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A COMPARATIVE ANALYSIS OF EPILEPSY SEIZURE TYPES AND THEIR DEMOGRAPHIC, CLINICAL, AND ELECTROENCEPHALOGRAPHIC CHARACTERISTICS IN AZERBAIJAN (2005–2009 VS. 2019–2023)

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This study compares the distribution of seizure types and their associated demographic, clinical, and electroencephalographic features in Azerbaijani epilepsy patients across two distinct periods: 2005–2009 and 2019–2023. A retrospective analysis was conducted on two cohorts: 322 patients (2005–2009) and 328 patients (2019–2023). Variables included seizure type (focal, generalized, unclassified), age, sex, marital status, family history, seizure frequency, etiology, and electroencephalographic findings. Focal seizures predominated in both cohorts (65.9 % vs. 57.9 %), while generalized seizures were more common among pediatric patients and those with family history. Structural etiology was strongly associated with focal seizures; genetic causes predominated in generalized seizures. Electroencephalographic findings showed clear associations with seizure type. Combination therapy increased over time. While focal seizures remain dominant, changes in genetic diagnosis and treatment preferences highlight evolving epilepsy care in Azerbaijan. These findings emphasize the need for expanded diagnostic capacity and access to newer antiepileptic drugs.

Key words: epilepsy, seizure type, electroencephalography, focal seizures, generalised seizures, Azerbaijan.

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ПОРІВНЯЛЬНИЙ АНАЛІЗ ТИПІВ ЕПІЛЕПТИЧНИХ НАПАДІВ, ЇХ ДЕМОГРАФІЧНИХ, КЛІНІЧНИХ ТА ЕЛЕКТРОЕНЦЕФАЛОГРАФІЧНИХ ХАРАКТЕРИСТИК В АЗЕРБАЙДЖАНІ (2005–2009 VS 2019–2023)

У даному дослідженні порівнюється розподіл типів нападів та пов'язаних з ними демографічних, клінічних та електроенцефалографічних характеристик у пацієнтів з епілепсією, які проживають в Азербайджані, протягом двох різних періодів: 2005–2009 та 2019–2023. Ретроспективний аналіз було проведено на двох когортах: 322 пацієнти (2005–2009) та 328 пацієнтів (2019–2023). Змінні включали тип нападів (фокальні, генералізовані, некласифіковані), вік, стать, сімейний стан, сімейний анамнез, частоту нападів, етіологію, електроенцефалографічні дані. Фокальні напади переважали в обох когортах (65,9 % проти 57,9 %), тоді як генералізовані напади були більш поширені серед дітей та пацієнтів із сімейним анамнезом. Етіологічна структура була тісно пов'язана з фокальними нападами; генетичні причини переважали при генералізованих нападах. Електроенцефалографічні дані показали чіткий зв'язок з типом нападів. Комбінована терапія збільшувалася з плином часу. Хоча фокальні напади залишаються домінуючим видом, зміни в генетичній діагностиці та підходах до лікування свідчать про еволюцію системи лікування епілепсії в Азербайджані. Ці дані підкреслюють необхідність розширення діагностичних можливостей та доступу до нових протиепілептичних препаратів.

Ключові слова: епілепсія, тип нападів, електроенцефалографія, електроенцефалографія, фокальні судоми, генералізовані судоми, Азербайджан.

Epilepsy is a chronic neurological disorder defined by an enduring predisposition to generate unprovoked seizures, with considerable neurobiological, cognitive, psychological, and social consequences [1, 4]. It affects over 50 million individuals globally, making it one of the most prevalent neurological diseases worldwide. The World Health Organization recognizes epilepsy as a major public health concern due to its high burden, especially in low- and middle-income countries (LMICs), where nearly 80 % of the global epilepsy population resides [2, 3]. In these settings, limited access to diagnostic resources, trained specialists, and modern antiepileptic drugs (AEDs) often leads to delayed diagnosis and suboptimal management outcomes.

Seizure type classification plays a central role in the diagnosis, treatment, and prognostication of epilepsy. The International League Against Epilepsy (ILAE) emphasizes that appropriate classification of seizures – into focal, generalized, or unknown types – is essential for tailoring pharmacological interventions and predicting response to therapy [1]. Accurate classification typically relies on a combination of clinical semiology, patient history, electroencephalographic (EEG) recordings, and neuroimaging techniques. Among these, EEG remains a cornerstone diagnostic tool, providing insight into the underlying electrophysiological patterns and helping differentiate between seizure types [5, 13].

While large-scale epidemiological studies from high-income countries have significantly advanced our understanding of seizure type distributions and associated clinical features, there remains a notable paucity of comprehensive, longitudinal data from LMICs. Region-specific investigations are critical for capturing local patterns of epilepsy presentation, etiology, and response to therapy – data that can inform public health policies and optimize resource allocation [6]. In this regard, Azerbaijan presents a unique

case study. Despite advancements in neurological services over the past two decades, systematic studies that examine temporal changes in seizure classification and associated factors are lacking.

The purpose of the study was to assess comparatively the features of seizure types and their associated demographic, clinical, and electroencephalographic characteristics in Azerbaijani epilepsy patients across two distinct periods: 2005–2009 and 2019–2023.

Materials and methods. Two retrospective cross-sectional datasets were analysed: Cohort A (2005–2009) with 322 patients and Cohort B (2019–2023) with 328 patients.

The study population was recruited using a predefined, reproducible selection algorithm applied uniformly in both cohorts (see inclusion and exclusion criteria). Eligible cases were identified through a systematic review of institutional medical records during the specified study period.

Inclusion criteria were as follows: a confirmed diagnosis of epilepsy established according to the International League Against Epilepsy (ILAE) criteria; availability of complete clinical documentation allowing reliable classification of seizure type; age ≥ 5 years at the time of diagnosis or follow-up; sufficient follow-up data for seizure characterization.

Exclusion criteria included: acute symptomatic seizures or isolated provoked seizures; insufficient or ambiguous clinical, electroencephalographic, or neuroimaging data precluding seizure classification; incomplete datasets.

According to the study's goals, a retrospective comparative analysis of epilepsy seizure types and their associated demographic, clinical, and electrophysiological features across two distinct periods, 2005–2009 and 2019–2023, was conducted.

The study was conducted in accordance with the principles of the Declaration of Helsinki (as amended), the Council for International Organizations of Medical Sciences (CIOMS) International Ethical Guidelines for Health-related Research Involving Humans, and the standards of Good Clinical Practice (GCP).

This study used a retrospective design and analyzed previously collected medical records and clinical data, without direct patient contact or interference with diagnostic or therapeutic procedures. The study protocol was reviewed and approved by the local (university) ethics committee before data analysis. Given the retrospective nature of the study and the exclusive use of anonymized archival data, the ethics committee waived the requirement for obtaining individual written informed consent, in accordance with accepted international ethical standards.

All data used in the study were fully anonymized, and no personally identifiable information was included in the analytical database. Patient confidentiality and data protection were ensured throughout data collection, processing, and analysis. When archival data included information from patients under 18 years of age or from individuals legally recognized as temporarily or permanently incapacitated, the analysis was performed solely in an aggregated and anonymized manner, precluding any possibility of patient identification and eliminating the need for additional consent from legal representatives.

We analyzed cohorts of patients from hospitals in Ganja city, Azerbaijan (Ganja United City Hospital, polyclinics No. 1, 2, 3, and 4 of Ganja United City Hospital) based on a letter from the Azerbaijan Medical University for permission to conduct research work in the respective institutions (dated May 4, 2021). The seizure type prevalence, age, and gender distribution, familial predisposition) and seek to identify the features of symptoms and trends were evaluated. In addition, the etiological classifications based on seizure types according to ILAE criteria (2017) were performed. After diagnosis of the seizure type, the next step is diagnosis of epilepsy type, including focal epilepsy, generalized epilepsy, combined generalized and focal epilepsy, and also an unknown epilepsy group. The third level is that of epilepsy syndrome, where a specific syndromic diagnosis can be made. The 2017 classification incorporates etiology along each stage, emphasizing the need to consider etiology at each step of diagnosis, as it often carries significant treatment implications. Etiology is broken into six subgroups: structural (tumor, stroke, malformation) that directly cause seizures; genetic (results from a direct mutation, even if the specific gene is unknown); infectious (caused by CNS infections like meningitis, HIV, etc); metabolic (metabolic disorders); immune (caused by auto-immune disorders); and unknown. The etiology was analyzed according to information from patients' medical histories.

Electroencephalographic waves and their abnormalities were also evaluated. Based on the collected data, we aim to reveal how these variables have evolved and will provide valuable insights for clinicians, researchers, and health policymakers working to improve epilepsy diagnosis and management in Azerbaijan and similar LMIC settings.

Descriptive statistics summarized cohort characteristics. Pearson's Chi-square test assessed associations between seizure types and categorical variables. A p-value <0.05 was considered statistically significant.

Results of the study and their discussion. Focal seizures predominated (65.9 % in Cohort A; 57.9 % in Cohort B), followed by generalized (29.0 % vs. 35.7 %) and unclassified seizures (6.5 % vs. 6.4 %) in our research. Age distribution differed between cohorts, with Cohort A showing a peak incidence of seizures in the 20–29 age group (22.3 %), while Cohort B exhibited a broader age range, with focal seizures predominating in adults and generalized seizures more common in children, a statistically significant difference (p=0.002).

Both cohorts demonstrated a slight predominance of males (55 % in Cohort A and 52.6 % in Cohort B), with no statistically significant differences in seizure type between genders.

Generalized seizures were more commonly observed in single individuals, accounting for 86.3 % in Cohort A and 81.2 % in Cohort B, with marital status showing a significant association with seizure type in Cohort B (p<0.001).

Frequent seizures (>1/month) occurred in 73.3 % of Cohort A. In Cohort B, unclassified seizures had the highest frequency, with a significant association to seizure type (p<0.001). Frequent seizures occurring more than once per month were reported in 73.3 % of patients in Cohort A, while in Cohort B, it was 68.6 % and especially unclassified seizures exhibited the highest frequency, showing a significant association with seizure type (p<0.001) (Table 1).

Table 1

Comparative analysis of seizure characteristics between Cohort A and Cohort B

Parameter	Cohort A	Cohort B
Peak Age Group (years)	20–29 (22.3 %)	Broader distribution: Focal seizures in adults, generalized in children
Gender Distribution	Male: 55 %	Male: 52.6 %
Marital Status & Generalized Seizures	Single: 86.3 %	Single: 81.2 %
Frequency of Seizures (>1/month)	73.3 %	68.6 %
Most Frequent Seizure Type	–	Unclassified seizures showed the highest frequency

Structural etiology was the predominant cause of focal seizures in both cohorts (44.5 % in Cohort A and 55.3 % in Cohort B), whereas generalized seizures were primarily attributed to genetic origins (44.1 % in Cohort A and 60.7 % in Cohort B), and unclassified seizures mainly were associated with unknown causes, particularly in Cohort B (90.5 %) (Table 2).

Table 2

Etiological and EEG correlations of seizure types in Cohort A and Cohort B

Parameter	Cohort A	Cohort B
Focal Seizures – Structural Etiology	44.5 %	55.3 %
Generalized Seizures – Genetic Etiology	44.1 %	60.7 %
Unclassified Seizures – Unknown Etiology	—	90.5 %
EEG – Generalized Epileptiform Discharges (in Generalized Seizures)	71.6 %	42.7 %
EEG – Focal Seizures	Regional abnormalities, normal EEG	Regional abnormalities, normal EEG

Generalized epileptiform discharges were predominantly observed in patients with generalized seizures (71.6 % in Cohort A and 42.7 % in Cohort B), whereas regional abnormalities and normal EEG findings were more commonly associated with focal seizures.

Epilepsy is the most common neurological disorder in childhood. Accurate diagnosis is crucial; in older children, epileptic seizures must be differentiated from various paroxysmal non-epileptic events, while in neonates, most seizures are subclinical (electroencephalographically determined) [5, 12]. This comparative analysis of seizure types in Azerbaijani epilepsy patients across two timeframes reveals both consistent patterns and notable shifts in demographic and clinical features. The persistent predominance of focal seizures in both cohorts aligns with global findings that focal epilepsies represent the most common type, particularly in populations with higher rates of acquired structural brain damage [1, 7].

According to Chen Z, et al (2023), the incidence of epilepsy varies by age group and has a U-shaped bimodal distribution, with the highest rates observed in young children and the elderly. In children, the incidence is typically highest during the first year of life and then gradually declines. Acute seizures and infantile spasms are common in children with epilepsy and require additional care [2].

In our study, the decrease in focal seizure prevalence from 65.9 % in the 2005–2009 cohort to 57.9 % in the 2019–2023 cohort was accompanied by an increase in generalized seizures (from 29.0 % to

35.7 %), especially among children and those with a positive family history. This trend may suggest improved diagnostic recognition of generalized epilepsies, which are more likely to have a genetic origin. The stronger association between generalized seizures and family history in the recent cohort ($p<0.001$) supports this observation and is consistent with recent literature emphasizing genetic predisposition in generalized seizure syndromes [3].

Age distribution also shifted notably. While the earlier cohort showed a clear peak in the 20–29 age group, the later cohort demonstrated a broader spread of seizure types across age groups. Notably, generalized seizures were more common in pediatric populations in the recent cohort, suggesting that earlier identification and classification of seizures may have improved in recent years. These results are similar to those reported in the literature [3, 11, 14].

Gender did not appear to significantly influence seizure type in either cohort, though a slight male predominance was observed. Similarly, the relationship between marital status and seizure type showed stronger associations in the recent cohort, particularly with single individuals more frequently exhibiting generalized seizures ($p<0.001$). This could reflect differences in social support, lifestyle, or earlier age of onset.

One of the most striking findings was the high seizure frequency among unclassified seizure types in the recent cohort, with a significant association to seizure category ($p<0.001$). This may reflect diagnostic uncertainty, particularly when EEG findings or clinical semiology are insufficient for precise classification. Even with interictal EEGs, some seizures remain challenging to classify, emphasizing the need for long-term EEG monitoring and improved clinical protocols [9, 13, 15].

The etiology data further confirm global trends: focal seizures were structural primarily in origin, while generalized seizures were increasingly linked to genetic causes. Importantly, a substantial proportion of unclassified seizures had unknown etiology (90.5 % in Cohort B), underscoring limitations in diagnostic tools and the need for further investigation.

Our results are consistent with the literature. Thus, in their review article, Gogou M, et al (2022) outlined the basic concepts of seizures and epilepsy in children, as well as the main principles of treatment for this age group. The authors emphasized genetic causes, which account for approximately 30 % of cases. Therefore, the concept of genetic spectra is replacing the recognition of electroclinical syndromes. The authors' summary of currently available information on epilepsy in children is consistent with our findings that timely diagnosis and early access to specialized centres and optimal treatment positively impact prognosis and future neurological development [5].

The author examined cases of children and adults with new-onset seizures, focusing on differential diagnosis, classification, assessment, and treatment. Since new-onset seizures are common in neurological practice, occurring in approximately 8–10 % of the population, accurate diagnosis relies on a thorough history to exclude non-epileptic paroxysmal events. The article summarizes recommendations for neuroimaging, laboratory, and genetic testing, demonstrating that timely diagnosis and classification of new-onset seizures and new-onset epilepsy are key to selecting optimal therapy to maximize seizure control and minimize comorbidities [5].

In the early diagnosis of epilepsy, the role of EEG is crucial. This is a practical electrophysiological method for assessing paroxysmal states in children, enabling analysis of neuronal maturation and abnormal excitability of the cerebral cortex [10].

Kaushik JS, et al (2018) emphasized that EEG helps differentiate epileptic and non-epileptic clinical conditions, as well as focal and generalized seizures. Furthermore, the rational use of EEG is important for the diagnosis of epilepsy and various types of epileptic syndromes in children, as well as febrile seizures, first unprovoked seizures, status epilepticus, and unexplained coma [8]. In our work, EEG findings strongly correlated with seizure type in both cohorts. Generalized discharges were primarily seen in generalized seizures, while focal seizures more commonly showed regional abnormalities or even normal EEGs. This reinforces the critical role of EEG in seizure classification while also highlighting its limitations, particularly in cases of deep or intermittent epileptiform activity [9].

In summary, the analysis reveals evolving trends in seizure distribution, with generalized epilepsies becoming more frequently recognized in the pediatric population and unclassified seizures pointing to diagnostic limitations. These results highlight the continued relevance of seizure type as a clinical cornerstone in understanding epilepsy in Azerbaijan.

Our study has several limitations. The predominance of focal seizures observed in both cohorts of our study may partly reflect the population structure and referral patterns of the participating centres, which predominantly manage patients with focal epilepsies. Such referral bias is inherent to hospital-based cohorts and may limit the generalizability of the findings to the broader epilepsy population. Demographic

factors, including age distribution, epilepsy etiology, and access to diagnostic modalities, may influence differences in the proportion of generalized seizures between cohorts. Additionally, the proportion of unclassified seizures likely reflects real-world diagnostic limitations, particularly in retrospective datasets, rather than systematic misclassification. These factors should be considered when interpreting the results, as they may introduce selection bias and affect external validity. However, the use of standardized inclusion criteria, uniform classification methods, and consistent review procedures across cohorts strengthens the study's internal validity and supports the reliability of between-group comparisons.

Epilepsy diagnostic criteria in Azerbaijan have consistently been consistent with internationally recognized protocols and recommendations in this area throughout history. Naturally, certain changes occurred between 2005 and 2023 (such as ILAE diagnostic criteria), which inevitably impacted the initial diagnosis. However, due to the retrospective nature of our study, we reviewed medical records in their entirety and excluded cases where the diagnosis became questionable over time.

Conclusions

1. Focal seizures remained the most prevalent type (44.5 % in Cohort A and 55.3 % in Cohort B), predominantly linked to structural etiologies, particularly among adults. However, the relative increase in generalized seizures, particularly among children and patients with a family history of epilepsy, suggests growing awareness and diagnostic recognition of genetically influenced seizure syndromes.

2. Statistically significant associations ($p<0.001$) were observed between seizure type and age, marital status, family history, etiology, seizure frequency, and EEG findings.

3. The consistent presence of unclassified seizures and their strong association with high seizure frequency and unknown etiology emphasize persistent diagnostic challenges, particularly in the absence of long-term EEG monitoring or advanced imaging.

The findings underscore the importance of seizure type as a critical variable in both clinical evaluation and research in epilepsy. Addressing diagnostic gaps – particularly in cases with unclassified seizures – and expanding EEG capabilities are essential next steps for improving epilepsy care in Azerbaijan.

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