Association of the COVID-19 outbreak with acute stroke care in Switzerland

Gian Marco De Marchis1,2  |  Patrick R. Wright2  |  Patrik Michel3  |  Davide Strambo3  |  Emmanuel Carrera4  |  Elisabeth Dirren4  |  Andreas R. Luft5,6  |  Susanne Wegener5  |  Carlo W. Cerda7  |  Georg Kägi8,9  |  Jochen Vehoff8  |  Henrik Gensicke1,2  |  Philippe Lyrer1,2  |  Krassen Nedeltchev10  |  Timo Khaless10  |  Manuel Bolognese11  |  Stephan Salmen12  |  Rolf Sturzenegger13  |  Christophe Bonvin14  |  Christian Berger15  |  Ludwig Schelosky16  |  Marie-Luise Mono17  |  Biljana Rodic18  |  Andrea von Reding18  |  Guido Schwegler19  |  Alexander A. Tarnutzer20  |  Friedrich Medlin21  |  Andrea M. Humm21  |  Nils Peters22  |  Morin Beyeler9  |  Lilian Kriemler1,2  |  David Bervin23  |  Javier Fandino24  |  Lars G. Hemkens2,25,26  |  Pasquale Mordini27  |  Marcel Arnold9  |  Urs Fischer1,2,9  |  Leo H. Bonati1,2  |  the Swiss Stroke Registry Investigators‡

1Department of Neurology and Stroke Center, University Hospital Basel, Basel, Switzerland
2Department of Clinical Research, University of Basel, Basel, Switzerland
3Department of Neurology, Lausanne University Hospital—Centre Hospitalier Universitaire Vaudois (CHUV), Lausanne, Switzerland
4Department of Neurology, University Hospital Geneva, Geneva, Switzerland
5Department of Neurology, University Hospital Zurich and University of Zurich, Zurich, Switzerland
6Cerneco Center for Neurology and Rehabilitation, Vitznau, Switzerland
7Department of Neurology and Stroke Center, Neurocenter of Southern Switzerland, Lugano, Switzerland
8Department of Neurology, Canton Hospital St Gallen, St Gallen, Switzerland
9Department of Neurology and Stroke Center, University Hospital Bern—Inselspital, Bern, Switzerland
10Department of Neurology, Cantonal Hospital Aarau, Aarau, Switzerland
11Stroke Center, Kantonsprital Lucerne, Luzern, Switzerland
12Stroke Unit, Spitalzentrum Biel, Biel, Switzerland
13Stroke Unit, Cantonal Hospital Graubünden, Chur, Switzerland
14Department of Neurology, Hôpital du Valais, Sion, Switzerland
15Stroke Unit, Cantonal Hospital Grabs, Grabs, Switzerland
16Stroke Unit, Cantonal Hospital Münsterlingen, Münsterlingen, Switzerland
17Stroke Unit, Stadtsplital Wald and Triemli, Zurich, Switzerland
18Stroke Unit, Cantonal Hospital Winterthur, Winterthur, Switzerland
19Stroke Unit, Spital Limmattal, Schlieren, Switzerland
20Stroke Unit, Cantonal Hospital Baden, Baden, Switzerland
21Stroke Unit, HFR Fribourg—Hôpital Cantonal, Fribourg, Switzerland
22Department of Neurology and Stroke Center, Hirslanden Clinic Zurich, Zurich, Switzerland

De Marchis and Wright contributed equally to this work as co-first authors.
Fischer and Bonati contributed equally to this work as co-senior authors.
†Investigators of the Swiss Stroke Registry are listed in Appendix S1.

This is an open access article under the terms of the Creative Commons Attribution-NonCommercial-NoDerivs License, which permits use and distribution in any medium, provided the original work is properly cited, the use is non-commercial and no modifications or adaptations are made.
© 2021 The Authors. European Journal of Neurology published by John Wiley & Sons Ltd on behalf of European Academy of Neurology.
INTRODUCTION

In Switzerland, the incidence of SARS-CoV-2 infections during the first wave of the COVID-19 pandemic wave was high (342/100,000) [1]. To curb the pandemic, the Swiss Federal Council declared a national lockdown from 13 March 2020 to 26 April 2020, with a major impact on all domains of daily life. Schools and non-essential shops were closed nationwide, and all gatherings of more than five people in public spaces were banned. Unlike in many other countries, no strict confinement was imposed. These unprecedented circumstances raised concern about potential restrictions in medical care of acute cardiovascular diseases. Many stroke physicians perceived a decrease in the number of admitted patients with ischaemic stroke and intracerebral hemorrhage (ICH), similar to what has been reported in other countries [2–10]. The aim of this work was to investigate changes in weekly admissions, clinical patient characteristics, delivery of acute therapy and functional 3-month outcome amongst patients with acute cerebrovascular events during the lockdown period compared to rates from 2018 and 2019 based on the prospective Swiss Stroke Registry.

METHODS

This is a retrospective analysis of prospectively collected data from the Swiss Stroke Registry, an institutional review board approved national web-based registry designed for quality assurance and multi-centric research in acute stroke care in Switzerland. Registry
details have been given previously [11]. Briefly, the registry collects a standardized dataset of all patients with acute cerebrovascular events including a follow-up assessment after 3 months and is compulsory for all hospitals certified as Stroke Units or Stroke Centers, in line with European Stroke Organization criteria [12]. The registry includes 10 Stroke Centers and 12 Stroke Units, which—in contrast to Stroke Centers—do not perform acute endovascular treatments. The registry was implemented in the clinical data management system securTrial and data processing is aided by the software package securTrial [13]. The de-identified data that support the findings of this study are available from the corresponding author upon reasonable request.

For this analysis, consecutive patients with an acute ischaemic stroke, ICH or transient ischaemic attack (TIA) admitted to a certified Stroke Center or Stroke Unit between 1 January 2018 and 8 June 2020 were included to investigate any deviation in the observed from the expected admission rates during the first lockdown period, which was defined from 13 March 2020 to 26 April 2020. In addition, patient characteristics, acute therapy and functional outcome of patients admitted during the lockdown period were compared to those admitted in the same period in the years 2018 and 2019.

The weekly admissions for acute ischaemic stroke, TIA and ICH were compared between the two periods. Also compared was the time from symptom onset or last seen well to hospital admission; patient referral (e.g., ambulance or self-referral); severity of symptoms on admission (measured by the National Institutes of Health Stroke Scale [NIHSS]); rate of acute stroke treatments delivered (including intravenous thrombolysis [IVT] and endovascular therapy [EVT]); in-hospital performance measures defined as the time from hospital admission to start of IVT (“door-to-needle time”) or EVT (“door-to groin-puncture time”); rate of patients with wake-up stroke treated by IVT or EVT (defined as a stroke with symptoms that were present when the patient awoke but not prior to falling asleep); stroke etiology defined by the Trial of Org 10172 in Acute Stroke Treatment (TOAST) criteria [14] (cardiac embolism, small vessel disease, large artery atherosclerosis, other defined cause, multiple causes, no identified cause); in-hospital outcome including symptomatic intracerebral hemorrhage, all-cause mortality; level of disability at 3 months (measured by the modified Rankin Scale [15]); and all-cause mortality at 3 months. At 3 months, information on functional outcomes and mortality was available for 80% of patients.

**Geographical comparison**

Across geographical regions within Switzerland, the COVID-19 incidence rates differed during the first pandemic wave. “High-incidence” regions were defined as having more than 700 COVID-19 cases/100,000 people by 27 April 2020 according to the statistics of the Federal Office of Public Health; high-incidence cantons were Ticino, Geneva, Vaud, Valis. Weekly admissions for high-incidence regions were compared to the rest of the country [1].

**Statistical analysis**

As over the years 2015–2019 the number of weekly stroke admissions had been increasing following a linear trend, it was assumed that this trend would have continued in 2020 if the COVID-19 pandemic had not occurred. Hence, a linear model was fitted to the data from the years prior to 2020 and this model was used to quantify deviations from the expectation. Fitting this linear model simply to the total number of across-center hospital admissions would be problematic, however. Not all centers contributed their numbers to the study dataset from 2015 onward, but instead started contributing in later years. Each addition of a center leads to a jump in the total number of admissions in the year of its addition. To make sure that these jumps do not influence the estimate of our linear model of the steady increase of admissions over time, our analysis was repeated using three subsets of the study data: one containing all centers contributing since 2015 with years 2015–2020, one with all centers contributing since 2016 with years 2016–2020, and one with all centers contributing since 2018 with years 2018–2020 (which are all centers). Since the analysis described above revealed a clear decline of stroke admissions in the 2020 Swiss lockdown period, the question of whether the population of admitted cases had in some way changed was posed. Due to known, pandemic independent, temporal trends in certain variables a comparison of, for example, 2020 to 2015 was considered inappropriate. It was decided to compare the patient population of weeks 11–17 in 2020 to the patient population of weeks 11–17 in 2018 and 2019. The analysis period spanned from 1 January 2018 to 8 June 2020.

Categorical variables were summarized as counts and percentages, continuous ones as median and interquartile ranges. Categorical variables were compared with the Fisher’s exact test, continuous variables with the Wilcoxon rank-sum test. *p* values are two-tailed. *p* values <0.05 were considered statistically significant. Statistical analysis was performed by P.W. and G.D. using R (R Core Team 2019 [16]).

**RESULTS**

Overall, 28,310 patients were admitted between 1 January 2018 and 8 June 2020. Of these, 4491 (15.9%) were admitted during the lockdown period 2020 (*n* = 1487) and the same calendar period of 2018 and 2019 (*n* = 3004). The weekly admissions during the lockdown period decreased up to 22% compared to expectations from admission trends since 2018 (Figure 1). During three consecutive lockdown weeks, the admission rate was lower than the 5% quantile of expectations (probability of observing at least that many extreme values without the lockdown: 0.38%). In a sensitivity analysis excluding patients with TIA, the drop in admission was even more pronounced, with four consecutive lockdown weeks falling under the 5% quantile of expectations (probability of 0.02% without the lockdown) (Figure 1). A comparison to the years 2015–2019 did not change these findings (Figure S1). The geographical analysis revealed

---

**DE MARCHIS ET AL.**

---

**RESULTS**

Overall, 28,310 patients were admitted between 1 January 2018 and 8 June 2020. Of these, 4491 (15.9%) were admitted during the lockdown period 2020 (*n* = 1487) and the same calendar period of 2018 and 2019 (*n* = 3004). The weekly admissions during the lockdown period decreased up to 22% compared to expectations from admission trends since 2018 (Figure 1). During three consecutive lockdown weeks, the admission rate was lower than the 5% quantile of expectations (probability of observing at least that many extreme values without the lockdown: 0.38%). In a sensitivity analysis excluding patients with TIA, the drop in admission was even more pronounced, with four consecutive lockdown weeks falling under the 5% quantile of expectations (probability of 0.02% without the lockdown) (Figure 1). A comparison to the years 2015–2019 did not change these findings (Figure S1). The geographical analysis revealed
that the admission drop was more pronounced in regions with an average COVID-19 incidence than in regions with a high COVID-19 incidence (Figure 2a,b).

Table 1 summarizes the characteristics of patients admitted during the lockdown period (2020) versus during the same calendar period in 2018 and 2019. The distribution of cerebrovascular events was significantly different ($p = 0.006$) with higher proportions of ICH (9.3% vs. 7.1%) and TIA (19% vs. 17%) and a lower proportion of ischaemic strokes (72% vs. 76%) during the lockdown. Referral modes were significantly different ($p < 0.001$) during the lockdown, with more patients admitted through emergency medical services (48% vs. 42%).

Etiologies of stroke were significantly different ($p = 0.006$) during the lockdown, with fewer proportion of cardioembolic strokes (20% vs. 26%). There were no statistically significant differences for onset-to-door time. On admission, stroke severity (median NIHSS) was 2 (interquartile range 1–6) during the lockdown period versus 3 (interquartile range 1–7) in 2018–2019 ($p = 0.07$). There was no statistically significant difference in the proportion of patients treated with recanalization therapies, in the door-to-needle or door-to-groin times, nor in the disability and mortality rates between the lockdown period and the previous 2 years (Table 2).

**DISCUSSION**

The main finding of this nationwide observational study is that weekly rates of cerebrovascular events fell by up to 22% during the Swiss national lockdown compared to expectations from admission trends from the years 2018–2019. It is very unlikely that this is explained by chance alone. No evidence was found supporting assumptions that patients with milder strokes have not been admitted, since—during the lockdown—median NIHSS was lower compared to the previous 2 years. There were differences in the types and etiology of strokes with more ICH and fewer cardioembolic strokes during the lockdown.

According to a meta-analysis of 18 cohort studies including 67,845 patients, SARS-CoV-2 infection was associated with an increased odds of ischaemic stroke (odds ratio 3.58, 95% confidence interval 1.43–8.92) [17]. Yet, this did not translate into an observable increase of stroke admissions during the first peak of the pandemic. Instead, a reduction was observed in admissions for stroke, in line with what was reported for several other countries. For instance, in China, across 280 hospitals, there were fewer hospital admissions during the COVID-19 outbreak (~40%) [9]. In the USA, in the Get with the Guidelines—Stroke National Registry, stroke presentations decreased by an average of 15.3% per week between 4 February 2020 and 29 June 2020 compared with similar months in 2019 [18]. In Joinville, Brazil, there were 36.4% fewer stroke admissions during the COVID-19 restrictions in the city compared to the same period in 2019, with no difference in admissions for severe stroke and ICH [8]. In southern Spain, the number of hospital admissions was 25% lower compared to the previous months [5]. At the Hospital Clinic of Barcelona, Spain, there was a 23% decline of stroke admissions compared to March 2019 [19]. In two German academic centers, stroke admission rates decreased by 40% and 46% in the temporal context of the implementation of public health measures compared to 2019 [7].

As COVID-19 represents a risk factor for ischaemic stroke, as seen in a large study from Sweden, the reduction in stroke admission during the lockdown is intriguing [20]. Possible reasons for fewer stroke admissions include [21] that strict "stay at home" orders and fear of infection may have led patients with milder strokes not to seek care. However, no supporting evidence for this assumption was found: during the lockdown period, symptom severity was lower compared to the previous years. The underlying mechanisms for fewer admissions can only be hypothesized. Social
isolation, especially amongst the elderly, may have contributed to under-detection of stroke by proxies or delayed detections without admission to a stroke unit or stroke center. It is possible that stroke incidence itself has declined, for instance due to behavioral and environmental changes during the lockdown. Indeed, long working hours are associated with a 33% relative risk increase of incident stroke [22]. Air pollutants have a marked and close temporal association with admissions to hospital for stroke or mortality from stroke, as seen in a meta-analysis of observational studies [23]. Behavioral changes may have reduced the incidence of other respiratory tract infections known to be associated with stroke [24].

Despite the increase of referrals with emergency services, a lack of capacity in general or restrictions in acute stroke pathways are unlikely contributors to the observed decrease in admissions. In Switzerland, emergency services did not reach saturation although some patients had to be transferred to other hospitals. Moreover, all participating centers were reminded of the importance of completion of data entry during and after the first pandemic wave. It was deemed unlikely that stroke under-diagnosis or reduced case ascertainment in the Swiss Stroke Registry can explain the reported admission drop compared to pre-pandemic years.

The rate of recanalization therapies remained constant during the pandemic, in line with international observations [17]. Door-to-needle and door-to-groin times did not change significantly during the lockdown period, similarly to what has been found in a recent international multicenter cohort study across 20 stroke centers in Europe and Israel [25]. In China, however, stroke care was temporarily reduced in the majority of hospitals; accordingly, thrombolysis and thrombectomy rates dropped by about 25% compared to the same period in 2019 [9].

In regions with a high COVID-19 incidence a more pronounced drop in stroke admission rates was expected due to stricter
The population should be informed to seek urgent medical care in the case of acute neurological symptoms, irrespective of the pandemic situation. In conclusion, fewer patients than expected were admitted for cerebrovascular events in Switzerland during the lockdown period in 2020. Stroke severity was lower during the lockdown. Importantly, the Swiss healthcare system was able to ensure the same high standard of stroke care with the same availability, speed of delivery and short-term outcome as in the years before without a pandemic crisis. The population should be informed to seek urgent medical care in the case of acute neurological symptoms, irrespective of the pandemic situation.

**CONFLICT OF INTERESTS**

GMDM has been receiving support from the Swiss National Science Foundation (No. 32003B_200573, No. PBBEP3_139388); Spezialprogramm Nachwuchsförderung Klinische Forschung, University of Basel; Science Funds (Wissenschaftspool) of the University Hospital Basel; Swiss Heart Foundation; Bangerter-Rhyner-Stiftung; Swissslife Jubiläumsstiftung for Medical Research;
Swiss Neurological Society; Fondazione Dr Ettore Balli; De Quervain research grant; Thermo Fisher GmbH; travel honoraria by Bayer and BMS/Pfizer; speaker honoraria by Bayer and Medtronic. He is a member of the Steering Committee of PACIFIC Stroke (NCT04304508). Industry payments are made to the research fund of the University Hospital Basel. PM reports receipt of research support from Siemens, Cerenovus, iSchmaview, Medtronic, Stryker, the Swiss Heart Foundation and the Swiss National Foundation, receipt of consultant fees paid to the institution from Medtronic, Cerenovus, Phenox and Microvention during the conduct of the study, unrelated to the submitted work. FM has been receiving support from the Swiss Heart Foundation. All other authors report no disclosures related to the present paper.

AUTHOR CONTRIBUTIONS

Gian Marco De Marchis: Conceptualization (equal); data curation (equal); funding acquisition (equal); investigation (equal); validation (equal); writing—review and editing (equal). Patrick Wright: Data curation (equal); formal analysis (equal); validation (equal); writing—review and editing (equal). Patrick Wright: Data curation (equal); investigation (equal); validation (equal); writing—review and editing (equal). Philipp A Lyrer: Data curation (equal); investigation (equal); validation (equal); writing—review and editing (equal). Krassen Nedeltchev: Data curation (equal); investigation (equal); validation (equal); writing—review and editing (equal). Timo Kahles: Data curation (equal); investigation (equal); validation (equal); writing—review and editing (equal). Manuel Bolognese: Data curation (equal); investigation (equal); validation (equal); writing—review and editing (equal). Rolf Sturzenegger: Data curation (equal); investigation (equal); validation (equal); writing—review and editing (equal). Ludwig Schelosky: Data curation (equal); investigation (equal); validation (equal); writing—review and editing (equal). Christian Berger: Data curation (equal); investigation (equal); validation (equal); writing—review and editing (equal). Andrea von Reding: Data curation (equal); investigation (equal); validation (equal); writing—review and editing (equal). Friedrich Medlin: Data curation (equal); validation (equal); writing—review and editing (equal). Andrea M Humm: Data curation (equal); investigation (equal); validation (equal); writing—review and editing (equal). Nils Peters: Data curation (equal); investigation (equal); validation (equal); writing—review and editing (equal). Morin Beyeler: Data curation (equal); validation (equal); writing—review and editing (equal). Javier Fandino: Data curation (equal); investigation (equal); validation (equal); writing—review and editing (equal).
and editing (equal), Lilian Kriemler: Data curation (equal); investigation (equal); validation (equal); writing—review and editing (equal). David Bervini: Data curation (equal); investigation (equal); validation (equal); writing—original draft (equal). Lars Hemkens: Data curation (equal); investigation (equal); validation (equal); writing—review and editing (equal). Pasquale Mordasini: Data curation (equal); investigation (equal); validation (equal); writing—review and editing (equal). Marcel Arnold: Data curation (equal); investigation (equal); validation (equal); writing—review and editing (equal). Urs Fischer: Data curation (equal); investigation (equal); validation (equal); writing—review and editing (equal). Leo H Bonati: Data curation (equal); investigation (equal); validation (equal); writing—review and editing (equal).

ACKNOWLEDGEMENT
Open access funding provided by Universitat Basel.

DATA AVAILABILITY STATEMENT
The de-identified data that support the findings of this study are available from the corresponding author upon reasonable request.

ORCID
Gian Marco De Marchis https://orcid.org/0000-0002-0342-9780
Susanne Wegener https://orcid.org/0000-0003-4369-7023
Friedrich Medlin https://orcid.org/0000-0002-8477-899X

REFERENCES
1. Epidemiologische Zwischenbilanz zum neuen Coronavirus in der Schweiz und im Fürstentum Liechtenstein. Accessed July 22, 2021. https://www.bag.admin.ch/bag/en/home/krankheiten/ausbrueche-epidemien-aktuelle-ausbrueche-epidemien/ncov-situation-schweiz-und-international.html
2. Katsanos AH, Palaiodimou L, Zand R, et al. The impact of SARS-CoV-2 on stroke epidemiology and care: a meta-analysis. Ann Neurol. 2021;89(2):380–388.
3. Siegler JE, Heslin ME, Thou L, Smith A, Jovin TG. Falling stroke rates during COVID-19 pandemic at a comprehensive stroke center. J Stroke Cerebrovasc Dis. 2020;29:104953.
4. Siegler JE, Cardona P, Arenillas JF, et al. Cerebrovascular events and outcomes in hospitalized patients with COVID-19: the SVIN COVID-19 Multinational Registry. Int J Stroke. 2021;16(4):437–447.
5. Montaner J, Barragan-Prieto A, Perez-Sanchez S, et al. Break in the strokechain of survival due to COVID-19 Stroke. 2020;51:2307-2314.
6. Jasne AS, Chojecka P, Maran I, et al. Stroke code presentations, interventions, and outcomes before and during the COVID-19 pandemic. Stroke. 2020;51:2664-2673.
7. Hoyer C, Ebert A, Huttnner HB, et al. Acute stroke in times of the COVID-19 pandemic: a multicenter study. Stroke. 2020;51:2224-2227.
8. Diegoli H, Magalhaes PSC, Martins SCO, et al. Decrease in hospital admissions for transient ischemic attack, mild, and moderate stroke during the COVID-19 Era. Stroke. 2020;51(8):2315-2321.
9. Zhao J, Li H, Kung D, Fisher M, Shen Y, Liu R. Impact of the COVID-19 epidemic on stroke care and potential solutions. Stroke. 2020;51(7):1996-2001.
10. Yagh S, Ishida K, Torres J, et al. SARS2-CoV-2 and stroke in a New York healthcare system. Stroke. 2020;51(7):2002-2011.
11. Manco S, Disanto G, Blanco G, et al. Outcome of endovascular therapy in stroke with large vessel occlusion and mild symptoms. Neurology. 2019;93:e1618-e1626.
12. Waje-Andreassen U, Nabavi DG, Engelter ST, et al. European Stroke Organisation certification of stroke units and stroke centres. Eur Stroke J. 2018;3:220-226.
13. Wright PR, Haynes GH, Markovic M. secuTrialR: Seamless interaction with clinical trial databases in R. J Open Source Softw. 2020;5:2816.
14. Adams HP Jr, Bendixen BH, Kappelle LJ, et al. Classification of subtype of acute ischemic stroke. Definitions for use in a multicenter clinical trial. TOAST. Trial of Org 10172 in Acute Stroke Treatment. Stroke. 1993;24:35–41.
15. van Swieten JC, Koudstaal PJ, Visser MC, Schouten HJ, van Gijn J. Interobserver agreement for the assessment of handicap in stroke patients. Stroke. 1988;19:604-607.
16. R Core Team. 2019:A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria.https://www.R-project.org/
17. Katsanos AH, Palaiodimou L, Zand R, et al. The impact of SARS-CoV-2 on stroke epidemiology and care: a meta-analysis. Ann Neurol. 2021;89(2):380–388.
18. Srivastava PK, Zhang S, Xian Y, et al. Acute ischemic stroke in patients with COVID-19: an analysis from Get with the Guidelines—Stroke. 2021;52:1826-1829.
19. Rudilosso S, Laredo C, Vera V, et al. Acute stroke care is at risk in the era of COVID-19: experience at a comprehensive stroke center in Barcelona. Stroke. 2020;51:1991-1995.
20. Katsoularis I, Fonseca-Rodriguez O, Farrington P, Lindmark K, Fors Connolly AM. Risk of acute myocardial infarction and ischaemic stroke following COVID-19 in Sweden: a self-controlled case series and matched cohort study. Lancet. 2021;398(10300):599-607.
21. Aguiar de Sousa D, Sandset EC, Elkind MSV. The curious case of the missing strokes during the COVID-19 pandemic. Stroke. 2020;51(7):1921-1923.
22. Kivimaki M, Jokela M, Nyberg ST, et al. Long working hours and risk of coronary heart disease and stroke: a systematic review and meta-analysis of published and unpublished data for 603,838 individuals. Lancet. 2015;386:1739-1746.
23. Shah AS, Lee KK, McAllister DA, et al. Short term exposure to air pollution and stroke: systematic review and meta-analysis. BMJ. 2015;350:h1295.
24. Kulick ER, Alvord T, Canning M, Elkind MSV, Chang BP, Boehme AK. Risk of stroke and myocardial infarction after influenza-like illness in New York State. BMC Public Health. 2021;21:864.
25. Altersberger VL, Stolze LJ, Heldner MR, et al. Maintenance of acute stroke care following COVID-19 in Austria. Stroke. 2020:51:1991-1995.
26. Dimitrijevic J, Gavranovic M, Dzirlo K, et al. Cerebrovascular accidents in Sarajevo during the war. Rev Neurol (Paris). 1999;155:359-364.
27. Dimitrijevic J, Dzirlo K, Bratic M, et al. 10-year analysis of cerebrovascular accidents at the Neurology Clinic in Sarajevo (before, during and after the war). Med Afn. 2002;56:151-153.

SUPPORTING INFORMATION
Additional supporting information may be found in the online version of the article at the publisher’s website.

How to cite this article: De Marchis GM, Wright PR, Michel P, et al: the Swiss Stroke Registry Investigators. Association of the COVID-19 outbreak with acute stroke care in Switzerland. Eur J Neurol. 2022;29:724–731. doi:10.1111/ene.15209