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Impact of the COVID-19 pandemic on continuous EEG utilization

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Abstract

Introduction: The Coronavirus disease 2019 (COVID-19) has significantly impacted healthcare delivery and utilization. We assessed the impact of the COVID-19 pandemic on in-hospital continuous electroencephalography (cEEG) utilization, and identify areas for process improvement.

Methods: A 38-question web-based survey was distributed to site-Principal Investigators of the Critical Care EEG Monitoring Research Consortium, and institutional contacts for the Neurodiagnostic Credentialing and Accreditation Board. The survey addressed the following aspects of cEEG utilization: 1) General center characteristics, 2) cEEG utilization and review, 3) Staffing and workflow, 4) Health impact on EEG technologists.

Results: The survey was open from June 12 to June 30, 2020 and distributed to 174 centers with 79 (45.4%) responses. Forty centers were located in COVID-19 hotspots. Fifty-seven centers (72.1%) reported cEEG volume reduction. Centers in the Northeast were most likely to report cEEG volume reduction (OR 7.19 [1.53–33.83] p=0.012). Additionally, centers reporting decrease in outside hospital transfers reported cEEG volume reduction; OR 21.67 [4.57–102.81] p=<0.0001. Twenty-six centers (32.91%) reported reduction in EEG technologist coverage. Eighteen centers had PPE shortages for EEG technologists. Technologists at these centers were more likely to quarantine for suspected or confirmed COVID-19; OR 3.14 [1.01–9.63], p=0.058).

Conclusion: There has been a widespread reduction in cEEG volume during the pandemic. Given the anticipated duration of the pandemic and the importance of cEEG in managing hospitalized patients, methods to optimize use need to be prioritized to provide optimal care. Since the survey provides a cross-sectional assessment, follow-up studies can determine the long-term impact of the pandemic on cEEG utilization.

Keywords

EEG monitoring; critical care; health services; COVID-19

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The Coronavirus disease 2019 (COVID-19) was declared a pandemic in March 2020, and has significantly impacted healthcare delivery and utilization (1–4). The pandemic has resulted in challenges ranging from decreased access to healthcare, workforce and staffing issues, and disruption of medical education (2–8). Recent publications have addressed methods to facilitate both inpatient and outpatient workflow, including diagnostic and interventional procedural prioritization, during this time (2,9–11). Our objective was to assess the impact of the pandemic on continuous electroencephalography (cEEG) utilization and identify areas for process improvement.

As an important diagnostic and prognostic tool, cEEG is being increasingly utilized in the care of hospitalized neurologic and non-neurologic patients (12–14). Consensus recommendations by the American Clinical Neurophysiology Society (15) and the European Society of Intensive Care Medicine (16), have highlighted the use of cEEG in seizure detection, encephalopathy and coma work up, as well as monitoring depth of sedation in critically ill patients. Therefore, understanding the impact of the pandemic on cEEG use and availability is critically important in light of its utility in the management of delirium and disorders of consciousness that are being increasingly recognized in COVID-19 patients (17–19).

Methods

This study was approved by the Massachusetts General Hospital Institutional Review Board. We developed a 38-question web-based survey (SurveyMonkey, Inc; San Mateo, CA) to assess the impact of the COVID-19 pandemic on cEEG utilization in the critical care setting and on regular inpatient floors. Impact on EEG performed in the Epilepsy Monitoring Unit (EMU) was not assessed. The writing group was comprised of two dual-trained neurointensivists and neurophysiologists (SFZ, EJG), one epileptologist (MBW) and one neurophysiology program director (RJK). The survey was reviewed and endorsed by the Critical Care EEG Monitoring Research Consortium (CCEMRC) and the Neurodiagnostic Credentialing and Accreditation Board (ABRET). The survey was distributed to the site-Principal Investigators (PIs) for the CCEMRC and the institutional point of contact for ABRET. The survey was open from June 12, 2020 to June 30 2020. Only one response was allowed per center. Participation was voluntary, and there was no compensation for participation. The survey was not distributed on public social media platforms.

The survey questions were designed to focus on the following aspects of cEEG monitoring and utilization during the pandemic: 1) General center characteristics (type, size, location etc.), 2) cEEG utilization and review process, 3) Staffing and workflow and, 4) Health impact on EEG technologists. The centers were asked to compare their average cEEG volume (average number of cEEGs per week and per month) prior to the global spread of COVID-19 and its recognition as a pandemic, to the average cEEG volume in the time period starting with COVID-19 receiving a pandemic status and ending with the survey end date (June 30, 2020).

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Descriptive statistics were used to analyze the survey data. Fisher's exact test was used to determine univariate associations and reported as an odds ratio and confidence interval (OR [CI]). Significance was set at 0.05, and 2-sided P-values are reported.

Data availability

The data collected for this study are available from the corresponding author upon reasonable request.

Results

The survey was distributed to 174 centers; 84 (48.3%) of these centers were either CCEMRC members or had ABRET accreditation for EEG Long Term Monitoring; 79 centers responded (45.4% response rate). Forty centers were located in COVID-19 hotspots (cities or local areas where the virus was spreading widely). Hotspot designation was self-reported by the centers if they were located in a COVID-19 hotspot at any point prior to June 30, 2020. Figure 1 shows the average daily cases in each state during the survey period (June 12–30, 2020) and the cumulative number of cases in each state from the time the first case was reported in the state to the end of the survey period (June 30, 2020) (20). Table 1–3 summarize the main survey results, and distribution of results across centers located within and outside COVID-19 hotspots.

General Center Characteristics

Majority (n=67, 84.8%) of the centers were teaching hospitals and were located in large or metropolitan cities (n=60, 76.0%). Four centers (5.1%) were located outside the United States. Centers within the US were roughly evenly distributed across geographic regions. Pandemic related lockdowns (e.g. school closures, shelter in place, stay at home orders, etc.) were implemented prior to or during the survey period, across all regions where the responding centers were located. There were no significant differences in center characteristics between those located within COVID-19 hotspots vs. those that were not. The only exception was that majority of centers within the Northeast were located within COVID-19 hotspots (16/23, 69.6% located within a hotspot vs. 7/23, 30.4% located outside a hotspot; OR 3.05 [1.10–8.37] p=0.047). The percentage of centers located in hotspots across US geographic regions is shown in Figure 1C.

cEEG utilization and work flow

All 79 centers were performing cEEG prior to the pandemic. Fifty-seven centers (72.1%) reported a reduction in cEEG volume. Six Centers (7.6%) reported a slight increase in cEEG volume, with 5 (6.3%) of these being outside COVID-19 hotspots. Figure 2 shows the relation between center characteristics and changes in cEEG volume. Table 2 shows cEEG utilization across centers located within and outside COVID-19 hotspots. ContinuousEEG volume reduction was reported similarly across centers regardless of whether the center was located within COVID-19 hotspots (30/40, 75% vs. (27/39, 69.23%, OR 1.33 [0.50–3.52] p=0.374). More centers located in the Northeast reported reduction in cEEG volume compared with other US regions (91.30% reduction in the Northeast vs. 61.5% in other regions; OR 7.19 [1.53–33.83] p=0.012). Centers reporting reduction in outside hospital

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transfers were also more likely to report cEEG volume reduction (OR 21.67 [4.57–102.81] p=<0.0001).

Majority of centers reported no change in the frequency of cEEG interpretation and review (88.6%) or in the frequency of bedside annotation (89.7%) during the pandemic. Only 3 (3.8%) centers reported an increase in teleEEG (remote EEG interpretation services) during the pandemic, and 4 centers (5.1%) initiated teleEEG during the pandemic. A small number of centers (n=10, 12.7%) used alternate EEG applications such as reduced montage or rapid application systems prior to the pandemic. Four centers (5.1%) reported an increase in alternate EEG application systems and 3 initiated use of alternate EEG application systems during the pandemic. Seventy-six (96.2%) centers were performing cEEG in COVID-19 patients. The most common indications for cEEG in COVID-19 patients were paroxysmal events (88%) and coma (51%). Indications for cEEG in COVID-19 patients are shown in Figure 3.

Staffing and workflow

Table 3 summarizes impact of the pandemic on staffing, compensation and benefits. Twenty-six centers (32.9%) reported a decrease in technologist coverage during the pandemic. Decrease in technologist coverage was similar across centers within and outside COVID-19 hotspots. Twenty-five (31.7%) centers reported their technologists had been deployed to other roles including: symptom and temperature screening at hospital entry points, employee health and traffic control in COVID-19 testing areas, N95 mask decontamination and repackaging, Tyvek suit cleaning, personal protective equipment (PPE) distribution, hospital transport services, and teleneurology/telecommunication assistance.

Health impact on EEG technologists

18/78 (23.1%) centers reported personal protective equipment (PPE) shortages specifically for EEG technologists. PPE shortages were similar across centers regardless of whether the center was within or outside COVID-19 hotspots. 72 centers provided responses on specific type of PPE shortages. N95 mask shortages were most frequently reported (18/72, 25.0%), followed by face shields/gloves (10/72, 13.9%), gowns (9/72, 12.5%), surgical masks (7/72, 9.7%), and gloves (4/72, 5.6%).

Twenty-four centers (30.8%) had to remove technologists from direct patient care due to high-risk health conditions. Thirty-eight centers (48.7%) reported technologists had been quarantined due to suspected or confirmed COVID-19. Technologists at centers with PPE shortages were more likely to quarantine due to suspected or confirmed COVID-19 (12/17, 70.6% in centers with PPE shortages vs. 36/60, 43.3% in centers with no PPE shortages; OR 3.14 [1.01–9.63], p=0.058).

Discussion

Across all geographic regions of the US, most centers reported a reduction in cEEG volume as a result of the COVID-19 pandemic, regardless of location and whether within a hotspot or not. However, reduction was seen most commonly in centers in the Northeast, and those with reduced outside hospital transfers. The higher reduction in the Northeast may be a

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reflection of the early surge in cases along with high daily case rate during the peak surge. New York and Massachusetts, for example, reported >5000 cases/day and >3000 cases/day respectively during their peak surges in April 2020 (20). In addition majority of the centers from the Northeast participating in the survey were located in hotspots prior to or during the survey period. Reduction in cEEG volume has implications not only for critically-ill patients that would otherwise routinely undergo cEEG monitoring as part of their diagnostic evaluation, but also for COVID-19 patients who frequently have neurologic complications (17–19). Understanding the determinants of disruption in cEEG utilization, and developing methods for process improvement is important given the concern of a prolonged pandemic and recurrent COVID-19 surges.

The COVID-19 pandemic has resulted in a decrease in the volume of elective and emergency neurologic admissions (4,8). A reduction in direct neurology admissions, along with the decrease in outside hospital transfers, may have resulted in the decrease in cEEG volume seen in our study. Additionally, a higher threshold to order and perform diagnostic tests in order to mitigate risk of transmission also could have contributed to a decrease in cEEG volume. Developing protocols with guidance on which patients to prioritize for cEEG monitoring, as well as education of bedside providers and EEG technologists on the necessary safety precautions, may help address some of the barriers to cEEG use during the pandemic. Use of reduced montage and brief recordings, and use of a dedicated portable machine for COVID-19 confirmed patients are potential methods to increase access and minimize exposure (22).

Interestingly, we found minimal increase in the use of teleEEG during the pandemic. Telemedicine is playing an increasingly important role in delivery of healthcare to patients during the pandemic (10,23). TeleEEG has been shown to be a feasible and effective method for providing EEG services at hospitals that do not have dedicated clinical neurophysiologists or epileptologists (24). As we prepare for additional surges in the pandemic, teleEEG has the potential to overcome some of the challenges that result from the inability to transfer patients to centers preforming cEEG and lack of clinical neurophysiologists at smaller hospitals. However smaller hospitals would still require equipment and in-house technologists to support their remote EEG reading or alternatively teleEEG services that also provide a team of trained technologists.

While PPE shortages were seen in minority (23.1%) of centers, they were more likely to be associated with reported suspected or confirmed COVID-19 related quarantine among EEG technologists. The health impact of COVID-19 can decrease EEG technologist staffing and can subsequently decrease cEEG volume. Developing cEEG protocols that ensure appropriate training in the use of PPE, and ensuring adequate PPE supply is critical for the success of cEEG monitoring services during the pandemic. In order to avoid unnecessary cEEG studies and EEG technologist exposure, particularly in the setting of PPE shortages, studies ordered by non-neurologists should be approved by the neurology consult teams (11). In addition to provision of appropriate PPE for technologists, where possible patients should also be wearing masks (e.g. in the case of patients not on mechanical ventilation) (22).

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Mandatory furloughs, termination, deployment and compensation reduction for both EEG technologists and clinical neurophysiologists also create disruptions in cEEG workflow and volume. One-third (33.8%) of centers reported termination or furlough of their EEG technologists. With resumption of normal hospital workflow, technologist teams may need to be redesigned with cross-training methodologies to ensure adequate staffing for cEEG monitoring.

Majority of centers were performing cEEG in COVID-19 patients. Paroxysmal events and coma were common indications. In a case series of ten COVID-19 patients, the most common electrographic abnormality was generalized slowing (25). In another series of 22 patients, epileptiform discharges were commonly seen in COVID-19 patients (26). Additional reports have also described the presence of epileptiform discharges and periodic patterns in COVID-19 patients (27). Further work is needed to determine the diagnostic and prognostic significance of cEEG in COVID-19 patients.

Limitations of this study include potential selection bias, as centers more impacted by the pandemic may have been more likely to complete the survey. As the survey was anonymous differences in characteristics of centers that responded versus those that did not respond cannot be determined. Distribution of the survey to CCEMRC and ABRET participating centers may also result in a selection bias. Another limitation is that of recall bias. Details on the volume and acuity of neurology admissions during the survey period were not obtained, and their relation to changes in cEEG volume cannot be directly assessed. We did not assess the impact on revenue generated from cEEG or changes in cEEG duration. Finally the survey was a cross-sectional assessment, and a limitation to any COVID-19 related study is the rapidity with which data is changing with the emergence of new hotspots.

There has been a widespread reduction in cEEG volume during the COVID-19 pandemic. Given the anticipated duration of the pandemic, methods to optimize cEEG use need to be prioritized. Potential opportunities to improve cEEG access and utilization include development of EEG protocols for triage of patients with greatest need for cEEG, use of reduced montage EEG and brief recordings, enhancement of safety practices, increased availability of PPE, and consideration of expansion of tele EEG services. Technologist teams may also need to be redesigned with cross-training methodologies to ensure adequate staffing for cEEG monitoring. Follow up studies are also indicated to assess the long-term impact of the pandemic on cEEG access and utilization, as well as the subsequent impact on clinical care and outcomes.

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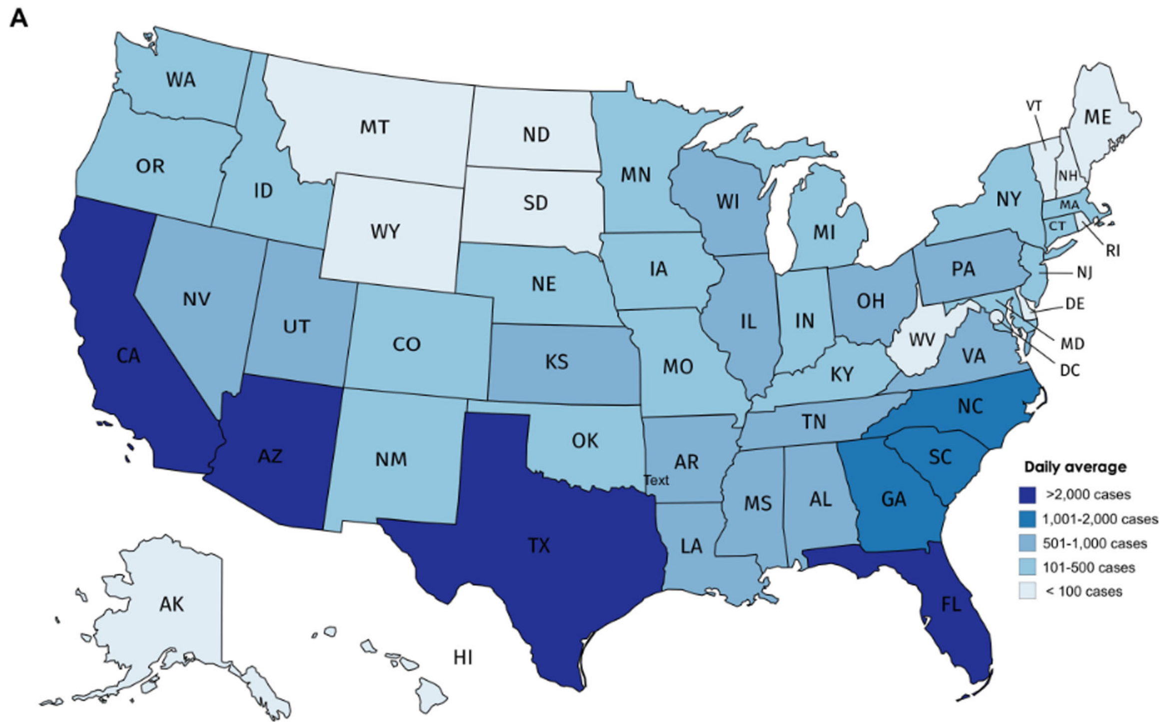

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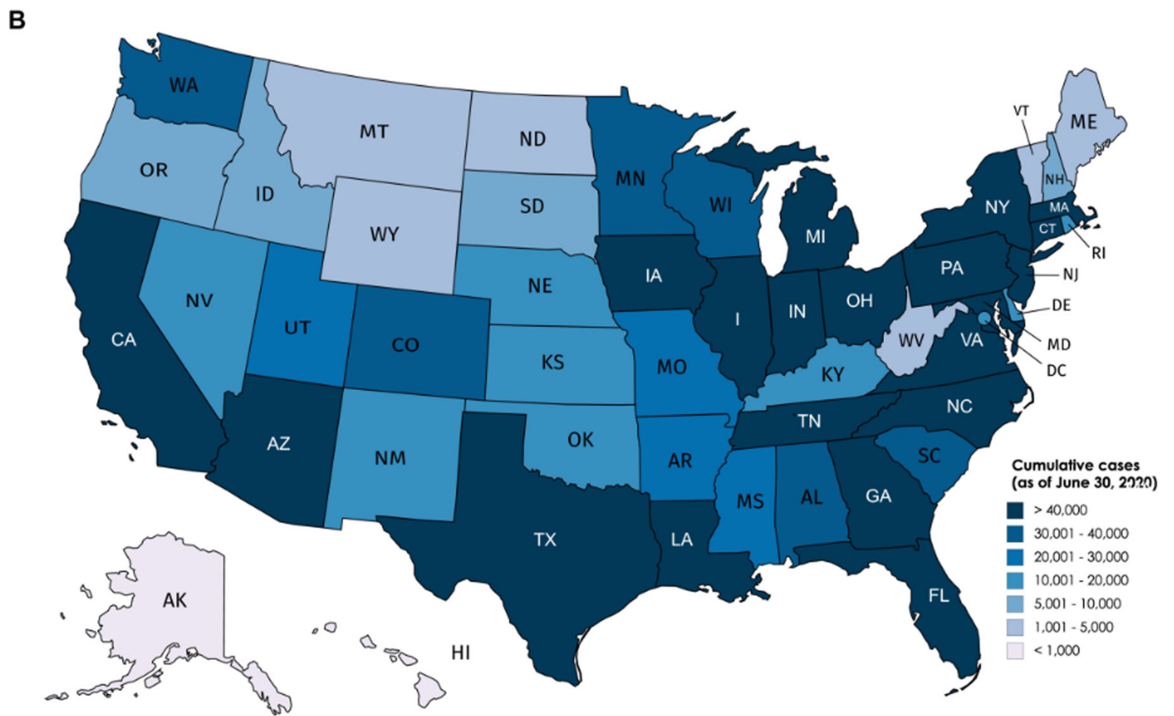

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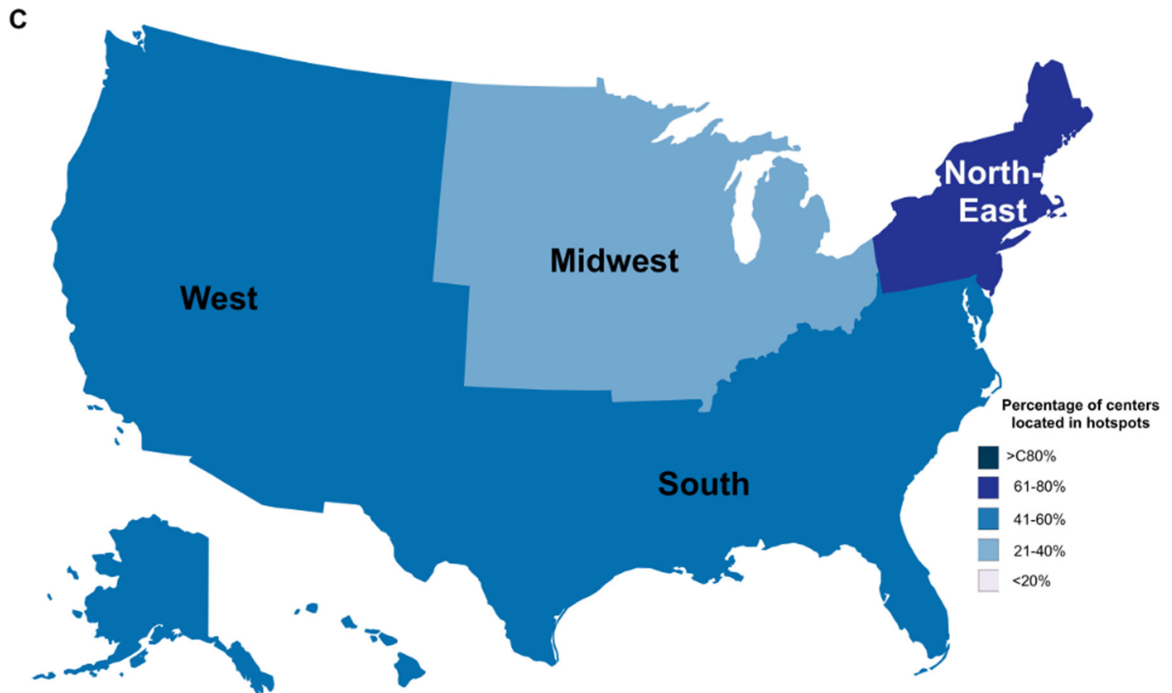

Figure 1. Map of COVID-19 cases during the survey period June 12-June 30

a. The map shows the daily average number of cases per state during the survey period June 12 to June 30, 2020. The data to generate the map was obtained from the CDC COVID data tracker (20).

b. The map shows cumulative number of cases per state from the time the first ever case was reported in the state to the end of the survey period (June 30, 2020). The data to generate the map was obtained from the CDC COVID data tracker (20).

c. Map shows the percentage of centers in each US geographic region that were located in hotspots at any time prior to June 30, 2020).

Maps were created with mapchart.net which is licensed under a Creative Commons Attribution-ShareAlike 4.0 International License (21).

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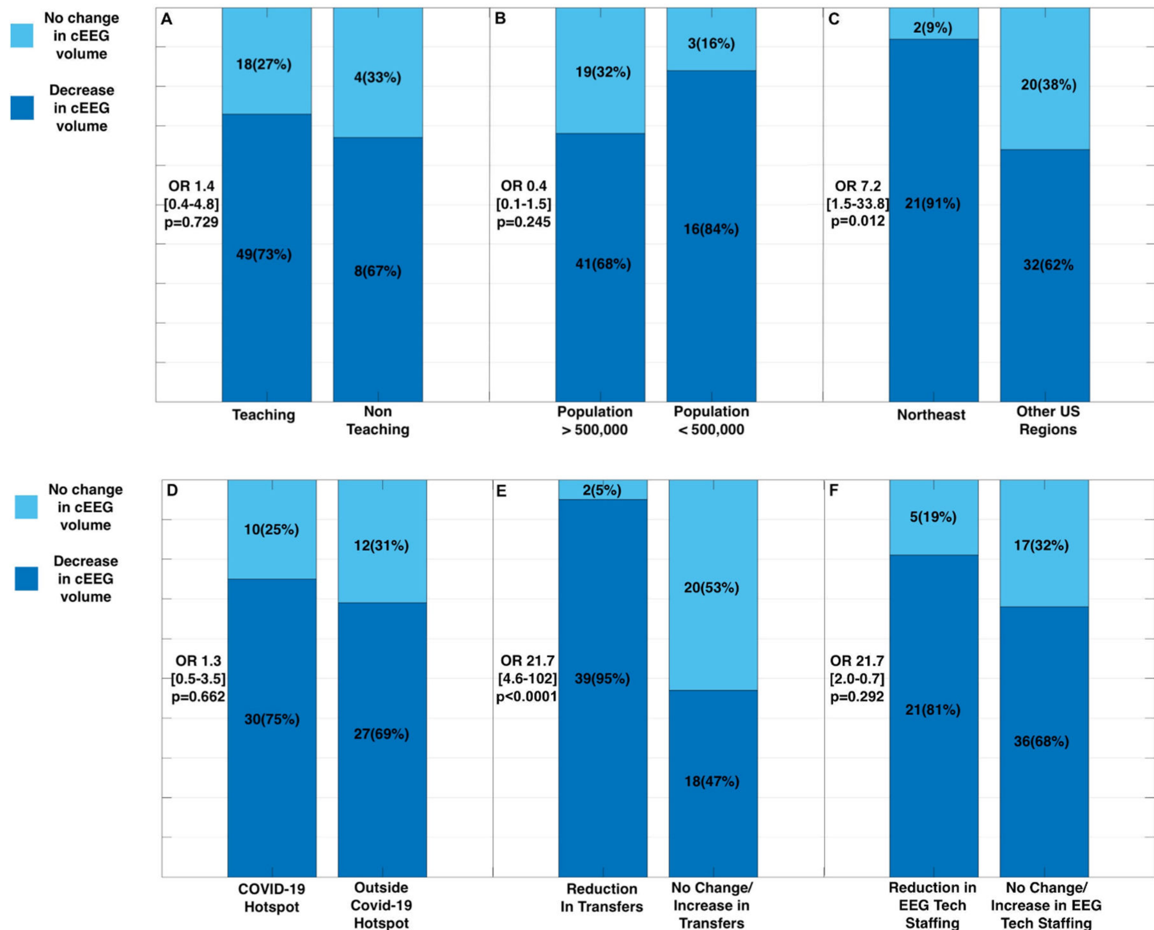

Figure 2. Relation of cEEG volume and center characteristics

- **a.** Reduction in cEEG volume in teaching vs. non teaching centers.
- **b.** Reduction in cEEG volume in centers located in metropolitan or large cities (population >500,000) vs. centers in small to medium cities and rural areas (population <500,000).
- **c.** Reduction in cEEG volume in centers located in the Northeast vs. other regions of the US.
- **d.** Reduction in cEEG volume in centers located within COVID-19 hotspots vs. outside hotspots.
- **e.** Reduction in cEEG volume in centers with decrease in outside hospital transfers for cEEG vs. those with no change or an increase in transfers for cEEG.
- **f.** Reduction in cEEG volume in centers that had a decrease in EEG technologist staffing vs. centers with no change or an increase in EEG technologist staffing.

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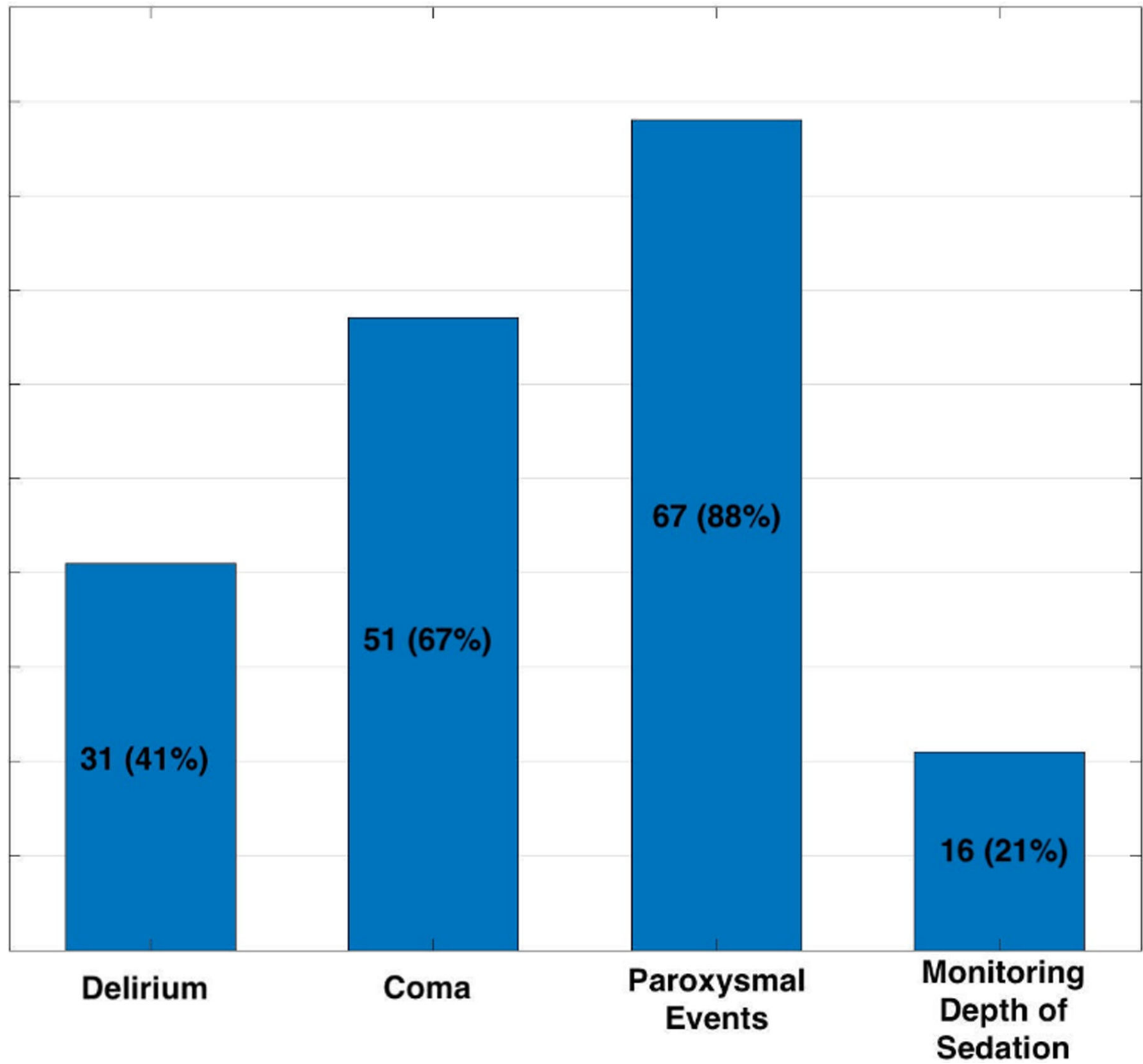

Figure 3. Common indications for cEEG monitoring

The figure shows common indications for cEEG monitoring in COVID-19 patients. 76 centers performed cEEG in COVID-19 patients.

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Table 1.

Center Characteristics

	All Centers N=79	Centers located in hotspots N=40	Centers located outside hotspots N=39	p-value
Teaching	67 (84.8%)	33 (82.5%)	34 (87.2%)	0.756
Non-teaching	12 (15.2%)	7 (17.5%)	5 (12.8%)	
Hospital location				0.843
Metropolitan (population > 1 million)	40 (50.6%)	21 (52.5%)	19 (48.7%)	
Large City (500,000 – 1 million)	20 (25.3%)	11 (27.5%)	9 (23.1%)	
Small-medium city (50,000–500,000)	17 (21.5%)	7 (17.5%)	10 (25.6%)	
Rural (<50,000)	2 (2.5%)	1 (2.5%)	1 (2.6%)	
Hospital geographic region				0.061
US-Midwest	16(20.3%)	6 (15%)	10 (25.6%)	
US-Northeast	23 (29.1%)	16 (40%)	7 (17.9%)	
US-South	20 (25.3%)	9 (22.5%)	11(28.2%)	
US-West	16 (20.3%)	9 (22.5%)	7 (17.9%)	
Other country	4 (5.1%)	0 (0.0%)	4 (10.3%)	
Hospital beds				0.927
000–099	2 (2.5%)	1 (2.5%)	1 (2.8%)	
100–199	4 (5.1%)	2 (5%)	2 (5.1%)	
200–299	8 (10.1%)	3 (7.5%)	5 (12.8%)	
300–399	10 (12.7%)	5 (12.5%)	5 (12.8%)	
400–499	9 (11.4%)	6 (15%)	3 (3.8%)	
500+	46 (58.3%)	23 (57.5%)	23 (59.0%)	
Pandemic related lock-down	79 (100%)	40 (100%)	39 (100%)	-
Additional ICU capacity opened in response to the pandemic	62 (74.5%)	34 (85.0%)	28 (70%)	0.180

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Table 2.

cEEG Utilization and Review

	All centers N=79	**Centers in hotspots N=40**	**Centers outside hotspots N=39**	**p-value**
Frequency of cEEG utilization pre-pandemic (All centers performed cEEG pre-pandemic)				0.962
0–10/month	7 (8.7%)	3 (7.5%)	4 (10.3%)	
10–50/month	22 (27.9%)	12 (30.0%)	10 (25.6%)	
50–100/month	21 (26.6%)	10 (25.0%)	11 (28.2%)	
>100/month	29 (36.7%)	15 (37.5%)	14 (35.9%)	
Change in cEEG volume during the pandemic				0.115
Greatly decreased (>50%)	28 (35.4%)	18 (45.0%)	10 (25.6%)	
Slightly decreased (25–50% reduction)	29 (36.7%)	12 (30.0%)	17 (43.6%)	
No change (25% less to 25 % more)	16 (20.3%)	9 (22.5%)	7 (17.9%)	
Slightly increased (>25–50%)	6 (7.6%)	1 (2.5%)	5 (12.8%)	
Greatly increased (>50%)	0 (0.00%)	0 (0.0%)	0 (0.0%)	
Centers receiving outside hospital transfers for cEEG pre-pandemic				0.766
Never	9 (11.4%)	6 (15.0%)	3 (3.8%)	
Rarely (<1/month)	17 (21.5%)	8 (20.0%)	9 (50.6%)	
Occasionally (>1/month and < 1/week)	29 (36.7%)	15 (37.5%)	14 (35.9%)	
Frequently (>1/week)	24 (30.4%)	11 (27.5%)	13 (33.3%)	
Change in cEEG transfers during the pandemic				0.957
Greatly decreased (>50%)	26 (29.1%)	11 (27.5%)	12 (30.8%)	
Slightly decreased (25–50% reduction)	18 (22.8%)	10 (25.0%)	8 (29.5%)	
No change (25% less to 25 % more)	36 (45.6%)	18 (45.0%)	18 (46.2%)	
Slightly increased (>25–50%)	2 (2.5%)	1 (2.5%)	1 (2.7%)	
Greatly increased (>50%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	
Centers performing teleEEG pre-pandemic	35 (44.3%)	16 (40.0%)	19 (48.7%)	0.290
teleEEG performed during the pandemic				0.382
None	40 (50.6%)	22 (55.0%)	18 (46.2%)	
Less than pre-pandemic	7 (8.9%)	1 (2.5%)	6 (15.4%)	
Same as pre –pandemic	25 (31.7%)	13 (32.5%)	12 (30.8%)	
More than pre-pandemic	3 (3.8%)	2 (5.0%)	1 (2.6%)	
Initiated during the pandemic	4 (5.1%)	2 (5.0%)	2 (5.1%)	
Alternate EEG application systems used pre-pandemic	10 (12.7%)	6 (15.0%)	4 (10.3%)	0.737
Alternate EEG application use during the pandemic				1.000
None	66 (83.5%)	33 (82.5%)	33 (84.6%)	
Less than pre-pandemic	0 (0.0%)	0 (0.0%)	0 (0.0%)	
Same as pre –pandemic	6 (7.6%)	3 (7.5%)	3 (7.7%)	
More than pre-pandemic	4 (5.1%)	2 (5.0%)	2 (5.1%)	
Initiated during the pandemic	3 (3.8%)	2 (5.0%)	1 (2.6%)	

	All centers N=79	Centers in hotspots N=40	Centers outside hotspots N=39	p-value
Real time review of cEEG pre-pandemic	50 (63.3%)	26 (65.0%)	24 (61.5%)	0.818
cEEG review frequency during the pandemic				0.670
Not changed	70 (88.6%)	36 (90.0%)	34 (87.2%)	
Decreased in frequency	5 (6.3%)	3 (7.5%)	2 (5.1%)	
Increased in frequency	4 (5.1%)	1 (2.5%)	3 (7.7%)	
cEEG annotated by bedside providers pre-pandemic	30 (38.0%)	15 (37.5%)	15 (38.5%)	0.818
Bedside providers annotation during the pandemic *				0.670
Not changed	70 (89.7%)	34 (85.0%)	36 (92.3%)	
Decreased in frequency	5 (6.4%)	3 (7.5%)	2 (5.1%)	
Increased in frequency	3 (3.9%)	3 (7.5%)	0 (0.0%)	
Centers performing cEEG in COVID-19 patients	76 (96.2%)	38 (95.0%)	38 (97.4%)	1.000
Protocol developed for cEEG in COVID-19 patients	58 (73.4%)	29 (72.5%)	29 (74.4%)	1.000
cEEG utilization in COVID-19 patients				0.224
0–10/month	61 (77.2%)	28 (70%)	33 (84.6%)	
10–50/month	17 (21.5%)	11 (27.5%)	6 (15.4%)	
50–100/month	1 (1.3%)	1 (2.5%)	0 (0.0%)	
>100/month	0 (0.0%)	0 (0.0%)	0 (0.0%)	

* 78 responses for this question

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Table 3.

Impact on Staffing, Workflow and Health

Staffing and Workflow	**All centers** N=70	**Centers in hotspots** N=40	**Centers outside hotspots** N=39	**p-value**
Full-time technologists pre-pandemic (median, IQR) [*]	9 (6–16)	8 (6–14)	10 (7–19)	0.268 [****]
24/7 EEG technologist coverage pre-pandemic	59 (74.7%)	30 (75.0%)	29 (74.4%)	1.000
EEG technologist coverage during the pandemic				0.474
Decreased	26 (32.9%)	15 (37.5%)	11 (28.2%)	
Not changed	52 (65.8%)	25 (62.5%)	27 (69.2%)	
Increased	1 (1.3%)	0 (0.0%)	1 (2.6%)	
Designated technologist for COVID-19 patients only	8 (10.1%)	3 (7.5%)	5 (12.8%)	0.481
Technologists deployed to other roles	25 (31.7%)	13 (32.5%)	12 (30.8%)	1.000
Reduction in technologist compensation/benefits [**]				0.801
Unchanged	51 (67.1%)	25 (67.6%)	26 (66.7%)	
Increased	4 (5.3%)	3 (8.1%)	1 (2.6%)	
Minor reduction (reduced by <25%)	12 (15.8%)	5 (13.5%)	7 (17.9%)	
Major reduction (reduced by >25%)	9 (11.8%)	4 (10.8%)	5 (12.8%)	
Reduction in compensation/benefits for clinical providers reading cEEG [***]				0.645
Unchanged	49 (63.6%)	25 (65.8%)	24 (61.5%)	
Increased	1 (1.3%)	1 (2.6%)	0 (0.0%)	
Minor reduction (reduced by <25%)	22 (28.6%)	9 (23.7%)	13 (33.3%)	
Major reduction (reduced by >25%)	5 (6.5%)	3 (7.9%)	2 (5.1%)	
EEG technologists terminated or furloughed [***]	26 (33.8%)	15	11	0.341
Paid or voluntary time off required to be taken for furloughed technologists [***]	19(24.7%)	11(28.9%)	8(20.5%)	0.437
Clinicians reading cEEG terminated or furloughed	1(1.3%)	1(2.6%)	0(0.0%)	0.494
Paid or voluntary time off required to be taken for furloughed clinicians [***]	4 (5.2%)	2(5.3%)	2(5.1%)	1.000
Health impact of the COVID-19 pandemic				
PPE shortages for technologists [*]	18 (23.1%)	9 (23.1%)	9 (23.1%)	1.000
PPE shortages for technologists [*]				1.000
Always	1 (1.3%)	0 (0.0%)	1 (2.6%)	
Mostly (> half the time but not always)	5 (6.4%)	3 (7.7%)	2 (5.1%)	
Sometimes (less than half the time)	12 (15.4%)	6 (15.4%)	6 (15.4%)	
Never	60 (76.9%)	30 (76.9%)	30 (76.9%)	
Technologists requiring quarantine due to confirmed or suspected COVID-19 [*]	38 (48.7%)	22(56.4%)	16(41.0%)	0.257
Technologists requiring hospitalization due to suspected or confirmed COVID-19 [*]	2 (2.7%)	1(2.6%)	1(2.6%)	1.000
COVID-19 related mortality among technologists	0 (0.0%)	0 (0.0%)	0 (0.0%)	-

Staffing and Workflow	All centers N=70	Centers in hotspots N=40	Centers outside hotspots N=39	p-value
Technologists removed from direct patient care due to high risk categories (e.g. age>65, medical conditions) *	24 (30.8%)	14(35.9%)	10(25.6%)	0.462

*78 responses

**76 responses

***77 responses

****Mann-Whitney U test

PPE: Personal Protective Equipment

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