PREVALENCE OF VISUAL IMPAIRMENT, REFRACTIVE ERROR AND PERINATAL FACTORS AFFECTING VISUAL IMPAIRMENT IN CHILDREN WITH CEREBRAL PALSY

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LIST OF ABBREVIATIONS

CDC	Centres For Disease Control And Prevention
CP	Cerebral Palsy
CPRC	Cerebral Palsy Research Cluster
CVI	Cerebral Visual Impairment
D	Dioptre
EPP	Estimated Pool Prevalence
ICD	International Classification of Diseases
GDP	Gross Domestic Product
KI	Key Informant
KIM	Key Informant Method
PVL	Periventricular Leukomalacia
RM	Ringgit Malaysia
SD	Standard Deviation
USA	United States of America
USM	Universiti Sains Malaysia
VA	Visual Acuity
WHO	World Health Organisation

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ABSTRAK

PENGENALAN:

Palsi serebri merupakan salah satu penyebab kurang upaya fizikal yang paling biasa di kalangan kanak-kanak dengan kekerapan dalam populasi pada kadar 2-4.4/1000. Kepentingan persepsi visual untuk kawalan postural bagi golongan ini telah tercatat dalam documentasi. Justeru, pemeriksaan dan pemantauan masalah mata golongan kanak-kanak palsi serebri adalah mustahak.

OBJEKTIF:

Untuk menentukan kelaziman masalah kurang upaya penglihatan dan rabun mata di kalangan kanak-kanak palsi serebri di Malaysia, dan menilai faktor yang mempengaruhi masalah kurang upaya penglihatan dan rabun mata.

METHODOLOGI:

Satu kajian keratan rentas telah dilaksanakan dalam bentuk pemeriksaan kesihatan di tiga negeri dalam Malaysia dengan mengadopsi cara informan kunci dari tempoh November 2017 ke Jun 2019. Kriteria kemasukan untuk kajian ini adalah semua kanak-kanak palsi serebri di Malaysia berumur antara 2 hingga 17 tahun.

KEPUTUSAN:

Sejumlah 168 kanak-kanak dari 3 negeri (Johor, Kelantan dan Sarawak)) telah mangambil bahagian dalam kajian ini. Kelaziman masalah kurang upaya penglihatan di kalangan kanak-kanak palsi serebri di Malaysia adalah 61.9%. Kekerapan rabun mata adalah antara yang paling tinggi (74.4%), seterusnya adalah kurang upaya kortikal penglihatan (30.4%) dan juling mata

(25%). Kekerapan rabun jauh (43.4%) melebihi rabun dekat (30.9%) dan exotropia (13.1%) adalah lebih kerap berbanding esotropia (11.9%). Perhubungan antara radang meninges atau ensefalitis sabagai punca factor mempengaruhi kurang upaya penglihatan adalah ketara dari segi statistik (p=0.046).

KESIMPULAN:

Kelaziman kurang upaya penglihatan (61.9%) dan rabun mata (74.4%) adalah lebih tinggi di kalangan kanak-kanak palsi cerebri. Perhubungan antara radang meninges atau ensefalitis sabagai punca factor mempengaruhi kurang upaya penglihatan adalah ketara dari segi statistic.

KATA-KATA KUNCI:

Palsi secebri, kurang upaya penglihatan, kurang upaya kortikal penglihatan, rabun mata.

ABSTRACT

BACKGROUND:

Cerebral palsy (CP) is the most common cause of physical disability in childhood, it occurs in 2-4.4/1000 population. The importance of visual perception in postural control and survival of patients with CP had been well documented. Early detection and treatment of ocular disorders is crucial.

OBJECTIVE:

To determine the prevalence of visual impairment and refractive error in children with cerebral palsy, and to evaluate aetiological factors affecting visual impairment in cerebral palsy children in Malaysia.

METHODOLOGY:

A cross sectional study was conducted in form of ophthalmology eye screening in three states in Malaysia adopting Key Informant Method (KIM) between November 2017 and June 2019. All children with cerebral palsy in Malaysia aged from 2 to 17 years old were included in this study.

RESULTS:

A total of 168 children were recuited from 3 states (Johor, Kelantan, Sarawak). The prevalence of visual impairment in children with CP in Malaysia was 61.9%. The most common ocular abnormality was refractive errors (74.4%), followed by cortical visual impairment (CVI) (30.4%), and strabismus (25%). Myopia (43.4%) was more common than hypermetropia (30.9%), and exotropia (13.1%) was more common than esotropia (11.9%). There was a

statistical significant association between meningitis /encephalitis and visual impairment in children with CP (p=0.046).

CONCLUSION:

There is a high prevalence of visual impairment (61.9%) and refractive errors (74.4%) in children with cerebral palsy in Malaysia. There was a statistical significant association between meningitis /encephalitis and visual impairment in children with CP.

KEYWORDS:

Cerebral palsy, visual impairment, cortical visual impairment, refractive error.

CHAPTER 1: INTRODUCTION

1.1 CEREBRAL PALSY

Cerebral palsy (CP) is a broad term which describes a group of disorders that primarily affects movement and posture. It is characterised by a non-progressive motor impairment that can lead to physical and mental dysfunction. CP is the most common cause of physical disability in children. This static neurologic condition occurs due to the insult of the immature brain before cerebral development is complete. As the brain continues to grow during the first two years of life, CP can occur as a result of brain injury during the periods of prenatal, perinatal, or postnatal.

Apart from the motor and posture disorder, it has come to consensus definition emphasized the non-motor feature of CP as impairment of sensation, cognition, communication, visual perception and/or behaviour and/or seizure disorder that often accompanies the required motor impairment (Marasini et al., 2011).

CP can be further grouped as spastic (monoplegic, diplegic, hemiplegic and quadriplegic) and non spastic (dyskinetic, dystonic, choreo-athetotic and ataxic) (Cans et al., 2007). Spastic diplegia is the most common type of CP (Ozturk et al., 2013; Park et al., 2016; Katoch et al., 2007). Spastic CP is defined as an increased tone and pathological reflexes.

Dvskinetic CP is an involuntary, recurring and occasional stereotype movement. The primitive reflex patterns predominate, and the muscle tone varies. Dystonic CP is dominated by abnormal postures and hypertonia. Patients with dystonic CP has involuntary movements, distorted voluntary movements, and abnormal postures due to sustained muscle contractions. Patients with choreo-athetotic CP usually experience hyperkinesia and hypotonia. Chorea means rapid involuntary, jerky and very often fragmented movements. Athetosis is described as having slower, constantly changing, writhing, or contorting movements. Ataxic CP is due to present loss of orderly muscular coordination. Thus movements occur with abnormal force, rhythm, and accuracy (Cans et al., 2007).

1.1.1 Prevalence of CP

World health organisation (WHO) estimates that the out of every 1000 live births, between 2 and 3 babies suffer from CP (Ferrari, 1995). There are some disparities in the prevalence of CP between the countries. In developed countries, CP affects an average of 2 in 1000 birth (Odding et al., 2006; Park et al., 2011; Paneth et al., 2006; Johnson et al., 2002; Yam et al., 2006). On the other hand, in developing countries, it can go up to 4.4 in 1000 births (Ozturk et al., 2013; Alimović, 2012; Cruz et al., 2006; Krigger, 2006; Himmelmann, 2006; Liu, 1999; Khandaker et al., 2019) (Figure 1.1.1). The prevalence of CP data across the world is described in Table 1.1.1.

Cerebral palsy (CP) is the most common childhood physical disability (Maenner et al., 2016). Till date, there is no published data specifically on the prevalence of CP in Malaysia. However based on the total registered children with physical disabilities (under 18 years old) released by the department of social welfare Malaysia in 2018 was 23,836 which encompass 0.3% of Malaysia population under 18 years old in 2018. This reflects that the exact number of children affected by CP is significantly high in Malaysia (Department of Social Welfare Malaysia, 2020).

Figure 1.1.1: Prevalence of CP worldwide

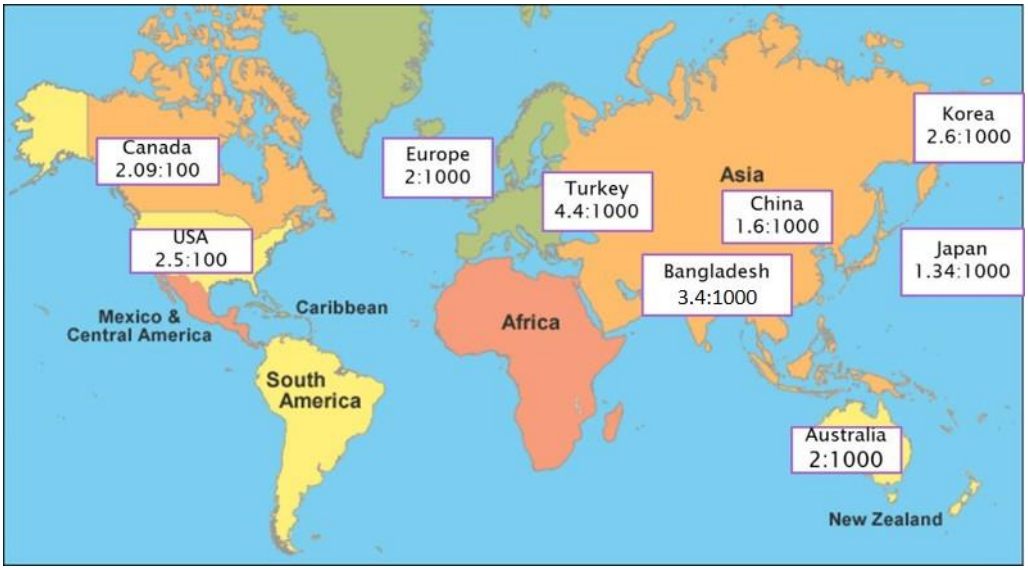

Table 1.1.1: Prevalence of CP per 1000 population according to country

Country	Journal/ Year	Date	Prevalence of CP per 1000
China, Hong Kong	Yam et al., (2006)	2003-2004	1.3
Japan	Paneth et al., (2006)	1977-1991	1.34
China	Liu et al., (1999)	1997	1.6
Sweden	Himmelmann, (2006).	1995-1998	1.92
United Kingdom	Paneth et al., (2006)	1984-1989	2.10
Norway	Odding et al., (2006)	1981-1993	2.214
Iceland	Paneth et al., (2006)	1953-1962	2.28
Australia	Paneth et al., (2006)	1956-1975	2.39
Netherlands	Odding et al., (2006)	1986-1988	2.44
Denmark	Odding et al., (2006)	1987-1991	2.80
United States of America (CDC)	Christensen, (2014)	2013	3.0
Bangladesh	Khandaker et al., (2019)	2014	3.4
Turkey	Ozturk et al., (2013)	2006	4.4

* CDC = Centres for disease control and prevention

1.1.2 Prevalence of Visual Impairment and Refractive Errors in Children with CP

Prevalence of visual disturbances in CP varies depending on the each journal's definitions and specific diagnosis. It has been estimated that ocular disorders such as refractive errors, strabismus, nystagmus, amblyopia, and cortical visual impairment (CVI) are seen in 38%- 92% of the patients with CP (Alimovic, 2012).

1.2 TYPES OF OCULAR DISORDERS IN CHILDREN WITH CP

Over the last half century researchers around the world concluded that visual impairment and refractive error are more common in children with CP. Nevertheless, there is a difference in the rate of visual impairment among the studies. This difference is due to the variation in the selection criteria and the term used to define CP, its subtypes, and ophthalmic problems. However, majority of the studies identified strabismus, refractive error and CVI as the common ophthalmic problems experienced by children with CP (Ozturk et al., 2013; Park et al., 2016; Black, 1982).

Children with CP has higher prevalence of strabismus which ranges between 25.5% to 55% (Marasini et al., 2011; Ozturk et al., 2013; Black, 1982; Katoch et al., 2007; Lew et al., 2015; Pigassou-Albouy and Fleming, 1975). This prevalence is much higher in prevalence compare to healthy children population; which range from 0.6 to 2.56% (Torp-Pedersen et al., 2017; Attada et al., 2016).

A systematic review and meta-analysis of refractive errors across the world according to the WHO regions by Hashemi et al. (2018) showed that the global estimation prevalence of myopia, hyperopia, and astigmatism in general healthy children population is 11.7%, 4.6%, and 14.9% respectively. Ozturk et al. (2013) mentioned that the prevalence of myopia, hyperopia, and astigmatism in children with CP were 39%, 29% and 39% respectively. This indicates that the prevalence of refractive error is higher in children with CP.

Some children with CP are spared from ophthalmic disorder, but are noted to have poor perception performance due to CVI; a visual impairment as a result of the defective function of retrochiasmatic part of visual system. CVI usually occurs in 11-53% among the children with CP (Khetpal and Donahue, 2007; Katoch and Kulkarni, 2007; Marasini, et al., 2011). According to Pennefather and Tin (2000); a detail study on ocular abnormalities associated with CP in premature birth children, the children suffered from CP has a statistical significantly higher risk of CVI occurred and strabismus. Even excluding those children with strabismus associated with cicatricial retinopathy of prematurity or CVI, the prevalence of strabismus was still higher in children with CP as compared to those without CP.

1.2.1 Prevalence of Visual Impairment and Ocular Disorder Among Different Subtypes of CP

Ocular disorders are known to be more common in spastic type compared to the non spastic CP (Park et al., 2016; Black, 1982). Ozturk et al. (2013) found that among the spastic CP, patients who had diagnosed with spastic quadriplegia had statistical significantly lower vision compared to the remaining patients with spastic CP subtypes, while the accommodative esotropia was statistically significantly frequent in CP cases with spastic diplegia.

Porro et al. (2005) mentioned that 54% of children affected by spastic hemiplegia suffer from CVI. Black (1982) revealed that the highest incidence of ocular motility disorder was seen in children with spastic hemiplegia. Only children with spastic type of CP were found to have CVI in this study with the overall rate of 11%. This study also showed that spastic diplegia is a high risk of refractive error and athetoid CP being the least risk. Fantl and Perlstein (1967) revealed that the hypermetropia predominates in the dystonic CP patients.

1.3 PERINATAL FACTORS THAT AFFECT VISUAL IMPAIRMENT

CP is multifactorial with considerable diversity in the aetiology and timing of cerebral damage (Stanley, 1994). Causative factors can be categorised as prenatally, perinatally and postnatally acquired. Prenatal risk factors include intrauterine infection (chorioamnionitis) and prematurity. Preterm babies who were born with very low-birthweight and with a neonatal history of sepsis, has a higher

risk of developing CP by approximately 4-fold. Perinatal risk factors for CP are: neonatal convulsions, birth asphyxia, instrument assisted delivery, neonatal jaundice, antepartum haemorrhage, and neonatal infection. There is a strong association between Low Apgar scores at 5, 10 and 20 min and development of CP (Odding et al., 2006).

Among the children with CP, perinatal asphyxia is reported as the most common aetiology of CVI (35.7%-60.8%). The premature children with CP also has a high prevalence of severe visual loss (16.7%-54.1%) (Ozturk at al., 2013; Khetpal and Donahue, 2007; Pennefather and Tin, 2000). Other causes of CVI in children with CP are hydrocephalus (19%), congenital structural abnormalities such as corpus callosum agenesis, lissencephaly, porencephalic cyst, Chiari (11%), seizure associated brain damage (10%), meningitis (9%), encephalitis (6%), head trauma (4%), shaken baby syndrome (7%), hypoglycemic episode (1%), and genetic disorders or congenital infections (5%) (Khetpal and Donahue, 2007).

Black (1982) concluded that children who acquired CP after the perinatal period half had significant refractive errors, and the overall incidence of refractive error in this group was exactly 50%, higher than in other series. Ozturk et al. (2013) from Turkey noted that among the 194 children with spastic CP, children with the spastic diplegia caused by prematurity were reported to have much higher frequency of strabismus and refractive errors.

Pennefather and Tin (2000) highlighted the correlations between prematurity and strabismus among CP patients. The study revealed that patients with CP who were

born prematurely recorded a higher prevalence of strabismus (51.8%) comparing to the premature birth children without CP (8.3%). Lower gestational age and birth weight in prematurity birth were found as an aetiological factor for increasing risk of strabismus and especially esotropia which was also mentioned in literatures (Ghasia et al., 2008; Katoch et al., 2007).

1.4 DATA COLLECTION WITH KEY INFORMANT SAMPLING METHOD

Key Informant Method (KIM) is a method of obtaining data from persons whose professional and/or organizational roles imply that they have knowledge of specific characteristics of the population being studied as well as potential pathways and constraints for community change (Warheit et al., 1978; Von Korff et al., 1992).

Key Informants (KI) are observant, reflective members of the community of interest who are knowledgeable about the culture and are both able and willing to share their knowledge. (Bernard, 2002). The KI selected for this study were the head villagers in the areas selected for this study. These village heads are the prominent figures in that villages and have knowledge of families whose children are CPs. The identified children by KI were invited to attend an ophthalmic screening and recruited for the study.

The KIM has been used to conduct studies regarding community health. Khandaker et al. (2019) implemented the KIM to develop a population-based surveillance database called Bangladesh CP registry. KIs were trained to identify and recruit the children with CP, living in a geographically defined area in a northern sub-district

of Bangladesh with a known denominator population. The recruited family with children with CP were given dates and venues of the medical assessment camps, which were conducted regularly in the study area.

Full systemic examination was perform by multidisciplinary comprised of paediatrician, physiotherapist, and counsellor in the medical assessment camp. The authors found that there was a significantly higher prevalence of intellectual impairment (eg: visual, hearing, speech and intellectual) among their cohort compared to their national data. Hence, this study postulated that their national data for the prevalence of intellectual impairment in CP was not representative of the true burden of CP in the nation. The authors also found that this method is cost effective and innovative in conducting such community based study.

1.5 RATIONALE OF THE STUDY

The aim of this study is to provide the first national eye study that adopt the KIM, thus to determine the prevalence of visual impairment, refractive error and factors affecting visual impairment in children with CP. This study aim to provide insights for clinicians in managing visual disability in patients with CP. Early intervention is useful in correcting the underlying deficit (refractive error, amblyopia, strabismus) which might have an additional effect on patients' functional dependence.

CHAPTER 2: OBJECTIVES

2.1 GENERAL OBJECTIVE

To determine the prevalence of visual impairment and refractive error and evaluate factors affecting visual impairment in CP children in Malaysia.

2.2 SPECIFIC OBJECTIVES

2.2.1 To determine the prevalence of visual impairment in children with CP.

2.2.2 To determine the prevalence of refractive error in children with CP.

2.2.3 To determine the factors affecting visual impairment in children with CP.

2.3 RESEARCH QUESTION

2.3.1 What was the prevalence of visual impairment in Malaysian children with CP?

2.3.2 What was the prevalence of refractive errors in Malaysian children with CP?

2.3.3 What were the factors associated with visual impairment in CP children in Malaysia?

CHAPTER 3: RESEARCH METHODOLOGY

3.1 STUDY DESIGN

Cross sectional study

3.2 STUDY LOCATION

Three states selected for which were Kelantan, Johor and Sarawak by the Universiti Sains Malaysia (USM) Cerebral Palsy Research Cluster (CPRC) according to their economic performance which was the gross domestic product (GDP) growth in year of 2016. The details concerning the selection of location is described in 3.14.1.

3.3 STUDY DURATION

From November 2017 till May 2020

3.4 STUDY REFERENCE POPULATION

All children with CP in Malaysia that attended the eye screenings.

3.5 STUDY POPULATION

Children with CP in Malaysia that attended the eye screenings.

3.6 SAMPLING FRAME AND SAMPLING UNIT

Children with CP aged ranged 2 to 17 years old, a total of 168 patients were recruited.

3.7 SAMPLE SIZE CALCULATION

3.7.1 Objective 1: To determine the prevalence of refractive error in Malaysian children with CP.

- Using Single Proportion Method and reference from Kozeis et al, 2007.
    - Proportion (p) = 62.9%
    - Precision (□) = 7.7%
    - Significant level (α) = 0.05
    - Drop-out = 10%
    - Sample size = 152
    - Corrected sample size = 169

3.7.2 Objective 2: To determine prevalence of visual impairment in children with CP.

- Using Single Proportion Formula and reference from Ozturk et al, 2013
    - Proportion (p) = 78.9%
    - Precision (□) = 6.5%
    - Significant level (α) = 0.05
    - Drop-out = 10%
    - Sample size = 152
    - Corrected sample size = 169

3.7.3 Objective 3: To determine the factors affecting visual impairment in children with CP.

- Using Cohen's guideline (1992) and medium effect size for multiple logistic regression

  - Power = 0.8
  - Significant level (α) = 0.05
  - Drop-out = 10%
  - Sample size = 84
  - Corrected sample size = 92

This study has recruited 168 patients which met the sample size calculation

3.8 SAMPLING METHOD

1. Three states were selected by CPRC based on their economic performance and GDP growth in the year of 2016.
2. A designated districts were selected within the states, the coverage area depended on the population's density, logistic and transportation accessibility for the participant to attend the health seeing camp.
3. By adopting KIM, the CPRC identified the KIs which were the head villagers live in the areas who are the prominent figures in that villages and have knowledge of families with children with CP.

3.9 DEFINITION OF TERM

3.9.1 Children

- According to Article of The United Nations Convention Rights of the Child (20 November 1989) "..... a child mean every human being below the age of eighteen years ....." (Buere 1998)

3.9.2 Cerebral Palsy

- CP is an abnormal pattern of movement or posture caused by a non-progressive brain injury or malformation that occurs while the child's brain is under development (Cans et al., 2007).

3.9.3 Visual Impairment

- Visual impairment is a reduction in vision from worse than 6/18 to non light perception that cannot be corrected with standard glasses or contact lenses according to the International Classification of Diseases (ICD) 2018.

3.9.4 Refractive Error

- A refractive error in which rays of light entering the eye parallel to the optic axis are brought to a focus falls outside of the retina according to the ICD 2020.

3.9.5 Significant refractive error

- Significant refractive error is spherical equivalent of +2.25 dioptres or more, or −2.25 dioptres or less, or astigmatism of 1.0 dioptre or more were defined to be clinically significant hyperopia, myopia and astigmatism, respectively.

3.10 SELECTION CRITERIA

3.10.1 Inclusion Criteria

- Children diagnosed with CP
- Aged 2 - 17 years old.

3.10.2 Exclusion Criteria

- Parents refuse for eye examination or follow up.

3.11 ETHICAL APPROVAL

- The ethical approval for this study was obtained from The Research and Ethics Committee, School of Medical Sciences, Universiti Sains Malaysia and consistent with the tenets of the Declaration of Helsinki.

- The approval (USM/JEPeM/1707347) which was dated on 7th November 2017 lasted for a year and ended in December 2017. Nevertheless, the extension of the study was permitted till 6th November 2018 (refer Appendix B & C).

3.12 FINANCIAL SUPPORT

- The study received financial support from RU Top Down.
- Grant number: 1001.CSKK.870020

3.13 RESEARCH TOOLS

- Snellen Chart for distance (Reichert, NY, USA)
- Kay pictures
- Cardiff cards
- Refraction set
- Occluder
- Binocular indirect ophthalmoscope (BIO) with 20D and 30D lens (Volk)
- Tonopen
- Portable slit lamp

3.14 DETAILS OF METHODOLOGY

3.14.1 Selection of Location

Three states were selected by CPRC based on the GDP growth in 2016; the high GDP growth state was Johor (5.7%), the moderate GDP growth state was Kelantan (4.8%), and the low GDP state was Sarawak (2.3%).

3.14.2 Selection of Coverage Area

Designated areas range from 5-7 kilometres in radius were selected within the selected states depending on the logistic and transportation accessibility for the participants to attend the health seeing camp.

3.14.3 Selection And Training of KI

The amount of KIs were decided based on the population density. The population density in Johor was 174 per kilometre square, Kelantan was 97 per kilometre square and Sarawak was 19 per kilometre square. The CPRC then selected a total number of KI selected in Johor was 32, Kelantan was 102, and Sarawak was 129.

Through the help of the local authorities, the head of villages were contacted and were invited to be volunteer KIs. They were then given one day course of training to understand and be able to identify children with disabilities (Figure 3.8). KIs were then given two months duration to recruit these children to attend the health screening camp on the designated date.

Figure 3.14.3: Training courses organised by the CPRC to train the KIs.

3.14.4 Health Camps for Children with CP

The health camps consisted of multiple subspecialty stations which include paediatrics, dentistry, rehabilitation, speech therapy, otorhinolaryngology and ophthalmology stations. Children and parents that attended the health camp were first given the information forms and written consent were obtained from guardians of these children. These children with the company of their parents were arranged to attend each stations. Children were given full systemic examinations by each stations with expertise in their own subspecialty. The diagnosis of CP and its subtypes were made by the paediatrician team.

All children that attended the ophthalmology station were given full ophthalmic examination. Children with CP were identified and selected for our study according to inclusion and exclusion criteria.

Figure 3.14.4: Briefing sessions with the healthcare staffs for the health camp screening.

3.14.5 Demographic Data, Systemic History, Ocular History and Ocular Examination

Patients' particulars and socio-demographic data were first obtained. Then antenatal, perinatal and postnatal history including the cause of CP were obtained from parents during the history taking. The subtypes of CP were identified and diagnosed by the paediatric team. The participants were then underwent an ophthalmology screening which include visual acuity, cover test, refraction, anterior segment examination and funduscopic examination. All these collected information were collected in a data collection sheet (refer Appendix

A). Children with visual impairments or refractive errors were referred to the nearest hospital with ophthalmologist for further management.

3.14.6 Visual Acuity

The distant visual acuity was tested with a Snellen chart; in which, a monocular vision was assessed at 6 metres distance. The younger children's visual acuity were measured monocularly using Kay pictures or Cardiff cards (Figure 3.14.7).

Figure 3.14.6: Assessment of visual acuity using Snellen Charts.

3.14.7 Cover Test

The participants were first examined at primary gaze. A cover test was performed by using an occluder to occlude his/ her eyes monocularly while the participants looked at far distance of 6 metres and at near distance of 30 centimetres.

3.14.8 Refraction

Refraction was carried out using manifest refraction by trained optometrists. Cycloplegic refraction was performed if indicated.

Figure 3.14.8: Refraction by trained optometrist

3.14.9 Anterior Segment Examination

An anterior segment examination were performed using a portable slit lamp examination.

3.14.10 Fundus Examination

Dilating drops such as Tropicamide 1% and Phenylephrine 2.5% were instilled for proper fundus assessment. The examination was done by the principle investigator using BIO with the +20D and +30D condensing lenses (Figure 3.14.10).

Figure 3.14.10: Fundusopy examination using BIO

3.15 VARIABLES

1. Independent Variables:
    a. Spastic monoplegia
    b. Spastic diplegia
    c. Spastic hemiplegia
    d. Spastic quadriplegia
    e. Non spastic type dystonia
    f. Non spastic type ataxia
    g. Non spastic type choreoathetoid

2. Dependent Variables
    a. Based on specific objectives 1
        - Emmetropia
        - Myopia
        - Hyperopia
        - Stigmatism

    b. Based on specific objective 2
        - Strabismus
            - Esotropia
            - Exotropia