of stroke. We found through linkage 15,580 unique episodes of care, of which 10,493 were ischemic stroke, 672 were subarachnoid hemorrhage, 1705 were intracerebral hemorrhage, and 2710 were TIAs (Table 1). As with Alberta and Ontario, records with missing MBUNs ($n = 202$) were assumed to be unique individuals. Estimates stratified by province/territory are provided in Table 2. The Ministry of Health and Social Services in Quebec reported a total of 13,503 stroke admissions across the fiscal year, comprised of 9199 ischemic strokes, 689 SAH, 1396 ICH, and 2219 TIAs (Table 2).

There were 24,164 NACRS records from outside of Alberta or Ontario. These were not analyzed due to incomplete reporting in these provinces. Instead, we used stroke events that only had NACRS records in Alberta and Ontario to project estimates of ED-only visits in the other provinces and territories. It was projected that 28,409 stroke events only presenting to the ED would occur outside of Alberta and Ontario, broken down into 9629 ischemic stroke, 555 subarachnoid hemorrhage, 911 intracerebral hemorrhage, and 17,314 TIAs (Table 1). If projections were made excluding patients with a query diagnosis prefix, the projected total was 15,304 comprised of 5190 ischemic stroke, 360 subarachnoid hemorrhage, 741 intracerebral hemorrhage, and 9013 TIAs (Table S2).

In total, this led to a combined estimate of 108,707 stroke events resulting in ED or hospital presentation in Canada, in the 2017 fiscal year (83,549 events if those having query diagnosis types are excluded, Table S2). Using 2017 Canadian population data ($n = 36,314,099$), this is 299.4 events per 100,000 individuals (Table 2).

Sensitivity analyses resulted in a ~3% decrease in the estimated number of stroke events ($n = 105,636$; Table S3) when only including stroke in the first diagnostic position and a ~8% increase in the estimated number of stroke events ($n = 117,253$; Table S4) when including stroke in the first two diagnostic positions of the administrative data record. The increase seen when including the first two diagnostic positions was predominantly driven by patients only presenting to the ED. A ~2% increase in the estimated number of stroke events ($n = 110,790$; Table S5) occurred when shortening the time windows considered for record linkage.

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Discussion

Through the use of linked administrative data, we estimate there were 108,707 stroke events resulting in hospital or ED presentation in Canada in the 2017–18 fiscal year; approximately 1 hospital or ED presentation for stroke occurs every 5 minutes. This is a crude incidence of 299.4 events per 100,000. These estimates provide a more comprehensive view of the burden of stroke on the healthcare system compared to previous estimates looking only as hospitalized stroke patients which produced estimates of 62,000 stroke hospitalizations occurring annually in Canada or approximately 1 every 9 minutes.[7] This has broad implications for health systems. Stroke is a time-sensitive and resource-intensive disease and if health systems are not equipped to handle this volume of patients, which we only expect has increased proportionally to population growth in the last 6 years, presenting to hospital with stroke it is possible that quality of care may decrease as a result.

Our data are compatible with other estimates of stroke incidence in Canada using different methodologies. Restricting to hospitalizations only, we estimate 149.7 events per 100,000 including TIA diagnoses and 126.9 events per 100,000 excluding TIAs, which is compatible with estimates of similar definition from Botly et al. (144.7 per 100,000) and PHAC (134 per 100,000) in the 2016–17 fiscal year.[5,6] Using different methodology, consisting of hospitalization records and physician billings claims, but not ED records, PHAC estimated an overall stroke and TIA incidence of 288 per 100,000 in adults 20 years of age and older.[6] This estimate is consistent with our overall estimate of 299.4 stroke events per 100,000 resulting in hospital or ED presentation across all ages.

This detailed methodology could help future estimates of the burden of stroke in Canada. Both advances in, and more widespread use of, neuroimaging have resulted in improved accuracy of diagnosis and changing diagnosis patterns. More patients with TIA are now correctly diagnosed as ischemic stroke based upon MR imaging, where they would have been classified as TIA in the past, and this reclassification may be more common in the young.[8–10] Cerebral venous sinus thrombosis is also increasingly recognized correctly due to the use of neurovascular imaging.[11] Additionally, the significant evolution of time-sensitive treatments, particularly for ischemic stroke patients, over the recent decades has changed how stroke patients are cared for both in the inpatient and ambulatory settings. Therapeutic advances necessitate advances in diagnostic accuracy. Further, continuing advances in primary and secondary prevention of stroke influence how many strokes and recurrent strokes occur. All of these factors mean that continuous evaluation of the burden of stroke in Canada, using consistent methodology and definitions, is highly relevant.

In interpreting our findings, it is important to keep our specific case definition (including ICD codes used, code diagnostic position, and linkage timeframes) in mind. We performed several sensitivity analyses and our estimates remained relatively stable, suggesting that our methods are robust. Widening our case definition to include stroke as a secondary diagnosis would increase estimates by 8% and taking a more conservative case definition by excluding rehabilitation, palliative, or convalescence codes would reduce our estimates by 3%. Shortening the record linkage time definition would increase our estimate by 2%. We have included events with only an ED record and a query diagnosis prefix in our overall estimate of 108,707 events. We have elected to include these query diagnosis events as these represent patients who require care and work-up and consideration of a stroke diagnosis. Additionally, the use of the query prefix may differ across physician and jurisdictions in ways which we cannot account for. It is also known that a substantial proportion of patients with low-risk suspected TIA or minor stroke show ischemia on follow-up MR imaging.[12] It is likely that some of these patients are captured by the query diagnosis prefix. Importantly, we are not estimating the true number of strokes which occur in Canada, but rather the number of stroke events which result in a hospital or ED presentation, where stroke is the main diagnosis recorded in the administrative data record. By definition, this means we have not counted strokes which never present to hospital (either not seeking any medical attention at all or seeking care in the community but never being referred to ED or hospital), individuals who die with stroke at home, or individuals without stroke as a main diagnosis. Due to this, we estimate the true incidence of stroke in Canada to be higher than what we have presented here.

Limitations

We have used a conservative definition in linking stroke events into episodes of care. Events occurring within 48 hours of an ED discharge or 28 days from a hospital discharge, within the same category of stroke (ischemic or hemorrhagic), are assumed to be related to the same event. However, it is possible this has resulted in an underestimate of the number of stroke events. As an example, a patient presenting to ED with a diagnosis of TIA and then again, the following day, with a diagnosis of ischemic stroke would be classified as a single event where it is possible these were two separate ischemic events. The administrative data definition of stroke used here is similar to one routinely used and validated in both Alberta and Ontario, with the addition of three codes to capture central venous sinus thrombosis events (I63.6, I67.7, and G08). In separate validation studies in Alberta and Ontario, these administrative data codes have shown high sensitivity and positive predictive value.[13,14] We assume this high coding accuracy is consistent country-wide, where in reality there may be regional differences in coding accuracy.

We have utilized data from Alberta and Ontario to determine age- and sex-specific estimates of the number of stroke events presenting to ED-only and have projected these estimates across the rest of the country. In doing so, we have made the assumption that the epidemiology, coding accuracy, and admission practices which occur in Alberta and Ontario are consistent across the rest of the country, which may not be accurate. This approach was taken, rather than using partial NACRS data from other provinces, because hospitals reporting to NACRS in provinces that do not mandate full NACRS reporting are likely systematically different from the hospitals that choose not to report. This may lead to selection bias that is difficult to quantify and mitigate. If NACRS reporting was mandated across all provinces and territories, disease surveillance and inter-provincial or territory comparisons would be much more accurate

Conclusions

We estimate that in 2017–18, there were 108,707 stroke events resulting in hospital or ED presentation, approximately once every 5 minutes, in Canada. This is an alarming metric which underscores the sheer magnitude of the challenge for stroke prevention in Canada. Our findings highlight the need for appropriate resource planning to ensure that high-quality stroke care can be

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maintained to optimize patient outcomes. Ongoing surveillance is essential for monitoring the growing burden of stroke on the healthcare system.

Supplementary Material. To view supplementary material for this article, please visit https://doi.org/10.1017/cjn.2022.338

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Data analysis, interpretations, manuscript preparation: JKH.
Data interpretation and manuscript editing for important intellectual content: AYXY, AG, RAJ, PL, MDH.

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