

## ORIGINAL CONTRIBUTION

# Break in the Stroke Chain of Survival Due to COVID-19

Joan Montaner<sup>1</sup> MD, PhD; Ana Barragán-Prieto, MD; Soledad Pérez-Sánchez, MD, PhD; Irene Escudero-Martínez, MD; Francisco Moniche, MD, PhD; José Antonio Sánchez-Miura; Lidia Ruiz-Bayo; Alejandro González, MD, PhD

**BACKGROUND AND PURPOSE:** Emergency measures to treat patients with coronavirus 2019 (COVID-19) and contain the outbreak is the main priority in each of our hospitals; however, these measures are likely to result in collateral damage among patients with other acute diseases. Here, we investigate whether the COVID-19 pandemic affects acute stroke care through interruptions in the stroke chain of survival.

**METHODS:** A descriptive analysis of acute stroke care activity before and after the COVID-19 outbreak is given for a stroke network in southern Europe. To quantify the impact of the pandemic, the number of stroke code activations, ambulance transfers, consultations through telestroke, stroke unit admissions, and reperfusion therapy times and rates are described in temporal relationship with the rising number of COVID-19 cases in the region.

**RESULTS:** Following confinement of the population, our stroke unit activity decreased sharply, with a 25% reduction in admitted cases (mean number of 58 cases every 15 days in previous months to 44 cases in the 15 days after the outbreak,  $P < 0.001$ ). Consultations to the telestroke network declined from 25 every 15 days before the outbreak to 7 after the outbreak ( $P < 0.001$ ). The increasing trend in the prehospital diagnosis of stroke activated by 911 calls stopped abruptly in the region, regressing to 2019 levels. The mean number of stroke codes dispatched to hospitals decreased (78% versus 57%,  $P < 0.001$ ). Time of arrival from symptoms onset to stroke units was delayed  $>30$  minutes, reperfusion therapy cases fell, and door-to-needle time started 16 minutes later than usual.

**CONCLUSIONS:** The COVID-19 pandemic is disruptive for acute stroke pathways. Bottlenecks in the access and delivery of patients to our secured stroke centers are among the main challenges. It is critical to encourage patients to continue seeking emergency care if experiencing acute stroke symptoms and to ensure that emergency professionals continue to use stroke code activation and telestroke networks.

**Key Words:** acute disease ■ coronavirus ■ diagnosis ■ pandemics ■ reperfusion ■ stroke

The international pandemic produced by coronavirus 2019 (COVID-19) has already affected  $>3.5$  million patients and killed 250 000 worldwide by the beginning of May, changing the rhythm of the planet in the last months.<sup>1</sup> Despite the emergency measures to treat patients with COVID-19 and contain the outbreak being the main priority at each of our hospitals, it is also important to consider the collateral damage of this crisis on patients with other acute diseases.

In fact, previous coronavirus outbreaks, such as South Korea experienced in 2015 due to Middle East

respiratory syndrome, resulted in changes in emergency care utilization.<sup>2</sup> In that situation, the number of emergency room visits during the peak of the Middle East respiratory syndrome epidemic decreased by 33.1% and was more pronounced for low-acuity diseases (eg, acute otitis media, 53.0%) than for high-acuity diseases (eg, myocardial infarctions, 14.0%; ischemic stroke, 16.6%).

Similarly, the COVID-19 outbreak has been shown to affect cardiovascular diseases, with an abnormally small number of patients with acute ST-segment-elevation myocardial infarction seeking medical help after

Correspondence to: Joan Montaner, MD, PhD, Neurovascular Research Group, Institute de Biomedicine of Seville, IBiS/Hospital Universitario Virgen del Rocío/CSIC/University of Seville, Av Manuel Siurot s/n, 41013, Seville, Spain. Email [jmontaner-ibis@us.es](mailto:jmontaner-ibis@us.es)

For Sources of Funding and Disclosures, see page xxx.

© 2020 American Heart Association, Inc.

Stroke is available at [www.ahajournals.org/journal/str](http://www.ahajournals.org/journal/str)

## Nonstandard Abbreviations and Acronyms

<b>COVID-19</b>	coronavirus 2019
<b>IV tPA</b>	intravenous tissue-type plasminogen activator

the establishment of infection control measures in Hong Kong.<sup>3</sup> The authors of that report claim that people are reluctant to go to a hospital during the COVID-19 outbreak, which explains the potential delays in seeking care; moreover, they also reported delays in evaluating patients with ST-segment-elevation myocardial infarction after hospital arrival.

We hypothesize that the COVID-19 pandemic is disruptive for stroke care across the globe since several elements of the stroke chain of survival are likely to be interrupted. Therefore, to better understand how the acute stroke care situation in the era of the COVID pandemic crisis might be affected, we evaluated the number of stroke cases attending and treated at a south European region before and during the outbreak.

## METHODS

All supporting data are available within the article and any data related with stroke during COVID-19 pandemic in our region is also available from the corresponding author upon reasonable request. Ethics approval was obtained from the local institutional review board that waived the need for patient consent (code 1041-N-20).

A descriptive analysis of the situation of acute stroke care before and after the COVID-19 outbreak is given for a stroke network located in southern Europe. Seville is a province with 1.94 million inhabitants and has 2-stroke units at the 2 large hospitals of Seville city (Hospital Universitario Virgen del Rocío and Hospital Universitario Virgen Macarena). One of these 2 hospitals is the reference thrombectomy center for Sevilla and a close smaller province (Huelva) with a total of 2.45 million inhabitants within its catchment area. The other hospital held the telestroke network for the whole region Centro Andaluz de Tele-ictus according to a centralized hub and spoke model, with one neurologist supporting (24 hours per day) the hospitals' network in the region.

All data on the activity of both stroke units are prospectively recruited on a daily basis, and those on mechanical thrombectomy are obtained from the prospective A Registry for Thrombectomy in Stroke Therapy From Andalusia registry maintained jointly by interventional neuroradiologists and vascular neurologists. Centro Andaluz de Tele-ictus has its own registry for all Andalusia, and data on the studied region (Seville and Huelva) have been used for this report.

Code stroke is activated by a unique coordinating center in there is suspicion following telephonic contact through the 061 or 112 numbers (local equivalents to 911). The coordinating center allocates the closest properly equipped transport resources from the regional network of ambulances. All those

code stroke activations are automatically recorded in the electronic medical records (DIRAYA, HCM-D).

To quantify the impact of the COVID-19 outbreak, all figures on stroke activity at each link of the chain were compared across time from 2 months before the outbreak until 15 days after (March 31, 2020) and also compared with the same period last year for some of the explored variables. This was also compared with the number of COVID-19 cases in the region in this period of time. Times from symptoms onset to arrival to hospitals, reperfusion therapy times (door-to-needle and door-to-puncture), and number of transient ischemic attacks attended at the emergency departments were also evaluated.

All categorical variables are presented as number and frequency (%), while continuous variables are presented as mean $\pm$ SD or median $\pm$ interquartile range. In bivariate analysis, the  $\chi^2$  test, Fisher exact test, Student *t* test, and Mann-Whitney *U* test, as appropriate, were used. All statistical analyses were performed using IBM SPSS Statistics V.23, IBM. A *P*<5% indicated a statistically significant difference.

## RESULTS

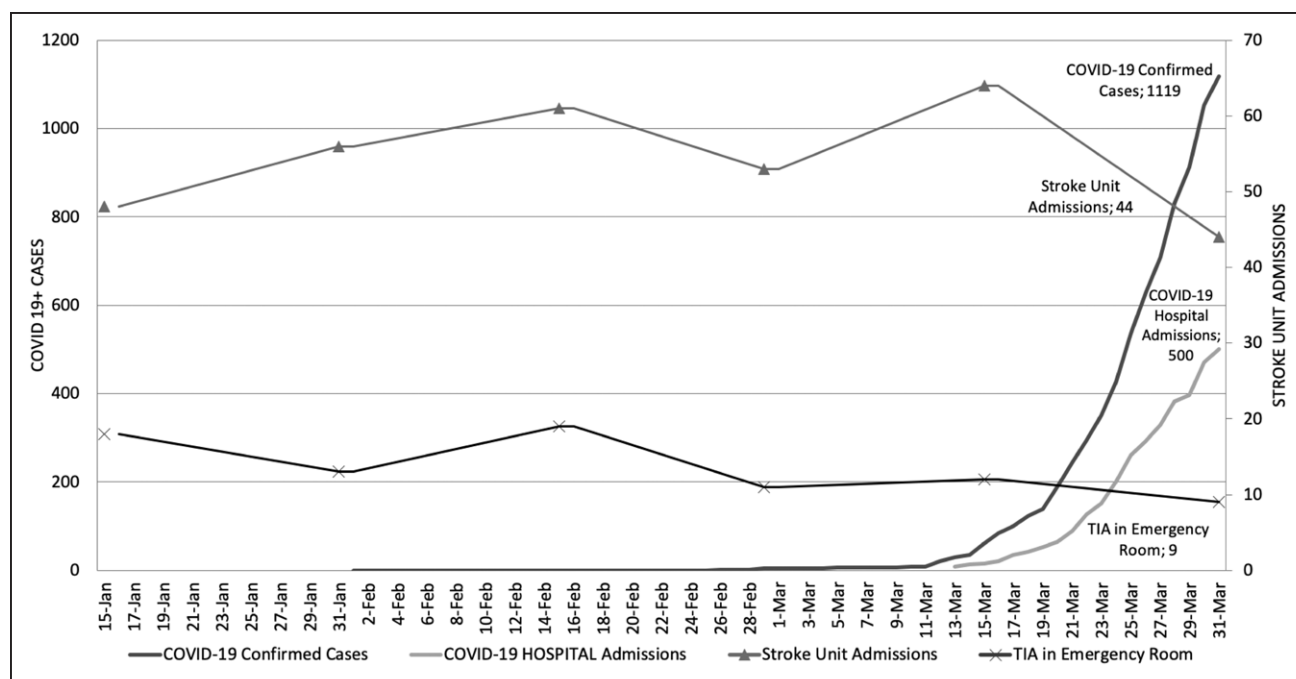
### COVID-19 Statistics at the Region

Spain, with 94 417 COVID-19 confirmed cases and 8189 deaths as of March 31, 2020, has one of the highest burdens of COVID-19 worldwide, and this picture probably underestimates the reality due to under-testing during the epidemic. In response, the government declared a national emergency and the alarm state, starting on March 15. In the area of Seville, the first case of COVID-19 was diagnosed on February 27, with 1119 cases by March 31, 2020, and the situation beginning to stabilize in the coming days, reaching the peak and plateau phases (Figure 1). Regrettably, almost 20% of the confirmed COVID-19 cases occurred among health care workers, especially those from emergency departments.

Following the confinement of the population, a clear decrease in the number of acute stroke cases attended and treated in our hospitals was seen, and also, the stroke activity outside of our hospitals (telestroke and ambulance transfers) decreased.

### In-Hospital Activity

The activity at both stroke units decreased sharply with a reduction of admitted cases of around 25%, going from a mean number of 58 cases every 15 days in the previous months to 44 cases in the 15 days after the outbreak (*P*<0.001; Figure 1). Ischemic strokes fell from a median of 50 cases per 15 days before COVID-19 to 36 cases during the 15 days after the alarm (*P*<0.001); this drop was not so important for hemorrhagic strokes with a median of 9 cases per 15 days periods before and 8 cases the 15 days after the alarm (*P*=0.371). The proportion of ischemic strokes was maintained in both periods of time (84% pre-COVID-19 versus 81% post-COVID-19, *P*=0.62). We also observed a 40% reduction



**Figure 1. Evolution of coronavirus 2019 (COVID-19) cases in the area of Seville and the number of strokes admitted to the Seville stroke units during the same period of time.**

TIA indicates transient ischemic attack.

in the number of patients with transient ischemic attack attending the emergency department. In fact, mean transient ischemic attack cases per 15 days before COVID-19 was 14.6 that fell to 9 cases during the 15 days after the alarm ( $P=0.14$ ).

Mean times of arrival to hospital from symptoms onset was delayed almost half an hour considering all code strokes (93 minutes pre-COVID-19 versus 119 minutes post-COVID-19,  $P<0.001$ ). Similarly, mean times of arrival from symptoms onset among those admitted to the stroke units were delayed more than half an hour (89 minutes pre-COVID-19 versus 127 minutes post-COVID-19,  $P<0.001$ ). No differences in median National Institutes of Health Stroke Scale scores at admission was observed in both periods of time (7 points pre-COVID-19 versus 8 points post-COVID-19,  $P=0.51$ ).

Regarding reperfusion therapies, thrombolytic therapy was also reduced (mean patients treated in 15 days periods before and after the alarm: 28 versus 23,  $P<0.001$ ) since fewer patients were attended. Also, the mean global number of thrombectomies performed by the reference center was reduced from a mean of 24 cases in 15 days before the alarm compared with only 17 cases after the alarm ( $P<0.001$ ). However, the proportion of treated patients with IV tPA (intravenous tissue-type plasminogen activator) remained stable (12% versus 11%  $P=0.938$ ). Similarly, considering any reperfusion therapy offered to the ischemic stroke patients admitted in our stroke units, the proportion remained stable, with 58% before the outbreak and 64% after ( $P=0.366$ ; Figure 2). Unfortunately, IV tPA onset suffered also delays

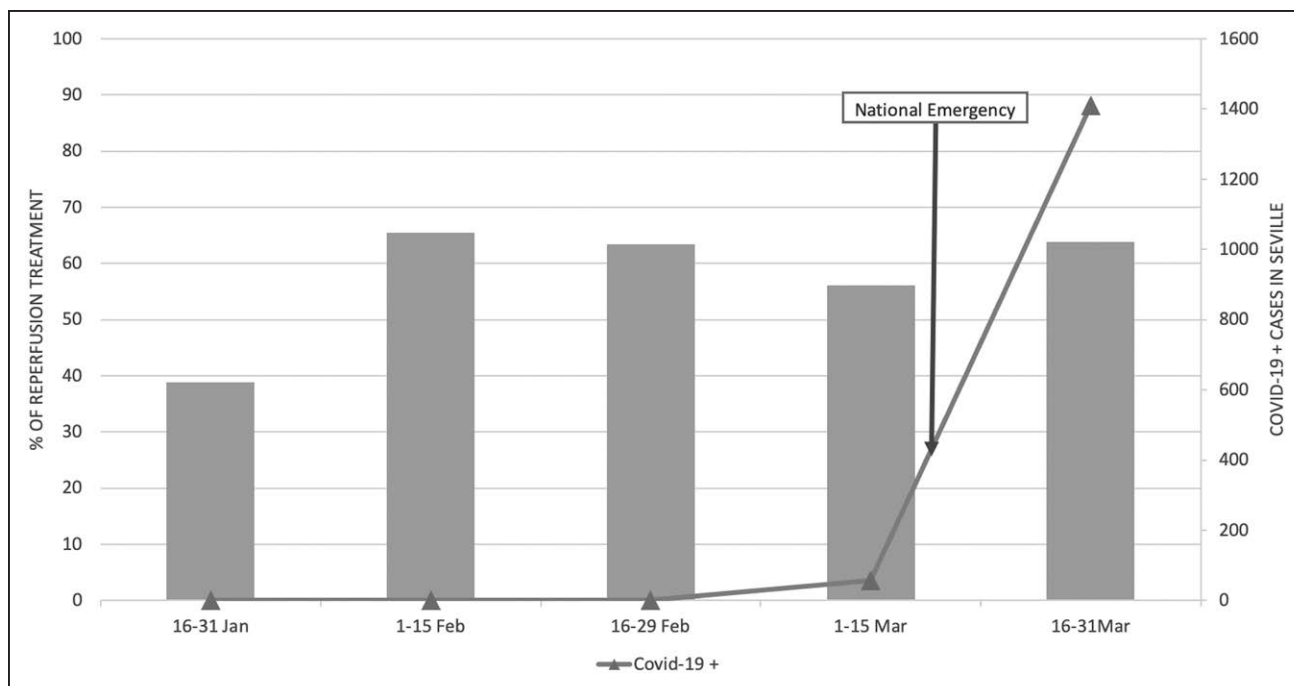
since door-to-needle time started 16 minutes later than usual (59 minutes pre-COVID-19 versus 75 minutes post-COVID-19,  $P<0.001$ ).

No difference in median National Institutes of Health Stroke Scale scores was observed between patients that received mechanical thrombectomy in both periods of time (16 points pre-COVID-19 versus 14 points post-COVID-19,  $P=0.46$ ). Median Alberta Stroke Program Early CT Score was also identical in both periods (9 points pre-COVID-19 versus 9 points post-COVID-19,  $P=0.97$ ). Surprisingly, mean times of arrival to thrombectomy reference center from symptoms onset improved during the pandemic (316 minutes pre-COVID-19 versus 293 minutes post-COVID-19,  $P<0.001$ ). And also, door-to-puncture times improved accordingly (141 minutes pre-COVID-19 versus 119 minutes post-COVID-19,  $P<0.001$ ).

### The Telestroke Network

The consultations to our telestroke network also suffered a dramatic decrease (Figure 3). In fact, telestroke consultations declined from all 8 smaller hospitals from Seville and Huelva covered by telestroke, from a mean of 25 consultations in the periods of 15 days before the outbreak to 7 after the outbreak began ( $P<0.001$ ). The patients that get therapy using the system also declined, since among consultations received, 29% were given reperfusion therapies before the outbreak compared with only 16% after the outbreak ( $P=0.49$ ).

A trend to increased stroke severity was observed among patients attended in the telestroke network



**Figure 2.** In-hospital activity: reperfusion therapy rates of patients with ischemic stroke admitted to the stroke units during the coronavirus 2019 (COVID-19) outbreak.

between both periods of time (median National Institutes of Health Stroke Scale 4 points pre-COVID-19 versus 10 points post-COVID-19,  $P=0.13$ ). Moreover, huge delays in symptoms onset to hospital arrival occurred in these smaller hospitals covered through telestroke network (161 minutes pre-COVID-19 versus 232 minutes post-COVID-19,  $P<0.001$ ).

### Stroke Codes Activation by 911

The number of calls to 911 increased dramatically during this time period, with almost 1 million telephone calls to the system only in our region during the first 2 weeks of the lockdown (source <http://www.epes.es/>). Although the prehospital diagnosis of stroke had an increase in the region by around 25% as compared with the previous year, unfortunately, this number of activations during the 15 days after the outbreak regressed to the 2019 level (Figure 4A), and the expected increase in activations expected for this period as compared to the same period of the previous year did not occur. The mean number of stroke codes dispatched to hospitals decreased since in the 15 days periods before the outbreak, 78% were dispatched to hospitals, and after the outbreak, only 57% of patients were dispatched to hospitals ( $P<0.001$ ; Figure 4B).

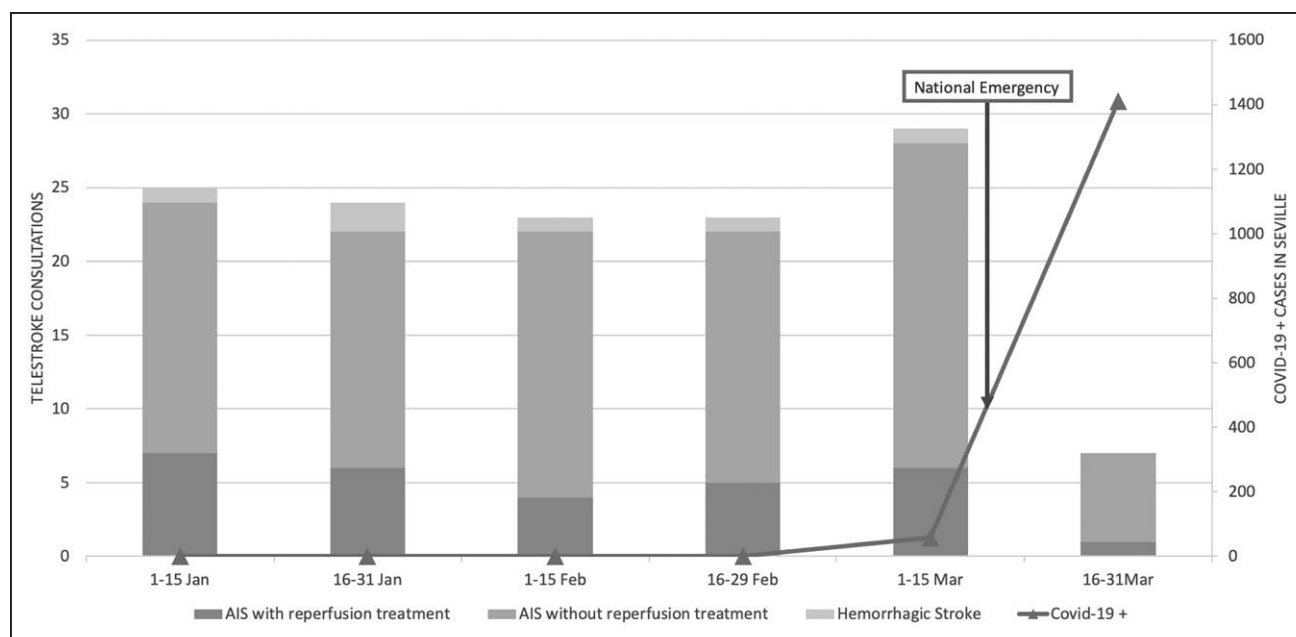
## DISCUSSION

We wondered how the measures aimed at COVID-19 are changing the way stroke patients are treated and

observed that the growing pandemic had produced a reduction in the number of acute stroke patients that come into our healthcare system. Unfortunately, we observed a sharp decrease in the number of stroke code activations and ambulance transfers, a reduction in consultations through telestroke, the number of patients admitted to our stroke units, and treated with IV tPA or receiving thrombectomy, which had a clear temporal relationship with the rising number of COVID-19 cases that crowded our hospitals.

This reduction in stroke activity is seen despite patients with COVID-19 perhaps being at increased risk of thromboembolism and that vascular inflammation might also contribute to the hypercoagulable state and endothelial dysfunction in such patients.<sup>4</sup> There are reports of abnormal coagulation parameters in hospitalized patients with severe COVID-19, and elevated D-dimer levels are strongly associated with in-hospital death, and many of them are receiving low molecular weight heparins.<sup>5</sup> In fact, some young strokes without vascular risk factors related to COVID-19 are being reported.<sup>6</sup> Therefore, alternative hypothesis to explain reduced numbers of stroke such as less activity and stress, more sleep, or other changes during the lockdown seem less plausible.

As the situation was rapidly worsening, we moved quickly to prepare to receive patients with stroke that might also be infected with COVID-19, putting protocols in place following key principles of minimizing exposure and maximizing resources. Specifically, we modified local protocols for acute stroke management at emergency department arrival and for IV tPA. Every



**Figure 3.** Telestroke network activity during the coronavirus 2019 (COVID-19) outbreak. AIS indicates acute ischemic stroke.

code stroke patient is treated as potentially infected with a designated COVID-19 scanner, and following head computed tomography, a chest computed tomography is done to all acute stroke cases to identify cases with lung infiltrates and shift them to the respiratory circuit of the hospital waiting for COVID-19 confirmatory tests. Also, for thrombectomy, the protection protocols were adapted, minimizing the use of anesthesia and intubation to avoid aerosols generation. Similar recommendations<sup>78</sup> have been developed in many countries, and some protocols are even published and available, such as Protected Code Stroke in the United States.<sup>9</sup>

However, these protocols will be useless if patients with stroke do not reach our hospitals or do so too late. So, where was the bottleneck? We think COVID-19 telephone-specific helplines had long delays in some regions during the first days of the crisis, and most of the people were seeking help through the 061 or 112 numbers (our 911) that probably collapsed at some moments. Another concern that we are unable to evaluate is whether some patients with stroke or their relatives did not even seek care at all, preferring to stay at home with symptoms than taking the risk of getting infected at the hospitals.

Although our ambulance service decreased dispatches of patients to stroke designated hospitals, the transport system did not collapse. They were under huge assistance pressure and, in fact, had to adapt, with some of the ambulances dedicated to suspected patients with COVID-19. Wearing the personal protection equipment takes some time that together with times lost in disinfecting ambulances has been probably responsible for generating some delays.

Prehospital diagnosis of stroke has been improving in the region in recent months and has increased by

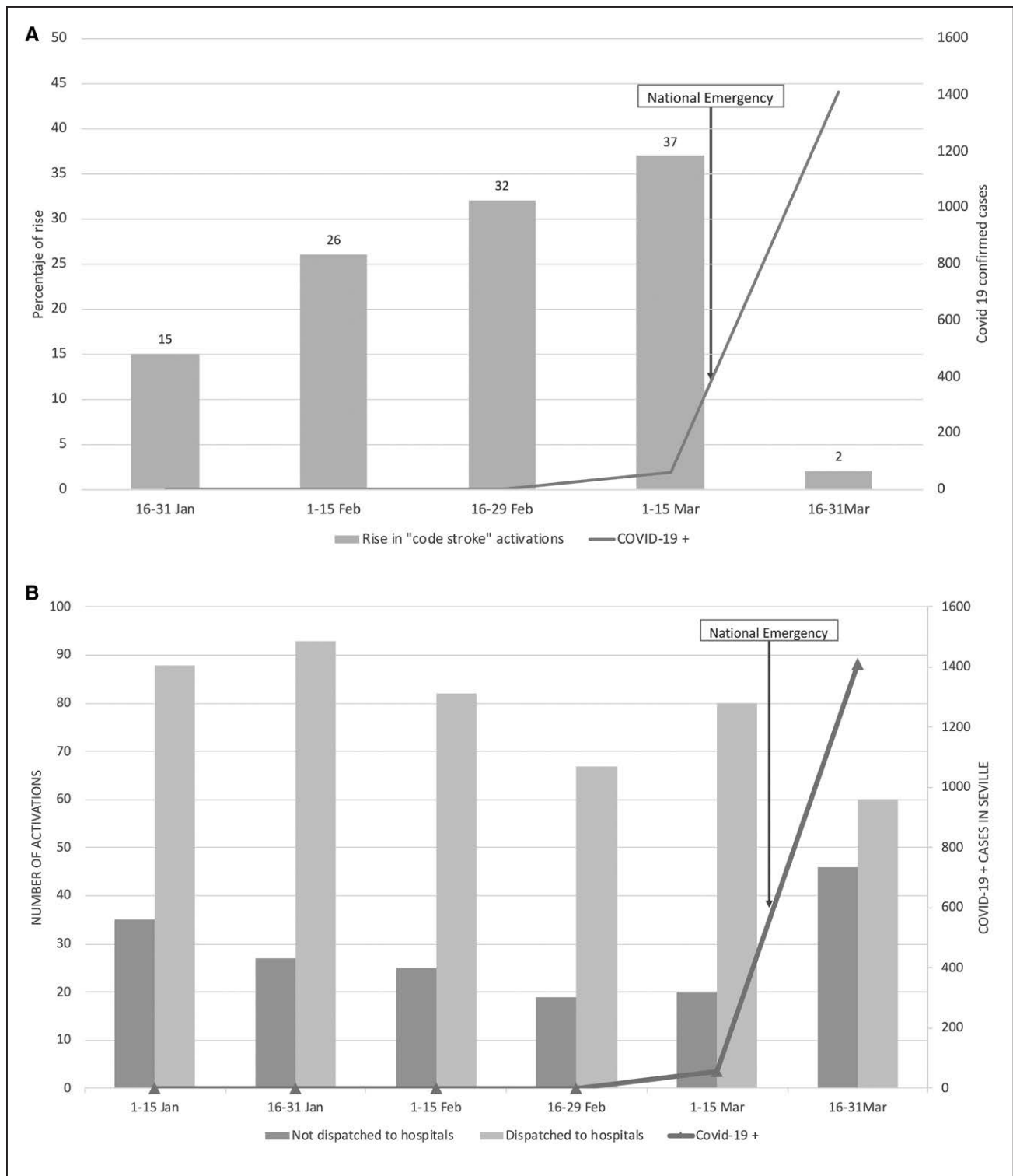
25% compared with the previous year. This increase is largely due to several actions taken from the Andalusian Stroke Plan; however, and unfortunately, these numbers have regressed to the level of last year due to the outbreak.

In many cases, the medical staff from the ambulances before attending patients at home tried recalling patients to be sure whether they need to be transferred to the hospitals, probably precluding some patients to receive a full evaluation at the hospitals. It is possible that some minor strokes were included in that pool, where triage strategies might have been overly restrictive. In fact, a 40% reduction in the number of patients with transient ischemic attack attending the emergency departments of our hospitals occurred.

Another problem is that awareness of stroke signs and symptoms of alarm among our colleagues at emergency departments who should activate telestroke or call neurologists might be suboptimal due to overreplacement of staff in the frontline since there was many of them personally affected by COVID-19 or at quarantines and had to be substituted by less experienced staff. This might also have been the case in smaller hospitals of the network since the telestroke activity was drastically reduced after the outbreak and fewer mild strokes were consulted.

Delays in reaching the hospital from the onset of stroke symptoms were observed both in the stroke units (delay of >30 minutes) and in the telestroke centers (delay of >1 hour). This could have an impact on the absolute reduction of reperfusion therapies administered during the pandemic. In fact, IV tPA was initiated 16 minutes later than usual, likely in connection with overcrowded emergency departments and new





**Figure 4. Extrahospital stroke activity during the coronavirus 2019 (COVID-19) outbreak.**

**A.** Percentage of code stroke activations during the COVID-19 outbreak compared with the previous year. **B.** The number of ambulance displacements of code stroke activations to the hospitals.

protocols and circuits established to manage strokes with suspected COVID-19.

For endovascular therapy, there were also reductions in the number of patients treated. Similarly, preliminary data from China shows that the number of

thrombectomies in Shanghai decreased by 50% in the first month after the Spring Festival compared with the same period in 2019.<sup>9</sup> However, thrombectomies were performed at the reference center surprisingly fast, probably reflecting the absence of road traffic in the region

during closure. Additionally, the neuroradiologists canceled all scheduled activities and interventions and were only attending emergencies, so the team really focused on cases of acute stroke.

In addition, patients who live at home by themselves may have less likelihood to be seen by family and friends until it is too late to get therapy and might even die from stroke without attending the hospitals. This could also have caused a reduction in the number of patients treated for stroke in our hospitals.

A crisis such as this places pressure on all aspects of a healthcare system, and this is likely to be more pronounced in less equipped and organized systems. Long-term underinvestment in health services, as seen in many countries following the 2008 financial crisis, impairs their ability to respond to surges in need for health care with sufficient health professionals, protective equipment, diagnostic test kits, and intensive care unit beds, and this is clearly the case of Spain.<sup>10</sup> An ongoing survey conducted by the European Stroke Organization and World Stroke Organization might identify whether differences in response to stroke care during the COVID-19 pandemic exist among regions across the globe. We anticipate that the more robust and well-equipped public healthcare systems will be better able to maintain stroke management during the pandemic.

Our results show how public health emergencies can indirectly affect unrelated hospital areas, and the key question is how we maintain our stroke services throughout the pandemic. We and others propose some ideas or solutions to ensure appropriate acute stroke pathways continue working and offering the best treatment possible under these challenging conditions.<sup>11</sup> These solutions might still be implemented for regions where the outbreak is ongoing, or in future disease outbreaks.

Stroke leaders and advocates, together with health authorities, should work with local mass media to encourage patients to continue seeking emergency care if experiencing acute stroke symptoms. A clear message about where to call and where to attend depending on COVID-19-related or -unrelated problems is critical to diminish the fear of the population, explaining that clean circuits are secured, and they will not get infected by attending the hospital seeking help for stroke or another acute severe disease. Separate telephonic helplines for COVID-19 and other conventional severe diseases would help avoid unnecessary delays in treating acute stroke.

The lockdown time might be an opportunity to improve education, especially of those who are at high risk of stroke, helping them to recognize a stroke and call emergency medical services immediately.

The establishment of centralized stroke centers where sufficient stroke care resources can be secured might help in some large cities with several fully equipped hospitals. It is important to remind the emergency medical

system and the population that these centers will be protected and will remain fully operational. That decision should be taken according to the incidence of COVID-19 cases in each region. The decision on when the Stroke Units should aim to remain COVID-19-free or become COVID-19 positive also depends on the local incidence of the disease. Continuous communication with the different levels of the hospital is critical to make that decision based on the availability of beds, respirators in the ICU units, and available personnel.

The use of rapid point-of-care tests to triage patients to our stroke units<sup>12</sup> or even to aid in the administration of reperfusion therapies outside of the hospitals would be extremely helpful (when available) in this critical situation when hospitals are overcrowded.

In conclusion, huge collateral damage to acute stroke patients is occurring during the COVID-19 pandemic. We are initiating fewer emergency treatments or missing the therapeutic window due to delays in hospital admission or referrals or patients preferring not to enter the hospital at all. The investigated region, Seville, is among the less affected areas of the country by COVID-19 with 4 times less cases than the Spanish average incidence and 8 times less cases than the areas with the highest incidence in the country such as Madrid.<sup>13</sup> Therefore, our findings are likely to be repeated, with greater impact, in other regions in the country, where the situation was much more chaotic and in other countries deeply hit by COVID-19.

In some regions, acute vascular diseases have probably killed more patients than COVID-19 during this period. The duration of the drop in acute stroke activity in our stroke units and the morbimortality associated with this fact will have to be evaluated carefully in the near future. Important lessons should be learned, and preparedness and innovation will help should there be similar outbreaks in the future.

## ARTICLE INFORMATION

Received April 5, 2020; final revision received May 11, 2020; accepted May 14, 2020.

### Affiliations

Department of Neurology, Hospital Universitario Virgen Macarena, Sevilla, Spain (J.M., A.B.-P., S.P.-S., J.A.S.-M., L.R.-B.). Neurovascular Research Laboratory, Vall d'Hebron Institute of Research (VHIR), Instituto de Biomedicina de Sevilla-IBiS, Barcelona, Spain (J.M., A.G.). Department of Neurology (I.E.-M., F.M.) and Department of Radiology, Interventional Neuroradiology (A.G.), Hospital Universitario Virgen del Rocío, Sevilla, Spain. Seville Critical Care and Emergency Unit, Sevilla, Spain (J.A.S.-M.).

### Acknowledgments

To all the healthcare professionals working in the ambulances, emergency departments, stroke units, and cath labs at these very difficult times. To Jesús Rodríguez-Baño from Clinical Unit for Infectious Diseases, Microbiology and Preventive Medicine for his daily info on new COVID-19 cases at the hospital and his help to establish safety protocols for our colleagues and stroke patients with suspicion of infection. To María Teresa Diaz Curiel from the Analysis and Evaluation Service (Virgen del Rocío Hospital) and José E. Arroyo Izquierdo from the Information and Statistics Systems Unit (Virgen Macarena

Hospital) for their help on exploitation of transient ischemic attack (TIA) data from the ED of both hospitals. To Ismael Muñoz for fruitful discussions on the role of emergency primary care physicians in the crisis and Wilfredo Lopez for sharing data on 911 coordinating center calls. To Elvira, who personally suffered this dramatic situation.

### Sources of Funding

The Neurovascular Research Group is part of the Spanish Neurovascular Disease Research Network (INVICTUS+, RD16/0019/0015).

### Disclosures

None.

## REFERENCES

- World Health Organization: Coronavirus disease (COVID-2019) situation reports. Available at: [https://www.who.int/docs/default-source/coronaviruse/situation-reports/20200507covid-19-sitrep-108.pdf?sfvrsn=44cc8ed8\\_2](https://www.who.int/docs/default-source/coronaviruse/situation-reports/20200507covid-19-sitrep-108.pdf?sfvrsn=44cc8ed8_2). Accessed May 8, 2020.
- Lee SY, Khang YH, Lim HK. Impact of the 2015 middle east respiratory syndrome outbreak on emergency care utilization and mortality in South Korea. *Yonsei Med J*. 2019;60:796–803. doi: 10.3349/yMJ.2019.60.8.796
- Tam CF, Cheung KS, Lam S, Wong A, Yung A, Sze M. Impact of Coronavirus Disease 2019 (COVID-19) Outbreak on ST-Segment-Elevation Myocardial Infarction Care in Hong Kong, China. *Circ Cardiovasc Qual Outcomes*. 2020;13:e006631. doi: 10.1161/CIRCOUTCOMES.120.006631
- Driggin E, Madhavan MV, Bikdeli B, Chuich T, Laracy J, Biondi-Zoccai G, Brown TS, Nigoghossian CD, Zidar DA, Haythe J, et al. Cardiovascular considerations for patients, health care workers, and health systems during the COVID-19 pandemic. *J Am Coll Cardiol*. 2020;75:2352–2371. doi: 10.1016/j.jacc.2020.03.031
- Tang N, Bai H, Chen X, Gong J, Li D, Sun Z. Anticoagulant treatment is associated with decreased mortality in severe coronavirus disease 2019 patients with coagulopathy. *J Thromb Haemost*. 2020;18:1094–1099. doi: 10.1111/jth.14817
- González-Pinto T, Luna-Rodríguez A, Moreno-Estébanez A, Agirre-Beitia G, Rodríguez-Antigüedad A, Ruiz-Lopez M. Emergency room neurology in times of COVID-19: malignant ischemic stroke and SARS-COV2 infection [published online April 30, 2020]. *Eur J Neurol*. doi: 10.1111/ene.14286
- Temporary emergency guidance to US stroke centers during the COVID-19 pandemic, on behalf of the AHA/ASA stroke council leadership [published online April 1, 2020]. *Stroke*. doi: 10.1161/STROKEAHA.120.030023
- Qureshi AI, Abd-Allah F, Alsenani F, Aytac E, Borhani-Haghighi A, Ciccone A, Gomez CR, Gurkas E, Hsu CY, Jani C, et al. Management of acute ischemic stroke in patients with COVID-19 infection: report of an international panel [published online May 3, 2020]. *Int J Stroke*. doi: 10.1177/1747493020923234
- Khosravani H, Rajendram P, Notario L, Chapman MG, Menon BK. Protected code stroke: hyperacute stroke management during the coronavirus disease 2019 (COVID-19) pandemic [published online April 1, 2020]. *Stroke*. doi: 10.1161/STROKEAHA.120.029838
- Legido-Quigley H, Mateos-García JT, Campos VR, Gea-Sánchez M, Muntaner C, McKee M. The resilience of the Spanish health system against the COVID-19 pandemic. *Lancet Public Health*. 2020;5:e251–e252. doi: 10.1016/S2468-2667(20)30060-8
- Zhao J, Rudd A, Liu R. Challenges and potential solutions of stroke care during the coronavirus disease 2019 (COVID-19) outbreak. *Stroke*. 2020;51:1356–1357. doi: 10.1161/STROKEAHA.120.029701
- Bustamante A, López-Cancio E, Pich S, Penalba A, Giralt D, García-Berrocoso T, et al. Blood biomarkers for the early diagnosis of stroke: the Stroke-Chip Study. *Stroke*. 2017;48:2419–2425. doi: 10.1161/STROKEAHA.117.017076
- COVID-19 in Spain: Geographical distribution. Available at: <https://covid19.isciii.es/>. Accessed May 8, 2020.

# Stroke