BRAIN MAGNETIC RESONANCE IMAGING FINDINGS IN CHILDREN WITH SEIZURES AT MOI TEACHING AND REFERRAL HOSPITAL, ELDORET, KENYA.

BY

JOAN CHERUTO CHEBII

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DECLARATION

Declaration by the Candidate:

I declare that this thesis is my original work and has not been presented for a degree or any academic credit in any other university or examining body. No part of this thesis may be reproduced without the prior written permission of the author and/or Moi University.

JOAN CHERUTO CHEBII

Registration Number: SM/PGR/13/17

Declaration by Supervisors:

This thesis has been submitted for examination with my approval as a university supervisor.

DR. LOICE SITIENEI
Lecturer and Consultant Radiologist

Department of Radiology and Imaging,

School of Medicine, Moi University - Eldoret, Kenya

DR. EREN OYUNGU
Senior Lecturer Department of Medical Physiology,
Consultant Pediatrician and Neurologist - Department of Child Health and Pediatrics,
School of Medicine, Moi University - Eldoret, Kenya

DEDICATION

I dedicate this work to my family that has supported me throughout the research process, the postgraduate program, and my entire academic journey.

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LIST OF ABBREVIATIONS

CSF	Cerebrospinal Fluid
CT	Computed Tomography
DWI	Diffusion Weighted Imaging
FCD	Focal Cortical Dysplasia
FLAIR	Fluid Attenuation Inversion Recovery
FOV	Field of View
GM	Grey Matter
GRE	Gradient Recalled Echo
GTC	Generalized Tonic Clonic
ILAE	International League against Epilepsy
NEX	Number of Excitations
MRI	Magnetic Resonance Imaging
MTRH	Moi Teaching and Referral Hospital
T1WI	T 1 Weighted Image
T2WI	T 2 Weighted Image
TE	Time to Echo

TLE	**Temporal Lobe Epilepsy**
TR	Repetition Time
WM	White Matter

DEFINITION OF TERMS

Children: Individuals aged below 18 years.

Imaging: It is the technique and process of acquiring radiological images of the interior of a body for clinical analysis and medical intervention, as well as visual representation of the function of some organs or tissues of the body (physiology).

Magnetic resonance imaging: This is an imaging modality that uses strong magnetic fields and radio-frequency pulses to obtain high-resolution images of the body. Hydrogen nuclei are used to generate detectable signals in MRI. Magnetic resonance images are created by sending radio-frequency pulses into patients lying in an external magnetic field, thereby perturbing hydrogen nuclei into producing signals of various intensities from different body tissues. In MRI, the resulting signals are mapped onto a gray-scale digital image.

Seizures: Sudden uncontrolled electrical disturbances in the brain that can cause changes in behavior, motor function, sensory function or levels of consciousness.

OPERATIONAL DEFINITION OF TERMS

Fever: Temperature of more than 38°Celsius within 24 hours of seizure onset.

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ABSTRACT

Background: Seizures are sudden uncontrolled electrical disturbances in the brain that cause changes in behavior, movement, or levels of consciousness. They are the most common pediatric neurological disorder. The high prevalence of seizure disorders in Sub-Saharan Africa is attributed to preventable risk factors including poor perinatal care and endemic infections. Diagnosis of seizures is highly dependent on clinical evaluation and electrical physiology. However, the two have limitations in identification of structural brain disorders that might underlie seizures. Radiological investigations play a key role in identification of such lesions but their use is limited by several factors including concern for radiation and cost. Early imaging investigation will increase diagnostic certainty and prevent brain damage, especially from lesions that would benefit from treatment. The aim of this study was to determine whether there were structural brain abnormalities in children with seizures sent for brain magnetic resonance imaging (MRI) at Moi Teaching and Referral Hospital (MTRH).

Objective: To describe the age distribution and clinical features of children with seizures imaged at MTRH. To determine the proportion of children with seizures with abnormal brain MRI findings at MTRH. To describe the observed brain MRI abnormalities in children with seizures at MTRH.

Methods: A descriptive cross-sectional study was conducted for a period of one year. It was conducted on 77 patients aged below 18 years, with seizures, and sent for brain MRI. Demographic data and clinical features were obtained using a questionnaire. The patients then underwent brain MRI on a 0.36 Tesla scanner. Information on demographic data, clinical features and brain MRI findings was then analyzed. Mean and median were used to summarize continuous data. Categorical variables were summarized using frequencies, percentages, charts and tables. Association between variables was determined using Chi-square test and a P value of <0.05 was considered statistically significant. Multivariate logistic regression with odds ratio was used to determine factors that predict brain MRI findings.

Results: Age range was 1 month to 17 years. Patients aged five years and below accounted for 51.9% of cases. Females were 59.7%. Generalized onset seizures were noted in 69.6% of study participants. Fever was present in 31.2% of cases. There were underlying conditions in 53.2% of cases with birth asphyxia being the most common underlying condition at 18.2%. Most patients (71.4%) had normal brain MRI findings. Global brain atrophy was the most common pathology among children with abnormal brain MRI findings, accounting for 45.5% of cases. Other pathologies included tumors and cystic encephalomalacia. Bivariate analysis showed a statistically significant association between age, underlying condition, seizure type and brain MRI findings with P values of 0.043, 0.001 and 0.014 respectively. Multivariate logistic regression showed that underlying condition was a strong predictor of MRI findings with an adjusted odds ratio of 3.21 and a confidence interval of (1.77, 6.88) meaning that the presence of underlying condition was 3 times more likely to affect MRI findings.

Conclusions: Majority of the children studied were aged 5 years and below. The most common seizure type was generalized onset. Abnormal findings were more likely to be found among children aged five years and below, with focal onset seizures, with underlying clinical conditions, and without associated fever. Global brain atrophy was the most common pathology in children with abnormal brain MRI findings.

Recommendations: Brain MRI is recommended for children with seizures who are under five years, with focal onset seizures, without associated fever and with underlying conditions as they are likely to have structural brain abnormalities.

CHAPTER ONE: INTRODUCTION

1.1 Background Information

1.1.1 Definition of Seizure Disorders

According to the International League Against Epilepsy (ILAE), seizures are defined as sudden uncontrolled electrical disturbances in the brain that can cause changes in behavior, movement or levels of consciousness (Fisher et al., 2017).

A seizure is a rapid, paroxysmal electrical discharge from the central nervous system (CNS) that causes involuntary motor, sensory or autonomic abnormalities with or without changes in sensorium. Normal brain function requires an orderly, organized and coordinated discharge of electrical impulses. The electrical impulses enable the brain to communicate with the spinal cord, nerves and muscles as well as within itself. Seizures may result when the electrical activity of the brain is disrupted. Seizures can cause changes in behaviour, movements or feelings and in levels of consciousness. Having two or more seizures at least 24 hours apart that aren't brought on by an identifiable cause i.e. unprovoked seizures is generally considered to be epilepsy. Seizure disorder is a broad phrase that refers to a variety of conditions, including epilepsy, febrile seizures and possibly single seizures as well as symptomatic seizures caused by metabolic disorders, infections, neoplasms, congenital brain anomalies, trauma e.t.c. There are many types of seizures, which range in symptoms and severity. Seizure types vary by where in the brain they begin and how far they spread. Most seizures last from 30 seconds to two minutes (Bhavani Shankar et al., 2022).

A shift in the normal balance of excitation and inhibition within the central nervous system can result in a seizure. Depending on the distribution of discharges, this abnormal brain activity can have various manifestations. These manifestations range

from dramatic convulsive activity to experiential phenomena that is not readily discernible by an observer.

Seizures are a common and frightening neurologic disorder in childhood. They occur in approximately 4−10% of children and account for 1% of all emergency department (ED) visits. Children under three years of age have the highest incidence of seizures and this incidence decreases with increasing age. There are many possible etiologies of a first attack of seizure in children including infection, neurologic/ developmental causes, traumatic head injury and metabolic disturbances (Chen et al., 2010).

Seizures are a medical emergency in children and a common cause of hospitalization with high mortality and morbidity. The clinical appearance and kind of seizure disorder are determined by the patient's age and neurological maturity. Simple and complicated seizures, focal or partial seizures as well as generalized seizures are all part of the clinical spectrum of seizure disorders. Approximately 5% of children are at risk of having a seizure and half of these children have their first seizure while they are very young. In the newborn phase, prevalence is higher (almost 1 percent in term and 20 percent in preterm neonates). The most common type of seizure in children is febrile seizures (Bhavani Shankar et al., 2022).

Epilepsy affects 3% of people at some point in their lives, with more than half of instances beginning in childhood. Epilepsy is the most common neurological disease treated by neurologists and the most prevalent chronic condition seen by pediatricians. In the pediatric age range, the incidence of epilepsy is 1% (Bhavani Shankar et al., 2022).

1.1.2 Classification of seizure Disorders

As per the new ILAE guidelines of 2017, there are three broad classes of seizures: focal onset, generalized onset and unknown onset seizures. Focal type includes automatisms, behavior arrest, hyperkinetic seizures, autonomic seizures, cognitive seizures, absence seizures, myoclonic–atonic seizures and myoclonic–tonic–clonic seizures. Generalized type includes tonic clonic seizures, clonic seizures, tonic seizures, myoclonic seizures, myoclonic-tonic-clonic seizures, myoclonic-atonic seizures, atonic seizures, epileptic spasms, typical seizures, atypical seizures and eyelid myoclonia. Seizure manifestations are dependent on the site of the excessive neuronal discharge (Fisher et al., 2017).

Seizure classification begins with the determination of whether the initial manifestations of the seizure are focal or generalized. The onset may be missed or obscured, in which case the seizure is said to be of unknown onset. The words “focal” and “generalized” at the start of a seizure name are assumed to mean of focal or generalized onset. For focal seizures, the level of awareness optionally may be included in the seizure type. Awareness is only one potentially important feature of a seizure, but awareness is of sufficient practical importance to justify using it as a seizure classifier. Retained awareness means that the person is aware of self and environment during the seizure even if immobile. A focal aware seizure (with or without any subsequent classifiers) corresponds to the prior term “simple partial seizure.” A focal impaired awareness seizure (with or without any subsequent classifiers) corresponds to the prior term “complex partial seizure.” Impaired awareness during any part of the seizure renders it a focal impaired awareness seizure. In addition, focal seizures are sub-grouped as those with motor and non-motor signs and symptoms at the onset. If both motor and non-motor signs are present at the

seizure start, the motor signs will usually dominate, unless non-motor (e.g., sensory) symptoms and signs are prominent. Focal aware or impaired awareness seizures optionally may be further characterized by one of the listed motor onset or non-motor onset symptoms, reflecting the first prominent sign or symptom in the seizure, for example, focal impaired awareness automatism seizure. Seizures should be classified by the earliest prominent motor onset or non-motor onset feature, except that a focal behaviour arrest seizure is one for which cessation of activity is the dominant feature throughout the seizure and any significant impairment of awareness during the course of the seizure causes a focal seizure to be classified as having impaired awareness (Fisher et al., 2017).

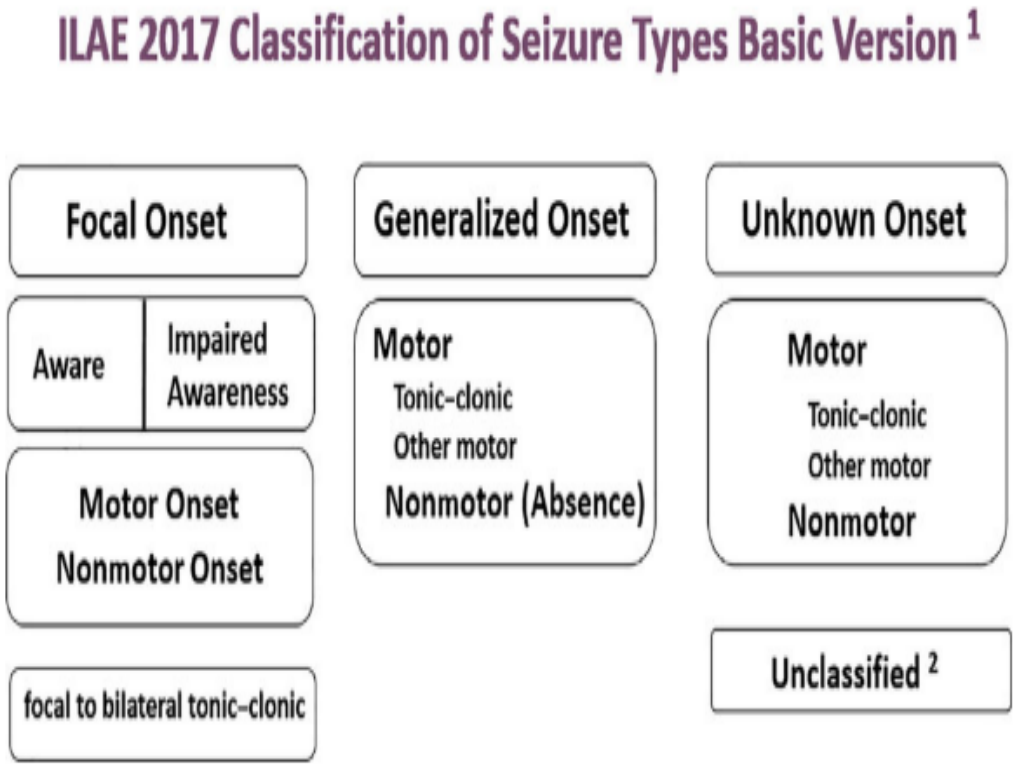


Figure 1: ILAE 2017 classification of seizure types (basic version)

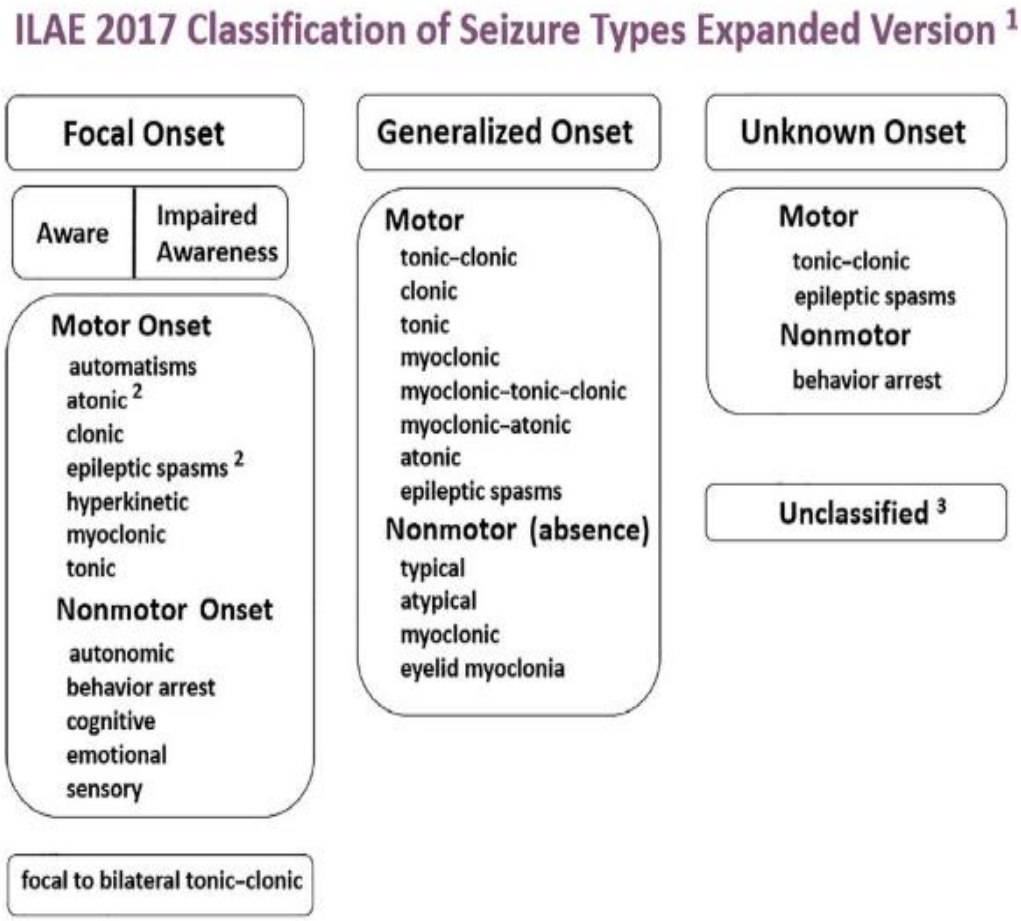


Figure 2: ILAE 2017 classification of seizure types (expanded version)

Focal Seizures

Focal seizures begin with an abnormal electrical discharge restricted to one small region of the brain. They are further categorized by the area of the brain in which they originate and their effect on consciousness, responsiveness, and memory. Symptoms can include altered behaviors, thoughts, or movements. Focal seizures can spread widely throughout the brain, causing a tonic–clonic seizure, which is a generalized seizure that involves a loss of consciousness (Fisher et al., 2017).

Focal seizures are sub-classified into motor onset and non-motor onset seizures. Focal motor onset seizures include automatisms, atonic seizures, clonic seizures, epileptic spasms, hyperkinetic seizures, myoclonic seizures and tonic seizures. Focal non-

motor onset seizures include autonomic dysfunction, behaviour arrest, cognitive dysfunction, emotional dysfunction and sensory dysfunction. There may also be transformation of focal seizures into bilateral tonic-clonic seizures (Fisher et al., 2017).

Focal seizures may be caused by an underlying structural abnormality in the brain. A person may have a cortical dysplasia, in which a region of the brain did not develop typically, with brain cells failing to form in proper layers. Focal seizures can also be due to head trauma, stroke, infection, tumour or other causes. Certain genetic disorders can also cause focal seizures. One type of epilepsy runs in families and causes seizures during sleep, for instance. Another such cause of focal seizures is tuberous sclerosis, a rare genetic disease that causes benign tumors to grow in multiple organs of the body, such as the brain, lungs, and heart, and triggers seizures. Focal seizures can be so mild that people remain completely aware during the seizures. These seizures often go undiagnosed until more severe seizures occur. Those that impair awareness are referred to as focal impaired awareness seizures.

Automatisms

Automatisms are non-purposeful, stereotyped, and repetitive behaviors that commonly accompany focal impaired awareness seizures. They occur in both focal and generalized seizures.

Atonic Seizures

Atonic seizures are a type of focal seizures that cause sudden loss of muscle strength. These seizures are also called akinetic seizures, astatic seizures, drop attacks or drop seizures. They are characterized by a sudden lack of muscle strength or tone which can cause the person to fall to the ground. The person usually remains conscious and may not always fall down.

Clonic Seizures

Clonic seizures consist of rhythmic jerking movements of the arms and legs, sometimes on both sides of the body. Jerking movements alone, as with a clonic seizure, may last a few seconds to a minute. Jerking or clonic movements that follow stiffening of muscles, as in a tonic-clonic seizure, can last a few seconds to 1 to 2 minutes. A clonic seizure may sometimes be hard to distinguish from a myoclonic seizure. The jerking is more regular and sustained during a clonic seizure.

Epileptic Spasms

An epileptic spasm consists of brief (1 to 3 second) events of arm, leg and head flexion (arms and legs pull into the body) or extension. Spasms typically occur in clusters with events occurring every 5 to 10 seconds over a 5 to 10 minute period. Spasms are often seen shortly after waking and clusters are typically seen several times per day.

Infants often become irritable and may cry during the cluster.

Hyperkinetic Seizures

Hyperkinetic seizures are characterized by motor seizures involving predominantly proximal limb or axial muscles in irregular sequential ballistic movements. The origin of hyperkinetic seizures is more commonly localized in the mesial frontal or orbitofrontal regions. Seizures often occur during sleep and recur repeatedly, with intervals of a few seconds. Sleep- related hyperkinetic epilepsy (SHE), previously named nocturnal frontal lobe epilepsy (NFLE), is a type of focal epilepsy characterized by a wide spectrum of seizures occurring predominantly during sleep, including hyperkinetic seizures. Exclusively or predominantly nocturnal hyperkinetic seizures are the typical manifestations in autosomal dominant sleep-related hyper-motor epilepsy (ADSHE), previously named autosomal dominant nocturnal frontal

lobe epilepsy (ADNFLE), which is associated with mutations in the neuronal nicotinic acetylcholine receptor sub units.

Myoclonic Seizures

Myoclonic seizures are a type of seizure that causes sharp, uncontrollable muscle movements. Myoclonic means 'muscle jerk'. Myoclonic seizures are usually minor and brief, but can happen with very severe seizure disorders. They are most common with childhood seizure conditions, but can also happen in adults.

Tonic Seizures

Tonic seizures are seizures in which sudden tension or stiffness may afflict the arms, legs or body. A tonic seizure causes a sudden stiffness or tension in the muscles of the arms, legs or trunk. The stiffness lasts about 20 seconds and is most likely to happen during sleep. Tonic seizures that occur while the person is standing may cause them to fall.

Autonomic seizures

Autonomic seizures are seizures characterized by altered autonomic function of any type at seizure onset or in which manifestations consistent with altered autonomic function are prominent (qualitatively dominant or clinically important) even if not present at seizure onset.

Behavior Arrest

A focal behavior arrest seizure is characterized by a decrease in amplitude and/or rate or arrest of ongoing motor activity during the seizure. Because brief behavior arrest is common and difficult to identify at the start of many seizures, the arrest must be persistent and dominant through the entire seizure.

Cognitive Seizures

These are focal seizures with forced thinking characterized by the presence of intrusive thoughts, ideas or crowding of thoughts occurring at seizure onset. This is a rare seizure type, seen in mesial parietal, posterior para-hippocampal and frontal lobe seizures.

Emotional Seizures

Emotional seizures are a type of focal seizures characterized by alterations in mood or emotion, or the appearance of altered emotion without the subjective emotion, at seizure onset. These emotional seizures may occur with or without objective clinical signs of a seizure evident to the observer.

Sensory Seizures

Sensory seizures are a type of focal seizures that can affect any of the five senses: touch, taste, hearing, vision, and smell. Sensory seizures may cause sensory symptoms affecting the senses, such as: hearing problems, hallucinations and olfactory or other distortions. These seizures involve the sensori-motor cortex.

Focal to Bilateral Tonic-Clonic Seizures

These seizures are called focal to bilateral tonic-clonic, because they start in a limited area on one side of the brain and spread to involve both sides. This is different from a generalized onset tonic-clonic seizure, which starts on both sides of the brain.

Generalized Seizures

Generalized seizures begin with a widespread, excessive electrical discharge involving both hemispheres of the brain. Symptoms include staring and blinking, jerking movements, loss of muscle tone, and stiffening of limbs. When the entire brain is involved, symptoms include rhythmic, full-body jerking. Seizures that arise from both hemispheres of the brain at the same time are characteristic of a type of

epilepsy that has been called primary generalized epilepsy or idiopathic generalized epilepsy.

Generalized seizures are sub-classified into motor and non-motor seizures. Motor seizures include tonic clonic seizures, clonic seizures, tonic seizures, myoclonic seizures, myoclonic-tonic-clonic seizures, myoclonic-atonic seizures, atonic seizures and epileptic spasms. Non-motor seizures include typical seizures, atypical seizures, myoclonic seizures and eyelid myoclonia.

The cause of generalized seizures is presumed to be genetic. Only rarely is the genetic abnormality known; more often it is unknown, and no other family members are known to have seizure disorders.

Tonic-Clonic Seizures

A generalized tonic-clonic seizure, formerly known as grand mal seizure, is defined as a seizure that has a tonic phase followed by clonic muscle contractions. Tonic-clonic seizures involve both stiffening and twitching or jerking of a person's muscles.

Myoclonic-Tonic-Clonic Seizures

Tonic: Muscles in the body become stiff. Atonic: Muscles in the body relax. Myoclonic: Short jerking in some parts of the body. Clonic: Periods of shaking or jerking of some parts of the body.

Myoclonic-Atonic Seizures

Myoclonic atonic seizures are rare childhood seizures. They are typically recognized as jerking muscle contractions followed by sudden muscle limpness.

Eyelid Myoclonias

Eyelid myoclonias are brief, repetitive, often rhythmic, fast myoclonic jerks of the eyelids with simultaneous upward deviation of the eyeballs and extension of the head. They are usually brief (less than 6 seconds) but frequent (occur multiple times a day).

Eyelid myoclonias are usually induced by eye closure. All patients are photosensitive resulting in light induction of seizures in daily life. Eyelid myoclonic status epilepticus may occur (seen in up to one fifth of patients and are repetitive and discontinuous episodes of eyelid myoclonias with mild impairment of awareness and responsiveness). Eyelid myoclonias may or may not be associated with impairment in awareness (absences with eyelid myoclonia). If absences with eyelid myoclonias do occur, impairment in awareness is usually mild.

Focal versus Generalized Seizures

In 2010, the ILAE defined focal as "originating within networks limited to one hemisphere. They may be discretely localized or more widely distributed. Focal seizures may originate in sub-cortical structures." Generalized from onset seizures were defined as "originating at some point within, and rapidly engaging, bilaterally distributed networks." Classifying a seizure as having apparently generalized onset does not rule out a focal onset obscured by limitations of the current clinical methods, but this is more an issue of correct condition than of classification. Furthermore, focal seizures may rapidly engage bilateral networks, whereas classification is based on unilateral onset. For some seizure types, for example, epileptic spasms, the distinction of a focal versus generalized onset may require careful study of a video-EEG recording or the type of onset may be unknown. A distinction between focal and generalized onset is a practical one, and may change with advances in ability to characterize the onset of seizures (Fisher et al., 2017).

Focality of seizure onset can be inferred by pattern matching to known focal-onset seizures, even when the focality is not clear strictly in terms of observable behaviour. A seizure is focal, for example, when it starts with deja vu and then progresses to loss

of awareness and responsiveness, lip-smacking, and hand-rubbing for a minute. There is nothing intrinsically “focal” in the description, but video- EEG recordings of countless similar seizures have previously shown focal onsets. If the epilepsy type is known, the onset can be presumed even if it is unwitnessed; for example, an absence seizure in a person with known juvenile absence epilepsy. Clinicians have long been aware that so-called generalized seizures, for example, absence seizures with EEG generalized spike-waves, do not manifest equally in all parts of the brain. The Task Force emphasized the concept of bilateral, rather than generalized, involvement of some seizures, since seizures can be bilateral without involving every brain network. The bilateral manifestations need not be symmetric. The term “focal to bilateral tonic–clonic” was substituted for “secondarily generalized.” The term “generalized” was maintained for seizures generalized from onset (Fisher et al., 2017) .

Unknown Onset Seizures

Clinicians commonly hear about tonic–clonic seizures for which the onset was unobserved. Perhaps, the patient was asleep, alone, or observers were too distracted by the manifestations of the seizure to notice the presence of focal features. There should be an opportunity to provisionally classify this seizure, even in the absence of knowledge about its origin. The Task Force therefore allowed further description of seizures of unknown onset when key characteristics, such as tonic–clonic activity or behaviour arrest are observed during the course of the seizure. The Task Force recommends classifying a seizure as having focal or generalized onset only when there is a high degree of confidence (e.g., ≥80%, arbitrarily chosen to parallel the usual allowable beta error) in the accuracy of the determination; otherwise, the seizure should remain unclassified until more information is available. It may be impossible

to classify a seizure at all, either because of incomplete information or because of the unusual nature of the seizure, in which case it is called an unclassified seizure. Categorization as unclassified should be used only for the exceptional situation in which the clinician is confident that the event is a seizure but cannot further classify the event (Fisher et al., 2017).

Seizures can also be classified as febrile or afebrile. Febrile seizures are seizures associated with fever (temperature higher than 38^0 Celsius) within 24 hours of onset of first seizure. They usually occur in about 2 to 5% of children 6 months to 5 years of age, but most occur between 12 months and 18 months of age. Febrile seizures may be simple or complex. Simple febrile seizures last less than 15 minutes, have no focal features, and do not recur within a 24-hour period. Complex febrile seizures last more than 15 minutes continuously or with pauses, or have focal features, or recur within 24 hours. About 90% febrile seizures are simple. Febrile seizures occur commonly due to bacterial or viral infections. Brain MRI is done if neurologic examination detects focal abnormalities or if focal features occur during the seizure or postictal period. Afebrile seizures are seizures not associated with fever (a temperature of more than 38^0 Celsius) within 24 hours of onset of first seizure (Fisher et al., n.d.).

Febrile seizure was defined by the 1993 International League Against Epilepsy (ILAE) as, “an epileptic seizure occurring in childhood after 1 month of age, associated with febrile illness not caused by an infection of the central nervous system, without previous neonatal seizure or previous unprovoked seizure, and not meeting criteria for other acute symptomatic seizure. In addition, febrile seizures were classified as simple febrile seizures or complex febrile seizures. A simple febrile seizure lasts less than 15 minutes, is initially generalized in nature, and occurs once

during a 24-hour period. In contrast, a complex febrile seizure lasts more than 15 minutes, has focal features at any time, or recurs within a 24-hour period (Chen et al., 2010).

In this study, definition and classification of the seizures was done by the referring clinician.

1.1.3 Neuroimaging of Seizure Disorders

Evaluation of seizure disorders involves identifying the symptoms, clinical condition of the case, laboratory evaluation, EEG recording, lumbar puncture in suspected meningitis and neuroimaging. Recent advances in neuroimaging play an important role in the condition, management and in guiding the treatment of pediatric seizure disorders. Functional neuroimaging provides further information and may show abnormalities even in cases where MRI was normal, thus further helping in the localization of the epileptogenic foci and guiding the possible surgical management of intractable/refractory epilepsy when indicated. Many focal lesions/ pathologies responsible for epilepsy are identified with neuroimaging. The yield of neuroimaging is high even in low risk groups. The imaging modality of choice is MRI because of its superior resolution compared to CT and ultrasound. MRI provides detailed evaluation of small lesions, radiation free (Mundhe, 2022).

Seizure disorder is a broad phrase that refers to a variety of conditions, including epilepsy, febrile seizures, and possibly single seizures and symptomatic seizures. The seizures are caused by metabolic disorders, infections, neoplasms, congenital brain anomalies, trauma e.t.c. Seizure disorders in children are commonly seen in clinical practice and in the assessment of these patients. They are a common medical emergency in children and a common cause of hospitalisation, with high mortality

and morbidity. Magnetic Resonance Imaging (MRI) is found to be the ideal and first imaging modality of choice for pediatric seizure disorders because of lack of radiation exposure (Bhavani Shankar et al., 2022).

MRI has replaced CT in the elective workup of seizure disorder in children. This is because of its capacity to portray neuro-anatomy, great grey-white matter distinction, great assessment of the condition of myelination and the detection of focal structural brain lesions. The use of magnetic resonance imaging (MRI) has improved the understanding of the underlying illness process, as well as the evaluation and therapy of seizure disorders. In roughly 12 to 14 per cent of individuals with newly diagnosed epilepsy, MRI can detect the seizure-causing lesion. Some indications for MRI in epileptic children have been provided by the International League against Epilepsy (ILAE) (Bhavani Shankar et al., 2022).

The causes of pediatric seizure disorders range from medically responsive to medically refractive lesions. Accurate condition can aid in prompt intervention resulting in reduction of morbidity associated with the epilepsy and helps in improving the quality of life of patient. MRI is the investigation of choice for accurate localization of lesion and follow-up due to its better spatial resolution, soft tissue delineation, multi-planar imaging capability and safety due to non-utilization of ionizing radiation. Better planning and use of the seizure protocol during MR scanning can accurately diagnose the lesion. This in turn will change the outcome via prompt management of these patients (Khandediya et al., 2021).

Seizures are a common complaint evaluated in pediatric emergency departments. There are various causes. These include epilepsy, intra-cerebral infections, brain

tumours, traumatic brain injury, metabolic disturbances, medications, vascular disorders, autoimmune conditions and toxins (Chandini et al., 2019).

Assessment of the condition of seizure disorders is a frequently encountered problem in clinical practice. Accurate condition of the condition of seizure is crucial for providing an effective treatment. In order to diagnose and find out the condition of the lesion, there are many neuro-radiological investigations that can be utilized. Since the mid 1980's, when MRI became widely available for clinical use, it has brought on revolutionary changes in the management of patients with epilepsy. MRI has been shown to be highly sensitive and specific in identifying the underlying cause of seizures. With its higher sensitivity, better spatial resolution, excellent soft tissue contrast, multi-planar imaging capability and lack of ionizing radiation it has emerged as the primary modality of choice in the evaluation of seizure disorders. In neuro-imaging of the pediatric population, MRI is preferred to computed tomography due to the fact that there is no radiation exposure. MRI is the investigation of choice in neuro-imaging of epileptic syndromes, acute cerebrovascular disease with seizure, developmental cortical malformations and vascular malformations. Its ability to identify subtle lesions, location, extent of the lesions and number of findings is excellent. MRI is an excellent tool for detecting anatomic substrates that underlie regional brain epileptogenesis and aids in formulating a syndromic or etiological condition so as to plan for further management (surgery, pharmacotherapy or both). MR imaging plays an important role in the evaluation of patients with seizures as well as in refractory cases. MR imaging identifies specific epileptogenic substrates as well as determines specific treatment and predicts prognosis. Employing appropriate imaging protocols and reviewing the images in a systemic manner helps in the identification of subtle epileptogenic structural abnormalities. The role of MRI in

epilepsy surgery in identifying the epileptogenic focus also lies in its ability to depict topographic relationships between epileptogenic lesion and the eloquent regions of brain. Postoperative MRI may detect reasons for failure to control seizures such as inadequate resection and can monitor tumor recurrence on follow up imaging. It is also useful for prognosticating postoperative seizure control (Chabarwal & Kardam, 2019).

In epileptology, MRI has revolutionized our ability to detect lesions, shifting the field from prevailing electro-clinical correlations to a multidisciplinary approach. It provides a unique, versatile, and non-invasive tool for brain-wide evaluation of patients with epilepsy. Numerous studies have related the presence and types of MRI abnormalities to clinical outcomes. In a cohort of 764 patients undergoing MRI at the time or soon after a first seizure, 23% had a potentially epileptogenic lesion, including stroke, trauma, a developmental abnormality or a tumor (Bernasconi et al., 2019).

MRI is fundamentally important and has become increasingly relevant in the evaluation and management of childhood epilepsy: supporting elucidation of condition, syndrome description, prognostication, and determination of opportunities for definitive interventions. Identification of focal brain lesions on MRI has supported the scale-up of surgical interventions, delivering favorable outcomes for epilepsy conditions that were hitherto associated with refractory seizures and poor outcomes. In infectious pathologies, it is useful in discerning etiological agents and supporting targeted and adequate microbial care. MRI is essentially an indispensable tool in an optimally functioning center that cares for people with epilepsy. However, MRI practices are variable worldwide, particularly in Sub Saharan Africa, on account of disparate resources, technical capacity, and infrastructure. Identifying candidates for

priority access is useful in informing judicious use where resources are limited (Samia et al., 2021).

Neuroimaging is a core investigation in the evaluation of early childhood epilepsy, which occurs in 1 to 2 out of 1000 children who are less than 3 years of age. Epilepsy has various causes, many of which manifest as structural brain abnormalities. Identification of structural abnormalities may inform additional testing, including genetic or metabolic investigations. Certain structural abnormalities portend a pharmaco-resistant course and may accelerate plans for surgical intervention. Because neuroimaging serves an important role in parsing condition and guiding management, clinical guidelines delineate the use of MRI in children presenting with seizures. Recent international guidelines recommend MRI specifically in early life epilepsy (ELE) for any child with seizure onset before the age of 2 years (Coryell et al., 2018).

Many studies have noted that neuroimaging modalities are of extreme value in the screening and definitive evaluation of seizures in children. Brain imaging detects lesions in a considerable proportion of patients presenting with seizures. These lesions may include tumours, intra-cerebral infections, cerebral malformations, small vascular abnormalities, brain atrophy, calcification and scars. Except for expanding space occupying lesions, most of these lesions do not require any surgical treatment, but their detection may have implications for future management should the epilepsy become intractable. Magnetic resonance imaging scan is the brain imaging investigation of choice in patients with epilepsy where there is appropriate indication. MRI brain scanning is preferred to computed tomography as it can detect lesions that are not detected by the CT scan e.g. small tumours, vascular malformations, hippocampal sclerosis and cortical dysplasia. It is also considered safe for the

pediatric age group as it does not contain ionizing radiation. The increasing availability of magnetic resonance imaging scanners means that all pediatric patients with unexplained seizures should be investigated. Structural lesions identifiable in pediatric patients with seizures are quite common and diverse. Significant proportion of these patients may potentially benefit from neurosurgical intervention. (Ministry of Health - Kenya, 2016).

Neuroimaging is recommended when localization-related seizure is known or suspected, when the epilepsy classification is in doubt, or when an epilepsy syndrome with remote symptomatic cause is suspected. MRI is the modality of first choice. Aims of structural imaging include locating the epileptogenic region, providing a surgical planning map, defining the relation of a focal lesion to eloquent areas and as a base for functional studies including Positron Emission Tomography (PET), Single Photon Emission Computed Tomography (SPECT), functional MRI and Magneto-encephalography (MEG). Axial and coronal T2WIs are usually the starting point to look for cerebral hemispheric asymmetry (both size and signal intensity), gyral folding pattern, blurring of the grey and white matter junction and symmetry of the white matter signal. Following this, volumetric T1WIs are reviewed and assessed for midline structures including the hypothalamic region, gyral folding pattern, cortical thickness, sulcal asymmetry, uniformity of cortical signal and sub-cortical and periventricular gray matter lesions. Finally, the hippocampi and temporal lobes are reviewed in detail (Article et al., n.d.).

Early childhood seizures occur in 2 to 4% of population with high prognostic rate. Pathology of the hippocampus is one of the major culprits. The hippocampus is located in the temporal lobe, near the inferior horn of the lateral ventricle. The main

input and output pathways of hippocampus are the entorhinal cortex and fornix respectively. Hippocampus inputs are gathered from temporal lobe, orbital and cingulate cortex, amygdala and olfactory bulb. The hippocampus prepares information to be processed in dentate gyrus. Three major data transferring pathways for hippocampus include the perforant pathway, the mossy fibre pathway and the Schaffer collateral pathway. The pyramidal cells, which are located in the middle of hippocampus, are responsible for the major electroencephalogram (EEG) waves. Asynchronous discharge is called a seizure. Some studies have demonstrated that the loss of neural cells in hippocampus could lead to temporal lobe epilepsy (Mahmoudzadeh et al., 2014).

Magnetic Resonance Imaging (MRI) is a useful method for biometric study of amygdala and hippocampus. Diagnosing hippocampal volume reduction is important in early stage of disease. New advances in MRI provide more sections with lower thickness and better image quality. Neuronal cell destruction and gliosis in the hippocampus are called hippocampal sclerosis. MRI is very sensitive in locating hippocampal sclerosis and atrophy and increased T2 signal are suggestive of the former. It has been noted that hippocampal anomalies are common in patients with neocortical epilepsies. Many children with hippocampal sclerosis underwent surgery for treatment. Hippocampal asymmetry has also been demonstrated in children with intractable seizures. Various studies demonstrated that total brain volume was reduced in patients with temporal lobe epilepsy and early onset seizures. These studies also showed that the extent of white matter volume reduction was not associated with seizure lateralizing manifestations (Mahmoudzadeh et al., 2014).

Seizures are the most common pediatric neurological disorder. Four to ten per cent of children suffer at least one episode of seizures in the first sixteen years of life. The incidence is highest in children less than three years of age, with a decreasing frequency in older children. Seizures account for about one per cent of all emergency department visits and about two per cent of visits of children's hospital emergency department visits. The incidence of recurrent unprovoked seizures in children and adolescents seems relatively consistent across all populations studied, ranging from 50 to 100 per l00, 000 person-years. Central nervous system infections and tumors are the main cause of seizures and acquired epilepsy in the developing world. Most cases are associated with increased mortality and morbidity, including subsequent epilepsy (Adhikari et al., 2013).

Seizures are the most common and frightening neurologic disorder of childhood. They occur in approximately 4−10% of children and account for 1% of all emergency department (ED) visits. Children under three years of age have the highest incidence of seizures and this incidence decreases with increasing age. There are many possible etiologies of a first attack of seizure in children. These include infections, neoplasms, neurologic/ developmental causes, vascular causes, traumatic head injury and metabolic disturbances (Chen et al., 2010).

Structural neuroimaging plays an important role in the evaluation, management, and treatment of the child with seizure disorders. The role of neuroimaging is to detect an underlying cerebral lesion(s) that may be causally related to the child’s seizure disorder or associated neurodevelopmental impairment. Imaging is obtained to establish etiology, to provide prognosis and to plan appropriate clinical care. MRI is considered the imaging modality of choice because it is superior in anatomic

resolution and characterization of pathological processes. Studies in children and in adults with childhood-onset epilepsy in both recent-onset and chronic seizure disorder find that MRI identifies more abnormalities than CT (Gaillard et al., 2009).

1.2 Statement of the Problem

Seizure disorder is a common neurological disorder globally affecting 70 million people. Up to 90% live in low-income and lower-middle income countries (L&LMICs) and over half of these are children. Seizures presenting in childhood are heterogeneous, with diverse underlying etiologies, clinical presentations, severity and prognosis. Neuro-behavioral and psychiatric comorbidities occur in up to 80% of children and are frequently under-recognized (Ackermann et al., 2019).

Seizures are the most common and frightening neurologic disorder of childhood. They occur in approximately 4 to 10% of children and account for 1% of all emergency department visits. Children under three years of age have the highest incidence of seizures, and this incidence decreases with increasing age. There are many possible aetiologies of a first attack of seizure in children including infections, neoplasms, neurologic/ developmental causes, vascular causes, traumatic head injury and metabolic disturbances (Chen et al., 2010).

Consistent with the global trend, the highest incidence of seizure disorders in Africa occurs in the pediatric population. The high prevalence of seizure disorders in Sub Saharan Africa is attributed to preventable risk factors including poor perinatal care, endemic infectious diseases and head injury. Factors contributing to the treatment gap in Sub Saharan Africa include limitations in accessing adequate diagnostic and treatment services as well as negative cultural and social beliefs (Samia et al., 2019).

Kenya faces a high burden of seizure disorders, particularly in children. Cultural beliefs, stigma, and lack of access to treatment and skilled human resources are potential causes of delayed condition and management. Potentially treatable and/or preventable etiologies, including adverse perinatal events, brain injuries and infections as well as familial genetics are common risk factors and causes. Premature mortality, neurological sequelae, behavioral problems, frequent hospitalization and injuries are common sequelae for children with seizure disorders in Kenya, all of which point to extremely poor outcomes. Access to appropriate investigations and treatment is highly variable and the treatment gap in Kenya remains unacceptably high. There is need for better public awareness, improved epidemiological understanding and access to affordable quality health care for all those affected. A national strategy is needed to inform further research and multi-sector approaches to improve outcomes for children with seizure disorders (Samia et al., 2019).

Pediatric seizures in developing countries are often poorly investigated and consequently poorly managed. Sociocultural misconceptions, financial difficulties and lack of facilities are often blamed. Even among medical practitioners, there seems to be a significant controversy on the need for neuroimaging investigations for pediatric patients presenting with certain clinical types of seizures. In the under-five age group, generalized seizures associated with fever often times are initially clinically diagnosed and managed as febrile seizures. Concerns for radiation risks may also account for scan rates in the under 5s being the lowest. The concern of radiation exposure to the relatively young brain tends to delay the decision of medical experts and patient relatives to present these patients for neuroimaging. This is further compounded by the currently slightly high cost of these investigations, especially MRI scanning. Unfortunately, the use of the more affordable ultrasound scans, for investigating the

brain for structural lesions is limited to infants with a patent fontanelle (Ndubuisi et al., 2016).

The controversy on the neuroimaging investigation for pediatric seizures also extends to the appropriate timing for CT or MRI scanning. The fact that more patients are referred as the age range increases is probably related to the fear of the long‐term risks associated with exposure to irradiation from computed tomographic scanning for the pediatric age group. The end result is poor outcomes of some of the cases due to missed condition of potentially curable brain lesions. Several studies have shown that the proportion of normal findings was least in the pediatric age group and increased as the age range increased (Ndubuisi et al., 2016).

The foregoing points to the possibility that children sent to radiology for neuroimaging may include those who would benefit from the investigation as well as those who are unlikely to benefit but end up being exposed to radiation. In deed neuro- imaging has been recommended for all children with refractory seizures, those with unexplained new onset seizures, those with recently diagnosed localization-related or generalized seizures who do not have the clinical and electro-encephalographic features characteristic of classical idiopathic focal or generalized epilepsy and for any child younger than 2 years of age with seizures. These children have the highest likelihood of identifying a symptomatic etiology for their seizures (Gaillard et al., 2009). However, there is no evidence that these recommendations guide requests for neuroimaging in MTRH, on the contrary, clinicians make individualized decisions on who to send for neuroimaging. It is unknown whether the results of neuroimaging are used to guide selection of patients so as to optimise the cost, utility and risk of neuroimaging. As noted by (Ndubuisi et al., 2016), when

neuroimaging facilities are not utilized during the patient investigation, certain types of neurological disorders could be wrongly diagnosed and the optimum management of such patients may be compromised. These factors also make it difficult to get true epidemiological data.

1.3 Justification of the Study

This study determined the brain magnetic resonance imaging findings among children with seizures and sent to the radiology department for neuroimaging in Moi Teaching and Referral Hospital.

MRI is fundamentally important and has become increasingly relevant in the evaluation and management of childhood epilepsy: supporting elucidation of condition, syndrome description, prognostication, and determination of opportunities for definitive interventions. Identification of focal brain lesions on MRI has supported the scale-up of surgical interventions, delivering favorable outcomes for epilepsy conditions that were hitherto associated with refractory seizures and poor outcomes. In infectious pathologies, it is useful in discerning etiological agents and supporting targeted and adequate microbial care. MRI is essentially an indispensable tool in an optimally functioning center that cares for people with epilepsy (Samia et al., 2021).

In the evaluation of pediatric patients with seizure disorders, it is important to arrive at an accurate condition of cause of seizure because symptomatic seizures may require specific management of the underlying disorder or may be responsive to specific anti-seizure medication, for instance vigabatrin in Sturge Weber Syndrome. Also, neuroimaging is useful in counselling and prognostication especially in seizures that might be refractile to treatment. The imaging modality of choice is MRI because of its superior resolution compared to CT (Gaillard et al., 2009).

Several studies have shown that structural lesions identifiable in pediatric patients with seizures are quite common and diverse. These are therefore missed out if no radiological investigations are carried out resulting in poor outcomes. Early neuroimaging investigations in patients with seizures would increase diagnostic certainty, improve delay in presentation, prevent progressive brain damage, especially from lesions that would potentially benefit from surgery as well as reduce cost on the long run, as a result of wrong decision or need for medication. It is not known how clinicians in MTRH decide on which children are sent for imaging. There is no control on which clinicians make the final decision to request for neuroimaging. It is probable that the children sent for imaging is a mix of those with and without specific indication. A significant proportion of these patients may potentially benefit from change of management like neurosurgical intervention (Newton et. al, 1994).

On the other hand, another group might benefit from not being sent for imaging. By doing this study, clinicians will be better advised on the need to either increase or reduce the number of children they send for neuroimaging. Failure to carry out this study will perpetuate the current practice of unguided referral for neuroimaging and perhaps fail to spur improvement in care of children with seizure disorders.

This study will also open new opportunities for future researchers in this area to evaluate the impact of this research and also do more research in any other relevant area of interest concerning neuroimaging of patients with seizures.

1.4 Research Question

What are the brain magnetic resonance imaging findings in children with seizures imaged at Moi Teaching and Referral Hospital?

1.5 Objectives

1.5.1 Broad Objective

The goal of this study was to describe brain magnetic resonance findings in children with seizures who are sent for brain MRI scanning in Moi Teaching and Referral Hospital.

1.5.2 Specific Objectives

1. To describe the age distribution and clinical features of children with seizures imaged at the radiology department in Moi Teaching and Referral Hospital.
2. To determine the proportion of children with seizures with abnormal brain MRI findings at Moi Teaching and Referral Hospital.
3. To describe the observed brain MRI abnormalities in children with seizures at Moi Teaching and Referral Hospital.

1.6 Study Limitation

This was an institution based study hence results may not be generalizable to the population. Only those patients with seizures who undergo imaging in MTRH were included. Some children may not be able to afford imaging and this is likely to introduce selection bias.

CHAPTER TWO: LITERATURE REVIEW

2.1 Introduction

According to the International League Against Epilepsy (ILAE), seizures are defined as sudden uncontrolled electrical disturbances in the brain that can cause changes in behavior, movement or levels of consciousness (Fisher et al., 2017).

Seizure disorder is a common neurological disorder that affects 70 million people globally. Up to 90% live in low-income and lower-middle income countries (L&LMICs) and over half of these are children (Ackermann et al., 2019).

Seizures are a common medical emergency in children and a common cause of hospitalization with high mortality and morbidity. The clinical appearance and kind of seizure disorder are determined by the patient's age and neurological maturity. Approximately 5% of children are at risk of having a seizure, and half of these children have their first seizure while they are very young. In the newborn phase, prevalence is higher (almost 1 percent in term and 20 percent in preterm neonates). Epilepsy affects 3% of people at some point in their lives, with more than half of instances beginning in childhood. Epilepsy is the most common neurological disease treated by neurologists and the most prevalent chronic condition seen by pediatricians. In the pediatric age range, the incidence of epilepsy is 1% (Bhavani Shankar et al., 2022).

Seizures presenting in childhood are heterogeneous, with diverse underlying etiologies, clinical presentations, severity and prognosis. Neuro-behavioral and psychiatric comorbidities occur in up to 80% of children and are frequently under-recognized (Ackermann et al., 2019).

Consistent with the global trend, the highest incidence of seizure disorders in Africa occurs in the pediatric population. The high prevalence of seizure disorders in Sub

Saharan Africa is attributed to preventable risk factors including: poor perinatal care, endemic infectious diseases and head injury. Factors contributing to the treatment gap in Sub Saharan Africa include limitations in accessing adequate diagnostic and treatment services as well as negative cultural and social beliefs (Samia et al., 2019).

Kenya faces a high burden of seizure disorders, particularly in children. Cultural beliefs, stigma, and lack of access to treatment and skilled human resources are causes of delayed condition and management. Potentially treatable and/or preventable etiologies, including adverse perinatal events, brain injuries, infections, as well as familial genetics are common risk factors and causes. Premature mortality, neurological sequelae, behavioral problems, frequent hospitalization, and injuries are common sequelae for children with seizure disorders in Kenya, all of which point to extremely poor outcomes. Access to appropriate diagnostic investigations and treatment is highly variable and the treatment gap in Kenya remains unacceptably high. There is a need for better public awareness, improved epidemiological understanding of seizure disorders within Kenya, access to affordable quality health care for all those affected and improved facilities for condition and treatment. A national strategy is needed to inform further research and multi-sector approaches to improve outcomes for children living with seizure disorders (Samia et al., 2019).

2.2 Demographic Factors of Children with Seizures who underwent MRI Scanning

A prospective cross-sectional study of 100 patients in the age group of 3 months to 18 years with a clinical history of seizure disorder was conducted at Justice K. S. Hegde Charitable Hospital, Nitte University. All these patients were subjected to MRI examination of the brain. The age distribution of the subjects was: 19 children

between the age group of 3 months to 1 year, 42 cases between 2 to 6 years, 27 cases between 7 to 12 years, and 12 cases between 13 to 18 years. This distribution showed that the maximum number of patients (42.0%) were in the age group 2 to 5 years, followed by 27.0% patients in the age group of 2 to 12 years. Out of the total patient population, 59 males and 41 females were observed showing slight male predominance (Bhavani Shankar et al., 2022).

A hospital based prospective study was conducted in Department of Radiocondition, Vilasrao Deshmukh Government Medical College, Latur, India. The study duration was 2 years (July 2018 to June 2019). All pediatric patients (age under 12 years) referred from the outpatient department (OPD) and the inpatient department (IPD) who presented with seizure disorders were included. The study included MRI brain evaluation of 100 cases of pediatric patients aged between 0 and 12 years. The most common age group in the study was 10 to 12 years (33%) followed by 0 to 3 years (29 %). 58 patients (58%) were males and 42 patients (42%) were females. Male to female ratio was 1.3:1 (Mundhe, 2022).

A cross sectional study was conducted to review and analyse the clinical characteristics and brain MRI findings in a cohort of children diagnosed with infantile spasms at King Abdulaziz University Hospital, Jeddah, Saudi Arabia. Fifty six children diagnosed with infantile spasms in infancy and early childhood were included. All of them underwent brain MRI for evaluation. The study was conducted in the period from January 2016 to January 2020. There were 32 female patients (57%) and 24 male patients (43%). The mean age of seizure onset was 5.9 ± 2.7 months, and the age range was from 2 to 13 months (Muthaffar, 2022).

A study was performed on 50 children under the age of 12 years who presented with seizure disorders. The study was conducted over a period of 1 year. Patients with trauma were excluded. The aim of study was to detect and characterize various lesions causing seizure disorders in pediatric age group (0 to 12years) and also to detect frequency with which they occurred using MRI. Majority of the children belonged to the age group of 1 to5 years (62%). The study population was composed of 29 males and 21 females with a mean age group of 1 to 5 years (Khandediya et al., 2021).

A cross-sectional study of all patients diagnosed with epileptic spasms was conducted at Muhimbili National Hospital, Tanzania. Paper based case notes and an electronic database of these patients under the age of five years for both inpatients and outpatients from July 2016 to January 2021 were retrieved and thoroughly reviewed. Most of the patients were males, constituting about 60% of the studied patients. More than 80% (60 patients) included in the study were below three years of age, with the rest being 4 to 5 years old. The median age of onset of patients with epileptic spasms was five months (IQR 1-12 months) (Mwalongo & Kija, 2020).

A descriptive study was conducted to determine the etiology of seizures in children aged between one month and five years in a tertiary care hospital in Guntur, India. This study was done on 100 cases admitted to pediatric department ward, Government General Hospital (Guntur), with seizures in the age group of one month to five years during the period of July 2018 and April 2019. Of the 100 cases, incidence of seizures was maximum in the age group of 1yr to 3yrs (42%). 54% of the cases were male and 46% were female thus male to female ratio was 1.17:1. 40 of the cases underwent neuroimaging (CT or MRI scanning) (Chandini et al., 2019).

775 children with newly diagnosed early life epilepsy (ELE) were enrolled in a study through 17 United States pediatric epilepsy centers between 2012 and 2015 the study was aimed at assessing the adherence to neuroimaging guidelines and the diagnostically relevant yield of neuroimaging in newly presenting early life epilepsy (ELE). Out of the 775 subjects, 367 (47.4%) were female. The mean age at epilepsy onset was 11.1 months. 65.7% of the subjects had onset before 1 year of age. The mean age at condition was 12.7 months (Coryell et al., 2018).

Medical files of 173 children who presented to the emergency department with a first afebrile seizure and underwent neuroimaging within 24 hours of presentation were retrospectively evaluated. There were 103 males (59.5%) and 70 females. The mean age was 80±60.4 months (1-204). One hundred twenty-one (70%) patients were older than 24 months of age. Of the 173 children, 87 (50.3%) had a CT scan only, 50 (28.9%) had MRI only, and 36 (20.8%) underwent both MRI and CT (İlk et al., 2017).

A hospital based prospective time bound clinical study was carried out in a Tertiary Care Centre in India over a period of two years. 95 pediatric patients (age under 12 years) referred from outpatient department and inpatient department who presented with seizure disorders were included. As regards demographics, most of the patients in the study were in the age group of 0–3 years followed by 10–12 years. There was a male preponderance with a male to female ratio of 2.1:1 (Anand et al., 2017).

A study aimed at investigating the pattern of childhood epilepsies was conducted in National Hospital Abuja, a tertiary care centre located in the capital city of Nigeria. 226 children were recruited in the study. Regarding the age distribution, 5.3% of the patients were infants, 19.9% were toddlers, 14.6% were of preschool age, 24.8% were

of the age range of 6-9 years and 35.4% adolescents between the ages of 10 to 17 years. 69.5% were male (Shatima & Ulonnam, 2014).

Among 551 children with seizures in a study to determine the profile of children admitted with seizures in a tertiary care hospital of Western Nepal, 57.5% were in the age group 6 months to 5 years with fever in 73.1% of the cases ($p < 0.001$). Afebrile seizure was common (80.3%) in age group 11 to 15 years. 61.3% were males whereas 38.7% were females, with male to female ratio of 1.58:1($p = 0.003$). Seizures were more common in males in age group 6 months to 5 years (66.4%) and 6 to 10 years (60.7%). However, in the age group 11 to 15 years it was found slightly more common in females (52.1%) (Adhikari et al., 2013).

Of 1,118 patients presenting with new onset afebrile seizures between January 2001 and February 2007, 28.3% were age 1–24 months. 52% were boys and 48% were girls. Of the 317 infants, 38.5% were between 1 and 6 months old, 27.5% were between 6 and 12 months whereas 34% were between 12 and 24 months. A total of 182 of 317 (57.4%) infants had MRI scans done. Younger infants were more likely to have an MRI (Hsieh et al., 2010).

Hospital records of 433 patients aged younger than 18 years who presented to the pediatric emergency department at the Changhua Children's Hospital, Changhua, Taiwan with seizure disorder from 2005 to 2007 were reviewed. During the 2-year study period, 319 patients (173 boys and 146 girls) presented to the emergency department (ED) with a first attack of seizure and were enrolled in the study. Of these 319 patients (mean age, 2.56 ± 2.98 years), 218 (68.3%) children presented with fever and 101 (31.7%) children were non-febrile. In this study, 299 (93.7%) of the 319 children who presented with a first attack of seizure were younger than 6 years of age.

Among them, 213 (71%) presented with fever and 86 (29%) were non-febrile. Among the 20 patients over the age of 6 years, seizures without fever occurred more frequently than seizures with fever ($p < 0.001$) (Chen et al., 2010).

Of 349 children enrolled in a study to determine brain magnetic resonance imaging findings in children with a first recognized seizure, 81% of the cases under-went a magnetic resonance imaging examination within six months after their first recognized seizure. Age of onset was distributed across the entire pediatric age range. The mean age of the sample was 9.7 years. 57% of the cases were female. 31% of those who underwent MRI scanning demonstrated at least one magnetic resonance imaging abnormality (Kalnin et al., 2008).

In a study to determine association of MRI findings and neuropsychological functioning after the first recognized seizure, 281 children had MRI examinations done. These were performed on magnet systems varying from 0.3 to 1.5 Tesla and consisted of standard sagittal, axial and/or coronal images, using typical clinical sequences. The children were aged between 6 and 14 years. There were roughly equal numbers of boys and girls. The children underwent MRI examination an average of 1.3 months after their first recognized seizure (Byars et al., 2007).

2.3 Classification of Seizures in Children who underwent MRI Scanning

A prospective cross-sectional study of 100 patients in the age group of 3 months to 18 years with a clinical history of seizure disorder was conducted at Justice K. S. Hegde Charitable Hospital, Nitte University. All these patients were subjected to MRI examination of the brain. According to this study, 82 patients had generalised seizures, with 74 of them having tonic-clonic seizures, which is the most common

type. It is also worth noting that just 18% of the patients had partial seizures (Bhavani Shankar et al., 2022).

A hospital based prospective study was conducted in Department of Radiocondition, Vilasrao Deshmukh Government Medical College, Latur, India. The study duration was 2 years (July 2018 to June 2019). All pediatric patients (age under 12 years) referred from the outpatient department (OPD) and inpatient department (IPD) who presented with seizure disorders were included. Out of the 100 participants, 60 children (60%) presented with generalized seizures, 29 (29%) with focal seizures while 11 patients (11%) had seizures of an unknown onset (Mundhe, 2022).

A study was performed on 50 children under the age of 12 years who presented with seizure disorders. The study was conducted over a period of 1 year. Patients with trauma were excluded. The aim of study was to detect and characterize various lesions causing seizure disorders in pediatric age group (0 to 12years) and also to detect frequency with which they occurred using MRI. The majority of cases had history of generalized tonic clonic seizures (Khandediya et al., 2021).

A descriptive study was conducted to determine the etiology of seizures in children aged between one month and five years in a tertiary care hospital in Guntur, India. This study was done on 100 cases admitted to pediatric department ward, Government General Hospital, Guntur with seizures in the age group of one month to five years during the period of July 2018 and April 2019. 94% of the cases had generalized tonic clonic seizures. 6% had focal seizures. 40 of the cases underwent neuroimaging (CT or MRI scanning) (Chandini et al., 2019).

Medical files of 173 children who presented to the emergency department with a first afebrile seizure and underwent neuroimaging within 24 hours of presentation were retrospectively evaluated. 44.5% of the cases had focal seizures whereas 55.5% had generalized seizures. 50.3% of cases had a computed tomography scan, 28.9% had magnetic resonance imaging whereas 20.8% underwent both magnetic resonance imaging and computed tomography. Neuroimaging results were abnormal in 24.3% of patients whereas 5.2% had an emergent intracranial pathology. The conditions associated with abnormal neuroimaging were focal seizures new-onset neurological deficits, preexisting neurological abnormalities, predisposing conditions, and being younger than 24 months of age (İlk et al., 2017).

In a study to determine the profile of children admitted with seizures in a tertiary care hospital of Western Nepal, it was found out that generalized tonic clonic seizures were the commonest type accounting for 69.9% of cases. These were followed by partial seizures at 19.8%, absence at 2.7% and myoclonic at 1.3%. Other seizure types including tonic, atonic comprised the remaining 6.4% of cases. Status epilepticus was present in 7.3% of the children (Adhikari et al., 2013).

According to a study on the role of neuroimaging in infants with new onset afebrile seizures, it was noted that nearly half the patient group (48.5%) had clear features of partial seizures; 38.4% of which were partial only and 10.1% partial with secondary generalization. 51.5% of cases had no clear partial features: tonic 7.6%, clonic 0.6%, tonic-clonic 28.7%, myoclonic 3.5%, atonic 0.9%, spasms 10.1%. MRI scanning was performed on 182 (57.4%) of the cases (Hsieh et al., 2010).

Hospital records of 433 patients aged less than 18 years who presented to the pediatric emergency department at the Changhua Children's Hospital, Changhua, Taiwan with seizure disorder from 2005 to 2007 were reviewed. It was noted that generalized tonic

clonic seizures was the most common seizure type (n = 227; 71.2%). In addition, generalized tonic clonic seizures occurred more commonly in patients who presented with fever than in those presenting without fever ($p < 0.001$) (Chen et al., 2010).

In a study to determine association of MRI findings and neuropsychological functioning after the first recognized seizure, 29% of the cases had generalized tonic–clonic seizures, 26% of whom had significant MRI abnormalities. 29% had complex partial seizures, 23% of whom had significant MRI abnormalities. 27% had partial seizures with secondary generalization, 21% of whom had significant MRI abnormalities. 13% had absence seizures, 12% of whom had significant MRI abnormalities. 6% had simple partial seizures, 3% of whom had significant MRI abnormalities. 1% had atonic, akinetic or myoclonic but none had significant MRI abnormality (Byars et al., 2007).

2.4 Febrile versus Afebrile Seizures

Hospital records of 433 patients aged less than 18 years who presented to the pediatric emergency department at the Changhua Children's Hospital, Changhua, Taiwan with seizure disorder from 2005 to 2007 were reviewed. During the 2-year study period, 319 patients (173 boys and 146 girls) presented to the emergency department with a first attack of seizure and were enrolled in the study. Of these 319 patients (mean age, 2.56 ± 2.98 years), 218 (68.3%) children presented with fever and 101 (31.7%) children were non-febrile. In this study, 299 (93.7%) of the 319 children who presented with a first attack of seizure were younger than 6 years of age. Among them, 213 (71%) presented with fever and 86 (29%) were non-febrile. Among the 20 patients over the age of 6 years, seizures without fever occurred more frequently than seizures with fever ($p < 0.001$) (Chen et al., 2010).

2.5 Primary/underlying condition

A study was performed on 50 children under the age of 12 years who presented with seizure disorders. The study was conducted over a period of 1 year. The aim of study was to detect and characterize various lesions causing seizure disorders in pediatric age group (0 to 12 years) and also to detect frequency with which they occurred using MRI. Only 15 patients came with history of repetitive episodes of seizures since childhood. 22 out of 50 patients had history of neonatal intensive care unit (NICU) stay after birth, while other had an uneventful history (Khandediya et al., 2021).

A cross-sectional study of all patients diagnosed with epileptic spasms was conducted at Muhimbili National Hospital, Tanzania. In this study, most patients with epileptic spasms had a history of a neurological insult that may have occurred during the prenatal, natal or post-natal period. Among 37 patients whose data on etiology were retrieved, 22 (59.5%) had birth asphyxia, 2(5.4%) had neonatal hyperbilirubinemia, and 1(2.7%) had a history of pre-eclampsia. Moreover, intrauterine infections, congenital brain formation, and prematurity occurred in 4(10.8%) each (Mwalongo & Kija, 2020).

Hospital records of 433 patients aged less than 18 years who presented to the pediatric emergency department at the Changhua Children's Hospital, Changhua, Taiwan with seizure disorder from 2005 to 2007 were reviewed. Family history of seizure-related disorders was noted in only 26 (8.2%) patients. Among the 319 studied patients, 9 patients had a history of developmental delay, with language development delay being the most common. Cough and rhinorrhea were more common in patients who presented with seizures and fever than in those who presented with seizures without fever ($p < 0.05$) (Chen et al., 2010).

2.6 Use of Anti-Seizure Medication

A prospective cross-sectional study of 100 patients in the age group of 3 months to 18 years with a clinical history of seizure disorder was conducted at Justice K. S. Hegde Charitable Hospital, Nitte University. All these patients were subjected to MRI examination of the brain. The study revealed that the majority of patients (70%) with seizures were treated with single anti-epileptic drugs and found to be controlled (Bhavani Shankar et al., 2022).

2.7 Brain MRI Findings in Children with Febrile Seizures

A descriptive study was conducted on 100 cases admitted to pediatric department ward, Government General Hospital, Guntur, India with seizures in the age group of one month to five years during the period of July 2018 and April 2019. It included children, one month to five years of age who presented with febrile seizures. Magnetic resonance imaging of the brain was done in 40 cases out of which 32 cases (80%) had abnormal findings. 25% of the cases had hydrocephalus. Basal exudates were noted in 12.5% of the cases, neurogranulomas in 6.25%, infarcts in 6.25%, edema in 18.75% whereas other changes like hypoxic ischemic encephalopathy and cerebral atrophy were noted in 31.5% of the cases (Chandini et al., 2019).

In a study to determine the profile of children admitted with febrile seizures in a tertiary care hospital of Western Nepal, magnetic resonance imaging of the brain revealed abnormalities in 45.9% of the cases. The most common finding was neurocysticercosis noted in 12% of the scans. Tuberculous meningitis and encephalitis each accounted for 1.5% of the cases (Adhikari et al., 2013).

In a study to determine hippocampal volume in children with convulsive status epilepticus, 80 children underwent MRI scanning. Quantitative measurement of

hippocampal volumes was performed using the images obtained from 3D-FLASH sequences.

Using MRIcroN (http://www.mccauslandcenter.sc.edu/mricro/mricron/index.html), regions of interest (ROIs) were drawn manually on successive coronal slices, using axial and sagittal views for further refinement, to encompass the entire hippocampus. The anatomic limits of the hippocampus were defined using the description given by Gousias et al. (2008; Hammers et al., 2003). This was performed separately by two individual observers (MY and MM), blinded to the clinical status of the child, and measurements were averaged for analysis. Unilateral hippocampal volume loss was found in 19.2 % of patients with febrile seizures (Yoong et al., 2013) .

A case report of a year old child with post infectious new onset prolonged febrile status epilepticus with on-going focal temporal lobe limbic epilepsy was done. Brain magnetic resonance imaging at day 25 showed T2-weighted and FLAIR signal hyper-intensity and bilateral cortical edema of temporal lobes and insular regions. Additional brain MRI at day 70 did not show any signal change, but moderate global brain atrophy (Milh et. al, 2011).

Among the 159 children included in a study to determine whether MRI is informative in febrile seizures, 45.3% were female and 47.2% under 18 months of age. 34.0% presented with complex febrile seizures. The baseline MRI examination was normal or revealed incidental findings in 87.4% and definite abnormalities in 12.6%. The most common type of definite imaging abnormality was sub-cortical focal hyper-intensity noted in 32.1% of the cases. Next most common were abnormalities of white matter signal followed by focal cortical dysplasia. Other abnormal findings were grey matter heterotopia, congenital midline abnormality, arachnoid cyst, focal decreased

volume, cortical focal hyperintensity, lateral ventricular enlargement, cortical atrophy and periventricular leukomalacia. Further examination of the significance of the sub-cortical focal hyper-intensities, which was the most common abnormality found in first febrile seizure, was done. Abnormalities were found in the sub-cortical white matter (12.5%), deep white matter (62.5%) and basal ganglia/thalamus (25.0%). Two were bilateral in the basal ganglia, one bilateral in the thalamus and one bilateral in the corona radiate/centrum semiovale. The remaining five were right-sided in the periventricular space, frontal lobe, and corona radiate/centrum semiovale. Among children with definite baseline imaging abnormality, 70.0% had one abnormality, 20.0% had two abnormalities, 5.0% had three abnormalities, none had four abnormalities, and 5.0% had five abnormalities (two of which were considered incidental). Among children with definite abnormalities, only the child with five abnormalities had incidental abnormalities (Hesdorffer et al., 2008).

During status epilepticus, a first magnetic resonance imaging was performed in twelve patients with fever as an associated clinical feature. No patient had abnormalities in the white matter. The investigation evidenced abnormal mesial temporal lobes on one or both sides that gave a hypointense signal in T1 and a hyperintense signal in T2 weighted images. Another child, investigated seven days after the first seizure, had areas of hyper-signal in the cortex, basal ganglia and brain stem, without hippocampal abnormalities. During follow-up, magnetic resonance imaging was performed in all patients within a median two years (range 0.5–6) after the end of the status epilepticus. Magnetic resonance imaging failed to disclose any abnormalities in only three cases. Selective hippocampal abnormalities were seen in seven patients. They consisted of atrophy in six cases, that was bilateral in five and unilateral in one and of hyper-signal affecting both hippocampi in T2 weighted images in six cases. One

patient had bilateral atrophy without signal abnormality and another one had bilateral hyperintense signal without atrophy. Three other patients had diffuse atrophy involving the neocortex as well of the hippocampi. Two patients had cerebellar atrophy associated with areas of hyper-signal in T2-weighted sequence within the hemispheric cerebellar cortex (Mikaeloff et. al, 2006).

Fourteen children were investigated within five days of a prolonged febrile convulsion. Magnetic resonance imaging done within 48 hours of seizure attack showed large hippocampal volumes and prolongation of T2 relaxation time. Patients investigated more than 48 hours from a prolonged febrile convulsion had large hippocampal volumes and normal T2 relaxation time. These data are strongly suggestive of hippocampal edema that is resolving within 5 days of a prolonged febrile seizures, but do not exclude the possibility of a pre-existing hippocampal lesion (Scott et.al, 2003).

A report by Silverstein & Alexander, (1998) recommended considering neurocysticercosis as a differential condition in children presenting with new onset febrile seizures even if the symptoms do not initially indicate neurocysticercosis or if the patient resides in an area where the disease is rare.

2.8 Brain MRI Findings in Children with Afebrile Seizures

A prospective cross-sectional study of 100 patients in the age group of 3 months to 18 years with a clinical history of seizure disorder was conducted at Justice K. S. Hegde Charitable Hospital, Nitte University. All these patients were subjected to MRI examination of the brain. The MRI findings were normal in 45 patients (45%) and abnormal in 55 patients (55%). MRI abnormalities were as follows: gliosis (45.5%), periventricular leukomalacia (12.7%), neuro-degenerative changes in the grey-white

matter (7.3%), focal cortical dysplasia (7.3%), mesial temporal sclerosis (5.5%), polymicrogyria (5.5%), and megalencephaly (1.8%) (Bhavani Shankar et al., 2022)

A hospital based prospective study was conducted in Department of Radiocondition, Vilasrao Deshmukh Government Medical College, Latur, India. The study duration was 2 years (July 2018 to June 2019). All pediatric patients (under the age of 12 years) referred from the outpatient department (OPD) and inpatient department (IPD) who presented with seizure disorders were included. Those with fever were excluded. A total of 100 children were study. Out of 100 patients studied, 85 patients (85%) had positive findings on MRI while 15 patients (15%) had normal MRI findings with no detectable lesions. In the study, the most common cause of seizures was infection (35%), followed by anoxia and hypoxic ischemic encephalopathy (HIE) (17%), malformations of cortical development (MCD) (8.2%), and acquired metabolic disorders and vascular causes (3.5%) each. In this study, a total of 32 patients were reported to have infection: tuberculosis (40.6%), encephalitis (9.3%), meningitis (21.8%), meningo-encephalitis (9.3%) and viral infection (12.5%) were common findings. It was noted that mesial temporal sclerosis was most common cause of isolated temporal lobe epilepsy. Hippocampal atrophy and secondary changes were found in 100% of patients while hippocampal T2 and FLAIR hyperintensity and abnormal architecture were seen in 75% patients. 7 patients had malformations of cortical development. Focal cortical dysplasia (FCD) was seen in 2 patients (14.2%) while rest of the pathologies like microcephaly, agyria, lissencephaly, polymicrogyria, heterotopia, schizencephaly were seen in one patient each (7.1%). Patients with cortical developmental malformations presented with epilepsy in early age group, particularly in infancy (less than 1 year of age). Out of 3 patients with acquired toxic-metabolic disorders, 1 patient each had chronic bilirubin encephalopathy, posterior

reversible encephalopathy syndrome (PRES) secondary to hypertension and medication-related leuko-encephalopathy. Out of the 5 patients with neoplastic etiology, 1 patient had a dysembryoplastic neuroepithelial tumor (DNET), 1 had a ganglioglioma, 1 had a high grade glioma, 1 had a pilocytic astrocytoma and 1 had a glioblastoma. Vascular pathology was noted in 3 patients. 2 patients (66.6%) had arterial infarcts and one had vasculitis. Out of the 2 patients presenting with demyelination on MRI, one patient had acute disseminated encephalomyelitis (ADEM) while the other had tumefactive demyelination (Mundhe, 2022).

A cross sectional study was conducted to review and analyse the clinical characteristics and brain MRI findings in a cohort of children diagnosed with infantile spasms at King Abdulaziz University Hospital, Jeddah, Saudi Arabia. Fifty six children diagnosed with infantile spasms in infancy and early childhood were included. All of them underwent brain MRI for evaluation. The study was conducted in the period from January 2016 to January 2020. Hypoxic ischemic encephalopathy was seen in 10 MRIs (17%); 9 MRIs (16%) were normal; 9 MRIs (16%) showed delayed myelination; 8 MRIs (14%) showed thinning and dysgenesis of the corpus callosum; 7 MRIs (13%) showed the dilatation of ventricles, atrophy and hydrocephalus; 5 MRIs (9%) showed congenital migration disorders; and the remaining MRIs (15%) showed periventricular leukomalacia, cortical tubers, non-specific white matter changes, basal ganglia abnormalities and the complications of meningitis (Muthaffar, 2022) .

A study was performed on 50 children under the age of 12 years who presented with seizure disorders. The study was conducted over a period of 1 year. Patients with trauma were excluded. The aim of study was to detect and characterize various lesions

causing seizure disorders in this pediatric age group (0 to 12years) and also to detect frequency with which they occurred using MRI. Out of 50 scans, 9 cases had no evidence of abnormality on MRI imaging. Focal cortical dysplasia was observed in 6 cases, tubercular meningitis and tuberculoma in 7 cases, neurocysticercosis in 4 cases, mesial temporal sclerosis in 6 cases, meningitis, hydrocephalus and ventriculitis in 5 cases, hypoxic ischemic encephalopathy in 3 cases, tuberous sclerosis in 2 cases and Sturge Weber syndrome in 2 cases. There was 1 case of vanishing white matter disease. 5 cases of pediatric tumours were observed with 2 cases of desmoplastic infantile ganglioglioma (DIG), 1 case of dysembryoplastic neuroepithelial tumour (DNET), 1 case of astroblastoma and 1 case of ganglioglioma (Khandediya et al., 2021).

A cross-sectional study of all patients diagnosed with epileptic spasms was conducted at Muhimbili National Hospital, Tanzania. The total sample size was 15. Twelve (80%) out of 15 patients whose magnetic resonance imaging (MRI) results were found had documented abnormal MRI findings, with most of them showing features suggestive of hypoxic-ischemic encephalopathy (HIE), old subdural hematoma, megalencephaly, bilateral hippocampal atrophy, severe brain atrophy, multicystic encephalomalacia, congenital hydrocephalus, and dandy walker malformations (Mwalongo & Kija, 2020).

Paediatric patients with juvenile myoclonic epilepsy and generalized tonic clonic afebrile seizures analysed were found to have lower grey matter volume in the bilateral thalami compared to controls. This led to the conclusion that micro-structural abnormalities exist early in the course of the disease and the thalamus might play a critical role in the pathogenesis of juvenile myoclonic epilepsy (Öztürk et.al, 2020).

In a study conducted to determine the clinical characteristics of children with epilepsy managed at a tertiary hospital in Africa, 48.8% of the study population had a brain MRI scan with contrast done. Children with associated fever were excluded. Reported findings from the brain MRI scans were as follows: Normal (26.4%), brain atrophy (19.7%), cystic encephalomalacia (12.5%), mesial temporal sclerosis (9.6%), white matter hyper intensities (7.7%), hydrocephalus (5.3%), benign enlargement of the subdural space (3.8%), periventricular leukomalacia (2.9%), corpus callosum agenesis (2.9%), delayed myelination (1.9%), tuberous sclerosis complex [sub-ependymal nodules, harmatomas, calcifications] (1.5%), hemi-megalencephaly (1.5%), meningeal enhancement (1.5%), holoprosencephaly (0.9%), schizencephaly (0.9%), lissencephaly (0.5%) and polymicrogyria (0.5%) (Samia et al., 2019).

Medical files of 173 children who presented to the emergency department with a first afebrile seizure and underwent neuroimaging within 24 hours of presentation were retrospectively evaluated. 50.3% of cases had a computed tomography scan, 28.9% had magnetic resonance imaging whereas 20.8% underwent both magnetic resonance imaging and computed tomography. Neuroimaging results were abnormal in 24.3% of patients whereas 5.2% had an emergent intracranial pathology. The conditions associated with abnormal neuroimaging were focal seizures new-onset neurological deficits, pre-existing neurological abnormalities, predisposing conditions and being younger than 24 months of age. Specific structural intracranial pathologies were as follows: ventriculoperitoneal shunt dysfunction, acute infarct in the left frontal lobe and post central gyrus, posterior fossa mass (medulloblastoma), effacement of the fourth ventricle, right subdural haemorrhage, sub-acute infarct in the right parietal and occipital lobes and thalamus with edema surrounding the lesion, and cerebellar atrophy, intra-parenchymal haemorrhage in the left parietal lobe and T2 hyper-intense

lesions in right parietal and occipital lobes consistent with posterior reversible encephalopathy syndrome (İlk et al., 2017).

A hospital based prospective time bound clinical study was carried out in a Tertiary Care Centre in India over a period of two years. 95 paediatric patients (age under 12 years) referred from outpatient department and inpatient department who presented with seizure disorders were included. Children with febrile seizures were excluded. 84 patients (88.4%) had positive findings on brain MRI. Infections were the commonest finding, comprising 25 patients (29.8%). This was followed by anoxia and hypoxic-ischemic encephalopathy in 21 patients (25.0%). Malformations of cortical development were seen next in 12 patients (14.3%). Phacomatoses and vascular causes constituted 5 patients each (5.9%). Mesial temporal sclerosis and miscellaneous causes constituted 4 patients each (4.8%). Demyelinating diseases and neoplasm were seen in 3 patients each (3.6%). Least common were inherited metabolic disorders comprising 2 patients (2.4%) (Anand et al., 2017).

A study was conducted in National Hospital Abuja, a tertiary care centre located in the capital city of Nigeria. It was aimed at investigating the pattern of childhood epilepsies. The study excluded children with febrile seizures. 226 children were recruited in the study, all of whom underwent brain MRI scanning. The study showed revealed that an abnormality was detected on brain MRI in 33.2% of the cases (Shatima & Ulonnam, 2014).

In a study to determine hippocampal volume in children with convulsive status epilepticus, 80 children underwent MRI scanning. Quantitative measurement of hippocampal volumes was performed using the images obtained from 3D-FLASH sequences.

Using MRIcroN (http://www.mccauslandcenter.sc.edu/mricro/mricron/index.html), regions of interest (ROIs) were drawn manually on successive coronal slices, using axial and sagittal views for further refinement, to encompass the entire hippocampus. The anatomic limits of the hippocampus were defined using the description given by Gousias et al. (2008; Hammers et al., 2003). This was performed separately by two individual observers (MY and MM), blinded to the clinical status of the child, and measurements were averaged for analysis. Unilateral hippocampal volume loss was found in 29.4 % of patients with afebrile focal seizures and epilepsy (Yoong et al., 2013) .

Magnetic resonance imaging in children with afebrile seizures demonstrated cerebral hemi-atrophy independent of vascular territory in all the eight patients during the chronic stage of the hemiconvulsion-hemiplegia-epilepsy syndrome. Additionally, crossed cerebellar atrophy was identified in two children. A striking MRI feature identified in the acute setting was pan-hemispheric cortical restricted diffusion on diffusion weighted imaging, not localized to a vascular territory, due to seizure activity. Associated variable MRI features identified during the chronic stage of the disease were sub-cortical cavitations in the affected hemisphere, smaller anterior, middle and posterior cerebral arteries on the affected side, a small corpus callosum and ipsilateral shift of the midline secondary to the volume loss. Furthermore, there was no evidence of hemosiderin on the gradient refocused scans (Van Toorn et al., 2012).

A study by Yoong et. al, (2012) found abnormalities on brain magnetic resonance imaging in 31.3% of children with convulsive status epilepticus. The main findings were that in over 30% of children brain magnetic resonance imaging abnormalities

was detectable in a median of one month following a convulsive status epilepticus episode and clinical features can predict those children who are most likely to have structural abnormalities on magnetic resonance imaging if it is performed as part of their follow-up investigations.

A study was carried out at University Sains Malaysia (USM) from January 2008 to June 2009. The aim of the study was to determine and compare the hippocampal volume in children with epilepsy and in children in a control group and to compare the mean of right and left hippocampal volume in control subjects. It was a cross sectional study of 40 children with epilepsy and 40 children in a control volunteer group. It was found out that the mean hippocampal volume on the right was 2.47 cm^3 (SD 0.52) whereas the mean hippocampal volume on the left was 2.40 cm^3 (SD 0.44). The overall mean on both sides was 2.43 cm^3 (SD 0.44) (Salmah et al., 2011).

According to a study on the role of neuroimaging in infants with new onset afebrile seizures, 57% of the MRI scans had 124 abnormal findings, 33 of which were incidental findings. A total of 28 of the 104 abnormal MRI scans had incidental findings only. The yield of abnormalities on MRI was comparable across age groups. Cerebral dysgenesis was the most common MRI abnormality accounting for 16% of all MRI scans. The incidence of dysgenesis was highest in the youngest age group with 16 in the 1 to 6 month age group. Cerebral dysgenesis included Aicardi syndrome/dysgenesis of the corpus callosum, band heterotopia, cortical dysplasia to include 5 cases of focal cortical dysplasia, Dandy-Walker, lissencephaly, polymicrogyria, schizencephaly, sub-ependymal heterotopias and tuberous sclerosis (Hsieh et al., 2010).

Of 349 children enrolled in a study to determine brain magnetic resonance imaging findings in children with a first recognized seizure, 81% of the cases under-went a magnetic resonance imaging examination within six months after their first recognized seizure. 31% of those who underwent MRI scanning demonstrated at least one magnetic resonance imaging abnormality. Two or more abnormalities were identified in 12% of the cases. 14% manifested magnetic resonance imaging abnormalities that were classified as significant because they were considered to be potentially etiologically related to the seizure condition. Of 87 children with at least one magnetic resonance imaging abnormality, the most common abnormalities included ventricular enlargement >1 cm (51%), leukomalacia/gliosis (23%), grey matter lesions (12%), volume loss (12%), various other white-matter lesions (9%) and encephalomalacia (5/87, 6%). Mild ventricular enlargement, in the range of 1.0-1.5 cm, was evident in 39 children, and 7 of these children exhibited other significant abnormalities. All 5 children with moderate ventricular enlargement (1.6-2.5 cm) exhibited other significant abnormalities. The most common locations for abnormalities were right frontal (21%), left parietal (16%), left frontal (13%), periventricular (13%), cerebellar (13%), and right parietal (10%). Temporal and hippocampal abnormalities were evident in 13 children (15%; 6 left, 6 right, and 1 bilateral) (Kalnin et al., 2008).

A study was carried out to characterize structural abnormalities associated with onset of seizures in children using MRI and a standardized classification system in a large prospective cohort. A total of 281 children aged 6 to 14 years completed an MRI within six months of their first recognized seizure. Most MRI examinations were performed with a standardized, dedicated seizure protocol and all were scored using a standard scoring system. Of the 281 children in this study, 87 (31%) had at least one

MRI abnormality. Two or more abnormalities were identified in 34 (12%) children. 40 children (14%) had MRI abnormalities that were classified as significant in that they were considered to be potentially etiologically related to the seizure condition. Of the 87 children with at least one MRI abnormality, the most common abnormalities were ventricular enlargement greater than 1 cm (44/87, 51%), leukomalacia/gliosis (20/87, 23%), grey matter lesions (10/87, 12%), volume loss (10/87, 12%), various other white matter lesions (8/87, 9%), and encephalomalacia (5/87, 6%). Mild ventricular enlargement, in the range of 1.0-1.5 cm, was found in 39 children, with 7 of these showing other significant abnormalities. All five children with moderate ventricular enlargement (1.6–2.5 cm) had other significant abnormalities. By location, the most common were right frontal (18/87, 21%), left parietal (14/87, 16%), left frontal (11/87, 13%), periventricular (11/87, 13%), cerebellar (11/87, 13%), and right parietal (9/87, 10%). Temporal and hippocampal abnormalities were observed in 13 children (15%; 6 left, 6 right, 1 bilateral). Children with symptomatic/cryptogenic seizures, both generalized and localization-related, were most likely to have at least one MRI abnormality (42.9% and 39.2%, respectively). Also, 23% – 30% of children with generalized idiopathic epilepsies had at least one MRI abnormality (Matthew Vanneman and Glenn Dranoff, 2011).

In a study to determine association of MRI findings and neuropsychological functioning after the first recognized seizure, 14% of 281 cases had MRI abnormalities that were judged to be significant in that they were possibly related to their seizures. Significant MRI abnormalities were as follows: Leukomalacia/gliosis (52.9%), ventricular enlargement > 1.5 cm (14.7%), encephalomalacia (11.8%), hippocampal atrophy (11.8%), hippocampal signal abnormalities (8.8%), grey matter

cortical dysplasias (8.8%), grey matter heterotopias (8.8%) and other grey matter lesions (5.9%) (Byars et al., 2007).

Of two hundred pediatric patients with seizures who had brain magnetic resonance scans, the studies were abnormal in 86% of patients with tumours and in 67% of those with strokes. The scans detected 84% of the 19 potentially curable lesions. There were no false positive studies. Seventy-nine per cent of the patients with seizures of less than one year's duration had an abnormal scan. However, the scan was also abnormal in 22% of patients with non-focal seizures of less than one year's duration (Gilday & Reba, 1972).

CHAPTER THREE: METHODOLOGY

3.1 Study Design

A descriptive cross-sectional study was conducted to describe brain magnetic resonance findings in children presenting with seizures in Moi Teaching and Referral Hospital.

3.2 Study Duration

The study was carried out for a period of one year (June 2021 to May 2022).

3.3 Study Area

The study was conducted at the Moi Teaching and Referral Hospital. This is a level six health facility located in Eldoret Town, Uasin Gishu County, Kenya. It is the second largest referral hospital in Kenya after Kenyatta National Hospital. It is 350 kilometers North West of the Kenyan capital (Nairobi). The hospital serves residents of Western Kenya region (representing at least twenty two counties) and parts of Uganda, Tanzania, Rwanda, Burundi and Southern Sudan with a population of approximately twenty four million people.

It was chosen because most children from the catchment area presenting with seizures are referred to the facility for radiological investigations as well as specialist management. It is also the teaching hospital for Moi University - College of Health Sciences that trains both undergraduate and postgraduate medical students.

Data was collected from the radiology and imaging department.

3.4 Study Population

The study was conducted on patients aged below18 years, presenting with seizures sent to the radiology and imaging department for brain magnetic resonance imaging.

3.5 Eligibility Criteria

3.5.1 Inclusion Criteria

1) Children presenting with seizures sent to the radiology department for magnetic resonance imaging.
2) Children aged below 18 years.

3.5.2 Exclusion Criteria

1) Children who had undergone head surgery, developed seizures and were sent to the radiology department for MRI scanning.

3.6 Sampling Techniques

3.6.1 Sample Size Determination

A census of all children presenting with seizures sent to the radiology department for brain magnetic resonance imaging for a period of one year was done. The sampling technique chosen was based on the number of pediatric patients with seizures sent for MRI scanning in MTRH in 2020 which was 81.

3.6.2 Study Schema

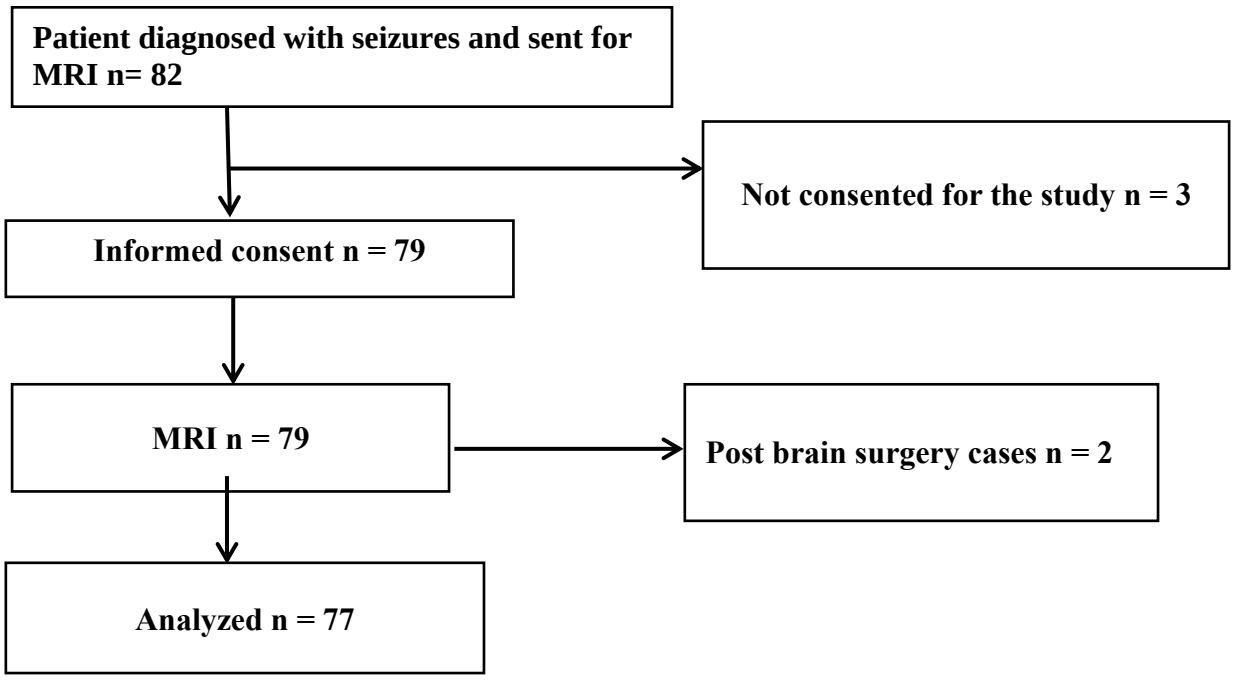


Figure 3: Study Schema

3.7 Study Procedure

Clinicians at the outpatients and inpatient departments were sensitized about the study and the information to be included in the patients' radiology requisition forms or medical files. Information included in the patients' radiology requisition forms or medical files included patient age, gender, seizure type, presence or absence of fever, presence or absence of underlying clinical condition, use of anti-seizure medication and response to anti-seizure medication. Definition and classification of the seizures was done by the referring clinician. Children who had been clinically diagnosed with seizures and sent to the radiology department for MRI scanning were identified. The researcher reviewed all radiology requests daily to identify patients who met the inclusion criteria. Consent was sought from parents/guardians accompanying the patients before they were taken for imaging. Assent was sought from any child above seven years. The consent and assent forms have been included in the appendix. Demographic data as well as information on fever as an associated clinical feature, seizure type, underlying clinical condition and use of anti-seizure medication was extracted from patient files through a questionnaire. Where necessary clarification was sought from the patient for missing data.

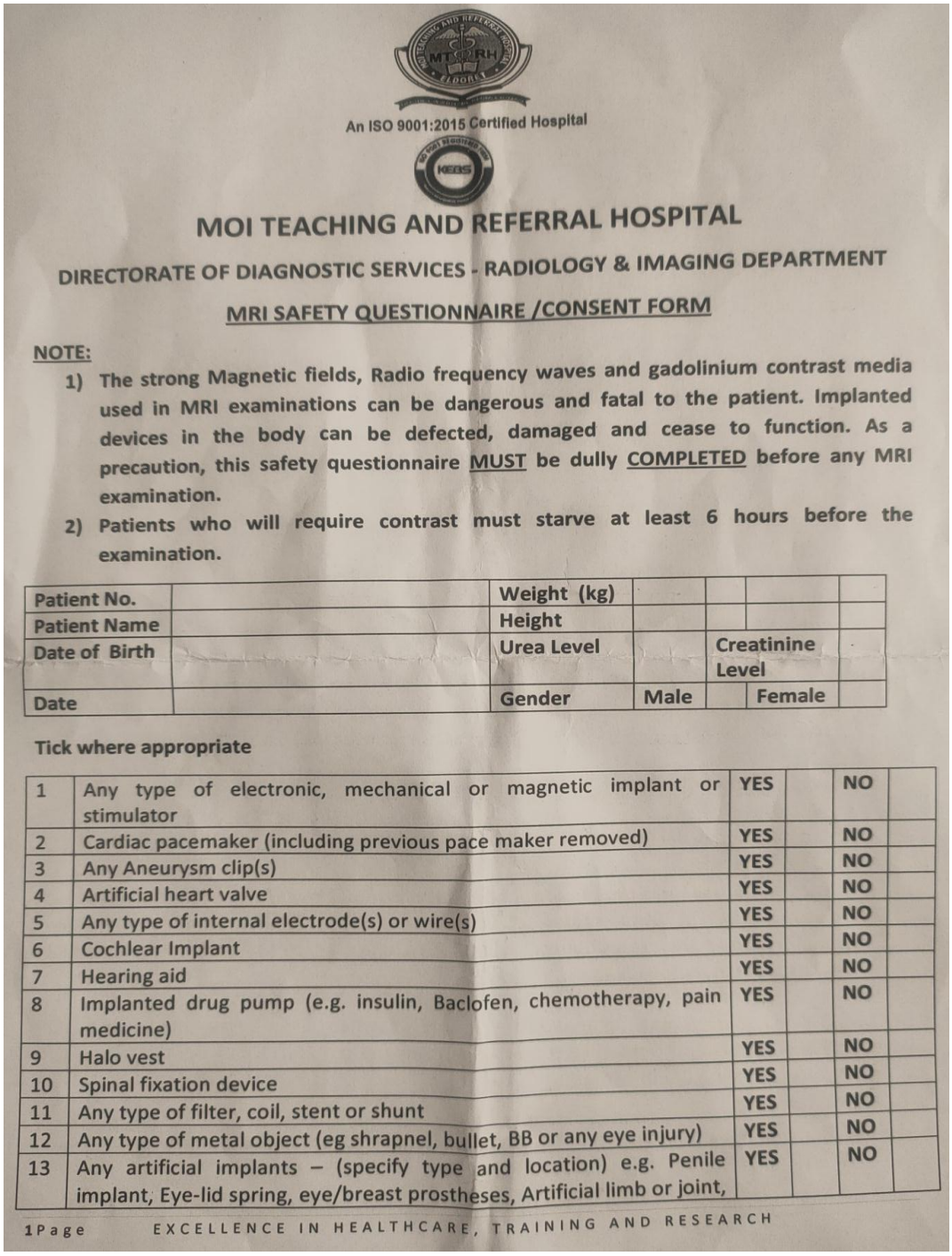
The MRI scans were done at the MTRH radiology and imaging department on a 0.36 Tesla Mindray Magsense MRI scanner using a standardized seizure protocol.

3.7.1 Patient preparation for brain MRI scanning

Patients were prepared for MRI scanning. Preparation for MRI scanning included:

1. Explaining the procedure to the patient conclusively.
2. A satisfactory written consent form was filled and signed by the patient or the parent/guardian.

3. Checking of renal function tests. Contrast medium, if indicated, was only to be administered to patients with a glomerular filtration rate (GFR) of more than 30 milliliters per minute.
4. Filling and signing of the MTRH MRI safety questionnaire/consent form.



An ISO 9001:2015 Certified Hospital

MOI TEACHING AND REFERRAL HOSPITAL

DIRECTORATE OF DIAGNOSTIC SERVICES - RADIOLOGY & IMAGING DEPARTMENT

MRI SAFETY QUESTIONNAIRE /CONSENT FORM

NOTE:

1) **The strong Magnetic fields, Radio frequency waves and gadolinium contrast media used in MRI examinations can be dangerous and fatal to the patient. Implanted devices in the body can be defected, damaged and cease to function. As a precaution, this safety questionnaire MUST be dully COMPLETED before any MRI examination.**
2) **Patients who will require contrast must starve at least 6 hours before the examination.**

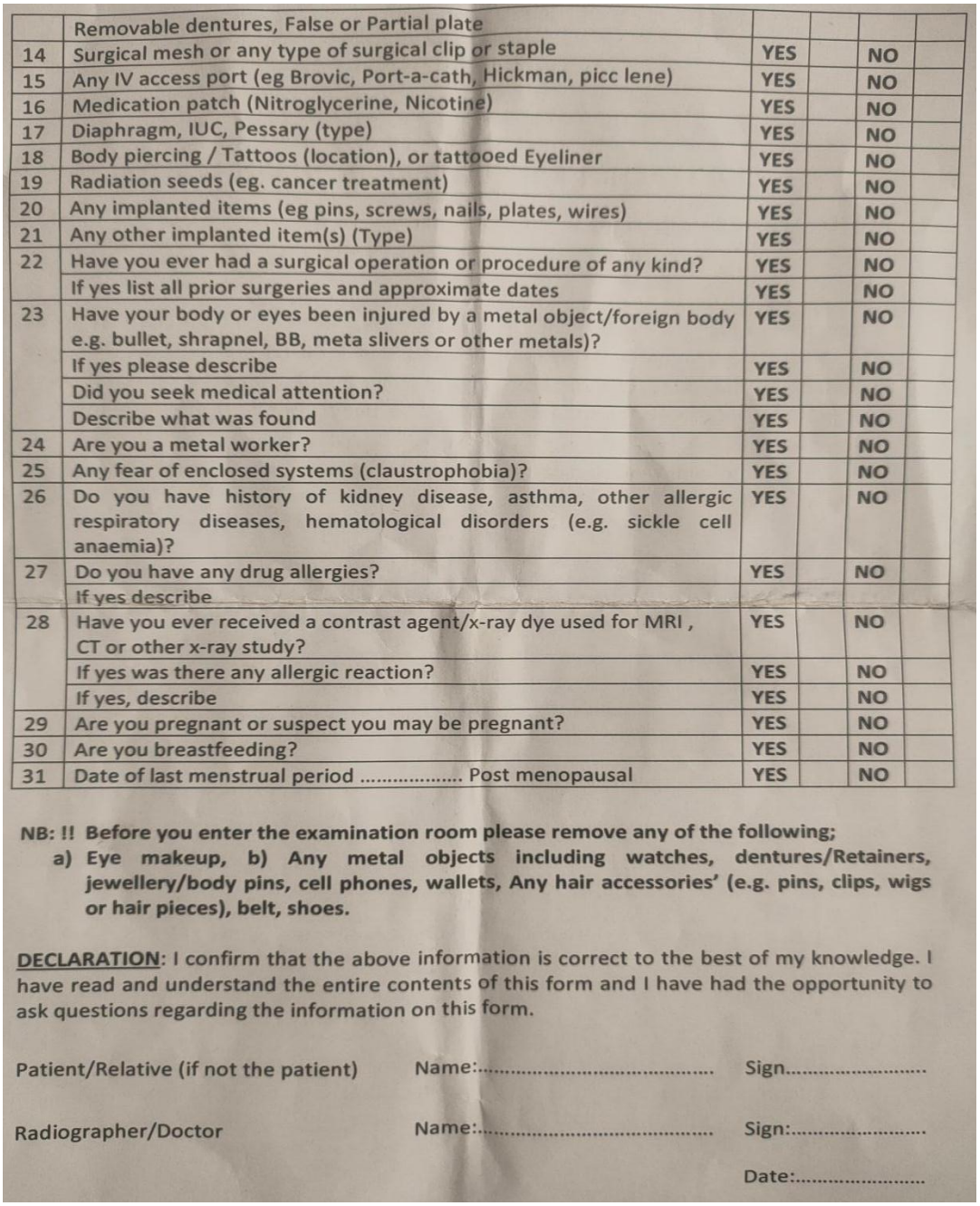
Patient No.		Weight (kg)				
Patient Name		Height				
Date of Birth		Urea Level		Creatinine Level		
Date		Gender	Male		Female	

Tick where appropriate

1	Any type of electronic, mechanical or magnetic implant or stimulator	YES		NO	
2	Cardiac pacemaker (including previous pace maker removed)	YES		NO	
3	Any Aneurysm clip(s)	YES		NO	
4	Artificial heart valve	YES		NO	
5	Any type of internal electrode(s) or wire(s)	YES		NO	
6	Cochlear Implant	YES		NO	
7	Hearing aid	YES		NO	
8	Implanted drug pump (e.g. insulin, Baclofen, chemotherapy, pain medicine)	YES		NO	
9	Halo vest	YES		NO	
10	Spinal fixation device	YES		NO	
11	Any type of filter, coil, stent or shunt	YES		NO	
12	Any type of metal object (eg shrapnel, bullet, BB or any eye injury)	YES		NO	
13	Any artificial implants – (specify type and location) e.g. Penile implant, Eye-lid spring, eye/breast prostheses, Artificial limb or joint,	YES		NO	

1Page EXCELLENCE IN HEALTHCARE, TRAINING AND RESEARCH

Figure 4: MTRH MRI safety questionnaire/consent form (Page 1)



	Removable dentures, False or Partial plate				
14	Surgical mesh or any type of surgical clip or staple	YES		NO	
15	Any IV access port (eg Brovic, Port-a-cath, Hickman, picc lene)	YES		NO	
16	Medication patch (Nitroglycerine, Nicotine)	YES		NO	
17	Diaphragm, IUC, Pessary (type)	YES		NO	
18	Body piercing / Tattoos (location), or tattooed Eyeliner	YES		NO	
19	Radiation seeds (eg. cancer treatment)	YES		NO	
20	Any implanted items (eg pins, screws, nails, plates, wires)	YES		NO	
21	Any other implanted item(s) (Type)	YES		NO	
22	Have you ever had a surgical operation or procedure of any kind?	YES		NO	
	If yes list all prior surgeries and approximate dates	YES		NO	
23	Have your body or eyes been injured by a metal object/foreign body e.g. bullet, shrapnel, BB, meta slivers or other metals)?	YES		NO	
	If yes please describe	YES		NO	
	Did you seek medical attention?	YES		NO	
	Describe what was found	YES		NO	
24	Are you a metal worker?	YES		NO	
25	Any fear of enclosed systems (claustrophobia)?	YES		NO	
26	Do you have history of kidney disease, asthma, other allergic respiratory diseases, hematological disorders (e.g. sickle cell anaemia)?	YES		NO	
27	Do you have any drug allergies?	YES		NO	
	If yes describe				
28	Have you ever received a contrast agent/x-ray dye used for MRI , CT or other x-ray study?	YES		NO	
	If yes was there any allergic reaction?	YES		NO	
	If yes, describe	YES		NO	
29	Are you pregnant or suspect you may be pregnant?	YES		NO	
30	Are you breastfeeding?	YES		NO	
31	Date of last menstrual period ..... Post menopausal	YES		NO	

NB: !! Before you enter the examination room please remove any of the following;

a) Eye makeup, b) Any metal objects including watches, dentures/Retainers, jewellery/body pins, cell phones, wallets, Any hair accessories' (e.g. pins, clips, wigs or hair pieces), belt, shoes.

DECLARATION: I confirm that the above information is correct to the best of my knowledge. I have read and understand the entire contents of this form and I have had the opportunity to ask questions regarding the information on this form.

Patient/Relative (if not the patient) Name:..... Sign.....

Radiographer/Doctor Name:..... Sign:.....

Date:.....

Figure 5: MTRH MRI safety questionnaire/consent form (Page 2)

5. The weight of the patient was taken and noted down.
6. Insertion of an intravenous cannula was done.
7. Removing all metal objects including jewelry, keys, coins, wallets, hearing aids, hairpins e.t.c.
8. The patient had to remove their clothing and put on a hospital gown.
9. The patient was instructed to keep still while in the MRI scanner.

3.7.2 Patient positioning for MRI brain scanning

The patient was the positioned in the MRI scanner couch, head first into the scanner. The upper limbs were placed on the side away from the head. The patient was the sedated if it was necessary. The head was supported with cushions to maintain a neutral position. Ear plugs were provided for extra comfort. The head coil was the placed over the patient's head.

Figure 6: Patient positioning for MRI brain scanning at the MTRH MRI Centre

Figure 7: Patient positioning for MRI brain scanning at the MTRH MRI Centre

3.7.3 Protocols, parameters and planning for MRI brain scanning

The scan extent was set (from the vertex to the cranio-cervical junction). The laser beam localizer was centered over the glabella. A topogram was obtained.

Pre contrast T1 weighted images, T2 weighted images, FLAIR images and post contrast images T1 weighted images was acquired as appropriate.

A three plane localizer was taken in the beginning to localize and plan the sequences. Localizer was less than 25 seconds.

For T2 weighted axial images, axial slices were planned on the sagittal plane. The position block was angled parallel to the genu and the splenium of the corpus callosum. The slices covered the whole brain from the vertex to the foramen magnum. The positioning block was checked in the other two planes. An appropriate angle was given in the coronal plane on a tilted head (perpendicular to the line of the third ventricle and the brainstem). Parameters used were: TR 3000-4000, TE 100-120, slice thickness 1mm, phase R>L, matrix 320x320, FOV 210-230, Gap 10%, NEX (average) 2.

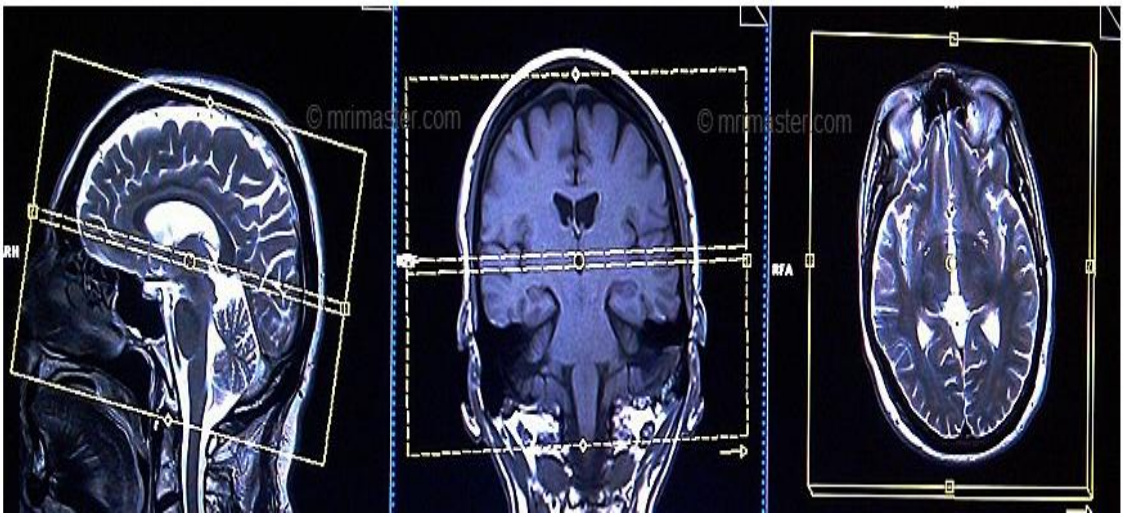


Figure 8: Planning for axial T2 weighted images

For T2 weighted FLAIR axial images, axial slices were planned on the sagittal plane. The positioning block was angled parallel to the genu and splenium of the corpus callosum. The slices covered the whole brain from the vertex to the foramen magnum. The positioning block was checked in the other two planes. An appropriate angle was given in the coronal plane on a tilted head (perpendicular to the line of the third ventricle and the brainstem). Parameters used were: TR 7000-9000, TE 110, Flip 130, slice thickness 1mm, Phase R>L, Matrix 320x320, FOV 210-230, Gap 10%, TI 2500, NEX (average) 2.

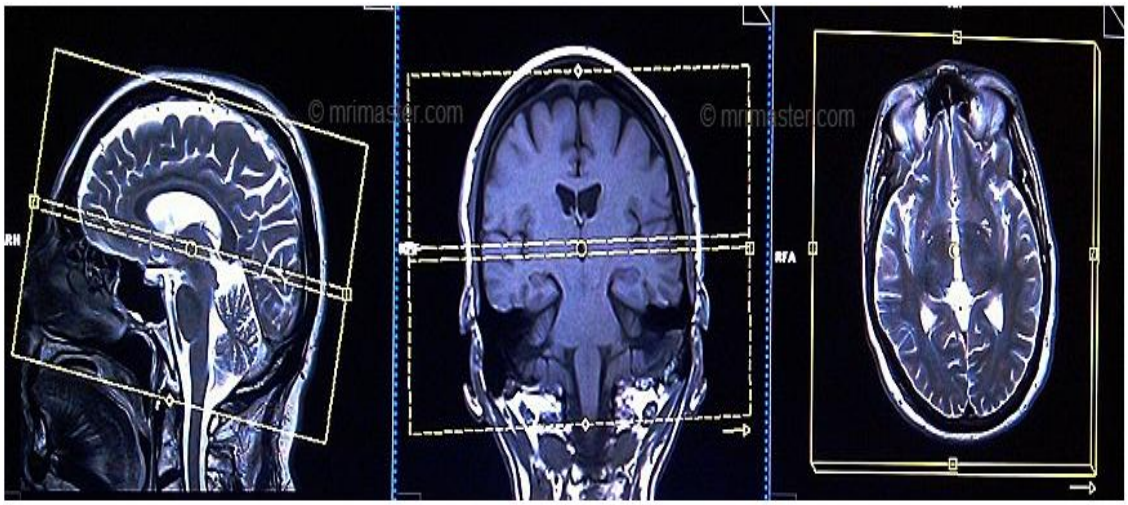


Figure 9: Planning for axial T2 FLAIR images

For T1 weighted coronal images, coronal slices were planned on the sagittal plane. The positioning block was angled perpendicular to the corpus callosum. The positioning block was checked in the other two planes. An appropriate angle was given in the coronal plane on a tilted head (perpendicular to midline of the brain). The slices covered the whole brain from the frontal sinus to the occipital protuberance. Parameters used were: TR 400-600, TE 15-25, Flip 90, slice thickness 1mm, Phase R>L, Matrix 320x320, FOV 210-230, Gap 10%, NEX (average) 2.

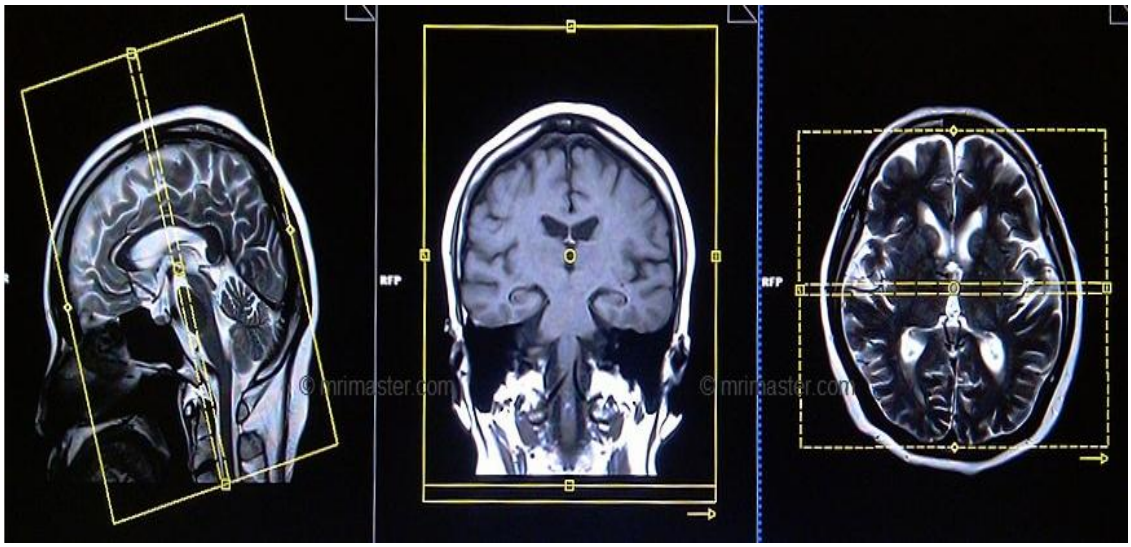


Figure 10: Planning for coronal T1 weighted images

For T2 weighted sagittal images, sagittal slices were planned on the axial plane. The positioning block was angled parallel to the midline of the brain. The positioning block was checked in the other two planes. An appropriate angle was given in the coronal plane on a tilted head (parallel to the line along the third ventricle and the brainstem). The slices covered the whole brain from one temporal lobe to the other temporal lobe. Parameters used were: TR 3000-4000, TE 100-120, Flip 130-150, slice thickness 1mm, Phase A>P, Matrix 320x320, FOV 210-230, Gap 10%, NEX (average) 2.

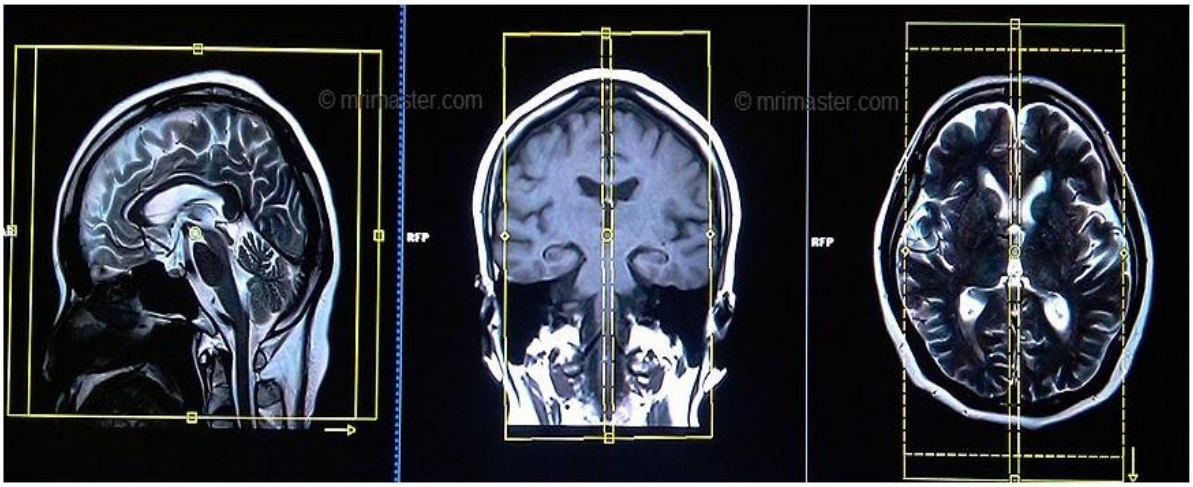


Figure 11: Planning for sagittal T2 weighted images

For dedicated hippocampal volumetry, inversion recovery (IR) oblique coronal images (TE: 51, TR: 3500, FOV: 250 mm, slice thickness: 1 mm) and oblique coronal T2WI (TR: 4000, TE: 101, FOV: 230, slice thickness: 2 mm) covering the whole brain was acquired. Oblique coronal plane was perpendicular to the long axis of hippocampus.

3.7.4 After care of the patient post MRI brain scanning

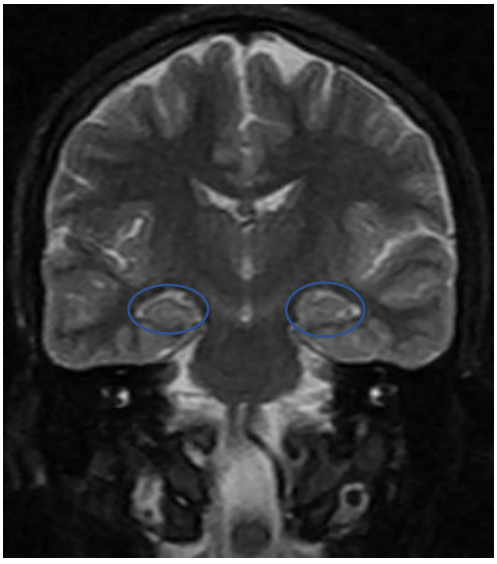
After the scan was completed, the patient was moved from the MRI scanner to the recovery room. The patient was monitored for two hours for complications, to the contrast or the technique. Patients who were sedated were monitored till they were fully awake then for another two hours before being released.

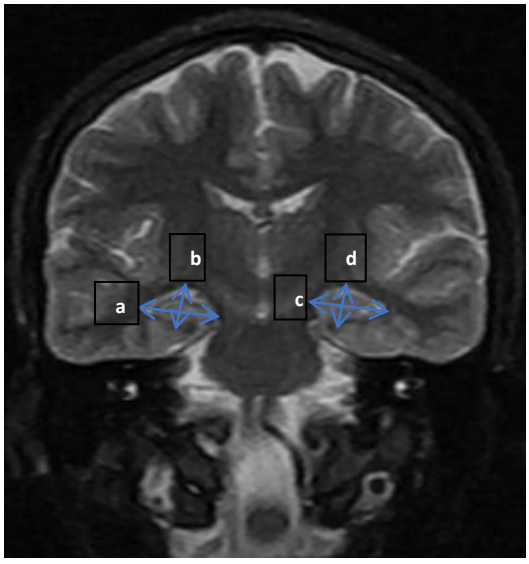
3.7.5 Obtaining of MRI brain findings from the scans

The MRI scans obtained were then reported. Hippocampal volumes, Cella Media Indices and lateral ventricular body widths were measured/ calculated.

For hippocampal volumetry, cross-sectional areas of both the hippocampi were measured in the coronal plane by tracing hippocampal boundary manually from hippocampal head to tail. The volume of each hippocampus was calculated by multiplying the cross-sectional area by a sum of section thickness and inter-slice gap i.e. hippocampal volume = {cross sectional area × (section thickness + inter-slice gap)}.

The volumes of both hippocampi were calculated by summing each of the cross-sectional volumes.





Coronal T2 weighted MRI brain images at the level of both hippocampi. Hippocampal volume was calculated by multiplying the hippocampal cross sectional area (in square centimetres) by a sum section thickness (in centimeters) and inter-slice gap. In this case, slice thickness was 3millimetres and slice gap was 20% (0.2). The length of the right hippocampus **(a)** was 2.40cm whereas the width **(b)** was 0.98cm. The length of the left hippocampus was 2.36cm **(c)** whereas the width **(d)** was 0.91cm.

Right hippocampal volume = {(2.40cm x 0.98cm) x (0.3cm + 0.2)}

$= 1.18cm^3$

Left hippocampal volume = {(2.36cm x 0.91cm) x (0.3cm + 0.2)}

$= 1.07cm^3$

Cella Media Index was calculated on axial brain MRI scans by dividing the bi-parietal diameter of the skull by the maximum external diameter of bodies of the lateral ventricles (cella media). Lateral ventricular body width was measured on axial brain MRI scans.

Information on demographic data, fever as an associated clinical feature and MRI scan findings was then analyzed.

3.8 Ethical Considerations

Approval: Approvals by the MTRH/Moi University Institutional Ethics and Research Committee (IREC), Moi Teaching and Referral Hospital and National Commission For Science, Technology & Innovation (NACOSTI) were sought before commencement of the study.

Consent: Informed consent was obtained from parents/guardians of the children. Assent was sought from children above 7 years of age.

Confidentiality: The information obtained from the participants, MRI requests and reports was kept confidential and was stored in a lockable cabinet. The data was entered into a password protected computer and using codes in place of individual names.

Benefits: There was no direct monetary benefit in the participation of the study. However, the study will benefit both patients and health care providers as it will describe the patterns of magnetic resonance imaging findings in children presenting with seizures which would otherwise be missed out if the radiological investigation was not done.

Risks: No major risks were encountered as a result of participating in the study over and above what would be expected for the standard MRI scanning for children with seizures since a standardized protocol was used. The only expected risk was the fear of personal data leaks which was handled by maintaining confidentiality of all the information provided.

3.9 Data Collection, Entry, Analysis and Presentation

The data was collected using questionnaires which bear no patient's identification. For identification purposes a study number was used instead. The questionnaires were filed in a study file which was kept under a lock and key to ensure confidentiality of information provided was maintained. To improve on the quality of data, the researcher checked on the completeness of the questionnaire on a daily basis before entering the data into a Microsoft access database.

Data was imported into SPSS version 24 where coding, cleaning and analysis were done. Descriptive statistics such as mean and corresponding standard deviation, the median and the corresponding inter quartile range were used to summarize the

continuous data such as age. Frequencies and corresponding percentages were used to summarize categorical data (sex, clinical features and brain MRI findings) of the patients. Comparison between sex and brain MRI findings was done using logistic regression. Comparison between different study categorical variables such as seizure type and brain MRI findings was done using Chi-square Test. A p-value of <0.05 was considered statistically significant. The data was presented in form of charts, tables, graphs and prose form.

3.10 Dissemination of Results

The results were disseminated through a thesis mock defense at the department of diagnostic radiology and imaging (Moi University School of Medicine). They will also be disseminated through a main thesis defense at the College of Health Sciences (Moi University). A manuscript will also be prepared and submitted to the university. Results can also be published in peer review journals as well as disseminated in conference presentations.

CHAPTER FOUR: RESULTS

4.1 Age distribution and clinical features of children with seizures and imaged at Moi Teaching and Referral Hospital

A total of 77 children were studied. The age range was 1 month to 17 years. Among the 77 children, 51.9% were aged 5 years and below. Those aged between 6 and 10 years accounted for 37.7% of cases whereas 10.4% were aged between 11 and 17 years. Mean age was 6.55 with a standard deviation of 5.73. There were more females than males 59.7 % and 40.3% respectively. These findings are depicted in Table 1 below.

Table 1: Demographic Data of Children Diagnosed with Seizures

Variable	Frequency (n)	Percent (%)
Gender		
Male	31	40.3
Female	46	59.7
Total	77	100
Age in Years		
Mean 6.55		
SD 5.73		
Age Distribution		
5 years and below	40	51.9
6 -10 years	29	37.7
11 - 17 years	8	10.4
Total	77	100

Majority (69.6%) of the patients had generalized onset seizures. The remaining 30.4% had focal onset seizures. This is depicted in Figure 12 below.

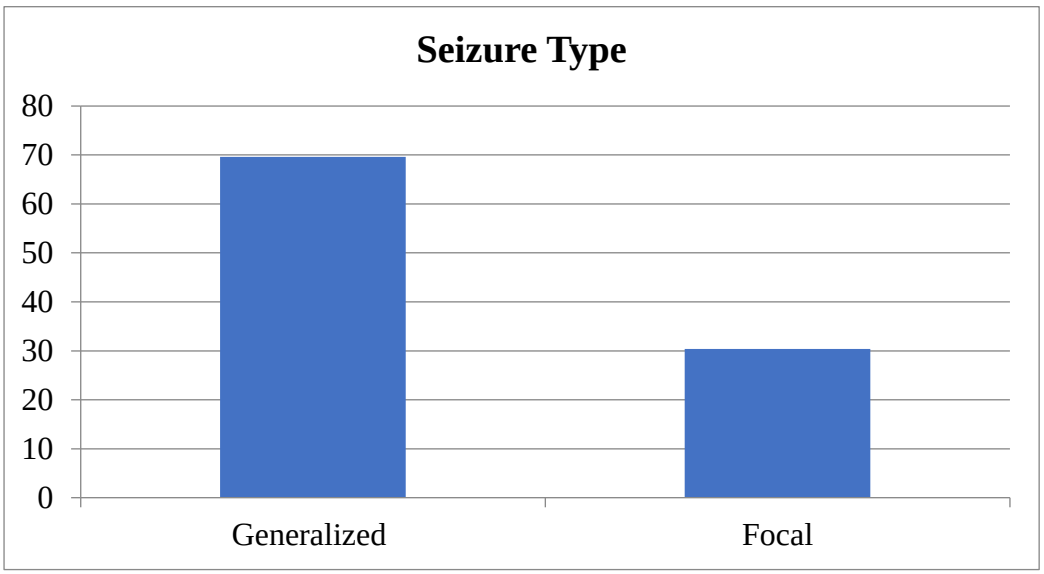


Figure 12: Seizure Type

A majority of the patients (68.8%) did not have fever. Fever was present in only 31.2 % of the patients. This is illustrated in Figure 13 below.

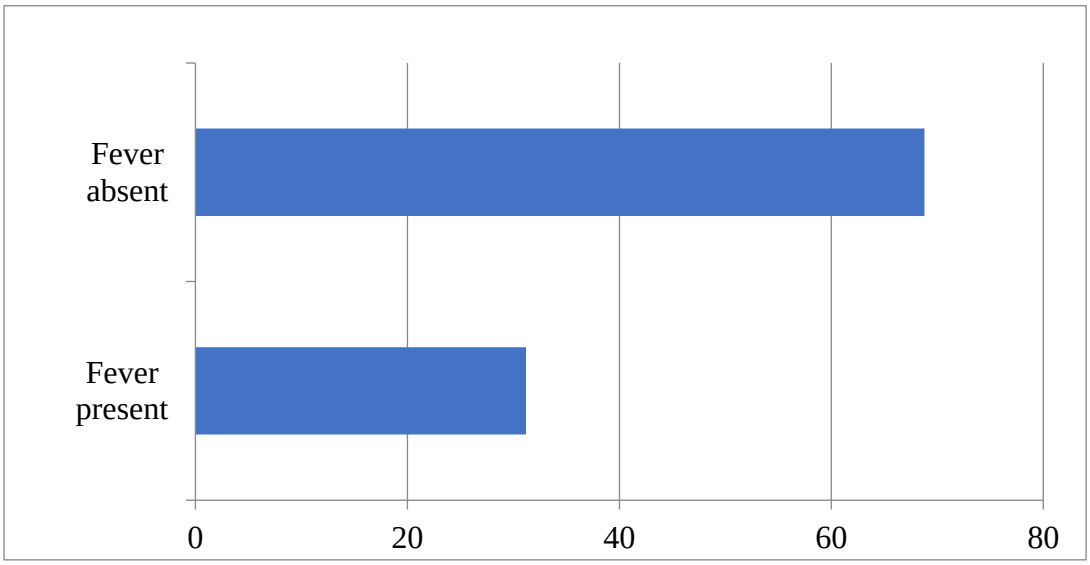


Figure 13: Presence or absence of fever

A majority of patients (46.8%) had no underlying clinical condition. Among those with underlying clinical condition, the most common one was birth asphyxia at 18.2%. Other underlying clinical conditions were observed with smaller frequencies. Table 2 below gives a summary of the underlying clinical conditions.

Table 2: Summary of Underlying Clinical Conditions

Variable	Frequency (n)	Percent (%)
None	36	46.8
Birth asphyxia	14	18.2
Sepsis	10	13.0
Prematurity	7	9.1
Trauma	3	3.9
Human Immunodeficiency Virus	2	2.6
Severe Acute Malnutrition	2	2.6
Maternal Human Immunodeficiency Virus	1	1.3
Acute lymphocytic leukemia	1	1.3
Sickle cell disease	1	1.3
Total	77	100

Majority of the patients (84.4%) were not on anti-seizure medication. Among the patients on medication, 11.7% of whom were on one anti-seizure medication whereas 3.9% were on two anti-seizure medications. This is demonstrated in Figure 14 below.

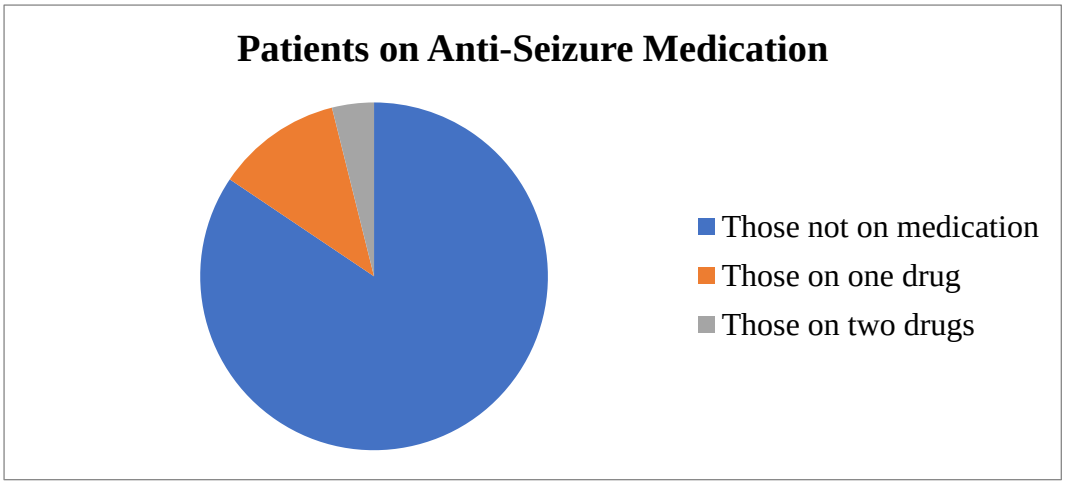


Figure 14: Patients on Anti-Seizure Medication

A small percentage (15.6%) of patients were on anti-seizure medication. Half of them (50%) of them had uncontrolled seizures, 25% had refractory seizures and the remaining 25% had been newly started on medication. These findings are depicted in Table 3 below.

Table 3: Response to Anti-Seizure Medication

Variable	Frequency (n)	Percent (%)
Uncontrolled seizures	6	50
Refractory seizures	3	25
Newly started on medication	3	25
Total	12	100

4.2 Proportion of children with seizures with abnormal brain MRI findings at Moi Teaching and Referral Hospital.

Majority of the patients (71.4%) had normal brain MRI findings. The remaining (28.6%) of patients had abnormal brain MRI findings. Figure 15 below illustrates these findings.

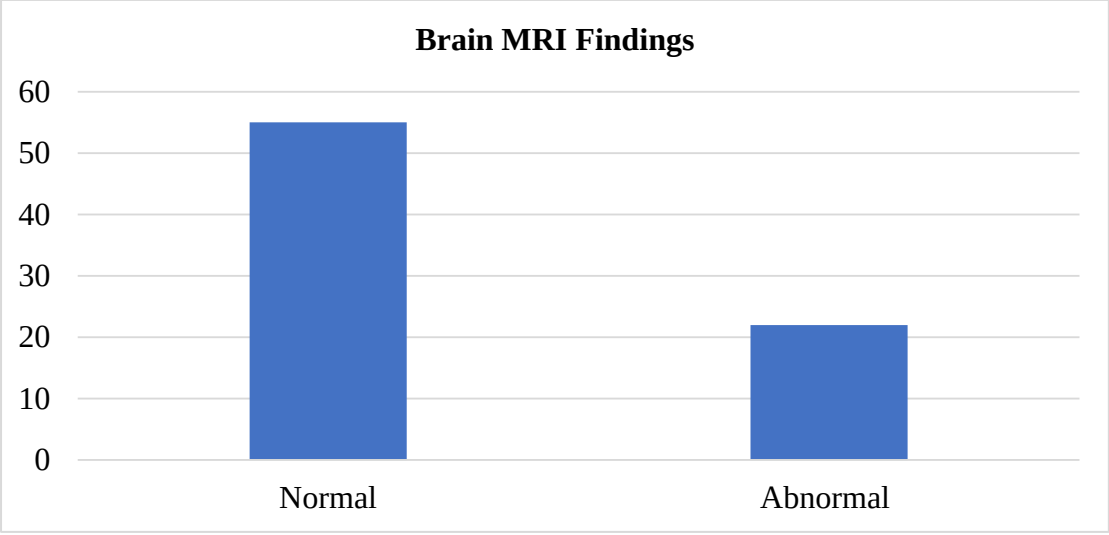


Figure 15: Brain MRI findings.

Majority (63.7%) of patients with abnormal findings were aged 5 years and below. 22.7% of patients with abnormal findings were aged between 6 years and 10 years. 13.6% with abnormal findings were aged between 11 years and 17 years. Figure 16 below illustrates these findings.

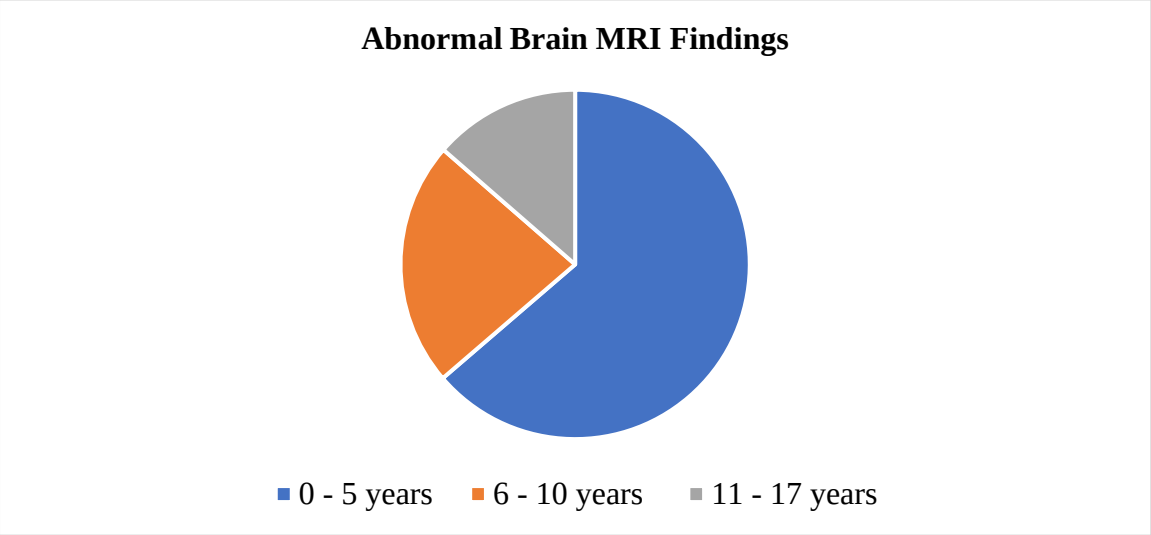


Figure 16: Abnormal Brain MRI Findings (Per Age Category)

A higher proportion of males (32.3%) had abnormal brain MRI findings compared to females (26.1%). Figure 17 below illustrates these findings.

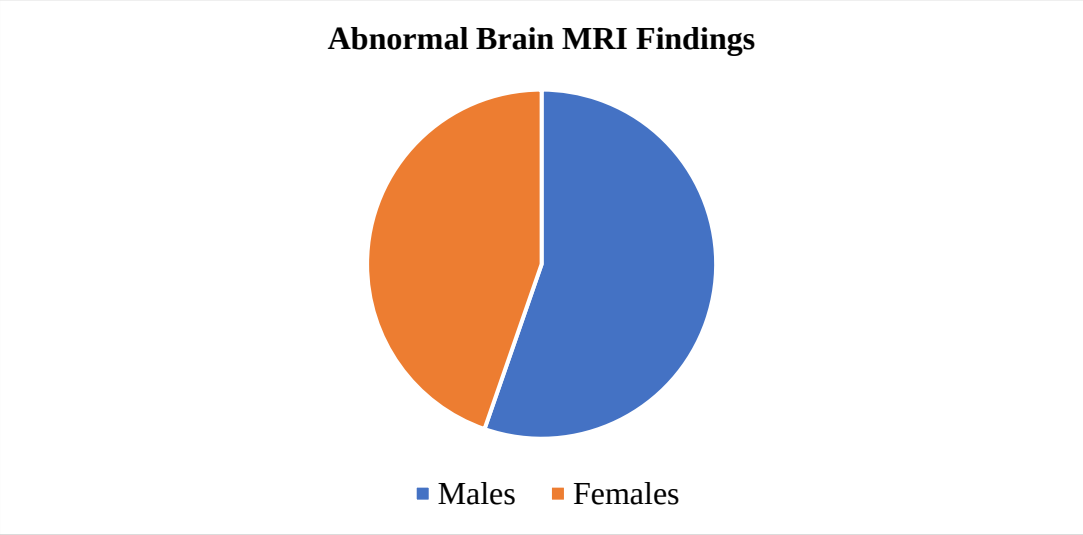


Figure 17: Abnormal Brain MRI Findings in relation to Gender

A higher proportion (31.8%) of patients with focal seizures had abnormal brain MRI findings compared to those with generalized seizures (28.6%). This is illustrated in Figure 18 below:

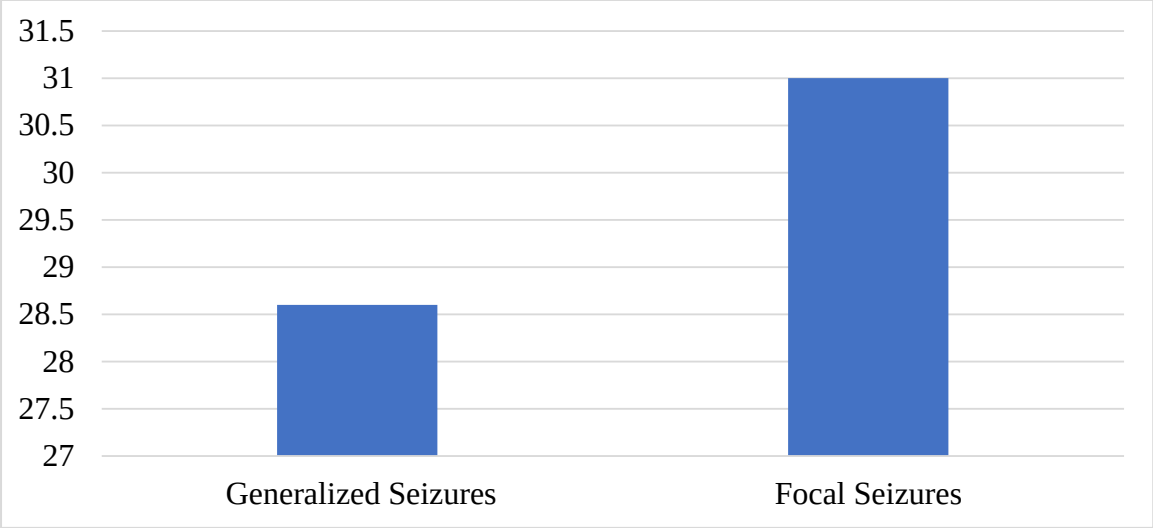


Figure 18: Abnormal Brain MRI Findings in relation to Seizure Type

Among patients with abnormal brain MRI findings, 16.7% had fever whereas 34% had no fever. Figure 19 below demonstrates these findings.

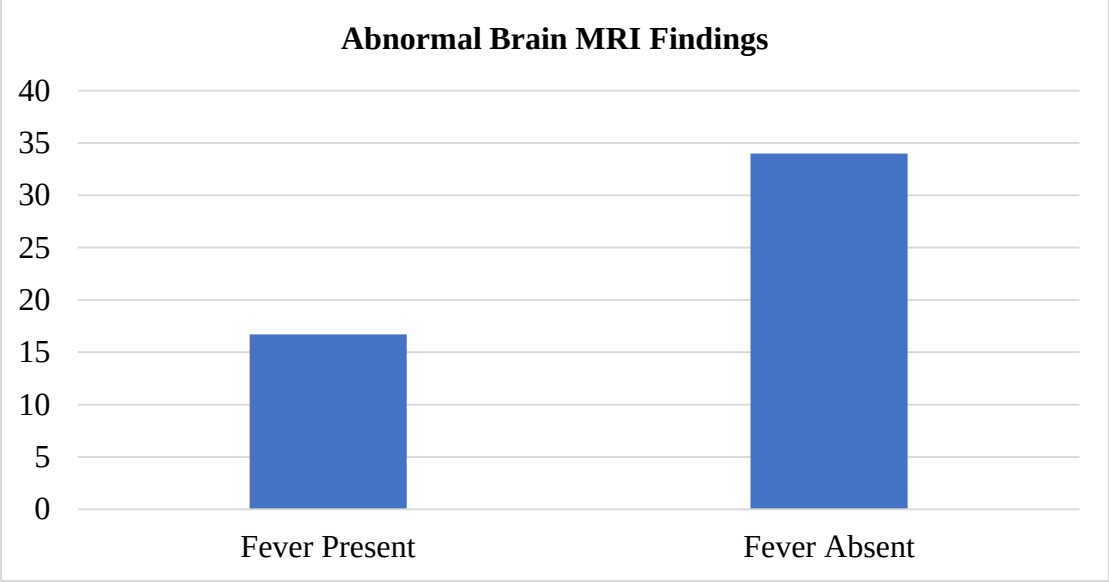


Figure 19: Abnormal Brain MRI Findings in relation to Fever

Among patients with abnormal brain MRI findings, 29.3% had underlying clinical conditions whereas 9.8% had no underlying clinical condition as illustrated in Figure 20 below.

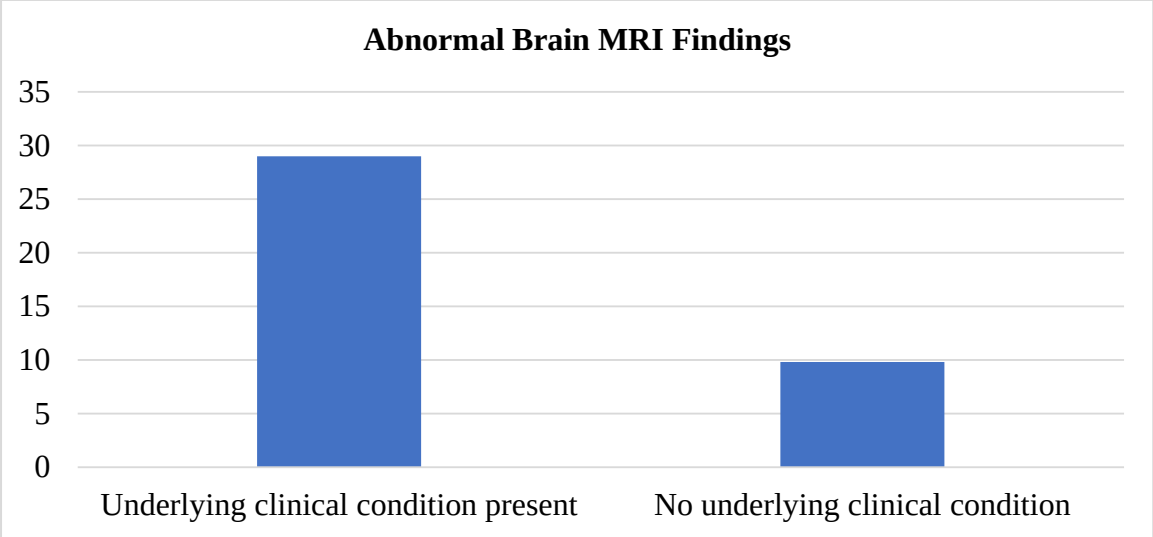


Figure 20: Abnormal Brain MRI Findings in relation to Underlying Clinical Condition

4.3 Observed brain MRI abnormalities in children with seizures at Moi Teaching and Referral Hospital.

The most common pathological brain MRI finding was global brain atrophy accounting for 12.9 % of all the study participants and 45.5% of those with abnormal brain MRI findings. This was followed by cystic encephalomalacia accounting for 2.6% of cases. Other pathological MRI findings were observed with smaller frequencies as depicted in the table 4 below.

Table 4: Abnormal brain MRI Findings

Variable	Frequency (n)	Percent (%)
Global brain atrophy	10	12.9
Cystic encephalomalacia	2	2.6
Band heterotopia	1	1.3
Hemimegalencencephaly	1	1.3
Lissencephaly type 1	1	1.3
Venous infarcts	1	1.3
Watershed ischemic infarct (left anterior cerebral artery and middle cerebral artery territory)	1	1.3
Fronto-temporal atrophy/altered signal left hippocampus (left hippocampal sclerosis)	1	1.3
Hypomyelination	1	1.3
Obstructive hydrocephalus	1	1.3
Tumor (Atypical Teratoid Rhabdoid Tumor)	1	1.3
Tumor (Choroid Plexus Papilloma)	1	1.3
Total	22	100

Mean volume for the right hippocampus was 1.87cm^3 (SD 0.52). Mean volume for the left hippocampus was 1.63cm^3 (SD 0.48). Male patients were noted to have higher bilateral hippocampal volumes compared to female patients as demonstrated in table 5 below. All patients without underlying condition had normal hippocampal volumes.

Table 5: Hippocampal volumes ($cm^{3)}$

Variable	Mean	SD
Right Hippocampal volume	1.87	0.52
Left Hippocampal volume	1.63	0.48
Right hippocampal volume (male)	1.99	0.49
Left hippocampal volume (male	1.74	0.50
Right hippocampal volume (female)	1.78	0.46
Left hippocampal volume (females)	1.56	0.48

4.4 Association between age, gender, clinical features and brain MRI findings of children with seizures at Moi Teaching and Referral Hospital

Bi-variate analysis between age, gender, clinical features and MRI findings showed a statistically significant association between age, underlying clinical condition, seizure type and brain MRI findings with p values of 0.043, 0.001 and 0.014 respectively. This is depicted in Table 6 below.

Table 6: Bi-variate analysis between age, gender, clinical features and brain MRI findings

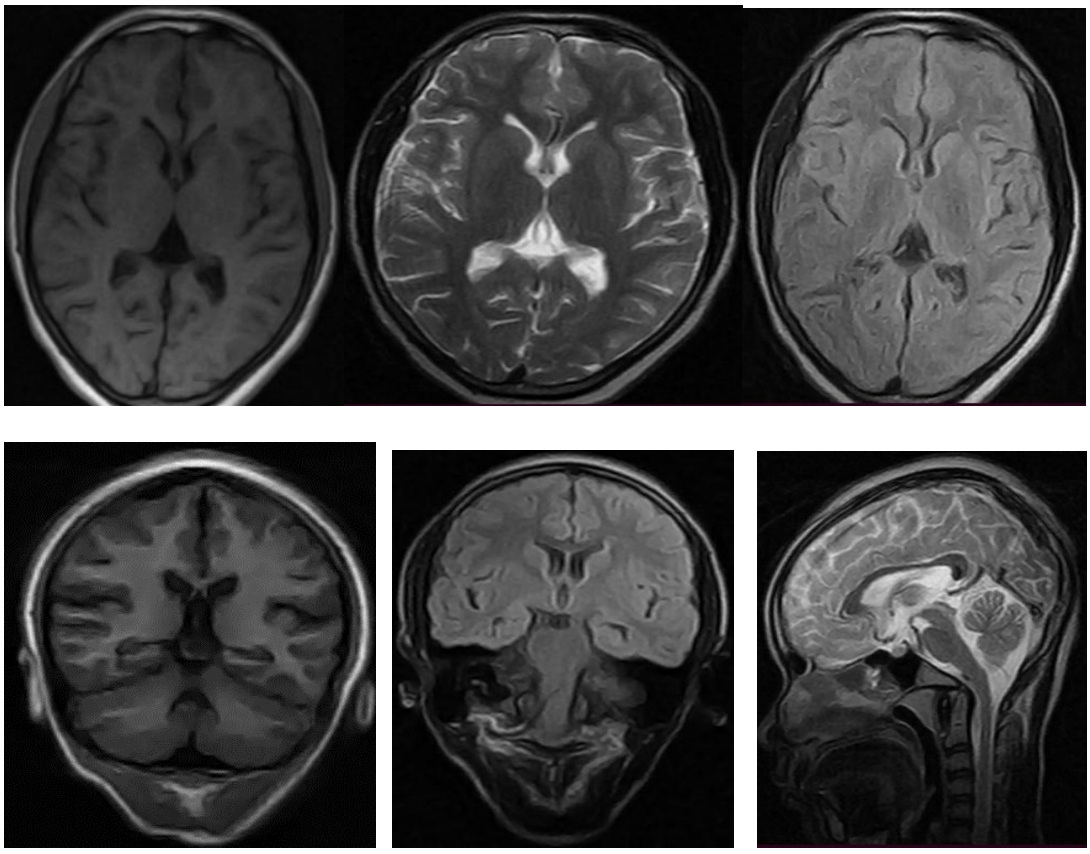
Variable	Abnormal brain MRI findings (%)	COR (95% CI)	P Value
Gender			
Male	32.3	0.74 (0.27,2.01)	0.612
Female	26.1	Reference	
Age			
Over 5 years	21.6	Reference	
5 years and below	35.0	1.88 (0.09, 3.87)	**0.043**
Underlying clinical condition			
Absent	27.8	Reference	
Present	29.3	4.21 (1.39,7.89)	**0.001**
Fever			
Present	16.7	Reference	
Absent	34.0	0.55 (0.17,1.78)	0.417
Seizure type			
Generalized	28.6	0.99 (0.20, 2.01)	
Focal	31.8	2.96 (1.43, 4.00)	**0.021**

Multivariate logistic regression showed that underlying clinical condition was a strong predictor of MRI findings with an adjusted odds ratio of 3.21 and a confidence interval of (1.77, 6.88) meaning that the presence of underlying clinical condition was 3 times more likely to predict MRI findings. This is depicted in Table 7 below.

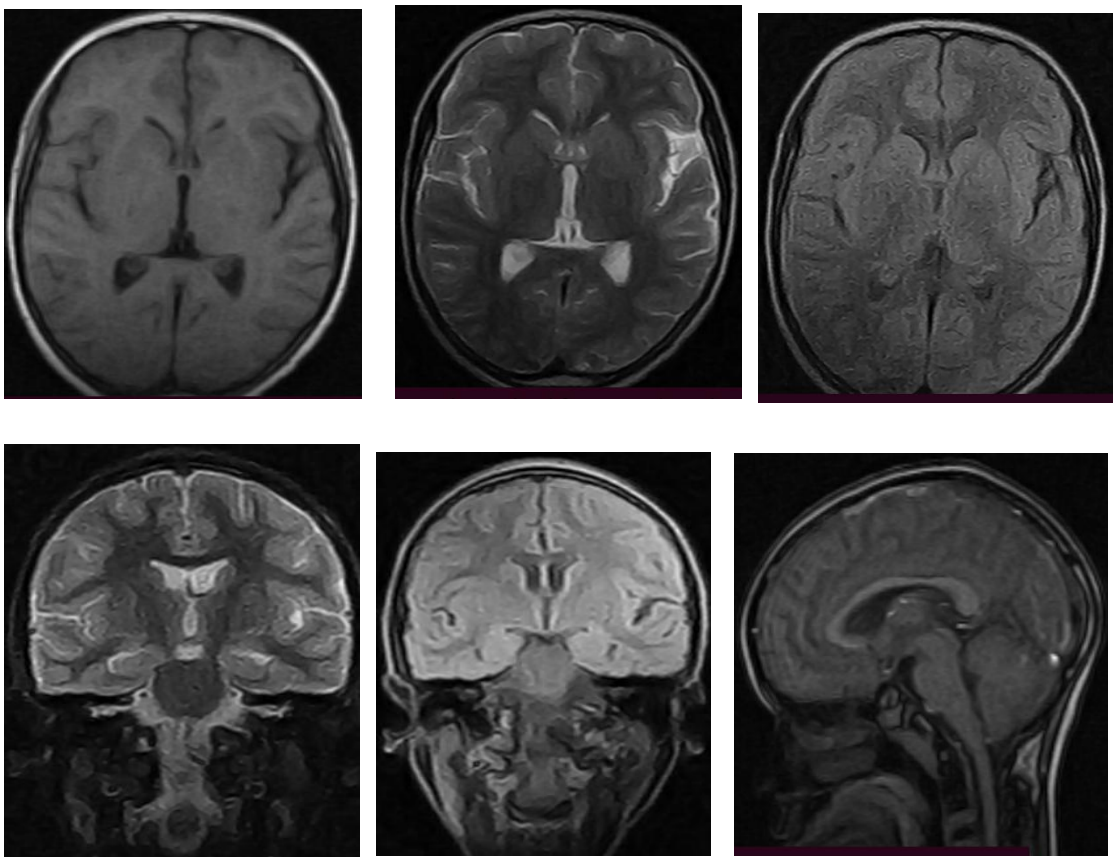
Table 7: Multivariate logistic regression analysis between age, underlying clinical condition and brain MRI findings

Variable	Abnormal brain MRI findings (%)	AOR (95% CI)	P Value
Age			
Over 5 years	21.6	Reference	
5 years and below	35.0	1.53 (0.99, 2.67)	0.050
Underlying clinical condition			
Absent	27.8	Reference	
Present	29.3	**3.21(1.77,6.88)**	**0.001**

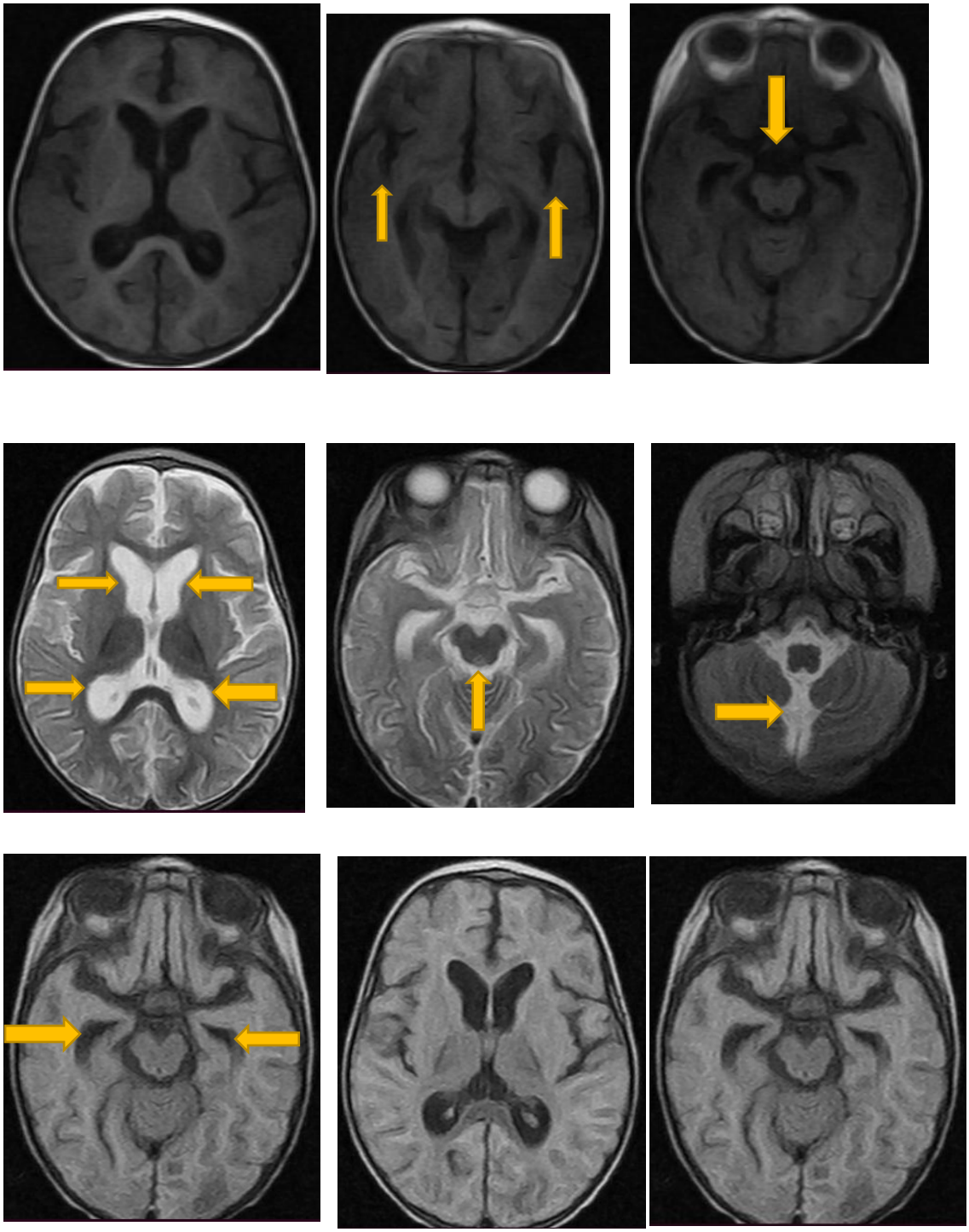
Sample Images



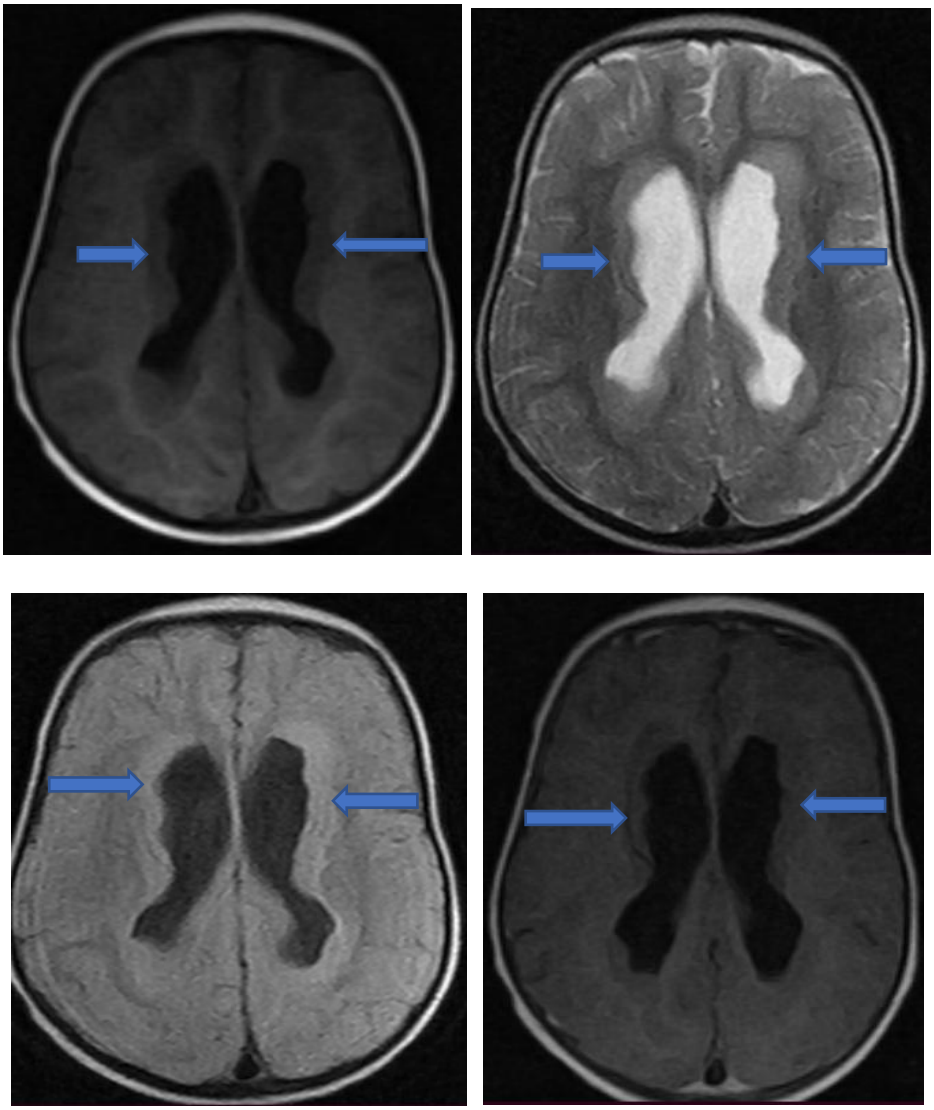
Sample image 1: Axial T1W, axial T2W, axial T2 FLAIR, coronal T1W, coronal T2 FLAIR and sagittal T2W magnetic resonance images of the brain of a 15 year old female with no underlying condition. The patient did not have associated fever. She was on one anti-seizure medication but had refractory seizures. The seizures were generalized onset type. The images demonstrate normal brain findings.



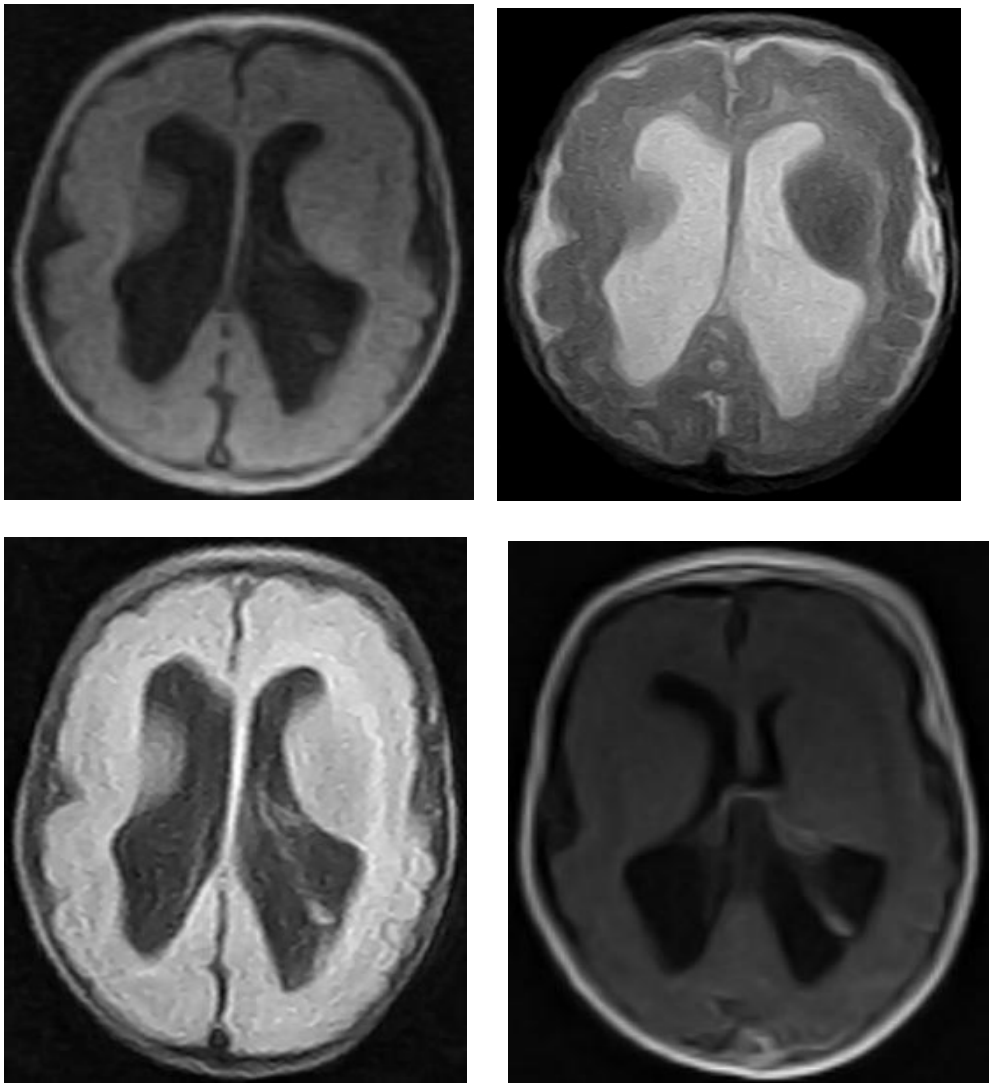
Sample image 2: Axial T1W, axial T2W, axial T2 FLAIR, coronal T2W, coronal T2 FLAIR and sagittal T1W post gadolinium magnetic resonance images of the brain of an 11 year old male who had sepsis with associated fever. He was not on anti-seizure medication. He presented with generalized onset seizures. The images demonstrate normal brain findings.



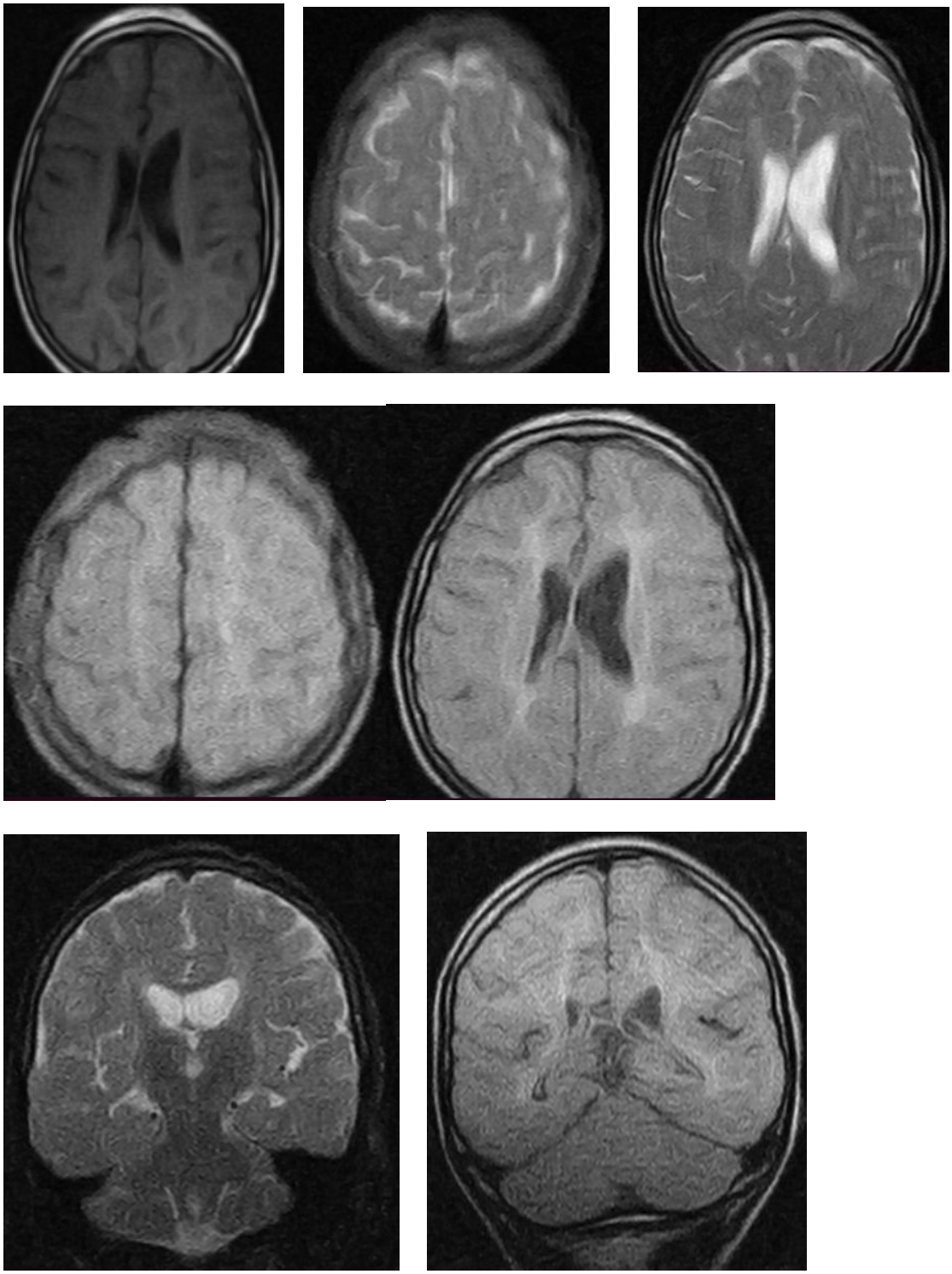
Sample image 3: Axial T1W, T2W and axial T2 FLAIR MRI brain images of a 7 year old female known to have HIV. She did not have associated fever. The patient was not on anti-seizure medication. She presented with generalized seizures. The images demonstrate prominent sulci, gyri, basal cisterns and dilatation of all the ventricles (ventriculomegaly), as demonstrated by the arrows. This is not consistent with the patient's age. These are features of global brain atrophy.



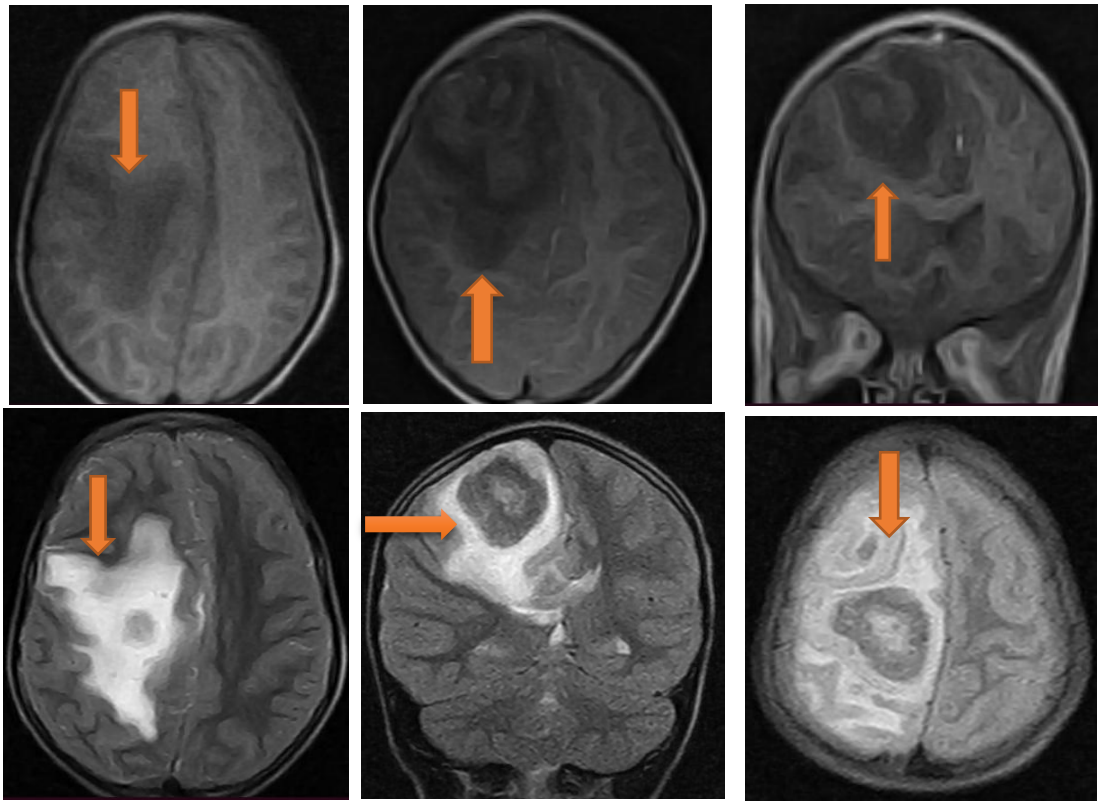
Sample image 4: Axial T1W, axial T2W, axial T2 FLAIR and axial T1W post gadolinium MR brain images of a 2 year old female who presented with generalized seizures. There was no underlying condition. The patient did not have associated fever. The images demonstrate a continuous ribbon of grey matter seen just deep to the cortex (arrows), separated from it with a thin layer of white matter. The overlying brain demonstrates some shallowness of sulci. These are features of band heterotopia.



Sample image 5: Axial T1W, axial T2W, axial T2 FLAIR and axial T1W post gadolinium MR brain images of the brain at the level of the body of the lateral ventricles in a 9 month male who presented with generalized seizures. There was no underlying condition or associated fever. The images demonstrate grossly abnormal brain outline, with only a few shallow sulci and shallow Sylvian fissures, taking on an hourglass or figure-8 appearance. There is also thickening of the cortex noted in the bilateral fronto-parietal region. These findings are consistent with type 1 lissencephaly.



Sample image 6: Axial T1W, axial T2W, axial T2 FLAIR, coronal T2W and coronal T2 FLAIR MR brain images of a 6-year-old male who was born prematurely. He presented with focal seizures. The images demonstrate an asymmetric left hemisphere, which is larger than the right one, compatible with hemi-megalencephaly. Moreover, there is a subtle loss of grey-white matter differentiation on the right side compared to the left. There is an abnormal T2 FLAIR signal on the left centrum semi-ovale.



Sample image 7: Axial T1W, axial T1 post gadolinium, coronal T1 post gadolinium, sagittal T1W post gadolinium, axial T2W, coronal T2W and axial T2 FLAIR MR brain images of a 3 year old female who presented with focal seizures. There was no underlying condition or associated fever. The patient was not on anti-seizure medication. The images demonstrate a large, heterogeneous, intra-axial supratentorial lesion that is predominantly hypointense on T1 weighted images and predominantly hyperintense on T2 weighted images. The lesion is centered in the right centrum semiovale. There is significant positive mass effect on the ipsilateral sulci and lateral ventricle and midline shift to the left. The lesion is surrounded by a large area of white matter T2/FLAIR hyperintensity, mostly in keeping with vasogenic edema. The mass exhibits minimal and heterogeneous contrast enhancement with a non-enhancing center, consistent with necrosis. Above features are demonstrated by the arrows. Histologically, this lesion was proven to be an atypical teratoid rhabdoid tumor (AT/RT).

CHAPTER FIVE: DISCUSSION

5.1 Introduction

Seizures presenting in childhood are heterogeneous, with diverse underlying etiologies, clinical presentation, severity and prognosis. Neuro-behavioural and psychiatric comorbidities occur in up to 80% of children and are frequently under-recognized (Ackermann et al., 2019).

Consistent with the global trend, the highest incidence of seizure disorders in Africa occurs in the pediatric population. The high prevalence of seizure disorders in Sub Saharan Africa is attributed to preventable risk factors including: poor perinatal care, endemic infectious diseases and head injury. Factors contributing to the treatment gap in Sub Saharan Africa include limitations in accessing adequate diagnostic and treatment services as well as negative cultural and social beliefs (Samia et al., 2021).

Evaluation of seizure disorders involves identifying the symptoms, clinical condition of the case, laboratory evaluation, EEG recording, lumbar puncture in suspected meningitis and neuroimaging (Mundhe, 2022). This will help in improving the quality of life of the patients. MRI is the imaging modality of choice for accurate localization of lesion and follow-up due to its better spatial resolution, soft tissue delineation, multi-planar imaging capability and safety due to non-utilization of ionizing radiation (Khandediya et al., 2021).

Kenya faces a high burden of seizure disorders, particularly in children. Cultural beliefs, stigma, and lack of access to treatment and skilled human resources are causes of delayed condition and management. Potentially treatable and/or preventable aetiologies, including adverse perinatal events, brain injuries, infections, as well as familial genetics are common risk factors and causes. Access to appropriate

diagnostic investigations and treatment is highly variable and the treatment gap in Kenya remains unacceptably high. There is need for better public awareness, improved epidemiological understanding of seizure disorders within Kenya, access to affordable quality health care for all those affected and improved facilities for condition and treatment. A national strategy is needed to inform further research and multi-sector approaches to improve outcomes for children living with seizure disorders (Samia et al., 2019)

The main objective of this study was to describe brain MRI findings in children with seizures in Moi Teaching and Referral Hospital.

5.2 Age distribution and clinical features of children with seizures imaged at Moi Teaching and Referral Hospital

This study found out that a majority (51.9%) of the patients studied were aged below five years and below. These results compare to those of a study conducted in a tertiary hospital in Kenya by (Samia et al., 2021), in Tanzania by (Mwalongo & Kija, 2020) as well as that done in India by (Bhavani Shankar et al., 2022) that had similar results at 52%, 56.9% and 55.3% respectively. Majority of the present literature shows that most of the patients studied are aged five years and below. Most studies show high incidence of seizures in younger children with a decreasing frequency in older age group.

Majority (59.7%) of the patients were female. This compares well to results from a study conducted in Saudi Arabia by (Muthaffar, 2022) which found that 57% of patients were female. However, this finding contrasted with that of most of the studies reviewed which revealed that a majority of the patients were male. These include studies by (Shatima & Ulonnam, 2014) in Nigeria with males accounting for 69.5% of

patients, (Mundhe, 2022) in India with males accounting for 58% of patients, (Khandediya et al., 2021) in India with males accounting for 58% of patients and (İlk et al., 2017) in Turkey with males accounting for 58.4% of patients. This difference could be attributed to the large sample size in the latter studies.

Majority of the patients (63.6%) had generalized seizures. This compared well to results of most of the literature reviewed. These include studies conducted by (Samia et al., 2021) in Kenya at 67.8%, (Ackermann et al., 2019) in South Africa at 71% and (Anand et al., 2017) in India at 66.3% as well as several other studies which also showed that generalized onset seizures were the commonest seizure type.

This study found out that a majority of the patients (68.8%) studied did not have associated fever. This contrasts to results from a study by (Chen et al., 2010) in Taiwan which revealed that 68% of the patients studied had associated fever. This difference could be attributed to the fact that the latter study was conducted in children less than 6 years of age.

This study found out that the most common other underlying clinical condition was birth asphyxia accounting for 18.2% of cases. This was also noted in a study conducted by (Shatima & Ulonnam, 2014) in Nigeria which showed that 13.7% of patients studied had birth asphyxia as the underlying clinical condition.

A majority of the patients were not on anti-seizure medication. Half of those on anti-seizure medication had uncontrolled seizures, a quarter had refractory seizures and the remaining quarter had been newly started on medication. These findings contrast to those of a study by (Bhavani Shankar et al., 2022) in India which revealed that the majority of patients with seizures were treated with single anti-epileptic drugs and were found to be controlled.

5.3 Proportion of children diagnosed with seizures with abnormal brain MRI findings at Moi Teaching and Referral Hospital.

This study revealed that approximately a third (28.6%) of the patients had abnormal brain MRI findings. This agrees with results from a study in a tertiary hospital in Kenya by (Samia et al., 2021) which showed that 33% of patients studied had abnormal brain MRI findings. Another study by (Shatima & Ulonnam, 2014) in Nigeria found out that 33.2% of patients studied had abnormal brain MRI findings. However, a study conducted in India by (Khandediya et al., 2021) noted that a majority (82%) of the patients had abnormal brain MRI findings. This difference could be attributed to the fact that the latter study were carried out in children aged 5 years and below.

This study also revealed that patients aged 5 years and below were more likely to have abnormal MRI scan findings compared to those aged above 5 years. This agrees with results from a study done in Tanzania by (Mwalongo & Kija, 2020).

This study also found out that male patients were more likely to have abnormal MRI scan findings compared to female patients. This agrees with results from a study done in Tanzania by (Mwalongo & Kija, 2020).

The study also established that patients with fever were more likely to have abnormal MRI scan findings compared to those without fever. This agrees with results from a study by (Sullivan, 2020) in the United States noted that children without fever were more likely to have brain MRI abnormalities. However, it contrasts with results from a study by (Chandini et al., 2019) in India found out that patients with fever were more likely to have abnormal brain MRI findings compared to those without fever.

The contrast can be explained by the fact that the study in India was conducted on children in the age group of 1 month to 5 years.

This study also revealed that male patients had higher hippocampal volumes compared to female patients. All patients without underlying condition were noted to have normal hippocampal volumes. A very small percentage of patients with underlying condition, focal seizures and no associated fever had unilateral hippocampal volume loss. This compares to a study by (Yoong et al., 2013) in the United Kingdom which revealed that a minority of patients who had afebrile focal seizures and epilepsy were noted to have unilateral hippocampal volume loss.

This study also showed that patients with underlying clinical condition were 3 times more likely to have abnormal MRI scan findings. This is comparable to results from a study by (Ndubuisi et al., 2016) in Nigeria showed that patients with underlying condition were 5 times more likely to have abnormal MRI scan findings.

Seizure types were found to relate to MRI findings at bivariate level of our analysis (p value = 0.014). These results are similar to those of a study done by (Kalnin et al., 2008) in the United States which also found out that focal onset seizure type had a significant association with MRI outcomes (p value = 0.018). However some studies did not find any relationship between seizure type and MRI outcomes.

5.4 Observed brain MRI abnormalities in children diagnosed with seizures at Moi Teaching and Referral Hospital.

This study established that the most common abnormal brain MRI finding was global brain atrophy accounting for 13% of cases. These findings are also reflected in another study done in India by (Chandini et al., 2019) which noted that the most common abnormal brain MRI finding was global brain atrophy at 17.7%. However, a study done in Tanzania by (Sungura et al., 2020) showed the main cause of seizures to be infection. (Zubcevic & Milos, 2015) in Canada revealed that delayed myelination/post hypoxic ischemic changes were the most common abnormal brain MRI finding. These differences could be attributed to fact that the latter studies were carried out for longer periods of time (6 years and 3 years respectively).

CHAPTER SIX: CONCLUSIONS AND RECOMMENDATIONS

6.1 Conclusions

1. Majority of patients were female and were aged 5 years and below. The most common seizure type was generalized onset. Majority of the patients had no associated fever. Most of the patients had no underlying condition.
2. Approximately a third of patients had abnormal brain MRI findings, most of whom were under five years of age, had focal onset seizures, underlying clinical conditions and no fever.
3. Among patients with abnormal MRI findings, global brain atrophy was the most common abnormality.

6.2 Recommendations

Brain MRI is recommended for children with seizures.

Brain MRI is highly recommended for children aged 5 years and below, those presenting with focal seizures, those with underlying clinical conditions and those without fever as they are more likely to have structural brain abnormalities.

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APPENDICES

Appendix I: Consent Form

My name is Dr. Joan Cheruto Chebii from the Department of Radiology and Imaging and I am carrying out a study on brain MRI findings in children with seizures in MTRH.

I am kindly requesting you to participate in the study.

What is the study about?

The study is about brain MRI findings in children presenting with seizures in MTRH. It is intended to determine whether there are structural abnormalities in the brain in these children who present with seizures.

What will happen to me during the study?

On giving consent, you will be asked a few questions about the child and the condition. You will be told about the procedure and any risks involved, if present.

You will not incur any risks or acquire any benefits by participating in this study. You will be given the same medical care as the rest of the patients who do not participate in the study. You can choose whether or not you would like to participate in the study. In case you refuse to take part in the study you will not be forced to participate.

If you have any questions, please feel free to ask and I was glad to assist you.

Certificate of Assent

- Do you understand this research study and are willing to take part in it?

  Yes ☐ No ☐

- Has the researcher answered all your questions?

  Yes ☐ No ☐

- Do you understand that you can pull out of the study any time?

  Yes ☐ No ☐

- I agree to take part in the study ☐

  OR

  I do not wish to take part in the study ☐

Signed: ……

Date: ……

Appendix II: Demographic/Personal Data

Instructions:

a) All sections should be filled accordingly.

b) Writings should be clear and legible.

c) The form is to be filled in by the principal investigator or assistant once the patient has given consent to be part of the study.

Serial No: …….

Date of Birth/ Age ……....

Gender ……

IP/OP No: …….

Date: …….

Contact No: ……...

Appendix III: Clinical Features of Children with Seizures sent for MRI Scanning

- Seizure type

  Focal onset ☐

  Generalized Onset ☐

  Unknown ☐

- Is there fever (a temperature recording of more than 38^0 Celsius) within 24 hours of onset of seizure?

  Yes ☐ No ☐ Unknown ☐

- Are there co-morbidities/underlying conditions that could contribute to the seizure?

  Yes (Specify if possible) ☐

  No ☐

  Unknown ☐

- Is the patient on medication for the seizure(s)?

  On one anti-epileptic drug ☐

  On two anti-epileptic drugs ☐

  Not on medication ☐

- Response to treatment

  Newly diagnosed ☐

  Controlled ☐

  Uncontrolled/Refractory ☐

Appendix IV: Brain MRI Findings

- Pathological Findings:
    1. None

       ……

    2. Infection (Specify if possible)

       ……

    3. Tumor (Specify if possible)

       ……

    4. Vascular Disorder (Specify if possible)

       ……

    5. Brain Atrophy

       ……

    6. Other

       …….

- Hippocampal Volume (cm^3)
    1. Right

       ……

    2. Left

       ……...

- Cella Media Index

  …….....

- Lateral Ventricular Body Width (mm)

  ……...

Appendix V: Study Schedule

Activity	**2020**				**2021**		**2022**
	Jan-Feb	Feb-June	Sep-Dec		Jan - Sep	Sep - Dec	Jan - Sept
Concept formulation							
Proposal writing							
Ethical approval							
Actual data collection							
Data analysis							
Report writing							
Presentation							

Appendix VI: Estimated Project Budget

Particulars	Quantity	Unit Cost (Ksh)	Total Cost (Ksh)
Research assistant	1	8000@ 9months	72,000
Biostatistician	-	-	50,000
Box files	5	500	2,500
Paper punch	1	500	500
Staples	2 packets	250	500
Stapler	1	500	500
Marker pen	5	100	500
Biro pens	2 dozen	250	500
Pencils	1 dozen	250	250
Printer	1	20,000	20,000
Photocopy	-	-	50,000
Internet	Monthly	5000	45,000
Printing cost	-	-	50,000
Thesis writing	1	50000	50,000
Binding of thesis	6	500	3,000
Correspondence for publishing journal	-	-	10,000
Laptop	1	30,000	30,000
SUB TOTAL			385,250
10% Contingency	-	-	38,525
Total			423,775

Appendix VII: IREC Approval

INSTITUTIONAL RESEARCH AND ETHICS COMMITTEE (IREC)

MOI TEACHING AND REFERRAL HOSPITAL
P.O. BOX 3
ELDORET
Tel: 33471//2/3

MOI UNIVERSITY
COLLEGE OF HEALTH SCIENCES
P.O. BOX 4606
ELDORET
Tel: 33471/2/3

Reference: IREC/2021/41
Approval Number: 0003873

4th May, 2021

Dr. Joan Cheruto Chebii,
Moi University,
School of Medicine,
P.O. Box 4606-30100,
ELDORET-KENYA.

Dear Dr. Chebii,

BRAIN MAGNETIC RESONANCE IMAGING FINDINGS IN CHILDREN WITH SEIZURES AND IMAGED IN MOI TEACHING AND REFERRAL HOSPITAL

This is to inform you that ***MTRH/MU-IREC*** has reviewed and approved your above research proposal. Your application approval number is ***FAN: 0003873.*** The approval period is **4th May, *2021- 3rd May, 2022.***
This approval is subject to compliance with the following requirements;

i. Only approved documents including (informed consents, study instruments, MTA) will be used.
ii. All changes including (amendments, deviations, and violations) are submitted for review and approval by ***MTRH/MU-IREC***.
iii. Death and life threatening problems and serious adverse events or unexpected adverse events whether related or unrelated to the study must be reported to ***MTRH/MU-IREC*** within 72 hours of notification.
iv. Any changes, anticipated or otherwise that may increase the risks or affected safety or welfare of study participants and others or affect the integrity of the research must be reported to ***MTRH/MU-IREC*** within 72 hours.
v. Clearance for export of biological specimens must be obtained from ***MTRH/MU-IREC*** for each batch of shipment.
vi. Submission of a request for renewal of approval at least 60 days prior to expiry of the approval period. Attach a comprehensive progress report to support the renewal.
vii. Submission of an executive summary report within 90 days upon completion of the study to ***MTRH/MU-IREC.***

Prior to commencing your study; you will be required to obtain a research license from the National Commission for Science, Technology and Innovation (NACOSTI) https://oris.nacosti.go.ke and other relevant clearances. Further, a written approval from the CEO-MTRH is mandatory for studies to be undertaken within the jurisdiction of Moi Teaching & Referral Hospital (MTRH), which includes 22 Counties in the Western half of Kenya.

INSTITUTIONAL RESEARCH & ETHICS COMMITTEE
04 MAY 2021
APPROVED
P. O. Box 4606 - 30100 ELDORET

Sincerely,

PROF. E. WERE
CHAIRMAN
INSTITUTIONAL RESEARCH AND ETHICS COMMITTEE

cc CEO - MTRH; Dean - SOP; Dean - SOM
Principal - CHS; Dean - SON; Dean - SOD

Appendix VIII: Hospital Approval (MTRH)

An ISO 9001:2015 Certified Hospital

MOI TEACHING AND REFERRAL HOSPITAL

Telephone :(+254)053-2033471/2/3/4
Mobile: 722-201277/0722-209795/0734-600461/0734-683361
Fax: 053-2061749
Email: ceo@mtrh.go.ke/directorsofficemtrh@gmail.com

Nandi Road
P.O. Box 3 – 30100
ELDORET, KENYA

Ref: ELD/MTRH/R&P/10/2/V.2/2010

11th May, 2021

Dr. Joan Cheruto Chebii
Moi University
School of Medicine
P.O. Box 4606-30100
ELDORET-KENYA

BRAIN MAGNETIC RESONANCE IMAGING FINDINGS IN CHILDREN WITH SEIZURES AND IMAGED IN MOI TEACHING AND REFERRAL HOSPITAL

In order to conduct research within the jurisdiction of Moi Teaching and Referral Hospital (MTRH) this includes 22 counties in the Western half of Kenya. You are required to strictly adhere to the regulations stated below in order to safeguard the safety and well-being of staff and patients seen at MTRH involved research studies.

1. The study shall be under Moi Teaching and Referral Hospital regulation.
2. A copy of MTRH/MU-IREC approval shall be provided.
3. Studies dealing with collection, storage and transportation of Human Biological Material (HBM) will not be allowed to export the HBM outside the jurisdiction of **MTRH.**
4. For those tests which are unavailable locally the PI is tasked to ensure sourcing of equipment and subsequent training of staff to build their capacity.
5. No data collection will be allowed without an approved consent form(s) to participants to sign.
6. Take note that **data** collected must be treated with due confidentiality and anonymity.

Permission to conduct research shall only be provided once all the requirements stated above have been met.

MOI TEACHING AND REFERRAL HOSPITAL
APPROVED
11 MAY 2021
SIGN.....
P. O. Box 3-30100, ELDORET

11/05/2021

DR. WILSON K. ARUASA, *EBS*
CHIEF EXECUTIVE OFFICER
MOI TEACHING AND REFERRAL HOSPITAL

c.c. - Senior Director, Clinical Services
- Director of Nursing Services
- HOD, HRISM

Appendix IX: National Commission For Science, Technology & Innovation (NACOSTI) Approval

REPUBLIC OF KENYA

NATIONAL COMMISSION FOR SCIENCE,TECHNOLOGY & INNOVATION

Ref No: **911735**

Date of Issue: **09/June/2021**

RESEARCH LICENSE

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