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Systematic Evaluation of Research Priorities in Critical Care Electroencephalography

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Abstract

Introduction—The Critical Care EEG Monitoring Research Consortium (CCEMRC) is an international research group focusing on critical care EEG and epilepsy. As CCEMRC grew to include 50+ institutions over the past decade, members met to establish research priorities.

Methods—We utilized an Analytical Hierarchy Process-based research prioritization method, adapted from an approach previously applied to a Department of Defense health-related research program. Forty-six CCEMRC members identified and scored a set of eight clinical problems (CPs) and 15 research topic areas (RTAs) at an annual CCEMRC meeting. Members scored CPs on three criteria using a 5-point ordinal scale: Incidence, Impact, and Gap Size; and RTAs on four additional criteria: Niche, Feasibility, Scientific Importance, and Medical Importance, each of which was assigned a weight. The first three RTA criteria were scored using a 5-point scale, and CPs were mapped to RTAs using a 4-point scale. The Medical Importance score was a weighted average of its mapping scores and the CP score. Finally, a Priority score was calculated for each RTA as a product of the four RTA criteria scores.

Results—The CPs with the highest scores were "Altered mental status" and "Long term neurologic disability after hospital discharge." The RTAs with the highest priority scores were

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"Development of risk prediction tools," "Multicenter observational studies," and "Outcome prediction."

Conclusion—Research prioritization helped CCEMRC evaluate its current research trajectory, identify high-priority near-term research pursuits, and create a roadmap for future research plans aligned with its mission. This approach may be helpful to other academic consortia and research programs.

Keywords

Critical Care EEG; Research prioritization; CCEMRC (Critical Care EEG Monitoring Research Consortium); CEEG (continuous EEG); ICU EEG; Research organization

Introduction

A small group of clinical neurophysiologists established the Critical Care EEG Monitoring Research Consortium (CCEMRC) in 2007. CCEMRC's mission is to provide a forum for collaborative research, promote quality improvement, and standardize clinical practice of critical care EEG. Since its inception, CCEMRC has published (1), validated (2) and revised standardized critical care EEG research terminology guidelines (3, 4), conducted a multicenter randomized controlled drug trial (5), established a multicenter EEG research database (6–8), and collaborations among its members have resulted in numerous original research articles (6, 7, 9–23).

CCEMRC has expanded to include members from more than 50 clinical centers. With this growth has come diversification of research interests. Aiming to achieve community consensus and focus on priorities, the authors developed and applied a novel systematic approach to identify, evaluate, and prioritize research areas relevant to CCEMRC's mission. This approach primarily aims to prioritize research topics that will produce the most clinical and scientific impact. The potential benefit is based on the number of clinical problems (CPs) a research topic addresses and the incidence, impact, and current care gaps related to each of the CPs that the research area could address. Through this approach, CCEMRC has intertwined pertinent clinical problems and relevant research pursuits to advance its clinically-focused scholarly mission.

Methods

We adapted a research prioritization method that was previously used for a Department of Defense health-related research program employing the Analytical Hierarchy Process (AHP) (24). The AHP is a structured process for analyzing and reconciling weighted criteria by a group of stakeholders (25, 26). The adaptation of the AHP used in the present study consisted of nine steps (see Fig. 1):

1. Participant recruitment/demographics
2. Identifying and defining clinical problems (CPs)
3. Identifying and defining the research topic areas (RTA)

4. Scoring of CPs
5. Scoring of RTAs
6. Mapping RTAs to CPs
7. Scoring the Medical Importance of RTAs
8. Comparing the importance of RTA rating criteria
9. Calculating priority scores for RTAs

1. Participant Demographics

Participants are the members of CCEMRC. Forty-six members who attended the bi-annual CCEMRC meeting on Feb 7, 2020, participated; demographic data is available for 44. All participants are neurologists, 80% practicing adult neurology and 20% child neurology. About two thirds of participants completed either a clinical neurophysiology or an epilepsy fellowship, and a third did both. About 20% (7/44) have neurocritical care training with additional EEG training. All members (except one) practice at academic institutions (Table S1 SDC).

2&3. Identifying and defining clinical problems and research topic areas:

CPs were defined as the medical conditions affecting patients for which gaps exist in knowledge that research could address. RTAs are the areas of investigation that can help close such CP related gaps. For example, non-convulsive seizures (NCSz) is a CP that has areas needing more research such as risk factors, treatment approach, and long term outcomes, which constitute a set of RTAs for this CP.

Two authors (MBW, ABC) created a preliminary list of CPs and RTAs and sought input from all CCEMRC members (~70) via email before the meeting. The members were asked to suggest additions, deletions and modifications to this list. Thus, a list of prospective CPs and RTAs was formulated. Members also received a survey in email before the meeting to assign weights to the scoring criteria for RTA (Feasibility, Niche, Scientific Importance and Medical Importance), and those who planned to attend the upcoming meeting were asked to complete the survey. Forty-six members completed the survey. All scoring criteria were created by two authors (MBW, ABC).

The RTAs were further grouped into six thematic categories, each containing 4–6 RTAs. During the meeting, the members were divided into 6 groups and each group characterized the RTAs by writing 1–2 sentences to allow inter-member definition, understanding and consistency, which was presented to and adjudicated by the larger group (Table S2, SDC). Members were free to decide which group to join, based on interests.

4. Scoring of Clinical Problems:

At the meeting, using a scorecard (Fig. S3-A and S3-B), each member rated every CP using a 5-point Likert scale (27) across three criteria: Incidence (of the clinical condition/disease), Impact (based on mortality, morbidity, cost), and Gap Size (i.e., "How much needs to be done to address the problem?"). These three scores were then scaled to lie between 0 and

1; we denoted the rescaled scores by I_j, V_j, G_j, where j referred to the participants (j = 1,2,…,46). For each CP, an overall score was calculated for each participant, j, as the average of the three scores, $CP_j = (I_j + V_j + G_j)/3$. (Table 1).

5. **Scoring of Research Topic Areas:**

Each of the six groups was assigned one of the six thematic RTA categories. Each member was then asked to rate each of the RTAs along a 5-point Likert scale using three criteria: Feasibility (F, "What is the probability of success?"), Niche (N, "Is CCEMRC better positioned than others to solve this?"), and Scientific Importance (S, "How much would our understanding increase? Would the knowledge generalize?") (Table 2 & Figs. S4-A and S4-B). The three scores were scaled to lie between 0 and 1; we denoted the rescaled scores by F_j, N_j, S_j, where j refers to the participants (j = 1,2,…,46) Although all RTAs were scored (Table 2), due to time constraints, not all were mapped. Each group was asked to present the two most important RTAs and the rationale for choosing them. Feedback was invited from the other members. In 4 of 6 sets of RTAs, the two RTAs recommended by the small group was accepted by the large group. For the other two sets of RTAs, the larger group recommended that more than two of the RTAs should be retained. Thus, 3 RTAs from one set and 4 from another were selected. Thus, total of 15 RTAs out of 27 were mapped to the 8 CPs (Table 3).

6. **Mapping RTAs to CPs:**

CCEMRC members then mapped each of the 15 RTAs to each of the eight CPs by assigning a score of 0–3 based on the degree to which the RTA addresses the CP (Fig. S5-A and S5-B) (mapping score). A higher mapping score indicated that an RTA was particularly relevant to the the CP. These scores were then normalized to lie between 0 to 1. The resulting scores $m_{i,j}$ express how strongly each RTA i is relevant to or maps onto CP j.

7. **Scoring the Medical Importance of RTAs:**

Each RTA was then assigned a Medical Importance score M_i, by taking a weighted average of the mapping scores, with weights given by the CP scores CP_k:

$$M_i = \sum_{k=1}^{8} m_{i,k} CP_k$$

In this way, RTAs that mapped more strongly (i.e., had higher mapping scores, $m_{i,j}$) onto more and higher priority CPs (i.e., CPs with higher scores, CP_k) received higher Medical Importance scores.

8. **Comparing the importance of RTA rating criteria:**

Using the AHP method, we calculated relative importance weights for each of the rating criteria applied to the RTAs [i.e., Feasibility (F), Niche (N), Scientific Importance (S), and Medical Importance (M)]. To accomplish this, members completed a six-question survey comparing the relative importance of each possible pairing of F, N, and S. For each pairwise comparison participants were asked to indicate whether the two factors were of equal importance (relative importance of 1); or if one factor was more important than the other, to indicate to what degree on a scale of 1 to 10. These scores were used to construct a pairwise comparison matrix for each rater, denoted $\widetilde{A_k} = \{\widetilde{a}_{ij}\}$, where k represented the rater (k = 1,2,…,46), and the index i denoted the rows, and j denoted the columns of the matrix. The matrix was constructed as follows: Let rows 1 through 4 be associated with F, N, S, M, respectively, and let columns 1 through 4 be ordered in the same way. Thus, $\widetilde{A_k}$ had four rows and four columns. The completed entries of the matrix were filled as follows: when $\widetilde{a}_{12}$ corresponded to the comparison of F vs. N, and a participant responded that F > N (i.e., Feasibility was more important than Niche), the relative importance was scored as a 9, and $\widetilde{a}_{12} = 9$ was entered. Otherwise, if F < N with a score of 9, the reciprocal, $\widetilde{a}_{12} = 1/9$ was entered. Note that the matrix was not symmetric. Instead, entries in the lower corner are reciprocal to entries in the upper corner, $\widetilde{a}_{ji} = 1/\widetilde{a}_{ij}$.

The survey yielded 46 pairwise comparison matrices from 46 participants. From these, the average pairwise comparison matrix was obtained, $\overline{A} = \frac{1}{46}\sum_{k=1}^{46}\widetilde{A_k} = \{\overline{a}_{ij}\}$. Each column was then normalized to sum to 1, yielding the normalized comparison matrix, denoted $A = \{a_{ij}\}$, where, $a_{ij} = \overline{a}_{ij}/\sum_{i=1}^{4}\overline{a}_{ij}$.

Finally, the relative importance weight w_j for each factor was obtained by averaging the entries in each row of $\overline{A}$, i.e. $w_i = \frac{1}{4}\sum_{k=1}^{4}a_{ik}$.

9. Calculating the Priority Scores of RTAs:

Finally, a Priority Score R_i was calculated for each RTA. This was performed by adding the scores for F, N, S, and M, weighted by their relative importance:

$$R_i = w_F F_i + w_N N_i + w_S S_i + w_M M_i$$

Results

Forty-six CCEMRC members (Table S1) participated in the survey and completed the questionnaire.

CP scoring:

Of the eight identified CPs, the highest Incidence score (4.4) was given for “Altered mental status (AMS)/ encephalopathy,” followed by “Long-term neurologic disability after hospital discharge” (3.9) (Table 1). “Refractory/super-refractory status epilepticus (RSE/SRSE)” received the highest score for impact (4.4), followed by “Coma/prognosis following cardiac arrest” (4.2). “RSE/SRSE” and “Long-term neurologic disability after hospital discharge” had the largest Gap sizes with scores of 4 for each; these were followed by “Secondary brain injury after acute brain injury (ABI)” (3.8). “Long-term neurologic disability after discharge” and “AMS/encephalopathy” had the highest CP scores (0.14 each). The “AMS/ encephalopathy” score was driven mainly by its incidence score.

RTA scoring:

Among all RTAs (Table 2), “Triage tools: who should get EEG, for how long” received the highest score for Feasibility (4.5), followed by “Developing test data sets for commercial products” and “Setting standards for evaluating commercial products,” with scores of 4.4 each. Members scored “Risk prediction tools” the highest (4.6) for Niche. The RTAs that received the next highest Niche scores (all at 4.5) were “Triage tools: who should get EEG, for how long,” “Level of aggressiveness for treatment of status epilepticus: seizure suppression vs. burst suppression” and “Multicenter observational studies”. The RTA with the highest Scientific Importance score was “Outcome prediction: ictal-interictal continuum (IIC)/seizures, subarachnoid hemorrhage (SAH) delayed cerebral ischemia (DCI), cardiac arrest coma, and post-traumatic encephalopathy” (4.9).

Mapping results:

The CP that mapped most strongly across all RTAs was “NCSz + IIC,” with a score range of 2.2–2.8. This was followed by “RSE/SRSE” with a score range between 2.1–2.9 and “Secondary brain injury after ABI” at’ a range of 1.7–3. On the other hand, the CP that mapped most weakly across all RTAs was “AMS/encephalopathy” with a score range between 1–2.2 (Table 3).

For the RTA mapping scores, the highest was seen for “Risk prediction tools” ranging from 1.9–2.8 and “Multicenter observational studies” ranging from 1.9–2.7, followed by “Research repositories” (2.2–2.6), as shown in Table 3.

Medical importance scores for RTAs.

Using a weighted average of the mapping scores with the weights given by the CP scores, each RTA was assigned a Medical Importance score. “Risk prediction tools” received the highest Medical Importance score of 0.28 (Fig 2), followed by “Multicenter observational studies” (0.275), “Research repositories” (0.273), and “Mechanisms of seizures/IIC” (0.271).

RTA priorities.

Based on the weights assigned by the AHP process to each of the four RTA criteria (Feasibility, Niche, Scientific Importance, Medical Importance), the RTAs with the highest scores were “Risk prediction tools” (0.80) and “Multicenter observational studies” (0.78). These were followed by “Outcome prediction” with at 0.77 (Fig. 2). The lowest RTA priority scores were “Optimizing timing of cEEG” at 0.49 and “Collaborations with basic scientists” at 0.55. (Fig. 2)

Discussion

As CCEMRC has grown in membership, the need has arisen to clarify its priorities. The systematic method presented herein allowed the consortium to identify 8 key CPs and 27 key RTAs, and to work systematically and objectively as a group to prioritize the RTAs in a short time.

“Risk prediction tools” had the highest overall RTA score, followed by “Multicenter observational studies” and “Outcome prediction.” This finding may affirm the importance of work to date by CCEMRC related to risk prediction models for assessing the probability of NCSz (6, 8, 17). These studies have found wide clinical application, particularly in triaging the allocation of the continuous-EEG resource to the patients at the highest risk. Future development of diagnosis-specific risk prediction tools will advance the understanding of neurological prognostication across heterogeneous populations and the risk of acute seizure occurrence and subsequent long-term disability. One advantage of our RTA prioritization method is that it identifies RTAs, such as “risk prediction tools,” that can improve health and care across multiple CPs.

“Outcome prediction,” particularly prediction of epileptogenesis, has been of interest in the ABI population. As more patients survive ABI and return to the community, their close post-discharge management, including potential epilepsy care, is paramount. Published literature suggests that IIC patterns or seizures in the acute phase are associated with a higher risk of epilepsy (28). The NORSE (New-Onset Refractory Status Epilepticus) study group, which started as a CCEMRC-driven multicenter prospective observational collaboration, has defined NORSE and FIRES (Febrile Infection Related Epilepsy Syndrome)(29). This lays the foundation for multicenter collaboration for research in this area. Finally, the cardiac arrest study group and the IIC groups are additional examples of CCEMRC working groups focusing on outcome prediction.

Fostering multicenter observational studies is a next logical phase of CCMERC growth. As noted, “Multicenter observational studies” was a high-priority research area. This research category also serves as the most common research approach adopted by various interest groups within CCEMRC over the past decade, as discussed with the outcome prediction RTA. Important examples of such early collaborations within CCEMRC are seen in the studies that defined the prevalence and established the significance of rhythmic and periodic EEG patterns.(6) Several multicenter studies assessing the impact of NCSz on clinical outcomes have been conducted in both adult and pediatric cohorts.(30, 31)

“NCSz/IIC” was identified as a clinical problem mapping to multiple CCERMC RTAs. Seizures affect approximately 20% of critically ill patients monitored with cEEG, and more than 90% are NCSz (32). The detection of NCSz remains a primary goal of cEEG monitoring. Nonconvulsive seizures and nonconvulsive status epilepticus (NCSE) are associated with high mortality, 33%, and 57%, respectively(31). However, it remains unknown whether treatment translates into improved patient outcomes. Furthermore, the impact of treatment of EEG patterns that represent possible NCSz or NCSE, known as the IIC, is more elusive. Ictal-interictal continuum, NCSz /NCSE represent common EEG findings in critically ill patients, and the CCEMRC is poised to lead future research addressing these critical knowledge gaps.

“Altered mental status/encephalopathy” was the CP that mapped most weakly across RTAs, despite being rated the highest for incidence. This is consistent with a real-world scenario of finding a high incidence of encephalopathy in critically ill patients as it represents a non-specific symptom present in various conditions. The CCEMRC members likely thought that pursuing a mere symptom of heterogeneous etiology will not be efficient; rather, focusing on the underlying primary brain injury and resultant variables that pose a risk of secondary brain injury are important areas needing research. The inclusion of an accompanying primary brain condition (e.g. TBI) in defining the encephalopathy may have resulted in different results.

Since all research organizations have limited resources, all must focus their energy and prioritize their pursuits. Different organizations have used an array of research prioritization methods.

National Institute of Health (33), Gates Foundation (34) (35), Google AI (36, 37), NASA(38), clinical departments within academic hospitals, and other clinical research consortia, such as for Parkinson disease, intracerebral hemorrhage, and pediatric status epilepticus have applied diverse methods to identify and prioritize research (39–41).

We believe that our method will be of particular value to organizations and programs with a well-defined mission, whose core values can be distilled into weighted criteria, and where a typical RTA has relevance across multiple CPs – a common scenario. This method is also potentially helpful for prioritizing research pursuits outside healthcare.

Limitations

Our method has several limitations. The identification and definitions of CPs and RTAs were based on consensus among a fine group of like-minded clinicians and researchers. A different group of stakeholders, even those with a mission similar to CCEMRC, may have reached other CPs, RTAs, criteria, or criteria weights than this group. As such, we may have excluded important CPs and RTAs. Further, CPs and RTAs, including those in this report, can be too high level, low level, or somewhere in between. Thus, the granularity of any CP or RTA could limit the utility of our approach and results. The scoring approach was largely subjective and based on the input from a limited group. Some of the scores could instead be calculated objectively. For example, the Incidence and Impact scores could directly reflect available data on measures of disease incidence, mortality, morbidity, and cost. Finally, this approach does not provide a research road map – i.e. a framework by which an organization should sequentially invest in specific research pursuits to achieve a specific operational goal. The method does, however, provide crucial inputs to the development of such a road map. Another limitation is sampling bias due to the interests of participants of this exercise. Therefore, the results of the survey may not represent the opinions of all CCEMRC members.

Conclusion

The research prioritization demonstrated the top research interests for the CCEMRC as “Risk prediction tools” and the top clinical problem as “NCSz/ IIC.” These results will facilitate shaping future research trajectory per the consortium’s mission. This methodology can be utilized by the other research groups and tailored to their mission to streamline their research initiatives. This method customization is reflected in the scoring criteria and weights in particular. Thus, although the results here may not reflect the mission and values of other organizations, the method is intended to be flexible and adaptable, to help any organization achieve its research objectives.

Supplementary Material

Refer to Web version on PubMed Central for supplementary material.

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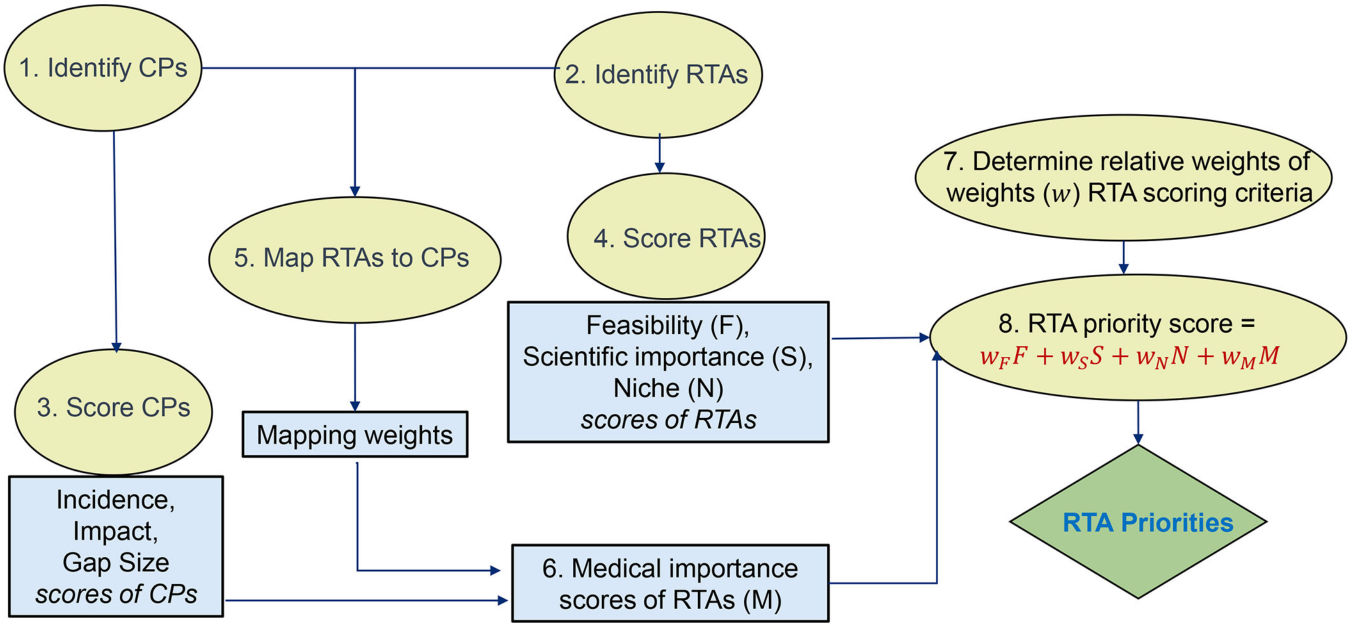

Figure 1:

Flow diagram depicting the identification, scoring, and mapping of clinical problems (CPs) with research topic areas (RTAs) by the Critical Care EEG Monitoring Research Consortium (CCEMRC); adapted from the Department of Defense health-related research program methodology for research prioritization. Ovals represent the steps involved in the process and rectangles represent the criteria used for scoring CPs and RTAs.

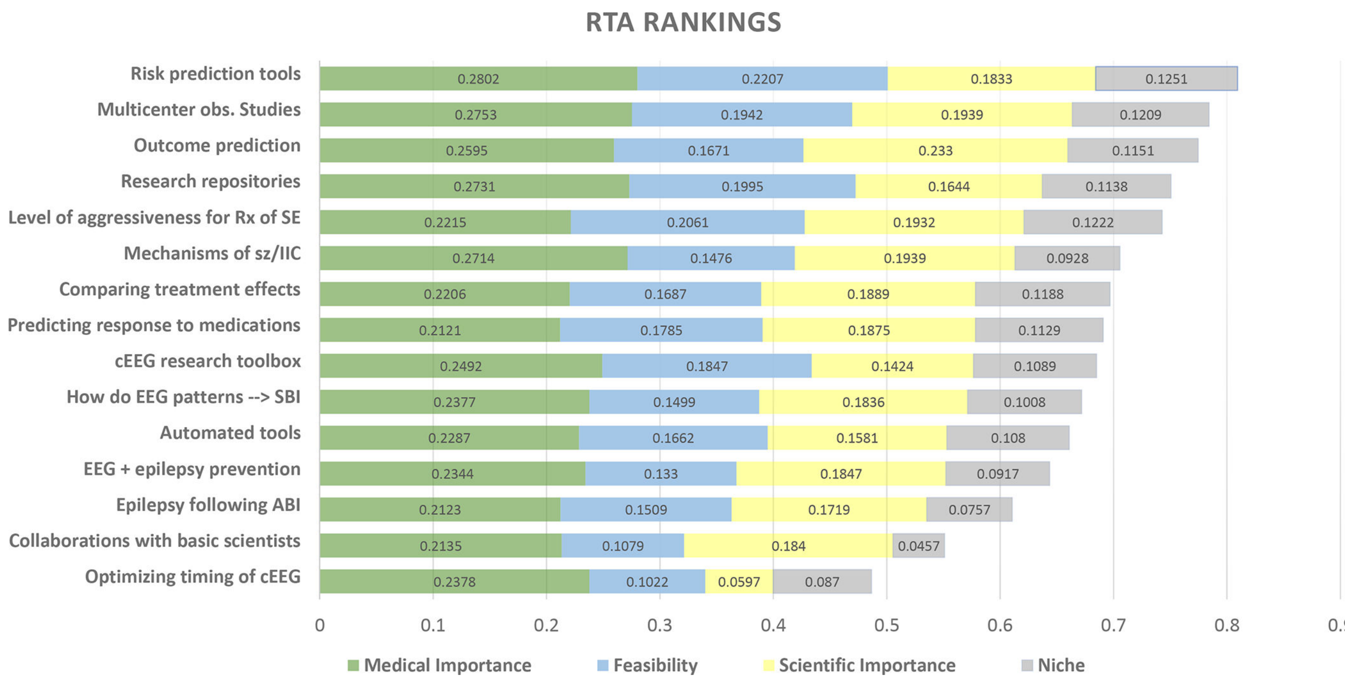

Figure 2:

Stacked bar-graph showing RTA Priority scores and individual scores for Medical importance, Feasibility, Scientific importance and Niche. RTA, Research Topic Areas. M, Medical importance; F, Feasibility; S, scientific importance; N, Niche; SE, status epilepticus, IIC, ictal-interictal continuum; cEEG, continuous EEG obs.: observational, Rx: Treatment, SBI: Secondary Brain Injury ABI: Acute Brain Injury, Sz: seizure.

Table 1:

Clinical problems and clinical problem (CP) scores

Clinical Problems	Incidence	Impact	Gap size	Normalized Average
1. Subclinical seizures and IIC patterns in critically ill patients	3.2	3.6	3.6	0.12
2. Coma/prognosis following cardiac arrest	2.5	4.2	3.3	0.12
3. Coma/prognosis following acute brain injury	3.0	3.8	3.7	0.12
4. Refractory / super-refractory status epilepticus	2.2	4.4	4.0	0.13
5. Altered mental status / encephalopathy	4.4	3.2	3.5	0.14
6. Long term neurologic disability after hospital discharge	3.9	3.7	4.0	0.14
7. Epilepsy following acute brain injury	2.5	3.4	3.7	0.11
8. Secondary brain injury following acute brain injury	2.9	3.4	3.8	0.12

IIC, ictal-interictal continuum.

Table 2:

RTA categories and scores for Feasibility, Niche, and Scientific importance.

Categories & Research Topic Areas	Feasibility	Niche	Scientific importance
1. Increasing efficiency and access to EEG monitoring			
Risk prediction tools	4.2	4.6	4.1
Triage tools: who should get EEG, for how long?	4.5	4.5	3.3
Optimizing timing of cEEG	2.5	3.5	2.0
Increasing access to EEG monitoring	3.5	4.0	3.1
2. Treatment of seizures and IIC patterns			
Relative effectiveness of drugs (e.g. IV perampanel)	3.4	3.0	3.6
Early treatment of status epilepticus (SE)	3.1	3.1	3.3
Level of aggressiveness for Rx of SE: sz supp vs burst suppression	4.0	4.5	4.2
EEG-driven interventions: seizure prophylaxis in acute brain injury	2.9	3.1	3.3
Predicting response to medications in NCSz/NCSE/RSE	3.6	4.2	4.1
Multimodal monitoring	2.6	2.0	4.0
3. Understanding secondary brain injury			
Development of epilepsy following acute brain injury (stroke, ICH, TBI, NORSE)	3.2	3.2	3.9
Mechanisms underlying sz/IIC in acute brain injury	3.2	3.7	4.3
When and how do EEG patterns lead to secondary brain injury	3.2	3.9	4.1
Developing collaborations with basic scientists	2.6	2.3	4.1
4. Automation:			
Developing test data sets for commercial products	4.4	1.6	2.1
Developing automated tools: detection, risk prediction, …	3.4	4.1	3.7
Setting standards for evaluating commercial products	4.4	2.8	2.8
Outcome prediction: IIC/sz, SAH DCI, Cardiac Arrest coma, PTE	3.5	4.3	4.9
Setting standards for evaluating / certifying commercial products	3.7	3.3	3.6
5. EEG role in improving clinical outcomes:			
Prediction of prognosis in: postanoxic coma, NORSE, SAH, TBI, PTE	3.1	3.8	3.6

Categories & Research Topic Areas	Feasibility	Niche	Scientific importance
Historical control trials / comparative effectiveness vs RCTs	2.8	3.0	3.6
EEG-drive intervention to prevention epilepsy after brain injury	3.0	3.6	4.1
EEG-driven interventions: relative effectiveness of treatment strategies in treating seizures and IIC patterns, over versus under treatment	3.5	4.4	4.2
6. Enabling collaboration and larger scale research			
Multicenter obs. studies (EEG -> central repository + imaging or probe data, outcomes) for comparative effectiveness research	3.9	4.5	4.3
Development of a standard cEEG toolbox for researchers	3.7	4.1	3.4
Partnering with biorepositories to evaluate novel “omics”	1.6	2.1	3.2
Creating repositories to warehouse EEG and other physiologic data	3.9	4.3	3.8

RTA, Research Topic Areas; Sz Supp: Seizure suppression; NCSz, Nonconvulsive seizures; NCSE, Nonconvulsive Status Epilepticus; RSE, Refractory Status Epilepticus; ABI, Acute Brain Injury; ICH, Intracranial Hemorrhage; TBI, Traumatic Brain Injury; NORSE, New-Onset Refractory Status Epilepticus; IIC, Ictal-Interictal Continuum; SAH, Subarachnoid Hemorrhage; DCI, Delayed Cerebral Ischemia; PTE, Post-Traumatic Encephalopathy; RCTs, Randomized Clinical Trials.

Table 3:

Mapping of Research Topic Areas to Clinical Problems

	RTAs to Clinical Problem Mapping For the <u>top 2 RTA</u>, assign a score 0–3 for mapping	**Subclinical sz + IIC**	**Coma after cardiac arrest**	**Coma after ABI**	**RSE / SRSE**	**AMS/ delirium**	**Post-hospital neuro disability**	**Epilepsy following ABI**	**2ndary brain injury**
Increasing efficiency of EEG monitoring	Risk prediction tools	2.8	2.6	2.6	2.5	1.9	2.3	2.4	2.3
	Optimizing timing of cEEG	2.6	2.0	1.9	2.4	2.0	1.7	1.7	2.0
Treatment of seizures and IIC patterns	Level of aggressiveness for Rx of SE	2.8	1.8	1.7	2.9	1.0	1.7	1.6	1.7
	Predicting response to medications	2.9	1.7	1.4	2.8	1.0	1.5	1.5	1.8
Understanding secondary brain injury	Epilepsy following ABI	2.2	1.2	1.4	2.1	1.1	2.0	2.6	2.0
	Mechanisms of sz/IIC	2.7	2.0	2.3	2.7	1.7	2.3	2.0	3.0
	How do EEG patterns --> SBI	2.6	1.7	1.8	2.5	1.4	1.9	2.1	2.4
	Collaborations with basic scientists	2.3	1.6	1.6	2.1	1.3	1.5	2.2	2.3
Automation	Automated tools	2.6	2.1	2.1	2.1	1.3	1.6	1.9	2.0
	Outcome prediction	2.6	2.6	2.5	2.3	1.5	2.1	2.1	2.2
EEG role in improving clinical outcomes	EEG + epilepsy prevention	2.9	1.9	1.8	2.8	1.2	1.6	1.8	2.3
	Comparing treatment effects	2.4	1.5	1.7	2.2	1.0	1.8	2.5	2.2
Enabling collaboration and larger scale research	Multicenter obs. Studies	2.7	2.4	2.4	2.4	1.9	2.2	2.4	2.5
	cEEG research toolbox	2.5	2.4	2.3	2.3	1.9	1.9	1.8	2.1
	Research repositories	2.6	2.5	2.5	2.5	2.2	2.2	2.2	2.3

IIC, ictal interictal continuum; ABI, acute brain injury; RSE, refractory status epilepticus; SRS, super refractory status epilepticus; AMS, altered mental status; SBI, secondary brain injury; Rx, Treatment, Obs, Observational; Sz: seizure