INTRODUCTION

In March 2020, the coronavirus disease of 2019 (COVID-19) was declared a pandemic by the World Health Organization (WHO), causing restructured healthcare systems worldwide.¹ During the pandemic, reports emerged describing a considerable drop in the number of stroke patients seen at local, regional, and national levels.²-⁹ However, most of these studies are reporting overall number of stroke admissions and/or procedures. Independently of these, by then unknown, decreasing stroke numbers, most healthcare
systems simultaneously altered their procedures and structure in order to provide adequate care to critically ill patients with COVID-19. Different changes, priorities, and strategies were chosen at each hospital, and to our knowledge, more detailed nationwide studies on this subject and how this differed from usual care have not yet been published. We hypothesized that the first phase of the pandemic influenced the in-hospital management of stroke. Further, that stroke research was halted. The aim of this "Neurology during a pandemic (NeuroPan) study" was to examine how the COVID-19 pandemic affected the specialized hospital-based stroke care and stroke research in Norway.

2 | MATERIALS AND METHODS

2.1 | Setting

Norway has a population of approximately 5.4 million inhabitants and is a country with large geographical differences, rural and remote areas and long distances. Forty-eight different hospitals take care of stroke patients, but more than 65% of all the patients are admitted to one of the 17 departments of neurology with a Stroke Unit in Norway. The neurological departments are located throughout Norway and are located at smaller district hospitals as well as larger university hospitals. Seven out of seventeen of the Stroke Units are comprehensive stroke centers.

In the Norwegian healthcare system, the general practitioners (GPs) act as gate keepers for referrals to secondary care specialists and hospitals except in emergencies such as acute stroke. The hospitals are almost exclusively publicly financed, and Norway has an all-covering national health insurance. Thus, all patients, irrespective of insurance, social, or financial status, enter the hospital on the same conditions and have the same access to diagnostics, treatment options, and further follow-ups.

The study was conducted as a web-based questionnaire survey during the primary stage of the COVID-19 pandemic in Norway in 2020. The link to the structured web-based questionnaire (Figure 1) about stroke management was distributed by e-mail to the Head of Stroke Units at all neurological departments in Norway.

2.2 | Questionnaire and outcomes

The design of the questionnaire was based on the authors’ clinical experience from the first weeks of the pandemic lockdown, in addition to their general knowledge and experience within stroke medicine, neurology, and questionnaire studies. The questionnaire was distributed in the end of April 2020 and consisted of thirty-five questions of general character concerning their department’s overall handling, impressions, and experiences regarding stroke patients during the initial phase of the pandemic between 12 March and 15 April 2020 (Figure 1). The Head of the Stroke Units were asked to answer the questionnaire by themselves and to answer the questions based on their impressions when accurate comparisons to the pre-pandemic period did not exist.

2.3 | Statistical analyses

For descriptive data, proportions, means, and standard deviations (SD) or 95% confidence intervals (CI) are given. Groups were compared using the t-test (continuous data) or the chi-square test (categorical data).

Statistical significance was defined by p < 0.05, using a two-sided test. Statistical analyses were performed using IBM SPSS Statistics for Windows, Version 26.00 (SPSS Inc., Chicago, IL, USA).

2.4 | Ethics approval

The Data Protection Officer at Akershus University Hospital (Norway) approved the study. The NeurorPan study was registered in the COVID-19 trial registration at the Norwegian Clinical Research Infrastructure Network. According to the Norwegian Health Research Act, no ethical approval was deemed necessary as patient data were not used.

3 | RESULTS

The responder rate was 94% (16 of 17 neurological departments). The department that did not participate did not give any reason for this. Eighty-one % (13/16) reported that the pandemic affected their department, and 63% (10/16) reported that the pandemic changed their management of stroke. Work schedules of both residents and specialists were changed in 25% (4/16) of the hospitals due to prioritization of demands and tasks.

Six out of sixteen (38%) Stroke Units reduced the number of hospital beds (Table 1). All 16 departments reported a drop in new acute admissions in terms of both stroke (ischemic stroke, hemorrhagic stroke, and transient ischemic attacks) and stroke mimics (Table 1). Further, fewer patients received thrombolysis (69%) and endovascular treatment (43%).

Seventy-five % of the hospitals made practical changes to the thrombolysis procedures with 19% switching from alteplase to tenecteplase, and half of the hospitals reported longer time than usual on thrombolysis assessments. In addition, the respondents reported that fewer patients were given the opportunity for proper follow-up (73%) and stroke rehabilitation (50%) (Table 1). The mandatory 3 months of follow-up consultations were postponed at 73% (11/15) of the hospitals. The in-hospital diagnostic evaluation of stroke did not change in the vast majority of hospitals (Table 1). Twenty-seven% (n = 4) decreased the proportion who received carotid ultrasound to reduce the possibility of SARS-CoV-2 exposure.
Stroke management during the initial phase of a pandemic
This questionnaire represents and effort to map experiences and management within stroke treatment during the Covid-19 pandemic in Norway. Your answers should reflect your situation in the period March 12 – April 15.

Compared to normal, what as the work situation in the Stroke Unit like?

Unchanged
Work duties were unchanged, but we had more work than before the pandemic
Work duties changed, and we had more work than before the pandemic
Work duties changed, but we had less work than before the pandemic
Our work schedule (shifts) changed as a consequence of the pandemic
We extended the working hours for doctors due to the pandemic
We reduced the number of beds for stroke patients during the pandemic
Have you had patients with Covid-19 and stroke? Only patients with Covid-19 before/concurrent with debut of stroke
How many patients with Covid-19 and stroke have you admitted?
Has the pandemic affected your course of treatment for stroke in your department?
Did you collaborate with other hospitals to find the best possible procedures for management of stroke during the pandemic?
Fewer patients were receiving thrombolysis than before the pandemic?
We made changes to the thrombolysis procedures (practical implementation)
We used tenecteplase rather than alteplase during the pandemic
We spent more time than usual on thrombolysis assessments
We increased the proportion of patients who received MRI in the acute phase
We increased the proportion of patients who received CT angiography in the acute phase to avoid carotid ultrasound
We reduced the proportion of patients who received carotid ultrasound to avoid SARS-CoV2 exposure
We changed the TIA protocols to reduce the number of admissions
Stroke patients had reduced access to rehabilitation services
We discharged patients faster than usual
Fewer stroke patients came to the hospital than usual
The stroke patients who came to the hospital were more severely affected than those we usually see
Stroke patients arrived at the hospital later than usual
There were fewer stroke mimics than usual
Fewer patients received extended etiologic assessment (telemetry, Holter, ultrasound)
Out-patient follow-ups after stroke were postponed
Reduced standard of care were available for stroke patients during the pandemic
Research projects involving stroke patients were halted during this period

Does the hospital usually perform thrombectomy
Have changes been made to the thrombectomy procedures
Were fewer patients offered thrombectomy during the pandemic compared to before
If yes to thrombectomy, were patients offered thrombectomy even though they had unknown infection status and had to be placed under general anesthesia during the procedures

Please rate the following statements (1 Strongly agree, 2 Agree, 3 Neither agree nor disagree, 4 Disagree, 5 Strongly disagree)
The academic community in Norway have collaborated to find good solutions for stroke patients during the pandemic
The academic community in Norway should have collaborated better to find good solutions for stroke patients during the pandemic

FIGURE 1  The structured questionnaire about stroke management during the initial phase of the COVID-19 pandemic in Norway
Three hospitals changed the procedure for TIA such that fewer patients were admitted for in-hospital evaluation. No hospital increased the proportion of patients who received MRI in the acute phase and only one hospital reported that fewer patients received extended etiologic assessment during the pandemic. Only one hospital discharged patients faster than usual.

38% (6/16) of the hospitals were involved in the treatment of patients with co-occurrence of acute stroke and COVID-19 disease.

Seven Norwegian hospitals perform endovascular treatment and all of them responded to the present questionnaire. Almost half of the thrombectomy centers changed their procedures during the pandemic (3/7), and three of the centers (43%) reported that fewer patients received endovascular treatment during the pandemic. All seven thrombectomy centers offered treatment to patients with unknown COVID-19 infection status despite that they had to be given general anesthesia during the procedure.

Overall, three out of sixteen departments (19%) reported that the academic community in Norway collaborated to find good solutions for stroke patients during the pandemic and 60% (9/15) acknowledged that the academic community should have collaborated even better in order to ensure sufficient quality of health care for stroke patients during the pandemic. Only four of the hospitals (25%) collaborated with other hospitals to find the best possible procedures for management of stroke during the pandemic.

Among departments conducting stroke research, all had to halt ongoing projects.

Overall, 43% (6/14) reported that the standard of care for stroke patients was worse during the pandemic compared to pre-COVID-19.

### DISCUSSION

The main findings were that 81% of the neurological departments changed their practice during the initial phase of the COVID-19 pandemic and that a worse standard of stroke care was reported by 43% of the hospitals.

During the lockdown, primary care physicians, emergency medical communication centers, and hospitals expressed concern regarding the impression that fewer people sought medical help for

| TABLE 1 Data on hospital-based stroke care during the COVID-19 pandemic in Norway |
|---------------------------------|---------------------------------|-----------------|
|                                  | All % (n)                        | Yes             | No               |
| **In-hospital management**      |                                 |                 |                  |
| The work situation changed      | 81 (13)                         | 19 (3)          |                  |
| Our work schedule was changed   | 25 (4)                          | 75 (12)         |                  |
| We reduced the number of beds for stroke patients | 38 (6) | 63 (10) |                  |
| The pandemic affected our course of treatment for stroke | 63 (10) | 38 (6) |                  |
| We made changes to the thrombolysis procedures (practical implementation) | 75 (12) | 25 (4) |                  |
| We used tenecteplase rather than alteplase | 19 (3) | 81 (13) |                  |
| We spent more time than usual on thrombolysis assessments | 50 (6) | 50 (6) |                  |
| Fewer patients received thrombolytic therapy | 69 (9) | 31 (4) |                  |
| We increased the proportion of patients who received MRI in the acute phase | 0 (0) | 100 (16) |                  |
| We increased the proportion of patients who received CT angiography to avoid carotid ultrasound | 20 (3) | 80 (12) |                  |
| We reduced the proportion of patients who received carotid ultrasound to avoid SARS-CoV-2 exposure | 27 (4) | 73 (11) |                  |
| We changed the TIA protocols to reduce the number of admissions | 21 (3) | 79 (11) |                  |
| Fewer patients received extended etiologic assessment | 6 (1) | 94 (15) |                  |
| We discharged patients faster than usual | 6 (1) | 94 (15) |                  |
| Stroke patients had reduced access to rehabilitation services | 50 (7) | 50 (7) |                  |
| The overall standard of care for stroke patients decreased during the pandemic | 43 (6) | 57 (8) |                  |
| **Out-of-hospital**             |                                 |                 |                  |
| Fewer stroke patients came to the hospital than usual | 100 (16) | 0 (0) |                  |
| Stroke patients arrived at the hospital later than usual | 100 (16) | 0 (0) |                  |
| The stroke patients who came to the hospital were more severely affected than those we usually see | 55 (6) | 45 (5) |                  |
| Fewer stroke mimics came to the hospital than usual | 100 (12) | 0 (0) |                  |
| Outpatient follow-ups after stroke were postponed | 73 (11) | 27 (4) |                  |
a number of serious conditions, including cerebrovascular diseases. All hospitals reported fewer admissions of suspected strokes and most of the hospitals had fewer interventions. Even though this nationwide study is based on a questionnaire and not absolute numbers, these impressions are confirmed by findings from Norway and other countries. The decrease in Norway has also mainly been in transient ischemic attacks and minor strokes and those admitted have been more severe than pre-COVID-19 as also reported in the present questionnaire study. Fewer patients received thrombolytic therapy and/or thrombectomy compared to usual. It remains unknown if this was an absolute or relative reduction in interventions based on fewer stroke hospitalizations. Half of the hospitals also used longer time than usual on the thrombolysis assessments. Almost half of the thrombectomy centers changed their procedures during the pandemic. Unfortunately, we do not have more information about what kind of changes. Almost all hospitals reduced their outpatient clinic activity during the lockdown, follow-ups were postponed, and stroke rehabilitation was less available. The long-term effect of the sudden decline in hospitalized stroke patients, procedure changes and limited rehabilitation and follow-ups are not known but may give an overall poorer outcome for stroke patients during the pandemic as compared to the pre-COVID-19 period. These topics should be evaluated in future studies when the pandemic has ended, and accurate and annually nationwide numbers are available from the Norwegian Stroke Registry. Interestingly, the in-hospital diagnostic work-up of stroke patients was reported as unchanged in the vast majority of hospitals. The number of hospital beds was reduced in 38% of the Stroke Units as part of the COVID-19 contingency plans. This has also been reported in other countries. Without a reduction of stroke admissions, the reduction in hospital beds may have contributed to reduced quality of stroke care and worse prognosis during the pandemic.

In a time of much uncertainty, there is a need for shared professional experience among clinicians. International protocols and consensus statements on how to protect stroke care pathways in the midst of a pandemic were rapidly available for the stroke community. Only four Norwegian hospitals reported to have collaborated on changes in treatment and diagnostic protocols to prepare for a surge of COVID-19 stroke patients and regular stroke patients. These changes included a switch from alteplase to tenecteplase, a reduction in the number of patient observations by stroke nurses after intravenous thrombolysis, more use of acute MRI for TIA patients and ruling out carotid artery stenosis using CT angiography rather than doppler ultrasound. Still, 60% called for better professional collaboration, which highlights the need for a national network allowing for communication and more active discussions within the stroke community.

All ongoing research projects were halted. This may be justified given the circumstances but pausing intervention trials may yield problems for the patients not receiving the intervention or follow-ups as intended. It is also imperative that grants and fellowships are extended for the affected time period to ensure that projects are completed according to protocol. The potential long-term repercussion is the lack of implementation of possible beneficial treatments for patients.

As far as we know, this is the first nationwide study to report on how the COVID-19 pandemic affected the stroke care pathways and management on a national level. The high responder rate should ensure representativity. The initial phase of the COVID-19 pandemic was fairly well controlled in Norway, with few patients in need for intensive care treatment, and few deaths compared to other countries. This scenario may of course change, but until now, patients with COVID-19 have not overcrowded the hospitals, and by the mid-October 2020 Norway had among the lowest mortality rates reported worldwide. Thus, the handling of stroke patients may differ and have larger public health consequences in other countries affected by the pandemic in greater extent. A limitation of the study is the use of the self-reported questionnaires; however, including 16 of all 17 neurological departments with a Stroke Unit should minimize systematic bias. Not all neurological departments in Norway have their own stroke registry. Therefore, the Head of the Stroke Units were asked to answer the questions based on their qualitative impressions when accurate comparisons to the pre-pandemic period did not exist. This lack of exact numbers and statistical comparisons are limitations of the present study.

5 CONCLUSION

During the initial phase of the COVID-19-pandemic in Norway, hospital-based stroke care and research were impacted. Contingency plans to ensure adequate stroke care in national emergencies should be in place, and collaboration within the Norwegian stroke community can be improved. More research on institutional and governmental strategies and priorities for stroke patients and prognosis during the pandemic is warranted.

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CONFLICT OF INTEREST

BWS has received speaking fees from Novartis, unrelated to the present work. ECS has received speaking fees from Bayer and Novartis, unrelated to the present work. AMS, ESK, KWF, and SHJ report no conflicts of interest.

DATA AVAILABILITY STATEMENT

The authors declare that the data supporting the findings of this study are available within the article.

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