Ocular manifestations of cerebral palsy in children attending MNH cerebral palsy clinic

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OCULAR MANIFESTATIONS OF CEREBRAL PALSY INCHILDREN ATTENDING MNH CEREBRAL PALSY CLINIC

By

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A Dissertation Submitted in (Partial) Fulfillment of the Requirements for Degree of Master of Medicine(Ophthalmology) of MuhimbiliUniversity of Healthy and Allied Sciences

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CERTIFICATION

The undersigned certify that they have read and hereby recommend for acceptance by Muhimbili University of Health and Allied Science a dissertation entitled:***"Ocular manifestations of Cerebral Palsy in children attending MNH CerebralPalsy clinic",*** in (partial) fulfillment of the requirement for the degree of Master of Medicine (Ophthalmology) ofMuhimbili University of Health and Allied Science.

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Date_____

DECLARATION AND COPYRIGHT

I, **Dr. BadriaKombeMushi**, declare that this **dissertation** is my own original work and that it has not been presented and will not be presented to any other university for a similar or any other degree award.

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DEDICATION

To my loving mother, Mrs. JovithaKombe, for her endless love and support

ABSTRACT

Background

Cerebral palsy is a chronic, static impairment of muscle tone strength, coordination and movement resulting from cerebral insult before, during birth and or perinatal period. It may be associated with ocular abnormalities such as refractive errors, strabismus, nystagmus, optic atrophy andcortical visual impairment (CVI). Ocular abnormalities in children with Cerebral palsy impair learning, movements and are associated with increased dependency on care takers. If these ocular abnormalities are detected early before visual maturation has occurred and visual therapy initiated, the vision of these children can improve tremendously which, ultimately reduce the dependency on caregivers and improve the child's quality of life.

Aim

To assess magnitude and pattern of ocular manifestations ofCerebral Palsy in children attending MuhimbiliNational Hospital Cerebral Palsy clinic.

Methodology

A hospital based descriptive cross-section study among 198 children aged 6 months up to 18 years attending Cerebral Palsy clinic at MuhimbiliNational Hospitalwas done. Study participants wereselected bysystematic random sampling followed by gathering of data through history taking, case notes review and a full ophthalmological assessment.

Results

There were 116 males and 82 females and the mean age was 44.2±35.8 months. Most of the studied children had spastic type of Cerebral palsy (83.4%), with birth asphyxia being the most likely cause (62.1%).About a half of the children who had attained the school going age were not enrolled in school. The overall incidence of ocular abnormalities in this study was 84%. Major ocular abnormalities identified in these cases were refractive errors 48%, nystagmus 21%, strabismus 20% and optic disc pallor 13%. Only 16% of the children with refractive errors had spectacle correction. Visual impairment was present in 74% of children, Cerebral visual impairment (CVI) was the commonest cause (80%). Ophthalmology clinic

attendance prior to the study was 32% with the mean age at first attendance being 20.1 months while Physiotherapy clinic attendance was 82% and mean age at first visit was 9.8 months.

Conclusion

Majority of children with cerebral palsy attending the MNH CP clinic hadvisual impairment caused by different ocular abnormalities. The commonest cause of visual impairment was CVI related to birth asphyxia.Most of them had never attended ophthalmology clinic and those who had started,attended at an advanced age.

Recommendation

Early ophthalmological assessment for every child attending CP clinic waspropose to recognizevisual impairment at the age where appropriate visual rehabilitation is worthwhile.

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ABBREVIATIONS

CMV	-	Cytomegalovirus
CP	-	Cerebral Palsy
CVI	-	Cortical visual impairment
EOM	-	Extra ocular muscle
IOP	-	Intra ocular pressure
LE	-	Left eye
MNH	-	Muhimbili National Hospital
MR	-	Mental retardation
MUHAS	-	Muhimbili University of Health and Allied Sciences
RE	-	Right eye
UNICEF	-	United Nations Children's Fund
VA	-	Visual acuity
VI	-	Visual impairment

DEFINITION OF KEY TERMS

Anterior segment : Anterior one third of the eye that includes the structures in front of the vitreous humour; the cornea, anterior chamber, iris, cilliary body and lens.

Astigmatism :A refractive error in which image of an object is distorted due to irregular curvature of cornea or in the shape of the crystallinelens, as light rays do not come to a point focus on the retina.

Cortical visual impairment: Decreased visual response caused by defective function of the retrochiasmatic part of the visual system in absence of any important ocular anomaly.

Cycloplegia : Paralysis of the cilliary muscle of the eye.

Hyperopia :A refractive error in which parallel rays of light entering the eye reach a focal point behind the plane of the retina, with accommodation relaxed. It is also called long sightedness.

LEA gratings: Preferential looking test for infants or children and adults with disabilities to determine detection acuity with grating levels printed on each handle with units as cpcm(cycles per centimeter of surface).

LogMAR chart:A visual acuity assessment chart comprising of equal number of letters in each row.

Myopia:A refractive error condition in which parallel light rays from an object at optical infinity are focused by the eye in front of the retina, with accommodation relaxed. It is alsocalled short sightedness.

Nystagmus: Rhythmic oscillation of one or both eyes around one or more axes.

Ophthalmoscope: An instrument used to view the posterior segment of the eye.

Posterior segment : Posterior two-thirds of the eyethat includes the anterior hyaloid membrane and all of the optical structures behind it; the vitreous humor, retina, choroid and optic nerve.

Refraction: An objective and subjective eye examination procedure that measures a person's prescription for eyeglasses or contact lenses.

Refractive error: Manifestation of the relationship between the optical components of the eye and the overall axial length of the eye.

Retinoscope: An instrument for objectively determining the refractive error of the eye.

Snellen chart: An eye chart used to measure visual acuity at a definite distance.

Slit lamp: An instrument consisting of a high-intensity light source and biomicroscope that can be used to examine the lids and anterior segment of the eye.

Visual acuity: Sharpness of vision, measured by the ability to discern letters or numbers at a given distance according to a fixed standard.

CHAPTER ONE

1.0 INTRODUCTION

Cerebral palsy(CP) is a chronic, static impairment of muscle tone strength, coordination and movement resulting from cerebral insult before, during birth and or perinatal period(1).As the condition is non-progressive, the diagnosis is usually made when the child is 6 months or more to rule out other progressive brain disorders(2). Common causes include prematurity, hypoxia during or shortly after birth and infections affecting the brain like meningitis and encephalitis.Maternal infections such as Toxoplasmosis, rubella and Cytomegalo Virus (CMV) may also result into cerebral palsy(3–5).

Cerebral palsy may exist in several forms(1),depending on the area of the brain affected(6). It may exist as spastic form when the pyramidal tracts are affected;dyskinetic form when the extrapyramidal tracts are the area affected; ataxic form when the cerebellum is affected or hypotonic form.It is also classified according to specificlimb(s) affected(7).It is called monoplegiaif one limb is affected;hemiplegia if an arm and leg both on the same side of the body are affected; paraplegia when both legs are affected but arms are unaffected or quadriplegia when all four limbsare affected.

Cerebral palsy may be associated with other neurological disorder such as epilepsy and mental retardation. Also deafness, visual impairment and language deficit may be present(1,8–10).Visual impairment is one of the most common morbidity in CP children ranging from 38% to 92% and it impairs further development and functioning in a child with CP(9–11). Common ocular findings include refractive errors, strabismus,nystagmus, optic atrophy and Cerebral Visual Impairment (CVI).Congenital infection such as CMV and rubella that may be the cause of CP may also cause cataract, retinopathy and congenital heart disease(8).

To detect these abnormalities, thorough physical and ophthalmological assessments are needed.Examination of children with CP is challenging due presence of physical impairment, hearing impairment and sometimes cognitive impairment.

Caring of children with cerebral palsy is trans-disciplinary and involves physical rehabilitation, pediatric and ophthalmic care and family counselingtogether with special education for the affected child(1,4,12). Children should be encouraged to use the residue vision available and parents motivated to integrate them into the care of different health and rehabilitation specialists(5).

Parents and caretakers also need counseling and a support system where possible as caring for children with cerebral palsy has economic and psychosocial burden in terms of funds used in management of CP and its associated conditions, assistive device needed and time spent in different clinics(12–14).Unrecognized visual impairment in children with CP affects the child's learning and social integration ability which increases dependency on caregivers and decreases the child's quality of life.The aim of the study was to assess ocular manifestations among children with CP attending MNH cerebral palsy clinic.

1.1 Literature review

Prevalence

Cerebral palsy is a common cause of severe physical disabilities in childhood. It is attributed by insult in the developing brain of a child prior, during and shortly after birth. Prevalence of cerebral palsy differs by region and from year to year and is likely to be high in developing countries due to frequent exposure to infections during pregnancy, poor maternal nutrition, birth trauma, and cerebral infection(4,15). Prevalence of cerebral palsy in Egypt was found to be 3.6 in 100,000 live births while in western countries is about 2 per 100,000 live births(1,3,8).

Risk factors

Risk factors for a child developing cerebral palsy include premature birth, low birth weight, neonatal jaundice and neonatal seizures(4,8,16).In a study done in India by Gowda V. et al, hypoxic ischemic encephalopathy was the commonest risk factor contributing 43%, followed by prematurity (15%), meningitis (10%) and neonatal sepsis (4%)(8). Another study by Suvanand S. et al found ischemic encephalopathy to be 36.1% followed by low birth weight and neonatal convulsions(17). However, review of studies done in Europe found premature birth to be the commonest risk factor followed by hypoxic ischemic encephalopathy, brain malformation and postnatal infection(16).

Sex

Cerebral palsy has been found to be predominant in males, with M: F ratio ranging from 1.2:1 to 1.7:1. In a study done in Kenyaby Njambi L, males comprised 58%, in Egypt El-Hawary found male comprising 67% and from a study in India by Gowda V, males were 60% of the studied children with Cerebral palsy(3,4,8,9).

Associated features

Cerebral palsy can manifest in different forms depending on the area of the brain affected. Spastic sub-type has been found to be the commonest form in all studies done. It comprised of 60%-88%(6,8,12,15,17). Other subtypes which are dyskinetic, ataxia and hypotonia existed in

smaller proportion.Spastic type of CP is associated with increased ocular manifestations due to extensive, diffuse injury of the involved brain(4,6,16,18).

Children with cerebral palsy have other neurological disorders associated with brain insults, the commonest being mental retardation, epilepsy and speech/language disability(8–10,12,15,19). In Uganda, learning disability was found to be 75.6%, epilepsy being 45.2% and speech/language disorders were found in 37.0% of the children with cerebral palsy(15). A study in Punjab, India by Sharma R. found 43.5% of children with CP also had mental retardation and 28.6% had epilepsy (12). In Sweden, learning disability was present in 40% while epilepsy was present in 20%(19).

Although in CP the brain damage is non-progressive, gross motor function ability may deteriorate over time and therefore physiotherapy is important to promote function and developmental capabilities of the child(1,12).A study in India found that only 55.6% of children received physiotherapy and it was mostly infrequent(12). In Ireland howeverParkes J. et al study showed 96% of children with CP received physiotherapy with 59% receiving at least twice per week(20).

Education

Education in children with cerebral palsy is likely to be affected by learning disabilities, uncorrected visual impairment and need of assistive devices(4,11), in India, it was found that only 4.8% of children received special education even though 42.8% of the children had mental retardation(12). In Ireland, 57.5% of children with cerebral palsy were in mainstream schools and the remainder 42.5% attended special schools(11). In Sweden, all children with normal cognitive attended mainstream schools and those with learning disability attended special school(19).

Ocular abnormalities

Ocular abnormalities are a frequent manifestation in children with CP due to likely involvement of visual cortex in the primary brain insult and association of some of prenatal infection such as rubella and toxoplasmosis with both brain and ocular presentation(1).

Prevalence of ocular abnormalities in children with CP have been shown to differ in different studies done, ranging from 28.2% in Nigeria and 68% in India(6,18). In Kampala, UgandaKakooza-Mwesige L. et al found visual abnormalities in children with CP to be 29.6%(15). A cross section hospital based studies among children attending occupational therapy at Kenyatta hospital in Kenya, found ocular abnormalities in 58.3% of children with CP(4).One studies' review showed visual problems in children with cerebral palsy to range from 38% to 92% depending on the selection criteria of the cohort(11).

In China, a study by Hou M. among 354 children with CP found 38.98% of children had visual disorders. In this study, there was significant correlation between spastic subtype and visual disorders(10). Another study in Canada by Venkateswaran D. et al found visual disorders to be present in 80% of children with spastic quadriplegic CP(9).Abnormalities included peripheral ocular abnormalities such a strabismus, refractive errors, nystagmus, optic disc changes and central cortical visual impairment(1,4).

Visual acuity

Reduction in visual acuity (VA) can be as high as 98% in children with CP(1).The severity of reduced vision depend on the type of CP being high in spastic type. Other factors such as strabismus, cataract and refractive errors also contribute to reduced visual acuity.Measuring VA in children with CP is challenging since VA depend on the age of the child, ability to speak and understand. Still VA can be obtainable in as high as 88% of children using appropriate tool for each individual child(8,16) .In the review of Europe and UK registers, it was found that 11% of children with CP had VA of less than 6/60(16).A study in India by Katoch S.(6), found 11.5% of children could not fixate on light and 1.5% had VA of less than 6/60, and Ozturk AT et al in Turkey found thatamong children with spastic CP,27.8% had VA of less thanLogMAR 1.0(21).

CVI is one of the causes of reduced VA in children. It can be present in about 40-70% of children with CP and presents with reduced visual perception and may also present with unusual optic disc hypoplasia(1). The brain injury in posterior visual pathway causes difficulties in processing and interpreting visual information in the visual cortex(6).A study in

Kenya found CVI to be 48.5%, in India it was found to be 28% and in Canada it was 12.1%(4,6,9). A review of studies in Europe found CVI among children with CP to range from 16%- 80%(11).

Refractive errors

Refractive error is another cause of reduced VA in children. Recognition of refractive error and use of prescribed glasses for children with CP is challenging. Mounting a frame in a child with no neck control is difficulty and makes parents and teachers to give up. A review in Europe found that 50% of children with refractive error requiring glasses did not have prescription for glasses(11).In Kenya, refractive error was found in 39%, of these hyperopia constituting 40% and myopia 60%(4). In other studies though, hyperopia has been found to be dominant. In India hyperopia was 20%, myopia 13.5% and astigmatism 34% while in Ireland, hyperopia was found in 54%, myopia in 17.8% and astigmatism in 36.2%(6,22).

Strabismus

Strabismus is also common in children with cerebral palsy. It is thought to be caused by lesions in the subcortical oculamotor centers and cerebellar lesions disrupting normal binocular vision(4,6). Esotropia is more common than exotropia(11).A study in Turkey found 55.2% of children with CP had strabismus with esotropia being 2.5 times more than exotropia(21). In India, strabismus was present in 39% with esotropia being 17% and exotropia 22% while in Kenya strabismus was 34.5%(4,6).

Nystagmus

Prevalence of nystagmus is higher in children with CP than the 0.28-1% of the general population(11).Studies have shown nystagmus to range from 12.8% in Kenya, 5.5% in India to 18.6% in Turkey(4,6,21).

Optic disc changes

Optic disc pallor was found in fundus examination in children with cerebral palsy in different studies.In Kenya, optic disc atrophy was found in 5.3% of children, in India temporal disc pallor was found in 11% of the children while generalized disc pallor was found in 5.5% of

the children(4,6). In Italy,a study among children with spastic CP found temporal disc pallor in 14% and generalized disc pallor in 25%(23). In Canada, 7.2% of children with spastic CP had optic atrophy(9).

Other findings

Other ocular findings found in children with CP were corneal scars, cataracts, maculopathy and eyelid anomalies. These constituted 5% in a study done in Kenya by Njambi L. et al(4). A study in Canada found 1 patient (1.2%) with CMV retinopathy(9). In India study, 1 patient (0.5%) had fundal coloboma, 2.5% had developmental cataract and 1.5% had IOP above 21mmHg(6).

In general, Visual impairment is a common finding in children with cerebral palsy. The commonest cause of VI has been found to be CVI, found in 48.7% in Kenya and 28% in India(4,6). The second common cause was strabismus followed by refractive errors.

Ophthalmology clinic attendance

The age of the child at the first ophthalmologic consultation is important in determining the visual outcome. In a study done in Turkey by Ozturk AT et al, the mean age for the first visit was 64.7 months. Of the children in the study, 47.9% had no prior ophthalmologic exam, none had regular follow ups or ocular surgery done(21).Visual impairment has impact on the child ability to learn through imitation and reading ability irrespective of cognitive ability(4). Impaired learning and reading ability interferes with academic and social performance decreasing further the child’s quality of life.

1.2 Problem statement

Ocular abnormalities are a frequent manifestation in cerebral palsy patients. Being able to see and understand images have a major impact on people's function in their daily lives. Much of a child's success at home and in school depends on visual processing(4,24).

Studies have shown that as much as 75% of children with cerebral palsy experiences ocular problems with visual acuity difficulties(6,11,21).Visual impairment in children with Cerebral palsy may go unnoticed due to absence of gross external ocular abnormality in some cases or due to health care providers focusing on other aspects of the child's health(16,18).

Most children are brought late for ophthalmological assessment and during that time, visual system maturation may have already occurred and amblyopia set in, at which stage visual rehabilitation is slow and cannot completely reverse the process(11).These children need all the help available and visual function should be at its best. Children have remarkable ability torecover from visual impairment when causes of visual impairment are identified and treatment is instituted at an early stage(11).

No prior study had been done in Tanzania to determine ocular manifestation in children with Cerebral Palsy.At MNH, there was no established routine ophthalmological review of children with CP. There was a knowledge gap on how common they are and if these ocular abnormalities were managed and hence this study proposed to evaluate the prevalence of ocular abnormalities in children with cerebral palsy.

1.3 Rationale

Children with cerebral palsy can benefit immensely if vision is corrected when a child is young before maturationof the visual system. Recognition of associated ocular causes of visual impairment and managing them early on can prevent visual impairment and hence increase social independency and help improve vision related quality of life(24).

This study was done to explore and document variety of ocular manifestationsamong children with cerebral palsy in Tanzania. The findings will be used to establish strategies that will enable children with CP to have early full ophthalmological examination in order to detect the ocular abnormalities and initiate necessary therapy for better livelihood of these physically challenged children.

1.4 Research questions

1. How common are ocular manifestations in children with cerebral palsy attending the MNH CP clinic?
2. What are the common ocular problems in children with cerebral palsy attending the MNH CP clinic?
3. What are the causes of visual impairment inchildren with cerebral palsy attending the MNH CP clinic?
4. What proportion of children with CP has been under care of an ophthalmologist?

1.5Objectives

1.5.1 Main objective

To assess the magnitude and pattern of ocular manifestations in children with cerebral palsy attending the MNH pediatrics cerebral palsy clinic.

1.5.2 Specific objectives

1. To determine the prevalence of ocular abnormalities in children with cerebral palsy at MNH cerebral palsy clinic
2. To determine the type of ocular problems in children with cerebral palsy
3. To assess the causes of visual impairment in children with cerebral palsy
4. To determine the proportion of children with CP that were under Ophthalmologist's care prior to the study

1.6 Conceptual framework

CARE OF A CHILD WITH CP

Early recognition of ocular manifestation in children with CPis important as it provides an opportunity for visual therapy during the critical time for visual development and hence promoting their visual potential (11).

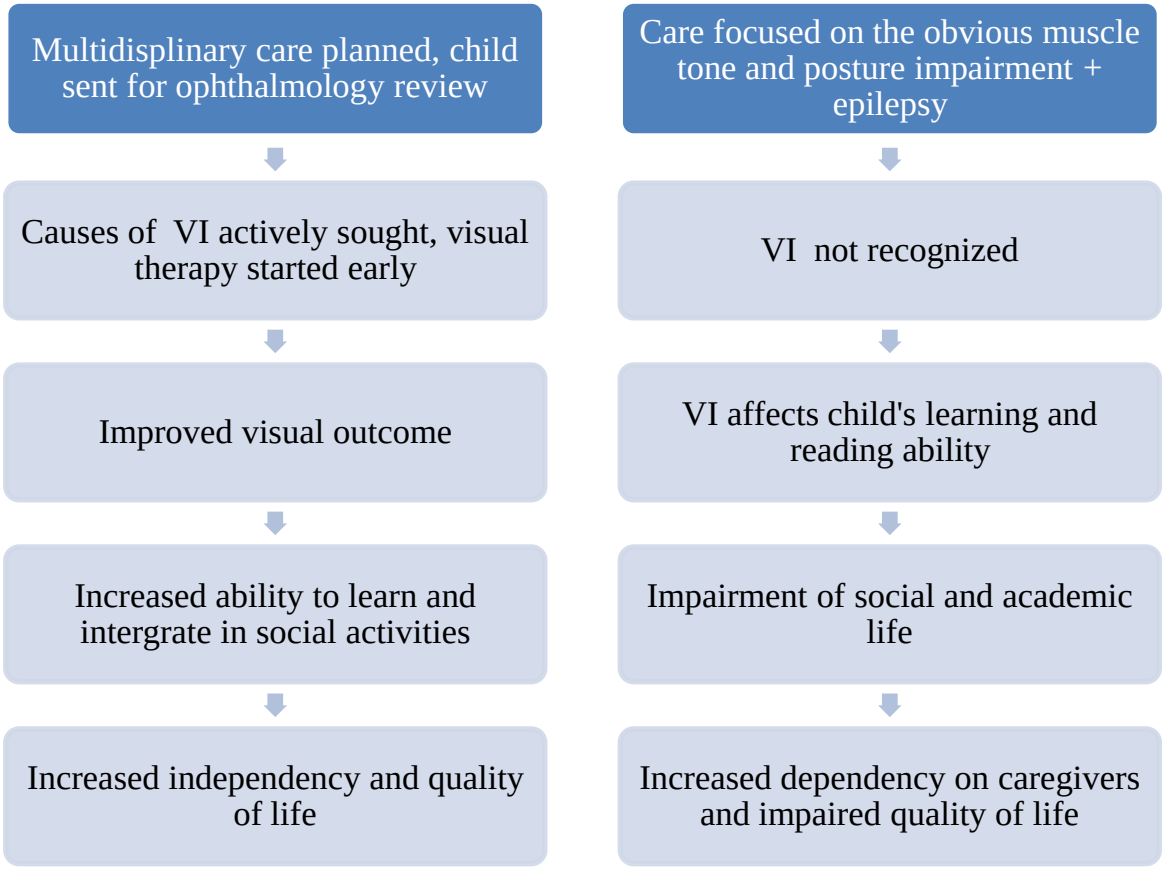


Figure 1: Conceptual framework

CHAPTER TWO

2.0 METHODOLOGY

2.1 Study design

This was a hospital based descriptive cross sectional study.

2.2 Study area

This study was conducted at the Pediatric CP clinic and Ophthalmology clinic at Muhimbili National Hospital located in Ilala district of Dar es salaam, Tanzania. Muhimbili National Hospital is the largest tertiaryreferral hospital and serves patients referred from other health facilities all over the country. The Pediatric department at MNH runs Cerebral Palsy clinic every Wednesday. The clinic attends an average of 110 Cerebral palsy children every month, majority being follow-up cases and about 5 new cases each month. For a six months period prior to the study, a total of 306 children were attended. Children up to 18 years are attended; those above 18 years old are shifted to adult Neurology clinic in the Internal Medicine department.(Source: MNH Cerebral palsy clinic database, July-December, 2015).



Figure 2: Map of Tanzania showing regions

2.3Target population

Children aged 6 months up to 18years diagnosed with cerebral palsy. The UNICEF definition of a child is a person below the age of 18 but the diagnosis of CP is made when the child is at least 6months old to rule out other brain disorder (2,25).

2.4 Study population

All children aged 6 months old up to 18 years old diagnosed with cerebral palsy attending the pediatric cerebral palsy clinic at MNH between September 2016 and February 2017.

2.5Sampling design

Systematic sampling of all the patients diagnosed with cerebral palsy aged 6 months up to 18 years of age attending MNH pediatricCP clinic from September 2016 and February 2017 was done.

2.6Sample size estimation

Sample size was estimated usingthe calculation of sample size for prevalence studies as follows:

$n= [z^2 P(100\%-P)] /d^2$

Where

n = required sample size

z= statistic value for the level of confidence (1.96)

P= expected prevalence in percentage

d= margin of error

From the study conducted at Kenyatta national hospital by Njambi et al,the prevalence of ocular abnormalities in children with CP was 58.3%(4).

z = 1.96,

d = 7%

$$\frac{[1.96^2 X 58.3 X (100-58.3)]}{7^2}$$

Thus the minimum sample size required was 191 patients.

2.7Inclusion criteria

All children diagnosed with CP aged 6 months up to 18 years attending pediatric CP clinic at MNH during the period of September 2016 and February 2017.

2.8Exclusion criteria

- Children attending the cerebral palsy clinic with emergency condition such that they were not able to be taken to the Pediatric ophthalmology clinic for evaluation.
- Refusal of parents to participate

2.9Data collection

Study Protocol

Patients were recruited from the Pediatrics CP clinic on Wednesdays from September 2016 to February 2017, where 8 children were selected by systematic selection from the appointment list of that day. The total number of patients on the appointment list was divided by 8 to get the interval number for systematic selection of patients to be recruited for that particular clinic day. A minimum of 8 children each week allowed recruitment to go on throughout the 26 weeks study period in order to reach the required minimum sample size. After initial data collection that included baseline information and ocular history at CP clinic; the patients were scheduled for complete ophthalmology assessment on Friday /Monday Pediatrics Ophthalmology clinic. Children on follow up clinic who were already recruited were removed from the sampling list to avoid double recruitment.

As all participants were minors, the guardian/caregiver of the patient was informed about the study by the principal investigator or research assistant. Ifshe/he agreed to participate in the study, she/he signeda written consent form. The contact number of the guardian/caretaker was taken for follow up. Caregivers that didn’t show up for the initial appointment were contacted through the phone and another appointment made on Monday or Friday depending on their wishes.

A nurse was used as a research assistant and was trained on recruiting patients from the CP clinic, taking baseline information from caretakers by interview, retrieving patient's treatments records and organizing patients visit to the Ophthalmology clinic.
A questionnaire with 3 parts wasused to record the information(26).

PART I: BASELINE INFORMATION

Baseline information was collected by the principal investigator/ assistant researcherfrom interview with the caretaker, birth cards and treatment records from the patient's file. All patients; new cases and follow up case were included.

The information includedname, age, gender, residency (region), prenatal history, birth history, postnatal infections, type of CP, treatment history, associated problems, education and enrollment into physiotherapy.The age for starting early childhood education was taken to be 5 years old (60 months) (27). The Pediatric neurologist present at the clinic was consulted in case of ambiguity in the diagnosis written in the patient records.

PART II: OCULAR HISTORY.

Information was taken from the caretaker on whether the child hadany history of eye problems, if so, the care given and if the child has ever been attended by an ophthalmologist.

PART III: OCULAR ASSESSMENT

This was done at the Pediatric ophthalmology clinic. The assessment was done by the principal investigator under supervision of a Pediatric ophthalmologist and Optometrist experienced in refraction of children.

Visual acuity, refraction and ocular alignment was assessed. Detailed anterior and posterior segment examination was also done. Patients with conditionsrequiring ocular management were managed accordingly by Pediatric Ophthalmologist.

MEASUREMENT TOOLS

- Visual acuity was assessed in all the children with correction and binocular Visual acuity was taken due to young age and associated neurological difficulties(23).
  Visual acuity was assessed using different modalities like Lea grating, Cardif cards, Kay pictures and Snellen charts as per age and the child's clinical severity(16,21).Childrenup to 2 years old and older children not able to cooperate wereevaluated using Lea grating at 67cmwhich give resolution acuity in cycles per centimeter (cpcm). Inolder children able to cooperate, Cardif cards, Kay pictures, Sheridan-Gadner and Snellenoptotypes were used, which give recognition acuity expressedin Snellenfractions(23). In children whose vision was not assessable,signs of light perception were assessed by either blinking reflex or facial turning from bright pen-torch light in a dark room.The positive response by either blinking or face turning away from light was labeled as light perception (LP) and a negative response was labeled as no light perception (NLP).Interpretation of Visual acuityby age was done according to International classification of visual impairment (Appendix IV).

- In children that we used Lea gratings, vision was recorded as normal if he/she could see stripes of 2 cpcm or more and was considered to be impaired if was recorded below 2 cpcm(28).

- Intraocular pressure was measured by rebound tonometer (iCARE model) since it is portable and easy to use in children. It doesn't require use of slit lamp, staining or topical anaesthesia. An average of 3 readings was taken in each eye. IOP was classified as ≤5mmHg being low pressure, 6-21mmHg being normal and >21mmHg to be high intraocular pressure(29).

- Visual axis alignment to detect strabismus (present or absent), was evaluated using the Hirschberg Test of corneal reflex(23).

- Presence of nystagmus was noted using a pen torch.

- Refractive errors were assessed by cycloplegic refraction where cycloplegia was achieved by cyclopentolateeyedrop1%, 2 drops 5 minutes apartfollowed by retinoscope after 30 minutes.

  -Hyperopia was defined asretinoscopic findings of >+2D in 6months – 3 years old. And >+1D in ≥3 years old.

  -Myopia was defined as a retinoscopic finding of >-0.5D

  -Astigmatism was defined as refractive error difference of >1D between the two meridian(6,22).

- Anterior segment examination was conducted using indirect ophthalmoscope and slit lamp biomicroscopewhere possible(4). Children of young age, those not cooperative and with severe gross motor functions were not examined using the slit lamp microscope which entails a child to rest his/her chin and forehead onto the chin rest and forehead strap respectively.
- Posterior segment examination was carried out by indirect ophthalmoscope and +20D lens after pupil dilatation bycyclopentolateeyedrops 1%.

Ophthalmic assessment was taken in parts when it was not possible to perform all examination in a single clinic visit. This depended on the child's mood, fatigue, attentiveness and if she/he had been to another clinic on the same day as reported by the parent(30). The parent/guardian was given an appointment for the next clinic day to complete visual assessment of the child.

2.10Data analysis

The study data were transferred from the hand-written data forms into a data spreadsheet and analyzed with SPSS (version 20.0, IBM LTD, Carolina, USA).Frequencies, proportions and mean/mode were selected according to level of measurement of each of the key variable of interest. In analysis of refractive error, the Right eye was used(22). Student *t*-test was used in the statistical analysis of mean difference and P value of < 0.05 was considered statistically significant.

2.11Ethical consideration

Ethical approval to carry out this study was obtained from the Research and Publication Committees of MUHAS on 22nd June 2016 and the Directorate of Research and Publication of MNH through Executive director of MNH on 5th July 2016.

All children aged 6 months up to 18 years attending the Pediatric CP clinic at MNH were offered the opportunity to participate in the study. The study was explained to the parents/care takers who were asked to sign a written consent after agreeing for the child's participation in the study. All children found with ocular manifestations were managed accordingly. All data collected were treated with strict confidentiality and stored in locked cabinets and in coded computers.

CHAPTER THREE

3.0 RESULTS

A total of 198 children with cerebral palsy were examined during September 2016- February 2017 study period.There were 116 (58.6%) males and 82 (41.4%) females, male being more than female by a ratio of 1.4:1. Mean age was44.2±35.8months and ranged from 6 to 162 months.

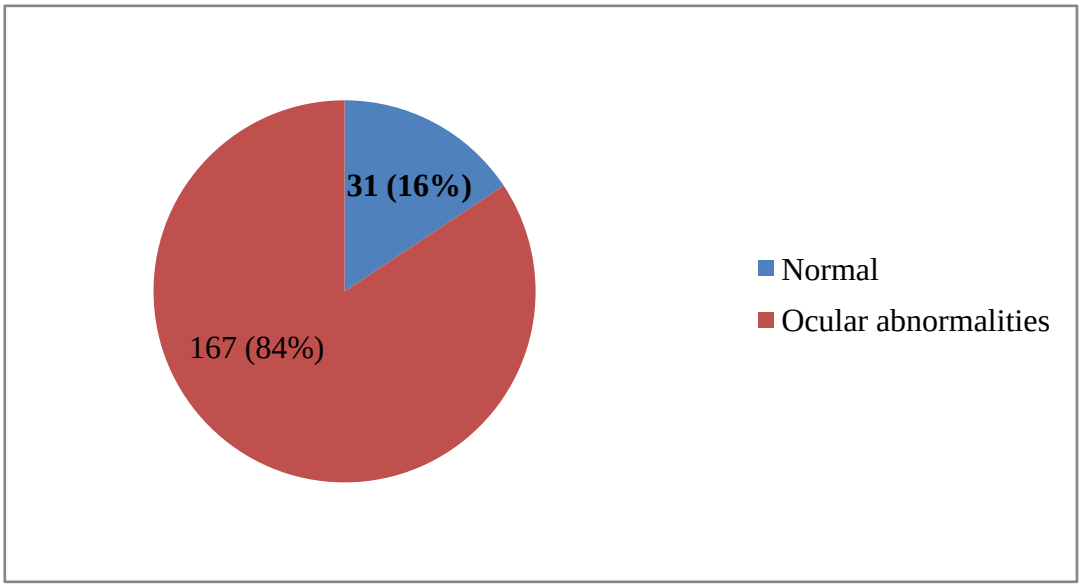
Table 1: Social demographic characteristics of the study population (N=198)

Characteristics		Sex			
		Male	**Female**	**Total**	**Percentage**
Region	Dar es Salaam	95	72	167	**84.3**
	*Others	21	10	31	15.7
Age(months)	6 -36	67	46	113	**57.1**
	37-72	25	24	49	24.7
	73-108	12	6	18	9.1
	Above 108	12	6	18	9.1
Type of CP	Spastic	93	66	159	**80.3**
	Dyskinetic	18	10	28	14.1
	Ataxic	1	2	3	1.5
	Hypotonic	4	4	8	4.0
Possible causes	Prenatal infection	1	0	1	0.5
	Prematurity	5	3	8	4.0
	Birth asphyxia	73	50	123	**62.1**
	Postnatal infection	46	31	77	38.9
School enrollment	Pre-school	86	63	149	**75**
	Enrolled	16	8	24	12
	Not enrolled	14	11	25	13
Other findings	Seizures	62	49	111	**56.1**
	Hearing impairment	7	4	11	5.6
	Speech impairment	56	41	97	49.0

**Other regions included Coastal region, Zanzibar, Tanga, Morogoro, Dodoma, Manyara, Lindi, Mtwara and Iringa.*

Majority of children belonged to 6-36 months age group and came from Dar essalaam. Most of the studied children had spastic type of Cerebral palsy with birth asphyxia being the most likely cause.Seizure was mentioned as the most common associated neurological condition.Most of the children were in the pre-school age group. Among those in school age, about half of them were not enrolled in school. (Table 1).

Figure 3 Proportion of study group with ocular abnormalities (N=198)



The proportion of children with ocular abnormalities in the study group was 84% (Figure 3).

Table 2: Distribution of ocular abnormalities by sex among the study group

Characteristics	Sex		Total* (%)
	Male	Female	
Refractive errors	53	42	**95 (48)**
Nystagmus	22	19	41 (21)
Strabismus	19	20	39 (20)
Optic disc pallor	15	9	24 (13)
**Not viewed	4	2	6 (3)
Glaucoma	1	3	4 (2)
Cataract	1	2	3 (2)
Pseudophakia	1	2	3 (2)
Corneal opacity	3	0	3 (2)
Microphthalmos	0	2	2 (1)
Chorioretinal thinning	0	2	2 (1)
Coloboma	0	1	1 (1)

Note (*) Percentage of the sample size used 198

***Posterior segment not viewed due to hazy media*

The commonest ocular abnormality was refractive errors, followed by nystagmus and strabismus (Table 2). Among children with strabismus, exotropia (54%) was more common than esotropia.

Table 3: Best corrected Visual acuity (BCVA) according to type of CP

Binocular BCVA	Type of CP			
	Spastic	Dyskinetic	*Others	**Total *(%)**
Normal (≥6/18)	43	4	4	**51(26)**
Moderate impairment (6/24-6/60)	40	15	2	57(29)
Severe impairment (<6/60-3/60)	16	3	1	20(10)
Blind (<3/60)	60	6	4	70(35)
Total	159	28	11	198(100)

NOTE: Other types of CP included ataxic and hypotonic.

Table 4: Causes of visual impairment among study subjects with visual impairment (N=147)

	VA conclusion		
	Mild- Moderate impairment	**Severe impairment& Blind**	**Total *(%)**
CVI	44	73	**117(80)**
Refractive errors	31	43	74(50)
Nystagmus	4	35	39(27)
Optic atrophy	10	13	23(16)
Others	6	11	17(12)

*NOTE: * Percentage out of 147 children with visual impairment*

Other ocular abnormalities associated with visual impairment were glaucoma, cataract, pseudophakia, microphthalmos, corneal opacity and optic disc coloboma.

Most of the children had visual impairment, with only 26% having normal visual acuity (Table 3). Among the 147 children with visual impairment, the cause in the majority was Cerebral Visual Impairment as shown in Table 4. Other common causes were strabismus, refractive errors and nystagmus.

Figure 4: Distribution of refractive errors among the study population

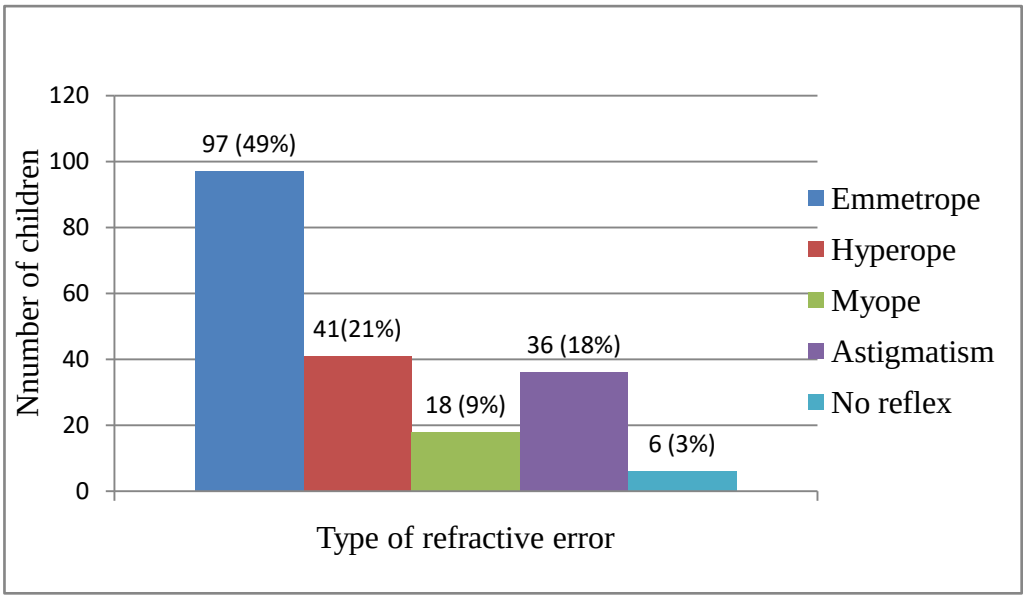
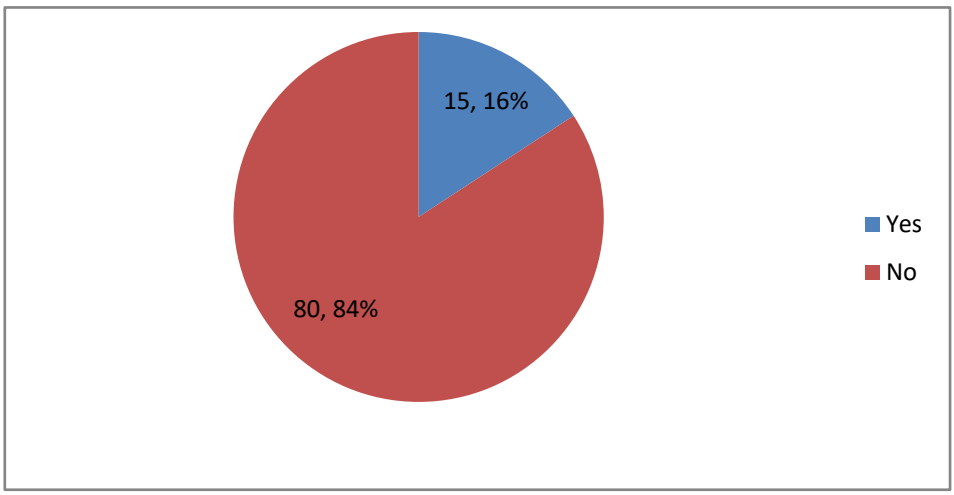


Figure 5 Use of spectacles among children with refractive errors (N=95)



Presence of refractive errors was found in about half of the children (Figure 4) hyperopia being the commonest type of refractive error. Refraction could not be carried out in 3% of children due to presence of corneal scar or cataract. Majority of children with refractive errors had no spectacles (Figure 5).

Figure 6: Prior visit to ophthalmology clinic (N=198)

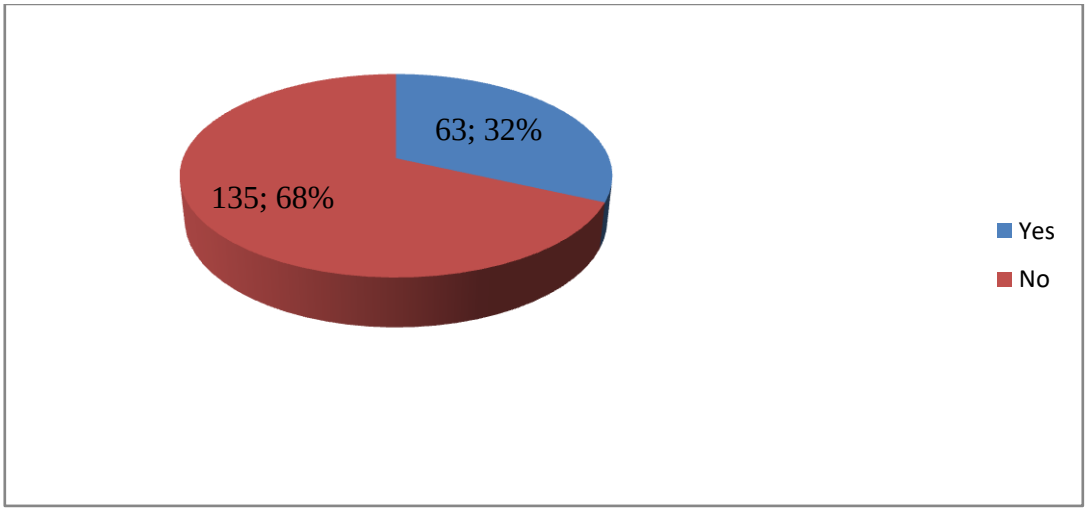


Table 5: Comparison of Physiotherapy clinic and Ophthalmology clinic attendance

	Physiotherapy clinic	Ophthalmology clinic
Attended	162 (82%)	63 (32%)
Not attended	36	135
Mean age at first visit (months)	9.83	20.11
Standard deviation (months)	7.75	22.94
Median age at first visit (months)	8	13

Paired sample test done among the 53 children who had attended both Physiotherapy and Ophthalmology clinics prior to the study, p=0.007.

Majority of the children had never been attended by an Ophthalmologist (Figure 6). Those who had attended Ophthalmology clinic, the age at the first visit was significantly advanced as compared to the age they started physiotherapy clinic (Table 5)

CHAPTER FOUR

4.0 DISCUSSION

This study is in agreement with previous studies which showed CP to be more common among boys than among girls since there were more males than female with a male:female ratio of 1.4:1 (3,4,8,9). The explanation as to why there were more males than females is not straight forward but may reflect the documented African culture of giving priority for a male child in many aspects like education and health care.

Cerebral palsy (CP) is a non-progressive brain disorder,which affects the immature brain of children.The findings of the study revealed that spastic type of CP was most prevalent followed by dyskinetic which is also in agreement with other studies from different part of the world (6,8,12,15,17).Majority of the children belonged to the 6-36 months age group probably as these were newly diagnosed and hence needed short interval follow up, more specialized clinic and investigations while older patients are referred back to attend general pediatric clinics in hospitals near their homes. Presence of seizures as the most common associated feature has also been reported in other studies (12,15,19). The most common possible cause was birth asphyxia which is also reported as the most likely cause in studies done in developing countries reflecting the ongoing challenges in maternal health as compared to developing countries where the most common cause of cerebral palsy is prematurity (8,16,17).

The study also found that about half of the children in the school age were not attending any school. In India, community based study found more than 90% of children with CP were not attending schools in contrast to Europe where all children attended either regular or special need school (11,12,19). Poor school attendance in our setting may be related to learning disability in the children, lack of awareness that these children benefit when in school, poverty of parents to enroll them to special needs schools, lack of assistive devicesand hence dependency on the care taker for their movement to and from the schooland uncorrected visual impairment (4,11).

The present study found ocular abnormalities in 84% of the children. In other studies ocular abnormalities ranged from 28% to 92% and were more common in the spastic subtype(6,9–11). Several ocular pathologies have been reported among children with CP. Strabismus and refractive errors were among the commonest reported abnormalities (1, 4). Same findings have been noted by this study where refractive errors, strabismus and nystagmus were common. These have been reported to be associated with amblyopia hence explaining the fact that there was high proportion of patient with visual impairment.

Since majority of the children in this study had spastic cerebral palsy, this could explain the high prevalence of ocular abnormalities. Also Muhimbili National Hospital being a tertiary hospital, the children attending the CP clinic are more likely to have severe form of CP and therefore increased prevalence of ocular manifestation.

Visual impairment was present in 74% of the children withCVIbeing the most common cause. Several studieshave reported that Cerebral palsy and CVI share a common origin since in CVI there is a deficit of visual function caused by damage to, or malfunctioning of, the retrogeniculate visual pathways. There is damage of optic radiations, occipital cortex and visual associative areasin the absence of any major ocular disease. In CP, mainly the one related to hypoxic–ischemic encephalopathy, the damage does not only affect the motor pathways but also the visual pathway. The results of the present study has found the same, where many of the children who had visual impairment, the cause was CVI(22,23). Spastic type of CP usually present with diffuse brain injury and constituting >80% of our study group would explain why CVI was prevalent.Prevalence of CVI in other studies is variable ranging from 16% to 80% depending on the study group(1,4,11). Since CVI presents without external ocular manifestation, its identification and management requires ophthalmological assessment and follow up. The age for initiating therapy in patient with CVI is crucial with young children less than 3 years more likely to achieve better results.

Refractive errors were present in about half the children with hyperopia being the commonest type. This is in line with other studies which have shown similar result with refractive errors

ranging from 39% to 78% and hyperopia being the prevalent type (4,21,22). Refractive errors is one the commonest correctable causes of visual impairment and a pair of correction spectacle increases these children social interaction and incidental learning. Refractive error in children with Cerebral palsy is thought to result from impairment of emmetropization process (22). Another challenge in children with refractive errors is use of spectacles. We found only 16% of those in need of refractive correction using spectacles while in Europe 50% had correction spectacles (11). Poor spectacle use may result from unrecognized refractive errors as evidenced by poor ophthalmology clinic attendanceand probably a reflection of a popular belief in our society that children do not need glasses as they further destroy their eyes making the children more dependable on glasses.

The current study report about two thirds of the studied children had no previous ophthalmological evaluation despite the fact that the Cerebral palsy clinic and Pediatric Ophthalmology clinic services are offered in the same building. The proportion seems to be a bit higher to similar previous studies. A study done in Turkey showed 47.9% of the children with cerebral palsy had no prior ophthalmologic evaluation(21). Another study among children with developmental delay revealed about 29% of them had no prior ophthalmological review (31), this makes them to be at higher risk of delay in management and puts them at higher risk of developing amblyopia. The high prevalence to VI in this study group can be explained by this fact. The other explanation could be that these children have no striking gross external ocular abnormalities; as such they can be easily overlooked by non-Ophthalmologist health practitioners. It is also a reflection of lack of protocol that requires every child with cerebral palsy to undergo ophthalmological assessment. Consultation to Ophthalmology clinic is more likely to be based on care giver's complaintabout the ocular health of the child or health practitioner's judgment.

The results ties with other studies which showed that there is more focus on the gross motor and tone impairment,since more than two third of children were enrolled for physiotherapy (16).Obvious motor and tone disability could explain why majority of children (82%) were

attending physiotherapy clinic. These results are similar to the study done in Turkey which showed more children attending physiotherapy clinic (79.4%) compared to those attending Ophthalmology clinic.Another study done in India, showed physiotherapy attendance was at 55.6%, though this was lower than what found in this study (12). This could be explained by the fact the India study was a community based cross-sectional study, while the present was a hospital based and therefore children attending a CP clinic are more likely to be enrolled for physiotherapy clinic than those in the community.

The findings of this study showed that children had other associated medical problems like seizures, hearing loss and needed to attend many other specialized clinics. Apart from CP clinic and physiotherapy; they may also need speech therapy and hearing therapy (5). Attending all these clinics have financial and time constraints to the family (1,13,14). If a family has to opt for clinics to attend, Eye clinic may be opted out due to less obvious presentation.

Those who were attending Ophthalmology clinic, the mean age for starting the clinic were significantly advanced (20 months) as compared to mean age at starting physiotherapy clinic which was 9 months. A study in Turkey showed mean age at starting eye clinic to be 64 months (21). At this advanced age, the child would be expected to acknowledge visual recognition, and the caretaker may easily notice any sign of visual impairment and hence consult ophthalmology service.

CHAPTER FIVE

5.0CONCLUSION AND RECOMMENDATION

5.1 Conclusion

Most of the children with Cerebral palsy had ocular abnormalities and were visually impaired.Visual impairment was mainly caused by CVI related to birth asphyxia. The common ocular abnormalities were refractive errors, nystagmus and strabismus. Half of the children had refractive errorswith majority of them having nospectacle correction. Majority of the children had never attended ophthalmology clinic and those who hadstarted, attended at an advanced age.

5.2 Recommendations

1.A link between Cerebral palsy, Physiotherapy and Pediatric ophthalmology clinic is proposed such that every child diagnosed with CP is referred to Ophthalmology clinic for identification of visual impairment and provision of early visual rehabilitation and spectacle correction when needed.

2. Health education to caretakers and community at large is proposed on early ophthalmological review to improve the quality of life of the children with CP.

5.3 Study limitations

1. Radiological examination was not done as part of this study and therefore presence or absence of retro-chiasmal lesion which might have explained some of ocular presentations were missed. This was done to avoid financial burden to the parents
2. Being a cross sectional study, this study only provide a snap shot of the children attending the clinic and the results cannot be generalized for the whole community.

5.4 Study mitigations

1. Clinical history was used to rule out presence of other cerebral lesions. Where radiological studies had already been done, they were inferred to.
2. Muhimbili being the National hospital, capturing some patients referred from different parts of the country increased generalization of our findings.

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APPENDICES

APPENDIX I: QUESTIONAIRE

OCULAR MANIFESTATIONS AMONG CHILDREN WITH CEREBRAL PALSY ATTENDING CP CLINIC AT MNH.

Name:

Registration No: **Questionnaire No:**

PART I: BASELINE INFORMATION

1. Age (months)
2. Sex M/ F
3. Residency (Region) ……..
4. Type of CP
    a) Spastic
    b) Dyskinetic
    c) Ataxic
    d) Hypotony
5. Possible cause
    a) Prenatal infection
    b) Prematurity
    c) Birth Hypoxia
    d) Postnatal infection
6. Other neurological findings
    a) Seizure
    b) Hearing impairment
    c) Speech impairment
7. Attending school?

    a) Yes b) No c) Pre-school (<60 months)

    If no, why?.....

    If yes special school? YES / NO.

8. Enrolled into physiotherapy?
   a) Yes b) No
   If no, why?……..
   If YES, started at which age?.....Frequency ……

PART II: OCULAR HISTORY

9. Any history of eye problems?
   a) Yes b) No
10. If yes, Care given: …….
11. Ever attended by eye doctor?
    a) Yes b) No
    If Yes, at which age?.....

PART III: OCULAR ASSESSMENT

12. Visual acuity RE LE
13. VA conclusion:
    a) Normal vision
    b) mild-moderate impairment
    c) Severe impairment
    d) Blindness
14. IOP RE LE
15. IOP conclusion
    a) Low
    b) Normal
    c) High
16. Refraction
    a) Right eye-
       Left eye-

17. Refraction conclusion (Type of refractive error) :
    a) Emmetrope
    b) Hyperope
    c) Myope
    d) Astigmatism
18. If have RE, using spectacles? a)yes b) no
19. Strabismus present? a) yes b) no
20. If yes, which type?
    a) esotropia b) exotropia
    c) hypotropia d) hypertopia
21. Anterior segment examination
    a) Normal
    b) Nystagmus?
    c) Cataract?
    d) Others ……
22. Posterior segment examination
    a) Normal fundus
    b) Optic pallor/ optic atrophy
    c) Coloboma
    d) Others ……...
23. CVI present
    a) Yes b) No

APPENDIX II: CONSENT FORM: ENGLISH VERSION

Title: Ocular manifestations in children with cerebral palsy attending pediatric CP clinic at Muhimbili National Hospital.

Greetings! I am Dr. BadriaMushi, a 3rd year resident in the Department of Ophthalmology at Muhimbili University of Health and Allied Sciences (MUHAS).
I am conducting a study with the above title as part of my study program.

Aim of the study:To determine the prevalence of ocular manifestations in children with cerebral palsy attending Pediatric cerebral palsy clinic at Muhimbili National Hospital.

Participation in this study:All children aged 6 months up to 18 years with cerebral palsy presenting at MNH Pediatric CP clinic between September 2016 and February 2017.
This study involves taking history about general information, his/her cerebral palsy condition and ocular problems.

It also involves measurement of visual acuity by different charts, refraction under cycloplegia, measurement of intraocular pressure and examination of anterior and posterior segment of the eyes. History and physical examination will both be performed by me, the principal investigator or my research assistant. If you decide not to participate in this study, your child's care will not be affected in any way and he/she will still receive appropriate care, as any other patient at the clinic.

Risks: This study will have no physical risks to your child since the above means of measurements are painless and non-invasive procedures. Management of your child will proceed accordingly and will not be impacted by research considerations. However any reported subject discomfort will be immediately addressed and mitigated.

Benefits:If you agree to participate in this study, your child will benefit by having different measurements evaluating presence of ocular problem and if found will be managed accordingly. The results of the study will also help bridge the gap of knowledge to both

medical personnel and community on importance of seeking early ocular care in children with cerebral palsy and therefore starting early visual therapy.

Confidentiality: All data collected will be treated with strict confidentiality and stored in locked cabinets, encrypted computers and will not be revealed to anybody outside the research team.

Cost: Patients will not be required to make any payments to participate in this study and there will be no financial compensation for participation.

Who to contact:For further information, questions or queries, you can contact:

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Tel: 022 2150302-6, 2152489.

Signature:

I, _____ have read/been told the contents of this form. My questions have been answered. I agree to participate in this study.

Signature of parent/caretaker_____

Signature of researcher_____

Date of signed consent_____

APPENDIX III: FOMU YA RIDHAA YA KUSHIRIKI KATIKA UTAFITI

Jina la utafiti:Matatizo ya macho katika watoto wenye mtindio wa ubongo wanaohudhuria kliniki ya watoto ya mtindio wa ubongo hospitali ya taifa Muhimbili.

Habari, Mimi ni Dkt. Badria Mushi, mwanafunzi wa mwaka wa tatu wa udaktari bingwa wa magomjwa ya macho katika Chuo Kikuu cha Afya na Sayansi Shirikishi Muhimbili (MUHAS). Ninafanya utafiti wenye jina la hapo juu kama sehemu ya mafunzo yangu.

Lengo la utafiti: Kuangalia uwepo wa matatizo ya macho katika watoto wenye mtindio wa ubongo wanaohudhuria kliniki ya watoto ya mtindio wa ubongo katika Hospitali ya taifa Muhimbili.

Ushiriki katika utafiti: Mtoto mwenye umri wa kuanzia miezi 6 hadi miaka 18 watakaohudhuria kliniki ya watoto ya mtindio wa ubongo kati ya Septemba 2016 hadi Februari 2017.

Utafiti huu utahusisha kuchukua maelezo ya jumla kuhusu mtoto, hali yake ya mtindio wa ubongo na matatizo ya macho.

Pia utahusisha kupima uwezo wa macho kuona, kupima uhitaji wa miwani, presha ya macho na kuchunguza sehemu ya mbele na ndani ya jicho. Kuchukua maelezo na kumpima mtoto kutafanywa na mimi, mtafiti mkuu au mtafiti msaidizi.

Kama ukiamua kutoshiriki katika utafiti huu, huduma ya mwanao haitaathirika kwa namna yoyote na atapata huduma stahiki kama wagonjwa wengine hapa kliniki.

Madhara : Utafiti huu hauna madhara yoyote kwa sababu vipimo vilivyatajwa hapo juu havileti maumivu. Matibabu ya mwanao yataendelea kama inavyostahili na hayataathiriwa na utafiti huu. Kama ikionekana mtoto anajisikia vibaya, suala hilo litashughulikiwa kwa haraka.

Faida : Kama ukikubali kushiriki katika utafiti huu, mwanao atafaidika kwa kufanyiwa vipimo mbalimbali kuangalia kama ana tatizo lolote la amcho , na tatizo likionekana atapatiwa matibabu stahili.

Matokeo ya utafiti huu yatasaidia kuongeza ufahamu kwa wahudumu wa afya na jamii kuhusu umuhimu wa kupata huduma za macho mapema kwa watoto wemye mtindio wa ubongo na hivyo kuanzishiwa matibabu ya macho mapema.

Usiri : Taarifa zote zitakazokusanywa zitawekwa kwa usiri mkubwa na kuhifadhiwa katika sanduku lililofungwa na kompyuta iliyofungwa na hazitadhihirishwa kwa mtu yoyote asiyehusika kwenye utafiti huu.

Gharama : Mgonjwa hatahitajika kutoa malipo yoyote ili kushiriki katika utafiti na hatolipwa kwa ajili ya kushiriki katika utafiti.

Mawasiliano : Kwa maelezo zaidi, maswali au dukuduku, unaweza kuwasiliana na:

Mtafiti Mkuu,
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Sahihiyamakubaliano:

Mimi, _____,

nimesoma/nimesomewamaelezoyoteyaliyomokwenyefomuhii na nimeelewa. Maswaliyanguyamejibiwa na nikotayarikushiriki.

Sahihiyamshiriki _____

Sahihiyamtafiti _____

Tarehe _____

APPENDIX IV: VISUAL ACUITY CHARTS

World Health Organization International Classification of Disease Version 10 (ICD-10)

Downloaded from: http://apps.who.int/classifications/icd10/browse/2010/en#/H53-H54

The table below provides a classification of severity of visual impairment recommended by the resolution of the International Council of Ophthalmology (2002) and the Recommendations of the WHO Consultation on "Development of Standards for Characterization of Vision Loss and Visual Functioning" (Sept 2003)

If the extent of the visual field is taken into account, patients with a visual field of the better eye no greater than 10° in radius around central fixation should be placed under category 3.

Category	**Presenting distance visual acuity**	
	Worse than:	**Equal to or better than:**
0 Mild or no visual impairment		6/18 3/10 (0.3) 20/70
1 Moderate visual impairment	6/18 3/10 (0.3) 20/70	6/60 1/10 (0.1) 20/200
2 Severe visual impairment	6/60 1/10 (0.1) 20/200	3/60 1/20 (0.05) 20/400
3 Blindness	3/60 1/20 (0.05) 20/400	1/60* 1/50 (0.02) 5/300 (20/1200)
4 Blindness	1/60* 1/50 (0.02) 5/300 (20/1200)	light perception
5 Blindness	No light perception	
9	Undetermined or unspecified	
	* or counts fingers (CF) at 1 metre.	

Binocular Corrected Visual Acuity by Cardiff Acuity Test tested at a distance of 50 cms

	12 months to 17 months	**18 months to 23 months**	**24 months to 29 months**	**30 to 36 months**	**37 months and older**
Range normal for age, no Vision Impairment	6/6 6/7.5 6/12 6/15 6/19 6/24 6/30 6/38 6/48	6/6 6/7.5 6/12 6/15 6/19 6/24	6/6 6/7.5 6/12 6/15	6/6 6/7.5 6/12	6/6 6/7.5
Vision impairment suspected	6/60 6/76 6/96	6/30 6/38 6/48 6/60 6/76 6/96	6/19 6/24 6/30 6/38 6/48 6/60 6/76 6/96	6/15 6/19 6/24 6/30 6/38 6/48 6/60 6/76 6/96	6/12 6/15 6/19 6/24 6/30 6/38 6/48 6/60 6/76 6/96

Color code: *Yellow=Mild impairment, Green=Moderate impairment, Red=Severe impairment*