Critical Care Explorations
April 2026 • Volume 8 • Number 4 • e1402

OBSERVATIONAL STUDY

OPEN

Electroencephalogram Monitoring in Critical Care: Multicenter Analysis of Timing, Duration, and Readmissions

Alexandra-Maria Tăuțan, PhD[1]
Marjan Sarami[2]
Shadi Sartipi[1]
Niels Turley[2]
Aditya Gupta[2]
Manohar Ghanta[2]
Marta P. Fernandes[1]
Ayan Mitra[2]
Jennifer Kim[3]
Aaron F. Struck[4]
M. Brandon Westover[2]
Sahar F. Zafar[1]

IMPORTANCE: Gaining insights into acute and critical care electroencephalogram (EEG) practice patterns can enable more efficient resource utilization without compromising care quality.

OBJECTIVES: We aimed to identify factors associated with the timing of EEG initiation during acute care hospitalizations, the duration of EEG monitoring, and hospital readmissions with EEG monitoring.

DESIGN, SETTING, AND PARTICIPANTS: This is a retrospective cohort study of inpatient admissions to three academic medical centers between 2009 and 2024. Patients were included if older than 18 years and underwent EEG monitoring (routine or long-term) during the hospitalization. Demographic and clinical variables were extracted, along with admission information, primary diagnosis defined by the *International Classification of Diseases* (ICD), 9th Edition and 10th Edition codes, drug administration, and characteristics of EEG use: timing of EEG initiation during hospitalization, duration of monitoring, presence of seizures, and rhythmic and periodic patterns (RPPs). Descriptive statistics and regression analysis were performed.

MAIN OUTCOMES AND MEASURES: Our outcome measures were: 1) time to EEG monitoring relative to the day of admission (hr), 2) duration of monitoring (hr), and 3) readmissions with EEG monitoring within 12 months of the first admission.

RESULTS: A total of 34,773 patients met the inclusion criteria. The most frequent primary neurologic admission diagnosis based on ICD codes were seizures/status epilepticus ($n = 3219$, 9.26%), traumatic brain injury ($n = 1825$, 5.25%), and ischemic stroke ($n = 1787$, 5.14%). The most frequent nonneurologic primary diagnostic category was toxic-metabolic disease and altered mental status ($n = 6798$, 19.55%). Key covariates associated with earlier EEG monitoring during the index admission were primary diagnostic categories of cardiac arrest/anoxic brain injury and seizures/status epilepticus. A diagnosis of aneurysmal subarachnoid hemorrhage, electrographic seizures, and lateralized periodic discharges were associated with longer durations of monitoring. Patients with a diagnosis of sepsis had later and shorter duration of monitoring. Factors associated with readmissions with EEG monitoring included a primary index admission diagnosis of seizures/status epilepticus and brain tumors. Presence of electrographic seizures, RPPs was associated with longer monitoring duration (29.03 hr; interquartile range [IQR], 3.43–73.80 hr). However, even among patients without seizures or RPPs, the median duration of monitoring was 16.78 hours (IQR, 0.82–37.34 hr).

DOI: 10.1097/CCE.0000000000001402

KEY POINTS

Question: What factors are associated with the timing of electroencephalogram (EEG) initiation, duration of EEG monitoring, and hospital readmissions with EEG monitoring among adults hospitalized in an acute care setting?

Findings: In this retrospective cohort study of 34,773 adults hospitalized with (EEG) monitoring across academic medical centers (2009–2024), neurologic diagnoses such as seizure/status epilepticus and cardiac arrest/anoxic brain injury were associated with earlier EEG initiation, while electrographic seizures and periodic and rhythmic patterns were associated with longer monitoring duration. Patients with nonneurologic conditions, including sepsis, generally underwent EEG monitoring later and for shorter durations.

Meaning: These findings suggest that EEG triage and monitoring duration in acute care settings may be optimized by prioritizing earlier monitoring for high-risk nonneurologic patients and discontinuing monitoring sooner when seizures or rhythmic and periodic patterns are absent.

CONCLUSIONS AND RELEVANCE: Characterizing EEG utilization patterns in critically ill patients allows identification of potential areas for practice optimization. Patients admitted with primary nonneurologic diagnoses underwent EEG monitoring later and for shorter durations compared with those admitted with primary neurologic conditions. These findings suggest opportunities to refine EEG triage and resource allocation, including earlier initiation of monitoring in nonneurologic patients at elevated seizure risk (e.g., sepsis) and timely discontinuation of EEG in patients without seizures or RPPs.

KEYWORDS: critical care; electroencephalogram; rhythmic and periodic patterns; seizures

The American Clinical Neurophysiology Society (ACNS) and the European Society of Intensive Care Medicine (ESICM) have published consensus recommendations on the use of electroencephalography in the critical care setting (1–3). These guidelines support electroencephalogram (EEG) use for the diagnosis and management of nonconvulsive seizures and status epilepticus, evaluation of altered mental status in patients with and without acute brain injury, and neuroprognostication in comatose survivors of cardiac arrest/anoxic brain injury and severe brain injuries (4). Additional indications include ischemia monitoring and evaluation of paroxysmal events (5). Current recommendations emphasize prompt EEG initiation and longer monitoring durations in patients at high risk of seizures or ischemia (2).

Critically ill patients are also at risk for rhythmic and periodic patterns (RPPs), which are associated with increased seizure risk and worse functional and cognitive outcomes (6). Accordingly, extended monitoring is recommended when RPPs are identified on early EEG recordings (7, 8).

Despite these consensus recommendations from the ACNS (2, 3) and ESICM (1, 4), access to EEG remains variable across institutions due to differences in resources and expertise availability (9, 10). Understanding real-world EEG practice patterns may help optimize resource utilization while maintaining quality of care. Prior studies suggest that EEG use broadly aligns with guideline-supported indications (11). However, factors influencing the timing of EEG initiation and duration of monitoring remain poorly characterized.

This multicenter study across three regional academic medical centers aimed to identify clinical factors associated with: 1) timing of EEG initiation during hospitalization, 2) duration of monitoring, and 3) acute care readmissions with EEG monitoring within 12 months, in a diverse cohort of medical, neurologic, and surgical inpatients. Identifying drivers of practice variation may help refine guidelines and improve EEG utilization in the critical care setting.

METHODS

Primary Research Question

Describe practice patterns in EEG utilization and identify clinical factors associated with timing of EEG initiation, duration of monitoring, and readmissions with EEG within 12 months.

Study Design and Cohort

This retrospective cohort study included patients admitted to three academic medical centers in the Boston area between March 2009 and December 2024.

All centers are tertiary referral hospitals and level 1 trauma centers, and they have dedicated neurocritical care units. Inclusion criteria were: age older than 18 years, inpatient admission, and underwent any EEG monitoring (routine or continuous) during hospitalization. Epilepsy monitoring unit admission and EEG performed solely for research purposes were excluded from this study. All sites recommend initiating EEG monitoring as soon as possible after order placement. However, timing may depend on technologist availability, particularly after hours. Continuous 24/7 EEG coverage was not consistently available at all sites during the entire study period.

Collected Variables

For each patient, we collected: 1) demographics: age, sex, race, and ethnicity; 2) admission information: admitting unit, length of hospitalization, and discharge disposition; 3) clinical variables: primary diagnostic categories, Charlson Comorbidity Index (CCI), and Sequential Organ Failure Assessment (SOFA) score; 4) drug administration; and 5) EEG characteristics: time of EEG initiation relative to admission, duration of monitoring, EEG sessions per inpatient admission, seizures, and RPP findings (generalized periodic discharge [GPD], lateralized periodic discharge [LPD], and lateralized rhythmic delta activity). Demographics, admission variables, drug administration, and EEG characteristics were extracted from administrative data. Primary admission diagnoses were determined using the *International Classification of Diseases* (ICD), 9th Edition and 10th Edition codes recorded for each admission (**Appendix A**, **Table A1**, https://links.lww.com/CCX/B616). Admitting units were standardized under a unified nomenclature (Appendix A, **Table A2**, https://links.lww.com/CCX/B616), and discharge disposition was harmonized into four categories: deceased, hospice, further care, or home (Appendix A, **Table A3**, https://links.lww.com/CCX/B616). Medication classes include anesthetics (IV, inhalational and local formulations), antibiotics, anti-seizure medication (ASM), opioids, and vasopressors (Appendix A, **Table A4**, https://links.lww.com/CCX/B616). CCI score was calculated based on ICD codes (12). SOFA score was calculated on the day of admission using available inpatient data (13). Identification of seizures or RPPs was extracted from medical notes using a natural language processing algorithm (14).

Outcomes

Our outcome measures were: 1) time to EEG monitoring relative to the day of admission (hr), 2) duration of monitoring (hr), and 3) readmissions with EEG monitoring within 12 months of the first admission.

Standard Protocol Approvals

This study was approved by the institutional review boards of Massachusetts General Hospital (protocols number 2023P000487, Brain Informatics Database, March 29, 2023, number 2024P002630: EEG Guided Treatment in Acute Care, November 6, 2024) and Beth Israel Deaconess Medical Center (protocols number 2022P000481: Encephalopathy Generalized Grading Scale, August 01, 2022, number 2022P000417, Brain Informatics Database, July 22, 2022) and performed according to the ethical requirements outlined in the Declaration of Helsinki. The requirement for informed consent was waived for this retrospective analysis.

Statistical Analysis

Continuous variables were summarized using median and interquartile range (IQR) and categorical variables as proportions.

Group analysis was performed for time from admission to EEG monitoring (< 6, 6–12, 12–24, 24–48, 48–72, and > 72 hr) and duration of monitoring (< 1, 1–6, 6–12, 12–24, 24–48, and > 48 hr). The categories were data-driven and informed by prior work and guidelines (1, 8, 15).

Normality was assessed with the Shapiro-Wilk test. Continuous variables were compared using independent *t* tests or one-way analysis of variance for normally distributed data, and the Mann-Whitney *U* test or the Kruskal-Wallis test for nonnormal distributions. The chi-square tests were used for categorical variables. Statistical significance was defined as *p* value of less than 0.05.

Given the large sample size, effect sizes were also calculated using the pooled standardized mean difference (SMD) for continuous variables and the maximum

absolute standardized difference (ASD) for categorical variables. An SMD of 0.2–0.5 indicated a small effect, 0.5–0.8 moderate, and greater than 0.8 large (16). An ASD less than 0.1 indicated acceptable group balance, whereas an ASD greater than 0.1 suggested imbalance (17).

Ordinary least squares (OLS) regression examined associations between admission/clinical variables and time to EEG initiation and duration of monitoring. For time to EEG initiation models, medications administered on the first hospitalization day were included. For monitoring duration, medications administered during EEG monitoring were included. For readmission analysis, medications administered during the entire index admission were included. Logistic regression was used to assess readmissions, excluding patients who died during the index hospitalization.

Multicollinearity was assessed using Pearson correlation. Model significance was reported using *F*-statistic and adjusted (pseudo) R^2, while predictor effects were reported using as β coefficient or odds ratio (OR), *p* value, and 95% CIs as appropriate.

RESULTS

A total of 34,773 patients met the inclusion criteria, accounting for 40,221 inpatient admissions (**Appendix B**, **Table B1**, https://links.lww.com/CCX/B616). The first admission was considered the index admission, and EEG utilization patterns were analyzed during this hospitalization. Cohort demographics are summarized in **Table 1**, and clinical and operational characteristics in **Table 2**.

The median length of hospitalization was 9 days, with a median EEG monitoring duration of 20.88 hours and median time from admission to EEG initiation of 30.88 hours. ASMs were prescribed in 50.34% of patients (*n* = 17,504), 52.46% received anesthetics (*n* = 18,241), 53.58% received antibiotics (*n* = 18,632), and 54.91% received opioids (*n* = 19,094).

The most common neurologic primary admission diagnoses were seizures/status epilepticus (*n* = 3219, 9.26%), traumatic brain injury (*n* = 1825, 5.25%), and ischemic stroke (*n* = 1787, 5.14%). The most frequent nonneurologic diagnoses was toxic-metabolic disease and altered mental status (*n* = 6798, 19.55%), other disease (*n* = 5445, 15.66%), and cardiac disease excluding cardiac arrest (*n* = 2145, 6.17%).

The most common electrographic abnormalities were seizures (*n* = 3196, 9.1%), GPDs (*n* = 2731, 7.85%), and LPDs (*n* = 1811, 5.21%).

Timing of EEG Monitoring

Early EEG monitoring (< 6 hr from admission) occurred in 4,310 patients (12.59%), while 3,961 (11.57%) underwent EEG between 6 and 12 hours, 7,206 (21.05%) between 12 and 24 hours, 5,166 (15.09%) between 24 and 48 hours, 1,852 (8.3%) between 48 and 72 hours, and 10,728 (31.35%) more than 72 hours after admission. **Figure 1*A*–*C*** shows the distribution of admitting unit, medications, and primary diagnostic category across the six time to EEG monitoring windows. The full breakdown of variables for time from admission to EEG monitoring is available in Appendix C (**Table C1**, https://links.lww.com/CCX/B616).

Timing of EEG initiation varied by admitting unit. Patients admitted to neurology floors more often underwent earlier monitoring, with 69.9% (*n* = 3252) receiving EEG within 6–24 hours compared with 30.1% (*n* = 1398) after 24 hours ($p < 0.05$; ASD = 0.65). In contrast, patients admitted to nonneurologic ICUs and medical wards more commonly underwent later monitoring, with 24.7% (*n* = 3663) receiving EEG within 6–24 hours and 61.1% (*n* = 9029) monitored greater than 72 hours after admission ($p < 0.05$; ASD = 0.21).

Patients receiving ASMs on the day of admission were more likely to undergo early EEG, with 17.1% (*n* = 2185) monitored within 6 hours, compared with 9.7% (*n* = 1201) receiving antibiotics, 10.9% (*n* = 1447) opioids, 13.6% (*n* = 1646) anesthetics, and 10.7% (*n* = 513) vasopressors ($p < 0.05$; ASD = 0.22).

Patients with neurologic diagnoses or cardiac arrest/anoxic brain injury had shorter times to EEG initiation. Overall, 82.33% of patients with seizures/status epilepticus (*n* = 2493) and 90.6% with cardiac arrest/anoxic brain injury (*n* = 637) underwent EEG within 24 hours of admission.

In the OLS regression model (**Fig. 1*D***; adjusted $R^2 = 0.096$; F [29, 34,737] = 128.4; $p < 0.05$), the strongest predictors of earlier EEG initiation were cardiac arrest/anoxic brain injury (β = 83.49; 95% CI, 66.48–100.50; $p < 0.05$), seizures/status epilepticus(β = 45.31; 95% CI, 35.75–54.86; $p < 0.05$), and dementia (β = 44.39; 95% CI, 18.47–70.32; $p < 0.05$). Later EEG initiation was associated with other disease diagnoses

TABLE 1.
Cohort Demographics

Characteristic	Study Cohort (n = 34,773)
Age at admission, yr, median (interquartile range)	65 (52–75)
Female sex, *n* (%)	16,015 (46.05)
Race, *n* (%)	
White	23,919 (68.78)
Black or African American	3,820 (10.98)
Other	7,034 (20.22)
Ethnicity, *n* (%)	
Non-Hispanic	26,084 (75.01)
Hispanic	2,481 (7.13)
Unknown	6,208 (17.85)

n = number of patients.

(β = –77.96; 95% CI, –86.61 to –69.30; $p < 0.05$), admission to nonneurosurgery floor (β = –61.46; 95% CI, –69.59 to –53.33; $p < 0.05$), and sepsis (β = –48.74; 95% CI, –61.03 to –36.44; $p < 0.05$; Appendix C, **Table C2**, https://links.lww.com/CCX/B616).

Duration of EEG Monitoring

The largest proportion of patients (26.23%, *n* = 9122) underwent short EEG sessions (< 1 hr). Monitoring durations greater than 48 hours occurred in 23.11% (*n* = 8035), while 20.40% (*n* = 7095) were monitored for 24–48 hours (**Appendix D**, **Table D1**, https://links.lww.com/CCX/B616). Median duration of monitoring is consistent throughout the study timeline (**Appendix F**, **Table F1**, https://links.lww.com/CCX/B616). **Figure 2*A*–*D*** shows EEG monitoring duration across different admitting units and primary diagnoses, among patients receiving different medications, and among patients with RPPs.

Monitoring duration differed by admitting unit. Among patients admitted to nonneurologic units, 34.7% (*n* = 7691) were monitored for less than 1 hour, compared with 25.8% (*n* = 4343) monitored for greater than 48 hours ($p < 0.05$; ASD = 0.14). In contrast, only 15.5% of patients (*n* = 800) on neurology floors had monitoring for less than 1 hour, while 34.3% (*n* = 1725) were monitored for greater than 48 hours ($p < 0.05$; ASD = 0.43). Patients admitted to neurology units were more likely to undergo a longer duration of monitoring with 40.8% of patients (*n* = 3692) monitored for greater than 48 hours compared with 9.2% (*n* = 1431) that were monitored for less than 1 hour ($p < 0.15$; ASD = 0.35).

Patients receiving vasopressors or anesthetics were more likely to undergo prolonged monitoring. Among patients receiving vasopressors, 38.5% (*n* = 1991) were monitored for greater than 48 hours, and 23.1% (*n* = 1193) for 24–48 hours ($p < 0.05$; ASD = 0.56). Similarly, 33% of patients (*n* = 4301) receiving anesthetics underwent monitoring greater than 48 hours, and 25% (*n* = 3374) for 24–48 hours ($p < 0.05$; ASD = 0.70). There is an overlap between patients receiving vasopressors and IV anesthetics (Appendix F, **Table F3**, https://links.lww.com/CCX/B616). Patients receiving both agents (*n* = 1014, 2.9%) had an overall longer monitoring duration (45.63 hr; IQR, 25.46–73.54 hr), when compared with patients administered all classes of anesthetics without vasopressors (23.68 hr; IQR, 1.36–59.52 hr) or vasopressors only (24.42 hr; IQR, 1.82–54.20 hr). Among patients receiving ASMs during monitoring, 18.7% (*n* = 2863) were monitored for less than 1 hour, and 30.4% (*n* = 4665) were monitored for greater than 48 hours.

Longer monitoring was also observed for specific diagnoses. Monitoring greater than 48 hours occurred in 37.6% of patients (*n* = 1211) with a primary diagnostic category of seizures/status epilepticus, 62.3% (*n* = 451) with aneurysmal subarachnoid hemorrhage, 27.8% (*n* = 508) with traumatic brain injury, and 52.7% (*n* = 371) with cardiac arrest/anoxic brain injury ($p < 0.05$; ASD = 0.28). In contrast, 34.5% of patients (*n* = 2349) with toxic-metabolic encephalopathy or altered mental status were monitored for less than 1 hour.

Detection of RPPs was associated with longer monitoring. Among patients with LPDs, seizures, and GPDs, 60.4% (*n* = 1093), 50.8% (*n* = 1623), and 46.3% (*n* = 1266), respectively, were monitored greater than 48 hours ($p < 0.05$; ASD = 0.47, 0.50, and 0.42, respectively). Patients with seizures or RPPs (*n* = 6843, 19.68%) had a median monitoring duration of 42.26 hours (IQR, 8.86–93.30 hr) compared with 17.96 hours (IQR, 0.87–38.42 hr) among those without (*n* = 27,930, 80.32%; $t = 34.6$; $p < 0.05$). This pattern remained consistent when stratified by neurologic vs. nonneurologic units.

TABLE 2.
Patient Characteristics at Their First Hospital Admission

Characteristic	Study Cohort (*n* = 34,773, No. of Hospital Stays = 34,773)
Primary diagnostic categories, *n* (%)	
Neurologic	
Aneurysmal subarachnoid hemorrhage	723 (2.08)
Brain tumor	1,603 (4.61)
Cardiac arrest/anoxic brain injury	704 (2.02)
Dementia	260 (0.75)
Intracerebral hemorrhage	973 (2.80)
Ischemic stroke	1,787 (5.14)
Neuroinflammatory and infectious disease	646 (1.86)
Other neurologic disease	1,433 (4.12)
Seizures/status epilepticus	3,219 (9.26)
Traumatic brain injury	1,825 (5.25)
Nonneurologic	
Cardiac disease (excluding cardiac arrest)	2,145 (6.17)
Other disease	5,445 (15.66)
Psychiatric disease	596 (1.71)
Sepsis	1,652 (4.75)
Toxic-metabolic disease and altered mental status	6,798 (19.55)
Charlson Comorbidity Index, *n*, median (IQR)	2 (0–3)
Sequential Organ Failure Assessment, *n*, median (IQR)	1 (0–3)
Time to EEG initiation, hr, median (IQR)	30.88 (11.83–100.7)
EEG duration, hr, median (IQR)	20.88 (0.93–45.85)
EEG recurrences per stay, *n*, median (IQR)	1 (1–1)
Patients with identified rhythmic and periodic patterns and seizures (%)[a]	
Seizure	3,196 (9.19)
Lateralized periodic discharge	1,811 (5.21)
Generalized periodic discharge	2,731 (7.85)
Lateralized rhythmic delta activity	1,298 (3.73)
Patients on medications of interest during the initial admission (%)[a]	
Anti-seizure medication	17,504 (50.34)
Anesthetics (IV, inhalational, and local formulations)	18,244 (52.46)
Antibiotics	18,632 (53.58)
Vasopressors	8,844 (25.42)
Opioids	19,094 (54.91)
Length of hospitalization, d, median (IQR)	9 (4–21)
Discharge disposition, *n* (%)	
Home	18,789 (54.03)
Further care	9,558 (27.49)
Hospice	917 (2.64)
Deceased	3,968 (11.41)
Follow-up time within 1 yr of first admission, mo, median (IQR)	1.22 (0.0–9.22)
Patients with readmissions, *n* (%)	3,762 (10.88)

EEG = electroencephalogram, IQR = interquartile range, *n* = number of patients.
[a]A single patient may be counted under multiple categories if these are overlapping.

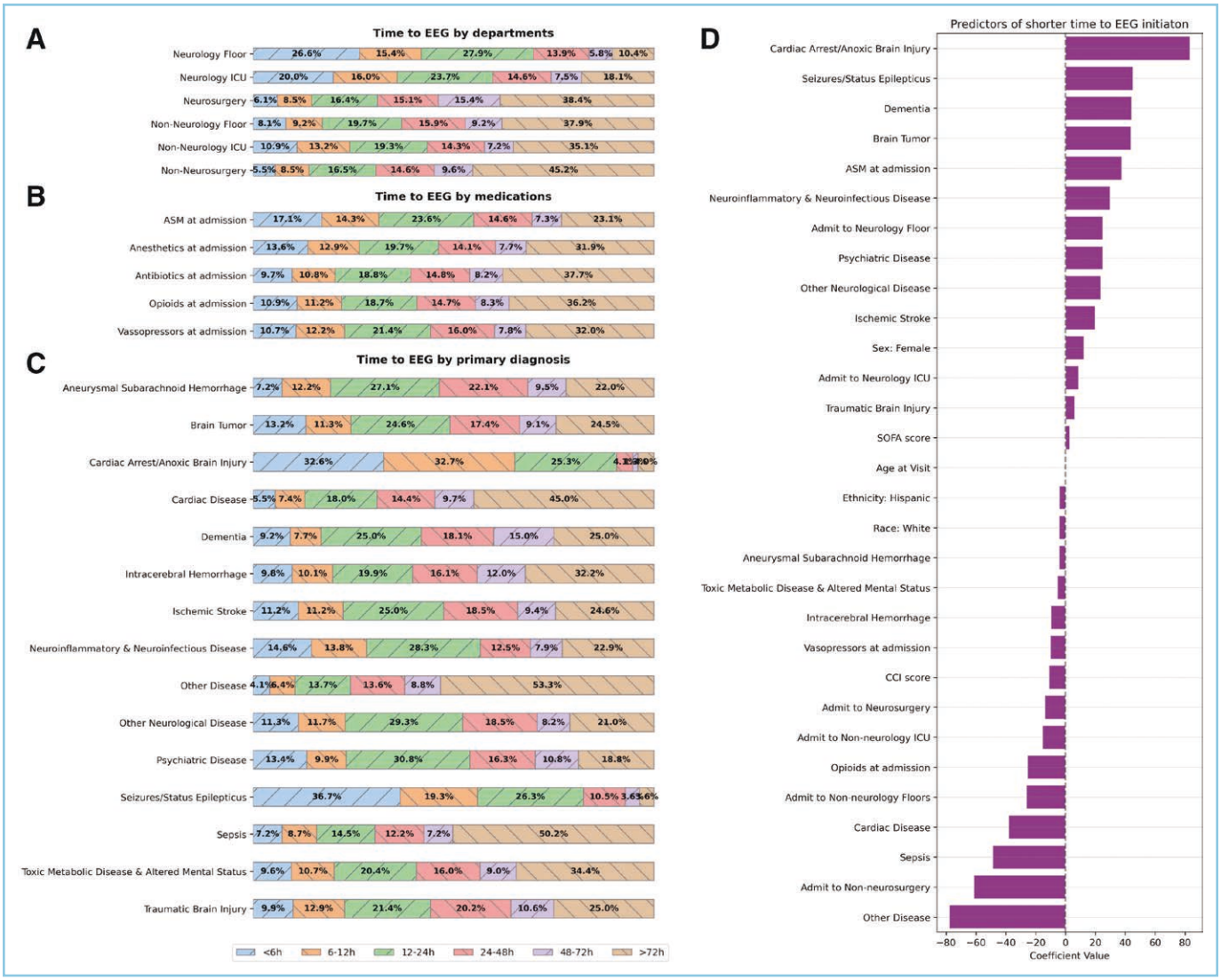

Figure 1. Time to electroencephalogram(EEG) monitoring relative to admission date. **A**, Distribution of admitting units. **B**, Distribution of medications of interest provided on the day of admission. **C**, Distribution of primary diagnosis. **D**, Predictors of shorter time to EEG monitoring from admission based on ordinary least squares regression. ASM = anti-seizure medication, CCI = Charlson Comorbidity Index, SOFA = Sequential Organ Failure Assessment.

Monitoring was consistently longer in neurologic units. Among patients with RPPs, the median monitoring duration was 57.13 hours (IQR, 24.78–132.74 hr) in neurologic units compared with 26.7 hours (IQR, 1.33–71.83 hr) in nonneurologic units. Similarly, among patients without RPPs or seizures, the median duration of monitoring was 24.9 hours (IQR, 6.36–49.91 hr) in neurologic departments vs. 5.43 hours (IQR, 0.78–29.33 hr) in nonneurologic departments (Appendix F, **Table F4** and **Fig. F1**, https://links.lww.com/CCX/B616).

Patients with a longer monitoring duration (> 48 hr) had an extended length of hospitalization (median, 14 d; IQR, 7–27.5 d) as compared with the median 9 days hospitalization for the entire cohort (Appendix F, **Table F2**, https://links.lww.com/CCX/B616). Patients with a longer hospitalization than the median consistently showed longer times to electroencephalogram initiations across both neurologic and nonneurologic diagnoses when compared with patients with shorter hospitalization (Appendix F, **Fig. F2**, https://links.lww.com/CCX/B616).

In the OLS regression model (pseudo R^2 = 0.21; F [34, 34,773] = 284.6; $p < 0.05$), the strongest predictors of prolonged monitoring were aneurysmal subarachnoid hemorrhage (β = 56.13; 95% CI, 51.48–60.77; $p < 0.05$), LPDs (β = 43.03; 95% CI, 40.17–45.89; $p < 0.05$), and electrographic seizures

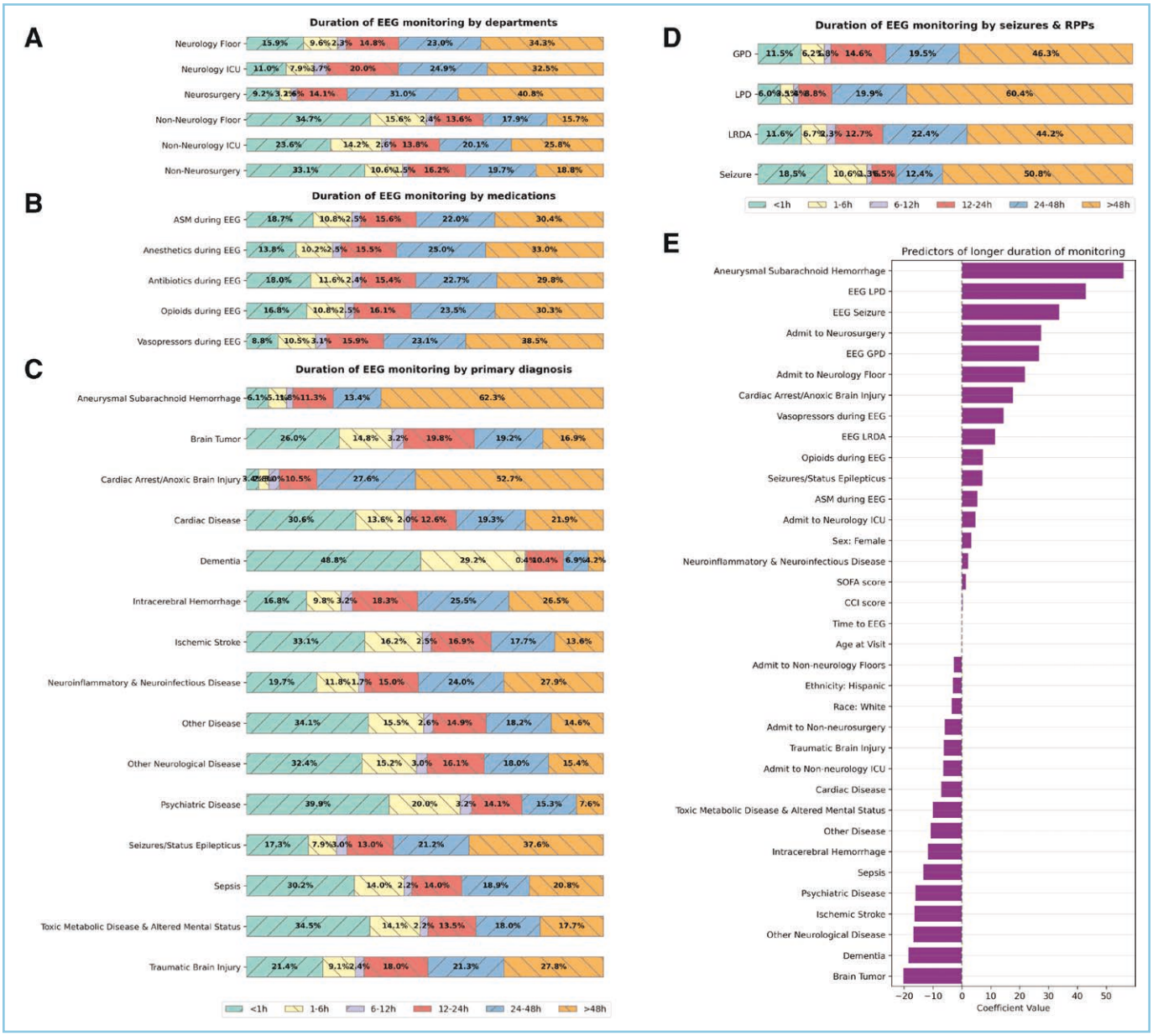

Figure 2. Duration of electroencephalogram (EEG) monitoring. **A**, Distribution of admitting units. **B**, Distribution of medications of interest provided during the EEG monitoring. **C**, Distribution of primary diagnosis. **D**, Distribution of EEG findings. **E**, Predictors of longer EEG monitoring based on ordinary least squares regression. ASM = anti-seizure medication, CCI = Charlson Comorbidity Index, GPD = generalized periodic discharge, LPD = lateralized periodic discharge, LRDA = lateralized rhythmic delta activity, RPPs = rhythmic and periodic patterns, SOFA = Sequential Organ Failure Assessment.

(β = 33.91; 95% CI, 31.75–36.08; $p < 0.05$; **Fig. 2*E***, Appendix D, Table D2, https://links.lww.com/CCX/B616). Shorter monitoring durations were associated with brain tumors (β = −20.43; 95% CI, −23.80 to −17.07; $p < 0.05$), dementia (β = −18.64; 95% CI, −25.70 to −11.59; $p < 0.05$), other neurologic diseases (β = −16.86; 95% CI, −20.27 to −13.46; $p < 0.05$), ischemic stroke (β = −16.50; 95% CI, −19.63 to −13.37; $p < 0.05$), psychiatric disease (β = −16.25, 95% CI, −21.16 to −11.35; $p < 0.05$), and sepsis (β = −13.46; 95% CI, −16.81 to −10.10; $p < 0.05$).

Readmissions With EEG Monitoring

Within 12 months of the index admission, 2053 patients (5.90%) had readmissions with EEG monitoring. The median age of these patients was 64 years (IQR, 52–74 yr), and 47.3% were female. Patients with readmissions

had lower median SOFA scores (0, IQR: 0–1 vs. 1, IQR: 1–3) and Charlson Comorbidity Index scores (2 IQR: 0–4 vs. 2, IQR: 0–3) compared with patients with a single admission ($p < 0.05$; SMD = 0.26; SMD = 0.03). Further clinical characterization of patients with readmissions is available in **Appendix E** (**Table E1**, https://links.lww.com/CCX/B616).

Figure 3 shows the variables associated with readmissions with EEG monitoring based on a logistic regression model (pseudo $R^2 = 0.034$; $p < 0.05$). The strongest predictors of readmission with EEG monitoring from the index admission were seizures/status epilepticus (OR, 2.55; 95% CI, 2.02–3.23; $p < 0.05$), brain tumor (OR, 2.46; 95% CI, 1.76–3.46; $p < 0.05$), and other neurologic diseases (OR, 2.06; 95% CI, 1.50–2.82; $p < 0.05$; Appendix E, **Table E2**, https://links.lww.com/CCX/B616). Nonneurologic diagnoses including sepsis (OR, 1.60; 95% CI, 1.02–2.50; $p < 0.05$) and toxic-metabolic disease/altered mental status (OR, 1.64; 95% CI, 1.27–2.11; $p < 0.05$) were also associated with increased likelihood of repeat EEG monitoring.

DISCUSSION

In this multicenter cohort study, timing and duration of EEG monitoring varied substantially across primary diagnoses and admitting units. Overall, 12.59% of patients ($n = 4310$) received early electroencephalogram monitoring (< 6 hr from admission). Cardiac arrest/anoxic brain injury was among the strongest predictors of early EEG initiation, while aneurysmal subarachnoid hemorrhage, seizures, and LPDs were associated with longer monitoring durations. Markers of greater illness severity, including use of anesthetics and vasopressors were also associated with prolonged monitoring. Readmission with EEG monitoring was most associated with primary diagnoses of seizures/status epilepticus or brain tumors during the index admission.

Cardiac arrest/anoxic brain injury was a key predictor of early EEG initiation, and most of these patients also underwent prolonged monitoring (> 24 hr). This likely reflects ACNS, American Academy of Neurology, and Neurocritical Care Society recommendations supporting EEG monitoring for assessment of injury severity and prognostication following cardiac arrest (2, 18). The American Heart Association recommends EEG monitoring within the first 72–120 hours after cardiac arrest, particularly in patients who remain comatose after return of spontaneous circulation (19). While prolonged monitoring is often recommended, our findings suggest potential opportunities to optimize EEG utilization. Prior studies demonstrate that malignant EEG patterns such as complete suppression, synchronous burst suppression, or GPDs on a suppressed background carry poor prognosis regardless of the timing of detection within the first 72 hours after arrest (20, 21). In such cases, shorter monitoring with repeat assessments may be sufficient. Similarly, continuous delta, theta, or alpha activity has similar prognostic implications independent of timing (22), suggesting earlier discontinuation of monitoring may be reasonable in selected patients. In contrast, low-voltage background, discontinuous activity, or heterogeneous burst suppression may have time-dependent prognostic significance and justify longer monitoring durations (22). Excluding cardiac arrest/anoxic brain injury from our analysis maintained the trends presented (Appendix G, **Figure G1**, https://links.lww.com/CCX/B616).

EEG was initiated earlier among patients admitted to neurology floors compared with those in neurologic ICUs (Appendix F, **Table F5**, https://links.lww.com/CCX/B616). This may reflect higher initial suspicion for seizures and greater clinical stability in neurology floor patients. In contrast, neurologic ICU patients (particularly those with trauma, hemorrhage stroke, or subarachnoid hemorrhage) often require urgent interventions early in the hospitalization, potentially causing later EEG initiation after stabilization.

Admission to nonneurologic units and nonneurologic primary diagnoses were associated with later EEG initiation, likely reflecting secondary neurologic complications during hospitalization. However, growing evidence suggests that brain dysfunction secondary to ischemia, edema, and seizures is common in nonneurologic conditions, particularly in sepsis. Up to 30% of patients with sepsis-associated encephalopathy develop seizures, and 5–20% (23) also have periodic discharges. In our cohort, sepsis was associated with later EEG initiation and shorter monitoring durations. Earlier EEG monitoring in such high-risk populations may improve detection of subclinical seizures and early neurologic deterioration (21), potentially enabling earlier intervention and improved outcomes

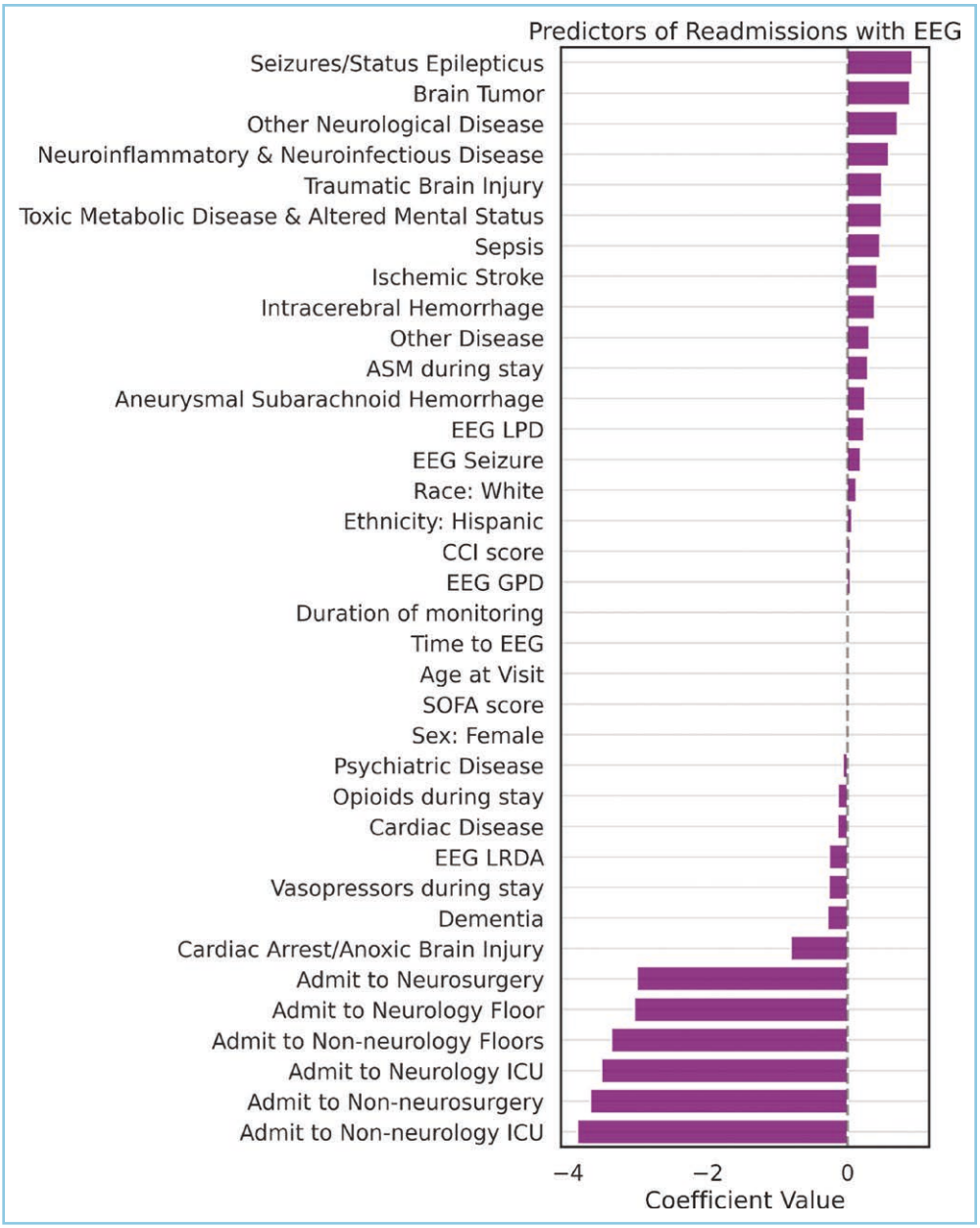

Figure 3. Predictors of readmission with electroencephalogram (EEG) monitoring within 12 mo of initial hospitalization. ASM = anti-seizure medication, CCI = Charlson Comorbidity Index, GPD = generalized periodic discharge, LPD = lateralized periodic discharge, LRDA = lateralized rhythmic delta activity, SOFA = Sequential Organ Failure Assessment.

(15, 24). Further work is needed to determine whether additional clinical factors should guide earlier EEG initiation in these patients.

Aneurysmal subarachnoid hemorrhage was the strongest predictor of prolonged EEG monitoring, likely reflecting adherence to guideline recommendations (2, 18) and institutional protocols supporting extended monitoring during periods of highest risk for delayed cerebral ischemia. Current recommendations suggest monitoring from approximately day 3 to day 14 following hemorrhage or until risk of vasospasms had resolved (2). No established criteria exist for monitoring duration in other ischemic conditions, though early monitoring may be considered in settings such as the first 24–48 hours after a transient ischemic attack, when stroke risk is highest (25, 26).

Patients with RPPs were monitored longer than those without such findings, consistent with their higher seizure risk across both neurologic and non-neurologic units. However, even patients without seizures or RPPs had median monitoring durations of 17.96 and 24.97 hours, respectively, among those admitted to neurology units, suggesting potential opportunities to optimize resource utilization. While excessive monitoring may strain limited resource (10), insufficient monitoring risks missing seizures or evolving pathologic patterns. Clinical tools such as the 2HELPS2B score may help guide monitoring duration by incorporating findings from an initial 1-hour screening session. If no epileptiform abnormalities or RPPs are detected during early monitoring, the probability of seizure detection decreases substantially below 5% after ~16 hours without seizures (27), suggesting shorter monitoring may be appropriate for certain patients.

The highest rates of readmission with repeat EEG monitoring within 12 months occurred among patients with brain tumors and seizures/status epilepticus as

the primary diagnostic category during the index hospitalization. Identification of LPDs or electrographic seizures during initial monitoring was also associated with subsequent readmissions requiring EEG. Patients with repeat EEG admission had lower median SOFA and CCI scores, which may reflect survivorship, as individuals with greater illness severity may be less likely to survive until readmission. Because only readmissions involving repeat EEG were captured, these results do not represent overall hospital readmission rates. Prior work was shown that ASM use, longer monitoring duration, and multiple comorbidities are associated with readmission in critically ill patients with RPPs (28). In this multicenter cohort, we confirm that ASM use and primary admission diagnosis are also associated with repeat EEG (28) monitoring. Future work should focus on identifying patients more likely to require repeat monitoring and evaluating alternative approaches such as remote or limited-montage EEG to reduce preventable hospitalizations.

Several limitations should be considered. First, this retrospective study was conducted at centers with established EEG monitoring programs, which may limit generalizability to less specialized institutions. Second, we did not have access to EEG order details including the exact indication for EEG (i.e., concern for seizure, prognosis, etc). Although the protocol at all sites is to initiate EEG as soon as possible, the interval between EEG order placement and study initiation may differ between indications, with triage decisions being prioritized by indications (e.g., higher priority given for patients with high concern for status epilepticus). The variability in initiation timing across diagnostic categories may also reflect differences in clinical trajectories (e.g., later initiation in patients with nonneurologic primary diagnosis due to secondary neurologic symptoms occurring later during the hospitalization). While we account for primary diagnosis in our analysis, lack of exact indication for monitoring is a limitation. Furthermore, diagnostic categories were defined using ICD codes, which may introduce misclassifications (29). Third, our analysis focused on seizures and RPPs, while other EEG abnormalities (e.g., sporadic discharges, focal slowing, etc) may influence monitoring duration and were not evaluated. Fourth, institutional differences in unit structure and EEG availability, including technologist staffing and after-hours coverage, may have influenced monitoring practices. Finally, functional and cognitive outcomes were not assessed and should be incorporated in future studies to better evaluate quality of care.

In conclusion, this study characterizes patterns of EEG utilization during acute hospitalization, including timing, duration of monitoring, and readmissions with EEG. We identified opportunities to optimize EEG triage and resource utilization, particularly in patients with cardiac arrest, nonneurologic diagnoses associated with high seizure risk such as sepsis, patients without early epileptiform findings on EEG, and individuals at higher risk for repeat EEG monitoring.

1 *Value Based Health Care Center, Neurology Comparative Effectiveness Research Lab, Department of Neurology, Massachusetts General Hospital/Harvard Medical School, Boston, MA.*

2 *Clinical Data Animation Center, Department of Neurology, Beth Israel Deaconess Medical Center/Harvard Medical School, Boston, MA.*

3 *Department of Neurology, Yale University School of Medicine, New Haven, CT.*

4 *Department of Neurology, Washington University in St. Louis, St. Louis, MO.*

Supplemental digital content is available for this article. Direct URL citations appear in the printed text and are provided in the HTML and PDF versions of this article on the journal's website (http://journals.lww.com/ccejournal).

This work was supported by grants from the National Institutes of Health (R01NS131347).

Dr. Westover is a co-founder, scientific advisor, consultant to, and has a personal equity interest in Beacon Biosignals. Dr. Zafar received publishing royalties from Springer and Wolters Kluwer. The remaining authors have disclosed that they do not have any potential conflicts of interest.

For information regarding this article, E-mail: atautan@mgh.harvard.edu

REFERENCES

1. Claassen J, Taccone FS, Horn P, et al; Neurointensive Care Section of the European Society of Intensive Care Medicine: Recommendations on the use of EEG monitoring in critically ill patients: Consensus statement from the neurointensive care section of the ESICM. *Intensive Care Med* 2013; 39:1337–1351
2. Herman ST, Abend NS, Bleck TP, et al; Critical Care Continuous EEG Task Force of the American Clinical Neurophysiology Society: Consensus statement on continuous EEG in critically ill adults and children, part I: Indications. *J Clin Neurophysiol* 2015; 32:87–95

3. Herman ST, Abend NS, Bleck TP, et al: Consensus statement on continuous EEG in critically ill adults and children, part II: Personnel, technical specifications, and clinical practice. *J Clin Neurophysiol* 2015; 32:96–108
4. Le Roux P, Menon DK, Citerio G, et al: Consensus summary statement of the international multidisciplinary consensus conference on multimodality monitoring in neurocritical care: A statement for healthcare professionals from the Neurocritical Care Society and the European Society of Intensive Care Medicine. *Neurocrit Care* 2014; 21:S1–S26
5. Bleck TP, Smith MC, Pierre-Louis SJ, et al: Neurologic complications of critical medical illnesses. *Crit Care Med* 1993; 21:98–103
6. Zafar SF, Rosenthal ES, Jing J, et al: Automated annotation of epileptiform burden and its association with outcomes. *Ann Neurol* 2021; 90:300–311
7. Claassen J, Mayer SA, Kowalski RG, et al: Detection of electrographic seizures with continuous EEG monitoring in critically ill patients. *Neurology* 2004; 62:1743–1748
8. Struck AF, Tabaeizadeh M, Schmitt SE, et al: Assessment of the validity of the 2HELPS2B score for inpatient seizure risk prediction. *JAMA Neurol* 2020; 77:500–507
9. MacDarby L, Healy M, McHugh JC: EEG availability in the intensive care setting: A multicentre study. *Neurocrit Care* 2021; 34:287–290
10. Ney JP, Nuwer MR, Hirsch LJ, et al: The cost of after-hour electroencephalography. *Neurol Clin Pract* 2024; 14:e200264
11. Alvarez V, Rodriguez Ruiz AA, LaRoche S, et al; Critical Care EEG Monitoring Research Consortium (CCEMRC): The use and yield of continuous EEG in critically ill patients: A comparative study of three centers. *Clin Neurophysiol* 2017; 128:570–578
12. Gasparini A: Comorbidity: An R package for computing comorbidity scores. *J Open Source Softw* 2018; 3:648
13. Westover TM, Fernandes MB, Westover MB, et al: An immediate mortality prediction score that is robust to missing data. *OJS* 2025; 15:73–80
14. Sartipi S, Godfrey D, Tauțan AM, et al: Automated extraction of seizures and ictal-interictal continuum patterns from EEG reports to enable large-scale neurophysiology and neurocritical care research. *Soc Sci Res Net* 2025:5489575
15. Haider MA, Khalil MH, Fernandes MB, et al: Association of time to continuous EEG initiation with outcomes in critically ill patients. *J Clin Neurophysiol* 2026; 43:17–22
16. Andrade C: Mean difference, standardized mean difference (SMD), and their use in meta-analysis: As simple as it gets. *J Clin Psychiatry* 2020; 81:20f13681
17. Simoneau G, Pellegrini F, Debray TP, et al: Recommendations for the use of propensity score methods in multiple sclerosis research. *Mult Scler* 2022; 28:1467–1480
18. Rajajee V, Muehlschlegel S, Wartenberg KE, et al: Guidelines for neuroprognostication in comatose adult survivors of cardiac arrest. *Neurocrit Care* 2023; 38:533–563
19. Hirsch KG, Amorim E, Coppler PJ, et al: Part 11: Post-cardiac arrest care: 2025 American Heart Association guidelines for cardiopulmonary resuscitation and emergency cardiovascular care. *Circulation* 2025; 152(16_Suppl_2):S673–S718
20. Fatuzzo D, Beuchat I, Alvarez V, et al: Does continuous EEG influence prognosis in patients after cardiac arrest? *Resuscitation* 2018; 132:29–32
21. Fan TH, Premraj L, Roberts J, et al: In-hospital neurologic complications, neuromonitoring, and long-term neurologic outcomes in patients with sepsis: A systematic review and meta-analysis. *Crit Care Med* 2024; 52:452–463
22. Ruijter BJ, Tjepkema-Cloostermans MC, Tromp SC, et al: Early electroencephalography for outcome prediction of post-anoxic coma: A prospective cohort study. *Ann Neurol* 2019; 86:203–214
23. Sonneville R, Benghanem S, Jeantin L, et al: The spectrum of sepsis-associated encephalopathy: A clinical perspective. *Crit Care* 2023; 27:386
24. Desai M, Kalkach-Aparicio M, Sheikh IS, et al: Evaluating the impact of point-of-care electroencephalography on length of stay in the intensive care unit: Subanalysis of the SAFER-EEG trial. *Neurocrit Care* 2025; 42:108–117
25. Wardlaw J, Brazzelli M, Miranda H: Chapter 3: A systematic review and meta-analysis of stroke risk after transient ischaemic attack. In: *An Assessment of the Cost-Effectiveness of Magnetic Resonance, Including Diffusion-Weighted Imaging, in Patients With Transient Ischaemic Attack and Minor Stroke: A Systematic Review, Meta-Analysis and Economic Evaluation*. Walley T (Ed). Southampton, United Kingdom, NIHR Journals Library, 2014, pp 17–32
26. National Institute for Health and Care Excellence: Guidance: Overview: Stroke and Transient Ischaemic Attack in Over 16s: Diagnosis and Initial Management. 2019. Available at: https://www.nice.org.uk/guidance/ng128?utm_source=chatgpt.com. Accessed February 12, 2026
27. Westover MB, Shafi MM, Bianchi MT, et al: The probability of seizures during EEG monitoring in critically ill adults. *Clin Neurophysiol* 2015; 126:463–471
28. Rice HJ, Fernandes MB, Punia V, et al: Predictors of follow-up care for critically-ill patients with seizures and epileptiform abnormalities on EEG monitoring. *Clin Neurol Neurosurg* 2024; 241:108275
29. Guo LL, Morse KE, Aftandilian C, et al: Characterizing the limitations of using diagnosis codes in the context of machine learning for healthcare. *BMC Med Inform Decis Mak* 2024; 24:51