MEKELLE UNIVERSITY
COLLEGE OF HEALTH SCIENCES
SCHOOL OF MEDICINE
DEPARTMENT OF PEDIATRICS AND CHILD HEALTH

A Study on Electroencephalography (EEG): Its Indications, Findings, and Predictors of Abnormal Results In Pediatrics Age group at Ayder Comprehensive Specialized Hospital, Mekelle, Northern Ethiopia

BY: Freweini Gebremeskel (MD)

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DEPARTMENT OF

NAME OF INVESTIGATOR	Freweini Gebremeskel (MD)
NAME OF ADVISORS	Dr. Abraha G/zgabhier (Neurologist, Assistant Professor of Pediatrics and Child health) Dr. Niguse Tsegay (MD, Assistant Professor of Pediatrics and Child health) Dr.Simret Nigus (MD, Assistant Professor of Pediatrics and Child health) Dr.Gebremedhn Gebremichael (MD, Assistant Professor of Pediatrics and Child health) Mebrahtu K (Public health)
	A Study on Electroencephalography (EEG): Its Indications, Findings, and Predictors of Abnormal Results in Pediatrics Age group at Ayder Comprehensive Specialized Hospital, Mekelle, Northern Ethiopia
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ADDRESS OF THE INVESTIGATOR	Phone Number- +251914767851 E-Mail: fruta.nanu@gmail.com

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MEKELLE, TIGRAY, ETHIOPIA

Declaration

Assurance of principal investigator

I agree to accept responsibility for the scientific, ethical and technical conduct of the research proposal project & provision of the required progress report as per terms and condition of the College of Health Sciences in effect at the time of grant is forwarded as the result of this application.

Name of Investigator	Signature	Date
Freweini Gebremeskel (MD)	_____	_____

Approval of the advisors

This thesis has been submitted with my approval as university advisor.

Name of the advisors	Date	Signature
Dr. Abraha G.		
Dr .Niguse T.		
Dr. Simret N.		
Dr.Gebremedh G.		
Mr.Mebrahtu K.		

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ACRONYMS AND ABBREVIATIONS

ACSH	Ayder Comprehensive specialized hospital
AED	Anti-Epileptic Drugs
AOR	Adjusted Odds Ratio
CHS	College of Health Sciences
CI	Confidence Interval
COR	Crude Odds Ratio
EEG	Electrocephalogram
GDD	Generalized Developmental Delay
GTC	Generalized Tonic Clonic
IRB	Institutional Review Board
MD	Motor Delay
MU	Mekelle University
TASH	Tikur Anbessa Specialized Hospital

Abstract

Background: Electroencephalography, often referred to as EEG, is a non-invasive electrophysiological imaging technique used to record the brain's electrical activity. In Ethiopia, particularly Tigray, there is no study a specific study on EEG study among pediatric age group, its indications, and findings at Ayder Comprehensive Specialized Hospital (ACSH) in Mekelle, Northern Ethiopia.

Objective: To study the indications for EEG, the prevalence of abnormal EEG results, and identify predictors of EEG abnormality in pediatrics age group at ACSH.

Methods : A cross-sectional study was carried out on 439 pediatric patients who underwent EEG study at ACSH for a range of neurological disorders from October 2019 to September 2024. Data were collected using a checklist, with the data source being electronic EEG records. The ODK collect mobile application was used for simultaneous data collection and entry. After exporting data to SPSS 27, both descriptive and inferential statistics were applied. Binary logistic regression was fitted to identify predictors of EEG abnormality. A p-value less than 0.05 was used to declare statistical significance.

Result: The mean age of the study participants is 7.9 years and about two-third (63.6%) were male. More than three-fourths (77.0%) were right-handed and the most common clinical diagnosis wa generalized epilepsy (62%) and 89% of the participants had seizure history. The most prevalent EEG finding was generalized epileptiform (43.1%). Overall, two-thirds (66.5%) of the EEG studies exhibited abnormality. The odds of abnormal EEG findings were almost five times higher in children not on remission (AOR=4.6, 95% CI: 1.9 to 11.2, p=0.001). The odds of abnormal EEG were seven times higher in children with history of seizure (AOR=7.0, 95% CI: 3.4 to 14.3, p<0.001). The odds of abnormal EEG findings were found to increase by 20% as duration of epilepsy rises by one year (AOR=1.2, 95% CI: 1.1 to 1.4, p=0.001). The odds of abnormal EEG results were 12.6 times higher among children who had no febrile seizures than their counterparts (AOR=12.6, 95% CI: 1.4 to 111.3, p=0.022).

Conclusion and Recommendations: In the present study, the prevalence of abnormal EEG results was higher compared to other Ethiopian studies due to different reasons. Factors remarkably related to EEG abnormality are duration of seizure/epilepsy, febrile seizure, seizure history, and remission status. Therefore, more emphasis should be given to children with an on-going seizure (not on remission) and long history of seizure. Further research on the relationship between EEG abnormality and febrile seizure should be conducted and supported by concerned bodies.

Key words: EEG, Children, Mekelle, Ethiopia

1. INTRODUCTION

1.1.BACKGROUND

Electroencephalography, commonly known as EEG, is a non-invasive electrophysiological imaging technique that records the electrical activity of the brain. This technique, which was first demonstrated by the German psychiatrist Hans Berger, involves the use of electrodes placed on the human scalp to measure and amplify signals, plotting voltage variations over time (1). EEG has become a significant tool in both scientific research and medical. It provides a unique window into the workings of the human brain, allowing researchers and clinicians to study and diagnose a variety of neurological conditions (2). Today, EEG continues to be a crucial tool in understanding brain function and diagnosing neurological diseases (3).

Electroencephalography (EEG) offers several benefits in both the scientific research and medical fields, as highlighted in various journal articles: EEG is recognized for its high degree of temporal resolution, allowing it to measure neuronal processes in the time frame in which these processes occur, namely in the sub-second range (4,5). Another significant advantage of EEG is its portability, which enables its use in real-life environments. This makes it a versatile tool for studying brain function outside of traditional laboratory or clinical settings. Compared to other neuroimaging measures, EEG is relatively affordable, making it accessible for a wide range of applications (4). EEG is a non-invasive measurement method for brain activity, which contributes to its safety (2). EEG acquisition has revealed associations between brain functionality, cognition, and emotions, providing essential insights for psychologists and neuroscientists. In the medical field, EEG signals are employed for epilepsy diagnosis, brain injury monitoring, and sleep disorder research (6).

Electroencephalography (EEG) plays a crucial role in the diagnosis and management of epilepsy, a neurological condition involving recurrent seizures. During epilepsy diagnosis, EEG plays an important role since it records the electrical activity of the brain. Doctors often use EEG after a patient experiences their first seizure to look for changes in brain activity that are characteristic of epilepsy. In addition, the results of an EEG can help doctors monitor the effects of starting,

changing, or withdrawing anti-seizure medication. It is also used to monitor patients with subclinical or unrecognized seizures (7).

Electroencephalography (EEG) can also help determine the type of seizure and epilepsy a patient has. And also, certain triggers, like lack of sleep, can be identified through EEG. If a patient has partial seizures, spikes and sharp waves on the EEG in a specific area of the brain can show where the seizures are originating from. In some cases, long-term EEG monitoring, such as ambulatory EEG or video telemetry, may be recommended. These methods involve recording brain activity over one or multiple days, or even up to weeks in the case of invasive EEG-telemetry. Sleep EEG might help reveal atypical activity that doesn't show up on a routine EEG or help diagnose sleep-related epilepsies. These applications emphasize the value of EEG in advancing our understanding of epilepsy and improving its diagnosis and treatment (7–10).

1.2. STATEMENT OF THE PROBLEM

The overuse of Electroencephalography (EEG) in resource-limited settings, such as Ethiopia, presents a significant problem. While EEG is an invaluable tool in diagnosing and managing neurological disorders, its overuse can lead to several issues: The overuse of EEG can lead to the misallocation of limited healthcare resources. In resource-limited settings, it's crucial to ensure that EEG is used appropriately and efficiently. Maintenance for EEG machines can be a challenge in resource-limited settings2. Over-reliance on EEG can exacerbate health inequities, as not all patients may have access to this technology (11).

Adding to the complexity of the problem is the high prevalence of normal EEG findings. For instance, a study conducted in Nepal found that EEG was normal in 66.7%% of cases. This high prevalence of normal findings underscores the need for appropriate use and interpretation of EEG (12). Another study done in Tikur Anbessa Specialized Hospital also found that EEG was normal in 44.8% of the cases(13).

The issue is further exacerbated by the lack of research on the prevalence of abnormal EEG results and their determinants in developing countries, particularly Ethiopia. Notably, there is an absence of published studies on EEG, its indications, and findings in Ayder Comprehensive Specialized Hospital, located in Mekelle, Northern Ethiopia. This gap in data hinders the

development of effective strategies for the optimal use of EEG and the management of neurological disorders within the facility. As a result, there is an urgent need for a study to determine the indications for EEG, the prevalence of abnormal EEG results, and their predictors in this context.

1.3. SIGNIFICANCE OF THE STUDY

This study will address the current lack of research on the prevalence of abnormal EEG results and their determinants in Ethiopia, particularly at Ayder Comprehensive Specialized Hospital. By doing so, it will contribute to the existing body of knowledge and provide valuable insights specific to the context. Understanding the common indications for EEG, the prevalence of abnormal results, and their predictors can guide clinicians in making informed decisions about when to use EEG and how to interpret the results.

The study will also serve a crucial role in describing the common findings and indications for EEG signals at Ayder Comprehensive Specialized Hospital. This will provide a comprehensive overview of the EEG landscape in the hospital, offering valuable insights into the most frequent neurological conditions that necessitate the use of EEG

The results of this study can guide policy-making and resource allocation. By highlighting the areas where EEG is most needed and identifying the factors that predict abnormal results, policymakers and hospital administrators can allocate resources more effectively.By enhancing our understanding of EEG usage and its outcomes, healthcare providers can better diagnose and manage neurological disorders, leading to improved patient outcomes.

2. LITERATURE REVIEW

Different literature have addressed EEG indications, findings, and prevalence of abnormal findings. This section will try to summarize these things by reviewing some of the scientific articles.

2.1. Source of referral and EEG Indications

According to a study done in Tikur Anbessa Specialized Hospital (TASH), the most common source of referral for EEG was the neurologic referral clinic (82%) followed by medical ward (4%). The most prevalent indication for EEG was abnormal body movement with loss of consciousness (35.2%) followed by the need to taper anti-epileptic drugs (AEDs) (18.2%) (13).

A study conducted in Turkey, which examined 2045 EEGs in children ranging from 2 months to 20 years old, found that a pediatric neurologist requested 90.5% of the EEGs (14). Another study conducted in Canada also revealed that majority of EEG requests were made by neurologists (45%) succeeded by pediatricians (32%) and GPs (17%) (15). In contrary, another African study disclosed that pediatric neurologists were responsible for requesting 24% of the electroencephalogram studies, while pediatricians requested 45% of the cases. Compared to pediatricians and nonspecialists, pediatric neurologists made more reasonable and appropriate referrals. In 40% of the cases, the management was aided by the electroencephalogram studies. In this study, the most common source of referral was medical outpatient department followed by neurology outpatient department (16).

A study done in Israel based on the electroencephalographic data of 547 successive children and adolescents, aged between 5 and 16 years, found that the most frequent diagnostic indications for EEG were clinical seizures (42%), attention-deficit-hyperactivity disorder (23%), headaches (10.4%), syncope (9.9%), and tic disorder (4.9%) (17).

A study conducted in Jordan involving children aged 6 to 12 years revealed that 63.2% of all EEG referrals came from outpatient clinics, while inpatients accounted for the remaining 36.8%. The Pediatric Neurology Department was responsible for the most referrals, making up 28.8% of

the total. The primary diagnosis at the time of referral was suspected epilepsy (80%), followed by chronic conditions related to the central nervous system (CNS) (18).

2.2. Findings and prevalence of abnormal finding

The TASH study indicated that among patients who underwent an EEG, the generalized tonic clonic (GTC) seizure was the most prevalent, followed by the focal seizure. The study also found that a majority, over 90%, of the patients who had an EEG were right-handed. Abnormal findings were present in 55.2% of the cases, with Interictal epileptiform discharges accounting for more than half of these, followed by focal or generalized slowing. Additionally, epileptic patients taking phenobarbitone, phenytoin, carbamazepine, or a combination of two or more antiepileptic drugs showed a higher incidence of abnormal EEG results (13). Another study also found that EEG studies conducted for non-epileptic reasons, like syncope, were usually normal and could be predicted with high accuracy(16).

The study conducted in Israel revealed that only one-fourth (24%) of the EEG studies exhibited abnormal results (17). Similarly, a study carried out in Jordan discovered that merely 36% of EEGs exhibited abnormal results. Furthermore, all EEGs performed on children diagnosed with syncope and headaches were found to be normal (18).

2.3. Conceptual framework

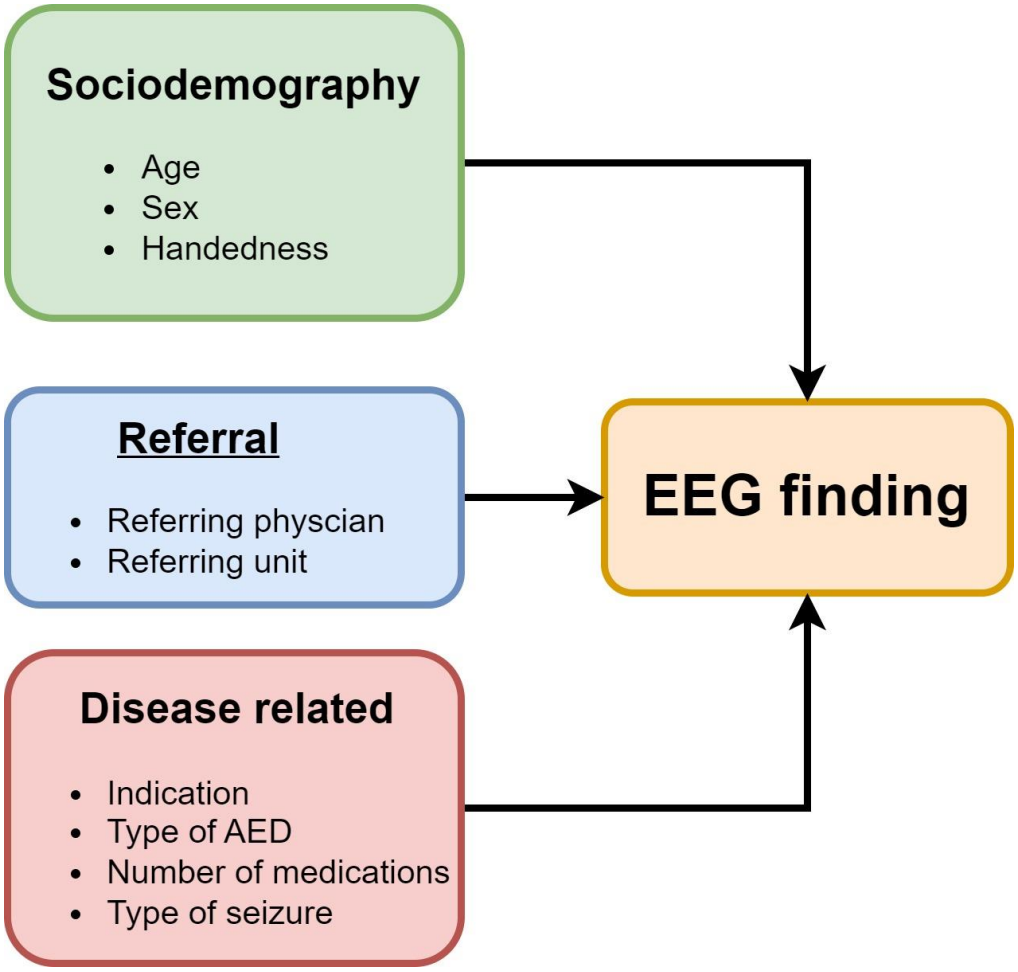

Figure 1: Conceptual framework of predictors of abnormal electroencephalography (EEG) finding

3. OBJECTIVES

3.1. General objective

- To study the indications for EEG, the prevalence of abnormal EEG results, and their predictors at Ayder Comprehensive Specialized Hospital.

3.2. Specific objectives

- Mention indications for electroencephalogram
- Describe electroencephalogram findings
- Determine the prevalence of abnormal electroencephalogram finding
- Identify predictors of abnormal electroencephalogram finding

4. METHODS

4.1.Study area

The study was conducted at Ayder Comprehensive Specialized Hospital (ACSH), located in Mekelle city, the capital of Tigray Regional State. Since its commencement in 2008, ACSH has been providing both referral and non-referral services to a population of around 9 million in its catchment areas, which include Tigray, Afar, and northeastern parts of the Amhara Regional States, as well as Eritrean refugees prior to the war. One of the key services provided by ACSH is a pediatric neurologic clinic, which is equipped with an electroencephalogram (EEG). This service is particularly relevant to our study as it directly involves the patient population and the diagnostic procedure (EEG) we are focusing on.

4.2.Study period

The study carried out from October 2019 to September 2024

4.3.Study design

A cross-sectional study design was employed.

4.4.Source population and study population

4.4.1. Source population

All pediatric patients in ACSH who underwent EEG for various neurological disorders.

4.4.2. Study population

All pediatric patients in ACSH who underwent EEG for various neurological disorders during the study period.

4.5.Eligibility criteria

4.5.1. Inclusion criteria

- All pediatric patients who underwent EEG for various neurological disorders.

4.5.2. Exclusion criteria

- Records that are incomplete.
- Any EEG records from adult patients.

4.6.Sample size and sampling procedure

4.6.1. Sample size

The sample size was calculated using the single population proportion formula. Proportion of abnormal EEG finding was taken from a previous study were taken from two previous studies conducted in Tikur Anbessa Specialized Hospital (TASH). The sample size was computed using EpiInfo 7.2.6. The prevalence of abnormal EEG in the above study was 55.2%. A 5% margin of error and 95% confidence interval are assumed during the calculation.

- The formula for single proportion formula is:

$$n = \frac{\left(z_{\alpha/2}\right)^2 p(1-p)}{d^2} = \frac{(1.96)^2 0.552(1-0.552)}{0.05^2} = 380$$

After adding 10% contingency, the minimum sample size required for this study was 418.

4.6.2. Sampling technique and procedure

The number of patients who underwent EEG in the past 5 years is 857. So, a systematic random sampling technique was applied and the value of k calculated as follows: K = 857/412, which is approximately 2 when rounded down. So, we randomly selected the starting point from the numbers 1 to 2. And then, every second EEG record was sampled/recruited.

4.7.Study variables

4.7.1. Dependent variables

- Abnormal EEG finding (coded as 0 for “No or Normal” and 1 for “Yes or abnormal”

4.7.2. Independent variables

- Sociodemographic characteristics (Age, Sex)
- Handedness
- Skull defect
- Medications
- Disease or diagnosis (seizure and epilepsy) related characteristics
- Growth and development
- Neuroimaging and other findings

4.8.Data collection procedure

A structured checklist was used for data collection. Data was collected by trained health professionals who have good understanding of medical terminology and concepts related EEG procedure and its findings. Their familiarity with clinical settings facilitated efficient data extraction. Source of data were electronic database dedicated for EEG.

4.9.Data quality assurance

To ensure the quality of our data, we implemented several measures. Initially, senior specialists in pediatrics and child health evaluated the checklist’s comprehensiveness and validity. Training was another key mechanism we used to maintain data quality. By providing training to the data collectors, we ensured that they fully understood the study objectives, data collection tools, and procedures. The principal investigator periodically oversaw the data collection process to spot any errors or inconsistencies. Quality assurance checks were implemented during data entry, and any discrepancies were immediately addressed. For data collection, we utilized the ODK Collect (Open Data Kit) mobile application. The use of ODK helped minimize data entry errors and

missing data. We trained the residents on the ODK Collect application and ensured that they were well-versed in using it for efficient and accurate data capture.

4.10. Data analysis

Data exported to SPSS 27 underwent descriptive and inferential statistical analysis. Frequency tables were created for categorical variables, while continuous variables were described using measures like mean and standard deviation. A binary logistic regression model was developed to evaluate the impact of independent variables on the binary outcome (EEG finding). Variables with ($p < 0.25$) in the bivariate analysis were included in the final multivariable model, with statistical significance declared at ($p < 0.05$). The Hosmer-Lemeshow test assessed model fit, and the Variance Inflation Factor (VIF) tested for multicollinearity among independent variables, with a VIF of less than five indicating no multicollinearity.

Descriptive statistics were presented in text, tables, or graphs. Logistic regression results, including odds ratios with confidence intervals and p-values, were reported to show the magnitude, direction, and significance of the association between abnormal EEG findings and predictors.

4.11. Ethical Consideration

Ethical clearance obtained from the Institutional Review Board of Mekelle University College of Health Sciences. Permission to collect data requested from Chief Clinical Director and Department of Pediatrics and Child Health. Data collected in this study is de-identified and stored in a password-secured personal computer.

5. Result

For this study a total of 439 EEG studies were reviewed and analyzed.

5.1.Sociodemography, medication, handedness and skull defect

The mean age of participants was 7.9 years (SD=5.0). About two-third (63.6%) of the studies were conducted in male patients. More than three-fourths (77.0%) of them were right-handed and the rest 6.8% and 16.2% were left-handed and intermediate, respectively. Around 70% of the EEG studies were referred by pediatrics and child health residents. Pediatric neurologists and pediatricians accounted for 15.3% and 4.6% of referrals, correspondingly. Only three children had skull defect. Before EEG, 159 (36.2%) of children were not on any anti-epileptic medication. The rest were on anti-epileptic medications like phenytoin (162, 36.9%), valproic acid (68, 15.5%), and phenobarbital (57, 13.0%).

Table 1: Sociodemography, skull defect, and medication related characteristics of children who underwent EEG study in Ayder Comprehensive Specialized Hospital from October 2019 to September 2024, N=439.

Characteristics		***Frequency (N=439)***	***Percent [95% CI]***
Referred by	Pediatric neurologist	67	15.3 [12.1, 18.8]
	Pediatric resident	311	70.8 [66.5, 74.9]
	Pediatrician	20	4.6 [2.9, 6.8]
	Intern	28	6.4 [4.4, 9.0]
	Unknown	13	3.0 [1.7, 4.9]
Sex	Male	279	63.6 [59.0, 68.0]
	Female	160	36.4 [32.0, 41.0]
Handedness	Right	338	77.0 [72.9, 80.7]
	Left	30	6.8 [4.8, 9.5]
	Intermediate	71	16.2 [13.0, 19.8]
Skull defect	No	436	99.3 [98.2, 99.8]
	Yes	3	0.7 [0.2, 1.8]
Medications	Phenytoin	162	36.9 [32.5, 41.5]
	Valproic acid	68	15.5 [12.3, 19.1]
	Phenobarbital	57	13.0 [10.1, 16.4]
	Carbamazepine	24	5.5 [3.6, 7.9]
	Clonazepam	4	0.9 [0.3, 2.2]
	Diazepam	2	0.5 [0.1, 1.5]
	Risperidone	14	3.2 [1.8, 5.2]
	Not on treatment	159	36.2 [31.8, 40.8]

	Other, specify	4	0.9 [0.3, 2.2]

5.2.Clinical and developmental characteristics

Nearly all (89%) had history of seizure and encephalopathy was reported in 8 (1.8%) of the children. The most common type of seizure found was generalized onset (316, 72.0%) followed by focal onset (69, 15.7%). Children without seizure accounted for 43 (9.8%) of the cases. Nearly three-fourths (73.8%) of children had normal development. Generalized developmental delay (GDD) was observed in 37 (8.4%) children.

Table 2: Clinical and developmental characteristics of children who underwent EEG study in Ayder Comprehensive Specialized Hospital from October 2019 to September 2024, N=439.

Characteristics		Frequency (N=439)	Percent [95% CI]
Sedated with	IV diazepam	3	0.7 [0.2, 1.8]
	IM diazepam	1	0.2 [0.0, 1.1]
	None	435	99.1 [97.8, 99.7]
History	Seizure	389	88.6 [85.4, 91.3]
	Behavioral concern	36	8.2 [5.9, 11.0]
	Encephalopathy	8	1.8 [0.9, 3.4]
	Other, specify	37	8.4 [6.1, 11.3]
Seizure type	Focal onset	69	15.7 [12.5, 19.3]
	Generalized onset	316	72.0 [67.6, 76.0]
	Unknown onset	11	2.5 [1.3, 4.3]
	No seizure	43	9.8 [7.3, 12.8]
Development	Normal	324	73.8 [69.5, 77.8]
	Motor delay	7	1.6 [0.7, 3.1]
	Language delay	10	2.3 [1.2, 4.0]
	Social and cognitive delay	17	3.9 [2.4, 6.0]
	GDD	37	8.4 [6.1, 11.3]
	NA	8	1.8 [0.9, 3.4]
	Incomplete note	29	6.6 [4.6, 9.2]
	Other, specify	7	1.6 [0.7, 3.1]

5.3.Indication or clinical diagnosis

The most common diagnosis or indications for EEG were generalized epilepsy (272, 62.0%), focal onset epilepsy (65, 14.8%), and non-convulsive seizure (36, 8.2%). The number of EEG studies performed for the purpose of tapering the dose of anti-epileptic drug or remission were 24 (5.5%).

Table 3: Clinical diagnosis or indications among children who underwent EEG study in Ayder Comprehensive Specialized Hospital from October 2019 to September2024, N=439.

Characteristics		Frequency (N=439)	Percent [95% CI]
Remission/Tapering	No	415	94.5 [92.1, 96.4]
	Yes	24	5.5 [3.6, 7.9]
Clinical diagnosis	Generalized epilepsy	272	62.0 [57.4, 66.4]
	Focal onset epilepsy	65	14.8 [11.7, 18.4]
	Unknown onset epilepsy	6	1.4 [0.6, 2.8]
	Nonconvulsive seizure	36	8.2 [5.9, 11.0]
	Infectious encephalitis	3	0.7 [0.2, 1.8]
	ASD	16	3.6 [2.2, 5.7]
	ADHD	3	0.7 [0.2, 1.8]
	Febrile seizure	7	1.6 [0.7, 3.1]
	Mixed epilepsy	8	1.8 [0.9, 3.4]
	GDD	3	0.7 [0.2, 1.8]
	SE	5	1.1 [0.4, 2.5]
	Epileptic encephalopathy	5	1.1 [0.4, 2.5]
	Syncope to R/O atonic seizure	5	1.1 [0.4, 2.5]
	Other, specify	5	1.1 [0.4, 2.5]

5.4.EEG result

Regarding background EEG result, 373 (85.0%) EEG studies showed normal and symmetric background and generalized slow background was seen detected in 51 (11.6%). The most common EEG finding was generalized epileptiform (189, 43.1%) followed by focal epileptiform (77, 17.5%). Overall, two-thirds (292, 66.5%) of EEG studies were abnormal and the rest one-third were normal (147, 33.5%).

Table 4: EEG result of children who underwent EEG study in Ayder Comprehensive Specialized Hospital from October 2019 to September 2024, N=439.

Characteristics		Frequency (N=439)	Percent [95% CI]
Background	Normal and symmetric	373	85.0 [81.4, 88.1]
	Generalized slowing	51	11.6 [8.9, 14.9]
	Right focal slow	9	2.1 [1.0, 3.7]
	Left focal slow	6	1.4 [0.6, 2.8]
Finding	Focal epileptiform	77	17.5 [14.2, 21.3]
	Generalized epileptiform	189	43.1 [38.5, 47.7]
	Normal	147	33.5 [29.2, 38.0]
	Other state	28	6.4 [4.4, 9.0]
Overall EEG finding	Normal	147	33.5 [29.2, 38.0]
	Abnormal	292	66.5 [62.0, 70.8]

5.5.Predictors of normal EEG finding

A binary logistic regression was conducted to identify independent/significant predictors of EEG results among children undergoing EEG studies at Ayder Comprehensive Specialized Hospital. Based on the multivariable analysis, four variables were found to be significantly related to EEG findings. The odds of abnormal EEG findings were almost five times higher in children sent for EEG studies without an indication of tapering anti-epileptic doses or remission (AOR=4.6, 95% CI: 1.9 to 11.2, p=0.001). Nearly three-fourths of EEG studies conducted in children with seizure history were abnormal, and the odds of abnormal EEG were seven times higher in this group of children than children with no history of seizure (AOR=7.0, 95% CI: 3.4 to 14.3, p<0.001). The duration of epilepsy among children with normal EEG findings and abnormal EEG findings was 1.4 years and 2.4 years, respectively. The odds of abnormal EEG findings were found to increase by 20% as duration of epilepsy rises by one year (AOR=1.2, 95% CI: 1.1 to 1.4, p=0.001). The last but not least predictor of EEG results was febrile seizures. The odds of abnormal EEG results were 12.6 times higher among children who had no febrile seizures than their counterparts (AOR=12.6, 95% CI: 1.4 to 111.3, p=0.022). The multivariable model was a good fit for the data (Hosmer-Lemeshow test: p=0.802). The mean VIF result was 1.06, indicating that there was no multicollinearity issue in the final multivariable model.

Table 5: Predictors of EEG result among children who underwent EEG study in Ayder Comprehensive Specialized Hospital from October 2019 to September 2024, N=439.

Predictor		EEG finding, n (row %) or mean		Bivariate analysis		Multivariable analysis	
		Normal	Abnormal	COR [95% CI]	p-value	AOR [95% CI]	p-value
EEG sent for remission/ tapering anti-epileptic drug dose							
	Yes	12 (50.0)	12 (50.0)	1		1	
	No	135 (32.5)	280 (67.5)	2.1 [0.9, 4.7]	0.083	4.6 [1.9, 11.2]	0.001
Taking phenobarbital							
	Yes	12 (21.1)	45 (78.9)	2.0 [1.0, 4.0]	0.036	1.7 [0.9, 3.6]	0.125
	No	133 (35.0)	247 (65.0)	1		1	
Seizure history							
	Yes	109 (28.0)	280 (72.0)	8.1 [4.1, 16.1]	<0.001	7.1 [3.5, 14.4]	<0.001
	No	38 (76.0)	12 (24.0)	1		1	
Duration of epilepsy (years)		1.4 Years	2.4 Years	1.3 [1.1, 1.4]	<0.001	1.2 [1.1, 1.4]	0.001
Febrile seizure							
	Yes	5 (83.3)	1 (16.7)	1		1	
	No	142 (32.8)	291 (67.2)	10.2 [1.2, 88.5]	0.034	12.5 [1.4, 110.2]	0.023

6. Discussion

The purpose of this study was to describe indications for EEG, determine the prevalence of abnormal EEG result, and identify predictors of abnormal EEG result. The most common indications for EEG or clinical diagnosis were generalized epilepsy, focal onset epilepsy, non-convulsive seizure, and ASD. Two-thirds of children had abnormal EEG result and the likelihood of abnormal EEG result was higher among children with history of seizure, longer duration of epilepsy, not on remission, and not febrile.

In our study, the prevalence of abnormal EEG findings was 66.5%, with a 95% confidence interval ranging from 62.0% to 70.8%. The prevalence of abnormal EEG is higher than in two other Ethiopian studies conducted among the general population at Tikur Anbessa Specialized Hospital, which ranged from 55.2% to 59.4% (13,19). In addition, the prevalence in our study area was also significantly higher than the findings from studies conducted in Jimma (20), which reported 43.2%, and other African countries(21). The differences may be attributed to the selection criteria. In our study, only children were included, while the other studies involved both children and adults. Another reason is that approximately 87% of our study participants had seizures or abnormal body movements. Supporting this finding, a study by Fisher et al. emphasized that around 60-70% of patients presenting with seizures will show abnormalities on an EEG (22).

According to our study, the most common seizure/epilepsy type was generalized epilepsy followed by focal onset epilepsy and non-convulsive seizure. This finding was in line with the study conducted by by Biniyam A. Ayele and his colleagues. According to the study by Biniyam A. Ayele et. Al, the most common seizure type was generalized tonic clonic seizure which accounted for 45.5% of the study participants (13).

The odds of abnormal EEG results were higher in children who are not in remission or whose anti-epileptic medications are not being tapered. Additionally, the current study demonstrated that abnormal EEG findings are significantly higher in children with a seizure history. These findings are in line with several studies. Children who are in remission or being considered for tapering their medications have more stable neurological conditions, leading to a lower

likelihood of abnormal EEG findings than their counterparts. In other words, children who are not in remission experience more frequent seizures, which are associated with an increased chance of abnormal EEG results. Changes in cortical excitability and synaptic connection are the explanations for EEG abnormalities in children with a history of seizures. Recurrent seizures can cause structural and functional changes in the human brain that can be detected with an electroencephalogram (EEG). Even without any clinically detectable seizure, this change may contribute to the persistence of abnormal EEG result or pattern.Therefore, health professionals should give priority to children with an ongoing seizures rather than those in remission state (23,24).

The current study also highlighted that children with longer duration of epilepsy were more likely to have abnormal EEG pattern. A study conducted in Jimma Medical Center of Ethiopia also found a higher prevalence of EEG abnormality among patients with longer duration of epilepsy(20). Other studies also support this finding and indicate that the cumulative effect of recurrent seizures on the brain's electrical activity, following a longer duration of epilepsy, increases the chance of obtaining abnormal EEG results(23–25).

The final finding of our study is that children with febrile seizures had a lower chance of abnormal EEG results. This is because, in our study, these children had a shorter duration of seizure experience compared to those without febrile seizures but with more severe forms of seizure/epilepsy. The mean duration of seizures/epilepsy in the febrile seizure group was 1.4 years, whereas in those with other types of seizures/epilepsy, it was 2.1 years. Therefore, febrile seizures are not strongly associated with abnormal EEG results due to the insufficient duration to induce significant changes in brain activity and structure. However, it is noteworthy that febrile seizures may still pose a risk for future epilepsy.

7. Conclusion

In the present study, the prevalence of abnormal EEG results was higher compared to other Ethiopian studies due to different reasons. The most common type of epilepsy found was generalized epilepsy. The factors remarkably related to EEG abnormality were duration of seizure/epilepsy, febrile seizure, seizure history, and remission status. The chance of EEG abnormality was significantly higher in long-standing seizure/epilepsy, children with seizure history, children not on remission, and seizures not related to fever.

8. Recommendations

For Health Professionals and researchers

- Health professionals should give more emphasis to children with an ongoing seizure than children on remission for EEG study
- Health professionals should ensure that children with longer history of epilepsy are getting more priority and receiving regular and thorough EEG assessments.
- Further research should be conducted, particulary, the association between EEG abnormality and febrile seizure

Health Bureaus and facilities

- Develop guidelines on the appropriate use of EEG study and tailored approaches based on clinical history and duration of seizure.
- Health bureaus and other concerned bodies should provide both financial and technical support to conduct further research on EEG abnormalities in pediatric age groups in developing countries like Ethiopia, which suffer from scarcity of evidence about EEG studies in this group of population.

Policymakers

- Policymakers should develop and implement policies that prioritize children with ongoing seizures and longer durations of epilepsy, particularly in terms of ensuring access to and availability of regular and comprehensive EEG surveillance.

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8. ANNEXES

9.1.1. Annex I. Checklist

Q.No.	Question	Response	Remark
1.	Code		
2.	EEG number		
3.	Age		(in years)
4.	Sex	1. Male 2. Female	
5.	Handedness	1. Right 2. Left 3. Intermediate	
6.	Skull defect	0. No 1. Yes 2. Not documented	
7.	Medications	1. Phenytoin 2. Valproic acid 3. Carbamazepine 4. Clonazepam 5. Diazepam 6. Risperidone 7. Not on treatment 8. Other, specify___	Multiple answer is possible
8.	Sedated with	1. IV diazepam 2. IM diazepam 3. Oral diazepam 4. Other,specify____ 5. None	
9.	History	1. Seizure 2. Behavioral concern 3. Encephalopathy 4. Other,specify	Multiple answer is possible
10.	Seizure type	1. Focal onset 2. Generalized onset 3. Unknown onset 4. No seizure	
11.	Duration of epilepsy		(in years)
12.	Duration of encephalopathy		(in years)
13.	Last episode		(days ago)
14.	Development	1. Normal 2. Motor delay 3. Language delay 4. Social and cognitive delay 5. GDD 6. NA 7. Incomplete note	

		8. Other,specify____	
15	Neuroimaging or other relevant workup finding		
16.	Clinical diagnosis	1. Generalized epilepsy 2. Focal onset epilepsy 3. Unknown onset epilepsy 4. Nonconvulsive seizure 5. Infectious encephalitis 6. ASD 7. ADHD 8. Language DD 9. Motor DD 10. GDD 11. SE 12. Other,specify	
17.	Background	1. Normal and symmetric 2. Generalized slowing 3. Righ focal slow 4. Left focal slow	
18.	Finding	1. Focal epileptiform 2. Generalized epileptiform 3. Focal slow 4. Other state, specify____	
19.	Conclusion		
20.	Rec		
21.	Reviewer		
22.	Other description to add		
23.	Overall EEG finding	1. Normal 2. Abnormal	