Validation of a pediatric guideline on basic electroencephalogram interpretation for clinicians

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Dedication

Dedicated to my parents the late Mr and Mrs Kander

Declaration

I, Veena Kander, do hereby declare that this research project submitted to the Central University of Technology for the degree MAGISTER TECHNOLOGIAE: CLINICAL TECHNOLOGY is my own independent work that has not been submitted before to any institution by me or any other person in fulfilment of the requirements for the attainment of any qualification.

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Signature of student Date

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Definitions

Epilepsy: Is defined as a neurological disorder marked by sudden recurrent episodes of sensory disturbance, loss of consciousness, or convulsions, associated with abnormal electrical activity in the brain (Berg *et al.*, 2010).

Treatment Gap: The difference between the number of people with active epilepsy (two or more unprovoked seizures on different days in the previous year) and the number whose seizures are approximately treated in a given population at a given point in time, expressed as a percentage (Mbuba *et al.*, 2008). This definition was developed by a workshop of the International League Against Epilepsy (ILAE).

Key For Abbreviations

AIDS:	Acquired immune deficiency syndrome
AED/AEDs:	Anti-epileptic drug
CNS:	Central Nervous System
CT:	Computed tomography
DF:	Degrees of freedom
EEG:	Electroencephalogram
HIV:	Human immunodeficiency virus
IBE:	International Bureau for Epilepsy
ILAE:	International League Against Epilepsy
MRI:	Magnetic resonance imaging
N:	Number
PWE:	People with epilepsy
PI:	Principal Investigator
SD:	Standard Deviation
TG:	Treatment Gap
RPCs:	Resource Poor Countries
WFN:	World Federation of Neurology
WHO:	World Health Organisation

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Summary

The incidence of epilepsy is high in sub-Saharan Africa and resource poor countries (RPCs). There are few neurologists and paediatric neurologists to manage people with epilepsy (PWE). Health care is often limited, particularly technological services, including electroencephalogram (EEG), video EEG monitoring, and Neuroradiology services. All these are important in the management of PWE.

Since 2008, informal electrophysiology training has been provided at the Red Cross War Memorial Hospital, in the Department of Paediatric Neurology. The Principal Investigator (PI) elected to develop a formal teaching course on EEG interpretation at the Red Cross War Memorial Hospital. A study was designed to evaluate the practical use of a handbook entitled "Handbook of Paediatric Electroencephalography: A guide to basic paediatric electroencephalogram interpretation." This has been developed to fulfill the need for basic understanding and interpretation of EEG amongst clinicians caring for children in sub-Saharan Africa who may not have access to, or be able to afford, training at a recognized facility or on-line.

In 2008, the department of Paediatric Neurology at the Red Cross War Memorial Hospital had their first African fellow from Kenya. By 2011, seven participants had undergone EEG training.

A quantitative research approach and design was used in order to evaluate the handbook in terms of the accessibility of the contents and its practical use. Quantification included the recruitment of participants who constituted the population sample, a pilot study, and the collection of data from comparative assessments of participants' use of the handbook, and from questionnaires completed by participants. This provided the researcher with the opportunity to improve and validate her knowledge of training in EEG interpretation. The researcher was able to quantify and compare the scores of participants using the handbook, as well as to compare their evaluative responses to its

content and practical use. Eleven of thirteen participants completed the study. The pre-training results showed a median percentage of 50 which increased to 70 percent post-test. A comparison of the scores of trained versus not-trained revealed that those participants who had undergone one-on-one training on site at the unit fared much better both in their interpretations, conclusions, and reporting of EEG findings. The responses from the evaluative and comparative survey between the two groups showed no significant difference across all questions, the majority of the questions on the relative usefulness of the handbook being rated 'agree' and 'strongly agree', thus supporting the finding that all participants found the handbook useful whether they had received one-on-one training or not.

The post-training results in EEG interpretation showed a stronger trend towards statistical significance ($p<0.06$) with trained participants and with the not-trained. These findings lend support to the success and usefulness of the handbook as a basic guide to paediatric EEG interpretation. The handbook was not aimed at making the electroencephalography reader an expert at a specialist level, but rather to maximize the reliability of the reading of EEG when screening electroencephalograms for important key diagnostic markers which would alter the child's management. This is the first published handbook on paediatric EEG in South Africa. The results of this study strongly suggest that the handbook is useful as a learning and reference tool in interpretation of paediatric EEG, both for individuals with access to one-on-one training as well as those without. It is intended that the handbook, in conjunction with one-on-one training, will form part of a post-graduate diploma course offered by the University of Cape Town on "basic electrophysiology and the management of children with epilepsy" for training neurologists and child neurologists, paediatricians and health care workers in sub-Saharan Africa.

Key words: Africa, EEG training, paediatric, handbook

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Chapter One: Introduction

1.1 Introduction

Epilepsy is one of the most common serious disorders of the brain. There are around fifty million individuals living with epilepsy worldwide irrespective of their age, ethnicity, socio-economic class or geographic location (World Health Organization, 2005). Nearly 80% of these live in resource poor countries (RPCs) (World Health Organization, 2005). In some parts of sub-Saharan Africa, owing to the lack of awareness of certain sectors of the population, epilepsy may not be perceived as a life threatening condition in comparison to other disorders such as human immunodeficiency virus (HIV)/ acquired immune deficiency syndrome (AIDS) and malaria. However, although people with epilepsy (PWE) in these countries still need care and treatment, the number of individuals who do not receive anti-epileptic drugs (AEDs) ranges from 65-95%, with the highest figures in the rural areas (World Health Organization, 2005). This is evident in a study done in 2008 in rural Kenya, where 89% of children with epilepsy were found not to be receiving AEDs (Mung'ala-Odera *et al.*, 2008). It has been suggested that one of the reasons for this is the extreme scarcity of adequately trained and experienced epilepsy specialists or neurologists in these countries, particularly in the area of paediatric neurology.

Epilepsy is defined as a neurological disorder marked by sudden recurrent episodes of sensory disturbance, loss of consciousness, or convulsions, associated with abnormal electrical activity in the brain (Berg *et al.*, 2010). Epilepsy is not a mental illness or a psychiatric disorder and neither is it infectious or contagious (Baskind & Birbeck, 2005) . Epilepsy cannot be cured, although it can be controlled in most cases with anti-epileptic medications. A diagnosis of epilepsy is made when two or more unprovoked seizures occur accompanied by a detailed history of events normally given by a parent, witness or caregiver (Berg *et al.*, 2010). The prognosis of seizure remission is unchanged with AED treatment after a first seizure as opposed to treatment after a second seizure (Hirtz *et al.*, 2003). The presence of

inter-ictal electroencephalogram (EEG) abnormalities alone is not sufficient to make a diagnosis of a seizure, and the absence of an abnormality does not exclude seizures.

The fact that there are few, or no, neurologists, or epilepsy specialists in many of the poorest countries in sub-Saharan Africa, limits progress in the field of neurology in these countries. In 2005 there were only five known published studies of epilepsy in sub-Saharan Africa (Preux & Druet-Cabanac, 2005). In 2010 there was approximately 1 neurologist for 10 million people in most of these countries (Birbeck, 2010b). Of those neurologists, it is not known how many were and is trained in paediatric neurological conditions (Wilmshurst *et al.*, 2011).

Technological services which include EEG, long term video EEG monitoring and Neuro-radiology (magnetic resonance imaging (MRI)/computed tomography (CT) are similarly scarce in sub-Saharan countries. The training of neurological professionals and neurophysiologic service providers remains a problem owing to the severe economic and financial difficulties affecting most sub-Saharan countries (Dechambenoit, 2010; Wilmshurst *et al.*, 2011).

In RPCs, EEG laboratories are frequently managed by technologists and paramedical personnel with no formal training in performing EEG recordings (Radhakrishnan, 2009). Neurology registrars often receive inadequate exposure to paediatric EEG interpretation and epileptology, even from the best of training centres. As a result, EEG results are often misinterpreted, leading to over diagnosis of epilepsy and unnecessarily prolonged use of AED therapy (Radhakrishnan, 2009; Wilmshurst *et al.*, 2011).

In this context, there is a need for educational materials, including standard guidelines for the diagnosis of epilepsy, to be produced and distributed to RPCs (World Health Organization, 2005). Although books and manuals for teaching neurophysiology exist, there is a pressing need for paediatric training programs, since there are few neurologists or neurophysiologists with paediatric experience in sub-Saharan Africa (Wilmshurst *et al.*, 2011). There are currently no locally

published handbooks/manuals in EEG in South Africa, and as far as the principal investigator is aware, none specifically relevant to RPCs or which encompass or specifically address the African context for paediatrics. In this context in particular, the current research will contribute to the development and improvement of the teaching of paediatric EEG.

1.2 Relevance of the study

There are many books/manuals/workshops and even online EEG training courses available for use in EEG training. However, these are not tailored for "African" needs. There are many regions which do not have reliable access to internet facilities; online tools are less helpful to these groups of potential child neurologists with appropriate EEG skills. THE PURPOSE OF THIS STUDY WAS TO DESIGN A GUIDELINE IN THE FORM OF A HANDBOOK ON BASIC PAEDIATRIC ELECTROENCEPHALOGRAM TECHNIQUES AND INTERPRETATION AND TO VALIDATE THE GUIDELINE. The material included in this handbook was designed to be used by child neurologists in training, paediatricians, adult neurologists (whose work entails managing children), and medical officers (who are the only health care providers in a region to care for children with epilepsy) who do not have prior experience in EEG. The handbook could be used as a platform/foundation/basis leading to more complex and specialised courses.

This handbook is intended to complement current courses/manuals that the World Federation of Neurology (WFN), World Health Organisation (WHO), International Bureau for Epilepsy (IBE) and International League against Epilepsy (ILAE), as well as online EEG training courses [The John Hopkins Atlas of Digital EEG: an interactive training guide, and VIREPA: virtual epilepsy academy] already in place for developing neurology skills in Africa. These courses are not readily accessible or affordable for neurology trainees in these countries.

The handbook, it is hoped, will enable those involved in, or in training for, caring for potentially epileptic children, particularly those in isolated regions with no expert support, to more accurately and effectively interpret paediatric abnormalities; the handbook can assist with the classification and diagnosis of epilepsy and epilepsy syndromes.

Typical EEG patterns may assist in correct diagnosis and appropriate management, such as the identification of typical absence and subclinical seizures or hypsarrhythmia in the case of infantile spasms. This would avoid inappropriate therapy in a child with typical absence epilepsy and potentially improve neurological outcome in a child with infantile spasms and sub-clinical seizures.

1.3 Aim

The aim of this study was to validate a handbook designed by the researcher on the interpretation of electroencephalograms in children.

1.4 Objectives

The following objectives to be achieved in the course of this study are:

- To address the educational needs of medical officers, paediatricians and trainee neurologists in the interpretation of EEG by designing a guideline in the form of a handbook on basic paediatric EEG
- To validate the handbook quantitatively by means of structured and prospective EEG interpretations pre- and post-training
- To assess the effectiveness of one-on-one training with the principal investigator
- To determine the level of EEG interpretation skills attained by the participating subjects, as well as the collection of quantitative data from the subjects' own experiences of using the handbook

1.5 Conclusion

The next chapter reviews the available literature relevant to epilepsy, paediatric epilepsy in particular, and its impact on sub-Saharan Africa and RPCs. The literature on the specific problems facing neurologists, paediatricians and medical officers in its diagnosis and treatment in these countries is discussed.

Chapter Two: Literature Review

2.1 Introduction

The continent of Africa, consisting of some 53 countries and islands, is the oldest inhabited place on earth (Owolabi, Bower & Ogunniyi, 2007). The Egyptians were the first to describe the brain and seizures amongst the many neurological disorders they recognised (Owolabi, Bower & Ogunniyi, 2007). Ironically, today, the burden of neurological diseases is largely unknown in Africa, owing to lack of, or absent data in many sub-Saharan African countries (Owolabi, Bower & Ogunniyi, 2007).

Resource poor countries (RPCs) have no conventional classification, but are recognised according to the World Bank as low income countries and these are where most people suffering from poverty, illiteracy and malnutrition reside. Health care in RPCs is often limited to a few public institutions, which cannot provide optimal services because of economic and administrative limitations. In these countries, the prevalence and incidence of epilepsy is thought to be higher than that of developed countries (Carpio & Hauser, 2009), although, owing to a lack of data, the understanding of the epidemiology is far from complete.

Data collection in these countries is compromised by lack of access to physicians or neurologists, and lack of diagnostic equipment such as CT and EEG. There are also difficulties with the capacity to interpret common EEGs findings as illustrated by Figure 2.1. below showing 3 hertz spike and wave activity. The classification of epilepsy and epileptic syndromes has become complicated and available studies use different definitions and inclusion criteria, which increase the difficulty of analysing and applying the data.

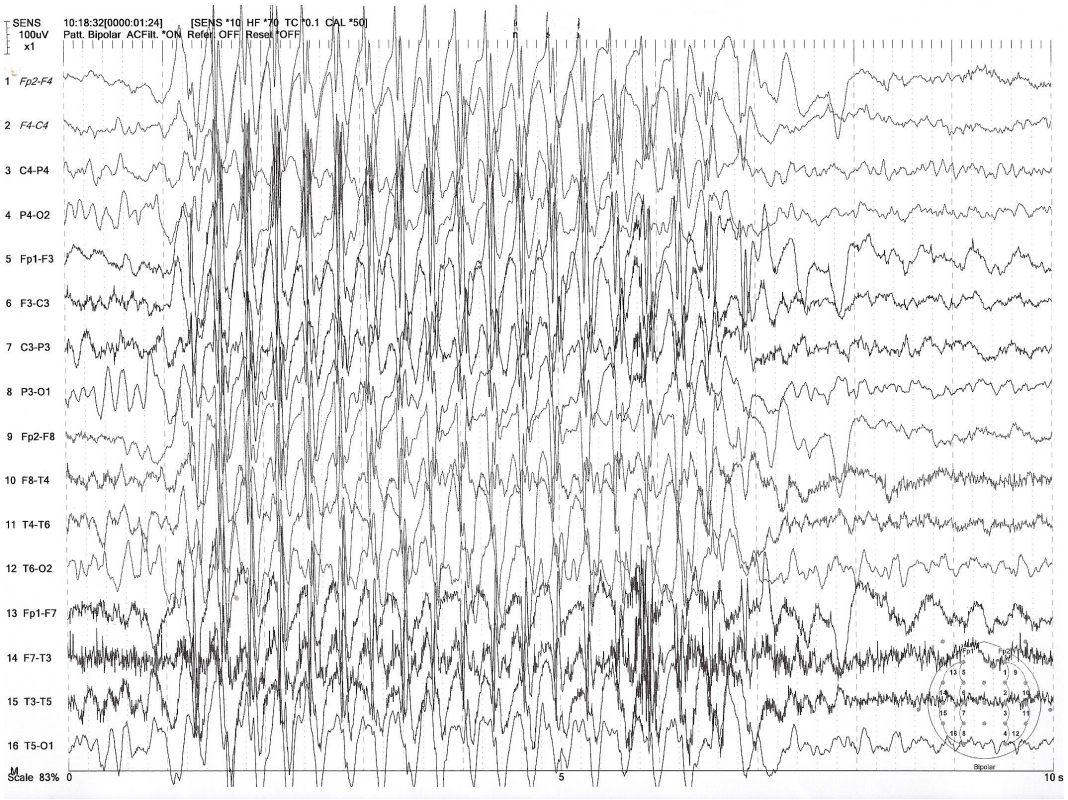

Figure 2.1: 3Hz spike and wave discharges, typical of absence epilepsy, recorded in a child during hyperventilation in a patient seen at the EEG laboratory at the Red Cross War Memorial Hospital on the 29th January 2013

2.2 Epidemiology of epilepsy

There exist scant data on the precise burden of neurological diseases in countries in Africa; however, recent studies performed in RPCs following the methodology based on the recommendations from the ILAE show the active prevalence of epilepsy to range from 3.8 to 15.4 per 1000 person-years. However, different study designs were used as well as different definitions of active epilepsy and comparisons were difficult to ascertain with these results owing to the uncertainty regarding age specific distribution and the broader case-inclusion criteria. The incidence of epilepsy was found by these studies to be highest among young and middle aged adults (Carpio & Hauser, 2009). The incidences of epilepsy in RPCs and sub-Saharan Africa in children and adults will be discussed in detail later in this chapter. In sub-Saharan Africa studies show the mean sex ratio of men to women is 1-4, with trauma being a potential reason for the high prevalence of epilepsy in men and, whilst there are no data to

support this, young women may hide their epilepsy in order to get married (Birbeck, 2010a; Birbeck, 2010b; Preux & Druet-Cabanac, 2005).

2.2.1 World-wide

The Epilepsy Atlas, published in 2005 jointly by the WHO, the ILAE and the IBE, is one the first comprehensive compilations for epilepsy ever attempted. It provides the current status of epilepsy from 160 countries, covering 97.5% of the world population (World Health Organization, 2005). It is estimated that brain disorders affect at least 250 million people in the "developing" world, of which epilepsy affects 40 million and 60% of those worldwide (Owolabi, Bower & Ogunniyi, 2007). The total global burden in neuropsychiatric diseases is expected to increase to 14.7% by 2020. Out of the $70 million that Global health research spends annually, only 10% is spent in RPCs, which constitute 90% of the world's disease burden (Owolabi, Bower & Ogunniyi, 2007).

2.2.2 Sub-Saharan Africa

Sub-Saharan Africa has the highest number of people with epilepsy (PWE) compared to the rest of the RPCs. Numerous studies on the prevalence of epilepsy in sub-Saharan Africa have been conducted. Although door to door surveys is the gold standard method to estimate prevalence of epilepsy, this can vary from country to country. Notably Ivory Coast recorded the highest rate in 2005 with 74.4/1000, Cameroon 70.0/1000 and Nigeria 37/1000 (Preux & Druet-Cabanac, 2005). Despite the abundance of epilepsy in RPCs, a known aetiology has been reported for less than 40% of cases, owing to lack of access to even basic investigations in most cases. Presumably, if the same technology were available as that used in industrialised countries, the percentage of epilepsy cases with an identifiable aetiology would increase considerably (Senanayake & Roman, 1993).

Data from sub-Saharan Africa countries show that central nervous system (CNS) infections, such as cerebral malaria, are the commonest

cause of epilepsy in children, and neurocysticercosis leads to epilepsy in 53% of people infected (Diop *et al.*, 2003). Many causes of epilepsy are preventable, either through improvement in public health measures, such as improved sanitation, vaccination programmes and improved maternal care, or through legislation to reduce trauma caused by road traffic accidents and alcohol abuse. Morbidity in epilepsy can be improved through earlier detection and prompt and adequate treatment. Genetic counselling is helpful were there exists a specific hereditary predisposition (Senanayake & Roman, 1993; Wilmshurst *et al.*, 2011).

These factors contribute to stigmatisation in many communities in sub-Saharan Africa and increase epidemiological inaccuracy, as seizures are not reported. The rate of mortality with epilepsy is much more frequent in sub-Saharan Africa due primarily to status epilepticus, falls, drowning, and burns (Jamison, 2006).

2.2.3 South Africa

Since South Africa's first democratic election in 1994, massive social reconstruction has taken place in the country, including major healthcare reformation. Resources have been shifted from large tertiary-level hospitals to greatly expand the primary and secondary levels of care. However, in spite of this restructuring, a dual healthcare system still exists, with 85% (38 million) of the population relying on an over-stretched state healthcare system and 15% (7 million) covered by private healthcare. South Africa, like all other sub-Saharan countries, has a scarcity of data relating to epilepsy, marked inequalities relating to management with the continued existence of the dual healthcare system, and a large treatment gap in some areas (Eastman, 2005).

The extent of the burden of epilepsy in South Africa is largely unknown and likely to be greater than that typically found in RPCs (Christianson *et al.*, 2000). A more recent local study performed on children in the Northern Province by Christianson *et al.* (2000) demonstrated an active prevalence of 6.7/1000 compared to previous studies undertaken in the 1960s, where a prevalence of epilepsy was reported to be 2.2/1000 and 3.7/1000

respectively (Christianson *et al.*, 2000; Eastman, 2005). In another study performed by Gill *et al.* (2001) at a rural hospital in KwaZulu Natal, epilepsy accounted for 16 percent, out of which children below the age of 15 years amounted to 12 percent with non-communicable diseases. A detailed review of 1017 children presenting with epilepsy at the Red Cross War Memorial Hospital in 1995, found the following conditions: structural brain lesions (56%), hypoxic ischaemic encephalopathy (55%), meningitis (61%), granulomata (75%), trauma (58%), metabolic disturbances (43%), cerebrovascular lesion (72%), and identified degenerative illness (50%) to be secondary causes of their epilepsy. Amongst the poor of the Western Cape, perinatal hypoxia, meningitis, granulomata (cysticercosis and tuberculosis) and trauma have a high prevalence and are all potentially preventable (Leary *et al.*, 1999). In addition, certain events, such as breath-holding attacks, syncope, and pseudo-seizures can also mimic epileptic seizures (Wilmshurst, 2011). Apart from neurocysticercosis and trauma, HIV/AIDS is also a common cause of epilepsy in South Africa.

At the end of 2011 an estimated 5.38 million of HIV positive people were recorded in South Africa. Epilepsy is a frequent manifestation of CNS disorders, particularly in the advanced stages of HIV, and is therefore a major health concern in the country (Eastman, 2005; Samia *et al.*, 2013).

South Africa also has widely varied cultural attitudes and beliefs about epilepsy amongst its population. Two local studies show how such beliefs affect how epilepsy is treated and constitute a microcosm of issues affecting the management of epilepsy worldwide, but particularly in sub-Saharan Africa (Christianson *et al.*, 2000; Eastman, 2005). The treatment gap in South Africa is affected by the lack of available resources for the state healthcare system. While standard anti-epileptic drugs (AEDs) are available in the state healthcare system, newer agents are only available for private practice (Eastman, 2005).

2.3 What is epilepsy?

Epilepsy is defined “as the occurrence of two or more seizures without acute provocation” (Hirtz *et al.*, 2003). Epilepsy can occur as a result of a symptomatic aetiology or idiopathic/cryptogenic aetiology. In the case of symptomatic aetiology, there is no immediate cause of epilepsy, however prior identifiable brain injury, such as severe brain trauma or conditions such as cerebral palsy or mental retardation can contribute to the development of epilepsy. An idiopathic seizure is suspected to originate from genetic aetiology, such as benign rolandic epilepsy, and is not associated with a known central nervous system disorder. Cryptogenic seizures occur in otherwise normal individuals with a no clear aetiology (Hirtz *et al.*, 2003).

Globally the history of classification of seizures has largely rested upon astute observation and expert opinion. The first published classification by the International League against Epilepsy (ILAE) was in 1960 and the last updated classification was done in 1981. A revised classification of terminology in terms of concepts and approaches for classifying seizures and epilepsies was commissioned by ILAE during the 2005-2009 terms of the League. This re-organised system of classification is currently being used, as seen in Table 1 (Hirtz *et al.*, 2003).

Table 1: Classification of seizures (Berg *et al.*, 2010)

Generalised seizures
Tonic-clonic (in any combination)
Absence
Typical
Atypical
Absence with special features
Myoclonic absence
Eyelid myoclonia
Myoclonic
Myoclonic
Myoclonic atonic
Myoclonic tonic
Clonic
Tonic
Atonic
Focal seizures
Unknown
Epileptic spasms
Seizures that cannot be clearly diagnosed into one of the preceding categories should be considered unclassified until further information allows their accurate diagnosis.

2.3.1 Common causes in adults

Epilepsy in adults is caused by head injury, tumours and vascular diseases (Diop *et al.*, 2003). Head injuries are commonly caused by road accidents owing to poor traffic regulations as well as lack of seat-belt policy and absence of a helmet law for motor cycle riders. Other factors contributing to head injuries include work-related injuries, injuries from war and, in South Africa, from fights amongst individuals using heavy sticks and knobkerries (stick with a round knob at the end also known as an African club), a popular pastime amongst some groups of the population and one that is both a national sport and a means of settling grievances. In tropical countries such as India, head injuries occur from accidental falls in the course of climbing trees to gather coconuts or 'tapping toddy' (a method used in tropical countries to extract

the traditional alcoholic beverage from coconut or palm trees) (Preux & Druet-Cabanac, 2005; Senanayake & Roman, 1993).

Between 1 and 10% of cases of epilepsy in sub-Saharan Africa are found to have brain tumours, a situation which is similar to that in industrialised countries.

In sub-Saharan Africa many tumours are only diagnosed in the advanced stages owing to the lack of CT scans (Preux & Druet-Cabanac, 2005).

Stroke causes 90% of deaths in RPCs (Aarli, Diop & Lochmuller, 2007). Brain lesions caused by strokes often cause epilepsy. Between one and forty two percent of patients with epilepsy have cerebral vascular disease. The management of high blood pressure in sub-Saharan Africa is poor and the paucity of neuro-imaging increases the risk factor of strokes (Preux & Druet-Cabanac, 2005).

Alcoholism is a growing problem in developing countries, the consumption of illicit alcohol in particular (Senanayake & Roman, 1993).

2.3.2 Common causes in children

There exists a paucity of data on the burden or causes of epilepsy in RPCs, particularly in children living in sub-Saharan Africa (Mung'ala-Odera *et al.*, 2008). Furthermore there is little data on estimates of children living with epilepsy in RPCs and sub-Saharan Africa, and even less data on incidence and risk factors associated with epilepsy in children. In 2001 and 2003 respectively two surveys were conducted in rural sub-Saharan Africa to determine the prevalence, incidence and risk factors in children in these areas. All children born between 1991 and 1995 were screened using a questionnaire from June 2001 to April 2002 and then again in September 2003 to January 2004. In the first survey, out of 10218 children, 110 had epilepsy. In the second survey, which was a larger study consisting of three phases, 39 children from the same birth cohort with previously undiagnosed epilepsy were identified. According to these surveys, the risks included antenatal problems (lack of prenatal

care), perinatal problems (home births, untrained birth attendants, birth difficulty), postnatal problems (neonatal insults), children not immunized, and history of febrile seizures (Mung'ala-Odera *et al.*, 2008). The study concluded that 0.2% of children between the ages of 6-12 years develop epilepsy each year, with a history of febrile seizures and family histories identified as the most important risk factors. Nearly half of the children with active epilepsy were less likely to attend school as a result of their cognitive impairment.

As previously mentioned, few studies have to date been conducted to estimate the prevalence of epilepsy in sub-Saharan Africa. Door to door surveys in Tanzania and Senegal, and a population based survey in Kenya, to name a few, estimated the prevalence of epilepsy to be 7.4,14.2 and 11/1000 respectively (Carpio & Hauser, 2009; Mung'ala-Odera *et al.*, 2008).

Perinatal complications increase the risk of epilepsy as most children in sub-Saharan Africa are born at home without professional help. Neonatal hypoxia, watershed cerebral ischemia and obstetric injuries are some of the common injuries occurring in this context. In sub-Saharan Africa most febrile seizures are malaria induced fever seizures. It is unclear whether the seizures are related to primary CNS involvement or are truly febrile seizures. However, febrile seizures are often severe in children and recur frequently. Several studies have found high risk of epilepsy with cerebral malaria (Preux & Druet-Cabanac, 2005).

In the case of neuroinfections encephalitis and bacterial meningitis (meningococcal) are the most common causes. A study in Dakar, Senegal found that 18% of patients with the measles virus had epilepsy. Seizures occur in HIV patients through direct invasion of the CNS or during opportunistic infections (cryptococcocis, herpes simplex virus, toxoplasmosis and tuberculosis).

Parasites can cause seizures or long term epilepsy by producing encephalitis or localised lesions. Neurocysticercosis is endemic in many countries in sub-Saharan Africa. Family history of epilepsy is noted in between 6 and 60% of patients studied in sub-Saharan Africa.

Consanguinity is common and as high as 96% in Mali (Preux & Druet-Cabanac, 2005). Lead poisoning also occurs from burning lead containing batteries in RPCs to cook or provide warmth (Senanayake & Roman, 1993).

2.3.3 Diagnosis of epilepsy

The diagnosis of epilepsy is made on clinical grounds and should be confirmed by a professional with expertise in epilepsy (World Health Organization, 2005). Performing an EEG would be helpful to the diagnosis if epilepsy is strongly suggested but can certainly classify seizure type or syndrome and can assist with prognosis (Radhakrishnan, 2009; World Health Organization, 2005). Specific conditions, such as infantile spasms, are often diagnosed late in sub-Saharan Africa and the condition is further exacerbated by the lack of access to EEG (Wilmshurst *et al.*, 2013). Neuro-radiology (CT/MRI) is not necessary in the diagnosis of all patients with well characterized epilepsies; however, it is required with focal seizures or with unsatisfactory seizure control. In addition, functional MRI is ideally required for epilepsy surgery programmes (Gaillard *et al.*, 2009). In rural sub-Saharan Africa and RPCs, the probability exists that the basic chemistry and genetic investigations may not be readily available to assist with the diagnosis of epilepsy.

2.3.4 Electroencephalograms

Since 1929, when Hans Burger recognised the use of brain wave frequencies as a clinical tool, EEGs have been used as an assessment for epilepsy (Hans Berger Centenary Symposium on Epilepsy *et al.*, 1974; Kander *et al.*, 2012). Often EEGs are commonly misdiagnosed and in these cases can have serious consequences (Benbadis, 2013). The tendency on the part of neurologists to over read normal EEGs as abnormal is the major contributor to the misdiagnoses of epilepsy. The reasons are mostly related to the lack of standards or mandatory training in EEG, and the assumption that all neurologists are trained to read EEGs (Benbadis, 2013). Having an EEG carries the potential

of negative consequences for a patient, as the consequences of being misdiagnosed with epilepsy are obvious and serious. It is very difficult to undo an incorrect diagnosis provided by an erroneous EEG interpretation. Many paediatricians and physicians in sub-Saharan Africa are not trained in EEG interpretation and thus are ill equipped to draw the correct conclusions from EEGs. The quality of EEG recording and interpretation cannot be ensured in RPCs, even though the diagnosis of epilepsy is not always straightforward and may require EEG confirmation (Radhakrishnan, 2009; Senanayake & Roman, 1993).

From this background the question arises: How do we solve this dilemma of EEG misinterpretation in RPCs generally, and in sub-Saharan Africa in particular? This is not a new problem and was addressed by classic pioneers in the field of epilepsy and EEGs 25 years ago (Benbadis, 2013). The consensus amongst researchers and practitioners is that the essence of EEG reading, a pattern recognition skill that can be acquired from introductory primers, atlases and comprehensive textbooks, is a process far more complex than looking at a lesion on an MRI study (Miller & Henry, 2013). The EEG is at risk of much abuse and over utilization as the diagnosis of seizures is known to rely mainly on the capturing of a detailed history of the patient, which requires skill and time on the part of medical practitioners (Benbadis, 2013; Kander *et al.*, 2012). Every practitioner, be she or he a paediatric neurologist/paediatrician, and medical officer, needs to be able to order EEGs with insight, and to interpret and understand the importance of the results (Miller & Henry, 2013). However, EEG studies can be a helpful tool in the process of excluding a diagnosis, supporting a diagnosis, and/or rendering appropriate treatment for epilepsy or epilepsy syndromes (Kander *et al.*, 2012).

2.4 Stigma and treatment gap

Stigma associated with epilepsy has long being recognized as a major burden on PWE and their families.

The combination of poverty, social role expectations, limited medical care,

and traditional beliefs severely limits the lives of PWE (Baskind & Birbeck, 2005). In terms of traditional beliefs, in sub-Saharan Africa a wide-spread belief exists that seizures are contagious (Diop *et al.*, 2003). In addition, epilepsy is perceived by some population groups to be an affliction due to supernatural forces, the effect of ancestral or bad spirits. Other perceived causes include witchcraft and poisoning (Baskind & Birbeck, 2005). As a result PWE in these areas often do not seek medical help due to the social stigma, myths and misconceptions associated with epilepsy (Radhakrishnan, 2009). Families holding supernatural beliefs will seek care from traditional healers as they are seen to have the power to mediate witchcraft/angered ancestors or the breaking of taboos, rather than seeking hospital or clinic based care. For example, bush teas (a variety of herbal concoctions which can vary from healer to healer), a popular and common treatment for adults, may be given to children for febrile seizures. When given to an unconscious child this infusion can cause severe oral burns and aspiration pneumonia can occur (Baskind & Birbeck, 2005). If a child with malaria induced febrile seizures is 'treated' by traditional healers, she or he will exhibit higher malarial parasitaemia on presentation than he or she would if not medically treated and would require longer hospitalization (Baskind & Birbeck, 2005).

Poverty and poor education are widespread in sub-Saharan Africa and together impose a heavy burden of infectious diseases on children and adults alike in their daily lives. In the rural areas family members rely on each other to complete daily tasks for survival (fetching water, cutting firewood, growing food). In sub-Saharan Africa, most of the cooking is done over open fires and in cold winter month's fire is used for warmth. Therefore, burn scars, as shown in Figure 2.2, caused by falling into open fires, are seen as the most obvious stigmata of epilepsy and intractable seizures (Baskind & Birbeck, 2005). As a result of these injuries, PWE are unable to contribute towards manual chores, thus increasing stigma and decreasing the social and economic opportunities available to these individuals.

The range of limitations of opportunities includes marital limitations for women, who are perceived as poor choices for performing the duties

of mother and wife; lost opportunities for education as parents choose not to invest in a child with epilepsy; expulsion of children with epilepsy from school by teachers because of their seizure disorder; vulnerability of unmarried adult women to sexual exploitation, physical abuse and poverty. Social isolation also occurs but on a smaller scale and PWE are often hidden from visitors (Baskind & Birbeck, 2005).

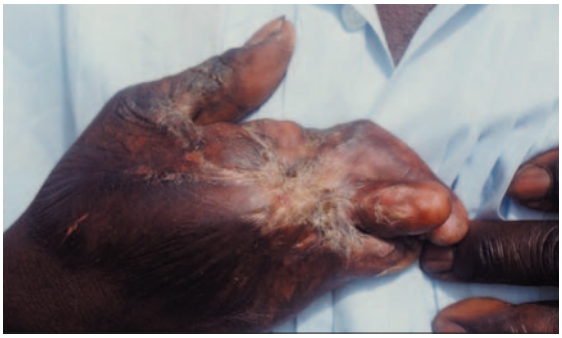

Figure 2.2: A disfigured hand of an epileptic caused by fire (Preux & Druet-Cabanac, 2005)

In 1997 the "Out of the Shadows" program was launched jointly by the WHO, the ILAE and the IBE. This is a global campaign against epilepsy and its mission statement is "to improve the acceptability, treatment, services and prevention of epilepsy worldwide", in order to address discrimination against people with epilepsy, and to diminish the treatment gap (TG) in the resource poor regions of the world (Diop *et al.*, 2003). Several studies conducted in RPCs between 1997-1998 have reported that the TG amounts to 90% of PWE not receiving the appropriate treatment for their condition (Scott, Lhatoo & Sander, 2001). In Africa alone the treatment gap was 49% with rural and urban population at 73% and 47% respectively (Radhakrishnan, 2009). The studies listed the following causes for the TG: cost of treatment, superstition and cultural beliefs, unavailability of drugs, long distance to health facilities, traditional treatment, and inadequate skilled manpower (Mbuba *et al.*, 2008). It was not surprising that the causes attributed to the highest medians were related to health systems, lack of access to AEDs, shortage of trained professionals, and cost of AEDs. The overall results suggested that TG can be addressed through educational interventions and supply of AEDs by targeting health providers including traditional

healers. Health providers will need to improve their skills in the diagnosis and management of epilepsy. PWE must be educated repeatedly on when and how to take their AEDs and how to live positively with epilepsy. However, a large number of PWE in RPCs soon discontinue their treatment within one year of being diagnosed and initiated to AEDs (Radhakrishnan, 2009). Some of the reasons cited for this are patients' inability to afford the treatment and lack of understanding of the implications of non-compliance (Radhakrishnan, 2009). Surgical interventions have made remarkable advances over the past two decades. Many focal lesions can now be surgically resected in patients with refractory focal epilepsies. However, epilepsy surgery in RPCs is rarely available, compared to 18 out of 24 (75%) having access to surgery for epilepsy in developed countries (Radhakrishnan, 2009). A survey conducted by the ILAE, the IBE and the WHO found that epilepsy surgery was available in only 13% of RPCs. Despite the lack of medical infrastructure and multidisciplinary teams in RPCs, epilepsy surgery programmes have in recent years been producing results comparable to those of developed countries (Birbeck, 2010a; Birbeck, 2010b; Radhakrishnan, 2009).

2.5 Lack of infrastructure in Sub-Saharan Africa

Epilepsy is not recognized as a public health prioritization, despite that fact that it can be treated effectively with the correct medication. However, owing to the lack of supply or choice of AEDs, this aspect has been the most important obstacle in the way of the care of PWE (Scott, Lhatoo & Sander, 2001). Ideally the choice of AEDs should be based on the seizure type/syndrome of the patient. Carbamazepine is the most frequent AED prescribed in Nigeria which has in the region of 17 paediatricians with neurology experience (Dr Okunola Olusola Peter, Personal Communication 2013, May 14). The use of phenobarbitone in sub-Saharan Africa and RPCs is based on economic factors rather than on efficacy and suitability – the average cost is around $5 USD per person per year. Other AEDs, such as phenytoin, carbamazepine and valproate, are two or three times more expensive and only those PWE with resources can afford the more expensive newer AEDs

(Radhakrishnan, 2009).

In a recent African child neurology association workshop in Uganda it was noted that, out of the 34 African countries represented, 11 had no access to second line AED's (Wilmshurst *et al.*, 2013). All AEDs are priced in US dollars and when translating the costs, the first line AEDs in RPCs are more expensive than they are in higher income countries (Radhakrishnan, 2009). Around 45 % of people in sub-Saharan Africa live on less than 1 dollar a day and have to bear the cost of their own treatment, thus making epilepsy care extremely challenging (Aarli, Diop & Lochmuller, 2007; Radhakrishnan, 2009).

Journal publications on the aspects of epilepsy in Africa are scarce. From 1995-2005 the number of epilepsy related articles published increased from 3 to 7, with South Africa, Egypt, Ethiopia and Nigeria being the major contributors. Articles are rejected by high impact journals in neurology and neurosciences owing to methodological inadequacies, which in turn are due to infrastructural deficiencies in many African countries (Owolabi, Bower & Ogunniyi, 2007).

In the context of an inefficient and unevenly distributed healthcare system, there is lack of nurses and hospital beds for neurologic disorders in sub-Saharan Africa. Neurologic services (EEG, EMG, neuro-radiology and stroke units), as mentioned previously, are rare or non-existent in some Sub-Saharan African countries, all of which resources are required for advanced epilepsy care in the developing world (Radhakrishnan, 2009).

It is and will continue to be the responsibility of the local neurologists to identify the needs to be met in epilepsy care and some of the infrastructural challenges to meeting these which face sub-Saharan Africa are, for example, equipment for diagnosis, treatment and research. The latter would provide the world with clearer and more comprehensive insight into neurological diseases affecting sub-Saharan Africa. The use of EEGs could assist epidemiology studies with reclassification of seizure types and treatment.

2.6 Lack of training staff

Sub-Saharan Africa has the lowest ratio of neurologists per 100 000 of the population worldwide, and the few neurologists that these countries have are based in cities. The majority of the population in sub-Saharan Africa live in rural areas and have limited or no access to neurologists (Owolabi, Bower & Ogunniyi, 2007).

The diagnosis of epilepsy is fundamentally a clinical judgement made on the basis of a clinical history. The accuracy of the diagnosis depends on the skill and experience of the physician and the quality and reliability of the information provided by the witness or family member (Radhakrishnan, 2009). However, with the shortage of neurologists in sub-Saharan Africa (Figure 2.3), most people with epilepsy are diagnosed and treated by physicians who have no specific training or expertise in epilepsy management (Radhakrishnan, 2009). This occurs in many countries in sub-Saharan Africa where PWE are cared for by psychiatrists and where epilepsy is perceived as a mental rather than a neurological disease. The number of psychiatrists practising in sub-Saharan Africa is far greater than the number of paediatricians or neurologists and/or especially paediatric neurologists. Although, having their epilepsy managed by psychiatrists has is benefits due to the comorbidities associated with epilepsy, PWE have to carry the added stigma of attending psychiatric clinics. Psychiatrists in these countries in particular are also not trained in the most current interventions for epilepsy.

The majority of PWE in most sub-Saharan African countries first seek the advice of traditional healers before attending medical services. In sub-Saharan Africa traditional healers outnumber health care workers and payments of fees can be made in alternative ways: in kind, which usually takes the form of livestock, or part livestock and part cash. A traditional healer can spend many hours with his or her patients giving emotional support, whereas medical doctors have limited time per patient. However, attempts have been made to work with traditional healers in a few countries and the results have been positive (Wilmshurst *et al.*, 2013).

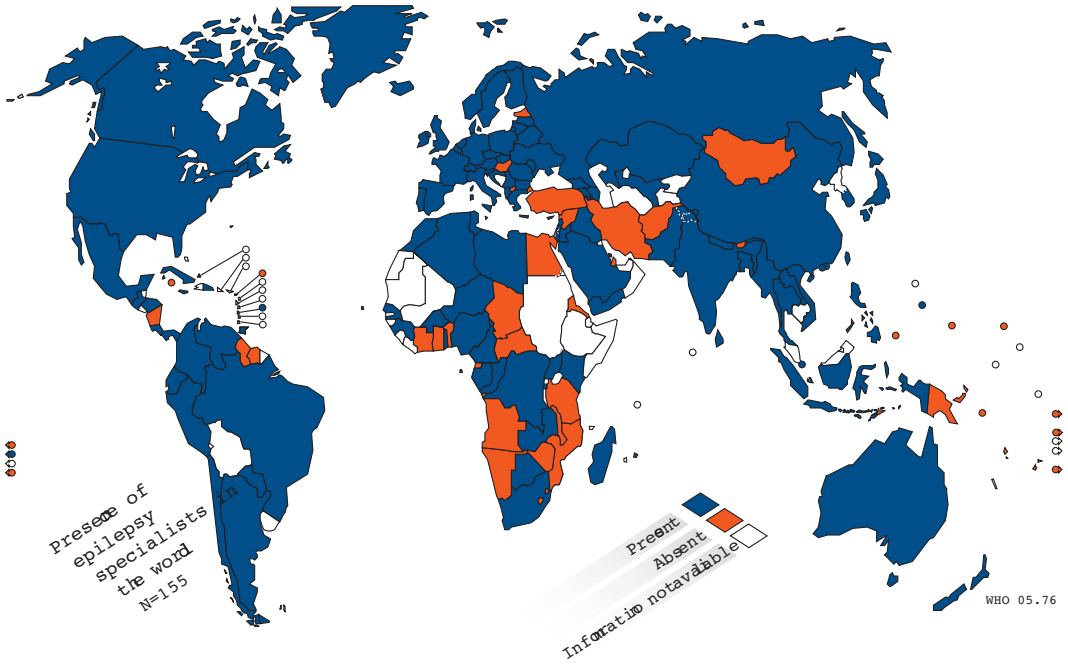

Figure 2.3: Map showing the presence of epilepsy specialists in the world, adapted from the Atlas of Epilepsy Care in the World 2005 (World Health Organization, 2005)

The Atlas of Epilepsy Care, which was published in 2005 jointly by the WHO, the ILAE and the IBE, shows that only 2.6% of the countries in Africa have facilities to train epileptologists as shown in Figure 2.4. A further survey conducted by the WFN in 2006 showed only 4 African countries were represented as having these facilities, with only 26 neurology registrars documented (Owolabi, Bower & Ogunniyi, 2007). These facts are confirmed and reinforced in Figure 2.5: whilst only 2.1% of the low income countries in the world have training programmes in epileptology, the majority of the training offered is in the higher middle and high income countries. This figure may have increased marginally; for example, there is adequate paediatric training available in South Africa (Wilmshurst *et al.*, 2011). In 2007, there were four centres in South Africa training adult neurologists, one in Durban (from Libya), one in Stellenbosch, one in Cape Town (from Mozambique) and one in Johannesburg (Aarli, Diop & Lochmuller, 2007).

The problem most of the neurology registrars in Africa face is inadequate access to the Internet and to neurology literature as well as insufficient

training in all neurosciences. Foreign training is expensive and occurs as a result of limited local training programmes, and when these neurologists return to their homeland, it is questionable whether their training is suitable to local pathology, equipment, high costs and circumstances. Often new specialists stay in the overseas countries where they qualify, and become part of the “brain drain” phenomenon (Aarli, Diop & Lochmuller, 2007).

In 2005 there was no training in South – East Asia listed but this has since changed with training now available in India and Kuala Lumpur (Prof CT Tan, Personal Communication 2012, December 29). Training programmes are rarest in Africa, in the regions where they are most needed owing to the overwhelming burden of neurological diseases in most African countries.

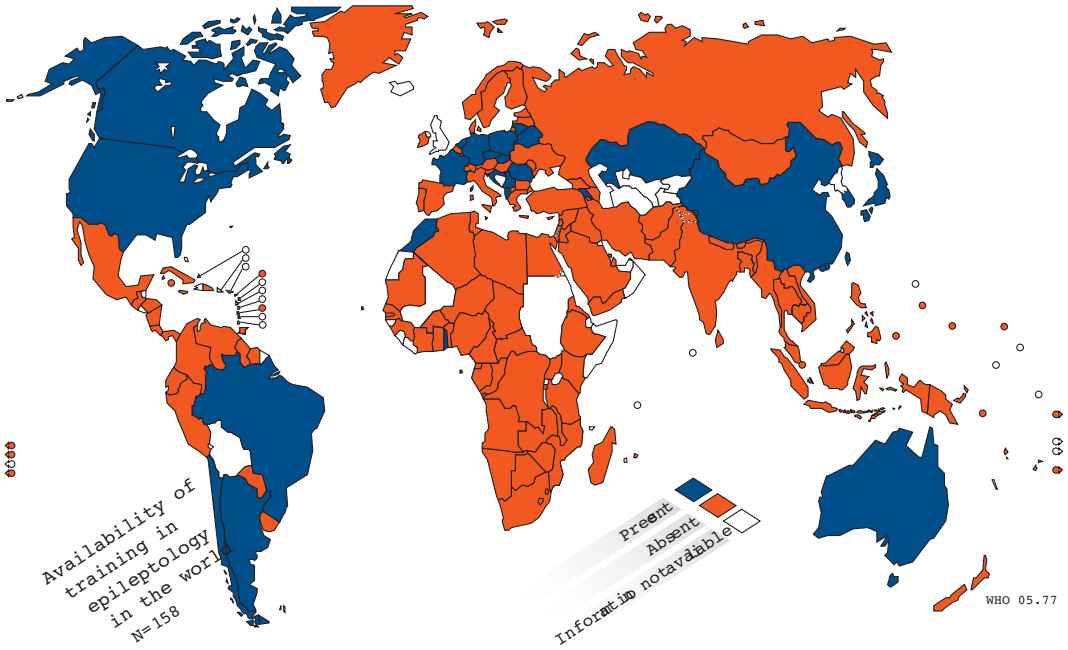

Figure 2.4: Training in epileptology in the world adapted from the Atlas of Epilepsy Care in the World 2005 (World Health Organization, 2005)

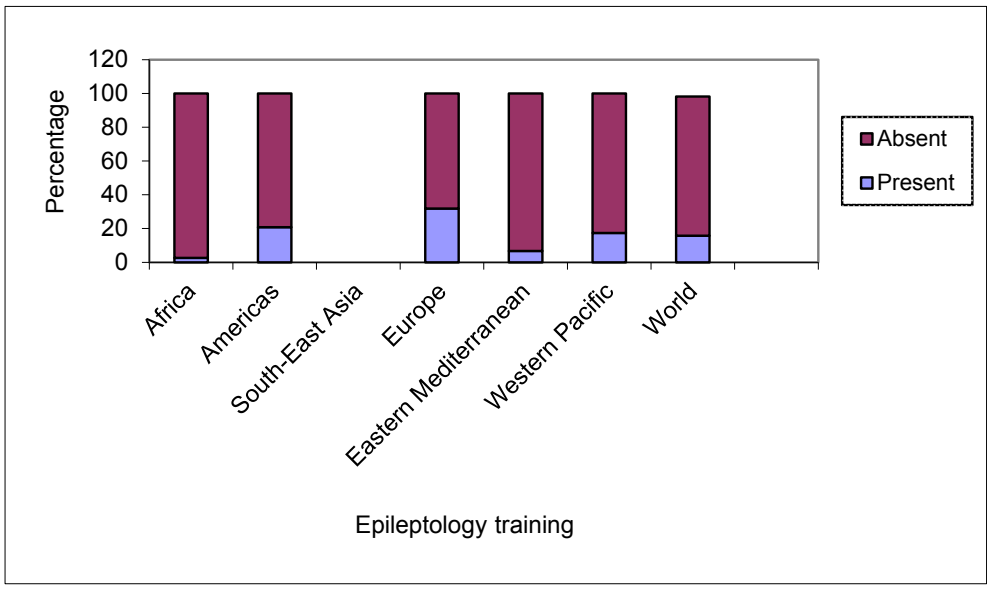

Figure 2.5: Present training in epileptology in WHO regions and the world (n=158). Adapted from the Atlas of Epilepsy Care in the World 2005 (World Health Organization, 2005)

2.7 Red Cross War Memorial Hospital

The Red Cross War Memorial Children's Hospital in Cape Town is the largest children's hospital in sub-Saharan Africa with over 300 dedicated paediatric beds. The neurology and neurophysiology departments assess over 1600 patients with epilepsy and perform over 1000 EEG studies per annum respectively. The neurophysiology department at the hospital is the only government centre dedicated to children and has the capacity to perform video EEG and intracranial monitoring on children as part of their assessment for epilepsy surgery. Since 2000 the department has formally trained seven paediatricians from the sub-Saharan countries (five from South African, one from Kenya and one from Saudi Arabia) in paediatric neurology, as well as trainees from Uganda and Nigeria who were exposed to EEG skills over 6-8 week periods.

In future months and years the department will be seeing an increase in the intake of trainees for neurology. A further trainee will complete formal paediatric neurology training in 2013, a further three trainees

from Nigeria, Ghana and Tanzania will commence full training over 2014/2015, and in addition, the department is receiving increasing numbers of requests for shorter “training/exposure” to neurophysiology concepts from diverse African countries (Wilmshurst *et al.*, 2011). Thus, it can be argued, particularly in relation to this study, that there is a need for a more formalised structured training template to meet these needs (Wilmshurst *et al.*, 2011).

2.8 Conclusion

The literature reviewed in this chapter of studies and surveys done in RPCs and in sub-Saharan countries concerning access to and availability of resources for diagnosing and treating epilepsy, paediatric epilepsy in particular, as well as the shortage of qualified child neurologists, points to the need for more training in neurophysiology in these countries. Therefore, in terms of this study, it can be argued that there is an urgent need for more a formalised structured training template to meet this need.

Chapter 3 will outline the research undertaken that would lead to fulfilling the need for basic understanding and interpretation of EEG amongst clinicians who care for children in sub-Saharan Africa and RPCs.

Chapter Three: Methodology

3.1 Introduction

This chapter describes the research design, process and methodology used for the validation of a guide in the form of a handbook for the use and interpretation of EEG on basic paediatric electroencephalogram techniques and interpretation by trainee and qualified clinicians, leading to the fulfilment of an existing need for basic understanding and interpretation of EEG amongst those clinicians who care for children in sub-Saharan Africa and in RPCs.

3.2 Study setting

The study was undertaken at the neurophysiology department of the Red Cross War Memorial Children's Hospital. This is a tertiary teaching hospital affiliated to the University of Cape Town, in South Africa. The hospital is the largest paediatric hospital and training centre in sub-Saharan Africa and the dedicated paediatric neurophysiology department with qualified and experienced staff is also the largest in the region. The service performs over 1000 EEGs a year.

3.3 Research Design

A quantitative research approach and design was used for this study. This approach allowed the researcher to increase and validate her professional knowledge of training in EEG interpretation and to quantify and compare the scores of participants using the handbook as well as their evaluative responses to its content and practical use.

A descriptive, exploratory design was selected to do a comprehensive investigation into, and validation of, the handbook as an educative and diagnostic tool for clinicians in RPCs since it is important, if the findings are to be of use and value to those working in under-resourced areas as

described in Chapters 1 and 2.

The first and developmental phase of the research was the literature review whose purpose, as outlined in Chapter 2, was an exploration of the available literature on the state of resources for, and training in, the use of EEG in sub-Saharan Africa and RPCs as part of a comprehensive investigation into the need for the development and validation of a handbook for the education and use of clinicians in those countries.

The quantification phases of the study included a recruitment of participants who constituted the sample of the population, a pilot study, and collection of data from comparative assessments of participant's use of the handbook and from questionnaires completed by participants (See Figure 3.1).

A pilot study on the content of the handbook was conducted with seven of the participants in the sample from 2008-2011 to determine the validity and reliability of the handbook in terms of its practical efficacy. This in turn would enhance the accuracy and validity of the findings of the study. Three of these participants also took part in the main study.

The handbook was adjusted in terms of content and language level/use according to the outcomes and recommendations of the pilot study group. The handbook consists of six chapters (see Addendum 1):

Chapter 1:
This chapter covers the measurements of the international 10/20 system, used to mark the positions for electrode placements.

Chapter 2:
Chapter two covers the different types of montages/derivation that can be used in EEG and how the EEG machine works with all its filter settings, and lastly polarities showing how the electrical potentials in the brain work.

Chapter 3:
Chapter three concentrates on the various artefacts (physiological/non-physiological) seen in an EEG recording.

Chapter 4:
Chapter four covers normal waveforms from neonatal to adolescence both during the awake and asleep states. It also covers normal variants found in children.

Chapter 5:
This chapter covers activation procedures (hyperventilation and intermittent photic stimulation) and sleep. Epileptiform and non-epileptiform activity is also discussed in this chapter.

Chapter 6:
This last chapter closes with guidelines on how to report an EEG, and examples of reporting, an EEG glossary for reporting, common epileptogenic disorders, and finally a table showing clinical presentations with recommendations.

The intention of the handbook was for the reader/trainee to use it to develop basic skills which would equip him or her in the interpretation of EEGs.

A prospective study was performed with 13 participants to validate the paediatric handbook on their ability to interpret EEGs following a training programme which had made use of the handbook.

3.4 Research process

Figure 3.1 represents an overview of the stages of the research.

Figure 3.1: Flow chart summarizing the phases of the study

3.5 Population and sampling

Letters of invitation were sent by the principal investigator (PI) to 15 prospective participants who would constitute the sample of the population. The participants were either affiliated to the neurophysiology department, were interested in neurology, and/or, through the African Child Neurology Association, were aware of the department's capacity and had requested training support in paediatric epileptology. Thirteen participants agreed to participate in the study, the group consisting of seven local and six international (from other African countries) inclusive of three (one local and two international) participants who were previously tested during the piloting of the handbook, and who were keen to have their training formalised.

Two new participants (two international) would have one-on-one training as they would be present in the department during the post-test period (February-March 2012). It was intended that one-on-one training would have taken place for five participants in total by the end of the study. The remaining eight participants had had no formal training in epileptology apart from knowledge acquired from the handbook. Although convenience sampling took place in terms of recruiting local participants, a proportion of international participants agreed to participate in the study according to the inclusion criteria. These participants were at the time of the study residing in various sub-Saharan countries and did not participate in the study in loco at the Red Cross Hospital, but agreed to do so using the handbook in their respective workplaces. The researcher specifically included sub-Saharan participants in the sample as the handbook was specifically intended for clinicians in RPCs. They were offered the opportunity to communicate with the researcher at any stage during the process of using the handbook (see chapter 5 – Limitations of Study).

3.5.1 The number of participants

Thirteen participants analysed a total of 40 EEGs each (20 structured and 20 prospective) of patients referred to the Red Cross War Memorial Hospital neurophysiology unit.

3.5.2 Inclusion and exclusion criteria for participation in the study

3.5.2.1 Inclusion criteria

- All participants who had completed pre-and post-test EEGs. For the current study all the participants were medical practitioners who were interested in EEG interpretation and reporting to improve their practice. It is envisaged that in the future and depending on, and informed by, the findings of this study, the program could be expanded to include other health care workers.

3.5.2.2 Exclusion criteria

- Participants who failed to complete the study screens i.e. reporting the preand post-test EEGs and reading the handbook.
- Paediatric neurologists and/or neurophysiologists with established formal training in epileptology from other institutions.
- Participants who have undertaken online EEG courses before or during the period in which the study was performed.

3.6 Special investigations

The following investigations took place in the study.

3.6.1 EEG exposure

To determine the level of the participants' EEG interpretation skills, as well as the collection of quantitative data on the subjects' experiences of using the handbook, a list of 10 EEGs, to be interpreted pre exposure to the handbook, and a further 10 EEGs, to be interpreted post handbook exposure, were selected on the basis of their

representation of the key common epilepsy diagnoses which should not be missed on an EEG. Thus this was a very focused and selected group of studies and referred to as the **"structured EEGs"**. In order to balance the realities of day to day practice, a further 10 pre, and 10 post, exposure to the handbook, EEGs, were used to further determine the efficacy of the handbook. These were collected from the first 20 patients referred to the neurophysiology unit from a set date, regardless of the diagnoses. The aim of this set of studies was to assess each participant's ability to correctly analyse those EEGs which would reflect the realities of day to day practice. These were referred to as the **"prospective EEGs"**. Each EEG consisted of 10 consecutive pages (200 seconds of data) as the participants did not consistently have access to software from Nihon Khoden to read digital EEGs. The participants were supplied with the following patient information prior to reporting the EEGs: the age and mental (cognitive) state of the child. The EEGs were recorded in the bi-polar montage using the 10/20 system (Figure 3.2/Table 2) (Niedermeyer & Lopes da Silva, 2005). The recordings were performed during the awake, natural sleep or sedated state of the child. Electroencephalogram reporting was done by the PI and independently reviewed by the supervisor. Each participant was given a copy of the handbook to read once all pre-test results were collated. Basic knowledge for learning and interpreting EEGs was included in the handbook and accessible to each participant.

3.6.2 Bi-polar montage

All EEGs were recorded by the PI using the standard bi-polar montage for either 20 minutes (an awake study) or 30 minutes (a sleep study). A derivation occurs when a particular pair of electrodes is connected to a single amplifier (the potential difference between two electrodes) in an EEG; this will produce a single line tracing. A montage is a particular arrangement using a number of different derivations simultaneously. The bi-polar montage represented in Figure 3.2/Table 2 is a longitudinal or anterior to posterior direction covering both parietal and temporal regions respectively (also known as the "double banana") (Niedermeyer & Lopes da Silva, 2005).

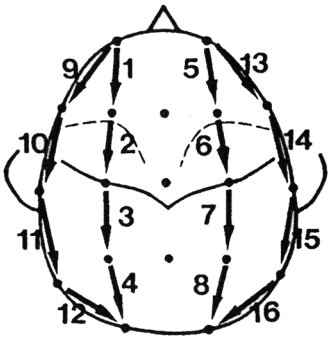

Figure 3.2: International (10-20) Electrode Placement for bi-polar EEG recording adapted from Niedermeyer & Lopes da Silva, 2005 to comply with South African practice right over left.

Table 2: Bi-polar Montage - adapted from Niedermeyer 2005 (Niedermeyer & Lopes da Silva, 2005)

Bi-polar montage
Fp2-F4
F4-C4
C4-P4
P4-O2
Fp1-F3
F3-C3
C3-P3
P3-O1
Fp2-F8
F8-T4
T4-T6
T6-O2
Fp1-F7
F7-T3
T3-T5
T5-O1

3.6.3 Data collection

3.6.3.1 Pro-formas

Five pro-formas were used for collating the data pre-and post-test (Appendix 2A, 2B, 3A, 3B & 4). The EEGs were reported according to the criteria and specifications of the National Institute of Clinical Excellence (NICE) (National Institute for Health and Clinical Excellence, 2011). The structured and prospective EEGs were reported by the PI and were independently reviewed by Professor Wilmshurst (Head of the Neurophysiology Laboratory, Red Cross Children's Hospital).

3.6.3.2 Pre-test EEG findings

Each participant reviewed the twenty EEGs (10 structured and 10 prospective) independently of the other participants. The structured EEGs were chosen by the PI and consisted of a range of normal and abnormal EEGs across the age spectrum, and the prospective EEGs were collated from 1 December 2011. There were seven local and six international (African) participants who comprised of two newly qualified neurologists (one from Kenya), one training neurologist, seven paediatricians (four from Nigeria and one from Rwanda), one training paediatrician and two medical officers. Participants were requested not to access additional information via the Internet or from text books. Those participants who were in contact with each other were asked not to discuss EEGs.

Participants were asked to interpret the EEG by ticking a box indicating whether the EEG was "normal", "abnormal" or "don't know". Participants were also given the age and mental (cognitive) state of the patients. In addition they were asked to report each EEG by analysing the background for normal/abnormal waveforms, any response to hyperventilation and photic stimulation, and for epileptiform activity i.e. disruption in background activity, interictal discharges, and electrical seizures. A final conclusion on the EEG completed the reporting (Addendum 2A and 2B). Two sets of data were collated at the end of this process, one for correct EEG

interpretation and the other for correct reporting. The scoring of the reporting was based on 5 key items of information identifiable on each EEG according to current practice in our unit (Table 3). Therefore scores per EEG report ranged from a minimum of zero to a maximum of five, depending on the number of items relevant to each EEG. Of the 40 EEGs examined, a total of 76 items could be reported pre-and post-test. The marks for the pre-test consisted of a total of 37 for structured, and 39 for prospective. Once the participants had performed the analysis, the findings were compared and then correlated with the original technologist report. The findings of the pre-test were withheld until completion of the post-test examples. Participants were their own internal control in reporting the EEGs. Analysing the EEG studies independently and then comparing the results allowed confirmation of consistency in the findings.

Table 3: Table used for scoring

1.Waveforms	Delta/theta/alpha/beta/sleep spindles/V waves/normal variants
2. Artefacts	Physiological/non-physiological
3. Abnormalities	Epileptic activity/encephalopathy
4. Hyperventilation/Intermittent Photic Stimulation	Activation of abnormalities/normal phenomena
5. Conclusion	Final outcome of EEG based on the above findings

Correct answer =1 mark; Wrong answer = 0 mark for each of the points in the table where relevant to the EEG

3.6.3.3 Post-test EEG findings after participants' reading of the handbook

Participants were each given the handbook and were allotted a month to read the text. The participants were allowed to use the handbook when conducting their post-test interpretations. All participants reviewed a further 10 structured and 10 prospective EEGs (as explained above - Addendum 3A and 3B). Electroencephalogram information and analyses would be the same as in the pre-test. Maximum marks obtainable for the post-test were 76, of which 39 were allocated for the structured, and 37 for

the prospective tests respectively. Once the participants had performed the analysis, the post-test findings would be collated.

3.7 Data collection instrument for evaluating the handbook

A survey in the form of a structured questionnaire (Addendum 4) designed to elicit participants' beliefs and opinions of the quality, accessibility and usefulness of the handbook was conducted with the participants. The questions were designed to quantify and compare the responses of specific groups of participants. The aspects of the handbook requiring evaluation included: 1) content, 2) language, 3) examples represented, 4) effectiveness, 5) teaching, and 6) improvement of the participant's practice from using the handbook. The questionnaire used the Likert 4 point rating scale from one (strongly disagree) to four (strongly agree) to evaluate the degree of agreement or approval of participants in terms of evaluating the handbook as seen in Figure 3.3.

Strongly Disagree	Disagree	Agree	Strongly Agree
1	2	3	4

Figure 3.3: 4 point scale used to evaluate the handbook

3.8 Analysis of results

After comparison between the pre-and post-test results the following data were analysed:

1. Correct EEG interpretation before and after reading the handbook.
2. Assessment of the effectiveness of one-on-one training exposure with the PI compared to the absence of one-on-one interaction i.e. using the handbook unmediated and in isolation.
3. Assessment of the accuracy of reports pre-and post-test by scoring each EEG.

4. Assessment of the accuracy of reports in a process of comparing trained and not-trained groups i.e. with or without one-on-one training.
5. Assessments of correct interpretation of EEGs compared to correct conclusions.
6. Assessment of the handbook in the introduction of basic skills in EEG.

3.9 Statistical analysis

3.9.1 Analysis of the EEG interpretation scores

A non-parametric Wilcoxon sign ranked test was used for analysis of the EEG interpretation due to the fact that the data were not 'normally distributed'. Independent means test using Levine's test for equality of the variances was performed for the analysis of the accuracy of reporting. The equality of variances is a statistical test to determine if there is a significant difference in the variance (standard deviation around the mean) between the two items being compared by the t-test. The t-test result differs slightly, depending on whether or not the variances are equal as determined by the Levene's test. A Levene's with $p<0.05$ indicates that the equality of variances is not assumed; a p-value of >0.05 indicates that the equality of variances is assumed.

3.9.2 Analysis of the evaluative questionnaire

Survey question results, including a comparison of responses between trained and not-trained participants were analysed using Pearson's Chi-squared test. All statistical analyses were performed using SPSS 20. The decimal point was rounded up to attain the calculated percentages.

3.10 Ethical clearance

The study protocol was approved by the Red Cross Children's Hospital Research Committee and the University of Cape Town Ethics Committee REC/REF 494/2011 (Addendum 5).

3.10.1 Consent

The process of obtaining consent from the participants in the study included e-mail correspondence for the international participants and face-to-face meetings with the local participants prior to the commencement of the study, during which the nature and purpose of the study were explained to them and consent forms distributed. The completed forms were collected and filed.

3.11 Conclusion

This chapter described in detail the research design and methodology used in this study, and the reasons for the quantitative research design used. The processes involved in choosing the setting and the sample for the participant group were described, as well as the data collection instruments and the methods of data analysis.

Chapter 4 presents detailed descriptions of the statistical analysis of efficacy in correct EEG interpretation of the pre-test groups after reading and using the handbook (trained and not-trained) compared to those post-test after one-on-one training (trained) and the not-trained after reading the handbook, as well as an analysis of the results of the survey which measured participants' beliefs and views on the usefulness of the handbook. This includes a comparison of responses between trained and not-trained participants.

Chapter Four: Results

4.1 Introduction

As described in Chapter 3, thirteen participants were approached to participate in this study. Two potential participants (one local and one international) were excluded from the sample for not completing the second phase of EEGs (Figure 4.1); the results of the remaining 11 participants were analysed. Each of the participants had had either no training or partial exposure to EEG interpretation. The group consisted of two medical officers, one training paediatrician, six qualified and experienced paediatricians, and two newly qualified neurologists. An analysis was done of the correct EEG interpretations. The analysis included a comparison of the results of those participants who had received one-on-one training with exposure to the handbook, and those with exposure to the handbook without one-on-one training and in isolation, as well as the accuracy of reporting pre-and post-test. In addition an evaluative survey of the 11 participants was conducted in order to gauge their perceptions and views of the usefulness of the handbook.

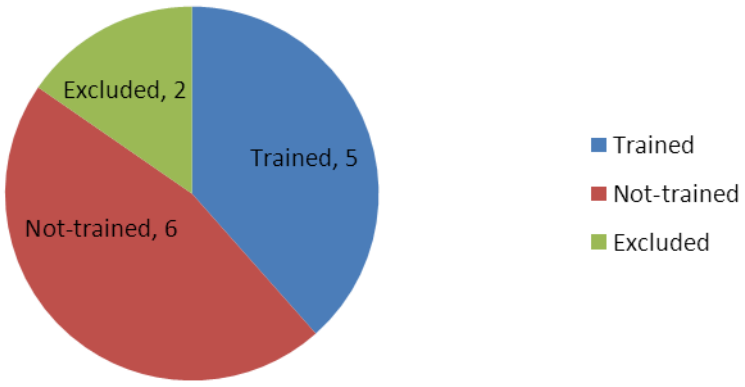

Figure 4.1: Pie chart summarising the sample of participants

4.1.1 Analysis of pre-versus post-test correct EEG interpretation

The statistical analyses of efficacy in correct EEG interpretation of the pre-test groups (trained and not-trained) was compared with that of the post-test groups after one-on-one training (trained) and those not-trained after reading the handbook are presented in Table 4.1 and Figures 4.2 and 4.3. The median pre-test percentage was 50%, with interquartile ranges 40% to 70%. The pre-test had an outlier (one participant had no knowledge of EEG prior to this study) who scored zero percentage. The median post-test percentage is 70% with interquartile ranges 60% to 80%.

Table 4.1: Pre-versus post-test diagnostic analysis of correct EEG data interpretation

	Trained & not-trained	% Median (IQR)	Min-Max
EEG pre-test	11	50 (40-70)	0-90
EEG post-test	11	70 (60-80)	45-95

The p value of < 0.06 supported a strong trend between the medians of the pre-test and the medians of the post-test. Therefore, the participants demonstrated their understanding of the basic knowledge as a result of using the handbook by the numbers of their correct EEG interpretations post-test. All 11 participants confirmed that no additional reading was undertaken between the pre-and post-test period.

The box plot (Figure 4.2) and line diagram (Figure 4.3) showed that the outlier improved significantly in the post-test. The line diagram indicates that two out of the 11 participants declined in the post-test analyses. Two international participants (one Kenya; one Nigeria), who had previously undergone one-on-one training with the PI, had a decline in their post-test results by 25% and 15% respectively. Two participants had the same results pre-and post-test.

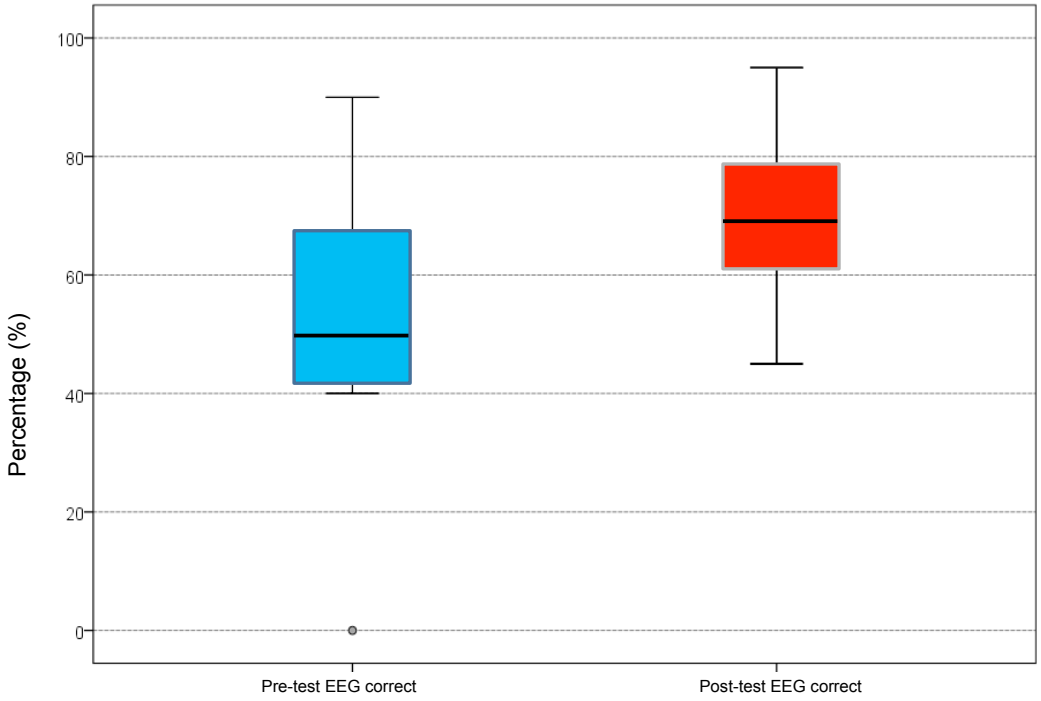

Figure 4.2: Box plot diagram - pre-versus post-test correct EEG interpretation

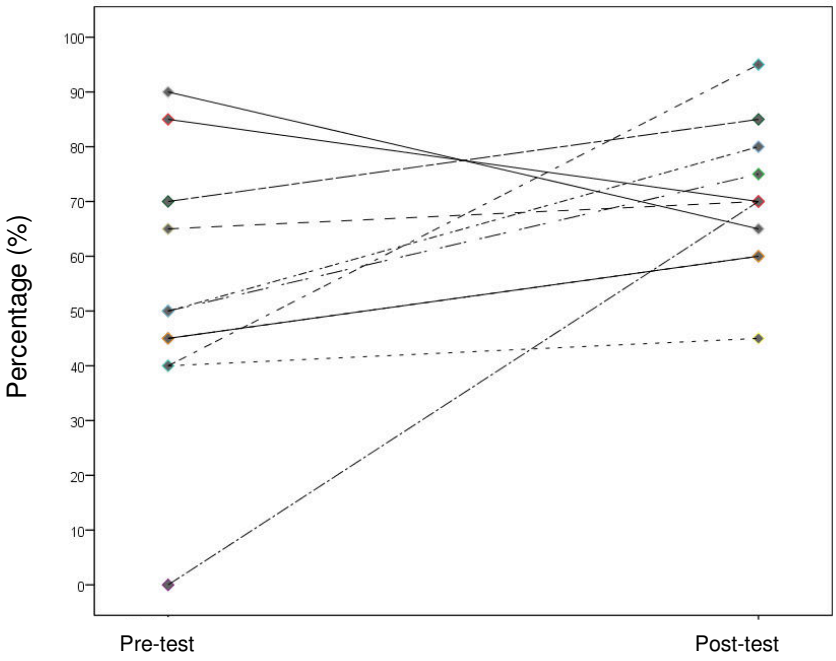

Figure 4.3: Line diagram depicting - pre-versus post-test correct EEG interpretation. Note 10 lines are visible as two participants have identical results and the lines overlap.

4.1.2 Analysis of one-on-one training

Five (45.5%) of the participants had one-on-one training with the PI during their time spent in the neurophysiology department. Two of the five underwent their training concurrently whilst going through the handbook during the post-test period. The remaining participants had previously received one-on-one training whilst attached to the paediatric neurology and neurophysiology department, their training during their long (two years Mphil attachment; n=2) or short (six week clinical attachment; n=1) stays in the department. A statistical analysis of the percentage pre-test correct EEG interpretation compared to the percentage of post-test correct EEG interpretation for one-on-one training data is presented in Figure 4.4.

During the pre-test period, the participants were divided into two groups, trained and not-trained, for the analysis of correct EEG interpretations. The trained participants (the group who either had already received one-on-one training during the pilot study (n=3) and or were about to have access to one-on-one training (n=2) varied between 0 to 90% with the interquartile range of 40-85%. The not-trained group (the group using the handbook in isolation without one-on-one training) showed a range from 40% with an outlier (n=1) at 65% and with interquartile range 45-50% Post-test, the minimum percentage with the trained participants increased in comparison to the pre-test from 0 - 65%, with a maximum of 95%, and with interquartile range 70-85%; this was as a result of one-on-one training with two of the international participants during the post-test period. However, two trained participants did decline post-test, as seen in Figure 4.3. The not-trained post-test minimum range increased from 40% to 45%, with interquartile range 60-75%. The outlier from the not-trained increased from 65% to 80% post-test.

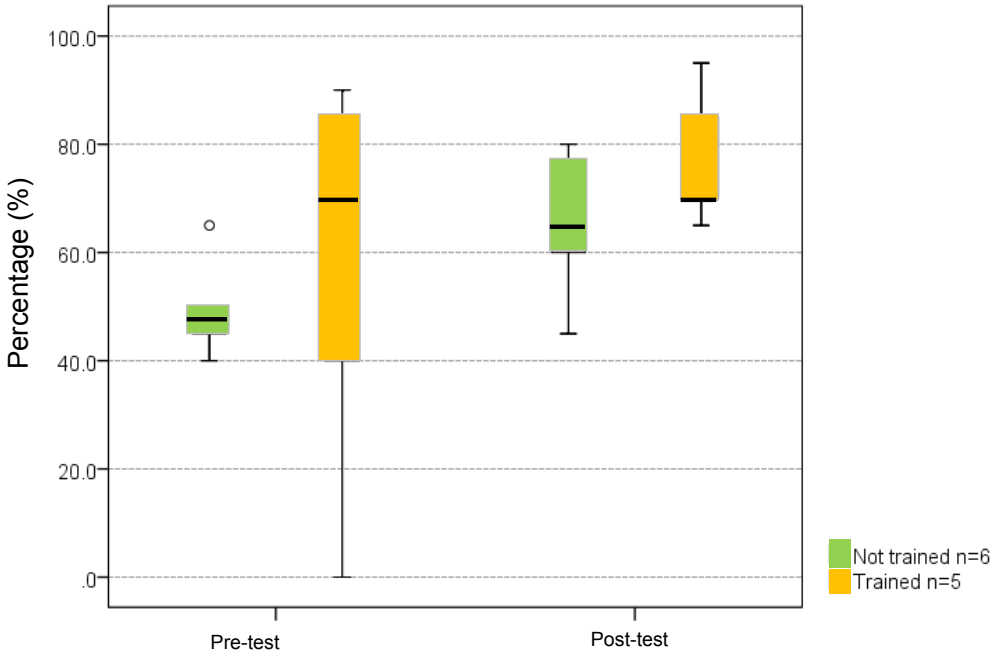

Figure 4.4: Box plot diagram depicting - pre-versus post-test correct EEG interpretation for one-on-one training

4.1.3 Analysis of accuracy of reporting

Descriptive analysis for accuracy of EEG reporting between the 11 participants is discussed under the following headings: 1) analysis of pre- versus post-test reporting, 2) analysis of reporting of trained versus not-trained, 3) analysis of correct conclusion on reporting versus correct EEG interpretation, and lastly 4) analysis of comparison between structured and prospective EEGs.

4.1.3.1. Analysis of pre-versus post-test reporting

The accuracy of reports on the EEGs was analysed, looking at the many variables (total scores, structured EEGs and prospective EEGs) of pre-and post-test scores and percentages as seen in Table 4.2. Overall, the mean value pre-test was 27.85% (min-max range: 0-78%) and showed an increase to 51.09% (min-max range: 26-88%) post-test of the 11 participants. EEG interpretation scores for the 11 participants are seen in Table 4.3.

Table 4.2: Pre-and post-test reporting scores and percentages for the participants (n=11).

Analyses	n	Minimum	Maximum	Mean	SD
Pre-test scores					
Total score (%)	11	0	59 (78)	21.18 (27.85)	21.82 (28.71)
Structured EEG score (%)	11	0	27 (73)	11.45 (30.95)	9.95 (26.90)
Prospective EEG score (%)	11	0	32 (82)	9.73 (24.95)	12.18 (31.24)
Post-test scores					
Total score (%)	11	20 (26)	67 (88)	38.82 (51.09)	17.23 (22.68)
Structured EEG score (%)	11	11 (28)	35 (90)	21.09 (54.08)	8.93 (22.89)
Prospective EEG score (%)	11	8 (22)	32 (87)	17.73 (47.91)	8.52 (23.06)

SD= standard deviation

Table 4.3: EEG interpretation scores and percentages for all participants' pre-and post-test

Analyses	n	Minimum	Maximum	Mean	SD
Pre-test scores					
Correct EEG (%)	11	0	18	10.55 (26.36)	4.95 (12.37)
Conclusion (%)	11	0	16	5.36 (35.23)	5.28 (6.75)
Post-test scores					
Correct EEG (%)	11	9	19	14.09 (13.40)	2.70 (13.19)
Conclusion (%)	11	0	19	9.36 (23.41)	5.45 (13.61)

SD= standard deviation

4.1.3.2. Analysis of reporting of trained versus not trained

Data from Table 4.2 and 4.3 were further divided into trained and not-trained for analysis as seen in Table 4.4. A comparison between trained versus not-trained showed the differences in scores: pre-test, trained=46.56%; not-trained=12.27% and post-test, trained=73.70%; not-trained=32.25% respectively. The trained group showed a 27.1% improvement whereas the not-trained group showed a 20% increase post-test. A t-test was performed looking at the mean difference between the trained and not-trained as seen in Table 4.4. There was no difference for the trained and not-trained in the pre-test reporting, with the t value =2.17 being nonsignificant ($p>0.09$). Post-test reported efficacy on all scores which were statistically significant with the exception of 'post-test correct'. This could be as a result of guessing the correct answer; however the reporting yielded a positive score ($p=0.01$) on 'correct conclusion'. Data was tested for equality of variance using Levene's test.

Table 4.4: EEG reporting- trained versus not-trained

Analyses	Group	n	Mean	SD	t-value	df	p-value
Pre-test							
Total score %	Trained	5	46.56	34.84	2.17	4.19	.09
	Not-trained	6	12.27	5.99			
Structured %	Trained	5	47.56	32.58	2.02	4.58	.11
	Not-trained	6	17.10	9.61			
Prospective %	Trained	5	45.64	37.76	2.23	4.12	.09
	Not-trained	6	7.72	5.13			
Correct EEG%	Trained	5	11.40	7.47	.46	4.36	.67
	Not-trained	6	9.83	1.72			
Conclusion %	Trained	5	8.20	6.87	1.65	4.45	.17
	Not-trained	6	3.00	1.79			
Post-test							
Total score %	Trained	5	73.70	9.49	**8.99**	**5.42**	**.00**
	Not-trained	6	32.25	4.39			
Structured %	Trained	5	76.42	9.48	**7.71**	**7.82**	**.00**
	Not-trained	6	35.47	7.83			
Prospective%	Trained	5	70.84	9.99	**8.73**	**5.29**	**.00**
	Not-trained	6	28.80	4.41			
Correct EEG%	Trained	5	15.40	2.51	3.37	8.80	.15
	Not-trained	6	13.00	2.53			
Conclusion%	Trained	5	13.60	3.72	**1.57**	**8.67**	**.01**
	Not-trained	6	5.83	3.92			

SD=standard deviation; Equal variances not assumed for all data; df=degrees of freedom

4.1.3.3. Analysis of correct conclusion on reporting versus correct EEG interpretation

Descriptive statistics for an analysis of correct conclusion on EEG reporting versus correct EEG interpretation of the 440 EEGs are presented in Table 4.5. The mean values of conclusions of EEG reporting for the 11 participants pre-test were 5.36 (13.4%) and post-test 9.36 (23.41%). Correct EEG interpretation pre-test was 10.55 (26.36%) and post-test 14.09 (35.23%). Participant's t- test results used to test for statistical significance between correct conclusions versus correct EEG interpretation are presented in Table 4.5. Data was tested for equality of variance with Levene's test. The t-test shows

that there is a statistically significant difference with $p<0.05$ in correct EEG interpretation compared to correct conclusion in reporting. Figure 4.5 shows a breakdown of correct EEG interpretation versus correct conclusion between the trained and not-trained group as seen in Table 4.4.

Table 4.5: EEG interpretation pre-and post-test

Analyses	Test	n	Mean	SD	t-value	df	p-value
Total no of EEGs interpreted (%)	Pre	11	21.18 (27.85)	21.82 (28.71)	-2.10	20	.05*
	Post	11	38.82 (51.09)	17.23 (22.68)			
Structured Totals (%)	Pre	11	11.45 (30.95)	9.95 (26.90)	-2.39	20	.03*
	Post	11	21.09 (54.08)	8.93 (22.89)			
Prospective Totals (%)	Pre	11	9.73 (24.95)	12.18 (31.24)	-1.79	20	.09
	Post	11	17.73 (47.91)	8.52 (23.06)			
No. correct EEG interpretation (%)	Pre	11	10.55 (26.36)	4.95 (12.37)	-2.09	20	.05*
	Post	11	14.09 (35.23)	2.70 (6.75)			
No. correct conclusions (%)	Pre	11	5.36 (13.40)	5.28 (13.19)	-1.75	20	.09
	Post	11	9.36 (23.41)	5.45 (13.61)			

All* are significant, $p<0.05$ for the t-test. The variance is equal for all scores

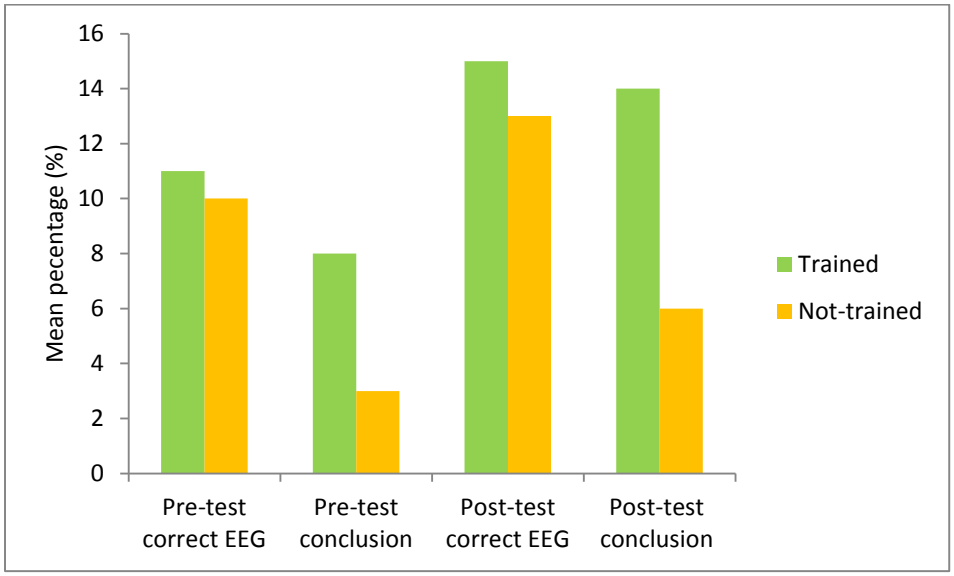

Figure 4.5: Graph on trained versus not-trained for correct EEG interpretation versus correct conclusion pre-and post-test

4.1.3.4 Structured versus prospective electroencephalograms

Descriptive statistics for analysis of reports of the 22 structured (EEGs collated by the PI of normal and abnormal EEGs across the age spectrum) versus the 22 prospective EEGs (collated from 1 December 2012 until the 20 prospective EEGs were performed) are presented in Table 4.6. Descriptive analysis using t- tests to test for statistical significance comparing structured and prospective EEGs for 22 participants (11 pre-and 11 post-test) in Table 4.7. The analysis shows that there is a mean difference of 6.08 points between structured and prospective (structured = better) and the difference is significant (p=0.004). The breakdown of how the interpretation of the structured EEGs fared compared to the prospective EEGs can be seen in Figure 4.6.

Table 4.6: Mean and standard deviations for one sample comparing structured and prospective EEGs for 22 participants (11 pre-and 11post-test)

One sample statistics	n	Mean	SD
Structured versus Prospective %	22	42.51-36.43	27.10-29.26

SD=standard deviation

Table 4.7: T-test comparing structured and prospective EEGs for 22 participants (11 pre-and 11 post-test)

Paired samples t-test	Mean	SD	95% Confidence interval	t-value	df	p-value
Structured versus Prospective %	6.08	8.91	2.13-10.03	3.2	21	0.004

SD= standard deviation: df= degrees of freedom

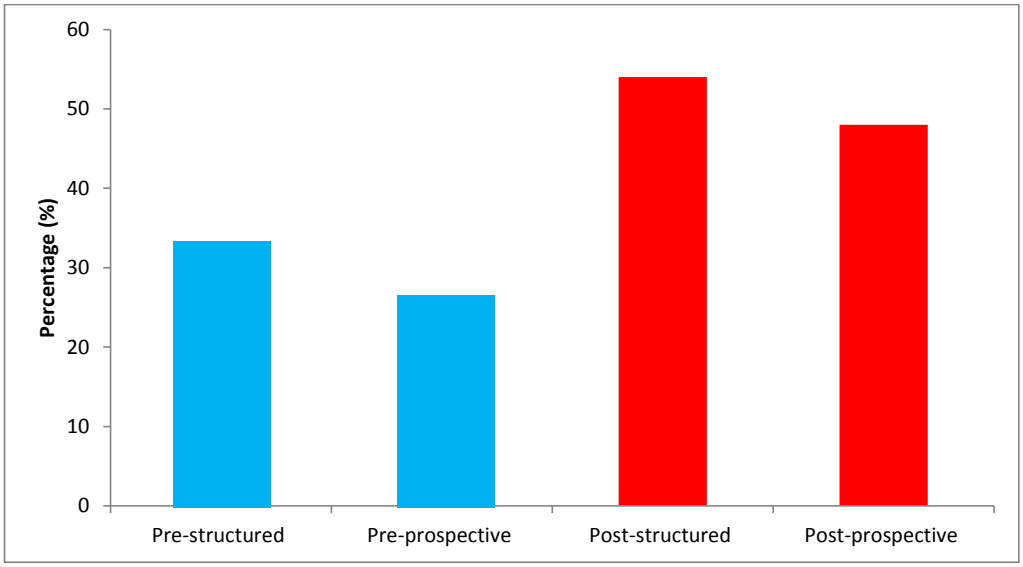

Figure 4.6: Graph on structured versus prospective EEGs- pre-and post-test

4.2 Analysis of evaluative survey and revision of handbook

The results of the survey which looked at participants' perceptions and views of the usefulness of the handbook are presented below. A comparison of the responses of trained and not-trained participants was analysed using Pearson Chi-Squared test and is presented in Table 4.8.

Overall, looking at the survey data, four out of the six questions had all participants ranging from agreeing to strongly agreeing. However, in two questions two participants did not answer the question as it was not relevant to their practice. The question on one-on-one teaching or e-learning had all participants agreeing that these would be more effective if done in conjunction with reading the handbook. Comments on the last question for those who had no prior knowledge were very positive regarding the basic information they received from the handbook. Some participants found the technical chapters confusing/ hard to understand. The question on the effectiveness of the handbook had the most number of two's (disagree) with the consensus being that a hands-on/practical approach in training would be useful in conjunction with the handbook.

Table 4.8: Survey responses: trained versus not-trained

Question No.	Chi Squared Value	df	p-value
Q1	.05	1	.82
Q2	1.39	2	.49
Q3*	5.24	2	.07
Q4	2.93	2	.23
Q6	.92	2	.63
Total score	4.95	7	.67

No stats are computed for Q5 because the groups were equal; * for Q3 the log likelihood ratio was significant at p=0.3; df= degrees of freedom

4.3 Conclusion

This chapter presented the results of the comparison between the EEG interpretation scores of participants with one-on-one training using the handbook and the scores of those who used the handbook without preliminary or training complementing the handbook, having simply read and assimilated the handbook before the post-testing. The results were also presented of an evaluative survey designed to elicit participants' perceptions and views of the contents and usefulness of the handbook (a brief description of the findings and preliminary analysis, to be discussed in detail in Chapter 5).

Chapter 5 presents a more detailed analysis of the findings from the testing of trained versus not-trained participants using the handbook and a discussion of both these and the participants' responses from the questionnaire.

Chapter Five: Discussion

There is a paucity of expertise amongst doctors and specialists in Africa who are skilled in electroencephalogram (EEG) interpretation (Wilmshurst *et al.*, 2011; Wilmshurst *et al.*, 2013). Medical schools in sub-Saharan Africa do not teach the basic principles of EEGs to their students (Wilmshurst *et al.*, 2011; Wilmshurst *et al.*, 2013). These issues were addressed in depth in the first 2 chapters (Benbadis, 2013). In order to address some of these challenges a handbook was devised focusing on teaching basic principles in paediatric EEG interpretation. This study aimed to validate this handbook. The training program which operates at the study site, a tertiary paediatric institute in South Africa, has provided access in terms of filling the training gap for many African doctors and paediatricians over the last five years and has identified considerable data about the deficiencies in EEG interpretation in the continent (Kander *et al.*, 2012). Great similarities have been identified relating to the challenges listed above to those found in other resource poor settings such as India (Radhakrishnan, 2009).

There are many books available on EEGs in the format of large volumes and full of technical terminology and descriptions which render them inaccessible to most practitioners in the epileptology field in RPCs. A number of training courses for epileptology, including online courses exist; however, many doctors from sub-Saharan Africa and RPCs cannot afford to attend these courses and/or do not have access to the Internet in rural areas (Dr Okunola Olusola Peter, Personal Communication 2013, May 14; www.aset.org (American Society of Electrodiagnostic Technologist). The handbook being trialled and evaluated in this study was produced with the aim of addressing this need for training in accurate and safe EEG interpretation. The content of the handbook will be used in the Red Cross War Memorial Hospital EEG training program as part of a one year diploma course affiliated to the University of Cape Town (active from 2015) and it is hoped that it will assist in promoting and developing paediatric EEG interpretive skills across sub-Saharan Africa and the African continent.

Pre-and post-test correct EEG interpretation data and analyses of accuracy of reports

The main findings of the study show that overall the handbook was efficacious in improving EEG interpretation on the part of participants in the study, with or without training, with the median range of correct scores increasing from 50% pre-test to 70% post-test. Post-test reporting also improved with an overall mean percentage increase of 23%. Although, the correct EEG interpretation did not produce the corresponding EEG conclusions, the change in interpretation before and after training with the handbook trended towards significance overall as seen in Table 4.4. However, the demonstrated effect of the handbook on improving EEG interpretation is limited by the small sample size. When comparing the scores of the trained versus the not-trained, those participants with one-on-one training fared significantly better in their interpretation scores, conclusion and reporting of EEG findings.

Based on the improvement of the post-test correct interpretation of EEGs, in this pilot series the handbook proved to be effective in assisting with accurate interpretation of paediatric EEGs, be they normal or abnormal. It is hoped that improved accuracy and competency in interpretation of EEGs as a result of the use of the handbook will in turn lead to the correct diagnosis and management of paediatric epilepsy and epilepsy syndromes by both trainees and professionals in the field of epileptology. In addition it is hoped that improving neurological outcomes in children would help to avoid, or will minimize, inappropriate therapy. As such the handbook aims to promote safe practice. However, there are no comparative articles to reference for this study.

One-on-one training

The results of this study showed that one-on-one training in and with the use of the handbook is an added advantage to ensuring more accurate interpretation of EEG. However, support with one-on-one

interaction should ideally be on-going in order to maintain and further develop interpretive skills. Internet links for group discussions where possible, weekly meetings and troubleshooting sessions would be valuable resources to enable this. It would be the recommendation of the investigators that this balance of one-on-once focused training with the hand-book and the on-going collaborations after training are part of the training program i.e. not the handbook in isolation.

Four of the participants who came from two of the African countries (one from Kenya and three from Nigeria) had previously received some EEG training at the Red Cross War Memorial Hospital. The impact of providing training to this number of practitioners involved in the care of children with epilepsy is already of significant potential impact in terms of increasing the service capacity in this field in Africa. The ripple effect of sending these doctors with significantly improved EEG skills ($p>0.06$) into different parts of Africa has the potential to change approaches to epilepsy in each region. A further four participants (one from Tanzania and three from Nigeria) would have had one-on-one training with the PI before submission of this thesis, thus increasing the numbers considerably. On-going contact and collaboration with these doctors confirms how they are promoting the recognition and the care delivery to children with epilepsy in their settings.

Analysis of survey

The responses to the survey conducted with the two groups for purposes of comparison showed no significant difference across all questions, and participants rated the majority of the questions as ‘agree’ and ‘strongly agree’, thus supporting the finding that all participants found the handbook useful whether they had received one-on-one training or not. The overall consensus of the participants was that one-on-one training, discussions or tutorials in addition, or complementary, to the handbook, would be beneficial.

The findings of the study can thus be said to have fulfilled the objective of the study in improving basic paediatric EEG training in sub-Saharan

African for clinicians, be it child neurologists in training, paediatricians, adult neurologists (whose work entails managing children in addition to adults), and for those medical officers who are the only health care providers available in a region to care for children with epilepsy.

Limitations of study

The results may have been understated due to: 1) some of the articipants' unsupervised use of the handbook and 2) time management issues. Although the entire study was conducted based on the assumption that the handbook was used in the manner in which it was intended to be used, this could not be closely monitored. The participants were required to work through the instructional materials within a one month time frame. The study did not stipulate a specific amount of time to be spent on the handbook and it was expected that each participant would determine the time that he or she needed in order to assimilate and master the information contained in the handbook. Such an expectation allowed the participants the flexibility to proceed through the handbook at their own learning rate. Unscheduled problems arose with the postal service in the sub-Saharan African countries, resulting in delays in the delivery of packages to the international participants. These two participants were allowed extra time to read and assimilate the handbook and thus it is unlikely that these differences in the length of the study impacted the results to any major extent. For future use of the handbook – key goals to be attained have been incorporated into the text and short assessment tools at the end of each section will be included.

Although not widespread, any participant's apparent lack of interpretation skill of an EEG calls into question the participants' level of comprehension of the written descriptors of the handbook. This apparent lack might also have been due to other factors, such as the relative ability or inability of participants to comprehend the technical aspects of EEGs. The technical aspects of EEG might have been a confounding issue to some of the participants who have no experience in technology i.e. sections on polarities and instrumentation, or

whose literacy level in English is relatively basic to it not being their home language or the official language of the region. Overall, the possibility exists that a lack of technical ability on the part of some participants might have had an influence on some of the correct EEG interpretations. The handbook is currently being edited by a renowned epileptologist and is due for publication in 2014. It is expected that he will suggest amendments and improvements to make the handbook more widely accessible, particularly to epileptologists and practitioners with a particular interest in the management of children with epilepsy in areas of sub-Saharan Africa.

Chapter Six: Conclusion

A handbook was developed as a learning tool to enable effective basic EEG interpretation by practitioners with little or no baseline knowledge. This study evaluated the use of this handbook in training sub-Saharan African practitioners in EEG interpretation. This is the first published handbook on paediatric EEG in South Africa and the overall results of this study suggest that such a handbook is and could be useful as a learning tool in the interpretation of paediatric EEG for individuals with access to one-on-one training as well as those without. It may also therefore complement all clinical attachments to the neurology unit at the Red Cross War Memorial Hospital and serve as a stepping stone for further EEG training such as that offered by online courses. The compact presentation of the handbook and the low cost implications relative to other training options such as online courses also make it an attractive and viable option in resource limited settings. In this context the handbook may assist in addressing the deficit in training of epileptology amongst doctors in sub-Saharan Africa, especially paediatricians. The handbook in conjunction with one-on-one training will form part of a diploma offered by the University of Cape Town on basic epilepsy interpretation for training neurologists and African health care workers.

Recommendations

In this study, the handbook was intended for the use of participants with zero or some knowledge of how to interpret paediatric EEGs and was designed to train them in the basics of EEG interpretation and to equip them with basic knowledge required for them to recognise waveforms. The handbook did not aim to make the paediatric electroencephalography reader an expert at a specialist level but was intended to enable her or him to more accurately and safely screen electroencephalograms for important key diagnostic markers which would alter the child's management. Although the results of the data collection and analysis showed improvements in EEG interpretation on the part of participants after

training with the handbook, the results also suggest some areas in which improvements can be made to both the handbook and the study, as well as to future studies. Training of this type is typically based on an apprenticeship concept – one trainer to a very small ratio of trainees.

Formalising the learning process through the dissemination of a handbook can be an excellent way of increasing the number of trainees who can be supported in a strategic way, particularly those in remote or resource-poor areas, and without their losing many of the benefits of a conventional or expensive training course in EEG interpretation. Measuring and evaluating the efficacy of the program makes it possible to "fine-tune" it in an on-going process of aiming for high quality outcomes in the field of EEG interpretation.

Based on the findings of the study, two different scenarios for future studies could be considered: 1) a longitudinal study investigating the benefits and effects of participants' possessing and using the handbook for longer periods of time in conjunction with one-on-one training and/or with e-learning, and 2) the study could be conducted with a larger and more representative cohort of subjects. Further research in terms of trialling and evaluating the handbook might improve, and/or continue to improve, its overall success as a learning tool, and in turn benefit paediatric epileptology in RPCs.

Thus the study, in showing measurable improvements in the EEG interpretation skills of the participants in the process of, and after, using the handbook would indicate that the handbook has the potential to benefit not only the participants in the study, but all sub-Saharan clinicians who do not have the resources to register for online epileptology courses. It is hoped that the handbook will in time put sub-Saharan Africa, South Africa in particular, on the global map in the area of epileptology training and will assist with the challenges and management of epilepsy in RPCs. It is intended that a process of continuous trialling of the handbook and of on-going reflection and feedback from users of the handbook on its contents and practical usefulness in the field will benefit not only those clinicians in remote and resource poor areas of sub-Saharan Africa, but also the Red Cross Children's Hospital (which, as was mentioned in Chapter 5,

will be using the handbook in EEG training program as part of a one year diploma course affiliated to the University of Cape Town from 2015) and the present researcher in the improvement of the handbook to ensure its optimal use and efficacy in those regions that need it most.

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Appendixes

Addendum 2a (structured selection)

Participant ……..

Please tick if the following 10 electroencephalograms are normal / abnormal or don't know. The age and mental state of the child will be given for each example. The examples are in the bi-polar montage using the 10/20 system.

Pre-training	**Normal**	**Abnormal**	**Don't know**
Patient 1. Age 11 yrs Mental state - awake Is this normal/abnormal activity/don't know in an 11 yr old? *Please explain your answer below?*			
Patient 2. Age 5 yrs Mental state - awake Is this normal/abnormal/don't know activity during hyperventilation? *Please explain your answer below?*			
Patient 3. Age 3 yrs Mental state - awake Is this normal/abnormal/don't know activity in a 3 yr old? *Please explain your answer below?*			
Patient 4. Age 10 yrs Mental state - awake Is this normal/abnormal/don't know activity during intermittent photic stimulation? *Please explain your answer below?*			
Patient 5. Age 6 yrs Mental state - awake Is this normal/abnormal/don't know activity in a 6 yr old? *Please explain your answer below?*			
Patient 6. Age 5 yrs Mental state - asleep Is this normal/abnormal/don't know activity in a 5 yr old? *Please explain your answer below?*			
Patient 7. Age 23 days Mental state – awake Is this normal/abnormal/don't know activity in a 23 day old? *Please explain your answer below?*			
Patient 8. Age 1 yrs Mental state – natural sleep Is this normal/abnormal/don't know activity in a 1 yr old? *Please explain your answer below?*			
Patient 9. Age 7 yrs Mental state – awake Is this normal/abnormal/don't know activity in a 7 yr old? *Please explain your answer below?*			
Patient 10. Age 5 months Mental state - awake Is this normal/abnormal/don't know activity in a 5 month old? *Please explain your answer below?*			

Briefly report EEG's (description & interpretation) for structured selection in 2a

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Patient 2

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Patient 3

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Patient 9

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Patient 10

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Addendum 2b (prospective selection)

Participant ……..

Please tick if the following 10 electroencephalograms are normal / abnormal or don't know. The age and mental state of the child will be given for each example when collected. The examples are in the bi-polar montage using the 10/20 system.

Pre-training	**Normal**	**Abnormal**	**Don't know**
Patient 11. Age 5 yrs Mental state-awake Is this normal/abnormal activity/don't know in a 5 yr old? *Please explain your answer below?*			
Patient 12. Age 11 yrs Mental state-awake/natural sleep Is this normal/abnormal/don't know in an 11yr old? *Please explain your answer below?*			
Patient 13. Age 9 yrs Mental state-awake/natural sleep Is this normal/abnormal/don't know in a 9 yr old? *Please explain your answer below?*			
Patient 14. Age 3 yrs Mental state-awake Is this normal/abnormal/don't know in a 3 yr old? *Please explain your answer below?*			
Patient 15. Age 1 month Mental state-natural sleep Is this normal/abnormal/don't know in a 1 month old? *Please explain your answer below?*			
Patient 16. Age 5 yrs Mental state-awake Is this normal/abnormal/don't know in a 5 yr old? *Please explain your answer below?*			
Patient 17. Age 6 yrs Mental state-awake Is this normal/abnormal/don't know in a 6 yr old? *Please explain your answer below?*			
Patient 18. Age 11 yrs Mental state-awake Is this normal/abnormal/don't know in an 11 yr old? *Please explain your answer below?*			
Patient 19. Age 11 yrs Mental state-awake/natural sleep Is this normal/abnormal/don't know in an 11 yr old? *Please explain your answer below?*			
Patient 20. Age 1 yr Mental state-awake/natural sleep Is this normal/abnormal/don't know in a 1 yr old? *Please explain your answer below?*			

Briefly report EEG's (description & interpretation) for prospective selection in 2b

Patient 11

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Patient 12

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Patient 19

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Patient 20

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Addendum 3a (structured selection)

Participant ……..

Please tick if the following 10 electroencephalograms are normal / abnormal or don't know. The age and mental state of the child will be given for each example when collected. The examples are in the bi-polar montage using the 10/20 system.

Post-training	**Normal**	**Abnormal**	**Don't know**
Patient 1. Age 10 yrs Mental state – natural sleep Is this normal/abnormal/don't know activity in a 10 yr old? Please explain your answer below?			
Patient 2. Age 2 yrs Mental state - awake Is this normal/abnormal/don't know activity in a 2 yr old? Please explain your answer below?			
Patient 3. Age 2 yrs Mental state – sedated sleep Is this normal/abnormal/don't know activity in a 2 yr old? Please explain your answer below?			
Patient 4. Age 7 yrs Mental state – dec loc Is this normal/abnormal/don't know activity in a 7 yr old? Please explain your answer below?			
Patient 5. Age 12 yrs Mental state - awake Is this normal/abnormal/don't know activity during intermittent photic stimulation? Please explain your answer below?			
Patient 6. Age 6 months Mental state - awake Is this normal/abnormal/don't know activity in a 6 month old? Please explain your answer below?			
Patient 7. Age 11 month Mental state – natural sleep Is this normal/abnormal/don't know activity in a 11 month old? Please explain your answer below?			
Patient 8. Age 11 yrs Mental state – natural sleep Is this normal/abnormal/don't know activity in a 11 yr old? Please explain your answer below?			
Patient 9. Age 4 yrs Mental state - awake Is this normal/abnormal/don't know activity in a 4 yr old? Please explain your answer below?			
Patient 10. Age 1 yrs Mental state - asleep Is this normal/abnormal/don't know activity in a 1 yr old? Please explain your answer below?			

Briefly report EEG's (description & interpretation) for structured selection in 3a

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Addendum 3b (prospective selection)

Participant ……..

Please tick if the following 10 electroencephalograms are normal / abnormal or don't know. The age and mental state of the child is given for each example. The examples are in the bi-polar montage using the 10/20 system.

Post-training	**Normal**	**Abnormal**	**Don't know**
Patient 11. Age 12 yrs Mental state-sedated/asleep Is this normal/abnormal activity/don't know in a 12 yr old? *Please explain your answer below?*			
Patient 12. Age 10 month Mental state-sedated/asleep Is this normal/abnormal/don't know in an 10 month old? *Please explain your answer below?*			
Patient 13. Age 7 yrs Mental state-natural sleep Is this normal/abnormal/don't know in a 7 yr old? *Please explain your answer below?*			
Patient 14. Age 5 month Mental state-natural sleep Is this normal/abnormal/don't know in a 5 month old? *Please explain your answer below?*			
Patient 15. Age 5 yrs Mental state-awake Is this normal/abnormal/don't know in a 5 yr old? *Please explain your answer below?*			
Patient 16. Age 2 yrs Mental state-sedated/asleep Is this normal/abnormal/don't know in a 2 yr old? *Please explain your answer below?*			
Patient 17. Age 1 yr Mental state-natural sleep Is this normal/abnormal/don't know in a 1 yr old? *Please explain your answer below?*			
Patient 18. Age 7 yrs Mental state-awake Is this normal/abnormal/don't know in an 7yr old? *Please explain your answer below?*			
Patient 19. Age 12 yrs Mental state-awake Is this normal/abnormal/don't know in an 12 yr old? *Please explain your answer below?*			
Patient 20. Age 4 month Mental state-natural sleep Is this normal/abnormal/don't know in a 4 month old? *Please explain your answer below?*			

Briefly report EEG's (description & interpretation) for prospective selection in 3b

Patient 11

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Patient 12

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Patient 20

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Addendum 4

Survey on the usefulness of the handbook

Participant……..

Please complete the following survey. We appreciate your help in further improving our handbook.

1. The sequencing of the chapters in this handbook makes easy learning

Strongly Disagree	Disagree	Agree	Strongly Agree
1	2	3	4

2. The language and terminology used in the handbook was easy to understand

Strongly Disagree	Disagree	Agree	Strongly Agree
1	2	3	4

If you disagree please give examples of words/phrases which were not easy to understand

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3. The examples covered in this handbook are a good representation of what can be seen in a resource poor country

Strongly Disagree	Disagree	Agree	Strongly Agree
1	2	3	4

If you felt that examples useful for your practice were missing, please describe these

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4. This handbook appears to be an effective way to teach electroencephalography

Strongly Disagree	Disagree	Agree	Strongly Agree

1 2 3 4

If you disagree please provide suggestions on how to improve it

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5. Do you think a different approach such as e-learning or 1 on 1 teaching would be more effective?

Disagree Agree

2 3

Please explain your answer choice

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6. Has the handbook changed or improved your practice?

Strongly Disagree Disagree Agree Strongly Agree

1 2 3 4

Please explain your answer choice

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For further comments:

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Addendum 5

UNIVERSITY OF CAPE TOWN

Faculty of Health Sciences
Faculty of Health Sciences Research Ethics Committee
Room E52-24 Groote Schuur Hospital Old Main Building
Observatory 7925
Telephone [021] 406 6338 • **Facsimile** [021] 406 6411
e-mail: sumayah.ariefdien@uct.ac.za

09 November 2011

HREC REF: 494/2011

Ms V Kander
c/o A/Prof J Wilmshurst
Neurophysiology
Red Cross War Memorial Children's Hospital

Dear Ms Kander

PROJECT TITLE: A PILOT STUDY TO VALIDATE THE DESIGN, DEVELOPMENT AND EFFECTIVENESS OF A PAEDIATRIC GUIDELINE ON BASIC ELECTROENCEPHALOGRAM INTERPRETATION FOR CLINICIANS.

Thank you for submitting your study to the Faculty of Health Sciences Human Research Ethics Committee for review.

It is a pleasure to inform you that the Ethics Committee has **formally approved** the above-mentioned study.

Approval is granted for one year till the 28 November 2012.

Please submit a progress form, using the standardised Annual Report Form (FHS016), if the study continues beyond the approval period. Please submit a Standard Closure form (FHS010)if the study is completed within the approval period.

Please address the following concern:
The consent form has (presumably) a grammatical error in the last line where it states " I consent for my name and the results to be stored confidentially and to be used as part of the published article". The participants should not be asked for their name to be used in the published article and this line should be re-written accordingly.

Please note that the ongoing ethical conduct of the study remains the responsibility of the principal investigator.

Please quote the REC. REF in all your correspondence.

sAriefdien

Yours sincerely

Wesley Blockman

PROFESSOR M BLOCKMAN
pp **CHAIRPERSON, HSF HUMAN ETHICS**

Federal Wide Assurance Number: FWA00001637.
Institutional Review Board (IRB) number: IRB00001938

This serves to confirm that the University of Cape Town Research Ethics Committee complies to the Ethics Standards for Clinical Research with a new drug in patients, based on the Medical Research Council (MRC-SA), Food and Drug Administration (FDA-USA), International Convention on Harmonisation Good Clinical Practice (ICH GCP) and Declaration of Helsinki guidelines.

The Research Ethics Committee granting this approval is in compliance with the ICH Harmonised Tripartite Guidelines E6: Note for Guidance on Good Clinical Practice (CPMP/ICH/135/95) and FDA Code Federal Regulation Part 50, 56 and 312.

sAriefdien

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Addendum 8

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October 21, 2013

Veena Kander
Senior Neurophysiologist
Red Cross War Memorial Hospital
Rondebosch
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