Title

Evaluating the feasibility of prehospital point-of-care EEG: The prehospital implementation of rapid EEG (PHIRE) study.

Journal

Journal of the American College of Emergency Physicians Open, 5(5)

Authors

Guterman, Elan
Mercer, Mary
Wood, Andrew
et al.

Publication Date

2024-10-01

DOI

10.1002/emp2.13303

Peer reviewed

Received: 30 May 2024 | Revised: 29 July 2024 | Accepted: 23 August 2024

DOI: 10.1002/emp2.13303

JACEP OPEN
JOURNAL OF THE AMERICAN COLLEGE OF EMERGENCY PHYSICIANS OPEN
A GLOBAL JOURNAL OF EMERGENCY MEDICINE
WILEY

BRIEF REPORT

Neurology

Evaluating the feasibility of prehospital point-of-care EEG: The prehospital implementation of rapid EEG (PHIRE) study

Elan L. Guterman MD, MAS[1,2] | Mary P. Mercer MD, MPH[3,4] | Andrew J. Wood MPH[1] | Edilberto Amorim MD[1] | Jonathan K. Kleen MD, PhD[1] | Daniel Gerard MS, NRP[4] | Colleen Kellison EMT-P[3] | Scott Yamashita BA[5] | Benjamin Auerbach[1] | Nikita Joshi MD[5] | Karl A. Sporer MD[4]

[1]Department of Neurology, University of California, San Francisco, California, USA

[2]Philip R. Lee Institute for Health Policy Studies, University of California, San Francisco, California, USA

[3]Department of Emergency Medicine, University of California, San Francisco, California, USA

[4]Emergency Medical Services, City of Alameda Fire Department, Alameda, California, USA

[5]Department of Emergency Medicine, Alameda Hospital, Alameda, California, USA

Correspondence
Elan L. Guterman, Department of Neurology, University of California, San Francisco, CA, USA.
Email: elan.guterman@ucsf.edu

Meetings: Future presentation at the American Neurological Association Annual Meeting on September 14, 2024.

Supervising Editor: Juan March, MD

Funding information
National Institute of Neurological Disorders and Stroke, Grant/Award Number: K23NS116128

Abstract

Background: Point-of-care electroencephalography (EEG) devices can be rapidly applied and do not require specialized technologists, creating new opportunities to use EEG during prehospital care. We evaluated the feasibility of point-of-care EEG during ambulance transport for 911 calls.

Methods: This mixed-methods study was conducted between May 28, 2022 and October 28, 2023. Emergency Medical Services (EMS) clinicians identified eligible individuals, provided emergent treatment, applied EEG, and obtained an EEG recording during ambulance transport. Eligible patients were aged 6 years or older and evaluated for seizure, stroke, or altered mental status. EMS clinicians completed a survey and a brief phone interview following every enrollment. Two epileptologists reviewed EEG recordings for interpretability and artifact.

Results: There were 34 prehospital encounters in which EEG was applied. Patients had a mean age of 69 years, and 15 (44%) were female. EEG recordings had a median duration of 10 min 30 s. It took EMS clinicians an average of 2.5 min to apply the device and begin EEG recording. There were 14 (47%) recordings where clinicians achieved a high-quality connection for all 10 electrodes and 32 (94%) recordings that were sufficient in quality to interpret. There were 24 (71%) recordings with six or more channels free of artifact for 5 min or more. All clinicians agreed or strongly agreed that the device was easy to use.

Conclusion: Among real-world prehospital encounters for patients with neurologic symptoms, point-of-care EEG was rapidly applied and yielded EEG recordings that could be used for clinical interpretation, demonstrating the feasibility of point-of-care EEG in future prehospital care.

1 | INTRODUCTION

1.1 | Background

Point-of-care electroencephalography (EEG) is a new technology with the potential to enhance prehospital clinical care delivered by Emergency Medical Services (EMS).[1–5] While conventional EEG technology is essential for monitoring brain electrical activity and guiding treatment for neurologic emergencies in the hospital, its application in the prehospital setting has been limited because of the time-consuming application process and the need for specialized technologists. In contrast, point-of-care EEG devices can be rapidly applied, do not require specialized technologists, and provide automated EEG interpretation for use by non-epilepsy-trained providers.[5–7] These advancements in EEG technology present an opportunity to explore real-time neuromonitoring with EEG during prehospital care to facilitate early detection and treatment of neurologic emergencies.

The Bottom Line

Point-of-care electroenephalography (EEG) devices can be rapidly applied and do not require specialized technologists, creating new opportunities to use EEG during prehospital care. This mixed-methods study evaluated the feasibility of point-of-care EEG during ambulance transport for 911 calls. Among 34 prehospital encounters in which EEG was applied, it took emergency medical services (EMS) clinicians an average of 2.5 minutes to apply the device and begin EEG recording, and 32 (94%) recordings were sufficient in quality to interpret. All clinicians agreed or strongly agreed that the device was easy to use. These results demonstrate the feasibility of incorporating point-of-care EEG in future prehospital care.

1.2 | Importance

Patients with suspected seizure and stroke account for over 5% of 911 calls while patients with traumatic injuries, including traumatic brain injury, account for an additional 20%.[8–12] These patients rely on EMS to identify their neurologic emergency. However, a large proportion of these are missed during EMS evaluation resulting in suboptimal care.[13–17] The use of EEG in the prehospital setting has the potential to help identify these patients and ensure appropriate treatment on-scene and rapid transport to a hospital that can deliver the care needed.

In light of this opportunity, two prior studies have examined the feasibility of EEG during prehospital transport using devices with eight and two electrodes. Both demonstrated the successful acquisition of EEG data.[1,2] Both also focused on limited-montage EEG with fewer electrodes than conventional EEG because these smaller EEG systems reduce the time required to deploy the device. Yet, despite the benefits of limited-montage EEG systems, they record less electrical activity, which may impact diagnostic performance. The 10-electrode Ceribell EEG System is a circumferential montage point-of-care EEG device widely implemented in the emergency department (ED) and hospital because it is fast to apply and maintains high sensitivity.[6,7,18] However, it has not been studied for use by EMS.

1.3 | Goals of this investigation

The current study aimed to determine the feasibility of EMS acquiring a 10-electrode point-of-care EEG recording in the prehospital setting.

2 | METHODS

2.1 | Study design and setting

The Prehospital Implementation of Rapid EEG (PHIRE) study was a mixed-methods study using structured review of electroencephalography (EEG) recordings, EMS clinician surveys, and field notes to examine the feasibility of obtaining EEG recordings during real-world ambulance transport for 911 calls. The study was conducted at Alameda Fire Department (AFD), a fire-based EMS agency in Northern California that operates four responding ambulances and employs approximately 100 first responder EMS clinicians (paramedics and emergency medical technicians [EMTs]) to provide advanced life support response to a population of roughly 75,000. Data were collected between May 28, 2022 and October 28, 2023. Enrollment was paused during the study period when research resources were limited. The Institutional Review Board of the affiliated health system approved this study. It granted a waiver of informed consent due to the minimal risk, the emergency nature of the assessments, and the infeasibility of obtaining consent at the time of the encounter. Although consent was not required, EMS clinicians were instructed to inform patients and their legally authorized representatives about the study, and if they declined participation, they would not be enrolled. The study used the Ceribell point-of-care EEG. Ceribell provided the EEG equipment (headbands and recording devices) but had no role in the study conception, funding, design, data analysis, manuscript drafting, or publication decision.

2.2 | Selection of participants

Eligible individuals included patients aged 6 years or older who were being evaluated by EMS for suspected seizure, stroke, or altered mental status during a 911 call, and who were transported to two hospitals (out of four hospitals in the region and 13 in the county). These criteria were selected to study the use of EEG in a broad group of patients with abnormal neurologic examination findings. Exclusion criteria included patients who were combative, had a skull defect or scalp wound precluding electrode placement, belonged to a protected population including pregnant women and prisoners, or stated (or had a legally authorized representative that stated) they chose not to participate in the study.

2.3 | Study protocol

There was mandatory comprehensive training for all EMS clinicians employed by AFD prior to study initiation. Training was a half-day session that included lecture-based didactics covering the study protocol and human subjects research, as well as a skills verification process that confirmed all EMS clinicians could identify eligible patients and apply the EEG device. The study team also provided training during shifts to answer questions and refresh knowledge about the study. The study protocol was identical for all EMS clinicians regardless of their level of training (paramedic vs. EMT).

The device used for this study was the point-of-care EEG developed by Ceribell. This device has been cleared by the U.S. Food and Drug Administration. It consists of a one-time use headband with 10 electrodes that create four electrode pairs in each hemisphere and a handheld, wifi-enabled recording device. The electrodes are configured circumferentially and cover the lateral regions of the brain but not the midline or parasagittal regions where seizures occur infrequently. The recording device collects patient information, displays the signal quality for each electrode, records EEG data, streams the EEG recording, and uploads the EEG recording to an online portal for remote review of the EEG. There were three ambulances participating in enrollment. Each ambulance was equipped with one recording device and multiple headbands to allow for successive enrollments (Figure 1).

EMS clinicians were instructed to identify eligible individuals during routine clinical duties and initiate point-of-care EEG after treating the patient according to the standard EMS agency treatment protocol, including addressing any emergent medical issues. One EMS clinician applied the headband on-scene or in the ambulance by securing the headband above the patient's ears, preparing each electrode by rotating a knob to clear away hair, and dispensing gel. Simultaneously, another EMS clinician connected the headband to the recording device and entered patient information. The team of EMS clinicians would then assess electrode signal quality, fix electrodes with poor connection quality, and start the EEG recording which was continued until hospital arrival. After the encounter, point-of-care EEG recordings were uploaded to an online portal and reviewed by two epileptologists (E.A. and J.K.K.). EMS clinicians were blind to the EEG findings during the encounter. EMS clinicians completed a survey and participated in a brief unstructured phone interview to describe their experience.

2.4 | Measurements

To measure the quality of the EEG data, two epileptologists (E.A. and J.K.K.) reviewed each point-of-care EEG recording. Bandpass filters in the review system were set at 1–70 Hz with a 60 Hz notch filter. First, the reviewers determined whether an EEG recording was interpretable, which was defined as having at least one EEG trace from a bipolar electrode pair that was free of artifact and showing cerebral signals. If the EEG was interpretable, the reviewers determined the number of EEG electrode pairs that were free of artifact, the duration of time that each EEG channel was free of artifact, whether there was focal slowing during the EEG recording, and whether there was a seizure during the EEG recording. When there was disagreement, the reviewers examined the EEG recordings together to achieve consensus. There was one encounter where the EEG recording was stopped and restarted, and this was treated as one continuous recording.

FIGURE 1 Point-of-care electroencephalography (EEG) device and ambulance set-up.

To measure the feasibility of using a point-of-care EEG device, EMS clinicians completed a survey after all encounters where EEG application was attempted regardless of whether the attempt led to the successful upload of an EEG recording. They were given the option to complete the survey electronically or by phone. The survey documented which steps of the EEG application process were completed, whether the EEG was applied in the field or ambulance, the number of minutes used to apply the EEG device, the number of minutes used to troubleshoot the electrode connection quality, ease of use (rated on a 5-point Likert scale), and barriers impeding the use of the EEG device. EEG application steps and barriers to EEG use were predefined and collected as dichotomous variables (yes vs. no). The number of minutes for EEG application and troubleshooting was estimated by the EMS clinicians after the encounter. To qualitatively assess the feasibility of using a point-of-care EEG device, EMS clinicians were given an

open-ended request to provide "other comments" in a text box and they were asked to provide comments by phone. This phone call occurred after the encounter and was conducted by one member of the research team (E.L.G.) who asked a single question requesting additional feedback about their experience. The phone call was kept brief to ensure it would be feasible for EMS clinicians to answer the question while they were on shift. These comments were recorded as field notes.

We also collected clinical information about each patient from the prehospital and hospital electronic health record, including age, sex, race, ethnicity, suspected prehospital diagnosis, heart rate, blood pressure, oxygen saturation, Glasgow Coma Scale score, and suspected alcohol and drug use. The vital sign parameters were the first measurements obtained by EMS during the prehospital encounter.

2.5 | Analysis

We performed descriptive statistics to assess EEG data quality and feasibility. The EEG data quality was analyzed as binary variables. We calculated the proportion of EEG recordings that had 1 or more channels that were free of artifact in each cerebral hemisphere for at least 10 s, for at least 1 min, and for at least 5 min. We calculated the proportion of EEG recordings that had six or more channels that were free of artifact for at least 10 s, for at least 1 min, and for at least 5 min. We calculated the proportion of EEG recordings that had focal slowing and the proportion of EEG recordings that captured a seizure. The provider survey and patient clinical data were analyzed as binary and categorical variables to describe the experience using point-of-care EEG and the patient population for whom EEG was applied. Statistical analyses were performed using Stata (Version 15.1, StataCorp).

For the qualitative assessment, field notes from the study were reviewed after data collection was complete. Rather than perform a coded thematic analysis, all field notes have been presented.

3 | RESULTS

There were 34 prehospital encounters where point-of-care EEG was applied. Patients had a mean age of 69.2 years (SD 21 years), 14 (41.2%) were female, and the majority received a suspected prehospital diagnosis of stroke (35.3%), altered mental status (23.5%), or seizure (14.7%) (Table 1).

The point-of-care EEG recordings had a mean duration of 13 min 22 s. Of the 34 prehospital encounters with a point-of-care EEG recording, there were 30 surveys completed by 11 EMS clinicians describing the experience. EMS clinicians reported an average of 2.5 min to apply the point-of-care EEG. There were 14 (47%) recordings with a high-quality connection achieved for all 10 electrodes. All clinicians agreed or strongly agreed that the device was easy to use (Table 2). The device was typically applied by two or more clinicians working together. The greatest challenges to using the device were entering patient information into the recording device and achieving a high-quality connection for all electrodes (Table 2; Table S1).

TABLE 1 Demographic and clinical characteristics of the patients.

Age[a]	**69 (IQR 58, 85)**
Female sex	11 (41.2%)
Race	
Asian	2 (6%)
Black or African American	11 (32%)
White	18 (53%)
Unknown or not reported	1 (3%)
Other	2 (6%)
Hispanic/Latinx/Spanish ethnicity	1 (3%)
Preferred language	
English	29 (85%)
Spanish	2 (6%)
Other	3 (9%)
Suspected prehospital diagnosis[b]	
Stroke	12 (35%)
Altered mental status	8 (24%)
Seizure/status epilepticus	5 (15%)
Other	9 (26%)
Systolic blood pressure[c]	150 (124, 166)
Diastolic blood pressure	92 (78, 104)
Heart rate	90 (75, 104)
Respiratory rate	18 (16, 20)
Oxygen saturation	97 (94, 99)
Blood glucose	120 (101, 154)
Body temperature	100.4 (98.8, 101)
Glasgow coma scale	14 (IQR 12, 15)
Suspected alcohol or substance use, N (%)	4 (12%)
Emergency department disposition	
Hospital admission	13 (38%)
Transfer to different acute care hospital	5 (15%)
Discharge home or non-acute care facility	7 (21%)
Death	0 (0%)
Unknown	9 (26%)

[a]Continuous variables expressed as median and interquartile range (IQR); categorical variables expressed as count and proportion (%).
[b]All patients were evaluated for suspected stroke, altered mental status, or seizure. For a subset of patients, EMS clinicians documented a different primary diagnosis. For example, a patient may have had altered mental status but received a primary diagnosis of sepsis. The alternative diagnoses included sepsis, generalized weakness, abdominal pain, acute respiratory distress, alcohol use, and diabetic hypoglycemia.
[c]Vital sign measurements were the first documented vital signs collected during the prehospital encounter.

Review of point-of-care EEG demonstrated that there were 32 (94%) recordings of adequate quality to interpret, 31 (91%) recordings with one or more channels free of artifact in each hemisphere for 1 min or more, 26 (76%) recordings with one or more channels free of artifact in each hemisphere for 5 min or more, and 24 (71%)

TABLE 2 Feasibility of point-of-care electroencephalography (EEG) during Emergency Medical Services (EMS) evaluation.

EMS clinician experience (*N* = 30)	
Time to apply EEG[a]	3 min (IQR 2, 3)
Time to troubleshoot poor electrode connection, mean	1 min (1, 1)
Duration of EEG recording	10.5 min (7.1, 13.5)
Location EEG applied	
In ambulance	29 (97%)
On scene	1 (3%)
EEG application, *N* (%)	
Headband placement	30 (100%)
Recorder set-up	30 (100%)
Electrode preparation	30 (100%)
Electrode signal check	29 (97%)
Achieving high-quality electrode signal[b]	14 (47%)
Starting recording	30 (100%)
Barriers to using EEG	
Finding the correct headband size	1 (3%)
Recorder set-up	14 (47%)
Achieving high-quality electrode signal	13 (43%)
Movement during transport	3 (10%)
Patient confusion	1 (3%)
EEG was easy to use, *N* (%)	
Strongly disagree	0 (0.0)
Disagree	0 (0.0)
Neutral	0 (0.0)
Agree	19 (63%)
Strongly agree	11 (37%)
Quality of EEG recording (*N* = 34)	
Interpretable data	32 (94%)
≥1 artifact-free channel in each hemisphere	
10 s or more	31 (91%)
1 min or more	31 (91%)
5 min or more	26 (76%)
≥ 6artifact-free channels	
10 s or more	30 (88%)
1 min or more	30 (88%)
5 min or more	24 (71%)
Seizure	0 (0%)
Focal slowing	1 (3%)

[a]Duration in minutes for all time variables; expressed as median and interquartile range (IQR).
[b]High quality defined as a "green light" indicator for all 10 electrodes.

recordings with six or more channels free of artifact for 5 min or more (Table 2). There was one recording that captured focal slowing and no recordings that captured seizure. The two (6%) recordings that could not be interpreted included one recording that was 2-s long and one recording with substantial artifact.

4 | LIMITATIONS

There are several limitations of this study. This study was performed at a single fire department with a track record of research collaboration and the engagement of the EMS clinicians may not generalize to other EMS agencies. The patients who underwent EEG had varied neurologic complaints but were not critically ill or unresponsive. Thus, these data do not speak to the use of point-of-care EEG among patients with high clinical acuity. This study was performed in an urban area where the time to transport patients is short and could not examine the quality of EEG during longer ambulance rides. Lastly, we did not specifically enroll patients expected to have abnormal EEG recordings; thus, we did not have the epileptologists provide a comprehensive clinical interpretation and could not explore the performance of point-of-care EEG in identifying abnormalities such as focal slowing or seizure.

5 | DISCUSSION

Among real-world prehospital encounters for patients with neurologic symptoms, point-of-care EEG was rapidly applied and yielded EEG recordings that could be used for clinical interpretation. However, the quality of EEG data varied substantially across recordings. Having a team of EMS clinicians ensured that multiple individuals could work together to apply the EEG so that device application was rapid, continued alongside routine prehospital care, and was easy. These data represent an important step in understanding the feasibility of incorporating point-of-care EEG into ambulance-based prehospital care.

Because EEG recordings can be used to screen for neurologic emergencies such as seizure and acute ischemic stroke, these findings raise questions regarding the future implementation of point-of-care EEG to inform treatment and triage decisions. Among prehospital encounters, approximately 2% involve patients with suspected stroke and 5% involve patients with suspected seizure.[8–12] The use of EEG in the prehospital setting has the potential to help EMS identify these patients so that patients with status epilepticus receive first-line benzodiazepine treatment on-scene and patients with acute ischemic stroke undergo transport to an appropriately specialized center to receive emergent care.[19–21]

Our finding that nearly 90% of EEG recordings were available for interpretation and yielded EEG data with multiple channels that were free of artifact reinforces the potential of acquiring high-quality EEG in the out-of-hospital environment. There are a limited number of prior studies exploring the feasibility of acquiring EEG data during ambulance transport where emergent medical needs, movement, and the involvement of clinicians without prior EEG experience complicate

EEG use. A study of single-channel EEG used two electrodes from a device that was designed for electrocardiography, not EEG, obtained recordings in 67% of eligible patients with trauma who were undergoing helicopter ambulance transport, and determined 84% of recordings yielded interpretable information.[2] A study of an eight-electrode EEG among patients with stroke obtained interpretable information in two-thirds of eligible patients.[1] The findings of the current study add to these studies demonstrating successful EEG application in a different study with a widely used point-of-care EEG device.

These data find that point-of-care EEG is feasible for use in the prehospital setting, raising questions about how to integrate these data to improve routine prehospital clinical care as well as biomedical research.

AUTHOR CONTRIBUTIONS

Elan L. Guterman conceived the study, designed the study, and obtained research funding. Elan L. Guterman, Mary P. Mercer, Colleen Kellison, Scott Yamashita, Benjamin Auerbach, Nikita Joshi, Daniel Gerard, and Karl A. Sporer supervised the conduct of the study and data collection. Andrew J. Wood managed the data, including quality control. Edilberto Amorim and Jonathan K. Kleen provided advice and reviewed the EEG recordings. Elan L. Guterman and Andrew J. Wood provided statistical advice on study design and analyzed the data; Elan L. Guterman drafted the manuscript. All authors contributed substantially to the manuscript revision. Elan L. Guterman takes responsibility for the paper as a whole.

ACKNOWLEDGMENTS

The authors thank David Buckley, Kyle Garcia, Courtney Shay, Amelia Breyre, Gurvijay Jains, and Manish Shah for their help in the conduct of the study. This work was supported by funding from the National Institute of Neurological Disorders and Stroke (K23NS116128). Elan L. Guterman received funding from the National Institute of Neurological Disorders and Stroke (K23NS116128), National Institute on Aging (5R01AG056715), and American Academy of Neurology. She receives personal compensation from JAMA Neurology and stock from Remo Health, which are unrelated to the submitted work. Edilberto Amorim received funding from the American Heart Association (20CDA35310297, 843457), Regents of the University of California, Department of Defense (ERP 220036, W81XWH-19-1-0861), the NIH (1K23NS119794, 1OT2OD032701), Cures Within Reach, and the Zoll Foundation.

CONFLICT OF INTEREST STATEMENT

The authors declare no conflicts of interest.

DATA AVAILABILITY STATEMENT

Deidentified data files, the data dictionary, and case report forms for this investigation as of May 1, 2023 are available upon request from the corresponding author.

ORCID

Elan L. Guterman MD, MAS https://orcid.org/0000-0003-0817-3144

REFERENCES

1. van Stigt MN, Groenendijk EA, van Meenen LCC, et al. Prehospital detection of large vessel occlusion stroke with EEG. *Neurology*. 2023;101(24):e2522-e2532. doi:10.1212/WNL.0000000000207831
2. Barton DJ, Coppler PJ, Talia NN, et al. Prehospital electroencephalography to detect traumatic brain injury during helicopter transport: a pilot observational cohort study. *Prehosp Emerg Care*. 2024;28(2):405-412. doi:10.1080/10903127.2023.2185333
3. Jakab A, Kulkas A, Salpavaara T, et al. Novel wireless electroencephalography system with a minimal preparation time for use in emergencies and prehospital care. *Biomed Eng OnLine*. 2014;13(1):60. doi:10.1186/1475-925X-13-60
4. Koreerat NR, Giese R. An observation of application of structural brain injury devices for traumatic brain injury evaluation in austere military prehospital settings. *Mil Med*. 2021;186(Supplement_1):579-583. doi:10.1093/milmed/usaa397
5. Vespa PM, Olson DM, John S, et al. Evaluating the clinical impact of rapid response electroencephalography: the DECIDE multicenter prospective observational clinical study. *Crit Care Med*. 2020;48(9):1249-1257. doi:10.1097/CCM.0000000000004428
6. Kamousi B, Grant AM, Bachelder B, Yi J, Hajinoroozi M, Woo R. Comparing the quality of signals recorded with a rapid response EEG and conventional clinical EEG systems. *Clin Neurophysiol Pract*. 2019;4:69-75. doi:10.1016/j.cnp.2019.02.002
7. Kamousi B, Karunakaran S, Gururangan K, et al. Monitoring the burden of seizures and highly epileptiform patterns in critical care with a novel machine learning method. *Neurocrit Care*. 2021;34(3):908-917. doi:10.1007/s12028-020-01120-0
8. Dylla L, Rice JD, Poisson SN, et al. Analysis of stroke care among 2019–2020 National Emergency Medical Services Information System encounters. *J Stroke Cerebrovasc Dis Off J Natl Stroke Assoc*. 2022;31(3):106278. doi:10.1016/j.jstrokecerebrovasdis.2021.106278
9. Dickson JM, Asghar ZB, Siriwardena AN. Pre-hospital ambulance care of patients following a suspected seizure: a cross sectional study. *Seizure*. 2018;57:38-44. doi:10.1016/j.seizure.2018.03.006
10. Dickson JM, Taylor LH, Shewan J, Baldwin T, Grünewald RA, Reuber M. Cross-sectional study of the prehospital management of adult patients with a suspected seizure (EPIC1). *BMJ Open*. 2016;6(2):e010573. doi:10.1136/bmjopen-2015-010573
11. California Emergency Medical Services Authority. Annual EMS data report, calendar year 2023. Published 2024. Accessed September 6, 2024. https://emsa.ca.gov/wp-content/uploads/sites/71/2024/06/2022-2023_Annual_EMS_Data_Report.pdf
12. National Emergency Medical Services Information System (NEMSIS). NEMSIS database. Accessed July 23, 2024. https://nemsis.org/view-reports/
13. Semmlack S, Yeginsoy D, Spiegel R, et al. Emergency response to out-of-hospital status epilepticus: a 10-year observational cohort study. *Neurology*. 2017;89(4):376-384. doi:10.1212/WNL.0000000000004147
14. Abramson TM, Rose E, Crow E, Lane CJ, Kearl Y, Loza-Gomez A. Paramedic identification of pediatric seizures: a prospective cohort study. *Prehosp Emerg Care*. 2020:1-7. doi:10.1080/10903127.2020.1831667
15. Lin CB, Peterson ED, Smith EE, et al. Emergency medical service hospital prenotification is associated with improved evaluation and treatment of acute ischemic stroke. *Circ Cardiovasc Qual Outcomes*. 2012;5(4):514-522. doi:10.1161/CIRCOUTCOMES.112.965210
16. Nielsen VM, DeJoie-Stanton C, Song G, Christie A, Guo J, Zachrison KS. The association between presentation by EMS and EMS prenotification with receipt of intravenous tissue-type plasminogen activator in a state implementing stroke systems of care. *Prehosp Emerg Care*. 2020;24(3):319-325. doi:10.1080/10903127.2019.1662862

17. Govindarajan P, Friedman BT, Delgadillo JQ, et al. Race and sex disparities in prehospital recognition of acute stroke. *Acad Emerg Med*. 2015;22(3):264-272. doi:10.1111/acem.12595
18. Vespa PM. Nonconvulsive electrographic seizures after traumatic brain injury result in a delayed, prolonged increase in intracranial pressure and metabolic crisis.2015.
19. van Putten MJAM, Hofmeijer J. EEG monitoring in cerebral ischemia: basic concepts and clinical applications. *J Clin Neurophysiol Off Publ Am Electroencephalogr Soc*. 2016;33(3):203-210. doi:10.1097/WNP.0000000000000272
20. Zhao G, Feng G, Zhao L, et al. Application of quantitative electroencephalography in predicting early cerebral ischemia in patients undergoing carotid endarterectomy. *Front Neurol*. 2023;14:1159788. doi:10.3389/fneur.2023.1159788
21. Foreman B, Claassen J. Quantitative EEG for the detection of brain ischemia. *Crit Care*. 2012;16(2):216. doi:10.1186/cc11230

SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

How to cite this article: Guterman EL, Mercer MP, Wood AJ, et al. Evaluating the feasibility of prehospital point-of-care EEG: The prehospital implementation of rapid EEG (PHIRE) study. *JACEP Open*. 2024;5:e13303. https://doi.org/10.1002/emp2.13303

AUTHOR BIOGRAPHY

Elan Guterman, MD, MAS, is an Associate Professor in the Department of Neurology at the University of California San Francisco Weill Institute of Neurosciences. She specializes in the care of patients with neurological conditions, particularly those seen in emergency and hospital settings.