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ORIGINAL ARTICLE

Impact of the coronavirus disease 2019 pandemic on stroke teleconsultations in Germany in the first half of 2020

Christoph Vollmuth[1] | Olga Miljukov[2] | Mazen Abu-Mugheisib[3] | Anselm Angermaier[4] | Jessica Barlinn[5] | Loraine Busetto[6] | Armin J. Grau[7] | Albrecht Guenther[8] | Christoph Gumbinger[6] | Nikolai Hubert[9] | Katrin Hüttemann[10] | Carsten Klingner[8] | Markus Naumann[11] | Frederick Palm[12] | Jan Remi[10] | Viktoria Rücker[2] | Joachim Schessl[13] | Felix Schlachetzki[14] | Ramona Schuppner[15] | Stefan Schwab[16] | Andreas Schwartz[17] | Adrian Trommer[18] | Christian Urbanek[7] | Bastian Volbers[16] | Joachim Weber[19,20,21] | Claudia Wojciechowski[5] | Hans Worthmann[15] | Philipp Zickler[11] | Peter U. Heuschmann[2,22] | Karl Georg Haeusler[1] | Gordian Jan Hubert[9]

[1]Department of Neurology, University Hospital Würzburg, Würzburg, Germany

[2]Institute of Clinical Epidemiology and Biometry, Julius Maximilian University of Würzburg, Würzburg, Germany

[3]Department of Neurology, University Hospital Braunschweig, Braunschweig, Germany

[4]Department of Neurology, University Hospital Greifswald, Greifswald, Germany

[5]Department of Neurology, University Hospital Dresden, Dresden, Germany

[6]Department of Neurology, University Hospital Heidelberg, Heidelberg, Germany

[7]Department of Neurology, Hospital Ludwigshafen, Ludwigshafen, Germany

[8]Hans Berger Department of Neurology, University Hospital Jena, Jena, Germany

[9]TEMPiS Telemedical Stroke Center, Department of Neurology, Munich Clinic Harlaching, Munich, Germany

[10]NEVAS Telemedical Stroke Network, Department of Neurology, University Hospital Munich, Munich, Germany

[11]Department of Neurology, University Hospital Augsburg, Augsburg, Germany

[12]Department of Neurology, Hospital Schleswig, Kiel, Germany

[13]Department of Neurology, Hospital Karlsruhe, Karlsruhe, Germany

[14]TEMPiS Telemedical Stroke Center, Department of Neurology, Center for Vascular Neurology and Intensive Care, Medbo District Hospital Regensburg, University of Regensburg, Regensburg, Germany

[15]Department of Neurology, Hannover Medical School, Hannover, Germany

[16]Department of Neurology, University Hospital Erlangen, Friedrich Alexander University of Erlangen-Nuremberg, Erlangen, Germany

[17]Department of Neurology, Hospital Nordstadt, Hannover, Germany

[18]Department of Neurology, Hospital Hubertusburg, Wermsdorf, Germany

[19]Clinic and University Outpatient Clinic for Neurology, Charité–Universitätsmedizin Berlin, Berlin, Germany

[20]Center for Stroke Research Berlin, Charité–Universitätsmedizin Berlin, Berlin, Germany

[21]Berlin Institute of Health, Berlin, Germany

[22]Comprehensive Heart Failure Center, Clinical Trial Center Würzburg, University Hospital Würzburg, Julius Maximillian University of Würzburg, Würzburg, Germany

Abbreviations: COVID-19, coronavirus disease 2019; NIHSS, National Institutes of Health Stroke Scale; SARS-CoV-2, severe acute respiratory syndrome coronavirus 2; TIA, transient ischemic attack; WHO, World Health Organization.

Karl Georg Haeusler and Gordian Jan Hubert contributed equally to this work.

Prof. Dr Claudia Sommer was not involved at any stage of the editorial process

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Correspondence
Karl Georg Häusler, Department of Neurology, University Hospital Würzburg, Josef-Schneider-Str. 11, 97080 Würzburg, Germany.
Email: Haeusler_K@ukw.de

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Abstract

Background and purpose: The effects of the coronavirus disease 2019 (COVID-19) pandemic on telemedical care have not been described on a national level. Thus, we investigated the medical stroke treatment situation before, during, and after the first lockdown in Germany.

Methods: In this nationwide, multicenter study, data from 14 telemedical networks including 31 network centers and 155 spoke hospitals covering large parts of Germany were analyzed regarding patients' characteristics, stroke type/severity, and acute stroke treatment. A survey focusing on potential shortcomings of in-hospital and (telemedical) stroke care during the pandemic was conducted.

Results: Between January 2018 and June 2020, 67,033 telemedical consultations and 38,895 telemedical stroke consultations were conducted. A significant decline of telemedical ($p < 0.001$) and telemedical stroke consultations ($p < 0.001$) during the lockdown in March/April 2020 and a reciprocal increase after relaxation of COVID-19 measures in May/June 2020 were observed. Compared to 2018–2019, neither stroke patients' age ($p = 0.38$), gender ($p = 0.44$), nor severity of ischemic stroke ($p = 0.32$) differed in March/April 2020. Whereas the proportion of ischemic stroke patients for whom endovascular treatment (14.3% vs. 14.6%; $p = 0.85$) was recommended remained stable, there was a nonsignificant trend toward a lower proportion of recommendation of intravenous thrombolysis during the lockdown (19.0% vs. 22.1%; $p = 0.052$). Despite the majority of participating network centers treating patients with COVID-19, there were no relevant shortcomings reported regarding in-hospital stroke treatment or telemedical stroke care.

Conclusions: Telemedical stroke care in Germany was able to provide full service despite the COVID-19 pandemic, but telemedical consultations declined abruptly during the lockdown period and normalized after relaxation of COVID-19 measures in Germany.

KEYWORDS
COVID-19, SARS-CoV-2, stroke, survey, telemedicine

INTRODUCTION

The World Health Organization (WHO) declared global pandemic of coronavirus disease 2019 (COVID-19) due to the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) has affected more than 108 million people worldwide, had caused more than 2.3 million deaths up to 16 February 2020, and is currently undergoing a second wave of infections in various countries [1]. The COVID-19 pandemic has unforeseen implications for all areas of medicine, including the care of patients with cerebrovascular diseases, as neurological departments have redistributed their capacity to ensure the care of patients with COVID-19. Furthermore, a decreased number of hospitalized stroke patients has repeatedly been reported, obviously due to social distancing and isolation or due to concerns regarding an increased in-hospital risk of SARS-CoV-2 infection [2–7].

On the other hand, there is growing evidence that COVID-19 is linked to acquired hypercoagulability, with an increased risk of venous as well as arterial thrombosis and embolism [8–10]. In addition, COVID-19-related depletion of angiotensin-converting enzyme 2 and subsequent endothelial dysfunction may also increase the risk of stroke [11]. In hospitalized COVID-19 patients, an ischemic stroke rate up to 3% and a hemorrhagic stroke rate up to 0.5% were reported [12–14]. Furthermore, COVID-19-associated ischemic strokes are reported to be more severe, with worse functional outcome and higher mortality than non-COVID-19 ischemic strokes [15].

Telemedicine is widely used to facilitate care of stroke patients in regional network hospitals (without a 24/7 presence of a neurologist) by stroke specialists at dedicated network centers. It has been demonstrated that this hub and spoke model improves the quality of stroke care in spoke hospitals, reducing mortality and morbidity of stroke patients [16]. In Germany, 22 telemedical stroke networks provide a substantial part of acute stroke care in rural areas. During the COVID-19 pandemic, it has been recommended to strengthen telemedical stroke networks, because teleneurology can play an important role in protecting patients and physicians from potential exposure to COVID-19 in outpatient and inpatient care (i.e., by optimizing the allocation of treatment resources and minimizing transport of patients between hospitals) [17].

Single-center observations from the United States and Germany report a significant decline in teleconsultations during the peak phase of the COVID-19 pandemic in March and April 2020 [18–21]. However, the implications of the COVID-19 pandemic for telemedical stroke care have not been analyzed in detail on a national level. On behalf of the German telemedical stroke networks, we analyzed routine data of telemedical consultations in German telemedical networks, hypothesizing a decline of stroke teleconsultations during the COVID-19 pandemic. Furthermore, we compared data of federal states in the southern and nonsouthern part of Germany, as the COVID-19 incidence in southern Germany was higher in the first half of 2020. Using a survey, we assessed potential shortcomings of in-hospital and (telemedical) stroke care in Germany in the first half of 2020.

MATERIALS AND METHODS

In this nationwide, multicenter study, all coordinators of German telemedical stroke networks, cooperating within the working group "Telemedical Stroke Care" of the German Stroke Society, were asked to contribute their data and to return a standardized questionnaire. Data of individual telemedical networks were included if teleconsultations had been documented 24/7 since January 2018. In accordance with local rules of data protection, anonymized data on teleconsultations were sent to the Institute of Clinical Epidemiology and Biometry, University Würzburg, Germany. In addition to the date of teleconsultation, patients' age, gender, stroke type (ischemic stroke, transient ischemic attack, hemorrhagic stroke, subarachnoid hemorrhage), stroke severity at time of consultation using the National Institutes of Health Stroke Scale (NIHSS) [22], and whether intravenous thrombolysis and/or endovascular treatment was recommended were assessed. Furthermore, the local network coordinators were asked to return a survey focusing on potential shortcomings of in-hospital stroke care as well as telemedical stroke care during the COVID-19 pandemic (Appendix S1), which was cross-referenced with spoke hospitals and network center(s).

The incidence of SARS-CoV-2 infections in all federal states of Germany was reported on a weekly basis by the German government's central Public Health Institute (the Robert Koch Institute, Berlin, Germany; https://www.rki.de). As Bavaria and Baden-Württemberg (both in the south of Germany) represented the only two federal states with a mean weekly incidence of more than 40 SARS-CoV-2 infections per 100,000 people, we compared teleconsultations of the participating networks in these two southern federal states of Germany to teleconsultations in the participating networks in other ("nonsouthern") parts of Germany (Figure 1, Table S1). Two telemedical stroke networks (FAST, Stroke-ARTEV) were allocated according to the localization of spoke hospitals requesting teleconsultations.

On 9 January 2020, the WHO declared the first COVID-19-related death worldwide, and on 27 January 2020, the first SARS-CoV-2 infection in Germany was detected. The first death due to COVID-19 in Germany was reported on 9 March 2020. On 16 March 2020, nationwide restriction measures (closing of schools, childcare facilities, and many stores) became effective in Germany. Thus, we defined this date as the start of the COVID-19 pandemic-related lockdown. In March 2020, we intended to analyze teleconsultations within the period from 1 January 2018 and 30 April 2020. As on 20 April 2020, relaxation of COVID-19 measures was implemented in Germany, we expanded data assessment to 30 June 2020, to be able to assess the impact of relaxation of COVID-19 measures on telemedical care.

In March 2020, the following research questions were defined. (i) Are we experiencing a temporary decline in the number of teleconsultations among (stroke) patients during the COVID-19 pandemic in Germany? (ii) Do patient characteristics, stroke type/severity, or acute stroke treatment differ during the peak phase of the COVID-19 pandemic? (iii) Do changes of telemedical stroke care differ in federal states with comparably high incidence of COVID-19? (iv) Are there shortcomings of in-hospital stroke care or telemedical stroke care during the COVID-19 pandemic?

Statistical analysis

Statistical analysis was performed using the Statistical Package for the Social Sciences version 26.0 (IBM SPSS Statistics), except for time series decompositions using R 4.0.2, the prophet (v0.6.1; Taylor & Letham 2020) package. Associations between patients' characteristics and time period were evaluated using Kruskal–Wallis test with post hoc tests for differences in continuous variables and chi-squared test for categorical variables. All reported *p*-values are two-sided, and the significance level was set to 0.05. Adjustment for multiple comparisons was applied in post hoc analyses. The impact of COVID-19 measures on the main outcome defined as daily number of consultations was evaluated by interrupted time series analysis using segmented Poisson regression (Appendix S1).

Standard protocol approvals, registrations, and patient consents

This study was approved with a waiver of authorization by the data security officer at the University and University Hospital of Würzburg, Germany and was in accordance with the 1964 Declaration of Helsinki and its later amendments.

RESULTS

Data of 14 telemedical networks were included in the analysis, including 31 network centers (range = 1–6 centers per network; Figure S1) and 155 spoke hospitals (range = 3–24 per telemedical

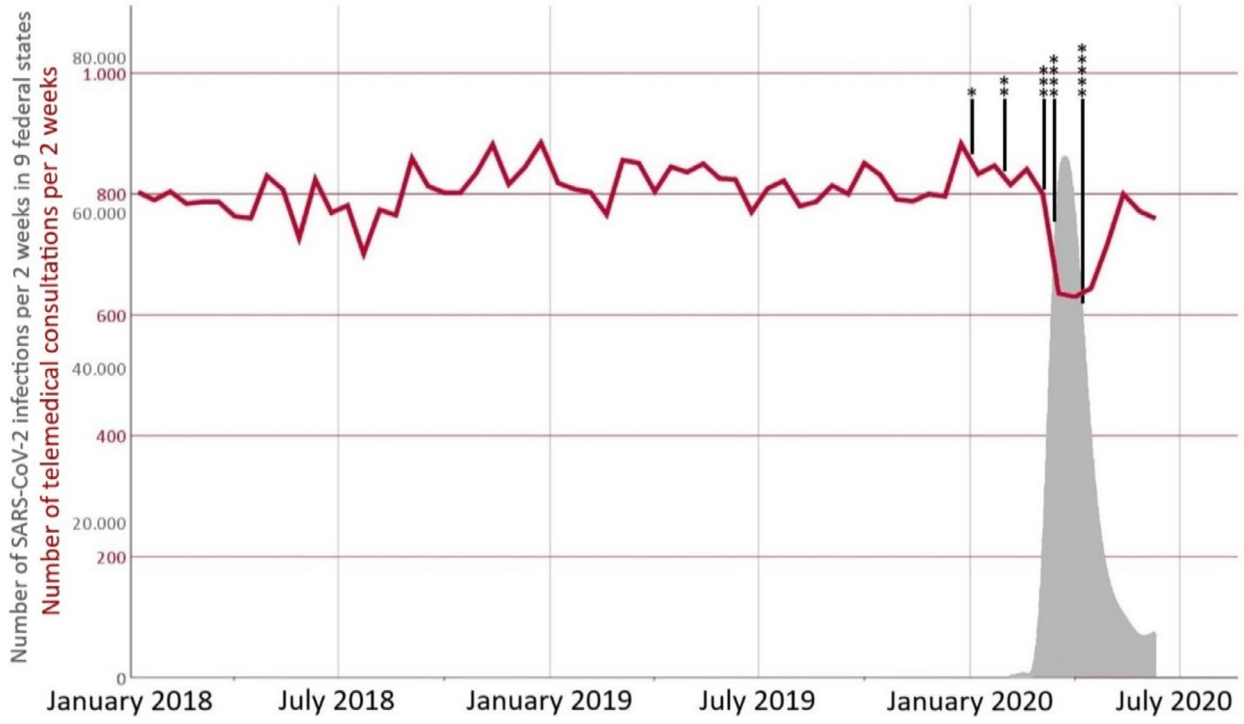

FIGURE 1 All (stroke and nonstroke) telemedical consultations (red line, red numbers) per 2 weeks from January 2018 to June 2020 in 10 German telemedical stroke networks. The number of severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) infections (gray) per 2 weeks in nine German federal states of participating telemedical stroke networks (according to the Robert Koch Institute, Berlin, Germany) is shown. *First death due to coronavirus disease 2019 (COVID-19) worldwide on 9 January 2020. **First patient with COVID-19 in Germany on 27 January 2020. ***First COVID-19-related death in Germany on 9 March 2020. ****Announcement of restriction measures in Germany on 16 March 2020. *****Relaxation of COVID-19 measures in Germany on 20 April 2020. [Colour figure can be viewed at wileyonlinelibrary.com]

stroke network) in nine federal states of Germany (Table S1). Ten of 14 telemedical networks provided additional data on teleconsultations from 1 May 2020 to 30 June 2020.

Teleconsultations during the observation period

Overall, 67,033 teleconsultations were completed within the observation period in participating networks (Table 1). Mean age of patients was 71 (SD = ±16) years, and 31,658 (49.6%) patients were female. Interrupted time series analysis revealed a constant level of telemedical consultations without a significant trend between 1 January 2020 and 15 March 2020 (β_1 = 1.0, p = 0.829; Table S2). The mean daily rate of telemedical consultations dropped by 13% in the first week of the lockdown (β_4 = 0.87, p = 0.015) and by an additional 16% between 23 March 2020 and 19 April 2020 (β_2 = 0.71, p < 0.001). After the relaxation of COVID-19 restrictions, the mean daily rate of telemedical consultations increased, but was lower (−6%, p = 0.494) compared to the mean daily rate of telemedical stroke consultations in the time period before the lockdown (between 1 January 2020 and 15 March 2020). As depicted in Figure 1, the number of telemedical consultations was inversely correlated to the incidence of SARS-CoV-2 infections in the federal states of participating networks.

The mean daily rate of telemedical consultations in Bavaria and Baden-Württemberg dropped by 11% in the first week of the lockdown (β_4 = 0.89, p = 0.066), and by an additional 16% between 23 March 2020 and 19 April 2020 (β_2 = 0.73, p < 0.001; Table 2, Figure S2A). The mean daily rate of telemedical consultations in the nonsouthern networks dropped by 21% in the first week of the lockdown (β_4 = 0.79, p = 0.077), and by an additional 15% between 23 March 2020 and 19 April 2020 (β_2 = 0.64, p < 0.001; Table 2, Figure S2B). After the relaxation of COVID-19 restrictions, the mean daily rate of telemedical consultations increased, but was lower (−6%, p = 0.49) in the two southern federate states and in the nonsouthern federal states (−5%, p = 0.77), if compared to the mean daily rate of telemedical stroke consultations in the time period before the lockdown (between 1 January 2020 and 15 March 2020).

Teleconsultations in stroke patients during the observation period

Of 55,958 teleconsultations with available diagnosis, 38,895 (69.5%) teleconsultations were stroke related (Table 2). The mean age of stroke patients was 73 (SD = ±14) years, and 18,674 (48.7%) were female. Interrupted time series analysis revealed a constant level of telemedical stroke consultations without a significant trend between

TABLE 1 Telemedical (nonstroke and stroke) consultations in participating German telemedical networks during the observation period

	Time period						
	1 January 2018–30 April 2020	1 January 2018–31 December 2018	1 January 2019–31 December 2019	1 January 2020–15 March 2020	16 March 2020–30 April 2020	1 May 2020–30 June 2020	Total
Telemedical stroke networks							
n	14	14	14	14	14	10	10–14
Network centers							
n	31	31	31	31	31	23	23–31
Spoke hospitals							
n	155	155	155	155	155	113	113–155
Consultations							
n	63,652	27,068	28,012	5706	2865	3381	67,033
Weekly average number of consultations							
Mean ± SD	524 ± 57	519 ± 34	538 ± 23	530 ± 35	433 ± 25	357 ± 82	512 ± 59
Weekly average number of consultations per network							
Mean ± SD	37.4 ± 3.3	37.2 ± 2.5	38.5 ± 1.7	38.1 ± 2.2	31.3 ± 2.4	35.9 ± 7.7	37.4 ± 3.3
Patients' age							
Mean ± SD	71 ± 16	71 ± 16	71 ± 16	71 ± 16	71 ± 15	70 ± 16	71 ± 16
Sex, female							
n (%)	30,295 (47.6)	13,114 (50.0)	13,180 (49.5)	2691 (49.3)	1310 (48.1)	1363 (49.0)	31,658 (49.6)

TABLE 2 Telemedical stroke consultations in German telemedical networks during the observation period

	Time period						
	1 January 2018–30 April 2020	1 January 2018–31 December 2018	1 January 2019–31 December 2019	1 January 2020–15 March 2020	16 March 2020–30 April 2020	1 May 2020–30 June 2020	Total
Telemedical stroke networks							
n	14	14	14	14	14	10	10–14
Stroke consultations							
n	36,742	15,928	15,946	3306	1562	2153	38,895
Patients' age, years							
Mean ± SD	73 ± 14	72 ± 14	73 ± 14	73 ± 14	73 ± 14	73 ± 14	73 ± 14
Sex, female							
n (%)	17,785 (48.4)	7774 (49.0)	7674 (48.4)	1600 (48.8)	737 (47.7)	889 (49.1)	18,674 (48.7)
Stroke consultations with stroke type							
n (%)	31,401 (85.5)	13,618 (85.5)	13,641 (85.5)	2807 (84.9)	1335 (85.5)	1790 (83.1)	33,191 (85.3)
Ischemic stroke							
n (%)	22,857 (72.8)	10,007 (73.5)	9854 (72.2)	2018 (71.9)	978 (73.3)	1311 (73.2)	24,168 (72.8)
Mean daily rate	27	27.4	27.0	26.9	21.7	21.5	26.5
TIA							
n (%)	6633 (21.1)	2775 (20.4)	2965 (21.7)	622 (22.2)	271 (20.3)	389 (21.7)	7022 (21.2)
Mean daily rate	8	7.6	8.1	8.3	5.9	6.4	7.7
Hemorrhagic stroke							
n (%)	1313 (4.2)	582 (4.3)	565 (4.1)	109 (3.9)	57 (4.3)	64 (3.6)	1377 (4.1)
Mean daily rate	2	1.6	1.5	1.5	1.2	1.0	1.5
Subarachnoid hemorrhage							
n (%)	323 (1.0)	138 (1.0)	135 (0.9)	38 (1.4)	12 (0.9)	15 (0.8)	338 (1.0)
Mean daily rate	0	0.38	0.37	0.51	0.26	0.26	0.37
Subdural or epidural hemorrhage							
n (%)	275 (0.9)	116 (0.8)	122 (0.9)	20 (0.7)	17 (1.3)	11 (0.6)	286 (0.9)
Mean daily rate	0	0.32	0.33	0.27	0.37	0.18	0.31
Recommendation to perform intravenous thrombolysis in ischemic stroke patients							
n (%)	4520 (19.8)	1973 (19.7)	1915 (19.4)	446 (22.1)	186 (19.0)	n.a.	4520 (19.8)
Mean daily rate	5.3	5.4	5.2	5.9	4.0	n.a.	5.3
Recommendation to perform endovascular treatment in ischemic stroke patients							
n (%)	2802 (12.3)	1144 (11.4)	1224 (12.4)	294 (14.6)	140 (14.3)	n.a.	2802 (12.3)
Mean daily rate	3.3	3.1	3.1	3.9	3.0	n.a.	3.3

(Continues)

TABLE 2 (Continued)

	Time period						
	1 January 2018–30 April 2020	1 January 2018–31 December 2018	1 January 2019–31 December 2019	1 January 2020–15 March 2020	16 March 2020–30 April 2020	1 May 2020–30 June 2020	Total
NIHSS score in ischemic stroke							
0–3							
n (%)	11,137 (58.5)	4812 (59.1)	4774 (58.0)	1045 (58.2)	506 (59.2)	587 (61.7)	11,724 (58.7)
Mean daily rate	13	13.2	13.1	13.9	11.0	9.6	12.9
4–10							
n (%)	5223 (27.5)	2242 (27.5)	2286 (27.7)	487 (27.1)	208 (24.3)	246 (22.8)	5469 (27.3)
Mean daily rate	6	6.1	6.3	6.5	4.5	4.0	6.0
>10							
n (%)	2662 (14.0)	1085 (13.3)	1171 (14.2)	265 (14.7)	141 (16.5)	119 (12.5)	2781 (13.9)
Mean daily rate	3.1	3.0	3.2	3.5	3.1	2.0	3.0

Abbreviations: n.a., not available; NIHSS, National Institutes of Health Stroke Scale; TIA, transient ischemic attack.

1 January 2020 and 15 March 2020 (β_1 = 1.0, *p* = 0.414). Compared to this period, the mean daily rate of telemedical stroke consultations dropped by 12% in the first week of the lockdown (β_4 = 0.88, *p* = 0.094), and by an additional 24% between 23 March 2020 and 19 April 2020 (β_2 = 0.76, $p < 0.001$; Figure S3). After the relaxation of COVID-19 restrictions, the mean daily rate of telemedical stroke consultations increased, but was lower (−3%, *p* = 0.774), if compared to the mean daily rate of telemedical stroke consultations in the time period before the lockdown (between 1 January 2020 and 15 March 2020).

Information on stroke type was available in 33,191 patients, including 24,168 (72.8%) patients with ischemic stroke, 7,022 (21.2%) with transient ischemic attack (TIA), 1,377 (4.1%) with hemorrhagic stroke, 338 (1.0%) with subarachnoid hemorrhage, and 286 (0.9%) with subdural or epidural hemorrhage. The NIHSS score at the time of consultation was available in 19,974 patients with ischemic stroke. Overall, 11,724 (58.7%) patients had an NIHSS score of 0–3 points, 5,469 (27.3%) had an NIHSS score of 4–10 points, and 2,781 (13.9%) had an NIHSS score greater than 10 points.

As depicted in Figure 2, stroke consultations during the lockdown period did not differ regarding patients' age (*p* = 0.32; Figure 2a), gender (*p* = 0.44; Figure 2b), or stroke severity (*p* = 0.32; Figure 2c). Within the observation period before 15 March 2020, intravenous thrombolysis was recommended in 4,520 (19.8%) and endovascular treatment in 2,802 (12.3%) patients with ischemic stroke (Figure 3). During the lockdown period, the mean daily rate of recommendations to perform intravenous thrombolysis significantly declined (4.0 vs. 5.9 before the lockdown period, $p < 0.001$), and there was a nonsignificant trend toward a lower rate of recommending intravenous thrombolysis in ischemic stroke patients (19.0% vs. 22.1% before the lockdown period, *p* = 0.052). The mean daily rate of recommendations to perform endovascular treatment declined significantly during the lockdown period (3.0 vs. 3.9 before the lockdown period, *p* = 0.02), whereas the rate of recommendations to perform endovascular treatment in ischemic stroke patients remained stable (14.3% vs. 14.6% before the lockdown period, *p* = 0.85).

Survey among coordinators of participating telemedical stroke networks

The survey (Appendix S1) was completed by coordinators of 14 telemedical stroke networks. Telemedical stroke care was limited at one (3%) of 31 network centers, which was reported to be unrelated to the COVID-19 pandemic. In-hospital stroke care was limited in at least one spoke hospital in six (43%) of 14 telemedical stroke networks during the COVID-19 pandemic, because the capacity of monitoring beds was insufficient (*n* = 4) or no stroke care could be provided at the spoke hospital temporarily (*n* = 4). Patients with COVID-19 were treated at 30 (97%) of 31 network centers. In five (16%) network centers, treatment of nonstroke patients with COVID-19 affected stroke care, as monitoring beds (on the intensive care unit or stroke unit) had to be reserved or used for patients with

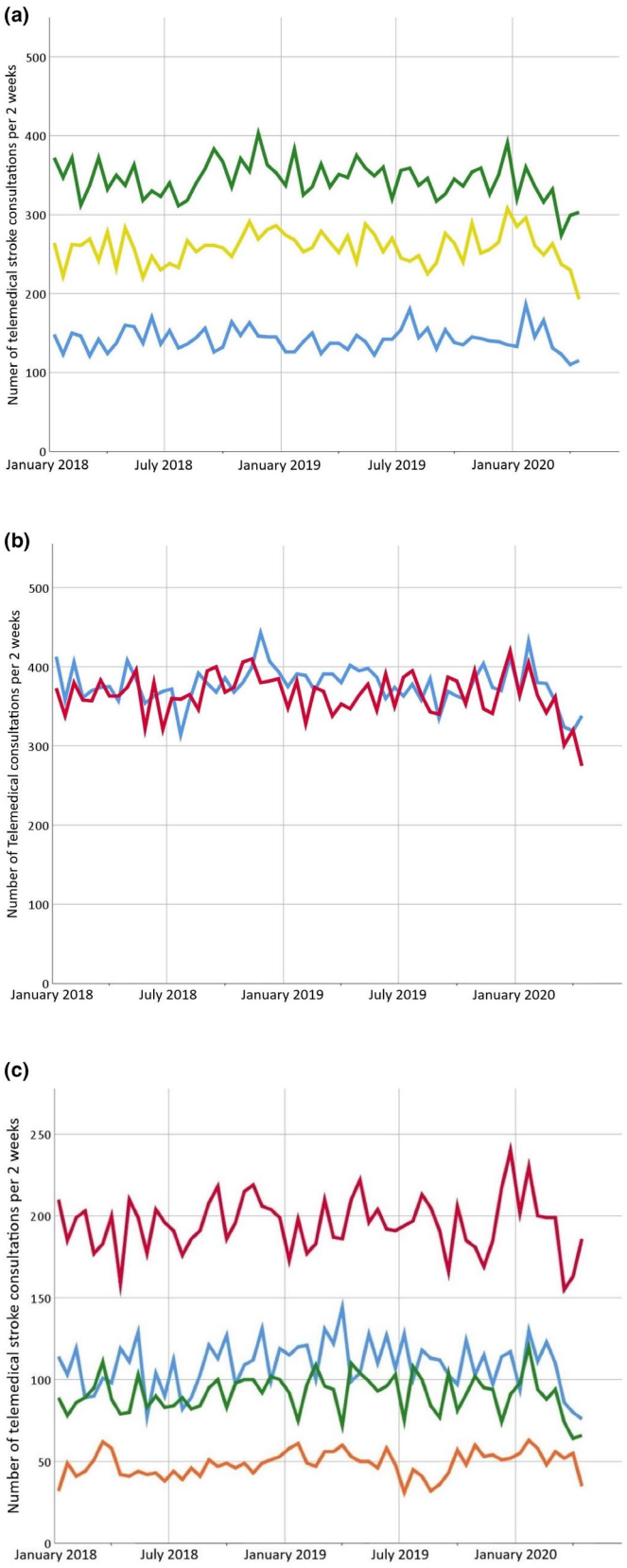

FIGURE 2 (a) Telemedical stroke consultations per 2 weeks from January 2018 to April 2020 in 14 German telemedical stroke networks with regard to patients' age: <60 years (blue line), 60–80 years (green line), and >80 years (yellow line). (b) Telemedical consultations per 2 weeks from January 2018 to April 2020 in 14 German telemedical stroke networks regarding male (blue line) and female sex (red line). (c) Telemedical stroke consultations per 2 weeks from January 2018 to April 2020 in 14 German telemedical stroke networks. Transient ischemic attack patients (blue line), minor stroke patients (National Institutes of Health Stroke Scale [NIHSS] score = 0–3 points, red line), patients with moderate stroke (NIHSS score = 4–10 points, green line), and patients with severe stroke (NIHSS score > 10 points, orange line) are shown. [Colour figure can be viewed at wileyonlinelibrary.com]

COVID-19 (n = 3), diagnostic procedures in stroke patients were delayed or limited (n = 1), or there were COVID-19-related shortages of staff (n = 1). Seventeen (55%) network centers reported treatment of stroke patients with COVID-19, and eight (26%) network centers reported treatment of these patients at the Department of Neurology. In-hospital treatment of stroke patients with COVID-19 affected the care of stroke patients without COVID-19 in one (3%) telemedical network, as monitoring beds were closed, and diagnostic procedures were delayed or canceled due to COVID-19-related hygiene regulations.

DISCUSSION

In this representative nationwide study, we demonstrate a significant decline of telemedical consultations as well as telemedical stroke consultations during the COVID-19 pandemic-related lockdown in Germany. Based on interrupted time series analysis, we furthermore observed a rebound of teleconsultations after the relaxation of COVID-19 restrictions in Germany. Interestingly, the rate of telemedical consultations was inversely correlated to the incidence of SARS-CoV-2 in the federal states of participating networks (not representing all parts of Germany; Figure 1). However, the observed fluctuations of (stroke) teleconsultations were similarly observed in federal states with rather high or rather low incidence of SARS-CoV-2 infections (Figure 4).

During the lockdown period, neither patients' age, gender, nor stroke type and stroke severity showed significant changes. This is not in line with previous publications, indicating a significant decline of the proportion of minor stroke and TIA patients [23]. Published single-center or single-network observations reported increasing or decreasing proportions of patients undergoing recanalization therapy, which was not the case in our analysis [18,19,24]. We observed a lower rate of recommendations to perform intravenous thrombolysis during the lockdown, but this was not statistically significant, as similarly reported in the German TEMPiS network (please see Table S1 for details) [20,21]. This finding may indicate that stroke patients may have arrived at later time points in the spoke hospitals.

Our results are also in line with the observed decline of in-hospital stroke treatment during March and April 2020 in several health care systems and also in Germany [25–30]. As a nationwide survey among German neurologists running a certified stroke unit revealed that 93% reported a decrease of hospitalized stroke

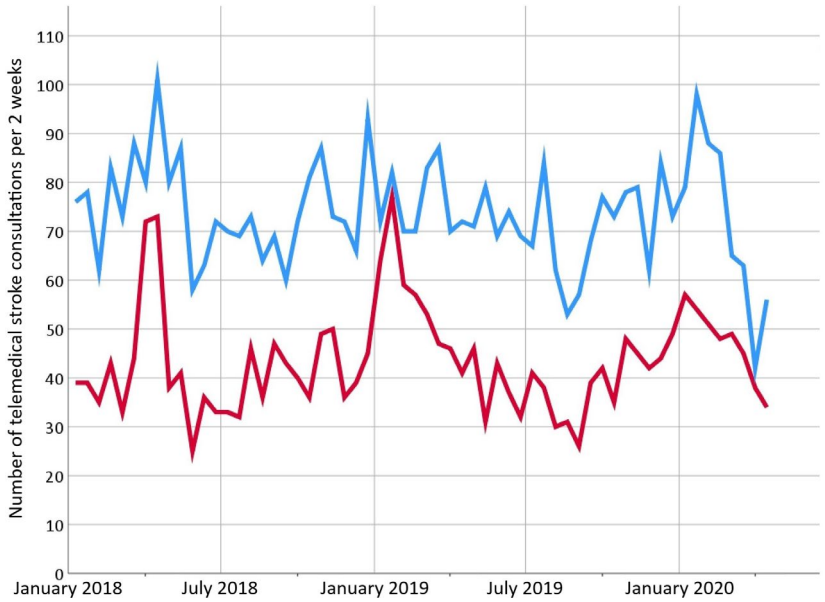

FIGURE 3 Telemedical stroke consultations per 2 weeks from January 2018 to April 2020 in 14 German telemedical stroke networks. Recommendations for intravenous thrombolysis (blue line) or mechanical recanalization (red line) are shown. [Colour figure can be viewed at wileyonlinelibrary.com]

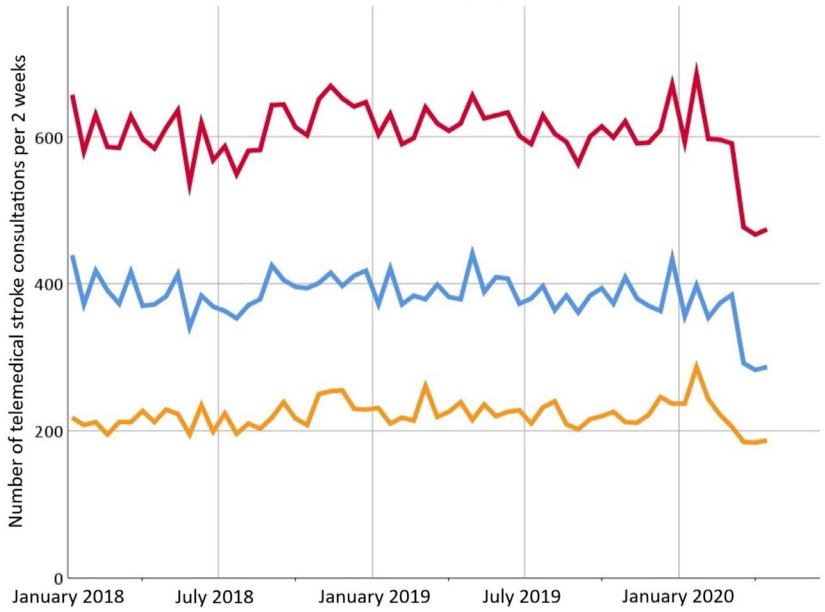

FIGURE 4 Telemedical stroke consultations per 2 weeks from January 2018 to April 2020 in 14 German telemedical stroke networks (red line), in seven telemedical stroke networks in the south of Germany (blue line), and in seven telemedical stroke networks in the nonsouthern parts of Germany (orange line) [Colour figure can be viewed at wileyonlinelibrary.com]

patients at their institution [31], it seems plausible that the observed alterations of telemedical stroke consultations mirror hospitalized stroke care during the COVID-19-related lockdown period. According to our data, it is plausible that the observed fluctuations of telemedical consultations and telemedical stroke consultations in particular reflect an avoidance of in-hospital presentation during the COVID-19-related lockdown period.

The conducted survey among coordinators of participating network centers revealed that almost all hospitals treated patients with COVID-19, and about 60% treated stroke patients with COVID-19. In-hospital treatment of stroke patients and diagnostic procedures in stroke patients were considered to be normal at the vast majority of stroke centers. This is discrepant from a recent survey including 426 stroke care providers from 55 countries, reporting shortcomings in stroke care in 77% of European respondents [32]. A possible explanation for this discrepancy could be the higher rate of intensive care facilities and a lower incidence of SARS-CoV-2 infections in Germany compared to other European countries. About 40% of the telemedical stroke network coordinators reported limited stroke care in at least one spoke hospital during the lockdown period. Of note, no network was reported to have limited their telemedicine service. As the maintenance of stroke care is crucial to limit stroke-related mortality and disability, it is reassuring that there was neither a shortage of telemedical staff nor restrictions by technical problems during the COVID-19 pandemic in the first half of 2020 in Germany.

Despite the reported strengths, the following limitations have to be taken into account. First, two German telemedical stroke networks were not able to add data to our analysis, as data assessment starting in January 2018 was mandatory to enable time series analyses. Nevertheless, the participating telemedical networks cover the

vast majority of teleconsultations in Germany. Second, the local incidence of stroke was not available, as our analysis is based on teleconsultation data only. Furthermore, we are unable to assess whether the proportion of patients taken directly to the specialist hospitals differed by time. However, it is unlikely that the source population of the treating hospitals changed during the pandemic period, and a similar decline of in-hospital stroke patients was reported in Germany [30]. Third, the reasons for the observed alterations in telemedical consultations cannot be elucidated in more detail and, therefore, should be addressed in future studies. Fourth, two of 14 networks were unable to provide data on stroke type, and three networks were unable to provide the NIHSS score on admission. However, given the large number of hospitals and patients involved and a constant proportion of available information on stroke type and stroke severity, a substantial bias is unlikely. Fifth, four of 14 telemedical networks did not provide data from May/June 2020, which might have had an impact on the results of the postlockdown period. However, data of all remaining telemedical networks showed a reciprocal increase of telemedical consultations after relaxation of COVID-19 measures, leading us to the assumption that a substantial bias is unlikely. Sixth, data of the TEMPiS network were already published [20,21].

Summary

Telemedical consultations and telemedical stroke consultations significantly declined during the COVID-19 pandemic-related lockdown in Germany and began to normalize after relaxation of COVID-19 measures. Decline of telemedical (stroke) consultations was observed nationwide in telemedical networks, independent of the incidence of SARS-CoV-2 infections in the southern and non-southern parts of Germany. We observed a lower rate of systemic thrombolysis during the lockdown period in March/April 2020, but this was not statistically significant. Although the majority of the participating network centers treated COVID-19 patients, relevant shortcomings regarding in-hospital treatment as well as telemedical stroke care were not reported. Our representative nationwide study demonstrates the robustness of teleconsultation services in Germany during the COVID-19 pandemic in the first half of 2020.

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CONFLICT OF INTEREST

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AUTHOR CONTRIBUTIONS

Christoph Vollmuth: conceptualization (equal), data curation (equal), formal analysis (equal), investigation (equal), methodology (equal), project administration (equal), resources (equal), supervision (equal), validation (equal), visualization (equal), writing–original draft (equal). Olga Miljukov: formal analysis (equal), methodology (supporting), visualization (equal), writing–original draft (equal). Mazen Abu-Mugheisib: data curation (supporting), formal analysis (supporting), investigation (supporting), writing–original draft (supporting). Anselm Angermaier: data curation (supporting), formal analysis (supporting), investigation (supporting), writing–original draft (supporting). Jessica Barlinn: data curation (supporting), formal analysis (supporting), investigation (supporting), methodology (supporting), writing–original draft (supporting). Loraine Busetto: data curation (supporting), formal analysis (supporting), investigation (supporting), writing–original draft (supporting). Armin J. Grau: data curation (supporting), formal analysis (supporting), investigation (supporting), writing–original draft (supporting). Albrecht Guenther: data curation (supporting), formal analysis (supporting), investigation (supporting), writing–original draft (supporting). Christoph Gumbinger: data curation (supporting), formal analysis (supporting), investigation (supporting), writing–original draft (supporting). Nikolai Hubert: data curation (supporting), formal analysis (supporting), investigation (supporting), writing–original draft (supporting). Katrin Hüttemann: data curation (supporting), formal analysis (supporting), investigation (supporting), writing–original draft (supporting). Carsten Klingner: data curation (supporting), formal analysis (supporting), investigation (supporting), writing–original draft (supporting). Markus Naumann: data curation (supporting), formal analysis (supporting), investigation (supporting), writing–original draft (supporting). Frederick Palm: data curation (supporting), formal analysis (supporting), investigation (supporting), writing–original draft (supporting). Jan Remi: data curation (supporting), formal analysis (supporting), investigation (supporting), writing–original draft (supporting). Viktoria Rücker: data curation

(supporting), formal analysis (supporting), investigation (supporting), writing–original draft (supporting). Joachim Schessl: data curation (supporting), formal analysis (supporting), investigation (supporting), writing–original draft (supporting). Felix Schlachetzki: data curation (supporting), formal analysis (supporting), investigation (supporting), writing–original draft (supporting). Ramona Schuppner: data curation (supporting), formal analysis (supporting), investigation (supporting), writing–original draft (supporting). Stefan Schwab: data curation (supporting), formal analysis (supporting), investigation (supporting), writing–original draft (supporting). Andreas Schwartz: data curation (supporting), formal analysis (supporting), investigation (supporting), writing–original draft (supporting). Adrian Trommer: data curation (supporting), formal analysis (supporting), investigation (supporting), writing–original draft (supporting). Christian Urbanek: data curation (supporting), formal analysis (supporting), investigation (supporting), writing–original draft (supporting). Bastian Volbers: data curation (supporting), formal analysis (supporting), investigation (supporting), writing–original draft (supporting). Joachim Weber: data curation (supporting), formal analysis (supporting), investigation (supporting), writing–original draft (supporting). Claudia Wojciechowski: data curation (supporting), formal analysis (supporting), investigation (supporting), writing–original draft (supporting). Hans Worthmann: data curation (supporting), formal analysis (supporting), investigation (supporting), writing–original draft (supporting). Philipp Zickler: data curation (supporting), formal analysis (supporting), investigation (supporting), writing–original draft (supporting). Peter U. Heuschmann: data curation (supporting), formal analysis (supporting), investigation (supporting), writing–original draft (supporting). Karl Georg Häusler: conceptualization (equal), data curation (equal), formal analysis (equal), investigation (equal), methodology (equal), project administration (equal), supervision (equal), validation (equal), visualization (equal), writing–original draft (equal). Gordian Jan Hubert: conceptualization (equal), data curation (equal), formal analysis (equal), investigation (equal), methodology (equal), project administration (equal), supervision (equal), validation (equal), visualization (equal), writing–original draft (equal).

DATA AVAILABILITY STATEMENT

We state that the data published are available and anonymized and will be shared on request by email to the corresponding author from any qualified investigator for purposes of replicating procedures and results.

ORCID

Christoph Vollmuth https://orcid.org/0000-0002-5893-1196
Olga Miljukov https://orcid.org/0000-0003-4790-5918
Loraine Busetto https://orcid.org/0000-0002-9228-7875
Christoph Gumbinger https://orcid.org/0000-0002-6137-1169
Karl Georg Haeusler https://orcid.org/0000-0002-6389-5054

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SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section.

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