Stroke

CLINICAL AND POPULATION SCIENCES

Changes in Stroke Hospital Care During the COVID-19 Pandemic

A Systematic Review and Meta-Analysis

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BACKGROUND AND PURPOSE: We systematically evaluated the impact of the coronavirus 2019 (COVID-19) pandemic on stroke care across the world.

METHODS: Observational studies comparing characteristics, acute treatment delivery, or hospitalization outcomes between patients with stroke admitted during the COVID-19 pandemic and those admitted before the pandemic were identified by Medline, Scopus, and Embase databases search. Random-effects meta-analyses were conducted for all outcomes.

RESULTS: We identified 46 studies including 129 491 patients. Patients admitted with stroke during the COVID-19 pandemic were found to be younger (mean difference, −1.19 [95% CI, −2.05 to −0.32]; I^2=70%) and more frequently male (odds ratio, 1.11 [95% CI, 1.01–1.22]; I^2=54%) compared with patients admitted with stroke in the prepandemic era. Patients admitted with stroke during the COVID-19 pandemic, also, had higher baseline National Institutes of Health Stroke Scale scores (mean difference, 0.55 [95% CI, 0.12–0.98]; I^2=90%), higher probability for large vessel occlusion presence (odds ratio, 1.63 [95% CI, 1.07–2.48]; I^2=49%) and higher risk for in-hospital mortality (odds ratio, 1.26 [95% CI, 1.05–1.52]; I^2=55%). Patients with acute ischemic stroke admitted during the COVID-19 pandemic had higher probability of receiving endovascular thrombectomy treatment (odds ratio, 1.24 [95% CI, 1.05–1.47]; I^2=40%). No difference in the rates of intravenous thrombolysis administration or difference in time metrics regarding onset to treatment time for intravenous thrombolysis and onset to groin puncture time for endovascular thrombectomy were detected.

CONCLUSIONS: The present systematic review and meta-analysis indicates an increased prevalence of younger patients, more severe strokes attributed to large vessel occlusion, and higher endovascular treatment rates during the COVID-19 pandemic. Patients admitted with stroke during the COVID-19 pandemic had higher in-hospital mortality. These findings need to be interpreted with caution in view of discrepant reports and heterogeneity being present across studies.

GRAPHIC ABSTRACT: An online graphic abstract is available for this article.

Key Words: coronavirus ■ hospitalization ■ ischemic stroke ■ mortality ■ thrombectomy ■ thrombolysis

There are increasing concerns regarding the impact of imposed health care and social restrictions in response to the coronavirus disease 2019 (COVID-19) pandemic on the management and care of patients with stroke.[1,2] Researchers and clinicians have expressed concerns regarding the negative impact of

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Nonstandard Abbreviations and Acronyms

COVID-19	coronavirus 2019
EVT	endovascular thrombectomy
IVT	intravenous thrombolysis
LVO	large vessel occlusion
MD	mean difference
OR	odds ratio
SARS-CoV-2	severe acute respiratory syndrome coronavirus 2

COVID-19 outbreaks on the ability of health care systems to provide timely assessment and acute therapies to patients with stroke.[3,4] COVID-19 imposed restrictions, and the ensuing suboptimal care delivery, could thus indirectly cause increased stroke-related mortality and disability.[5] Moreover, accruing data are indicating that COVID-19 may be associated with an increased risk of ischemic stroke and cryptogenic stroke in particular.[6,7]

In the present systematic review and meta-analysis, we systematically evaluated the impact of COVID-19 pandemic on stroke epidemiology and care across the world by analyzing available cohort studies reporting on baseline characteristics and outcomes of patients admitted with stroke during the first wave of the COVID-19 pandemic.

METHODS

We performed an aggregate data meta-analysis of cohort studies (prospective or retrospective) reporting on demographics, vascular risk factors, acute ischemic stroke treatment delivery, relevant time metrics, or hospitalization outcomes in relation to the imposed regional health care and social preventive measures as a response to the first wave of the COVID-19 pandemic, comparing between COVID-19 and pre-COVID-19 eras within the same institutions. We followed a prespecified study protocol previously published in the International Prospective Register of Ongoing Systematic Reviews PROSPERO (CRD42020188467)[8] and now present our findings according to the Preferred Reporting Items of Systematic Reviews and Meta-Analyses statement[9] and the American Heart Association Journals' implementation of the Transparency and Openness Promotion Guidelines. The authors declare that all supporting data are available within the article and in the Data Supplement. Preferred Reporting Items of Systematic Reviews and Meta-Analyses checklist and flow diagram (Figure I in the Data Supplement) are available in the Data Supplement.

Cohort studies reporting on patient demographics, vascular risk factors, acute ischemic stroke treatment delivery, with intravenous thrombolysis (IVT), endovascular thrombectomy (EVT) or both, relevant quality time metrics in acute stroke care or hospitalization outcomes for patients with stroke, were considered provisionally eligible. Eligible studies were finally included in the systematic review and meta-analysis if they reported differences in any of the aforementioned outcomes of interest between patients admitted with stroke after the COVID-19 pandemic outbreak and patients admitted with stroke before the COVID-19 pandemic outbreak in the respective health care settings from each region (historical controls). Studies stratifying patients according to their severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) infection status were excluded.

Quality control and bias identification in eligible studies was performed by the 2 independent reviewers who performed the literature search (Drs Katsanos and Palaiodimou) with the use of Newcastle-Ottawa Scale.[10] All emerging conflicts were resolved after discussion with a tie-breaking author (Dr G. Tsivgoulis).

Our predefined primary outcome measures were: (1) the rates of ischemic stroke patients receiving IVT and EVT therapies and (2) delivery times of systemic and endovascular reperfusion therapies between patients with ischemic stroke admitted after the emergence of COVID-19 pandemic compared with patients with ischemic stroke admitted during prepandemic epochs at the same institutional settings (historical controls). Secondary outcomes of interest and further description on the search strategy is provided in the Data Supplement.

We calculated the unadjusted odds ratios (ORs) and corresponding 95% CI for all dichotomous outcomes between patients admitted with stroke during the COVID-19 pandemic outbreak and patients admitted with stroke during a prepandemic period at the same institution. For continuous outcomes reported in median values and corresponding interquartile ranges, we estimated the sample mean and SD using the quantile estimation method, as previously described.[11,12]

The random-effects model (DerSimonian and Laird[13]) was used to estimate all pooled estimates for both dichotomous and continuous outcomes. Heterogeneity between included studies was assessed with the Cochran Q and I^2 statistics.[14] For the qualitative interpretation of heterogeneity, I^2 values of at least 50% were considered to represent substantial heterogeneity, while values of at least 75% indicated considerable heterogeneity.[14] The small-study effect (used as a proxy for publication bias) across included studies was evaluated for the dichotomous primary outcomes of interest (probability of IVT or EVT treatment during and before the COVID-19 pandemic) with both funnel plot inspection and the Egger's linear regression. The significance level for the Egger's test was set at 0.1.

To investigate for potential heterogeneity in the likelihood of reperfusion treatment delivery and mortality during the pandemic, compared with the prepandemic period, we performed subgroup analyses by categorizing studies according to the geographic location they were performed (Africa, Asia, Europe, North America, South America). All statistical analyses were conducted using the OpenMetaAnalyst[15] and Stata Statistical Software Release 13 for Windows (College Station, TX, StataCorp LP) computer software.

RESULTS

Our literature search retrieved 1329, 1105 and 1140 records in the Medline, Scopus, and Embase electronic databases, respectively (Figure I in the Data Supplement). After excluding duplicates and screening the titles and abstracts of the remaining 2523 records, we retrieved the full text of 62 records that were potentially eligible for inclusion. After reading the full text articles, we excluded 16 of them for not providing data on the predefined outcomes of interest, having no control groups for comparison, or providing overlapping data with other studies (Table I in the Data Supplement). Finally, we identified 46 observational cohort studies including a total of 129 491 patients who met our predefined inclusion and exclusion criteria (Table II in the Data Supplement).[16–61]

The risk of bias in included cohort studies has been assessed using the Newcastle-Ottawa scale and is presented in Table III in the Data Supplement. The overall score was 373 of 414 (90%), which is considered to be indicative of good quality studies. The majority of the included studies satisfied the selection and exposure ascertainment criteria. However, cohorts of certain studies were judged not to be truly representative of community patients suffering from stroke, as they included only specific patient subpopulations restricted to patients receiving MT,[17,31,58] IVT,[60] or any reperfusion therapies.[42] In another study, data regarding stroke incidence and treatment delivery were derived from telemedicine records.[26] Furthermore, description of the derivation of the exposed and nonexposed cohorts was not presented in one study.[45] Comparability was considered satisfactory in most of the included studies. All studies assessed the outcomes of interest based on medical record linkage. Limited follow-up duration of one month or less was present in several studies.[22,24,27,32,35,39,41,43,45,48,50,56,59]

For studies reporting the exact time intervals in both pandemic and prepandemic periods, stroke daily admission rates were consistently lower in the pandemic periods compared with the prepandemic periods, as defined in each included study (Table IV in the Data Supplement). Patients admitted with stroke during the COVID-19 pandemic were found to be younger (mean difference [MD], −1.19 [95% CI, −2.05 to −0.32]; I^2=70%, *P* for Cochran Q <0.001; Figure II in the Data Supplement) and more frequently men (OR, 1.11 [95% CI, 1.01–1.22; I^2=54%, *P* for Cochran Q<0.001; Figure III in the Data Supplement) compared with historical controls. In the analyses of other baseline characteristics (Table), no differences were uncovered on the prevalence of hypertension (OR, 1.08 [95% CI, 0.91–1.29]; I^2=69%, *P* for Cochran Q<0.001; Figure IV in the Data Supplement), atrial fibrillation (OR, 0.94 [95% CI, 0.83–1.06], I^2=25%, *P* for Cochran Q: 0.18; Figure V in the Data Supplement), diabetes (OR, 1.03 [95% CI, 0.94–1.13]; I^2=7%, *P* for Cochran Q: 0.38; Figure VI in the Data Supplement), dyslipidemia (OR, 1.13 [95% CI, 0.99–1.28]; I^2=0%, *P* for Cochran Q: 0.56; Figure VII in the Data Supplement), coronary artery disease (OR, 1.00 [95% CI, 0.91–1.10]; 4%, *P* for Cochran Q: 0.40; Figure VIII in the Data Supplement), and smoking (OR, 0.97 [95% CI, 0.81–1.17]; I^2=33%, *P* for Cochran Q: 0.13; Figure IX in the Data Supplement). Patients admitted with stroke after local COVID-19 pandemic outbreaks presented with more severe stroke syndromes compared with the prepandemic epochs, as evidenced by the higher baseline National Institutes of Health Stroke Scale scores (MD, 0.55 [95% CI, 0.12–0.98]; I^2=90%, *P* for Cochran Q<0.001; Figure X in the Data Supplement) and greater proportion of large vessel occlusion (LVO; OR, 1.63 [95% CI, 1.07–2.48]; I^2=49%, *P* for Cochran Q: 0.08; Figure 1) during the COVID-19 pandemic. No difference between studies estimates according to the continent they were performed was uncovered (*P* for subgroup differences, 0.473). No difference in the mean onset-to-door time was found between the 2 time periods (MD, −5.33 [95% CI, −54.99 to 44.34], I^2=80%, *P* for Cochran Q<0.001; Figure XI in the Data Supplement).

Among patients with an ischemic stroke, there was no difference in the overall likelihood of receiving IVT after the emergence of COVID-19 pandemic local outbreaks (OR, 0.97 [95% CI, 0.84–1.12]; I^2=57%, *P* for Cochran Q<0.001; Figure XII in the Data Supplement), however, disparity according to the continent the studies were performed was uncovered (*P* for subgroup differences <0.001). Studies from Asia (OR, 1.23 [95% CI, 1.17–1.30]; I^2=0%, *P* for Cochran Q=0.74) and Africa (OR, 2.54 [95% CI, 1.23–5.26]) reported an increased likelihood of IVT treatment during the COVID-19 pandemic compared with the prepandemic period, no difference in IVT rates was uncovered in either studies from North (OR, 0.85 [95% CI, 0.58–1.25]; I^2=53%, *P* for Cochran Q=0.03) or South America (OR, 1.16 [95% CI, 0.18–7.56]), while a decreased likelihood of IVT treatment during the pandemic period was uncovered for studies performed in Europe (OR, 0.79 [95% CI, 0.68–0.92]; I^2=2%, *P* for Cochran Q=0.42).

Patients admitted with stroke during the COVID-19 pandemic outbreak had a significantly higher probability of being treated with EVT, when compared with the corresponding EVT rates from the prepandemic periods at the same institutions (OR, 1.24 [95% CI, 1.05–1.47]; I^2=40%, *P* for Cochran Q=0.02). In subgroup analysis, no difference was detected between different continents (*P* for subgroup differences: 0.791; Figure 2). After dichotomizing studies according to their setting EVT treatment probability during the COVID-19 pandemic was reported to be significantly higher in population-based studies (OR, 1.31 [95% CI, 1.18–1.46], I^2=7%, *P* for Cochran Q=0.37), but not in hospital-based studies (OR, 1.16 [95% CI, 0.87–1.55], I^2=46%, *P* for Cochran Q=0.02). However, no difference was evident between the estimates provided by the 2 aforementioned subgroups (*P* for subgroup differences, 0.424; Figure XIII in the Data Supplement). In funnel plots asymmetry and evidence of small-study effects was uncovered in the relevant probabilities of IVT treatment (*P* for Egger test=0.036; Figure XIV in the Data Supplement) but not for EVT treatment (*P* for Egger test=0.265; Figure XV in the Data Supplement), between patients admitted with ischemic stroke

Table. Overview of Analyses on Baseline Characteristics, Treatments and Outcomes, Comparing Patients Admitted With Stroke During the COVID-19 Pandemic With Patients With Stroke in the Prepandemic Period

Variable	No. of studies	Effect estimate (95% CI)	I^2, *P* for Cochran Q
Baseline characteristics			
Age, y	36	MD, −1.19 (−2.05 to −0.32)	70%, *P*<0.001
Male sex	34	OR, 1.11 (1.01 to 1.22)	54%, *P*<0.001
Hypertension	16	OR, 1.08 (0.91 to 1.29)	69%, *P*<0.001
Atrial fibrillation	14	OR, 0.94 (0.83 to 1.06)	25%, *P*=0.18
Diabetes	16	OR, 1.03 (0.94 to 1.13)	7%, *P*=0.38
Dyslipidemia	13	OR, 1.13 (0.99 to 1.28)	0%, *P*=0.56
Coronary artery disease	13	OR, 1.00 (0.91 to 1.10)	4%, *P*=0.40
Smoking	12	OR, 0.97 (0.81 to 1.17)	33%, *P*=0.13
Baseline NIHSS	29	MD, 0.55 (0.12 to 0.98)	90%, *P*<0.001
Presence of LVO	6	OR, 1.63 (1.07 to 2.48)	49%, *P*=0.08
Onset-to-door time, min	22	MD, −5.33 (−54.99 to 44.34)	80%, *P*<0.001
Treatment*			
IVT	33	OR, 0.97 (0.84 to 1.12)	57%, *P*<0.001
Door-to-needle time, min	22	MD, 2.91 (−1.74 to 7.55)	95%, *P*<0.001
Endovascular thrombectomy	23	OR, 1.24 (1.05 to 1.47)	40%, *P*=0.02
Door-to-groin puncture time, min	17	MD, 1.27 (−10.44 to 12.99)	95%, *P*<0.001
Outcomes			
Length of stay, d	11	MD, −0.80 (−1.63 to 0.04)	77%, *P*<0.001
In-hospital mortality	24	OR, 1.26 (1.05 to 1.52)	55%, *P*<0.0001

COVID-19 indicates coronavirus disease 2019; IVT, intravenous thrombolysis; LVO, large vessel occlusion; MD, mean difference; NIHSS, National Institutes of Health Stroke Scale; and OR, odds ratio.

*For patients with acute ischemic stroke.

before and during the COVID-19 pandemic. In a post hoc sensitivity analysis of studies that included consecutive patients, with no time gaps between the prepandemic and pandemic periods, patients admitted with stroke during the pandemic had a higher likelihood of receiving EVT compared with those admitted just before the pandemic period (OR, 1.30 [95% CI, 1.07–1.57]). No heterogeneity was evident between studies (I^2=0, *P* for Cochran Q=0.51; Figure XVI in the Data Supplement). Within the patients with confirmed LVO, there was no difference in the probability of EVT treatment during and before the COVID-19 pandemic (OR, 0.90 [95% CI, 0.46–1.79]; I^2=40%, *P* for Cochran Q=0.09; Figure XVII in the Data Supplement). No differences in the mean door-to-needle time (MD, 2.91 [95% CI, −1.74 to 7.55]; I^2=95%, *P* for Cochran Q<0.001; Figure XVIII in the Data Supplement) and mean door-to-groin puncture times (MD, 1.27 [95% CI, −10.44 to 12.99], I^2=95%, *P* for Cochran Q<0.001; Figure XIX in the Data Supplement) were found before and during the COVID-19 pandemic.

There was no evidence of the increased duration of stroke hospitalization after the emergence of the COVID-19 pandemic related outbreaks (MD, −0.80 [95% CI, −1.63 to 0.04]; I^2=77%, *P* for Cochran Q<0.001; Figure XX in the Data Supplement). Patients suffering from strokes had higher odds for in-hospital mortality when

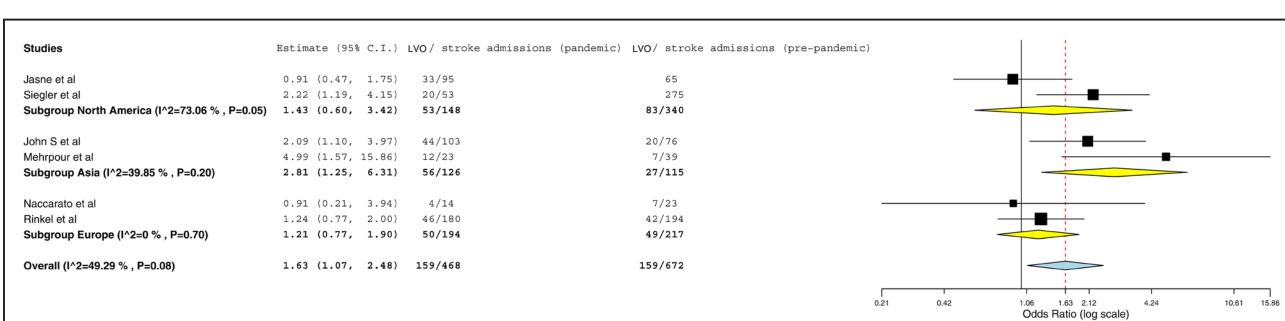

Figure 1. Pooled analysis on the probability of large vessel occlusion (LVO) prevalence among patients with stroke admitted during the coronavirus disease 2019 (COVID-19) pandemic compared with the prepandemic period.

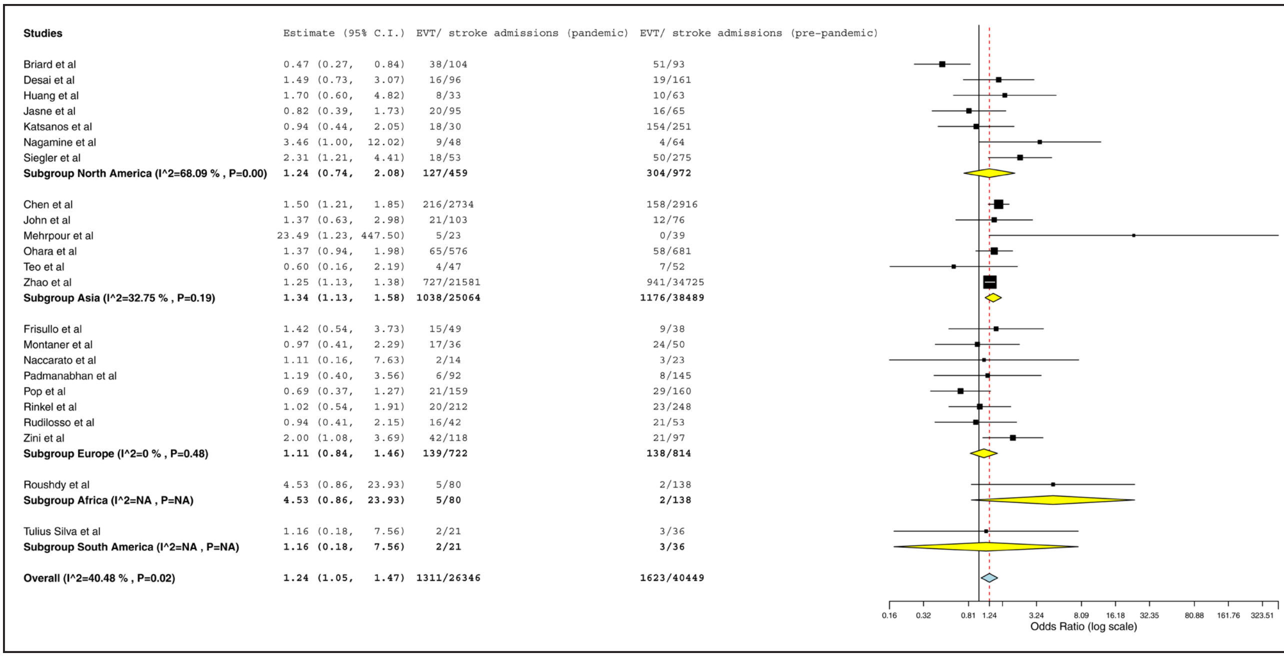

Figure 2. Pooled analysis on the probability of endovascular thrombectomy (EVT) treatment among patients with stroke admitted during the coronavirus disease 2019 (COVID-19) pandemic outbreak compared with the prepandemic period.

admitted during the COVID-19 pandemic compared with their historical counterparts (OR, 1.26 [95% CI, 1.05–1.52], *P* for Cochran Q<0.001; I^2=55%; Figure 3). No disparity in the likelihood of mortality during the pandemic period, compared with the prepandemic period, according to the different continents that studies were performed was evident (*P* for subgroup differences=0.984).

DISCUSSION

Our meta-analysis showed that patients admitted with stroke during the COVID-19 pandemic outbreak were younger, more frequently male, with more severe stroke syndromes, and higher prevalence of LVO at baseline. Although no difference in the rates of IVT administration for patients with acute ischemic stroke was observed during the COVID-19 pandemic, EVT rates were significantly higher compared with the prepandemic outbreak onset. No difference in the EVT rates for patients with confirmed LVO was found after the outbreak of the COVID-19 pandemic. No time delays regarding the presentation of patients to the hospital and the administration of systemic or endovascular reperfusion treatments were observed. Finally, patients suffering from stroke had higher odds of in-hospital mortality when admitted during the COVID-19 pandemic compared with their historical counterparts. No prolongation of hospital stay for patients with stroke was evident during the COVID-19 pandemic.

Evidence from case reports and cohort studies is accumulating supporting an association between COVID-19 infection and incidence of stroke among young populations in the absence of typical vascular risk factors.[62] COVID-19 infection has been suggested to trigger endothelial damage and immune-related hypercoagulability,[63,64] which ultimately can lead to thromboembolic phenomena and increased prevalence of intracranial occlusions in the brain circulation of young patients presenting with stroke symptoms.[65] Additionally, it is postulated that the higher prevalence of LVO and more severe stroke syndromes during the COVID-19 pandemic could be related to higher rates of undiagnosed and thus untreated atrial fibrillation following regional lockdowns, as highlighted by a recent Danish registry.[66] The male predominance in patients with COVID-19 infection suffering a stroke maybe related to the increased preponderance for severe disease in male patients[67]; previous observational cohort studies also suggest that the majority of young patients presenting with an intracranial LVO are males.[68–70] Males have been reported to have a higher likelihood of severe COVID-19 infection, hospitalization, ICU admission, and mortality compared with females.[67,71–73] Moreover, male patients with stroke and COVID-19 have been reported to experience more severe in-hospital complications and have worse outcomes compared with their female counterparts.[74]

The lack of difference in the rates of IVT administration for patients with acute ischemic stroke during the COVID-19 pandemic is in accordance with our previous meta-analysis, reporting no difference in the likelihood of IVT administration according to SARS-CoV-2 infection status.[6] The higher EVT rates observed in cohorts of patients admitted with acute ischemic stroke during the

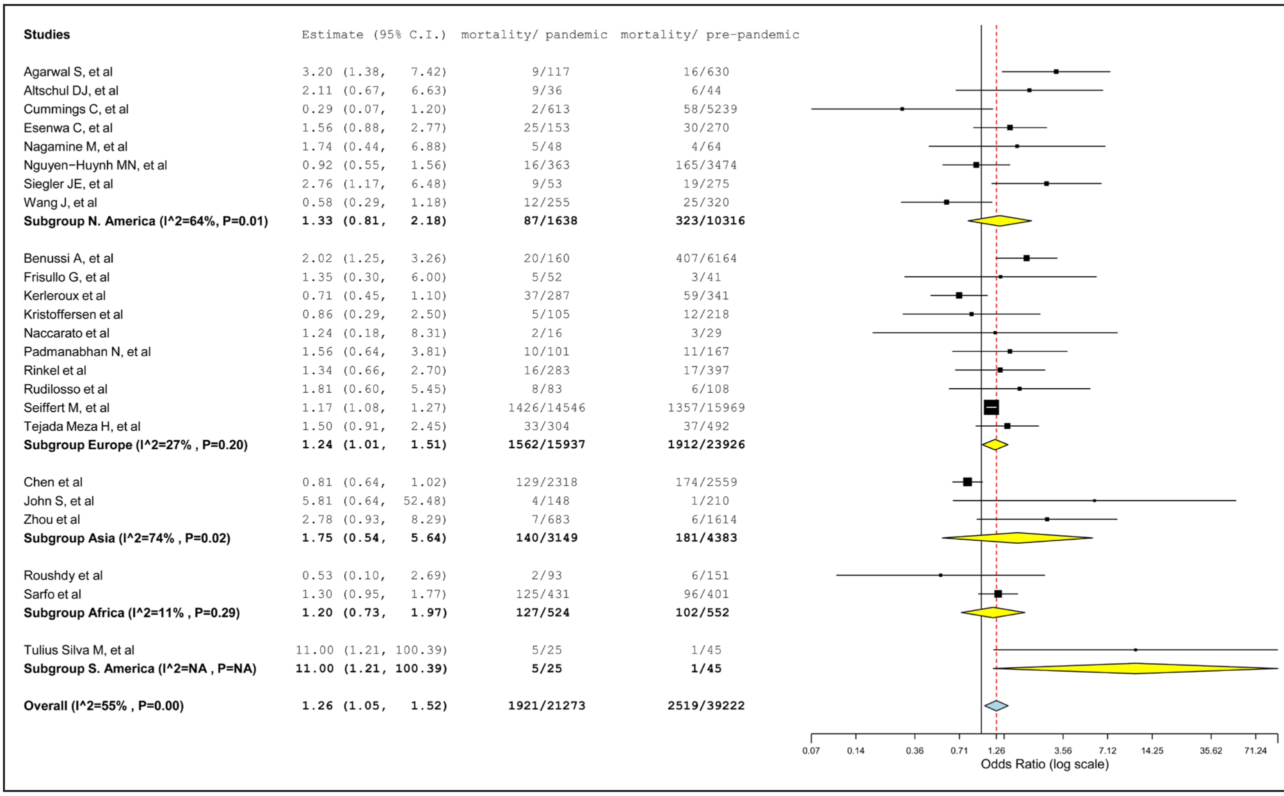

Figure 3. Pooled analysis on the probability of in-hospital mortality among patients admitted with stroke, patients with ischemic stroke with large vessel occlusion or patients receiving stroke reperfusion therapies during the coronavirus disease 2019 (COVID-19) pandemic outbreak compared with the prepandemic period.

COVID-19 pandemic outbreak, highlighted in the present work, could potentially be explained by the constellation of higher LVO rates among stroke admissions, as reported also in the present meta-analysis and discussed above, the lower admission rates of patients with milder stroke syndromes, as highlighted by previous studies,[75,76] and the wider implementation of EVT over time[77] thereby leading to a relative, rather than an absolute, increase of EVT procedures per ischemic stroke admission during the COVID-19 outbreak periods in comparison to the prepandemic historical epochs.[78] The fact that more severe strokes are overrepresented in hospital admissions during the pandemic, as also highlighted by the present meta-analysis, could partially be attributed to the decrease of hospital admissions for transient ischemic attacks, mild and moderate strokes during the pandemic, as older people with milder strokes may not present to the hospital during the pandemic because of fear, neglect, or symptoms underestimation.[3] Patients with mild stroke syndromes not seeking medical attention during the pandemic could provide an explanation for both the overall decreased stroke admission rates observed during the pandemic (Table IV in the Data Supplement) and the increased EVT rates among all stroke admissions during the pandemic compared with the prepandemic periods.

In our analyses, we uncovered no delays in prehospital and in-hospital pathways of stroke care. Regarding the prompt hospital presentation, it can potentially be attributed to social restrictions urging family members to spend significantly more time together at home, which might lead in turn to timely recognition of stroke symptoms and prompt EMS notification. Referral of Code Stroke patients by EMS was reported to be maintained sufficiently during the COVID-19 pandemic outbreaks,[79] while the mandated societal lockdown policies led to a significant reduction in road traffic[80] and thus more prompt patient transfer. In addition, patients presenting with more severe stroke symptoms have previously been reported to more likely use EMS services and be swiftly transported to the hospital.[81,82]

The lack of significant delays in systemic or endovascular treatment delivery can be associated with the overall decrease in total ED visits during the COVID-19 pandemic and the selective encounter of stroke teams with only the most severely disabled patients with stroke who ultimately did seek and received prompt medical attention and treatment, compared with patients with stroke with milder symptoms staying home and not receiving urgent care.[83] Therefore, it can be hypothesized that the lower ED visit volume, the lower number of total stroke cases, and the higher prevalence of severe stroke syndromes could have counterbalanced any potential delays associated with the default screening for infectious symptoms and application of personal protective equipment for every stroke admission during the COVID-19 pandemic.[84] The increased mortality rates in hospitalized patients with SARS-CoV-2 infection and stroke has been highlighted in our previous meta-analysis.[6] The lack of significant difference in the length of hospital stay during the COVID-19 pandemic could potentially be explained by both the increased in-hospital mortality rates of patients infected by SARS-CoV-2 and the increased demand for hospital beds at the peak of COVID-19 activity spread.[85]

To the best of our knowledge, the present systematic review and meta-analysis is the first to date to systematically evaluate the impact of the COVID-19 pandemic in stroke epidemiology and care using a predefined protocol comparing current acute stroke treatment metrics with the corresponding of the prepandemic era. On the contrary, several limitations need to be acknowledged. First, we need to highlight that this is an aggregate data meta-analysis and thus reported associations in study populations do not necessarily hold at the individual level. Lack of individual participant data did not allow us to adjust for potential confounders. Although we performed subgroup analyses according to the geographic location where each study was performed, national and regional disparities are expected. The population density and catchment areas of the medical institutions assessed in the present meta-analysis are 2 additional factors that could potentially account for the observed heterogeneity in the majority of the outcomes between different studies. Although a significantly higher probability of EVT treatment for all patients with stroke during the COVID-19 pandemic was uncovered in population-based studies, this association did not reach statistical significance in hospital-based studies. The lack of a significant association in the latter could be attributed to inadequate statistical power, as population-based studies included 20× more patients than hospital-based studies (Figure XIII in the Data Supplement). It should be noted again that in this meta-analysis we dichotomized patients admitted with stroke according to the time of their admission to the hospital (before or after the local pandemic outbreak) and not according to their SARS-CoV-2 infection status, which was assessed in our previous work.[6] Thus, the local prevalence of SARS-CoV-2 infection in included studies and any potential association with reported outcomes is unknown and most probably differs across the period assessed by the study. Also, there was considerable heterogeneity in some of the reported statistically significant associations including the relationship of COVID-19 with younger age and higher admission National Institutes of Health Stroke Scale score. Consequently, the relevant findings need to be interpreted with caution given the discrepancies reported across the included studies. Furthermore, the pandemic period in each included study was defined arbitrarily by the investigators, and in most cases according to the date of imposed health care or social restrictions. The prepandemic cohorts used for comparisons also varied considerably between studies, extending from patients admitted over a designated period just before the pandemic era or more remote periods (Table II in the Data Supplement). Moreover, we need to highlight that the pandemic period in included studies expands for a limited period of several months, which is presumably a short time interval to adequately reflect the impact of a pandemic on the health care stroke systems, and this can lead to underestimations due to insufficient observation time.

In conclusion, the findings of this systematic review and meta-analysis reveal increased proportions of younger patients and severe strokes attributed to a LVO, which had led to higher EVT treatment rates during the COVID-19 pandemic. Patients with stroke admitted during the COVID-19 pandemic also had a higher risk of in-hospital mortality. These observations require further confirmation by uninterrupted observation of the evolution of stroke epidemiology and care delivery over the total span and phases of the COVID-19 pandemic within the settings of appropriately designed prospective cohort studies.[86]

ARTICLE INFORMATION

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Supplemental Materials

Expanded Methods
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