CJC Open 6 (2024) 959–966

Original Article

An Interrupted Time-Series Analysis of the Impact of COVID-19 on Hospitalizations for Vascular Events in 3 Canadian Provinces

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ABSTRACT

Background: COVID-19 infection is associated with a pro-coagulable state, thrombosis, and cardiovascular events. However, its impact on population-based rates of vascular events is less well understood. We studied temporal trends in hospitalizations for stroke and myocardial infarction in 3 Canadian provinces (Alberta, Ontario, and Nova Scotia) between 2014 and 2022.

Methods: Linked administrative data from each province were used to identify admissions for ischemic stroke, intracerebral hemorrhage, cerebral venous thrombosis, and myocardial infarction. Event rates per

RÉSUMÉ

Contexte : L'infection par la COVID-19 est associée à un état pro-coagulant, à la thrombose et à des événements cardiovasculaires. Son incidence sur les taux d'événements vasculaires dans la population est cependant moins bien comprise. Nous avons étudié les tendances temporelles des hospitalisations pour un accident vasculaire cérébral (AVC) et un infarctus du myocarde dans trois provinces canadiennes (Alberta, Ontario et Nouvelle-Écosse) entre 2014 et 2022.

Méthodologie : Des données administratives couplées provenant de chaque province ont été utilisées pour recenser les hospitalisations

The COVID-19 pandemic was an unparalleled global health crisis that negatively impacted health and healthcare delivery.[1] Stroke and myocardial infarction (MI) are the leading causes of death and disability in Canada and worldwide,[2,3] and they account for a large proportion of hospitalizations and healthcare costs in Canada.[4,5] In the early phases of the pandemic, hospital visits for stroke and MI abruptly decreased, likely reflecting changes in health-seeking behaviour.[6-12] Surveillance beyond the early phase of the pandemic has shown a mix of the rates of such events declining,[13-16] remaining stable,[17,18], and rising.[19,20]

The increased risk of vascular events following COVID-19 has been described extensively.[21-23] In addition, access to primary care, which was already tenuous pre-pandemic, further declined during the pandemic, raising concerns about the quality of vascular preventive care.[24,25] In Canada, COVID-19 rates and pandemic management varied by province.[26] This variability, in conjunction with other provincial differences,

Received for publication April 5, 2024. Accepted April 26, 2024.

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See page 965 for disclosure information.

https://doi.org/10.1016/j.cjco.2024.04.010

100,000/quarter, standardized to the 2016 Canadian population, were calculated. We assessed changes from quarterly rates pre-pandemic (2014-2020), compared to rates in the pandemic period (2020-2022), using interrupted time-series analysis with a jump discontinuity at pandemic onset. Age group− and sex-stratified analyses also were performed.

Results: We identified 162,497 strokes and 243,182 myocardial infarctions. At pandemic onset, no significant step change in strokesper 100,000/quarter was observed in any of the 3 provinces. During the pandemic, stroke rates were stable in Alberta and Ontario, but they increased in Nova Scotia (0.44 per 100,000/quarter, $P = 0.004$). At pandemic onset, a significant step decrease occurred in myocardial infarctions per 100,000/quarter in Alberta (4.72, $P < 0.001$) and Ontario (4.84, $P < 0.001$), but not in Nova Scotia. During the pandemic, myocardial infarctions per 100,000/quarter decreased in Alberta (−0.34, $P = 0.01$), but they remained stable in Ontario and Nova Scotia. No consistent patterns by age group or sex were noted.

Conclusions: Hospitalization rates for stroke or myocardial infarction across 3 Canadian provinces did not increase substantially during the first 2 years of the pandemic. Continued surveillance is warranted as the virus becomes endemic.

pour un AVC ischémique, une hémorragie intracérébrale, une thrombose veineuse cérébrale et un infarctus du myocarde. Nous avons calculé les taux d'événements pour 100 000 admissions/trimestre, uniformisés pour correspondre à la population canadienne de 2016. Nous avons évalué les variations par rapport aux taux trimestriels d'avant la pandémie (2014-2020), comparativement aux taux pendant la pandémie (2020-2022), à l'aide d'une analyse de séries chronologiques interrompues avec discontinuité à saut fini au début de la pandémie. Des analyses stratifiées selon le groupe d'âge et le sexe ont également été réalisées.

Résultats : Nous avons recensé 162 497 AVC et 243 182 infarctus du myocarde. Au début de la pandémie, aucune variation progressive significative au niveau des AVC pour 100 000 admissions/trimestre n'a été observée dans aucune des trois provinces. Pendant la pandémie, les taux d'AVC sont demeurés stables en Alberta et en Ontario, mais ont augmenté en Nouvelle-Écosse (0,44 pour 100 000 admissions/trimestre; $p = 0{,}004$). Au début de la pandémie, une diminution graduelle significative du taux d'infarctus du myocarde pour 100 000 admissions/trimestre a été observée en Alberta (4,72; $p < 0{,}001$) et en Ontario (4,84; $p < 0{,}001$), mais pas en Nouvelle-Écosse. Durant la pandémie, le taux d'infarctus du myocarde pour 100 000 admissions/trimestre a diminué en Alberta (−0,34; $p = 0{,}01$), mais est demeuré stable en Ontario et en Nouvelle-Écosse. Aucune tendance constante n'a été observée selon le groupe d'âge ou le sexe.

Conclusions : Les taux d'hospitalisation pour un AVC ou un infarctus du myocarde n'ont pas augmenté de manière substantielle dans les trois provinces canadiennes durant les deux premières années de la pandémie. Une surveillance continue s'impose alors que le virus devient endémique.

including demography, rurality, and wealth distribution, led us to study temporal trends in the rates of vascular events in 3 different provinces (Alberta, Ontario, and Nova Scotia). Any interprovincial similarities or differences will provide insight into the differential impact of the pandemic on Canadian provinces and identify potential targets for future public health intervention.

Methods

Data sources and setting

We used the Canadian Institute for Health Information (CIHI) Discharge Abstract Database (DAD) to identify all admissions with the most responsible diagnosis of ischemic stroke, intracerebral hemorrhage (ICH), cerebral venous thrombosis (CVT), or MI, using validated case definitions (Supplemental Table S1) in the provinces of Alberta, Ontario, and Nova Scotia, Canada between April 1, 2014 and March 31, 2022.[27-29] These 3 provinces make up 53% of Canada's population—Ontario has 14.5 million residents (38.8% of Canada's population); Alberta has 4.5 million residents (11.6%); and Nova Scotia has 1.01 million residents (2.6%).[30] These provinces also provide diversity in rurality, age, and wealth distribution. In Canada, healthcare is delivered provincially, with each provincial ministry of health acting as a single payer for the healthcare system, with universal access for all residents.

To avoid double-counting interhospital transfers as multiple hospitalizations, any 2 records containing the same diagnosis within 24 hours of one another were treated as a single episode of care. In Alberta, complete data were not available for the first quarter of 2022 at the time of data access.

Statistical analysis

Standardized differences were used to compare baseline characteristics between the 2 time periods. Quarterly hospitalization rates for stroke (overall and by stroke type) and MI over the study period were calculated using census adult populations in each province, with linearly interpolated estimates for intercensal years. Overall crude rates and rates stratified by sex and age group (ages 18-45, 46-55, 56-65, 66-75, 76-85, and > 85 years) are presented. Data are also presented with age- and sex-standardization using the 2016 Canadian population to facilitate interprovincial comparisons. CVT data from Nova Scotia were not included due to low case counts; thus, data could not be released according to privacy regulations.

Interrupted time-series analysis was used to analyze quarterly admission rates in the pre-pandemic (April 1, 2014 − March 31, 2020) and pandemic periods (April 1, 2020 − March 31, 2022), with linear trends in both time periods, and allowing for a jump discontinuity between periods. The second quarter of 2020 (April 1 − June 30) was considered the first quarter of the pandemic, as it coincided with the first wave of the pandemic in Canada. Autocorrelation was assessed, using the Cumby and Huizinga test for serial autocorrelation in time series data.[31] Newey-West standard errors were used to account for heteroskedasticity and autocorrelation.[32]

Ethics

In Ontario, datasets were deterministically linked using unique encoded identifiers, and were analyzed at ICES (formerly the Institute for Clinical Evaluative Sciences). The use of Ontario's data in this project was authorized under section 45 of Ontario's Personal Health Information Protection Act, removing the need for research ethics board approval. In Alberta and Nova Scotia, ethics approval was obtained from the University of Calgary Conjoint Health Research Ethics Board (REB22-0339) and the Nova Scotia Health Research Ethics Board (REB #1027801), with waiver of consent.

Results

We identified 119,972 hospitalizations for stroke, and 185,798 hospitalizations for MI that occurred during the pre-pandemic period, and 42,525 hospitalizations for stroke, and 57,384 hospitalizations for MI that occurred during the pandemic period. The distribution of age and sex for strokes and MIs pre-pandemic and during the pandemic were similar in each of the 3 provinces (Table 1). The majority of strokes were ischemic (86%); 13% were ICH, and 1% were CVT.

All strokes

During the first quarter of the study period, the standardized rates of strokes were as follows, per 100,000/quarter: 35.9 in Alberta; 33.5 in Ontario; and 38.1 in Nova Scotia. Pre-pandemic, standardized rates (values are per 100,000/quarter [95% confidence interval {CI}]) were decreasing in Alberta (−0.08, [−0.16, −0.002], $P = 0.044$), and were relatively stable across the other 2 provinces (Ontario: −0.04 [−0.10, 0.02], $P = 0.177$; Nova Scotia: −0.05 [−0.15, 0.05], $P = 0.313$). At pandemic onset (values are per 100,000 [95% CI], no step change was observed (Alberta: −0.87 [−2.83, 1.10], $P = 0.375$; Ontario: −2.29 [−5.13, 0.55], $P = 0.110$; Nova Scotia: −0.81 [−2.95, 1.33], $P = 0.447$), followed by temporal stability during the pandemic (values are per 100,000/quarter [95% CI]) in Alberta and Ontario (Alberta: −0.02 [−0.40, 0.36], $P = 0.923$; Ontario: 0.25 [−0.32, 0.83], $P = 0.375$), and increasing rates in Nova Scotia (0.44 [0.15, 0.73], $P = 0.004$; Fig. 1).

Stroke subtypes

Temporal changes in standardized rates of stroke stratified by type (ischemic stroke, ICH, and CVT) in each province are shown in Supplemental Figures S1-S3. Standardized ischemic stroke rates in the pre-pandemic period were stable across all provinces, rates of change as follows (values are per 100,000/quarter [95% CI]: Alberta: −0.06 [−0.12, 0.01], $P = 0.080$; Ontario: −0.04 [−0.10, 0.02], $P = 0.183$.; Nova Scotia: −0.04 [−0.16, 0.08], $P = 0.525$). At pandemic onset, no step change was observed, as follows (values are per 100,000 [95% CI]: Alberta: −0.84 [−2.48, 0.80], $P = 0.303$; Ontario: −1.73 [−4.10, 0.64], $P = 0.145$; Nova Scotia: −0.59 [−4.04, 2.86], $P = 0.728$). During the pandemic, temporal stability continued as follows (values are per 100,000/quarter [95% CI]: (Alberta: −0.08 [−0.39, 0.23], $P = 0.607$; Ontario: 0.17 [−0.33, 0.67], $P = 0.501$; Nova Scotia: 0.24 [−0.38, 0.86], $P = 0.437$; Supplemental Fig. S1). Similarly, standardized ICH rates were also stable pre-pandemic, across all provinces, and no step change was observed. Temporal stability continued during the pandemic in Alberta and Ontario, but the rates increased in Nova Scotia (0.21 per 100,000/quarter [95% CI, 0.09, 0.34], $P = 0.001$; Supplemental Fig. S2). For CVT, pre-pandemic rates were stable in Alberta, but were

Table 1. Baseline characteristics of patients hospitalized for myocardial infarction and stroke in the provinces of Alberta, Ontario, and Nova Scotia, Canada

	Alberta			Ontario			Nova Scotia		
Condition	April 2014 to March 2020	April 2020 to March 2022	Standard difference	April 2014 to March 2020	April 2020 to March 2022	Standard difference	April 2014 to March 2020	April 2020 to March 2022	Standard difference
Myocardial infarction									
Number	35,823	10,901	—	130,030	39,408	—	19,945	7075	—
Age, y, mean (SD)	66.8 (13.7)	67.0 (13.4)	−0.015	68.4 (13.8)	68.0 (13.4)	0.036	67.2 (13.4)	68.1 (12.3)	0.072
Female, n (%)	10,960 (30.6)	3399 (31.2)	0.013	44,616 (34.3)	13,091 (33.2)	0.308	7163 (35.9)	2535 (35.8)	0.002
All stroke									
Number	21,726	7618	—	90,750	32,142	—	7496	2765	—
Age, y (SD)	71.3 (14.8)	71.3 (14.6)	0.003	73.3 (14.0)	72.9 (13.9)	0.031	71.9 (13.9)	72.0 (13.0)	0.012
Female, n (%)	10,029 (46.2)	3465 (45.5)	0.014	43,333 (47.7)	14,993 (46.6)	0.022	3543 (47.3)	1256 (45.4)	0.037
Ischemic stroke									
Number	18,900	6611	—	78,097	27,712	—	6678	2440	—
Age, y (SD)	71.9 (14.3)	71.9 (14.0)	0.003	73.80 (13.61)	73.45 (13.52)	0.026	72.2 (13.8)	72.3 (12.8)	0.007
Female, n (%)	8613 (45.6)	2970 (44.6)	0.013	37,265 (47.7)	12,923 (46.6)	0.022	3165 (47.4)	1105 (45.3)	0.042
Intracerebral hemorrhage									
Number	2534	900	—	12,046	4155	—	792	307	—
Age, y, mean (SD)	69.9 (15.2)	70 (15.2)	−0.003	71.63 (14.57)	70.75 (14.68)	0.061	70.0 (14.3)	71.4 (12.8)	0.103
Female, n (%)	1220 (48.2)	425 (47.2)	0.018	5684 (47.2)	1892 (45.5)	0.033	364 (46.0)	138 (44.9)	0.020
Cerebral venous sinus thrombosis									
Number	271	98	—	607	275		Data not available*		
Age, y, mean (SD)	45.9 (18.1)	46.6 (17.4)	−0.042	47.82 (18.95)	50.67 (19.56)	0.148			
Female, n (%)	175 (64.6)	61 (62.2)	0.048	384 (63.3)	178 (64.7)	0.031			

SD, standard deviation.

* Cerebral venous sinus thrombosis data from Nova Scotia were not included in this analysis, due to the limitation that, for some entire fiscal years, the number of cases was < 5, imposing constraints on data release.

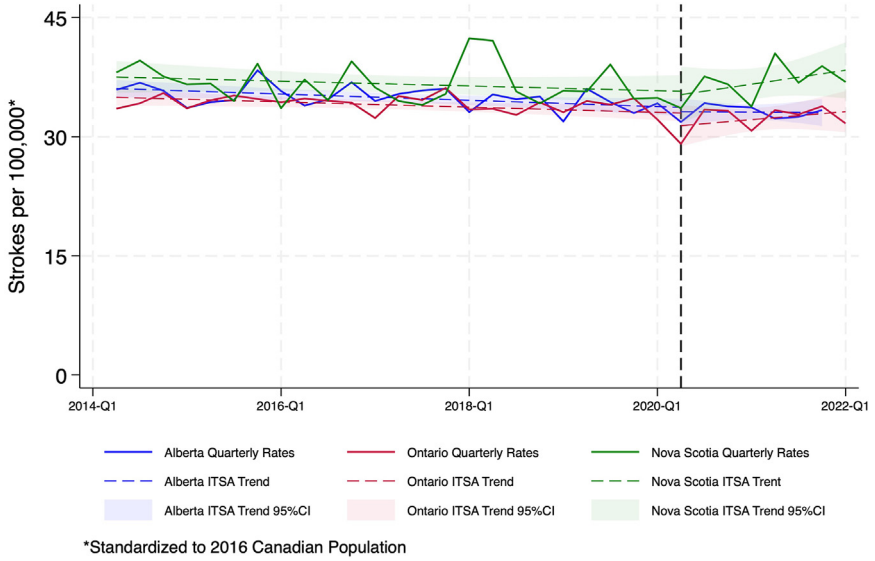

Figure 1. Quarterly rates of stroke per 100,000 individuals, standardized to the 2016 Canadian population for the provinces of Alberta, Ontario, and Nova Scotia (**solid lines**), and results of interrupted time-series analysis (ITSA; **dashed lines**), with 95% confidence intervals (CIs; **shaded bands**). The step changes observed at pandemic onset were not significant in any province. Pre-pandemic and pandemic slopes were not significantly different from one another in any province.

increasing in Ontario (0.003 per 100,000/quarter [95% CI, 0.002, 0.005], $P = 0.001$). At pandemic onset, no step change occurred, and during the pandemic, continued stability occurred in Alberta (−0.005 per 100,000/quarter [95% CI, −0.037, 0.026], $P = 0.726$), whereas rates increased temporally in Ontario (0.013 per 100,000/quarter [95% CI, 0.008, 0.017], $P < 0.001$; Supplemental Fig. S3).

MIs

During the first quarter of the study period, the standardized rates of MIs, per 100,000/quarter, were 61.1 in Alberta, 55.4 in Ontario, and 96.5 in Nova Scotia. Pre-pandemic, standardized rates (values are per 100,000/quarter [95% CI]) were decreasing in Alberta and Ontario (Alberta: −0.29 [−0.43, −0.15], $P < 0.001$; Ontario: −0.38 [−0.51, −0.24], $P < 0.001$), and they were stable in Nova Scotia (0.15 [−0.13, 0.43], $P = 0.27$). At pandemic onset (values are per 100,000 [95% CI]), a significant step decrease occurred in Alberta (4.72 [−6.45, −3.00]; $P < 0.001$) and in Ontario (4.84 [−8.93, −0.74]; $P = 0.02$), but no significant step change occurred in Nova Scotia (−1.71 [−13.70, 10.28], $P = 0.77$). During the pandemic, the rate of MIs (values are per 100,000/quarter [95% CI]) continued to decrease in Alberta (−0.34 [−0.59, −0.08]; $P = 0.01$), but it remained stable in Ontario (0.10 [−0.70, 0.90]; $P = 0.79$) and Nova Scotia (−0.68 [−3.37, 2.01], $P = 0.61$; Fig. 2).

Stratifying by age and sex

For all strokes, stratifying by age-group and sex showed that, across most strata, pre-pandemic rates (per 100,000/quarter [95% CI]) were stable (Supplemental Figs. S4-S6; Supplemental Table S2). Notable exceptions were the increasing rates among the male population aged 46-55 years in Ontario (0.11 [0.04, 0.19]), and the decreasing rates in the male population aged ≥86 years in Nova Scotia (−6.90 [−12.66, −1.14]). At pandemic onset, significant downward step changes (per 100,000 [95%CI]) occurred in Ontario among the male population aged 76-85 years (−11.18 [−20.18, −2.19]), and the female population aged ≥86 years (−58.70 [−80.58, −36.82]). During the pandemic, rates (per 100,000/quarter [95%CI]) were increasing in the female population aged 18-45 years (0.08 [0.04, 0.13]), the male population aged 46-55 years (0.36 [0.02, 0.71]), and the female population aged ≥86 years (4.26 [0.75, 7.78]) in Ontario. Pandemic rates also were increasing in the female population aged 66-75 years in Nova Scotia (2.29 [0.04, 4.54]).

We show in Supplemental Table S3 and Supplemental Figures S7-S9 the rates of MI, stratified by sex and age-group. Some fluctuations in changes in rate occurred, but we did not observe any consistent patterns. In Alberta, rates (per 100,000/quarter [95%CI]) were stable in all age and sex groups during the pandemic, except for the male population aged 66-75 years (−5.29 [−9.62, −0.95]) and the female population aged 76-85 years (−2.17 [−4.17, −0.18]), among whom rates were decreasing. Pre-pandemic rates were decreasing in the male population aged 66-75 years (−1.09 [−1.97, −0.21]), individuals aged 76-85 years (female: −1.38 [−2.70, −0.07]; male: −2.17 [−3.65, −0.69]), and individuals aged ≥ 86 years (female: −3.44 [−6.12, −0.76]; male: −4.38 [−8.74, −0.92]). Downward step changes in events/100,000 [95% CI] were observed in male individuals aged 46-55 years (−9.80 [−16.16, −3.44]) and 56-65 years (−17.10 [−28.68, −5.52]). In Ontario, rates per 100,000/quarter [95% CI] were decreasing pre-pandemic among the following groups: male individuals aged 18-45 years (−0.10 [−0.14, −0.07]); female individuals aged 46-55 years (−0.10 [−0.17, −0.03]); individuals aged 56-65 years (female: −0.18

[−0.29, −0.07); male: −0.41 [−0.73, −0.09]); individuals aged 66-75 years (female: −0.33 [−0.58, −0.09]; male: −0.90 [−1.29, −0.51]); those aged 76-85 years (female: −1.34 [−1.98, −0.69]); male: −2.00 [−3.07, −0.93]); and those aged ≥86 years (female: −3.28 [−4.03, −2.52]; male: −5.38 [−7.52, −3.24]). Significant downward step changes (values are per 100,000 [95% CI]) were observed in female individuals aged 46-55 years (−1.94 [−3.48, −0.39]) and ≥86 years (−37.83 [−57.28, −18.38]) and male individuals aged 46-55 years (−5.43 [−9.56, −1.29]), 56-65 years (−9.42 [−18.43, −0.42]), 66-75 years (−13.56 [−22.43, −4.70]), and 76-85 years (−27.59 [−48.18, −7.00]). During the pandemic, rates (values are per 100,000/quarter [95% CI]) were increasing in those aged 18-45 years (female: 0.07 [0.01, 0.12]; male: 0.09 [0.0004, 0.18]) and female individuals aged 46-55 years (0.31 [0.01, 061]). In Nova Scotia, rates were stable across both time periods, except for those among female individuals aged 46-55 years, for whom a significant step decrease was observed at pandemic onset (−26.76 per 100,000 [−43.20, −10.32]) and a significant increase in events per 100,000/quarter during the pandemic (5.28 [1.65, 8.90]).

Discussion

In this comprehensive study of 3 diverse Canadian provinces over 8 years (6 years pre-pandemic and 2 years during), we did not find any major increase in the rate of hospitalization for cardiovascular events during the pandemic, compared to the rate at baseline. Several studies have reported an association between COVID-19 infection and vascular events.[21-23] A self-controlled case series and matched cohort study of individuals with COVID-19 in Sweden, where COVID-19 is a reportable disease to the public health agency, found that the risk of ischemic stroke and MI approximately tripled in the first 2 weeks following the infection.[21] Another study using data from electronic health records of 48 million adults in the United Kingdom reported that the hazard of first arterial thrombosis was 22-fold higher among patients in the first week after COVID-19 diagnosis, compared to that among people without any infection.[33] These reports motivated the current study to test our hypothesis that hospitalizations for cardio- and cerebrovascular disease might increase during the pandemic to a level exceeding baseline trends, and that this may be more prominent in Alberta and Ontario, where COVID-19 waves were more severe than those in Nova Scotia.[34]

Documenting COVID-19 infection is increasingly difficult, owing to its variable severity and the fact that home-based rapid antigen test results are not reported to the public health agency or tracked in administrative data. The relative stability of hospitalizations for cardiovascular disease in the Canadian population is reassuring and likely is explained by the previous observation that the increased risk of vascular events associated with COVID-19 infection is driven mostly by patients with severe disease.[23,33] Despite widely publicized concerns around the ChAdOx1 nCov-19 (Oxford-AstraZeneca) vaccine being associated with increased CVT risk due to vaccine-induced immune thrombotic thrombocytopenia (VITT),[35,36] the rates of this condition were extremely low in Canada and elsewhere,[37] and rates of CVT remained stable overall and low in the current study.

Nevertheless, all public health measures to limit viral spread remain important to prevent severe infection and the post-COVID-19 condition (long COVID). In addition, outcomes after vascular events are worse when patients have concurrent COVID-19 infection, compared to the outcomes of patients without infection.[38] Finally, mounting evidence indicates increases in diabetes and hypertension incidence, 2 important vascular risk factors, after COVID-19 infection.[39-41] Our findings should not be interpreted as a lack of association between COVID-19 and cardiovascular events, but rather, at this time, we have not observed important excess in hospitalized cardiovascular events in the population. Continued surveillance of cardiovascular events is necessary, as our study period may not have been long enough to allow an observation of a rise in events.

A different pattern emerged for MI—that is, significant step decreases were observed in MI rates at pandemic onset in both Alberta and Ontario, but not Nova Scotia. Why a decrease occurred in MI but not stroke is not clear; however, systematic review data have shown a larger reduction in non-ST-segment-elevation MIs (NSTEMIs), compared to STEMIs, early in the pandemic.[42] One possibility is that individuals with less-severe MI events did not present to the hospital, whereas individuals with stroke presented regardless of its severity. Why MI and stroke were impacted differentially in Alberta and Ontario, compared to Nova Scotia, is not clear. However, one possibility is that, due to the smaller population in Nova Scotia, we were underpowered in this analysis. Two years into the pandemic, rates of MI remained lower than baseline levels in Alberta and Ontario; rates continued to decrease during the pandemic in Alberta, whereas they remained stable in Ontario. The reason for the decrease in MI rates in Alberta is unclear. One possibility is that COVID-19 was more fatal among elderly patients with vascular comorbidities, thus acting as a competing risk for MI in the group who traditionally had the highest incidence of MI. However, rates were also decreasing in these older age groups pre-pandemic. Additionally, our data do not include out-of-hospital deaths due to vascular events, and previous work has shown an increase in the number of out-of-hospital cardiac arrest patients during the pandemic who were determined to be dead on arrival.[43]

Unrelated to the pandemic, a striking finding was that the age- and sex-standardized rates of MI in Nova Scotia (averaging 97 events per 100,000/quarter across the time period) were almost double those of Alberta and Ontario (53 and 48 per 100,000/quarter, respectively). This finding is consistent with previous Public Health Agency of Canada reports showing higher age-standardized incidence and prevalence of acute MI, ischemic heart disease, and heart failure in the Atlantic provinces, compared to those in the rest of the country.[44,45] Standardized stroke rates also were higher in Nova Scotia than in Alberta and Ontario, but only by a magnitude of 10%, much less of an increase than that seen for MI. We hypothesize that this difference may reflect differences in primary prevention and access to both primary care and specialist care, especially in rural areas, in addition to higher rates of comorbidities and lifestyle factors, such as smoking.[46,47] These findings highlight striking and long-standing regional disparities in health and deserve further

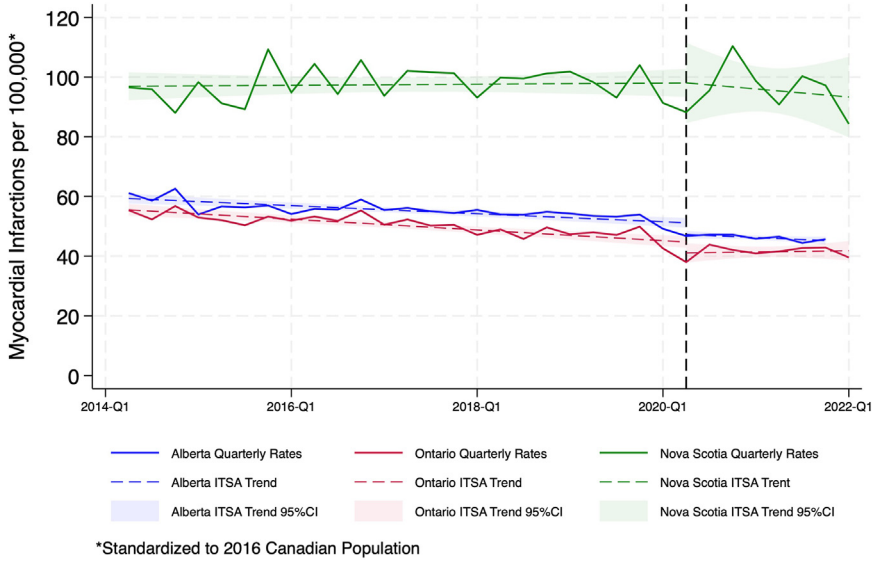

Figure 2. Quarterly rates of myocardial infarctions per 100,000 individuals, standardized to the 2016 Canadian population for the provinces of Alberta, Ontario, and Nova Scotia (**solid lines**), and results of interrupted time series analysis (ITSA; **dashed lines**) with 95% confidence intervals (CIs; **shaded bands**). The step change at pandemic onset was significant in Alberta and Ontario but not in Nova Scotia. Pre-pandemic and pandemic slopes were not significantly different from one another in any province.

dedicated work to identify strategies to improve cardiovascular health in Atlantic Canada.

This study has limitations. As with any study using administrative data, misclassification is a possibility, but the case definitions we used have high accuracy for patients with MI or stroke who were admitted to the hospital.[27-29] Administrative data are less sensitive and specific for events treated in an outpatient clinic or an emergency department. Thus, we did not study less-severe vascular events that did not require hospitalization. Although fluctuations in hospitalization thresholds may have occurred, as Canadian hospitals experienced occupancy crises, we likely have captured the most-severe events. In addition to potential fluctuations in hospitalization thresholds, changes in disease severity, as well as health-seeking behaviour in the population, may have occurred during the pandemic. Due to limitations in administrative data, we were not able to assess for changes in disease severity, health-seeking behaviour, or hospitalization criteria. By studying only hospitalized events, we also did not capture out-of-hospital deaths due to vascular events, which were known to have increased during the pandemic.[43] Due to the nature of administrative data, we were not able to assess if any changes in disease severity occurred during the pandemic period. Finally, we may have been underpowered to detect any changes in rates, because only 8 quarterly data points were available (7 in Alberta, as the last quarter of the study was not available), and confidence intervals were wide for all pandemic trend estimates.

In conclusion, we did not observe a substantial change in hospitalization rates for cardio- and cerebrovascular events across 3 Canadian provinces 2 years into the pandemic. Although this result is reassuring, given the association between COVID-19 infection and vascular outcomes, continued surveillance is warranted to monitor any further downstream impact of the pandemic on vascular events.

Data Statement

This document used data adapted from the Statistics Canada Postal CodeOM Conversion File, which is based on data licensed from Canada Post Corporation, and/or data adapted from the Ontario Ministry of Health Postal Code Conversion File, which contains data copied under license from ©Canada Post Corporation and Statistics Canada. Parts of this material are based on data and/or information compiled and provided by the Ontario MOH and Canadian Institute for Health Information (CIHI). The analyses, conclusions, opinions and statements expressed herein are solely those of the authors and do not reflect those of the funding or data sources; no endorsement is intended or should be inferred.

Portions of the data used in this report were made available by Health Data Nova Scotia of Dalhousie University. Although this research analysis is based on data obtained from the Nova Scotia Department of Health and Wellness, the observations and opinions expressed are those of the authors and do not represent those of either Health Data Nova Scotia or the Department of Health and Wellness. Portions of the data used in this report were made available by Alberta Health Services Data and Analytics. The interpretation and conclusions contained herein are those of the researchers and do not necessarily represent the views of Alberta Health Services.

Ethics Statement

The research reported has adhered to the relevant ethical guidelines.

Patient Consent

The authors confirm that patient consent is not applicable to this article. In Ontario, datasets were deterministically linked using unique encoded identifiers and analyzed at ICES

(formerly the Institute for Clinical Evaluative Sciences). The use of Ontario's data in this project was authorized under section 45 of Ontario's Personal Health Information Protection Act, removing the need for research ethics board approval. In Alberta and Nova Scotia, ethics approval was obtained from the University of Calgary Conjoint Health Research Ethics Board (REB22-0339) and the Nova Scotia Health Research Ethics Board (REB #1027801), with waiver of patient consent due to the use of retrospective de-identified data.

Funding Sources

This study was supported by ICES, which is funded by an annual grant from the Ontario Ministry of Health (MOH) and the Ministry of Long-Term Care (MLTC). This study was supported by the Ontario Health Data Platform (OHDP), a Province of Ontario initiative to support Ontario's ongoing response to COVID-19 and its related impacts. The opinions, results and conclusions reported in this paper are those of the authors and are independent from the funding sources. No endorsement by the OHDP, its partners, or the Province of Ontario is intended or should be inferred.

A.Y. holds a National New Investigator Award from the Heart & Stroke Foundation of Canada. M.K.K. holds the Lillian Love Chair in Women's Health, University Health Network, Toronto, Ontario, Canada. T.S.F. holds a Sauder Family/Heart&Stroke Professorship from the University of British Columbia, Vancouver, British Columbia, Canada. D.S.L. is the Ted Rogers Chair in Heart Function Outcomes, University Health Network, University of Toronto, Toronto, Ontario, Canada. This study was supported by the Canadian Institutes of Health Research (operating grant 179897).

Disclosures

The authors have no competing interests to disclose.

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Supplementary Material

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