

ORIGINAL PAPER

doi: 10.5455/medarh.2023.77.465-470

MED ARCH. 2023; 77(6): 465-470

RECEIVED: OCT 16, 2023

ACCEPTED: NOV 25, 2023

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Seizure Analysis Presented to Emergency Department in Saudi Arabia: New VS Chronic Cases

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ABSTRACT

Background: Epilepsy, characterized by recurrent unprovoked seizures, poses a significant global burden on individuals and healthcare systems. Accurate identification of underlying causes is vital for optimal intervention. However, studies reveal a lack of standardized approaches, potentially resulting in unnecessary investigations. **Objective:** We aimed to highlight the importance of avoiding unnecessary testing to minimize healthcare costs and resource waste. **Methods:** In the Emergency Department of King Fahd Hospital of the University (KFUH) in Alkhobar, a retrospective cross-sectional study encompassed 190 patients presenting with seizures from January 1, 2020, to December 31, 2022. The study aimed to elucidate the epidemiological profile and distinguish clinical and demographic factors between new onset seizures and known cases. **Results:** The study included 190 epilepsy cases, with 51.1% known and 48.9% new onset. Generalized tonic-clonic seizures were prominent (43.2%), and non-compliance (24.2%) was a leading cause. New onset seizures were associated with abnormal CT findings ($p=0.025$), drug use (74.2%), and intoxication (6.5%). Demographically, Saudis showed higher new onset prevalence (82.8%, $p=0.001$). **Conclusion:** The average length of stay was 5.93 hours, and the distribution of new vs. known cases was nearly equal among the 190 patients. Laboratory findings showed no significant associations with either group, mostly falling within the normal range. To optimize care further, we recommend continued refinement of protocols, emphasis on medication compliance.

Keywords: seizure, Epilepsy, emergency, medication, neurology.

1. BACKGROUND

Epilepsy is a seizure disorder defined as the occurrence of two or more unprovoked seizures that are 24 hours apart. (1) Seizures, characterized by sudden and involuntary changes in neurological function, present a considerable burden on individuals and healthcare systems worldwide. (2-4) In the United States (US), seizures account for about 1% of emergency department (ED) (5) visits, and it is reported that 11% of individuals will have at least one seizure in their lifetime. (6) Most cases of seizures encountered in the ED setting are due to secondary medical causes or substance abuse. (6)

Timely and accurate recognition of secondary or precipitating causes is crucial for administering appropriate interventions, optimizing patient outcomes, and preventing potential complications. (6) Laboratory and radiological testing play a pivotal role in the comprehensive assessment and accurate diagnosis of medical conditions, including seizures, providing invaluable insights into the underlying causes and seizure types and guiding effective treatment strategies. Nonetheless, unnecessary overordering of laboratory tests can lead to increased costs and misguided management. As a result of a lack of standardized ED approaches to acute seizures, studies have shown that up to fifty percent of all investigations ordered were deemed unnecessary. (7) In this research, we conducted a retrospective, cross-sectional study at the King Fahd Hospital of the University, Al Khobar, analyzing the medical records of 190 patients who sought treatment in the Emergency Department for seizures between 2020 and 2022. Our study aimed to explore the epidemiological profile of seizure presentations and assess the significance of laboratory tests in the evaluation process.

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2. OBJECTIVE

We aimed to highlight the importance of avoiding unnecessary testing to minimize healthcare costs and resource waste.

3. MATERIAL AND METHODS

A retrospective cross-sectional study was conducted in the Emergency Department (ED) at King Fahd Hospital of the University (KFUH) which is situated in Alkhobar. An academic tertiary center, KFUH offers medical services to a substantial patient population across the cities of Alkhobar and Dhahran. Caring for an estimated count of around 300,000 people in the area, the hospital stands as a prominent healthcare provider, offering an array of medical services.

The study focused on a cohort of 492 patients who sought medical attention between the period of January 1, 2020, and December 31, 2022, with seizures as their chief complaint. The primary objective of this investigation was to provide insights into their epidemiological profile and distinguish between the different factors, both clinically and demographically, between new onset seizures and known cases of seizures.

From this initial patient pool, an inclusion criterion was established to encompass adult patients aged 18 and above, with a deliberate emphasis on those with complete and comprehensive medical records. 183 patients below the age of 18 were excluded to maintain a focus on the adult population. An additional 74 patients were excluded due to incomplete medical information and lastly, 45 patients were omitted from the study due to instances of misdiagnosis. This approach yielded a final cohort of 190 patients.

Data was analyzed by IBM SPSS.21. All categorical variables were presented as frequencies and percentages while all continuous data was presented as Median (IQR) or mean (\pm SD). Chi-square test was used to check the association between variables, Mann Whitney U test was used to compare the medians of lab parameters. Statistical significance was set at $P < 0.05$.

4. RESULTS

The study population consisted of 110 males (57.9%) and 80 females (42.1%), with an age range of 18 to 89 years (mean \pm SD age 36.8 ± 17.6 years). The majority of cases 119 (62.6%) had age 21 – 40 years. Out of the total, 171 (90%) were Saudi and 19 (10%) were non-Saudi. Table-1

The majority of patients 82 (43.2%) had generalized tonic-clonic seizures, while 9 (4.7%) had Status Epilepticus, 6 (3.2%) had tonic seizures, 4 (2.1%) had focal onset seizures and 86 (45.3%) unknown. Non-compliance to medicine was the most common cause of seizure found in 46 (24.2%) cases, Structural was found in 12 (6.3%) cases, and the cause was unknown in 107 (56.3%) cases. CT was found abnormal in 57 (30%) of cases. The

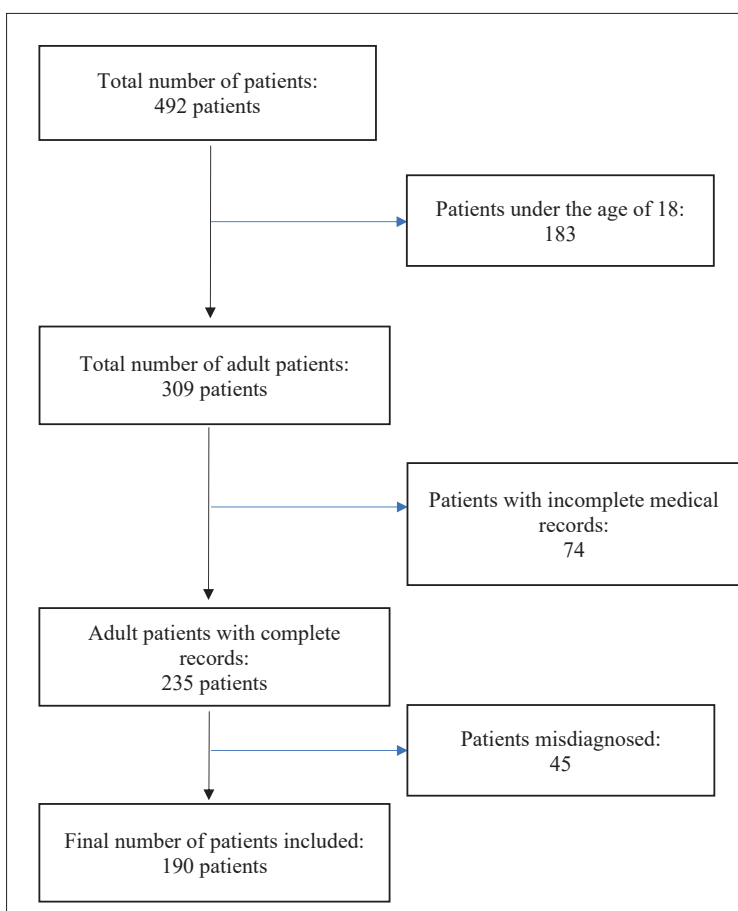


Figure 1: Flowchart of patients included in the study

		Frequency	Percent
Gender	Males	110	57.9
	Females	80	42.1
Age	< 20	17	8.9
	21 - 40	119	62.6
	41 - 60	31	16.3
	> 60	23	12.1
Nationality	Saudi	171	90
	Non-Saudi	19	10

Table-1. Demographics of cases (n=190)

average (SD) length of stay in ED was 5.93 (\pm 3.4) hours Table-2

Out of 190 diagnosed cases of epilepsy, 97 (51.1%) were known cases and 93 (48.9%) cases presented with new onset of seizure. Figure-2

A comparison of laboratory parameters between known cases and new cases of Seizure is presented in Table-3. All the parameters were statistically similar in known cases and new cases of seizure. There was no significant difference found between two groups (p -values >0.05)

Association of demographics of patients with a new onset of seizures is presented in Table-4. Gender distribution was statistically same in both groups ($p=0.4$). Proportion of new onset of seizure was significantly high in Saudis 77 (82.8%) as compared to non-Saudis 16 (17.2%) ($p=0.001$), New onset of seizure was significantly associated higher age group of cases 17 (18.3%) ($p=0.04$).

		Frequency	Percent
Seizure Types	Generalized Tonic-Clonic	82	43.2
	Status Epilepticus	9	4.7
	Tonic	6	3.2
	Focal	4	2.1
	Clonic	2	1.1
	Post Traumatic	1	0.5
	Unknown	86	45.3
General Causes of Seizure	Non-Compliance to medicine	46	24.2
	Structural	12	6.3
	Intoxication	7	3.7
	Metabolic	7	3.7
	Infections	5	2.6
	Psychogenic	3	1.6
	Others	3	1.6
	Unknown	107	56.3
	Specific Causes of Seizure	Breakthrough Seizure	46
Stroke		6	3.2
Uremic Encephalopathy		5	2.6
Amphetamine		3	1.6
Hyperglycemia		2	1.1
Psychogenic		3	1.6
Others		18	9.5
Unknown		107	56.3
Triage	I	2	1.1
	II	9	4.7
	III	106	55.8
	IV	73	38.4
	Not done	89	46.8
CT Findings	Normal	70	36.8
	Abnormal	31	16.3
Length of Stay in ED Hours	≤ 5	93	48.9
	>5 - 10	72	37.9
Mean (SD)=5.93 (±3.4) hours	> 10	25	13.2

Table-2. Clinical Characteristics of cases (n=190)

Association of clinical characteristics of patients with a new onset of seizures is presented in Table-4. Abnormal CT findings was significantly associated with cases of new onset of seizure ($p=0.025$). Majority of new cases 69 (74.2%) were taking drugs as compared to known cases 46 (47.4%) ($p=0.037$). Drug was also detected in new cases by urine analysis 63 (67.7%) ($p=0.047$). Types of seizure were statistically similar in both groups. Non-compliance to medicine was significantly associated with known cases of seizure ($p<0.001$), while Intoxication was significantly associated with new onset of seizure (6.5%) ($p=0.045$). Length of stay was statistically similar in both known and new cases of seizure.

5. DISCUSSION

In our comprehensive study, the distribution of seizure types among the patients displayed a notable pattern: the majority (43.2%) suffered from generalized

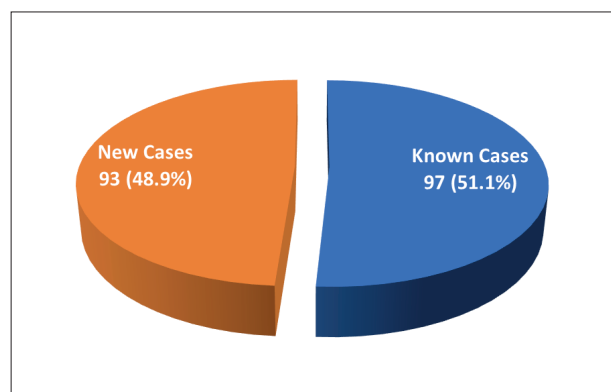


Figure-2. Onset of Seizures (n=190)

tonic-clonic seizures, while a smaller fraction experienced Status Epilepticus (4.7%), tonic seizures (3.2%), and focal onset seizures (2.1%). However, a significant percentage (45.3%) fell into the category of unknown seizure types. It is worth noting that within the context of new onset seizures at the Emergency Department of University Hospital, Karachi, Pakistan, generalized tonic-clonic seizures also prevailed as the most prevalent (74.2%) type of seizure, as documented in a study by reference. (8) Another finding emerged from another study, where generalized tonic-clonic seizures constituted the majority (76.6%) of all epileptic seizures. (9) This finding starkly contrasts with the observations made by Maloney et al., where focal seizures were predominant (71%), and generalized seizures were a minority (11%). (10) A community-based study conducted in the eastern province of Saudi Arabia found that among 136 patients, the majority were unclassifiable (51%), 38 patients (28%) showed partial seizure, and 28 patients (21%) demonstrated primary generalized seizure, which shows a lower rate generalized seizure compared to the findings of our study. However, the study included patients under the age of 18 and made a clear distinction between primary and secondary generalized seizure, which is challenging to do in the ER setting. (11)

Evaluating the causes underlying the seizures, non-compliance with prescribed medication surfaced as the primary culprit in 46 cases (24.2%). Structural abnormalities were detected as the etiological factor in 12 cases (6.3%), while the precise cause remained elusive in a significant number of cases, 107 (56.3%). A comparative analysis revealed that non-compliance with medication was significantly associated with known cases of seizure ($p<0.001$), while intoxication was notably linked with the emergence of new onset seizures (6 cases, 6.5%). A study conducted at Aga Khan University Hospital's Emergency Department delved into the causes of new onset seizures, uncovering structural brain abnormalities as the most prevalent cause, accounting for the majority (49%) of cases. Notably, similar to our study, instances of unattributable causation accounted for a significant proportion (23.6%). (8) Among 695 enrolled patients in another study, acute symptomatic seizures (ASS) were observed in 170 cases (24.5%), primarily triggered by metabolic-toxic abnormalities, with alcohol withdrawal emerging as the most prominent trigger (74.1% of all

	Normal Values	Median (IQR)			P-Values
		Overall	Seizure		
			Known Cases	New Onset	
WBC	4.0 -11.0	7.9 (5.7 – 10.3)	8.15 (5.83 – 11.13)	7.35 (5.7 – 10.1)	0.372
Hemoglobin	13.0-18.0	13.1 (11.7 – 14.9)	12.95 (11.3 – 14.4)	13.4 (11.8 – 15.1)	0.134
BUN	8.4-25.7	11 (9 – 15)	10 (8 – 15)	11 (9 – 15)	0.475
Creatinine	0.82	0.8 (0.7 – 1)	0.79 (0.68 – 0.98)	0.82 (0.7 – 1.05)	0.267
SGOT	5.0 – 34.0	20 (15 – 26)	19 (15 – 26)	20 (15 – 26)	0.805
SGPT	5.0 – 55.0	17 (11.5 – 27.5)	17 (11 – 28)	17 (12 – 25.25)	0.994
LDH	125 – 220	207 (175.5 – 256.5)	231.5 (187 – 274.5)	244.5 (179 – 285)	0.552
Lactic Acid	0.5 – 2.2	1.9 (1.4 – 3)	1.55 (1.28 – 3.2)	2.17 (1.36 – 3.07)	0.403
Creatine kinase	30.0 -200	123.5 (67.8 – 181.5)	125.5 (71.8 – 180.5)	118 (64 – 189.5)	0.909
pH	7.35 -7.45	7.4 (7.3 – 7.4)	7.37 (7.32 – 7.4)	7.37 (7.33 – 7.4)	0.986
HCO3	22 – 26	24.4 (21.4 – 25.8)	24.7 (21.2 – 26.1)	24 (21.4 – 25.5)	0.323
PCO2	35 – 45	45.5 (41.1 – 51.2)	45.4 (41.9 – 51.05)	45.6 (40 – 51.4)	0.422
Blood Glucose	70 -140	108 (95 – 137)	109 (96 – 136)	104 (95 – 143.75)	0.737
Magnesium	1.6 -2.6	2 (1.8 – 2.2)	1.96 (1.8 – 2.12)	1.97 (1.8 – 2.2)	0.46
Phosphorus	2.3 – 4.7	3.5 (2.8 – 4.1)	3.5 (2.7 – 4.1)	3.4 (2.8 – 4.1)	0.925
Sodium	136 – 145	139 (137 – 141)	139 (137 – 141)	139 (137 – 140.25)	0.93
Calcium	8.4 – 10.2	9.2 (8.8 – 9.6)	9.2 (8.7 – 9.6)	9.2 (8.9 – 9.6)	0.95

Table-3. Comparison of laboratory Parameters between known cases and New cases of Seizure (n=190). IQR=Inter-Quartile Range, WBC=White Blood Cell, BUN= blood urea nitrogen, SGOT= serum glutamic-oxaloacetic transaminase, SGPT= Serum Glutamic Pyruvic Transaminase, LDH= Lactate dehydrogenase

ASS cases). Additionally, 89.7% of patients exhibited unprovoked seizures, and of these, 377 individuals had a pre-existing epilepsy diagnosis upon presentation to the emergency room. (9). Another study investigating seizure patients' etiology found that among 99 patients with an identified etiology, traumatic brain injury (17.2%) was the most common, followed by other structural causes of epilepsy. (12) A high proportion of traumatic brain injury could be attributed to many patients being young adult males, who are at higher risk of developing a head injury. Consistent with our findings, a study examining compliance with medication revealed that a significant percentage of patients admitted to the ER for seizure were not adherent to AED (26.6%), indicating that non-adherence to medication seems to be a significant contributing factor to ER admission for seizure. (13)

Analyzing radiological findings in our cohort, CT scans revealed abnormal results in 31 cases (16.3%) of the patient cohort. These irregular findings were notably associated with cases of new seizure onset (p=0.025). Correspondingly, an earlier institutional study highlighted that 46% of adults with epilepsy who visited Emergency Departments underwent new imaging, with less than 3% of these cases resulting in acute changes to the management plan. (14) In accordance with our findings, a separate study involving 416 patients with a first seizure concluded that emergent imaging findings on non-contrast imaging were detected in a mere 12% of cases, with acute cerebral bleeding being the prevailing outcome. (15)

		Seizure		P-values
		Known Cases	New Onset	
Gender	Males	53 (54.6%)	57 (61.3%)	0.4
	Females	44 (45.4%)	36 (38.7%)	
Nationality	Saudi	94 (96.9%)	77 (82.8%)	0.001
	Non-Saudi	3 (3.1%)	16 (17.2%)	
Age	< 20	8 (8.2%)	9 (9.7%)	0.04
	21 - 40	63 (64.9%)	56 (60.2%)	
	41 - 60	20 (20.6%)	11 (11.8%)	
	> 60	6 (6.2%)	17 (18.3%)	

Table-4. Association of demographics of patients with a new onset of seizures (n=190)

Considering hospitalization rates, our study recorded that 37 patients (19.5%) were admitted to the hospital, while 153 patients (80.5%) were discharged. Factors such as advanced age, comorbidities, and the occurrence of status epilepticus appeared to elevate the likelihood of hospitalization. Interestingly, our recorded hospital admission rate contrasts with the findings of Anthony Khoo et al., where approximately half of the ED seizure presentations led to hospital admission. Specific parameters, including a pre-existing seizure disorder, a higher frequency of suspected seizures within the preceding 24 hours, and arrival at the hospital via ambulance, contributed to a higher probability of admission. (16)

When analyzing laboratory parameters, our study did not reveal any statistically significant differences between cases of new onset and known seizures. While direct comparisons between new onset and recurrent

seizure cases remain scarce, distinct analyses have explored lab values for each case category independently. In one study, pathology tests among nontraumatic recurrent seizure cases unveiled an abnormality rate of 18.3% (517/2831). Furthermore, 57.7% (56/97) of patients exhibited abnormal antiepileptic drug (AED) levels, a figure exceeding our study's finding of 47.4%, which could be attributed to the study's focus solely on nontraumatic patients. (17) Consistent with our findings, investigations into known seizure cases echoed outcomes observed in new onset seizure patients. In either scenario, laboratory testing demonstrated limited diagnostic value, primarily serving to elucidate the underlying etiology of the seizures. (17-19) Additionally, our study failed to find an association with creatine kinase and seizures, which have long been established to have a positive correlation in most instances. (19) This elevation usually occurs due to strenuous muscle contraction that occurs during seizures. (20)

In a notable trend, the duration of stay within the Emergency Department (ED) was largely consistent for both known and new cases. The majority of patients experienced stays falling within the under 5-hour bracket, followed by durations spanning from 6 to 10 hours, and finally, those exceeding 11 hours. Our analysis underscored a distinct finding: no statistically significant correlation emerged between the length of hospital stay and the differentiation between established cases of epilepsy and newly presented seizures. This observation may come from the implementation of a standardized protocol for managing such cases within our hospital setting. Moreover, it's worth highlighting that the patient profiles in both these cohorts exhibited high similarity, thereby possibly fostering comparable treatment plans. In the context of our study, the mean length of stay (LOS) was computed at 5.93 (\pm 3.4) hours. A similar investigation involving 365 patients yielded noteworthy insights, indicating an average LOS spanning from 45 minutes to 16 hours (21).

Even though our study has yielded valuable insight into the epidemiology of seizures in our region along with their correlation with certain laboratory investigations and clinical imaging, certain limitations should be taken into consideration. The retrospective cross-sectional design, centered within a single tertiary center, hampers our ability to establish causal relationships and temporal sequences. Reliance on medical records introduces potential biases and missing data. Our focus on patients presenting with seizures as their chief complaint within a specific timeframe may exclude cases with different profiles. Additionally, our retrospective approach limits the establishment of temporal relationships between factors and seizure outcomes and the inclusion of other

		Seizure		P-Values
		Known Cases	New Onset	
CT Head Done	Yes	47 (48.5%)	54 (58.1%)	0.184
	No	50 (51.5%)	39 (41.9%)	
CT Findings	Normal	33 (70.2%)	37 (68.5%)	0.03
	Abnormal	14 (29.8%)	17 (31.5%)	
Blood toxicology screen	Detected	46 (47.4%)	69 (74.2%)	0.037
	Not Detected	51 (52.6%)	24 (25.8%)	
Urine analysis for drugs	Detected	52 (53.6%)	63 (67.7%)	0.047
	Not Detected	45 (46.4%)	30 (32.3%)	
Types of Seizure	Generalized Tonic-Clonic	48 (49.5%)	34 (36.6%)	0.07
	Status Epilepticus	5 (5.2%)	4 (4.3%)	0.77
	Tonic	2 (2.1%)	4 (4.3%)	0.388
	Focal	1 (1%)	3 (3.2%)	0.28
	Clonic	2 (2.1%)	0 (0%)	0.16
	Post Traumatic	0 (0%)	1 (1.1%)	0.3
	Unknown	39 (40.2%)	47 (50.5%)	0.155
Cause of Seizure	Non-Compliance to medicine	40 (41.2%)	0 (0%)	<0.001
	Structural	3 (3.1%)	9 (9.7%)	0.06
	Intoxication	1 (1%)	6 (6.5%)	0.045
	Metabolic	3 (3.1%)	4 (4.3%)	0.66
	Infections	1 (1%)	4 (4.3%)	0.155
	Psychogenic	2 (2.1%)	1 (1.1%)	0.58
	Others	0 (0%)	3 (3.2%)	0.07
	Unknown	47 (48.5%)	60 (64.5%)	0.026
Length of Stay in ED Hours	\leq 5	45 (46.4%)	48 (51.6%)	0.47
	>5 - 10	38 (39.2%)	34 (36.6%)	0.71
	> 10	14 (14.4%)	11 (11.8%)	0.6

Table-5. Association of Clinical Characteristics of patients with a new onset of seizures (n=190)

factors such as treatment plan could have added to the benefit of this study.

6. CONCLUSION

In summary, our study provides valuable insights into seizure cases within the Emergency Department. Our diverse patient population, comprising both known and new onset cases, revealed demographic similarities, with no significant gender differences. Notably, the majority fell within the 21-40 age group (62.6%), and Saudi nationals constituted the majority (90%) of patients. Generalized tonic-clonic seizures prevailed at 43.2%. The average length of stay was 5.93 hours, and the distribution of new vs. known cases was nearly equal among the 190 patients. Laboratory findings showed no significant associations with either group, mostly falling within the normal range. To optimize care further, we recommend continued refinement of protocols, emphasis on medication compliance, and further research into factors influencing seizure presentations, ensuring tailored approaches in the dynamic realm of emergency care.

- **Author's contributions:** The all authors were involved in preparation of this article. Final proofreading was made by the first author
- **Conflict of interest:** The authors declare that research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.
- **Funding:** There is no any funding for the systematic review and meta-analysis.

REFERENCES

1. Falco-Walter J. Epilepsy-Definition, Classification, Pathophysiology, and Epidemiology. *Semin Neurol.* 2020;40(6):617-23. Epub 20201105. doi: 10.1055/s-0040-1718719. PubMed PMID: 33155183.
2. Bautista RE, Glen ET, Wludyka PS, Shetty NK. Factors associated with utilization of healthcare resources among epilepsy patients. *Epilepsy Res.* 2008;79(2-3): 120-129. Epub 20080312. doi: 10.1016/j.eplesyres.2008.01.003. PubMed PMID: 18339521.
3. eneviratne U, Low ZM, Low ZX, Hehir A, Paramaswaran S, Foong M, et al. Medical health care utilization cost of patients presenting with psychogenic nonepileptic seizures. *Epilepsia.* 2019; 60(2): 349-357. Epub 20181221. doi: 10.1111/epi.14625. PubMed PMID: 30577087.
4. Sánchez Fernández I, Amengual-Gual M, Barcia Aguilar C, Romeu A, Jonas R, Torres A, et al. Health care resource utilization and costs before and after epilepsy surgery. *Seizure.* 2023; 104: 22-31. Epub 20221126. doi: 10.1016/j.seizure.2022.11.012. PubMed PMID: 36463710..
5. Pallin DJ, Goldstein JN, Moussally JS, Pelletier AJ, Green AR, Camargo CA, Jr. Seizure visits in US emergency departments: epidemiology and potential disparities in care. *Int J Emerg Med.* 2008; 1(2): 97-105. Epub 20080605. doi: 10.1007/s12245-008-0024-4. PubMed PMID: 19384659; PubMed Central PMCID: PMC2657249.
6. Martindale JL, Goldstein JN, Pallin DJ. Emergency department seizure epidemiology. *Emerg Med Clin North Am.* 2011; 29(1): 15-27. doi: 10.1016/j.emc.2010.08.002. PubMed PMID: 21109099.
7. Koch C, Roberts K, Petrucci C, Morgan DJ. The Frequency of Unnecessary Testing in Hospitalized Patients. *Am J Med.* 2018; 131(5): 500-503. Epub 20171207. doi: 10.1016/j.amjmed.2017.11.025. PubMed PMID: 29224739; PubMed Central PMCID: PMC8628817.
8. Ali N, Dharamshi HA, Mustahsan S, Noorani S. Etiology and outcomes of new onset seizure in adult patients: A clinical experience from emergency department of a tertiary care center. *Pak J Med Sci.* 2022; 38(5): 1382-1388. doi: 10.12669/pjms.38.5.4411. PubMed PMID: 35799711; PubMed Central PMCID: PMC9247801.
9. Reinecke LCS, Doerrfuss JJ, Kowski AB, Holtkamp M. Acute symptomatic seizures in the emergency room: predictors and characteristics. *J Neurol.* 2022; 269(5): 2707-2714. Epub 20211102. doi: 10.1007/s00415-021-10871-5. PubMed PMID: 34727204; PubMed Central PMCID: PMC9021090.
10. Maloney EM, Chaila E, O'Reilly É J, Costello DJ. Incidence of first seizures, epilepsy, and seizure mimics in a geographically defined area. *Neurology.* 2020; 95(5): e576-e90. Epub 20200609. doi: 10.1212/wnl.0000000000009980. PubMed PMID: 32518150.
11. Al Rajeh S, Awada A, Bademosi O, Ogunniyi A. The prevalence of epilepsy and other seizure disorders in an Arab population: a community-based study. *Seizure.* 2001; 10(6): 410-414. doi: 10.1053/seiz.2001.0602. PubMed PMID: 11700993.
12. Khuda IE, Aljaafari D, Zeeshan MA, Nazish S, Mubbashir ES, Alsulaiman FA, et al. Preventable Etiologies of Epilepsies in Saudi Arabia: A Tertiary Care Experience. *Prim Care Companion CNS Disord.* 2021; 23(6). Epub 20211209. doi: 10.4088/PCC.20m02904. PubMed PMID: 34890498.
13. Awan SA, Khawaja I, Babar M, Khan F. Prevalence of Non-adherence to Antiepileptic Drugs in Patients With Epilepsy Presenting to Emergency With Fits. *Cureus.* 2022; 14(7): e27072. Epub 20220720. doi: 10.7759/cureus.27072. PubMed PMID: 35989764; PubMed Central PMCID: PMC9389025.
14. Salinsky M, Wong VSS, Motika P, Meuse J, Nguyen J. Emergency department neuroimaging for epileptic seizures. *Epilepsia.* 2018; 59(9): 1676-1683. Epub 20180718. doi: 10.1111/epi.14518. PubMed PMID: 30019464.
15. Kotisaari K, Virtanen P, Fors N, Strbian D, Scheperjans F. Emergency computed tomography in patients with first seizure. *Seizure.* 2017; 48: 89-93. Epub 20170417. doi: 10.1016/j.seizure.2017.04.009. PubMed PMID: 28441632.
16. Khoo A, Frasca J, Whitham E. Epilepsy and Seizure-Related Hospital Admissions to an Australian Neurology Unit: A Prospective Observational Study. *Hosp Top.* 2021; 99(1): 29-36. Epub 20201006. doi: 10.1080/00185868.2020.1828010. PubMed PMID: 33021468.
17. Burgess M, Savage S, Mitchell R, Mitra B. Pathology testing in non-trauma patients presenting to the emergency department with recurrent seizures. *Emerg Med Australas.* 2023; 35(5): 834-841. Epub 20230601. doi: 10.1111/1742-6723.14253. PubMed PMID: 37263625.
18. Sutton F, Barca D, Komoltsev I, Craiu D, Guekht A, von Oertzen T, et al. Testing blood and CSF in people with epilepsy: a practical guide. *Epileptic Disord.* 2020; 22(4): 381-398. doi: 10.1684/epd.2020.1191. PubMed PMID: 32782232.
19. Nass RD, Sassen R, Elger CE, Surges R. The role of postictal laboratory blood analyses in the diagnosis and prognosis of seizures. *Seizure.* 2017; 47: 51-65. Epub 20170227. doi: 10.1016/j.seizure.2017.02.013. PubMed PMID: 28288363.
20. Wang K, Yang J, Xu W, Wang L, Wang Y. Characteristics and treatments of patients with significantly elevated creatine kinase levels induced by seizures: Case report and literature review. *Clin Case Rep.* 11. England: © 2023 The Authors. Clinical Case Reports published by John Wiley & Sons Ltd.; 2023. p. e7788.
21. Huff JS, Morris DL, Kothari RU, Gibbs MA. Emergency department management of patients with seizures: a multicenter study. *Acad Emerg Med.* 2001; 8(6): 622-628. doi: 10.1111/j.1553-2712.2001.tb00175.x. PubMed PMID: 11388937.