




## ORIGINAL ARTICLE

# The decline in stroke hospitalization due to COVID-19 is unrelated to COVID-19 intensity

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## Abstract

**Background and Purpose:** During the coronavirus disease 2019 (COVID-19) pandemic many countries reported a decline in stroke volumes. The aim of this study was to analyze if the decline was related to the intensity of the COVID-19 pandemic.

**Methods:** The first pandemic year (1 March 2020 to 28 February 2021) overall and during the three COVID-19 waves were compared with the preceding year. Volumes of acute ischaemic stroke (AIS), subarachnoid hemorrhage, intracerebral hemorrhage and recanalization treatments (intravenous thrombolysis [IVT] and mechanical thrombectomy [MT]) were obtained from the National Register of Reimbursed Health Services. Door-to-needle time, onset-to-door time and National Institutes of Health Stroke Scale at admission were obtained from the Registry of Stroke Care Quality.

**Results:** During the pandemic year compared to the preceding year there were 26,453 versus 28,771 stroke admissions, representing an 8.8% decline ( $p < 0.001$ ). The declines (-10%, -11%, -19%) appeared in COVID-19 waves (spring 2020, autumn 2020, winter 2021) except for an increase (2%) during summer 2020. Admissions for AIS declined by 10.2% ( $p < 0.001$ ), whilst hemorrhagic stroke volumes were minimally decreased. The absolute volumes of IVT and MT decreased by 9.4% ( $p < 0.001$ ) and 5.7% ( $p = 0.16$ ), respectively. However, the proportions of ischaemic stroke patients receiving IVT (18% vs. 18%;  $p = 0.72$ ) and MT (6% vs. 6%;  $p = 0.28$ ) remained unchanged.

Petra Sedova and Julia Anna Kent contributed equally to this work.

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**Conclusions:** There was a decline in stroke admissions, but such decline was not related to COVID-19 incidence. The frequency of use of recanalization procedures (IVT, MT) and times (onset-to-door time, door-to-needle time) in AIS were preserved in the Czech Republic during the first year of the pandemic.

**KEYWORDS**

COVID-19, Czech Republic, intravenous thrombolysis, mechanical thrombectomy, stroke

## INTRODUCTION

For over 2 years the coronavirus disease 2019 (COVID-19) pandemic has challenged hospitals worldwide. Many studies [1–14] reported a decline in the number of stroke code activations and hospital admission rates during the first wave of the pandemic (March–May/June 2020) [15–28]. Consequently, a decline in the number of recanalization procedures (mechanical thrombectomy [MT] [18–20, 25, 29, 30] and intravenous thrombolysis [IVT] [10, 14, 16, 18–20, 23, 25–27, 30]) was observed. Furthermore, changes in stroke severity and indicators of acute ischaemic stroke (AIS) care quality (door-to-needle time [DNT], onset-to-door time [ODT]) have been noted in many countries, with more severe strokes at admission [5, 6, 27, 30] and higher stroke mortality rates [3, 9, 25].

In the Czech Republic (CR), a state of national emergency was declared on 12 March 2020. During the first coronavirus wave (March–May 2020), the CR was amongst the countries with the lowest incidence rate; however, the opposite was true for the later phases (September 2020 to February 2021), during which the CR was one of the most affected countries in the world.

Our initial report covering the first wave of the COVID-19 pandemic (March–May 2020) demonstrated a decline in stroke admission volumes and recanalization procedures in the CR [20].

It is unknown how the surge in COVID-19 cases in later phases and the following governmental protective measures influenced stroke admissions and management. In this study the impact of the COVID-19 pandemic on stroke volume and stroke management (recanalization therapy, DNT, ODT) during the first full year of the pandemic is evaluated.

## METHODS

### Study design

Data related to all stroke patients occurring in the CR were retrieved from the National Register of Reimbursed Health Services (NRRHS) for the years 2019, 2020 and 2021. DNT, ODT and stroke severity at admission (National Institutes of Health Stroke Scale, NIHSS) were obtained from the Registry of Stroke Care Quality (RES-Q) for March 2019, October 2019, April 2020 and October 2020. Only patients who were diagnosed with the following stroke types were included: subarachnoid hemorrhage (SAH), intracerebral hemorrhage (ICH) and ischaemic stroke (International

Classification of Diseases, 10th revision, codes I60, I61 and I63, respectively). The occurrence of each stroke type, the utilization of recanalization procedures (IVT, MT) and demographic parameters (age, sex) during the first pandemic year (1 March 2020 to 28 February 2021) overall and during the three COVID-19 waves within that year were compared with the preceding year (1 March 2019 to 29 February 2020).

### Czech Republic

In the CR, there is a public health insurance system. All health care services reimbursed from the public health insurance system by health insurance companies are reported to the NRRHS. Thus, the NRRHS collects and stores all data reported to health insurance companies by every healthcare provider.

### Registry of Stroke Care Quality (RES-Q)

Data on all stroke patients discharged with a stroke diagnosis from all accredited stroke centers in the CR are collected in the international RES-Q for 2 months every year (March or April and October). Further, RES-Q includes stroke management data including time to initiation of reperfusion therapy (DNT, ODT) and stroke severity as reflected by the NIHSS score.

### COVID epidemic in the CR

The CR was one of the least affected countries by the COVID-19 pandemic during the spring wave of 2020. By 31 May 2020, a total of only 9268 people (i.e., 881 cases per million) had tested positive for severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) (incidence 3.6 per million, 30 deaths per million) [31]. This success was followed by a significant surge in cases and the CR turned out to be one of the most heavily affected countries in the world in autumn 2020 and winter 2021. By 31 December 2020, 718,661 people (i.e., 68,373 cases per million) had tested positive, and by the end of February 2021 the total COVID-19 cases reached 1.24 million (i.e., 117,544 cases per million) [31]. Moreover, there was a substantial rise in case mortality, as the total number of deaths increased to 11,580 by 31 December 2020, and it had nearly doubled to 20,339 (1935 per million) by 28 February 2021 [31].

## Study periods

The COVID-19 pandemic year (March 2020 to February 2021) was compared with the immediately preceding year (March 2019 to February 2020). The pandemic year was divided into four periods according to COVID-19 incidence and compared to corresponding pre-pandemic months: spring (March–May 2020) first wave but with low COVID-19 incidence, summer (June–August 2020) with low COVID-19 incidence, autumn (September–December 2020) second wave with high COVID-19 incidence, and winter (January–February 2021) third wave with high COVID-19 incidence.

## Statistical analysis

Categorical variables are reported as absolute numbers and percentages. Continuous variables are presented as mean and standard deviation or median and interquartile range. The comparisons between years were performed using Fisher's exact test or the Mann-Whitney test, as appropriate. For overall volume analysis, the *p* value is based on two-sided Poisson means test. A *p* value of <0.05 was considered statistically significant. All statistical analyses were produced using R Statistical Software (version 4.0.3).

## Statement of Ethics

The present study conforms to the guidelines issued in the Declaration of Helsinki. Informed consent requirement was waived by the institutional ethics committees for this retrospective study

using anonymized clinical data, with no direct patient contact. The ethics committee of St Anne's University Hospital determined that this study does not constitute clinical research and is thus exempt from ethics committee review (communication received on 13 January 2021).

## RESULTS

The decrease in stroke admissions appeared in all COVID-19 waves (spring 2020, autumn 2020, winter 2021), and the decrease was greater as time and COVID-19 incidence progressed (−10.2%, −11.7%, −18.9%, respectively), except for the unexpected rise (+2%) in stroke admissions in summer 2020, when the COVID-19 pandemic was considered to potentially be over.

During the pandemic year 2020 compared to the prior year, the overall number of patients with stroke admitted to hospitals fell from 28,771 to 26,453 (8.8%, *p* < 0.001). Hemorrhagic stroke admissions remained stable, with only a slight decrease in the number of admitted patients with SAH and ICH, 1057–1024 (3.2%, *p* = 0.48) for SAH and 3286 to 3261 (0.8%, *p* = 0.77) for ICH. Only the decline observed in admissions for AIS reached statistical significance, as their number during the pandemic fell from 24,428 to 22,168 (10.2%, *p* < 0.001) in comparison to the pre-pandemic year (Table 1).

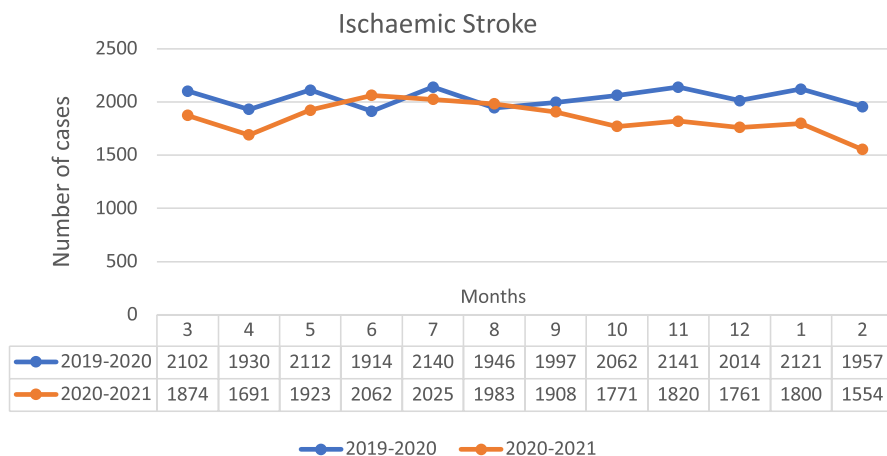
Comparing the first pandemic year to the previous year, the age of the admitted ischaemic stroke patients and the relative proportion of male patients remained unchanged for all stroke types.

Hospital admission rates for AIS fell significantly during all COVID-19 waves (Figure 1). The decline observed during the

**TABLE 1** Hospital admissions for all stroke types during the first year of the pandemic compared to the previous year

	1 year 1 year March 2020 to February 2021 [March 2019 to February 2020]	Low incidence wave First wave March– May 2020 [2019]	Summer "zero" COVID-19 June–August 2020 [2019]	High incidence waves Second wave September– December 2020 [2019]	Third wave January–February 2021 [2020]
Stroke total					
N	26,453 [28,771]	6615 [7290]	7084 [6940]	8716 [9738]	4038 [4803]
Relative change ( <i>p</i> value)	−8.8% (<0.001)	−10.2% (<0.001)	2.0% (0.23)	−11.7% (<0.001)	−18.9% (<0.001)
SAH (I60)					
N	1024 [1057]	262 [283]	301 [229]	335 [380]	126 [165]
Relative change ( <i>p</i> value)	−3.2% (0.48)	−8.0% (0.39)	23.9% (0.00)	−13.4% (0.10)	−31.0% (0.03)
ICH (I61)					
N	3261 [3286]	865 [863]	713 [711]	1125 [1152]	558 [560]
Relative change ( <i>p</i> value)	−0.8% (0.77)	0.2% (0.98)	0.3% (0.98)	−2.4% (0.59)	−0.4% (0.98)
AIS (I63)					
N	22,168 [24,428]	5488 [6144]	6070 [6000]	7256 [8206]	3354 [4078]
Relative change ( <i>p</i> value)	−10.2% (<0.001)	−12.0% (<0.001)	1.2% (0.53)	−13.1% (<0.001)	−21.6% (<0.001)

Abbreviations: AIS, acute ischaemic stroke; ICH, intracerebral hemorrhage; SAH, subarachnoid hemorrhage.



**FIGURE 1** Number of acute ischaemic stroke cases during the first pandemic year and the pre-pandemic year

autumn wave ( $-13.1\%$ ,  $p < 0.001$ ) with higher COVID-19 incidence was slightly greater compared to the decline during the spring wave ( $12.0\%$ ,  $p < 0.001$ ) with lower COVID-19 incidence. The most significant reduction was observed during the winter 2021 wave with the highest number of COVID-19 cases, as hospitalizations decreased by  $21.6\%$  ( $p < 0.001$ ) in comparison to the previous year.

Probably related to the reduction in the number of admitted AIS patients there was also a reduction in the volume of IVT procedures, with the most notable decline during the autumn wave ( $16.8\%$ ,  $p < 0.001$ ) and winter wave 2021 ( $11.9\%$ ,  $p = 0.041$ ), when COVID-19 cases were peaking, whilst there was a return to pre-pandemic levels ( $-0.4\%$ ) during the summer months when COVID-19 occurrence was low. A similar but not significant decline was reported for MT procedures, with the sharpest decline during the spring ( $12.5\%$ ,  $p = 0.151$ ) and winter 2021 waves ( $13.3\%$ ,  $p = 0.211$ ). During the first year of the COVID-19 pandemic, similar to the decrease in admission rates, there was a reduction in the volume of MT and IVT procedures in AIS patients, with numbers falling from 1350 to 1277 ( $5.7\%$ ,  $p = 0.160$ ) and 4322 to 3950 ( $9.4\%$ ,  $p < 0.001$ ), respectively. At the same time, the relative proportion of patients receiving recanalization procedures remained relatively stable compared to the pre-COVID year (Table 2).

For SAH, the decline in the number of admitted patients during the autumn ( $-13.4\%$ ,  $p = 0.1$ ) and winter waves ( $-31\%$ ,  $p = 0.03$ ) with high COVID-19 incidence was greater than during the first wave ( $-8.0\%$ ,  $p = 0.48$ ).

Using the RES-Q, the time to initiation of reperfusion therapy remained unchanged during the spring COVID-19 wave (DNT, 24 vs. 24 min,  $p = 0.5$ ; and ODT, 160 vs. 158 min,  $p = 0.23$ ) with improvement in ODT during the autumn wave (147 vs. 172 min;  $p = 0.009$ ). Stroke severity at admission did not differ comparing the years (NIHSS 6 vs. 6,  $p = 0.5$ ; NIHSS 6 vs. 6;  $p = 0.15$ ) (Table 3).

More detailed information on stroke type admission volumes and stroke management is presented in Tables 1–3 and Figures 1–3.

## DISCUSSION

Using nationwide data, the effect of the COVID-19 pandemic on hospital admission rates and ischaemic stroke acute care quality in

the CR during the first pandemic year was evaluated. A significant reduction in the total number of admitted stroke patients ( $8.8\%$ ,  $p < 0.001$ ) during the pandemic was observed compared to the previous year. However, only the decline in AIS reached statistical significance ( $10.2\%$ ,  $p < 0.001$ ), whilst ICH and SAH were unchanged. The most relevant results of our analysis are twofold. First, a significant decline in hospitalizations for total stroke during all COVID-19 waves regardless of COVID-19 incidence was found. Secondly, stroke hospital admissions returned to pre-pandemic levels during summer 2020, when the COVID-19 cases were low and the pandemic was considered to be over. The observed decline in AIS was accompanied by a decrease in the volume of recanalization procedures compared to the previous year, with an unchanged relative proportion of patients receiving IVT and MT. The time to initiation of reperfusion therapy was unchanged, suggesting that stroke management quality in the earliest stages of AIS was preserved.

No change in stroke severity at admission was observed, suggesting that people avoided hospitals regardless of stroke severity. Others have reported more severe strokes at admission during the pandemic [5, 6, 27, 30], indicating that patients with mild to moderate stroke or a transient ischaemic attack (TIA) did not seek medical help as consistently. Possible reasons proposed have included the fear of contracting the virus in the hospital setting [2, 3, 6, 12–14, 21–24, 27–29, 32] and the restrictive measures adopted during lockdown periods leading to social distancing, leading to more mild strokes or TIAs being unintentionally overlooked by the patients' relatives [5, 8, 12, 14, 16, 21, 22, 24, 27, 32].

To date, few studies have reported changes in hospitalization rates and stroke care quality during the second wave of the pandemic [22, 25, 33–35]. Our findings are in line with a recently published study by Katsouras et al. [35] (Greece, second wave November–December 2020), who observed a decline in acute stroke and acute coronary syndrome admission rates by  $33.7\%$  and  $33.3\%$ , respectively, compared to the same period in 2019.

In the CR the COVID-19 incidence rate was higher during the second wave in autumn 2020, which was accompanied by a sharper decline in stroke admission rates compared to the first wave of spring 2020 ( $11.8\%$  vs.  $10.2\%$ ). Yu et al. [25] (Ontario, Canada)

**TABLE 2** Demographic variables, recanalization procedures and mortality rates for acute ischaemic stroke patients

1 year	Low incidence wave			Summer "zero" COVID-19			High incidence waves		
	March 2019 to February 2020	March-May 2020	March-May 2019	June-August 2020	June-August 2019	September-December 2020	September-December 2019	January-February 2021	January-February 2020
Mean age ± SD	73.61 ± 12.41	73.58 ± 12.40	73.92 ± 12.32	73.30 ± 12.61	73.16 ± 12.71	73.38 ± 12.19	73.45 ± 12.16	73.87 ± 12.13	74.14 ± 12.55
Men, n (%)	12,039 (49.3%)	2648 (48.3%)	3017 (49.1%)	2991 (49.3%)	2945 (49.1%)	3482 (48.0%)	4060 (49.5%)	1621 (48.3%)	2017 (49.5%)
Relative change (p value)	-12.1% (<0.001)	-13.9% (<0.001)		1.5% (0.559)		-16.6% (<0.001)		-24.4% (<0.001)	
IVT, n (%)	3950 (17.8%)	976 (17.8%)	1056 (17.2%)	1071 (17.6%)	1075 (17.9%)	1265 (17.4%)	1477 (18.0%)	638 (19.0%)	714 (17.5%)
Relative change (p value)	-9.4% (<0.001)	-8.2% (0.080)		-0.4% (0.948)		-16.8% (<0.001)		-11.9% (0.041)	
MT, n (%)	1277 (5.76%)	296 (5.39%)	333 (5.42%)	327 (5.39%)	310 (5.17%)	451 (6.22%)	477 (5.81%)	203 (6.05%)	230 (5.64%)
Relative change (p value)	-5.7% (0.160)	-12.5% (0.151)		5.2% (0.526)		-5.8% (0.412)		-13.3% (0.211)	

Abbreviations: IVT, intravenous thrombolysis; MT, mechanical thrombectomy.

reported that the number of stroke patients visiting the emergency department did not drop to the degree of that noted during the first lockdown in the spring of 2020. Similarly, Richter et al. [33] (Germany) showed there was a greater decrease in admission rates for AIS during the first wave of spring 2020 compared to the second wave of autumn 2020, leading to possible explanations such as better public awareness about the detrimental effects of not seeking medical help in the case of stroke and a reduction in fear of contracting the virus. A study from Denmark reported a decrease in the number of stroke patients and stroke mimics during the first lockdown in Denmark (13 March 2020 to 17 May 2020) compared to the pre-pandemic year (1 January 2019 to 12 March 2020) [22]. At the same time, if the first pandemic year (13 March 2020 to 28 February 2021) was compared to the pre-pandemic year an increase in the total number of stroke patients was noted, with an increase in AIS cases but an unchanged number of ICH patients. These findings suggest that after the first lockdown period the number of stroke patients has been on the rise [22].

Whilst no change in demographic characteristics was observed, Richter et al. [33] reported a more significant decline in females with AIS during both waves compared to the pre-pandemic year, with only the change during the second wave being statistically significant. The authors attributed the observed difference to German women representing a greater proportion of care facility residents, one of the most vulnerable parts of the population during the pandemic, as well as to women being more serious about the severity of the pandemic and more inclined to follow restrictive measures [33].

Due to lower admission rates during the pandemic, the absolute volume of IVT procedures also decreased (but with a preserved relative proportion of AIS patients receiving such procedures) in all COVID-19 waves and returned to pre-pandemic levels during summer 2020. Comparable results were reported from Canada [25] and from Germany [33]. In our analysis a decline in the number of MTs in AIS patients (but with a stable percentage of AIS patients) during all time periods except for the summer 2020 was found. These results contradict the observed increase of MT procedures during the pandemic year in Germany [33]. On the other hand, data from Denmark [22] showed no change in the number of IVT and MT procedures during the pandemic; however, the authors hypothesized that these findings might be due to the smaller study cohort or the possible prevalence of milder strokes during the pandemic, even though no data regarding the NIHSS were reported.

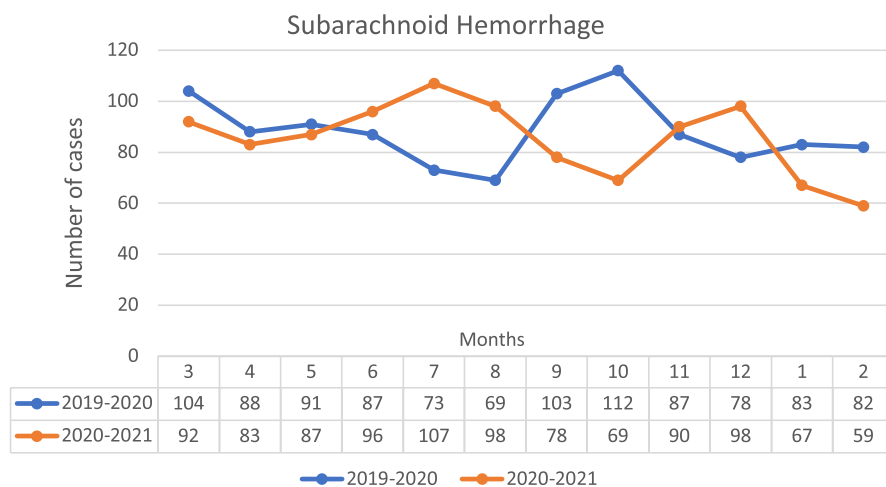
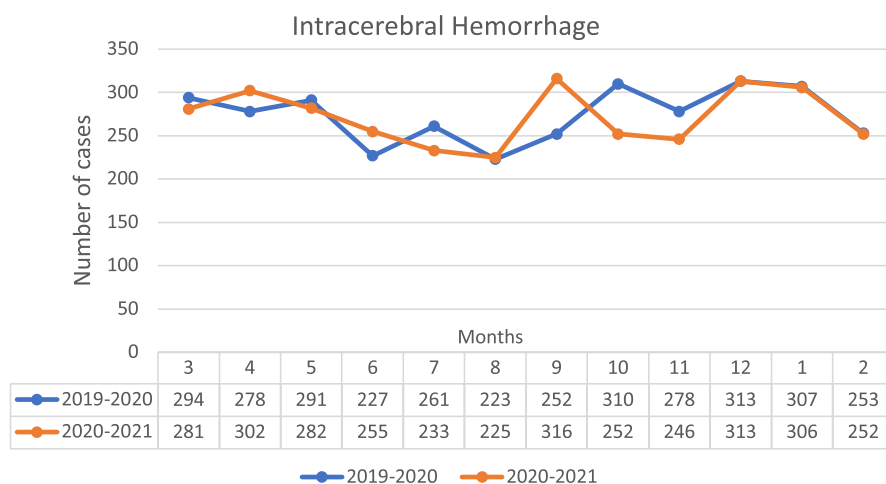
The observed decrease in admission rates of stroke patients during the second wave in autumn 2020 and the third wave in winter 2021 was comparable to the decline noted during the first wave of spring 2020 although the infection rate in the CR was higher at the later stages of the first pandemic year. These findings indicate that during the later waves people with stroke did not seek medical assistance in a similar manner compared to the first wave, whilst in other countries the decline was not as great [33], or stroke cases even rose [22]. Strict political measures leading to social distancing could have led to more TIAs being overlooked by the patients' relatives. People might have had ongoing fear of contracting the virus. Due to the

**TABLE 3** Parameters of stroke care in ischaemic stroke patients (I63) in 2019 and 2020 using RES-Q

	March 2019	April 2020	p value	October 2019	October 2020	p value
DNT (min), median (IQR)	24 (15–35)	24 (16–34)	0.52	23 (15–33)	22 (16–30)	0.46
ODT (min), median (IQR)	158 (85–375.5)	160 (84–387)	0.52	172 (85–430)	147 (80–336)	0.009*
NIHSS at admission median (IQR)	6 (3–13)	6 (3–12)	0.49	6 (3–12)	6 (3–13)	0.15

Abbreviations: DNT, door-to-needle time; IQR, interquartile range; NIHSS, National Institutes of Health Stroke Scale; ODT, onset-to-door time.

\*p value of <0.05 was considered statistically significant.

**FIGURE 2** Number of subarachnoid hemorrhage cases during the first pandemic year and the pre-pandemic year**FIGURE 3** Number of intracerebral hemorrhage cases during the first pandemic year and the pre-pandemic year

current study design, it could not be determined whether the drop in admission rates was due to the stroke incidence decline during the pandemic or patients with stroke being less likely to seek medical assistance. Our results also suggest that during the pandemic acute stroke care in the CR remained widely accessible and the quality of the earliest stages of ischaemic stroke care was preserved, as the relative proportion of patients receiving recanalization procedures was comparable to the pre-pandemic year and recanalization times remained stable.

One of the biggest strengths of this study is the nationwide data coverage. Furthermore, to date this is one of the few studies to evaluate the impact of the pandemic on stroke admission rates and care quality at the earliest stages of AIS during the entire first year of the pandemic.

## CONCLUSION

In this nationwide study in the CR the effect of the SARS-CoV-2 pandemic on stroke hospitalization and frequency of use of IVT and MT for AIS during the first COVID-19 pandemic year was evaluated. An 8.8% drop in stroke hospitalizations was found, with a statistically significant decrease only being noted in ischaemic stroke. The decline in stroke admissions occurred regardless of the level of COVID-19 incidence with a return to normal levels during pandemic “disappearance” in the summer months of 2020. The decline in ischaemic stroke admission rates was accompanied by a decrease in the absolute volumes of recanalization procedures (IVT, MT) but with a stable relative proportion of AIS patients receiving the procedures. Preserved recanalization times (DNT, ODT)

suggest stable acute management quality for ischaemic stroke. The unchanged NIHSS at admission would be consistent with the avoidance of hospital visits irrespective of stroke severity. As the pandemic continues, it is imperative that the public has increased awareness of the consequences of untreated serious medical conditions like stroke.

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### CONFLICT OF INTEREST

Tomas Bryndziar reports former employment at Bristol-Myers Squibb outside the submitted work.

### DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available upon request from the corresponding author.

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