Visual impairment and amblyopia in Malaysian pre-school children - The SEGPAEDS study

Fiona Chew Lee Min, MS Ophthal[1], Lakana Kumar Thavaratnam, MS Ophthal[2], Intan Nor Chahaya Bt Shukor, MRCPCH[3], Sunder Ramasamy, FRCS[2], Jamalia Rahmat, MS Ophthal[2], Daniel D Reidpath, PhD[4], Pascale Allotey, PhD[4], Joseph Alagaratnam, MS Ophthal[2]

[1]Department of Ophthalmology, Hospital Selayang, Selangor, Malaysia, [2] Department of Ophthalmology, Hospital Kuala Lumpur, Kuala Lumpur, Malaysia, [3] Department of Paediatrics, Hospital Segamat, Johor, Malaysia, [4] South East Asia Community Observatory (SEACO), Monash University Malaysia, Bandar Sunway, Malaysia

ABSTRACT

Introduction: Little is known regarding the extent of visual impairment amongst pre-school children in Malaysia.

Objective: To determine the prevalence of visual impairment and amblyopia in Malaysian preschool children.

Methodology: A cross-sectional, population-based study was conducted on children aged four to six years from 51 participating kindergartens in the district of Segamat, Johor, Malaysia from 20 March 2016 to 6 April 2016. All subjects had initial eye screening consisting of LogMar visual acuity, orthoptics examination and Spot vision screener assessment. Subjects who failed the initial eye screening were invited for a formal eye assessment consisting of cycloplegic refraction and a comprehensive ocular examination. Definitions of visual impairment and amblyopia were based on the Multi-Ethnic Pediatric Eye Disease Study criteria.

Results: A total of 1287 children were recruited. Mean subject age was 5.03 (SD:0.77) and males represented 52.3% of subjects. Subjects by ethnicity were Malay (54.8%), Chinese (27.7%), Indian (15.6%) and Orang Asli (1.9%). Formal eye assessment was required for 221 subjects and 88.8% required ophthalmic intervention. Refractive error, representing 95.4% of diagnosed ocular disorders, comprised of astigmatism (84%), myopia (9%) and hypermetropia (6.9%). With-the-rule astigmatism was present in 93.4% of the subjects with astigmatism. Visual impairment was present in 12.5% of our subjects, with 61% having bilateral visual impairment. Of the subjects with visual impairment, 59.1% had moderate visual impairment. The prevalence of amblyopia was 7.53%, and 66% of the amblyopic subjects had bilateral amblyopia.

Conclusion: Our study highlights an urgent need for initiation of preschool vision screening in Malaysia.

KEY WORDS:
Preschool, visual impairment, amblyopia, children

INTRODUCTION

Vision screening in children is challenging, limited by the child's attention span, cooperation and understanding. Though many studies have been done for school-going children, there is no global consensus on the ideal age and frequency of preschool children vision screening.[1,2] In the United States, the US Preventive Services Task Force recommends a minimum of one vision screening for children aged between three to five years old.[3] European countries commence vision screening as early as three to four years of age, whilst in Singapore, school-based screening starts at four to five years of age.[4]

There is currently no national vision screening programme for preschool children in Malaysia and limited data exists regarding the extent of visual impairment in Malaysian preschool children.[5-7] Hence, our study aimed to conduct a large, multi-ethnic survey to determine the prevalence of visual impairment (VI) and amblyopia in Malaysian preschool children.

MATERIALS AND METHODS

This population-based, cross-sectional study was conducted in the district of Segamat located in the state of Johor, Malaysia. Data collection commenced from 20 March 2016 to 6 April 2016. This research adhered to the tenets of the Declaration of Helsinki, and Institutional Review Board (IRB)/Ethics Committee approval was obtained from the Medical Research and Ethics Committee of the Malaysian Ministry of Health (NMRR ID NMRR-14-1465-22033).

Kindergartens in the five sub-districts of Segamat (Sungai Segamat, Bekok, Chaah, Jabi and Gemereh) were invited to participate in the study. All children from participating kindergartens were screened at their respective kindergartens and recruited as study subjects if they were four to six years of age and were able to perform either visual acuity (VA) or photorefraction screening. Subjects unable to perform VA testing would be excluded if they were unable to perform photorefraction screening. Subjects were divided into three age groups, which were the four- year old, five- year old and six- year old group.

All subjects had VA, orthoptics and photorefraction screening. Monocular VA of both eyes was assessed at 3 meters using retroilluminated ETDRS format minimum angle of resolution (LogMAR) charts (Wehen Vision, Guang Zhou, CN). Orthoptic screening included Hirschberg reflex and

This article was accepted: 25 December 2017
Corresponding Author: Fiona Chew Lee Min
Email: sabrefmin@gmail.com

extra-ocular movements. Subjects with VA worse than 0.2 LogMar units in either eye would have repeated VA screening at the end of the screening session by a different examiner. Photorefraction was done in a dimly lit room using Spot Vision Screener (Welch Allyn, Skaneateles Falls, NY)(Version 3.0.04.02)(Spot) in accordance with methods previously described.[8,9] Subjects wearing spectacles were instructed to use the spectacles for all tests except for Spot assessment.

Subjects would be discharged if they had a VA of 0.2 LogMar units or better in both eyes, a normal orthoptics assessment and a Spot result of 'all measurements within range'. Subjects who were unable to do visual acuity assessment would be discharged if they had a normal orthoptics and Spot assessment. Subjects were referred for formal eye assessment if they had visual impairment (VI) as defined by the Multi-Ethnic Pediatric Eye Disease Study (MEPEDS) criteria, a Spot result of 'complete eye examination recommended' and if any other ocular abnormalities were noted.[10]

Formal eye assessment at designated health clinics comprised of cycloplegic refraction using streak retinoscopy (Welch-Allyn, Skaneateles, NY) and a complete ophthalmic examination with the binocular indirect ophthalmoscope and 30- Dioptre lenses. Cycloplegic pupillary dilatation was achieved by instillation of cyclopentolate hydrochloride 1% (Cyclogyl) three times, at five-minute intervals. The refractive error thought to be most amblyogenic, was chosen as the main refractive error. Spectacles, when necessary, would be prescribed and ocular anomalies diagnosed would be referred to Hospital Segamat for further management.

VI and amblyopia were defined according to the MEPEDS criteria.[10] VA of 0.25LogMar units or worse was classified as mild VI. VA of better than 1.0LogMar units but worse or equal to 0.25LogMar units was noted as moderate VI. VA of 1.00LogMar units or worse was stated as severe VI. Subjects' mean values of VA, sphere, cylinder, axis and spherical equivalent (SE) of the right eyes (RE) were taken for analysis. A subject with VI in either eye was classified as having VI and the extent of visual impairment was based on the VI of the worse eye.

Unilateral amblyopia was diagnosed there was inter-ocular difference of 2 lines in best presenting VA in addition to one of the following: (a) strabismus (b) anisometropia consistent with the worse eye (-1.00D SE anisohypermetropia, -3.00D anisomyopia or -1.50D anisoastigmatism) (c) apparent visual axis obstruction for at least one week.[10] A subject with bilateral decreased best presenting VA was diagnosed with bilateral amblyopia if the subject had the corresponding history of obstruction of both visual axis or significant ametropia of both eyes (+4.00D hypermetropia, -6.00D myopia or 2.50D astigmatism).[10]

Sample size calculation of 1066 children was done using Creative Research Systems Sample Size calculator with a confidence level of 95%, a confidence interval of 3.0, a percentage of 50% and a population of 1091000 (based on the 2013 population of children in Johor).[11] Data were analyzed using SPSS version 13 (SPSS Statistics: Windows StudentVersion 13, Chicago, IL). One-way ANOVA was used to calculate means and multinomial logistic regression calculated odds ratio (OR) and confidence intervals (CI). A p value of <0.05 was taken as statistically significant.

RESULTS

A total of 51 kindergartens agreed for study participation. Seven children were excluded as they refused VA and were uncooperative for Spot assessment. The final subject tally was 1287 children (subject response rate 99.2%). Males represented 52.3% (673/1287) of subjects and mean subject age was 5.03 years (standard deviation, SD:0.77). Subjects were of Malay (54.8%), Chinese (27.7%), Indian (15.6%) and Orang Asli (Aboriginal Malays) (1.9%) descent. The four-year old group had less proportion of Malay (p=0.013) and Indian (p=0.001) subjects in comparison to the older age groups. Most subjects, 95.2% (1226/1287) did not have any medical illness (Table I).

VA testing was performed on 1270 (98.7%) subjects. The 6-year olds had better VA than 5- year olds (p=0.001) and five -year olds had better VA than four- year old subjects (p=0.003). Spot screening was successful in 1278 (99.3%) subjects. There was no significant difference between the spherical power, cylinder or spherical equivalent between the three age groups. The four-year olds had more oblique astigmatism (p=0.003), less with-the-rule astigmatism (p=0.001) and less anisometropia (p=0.048) in comparison to the older age groups (Table II).

VI was present in 12.5% (159/1270) of subjects, with 61% (95/159) having bilateral VI and 59.1% (94/159) having moderate VI. Bilateral VI was more common in 4-year olds compared to the older age groups (p=0.012). None of our subjects had VA of less than 1.0LogMar units. The prevalence of amblyopia was 7.53% (97/1287) and 66% (64/97) of the amblyopic subjects had bilateral amblyopia. There was no statistical difference between groups for the prevalence of amblyopia and visual impairment.

Formal eye assessment was required for 17.2% (221/1287) of subjects and 23.1% (51/221) of those subjects defaulted their formal eye assessment. Ophthalmic management was required in 88.8% (151/170) of formal eye assessment subjects. Of these subjects, 95.4% (144/151) had refractive error while 7 subjects had other diagnosis (2 partial nasolacrimal duct obstruction, 1 allergic conjunctivitis, 2 intermittent alternating exotropia, 1 constant esotropia and 1 suspected visual field defects). Aside from the subject with suspected visual field defects, the rest of the ocular conditions were potentially amenable to treatment (99.3%) (Table III).

Significant astigmatism was documented in 84% (121/144) subjects, where 93.4% (113/121) had with-the-rule astigmatism. The older age groups had significantly more astigmatism in comparison to the 4-year old group (p=0.002). Myopia (9%,13/144) and hypermetropia (6.9%,10/144) were less common in all groups. There was no significant difference between myopia and hypermetropia in all age groups (Table IV).

Table I: Demographic details of study subjects

n=1287	4-year old	5-year old	6-year old	CI	OR	p
Gender						
Male	187(21.7%)	277(32.2%)	209(24.3%)			
Female	176(28.7%)	244(39.7%)	194(31.6%)	-0.241, 0.165	-0.038	0.713
Ethnicity						
Malay	172(24.4%)	306(43.4%)	227(32.2%)	-0.226, 1.111	0.443	0.195
Chinese	155(43.5%)	116(32.6%)	85(23.9%)	-1.228, 0.407	-0.365	0.407
Indian	28(13.9%)	87(43.3%)	86(42.8%)	-0.053, 1.684	0.815	0.066
Orang Asli	8(32.0%)	12(48.0%)	5(20.0%)	-0.873, 0.210	-0.331	0.230
Medical illness						
Yes	21(34.4%)	20(32.8%)	20(32.8%)			
No	342(27.9%)	501(40.9%)	383(31.2%)	-0.574, 0.804	0.115	0.743

CI, 95% confidence interval; OR, odds ratio; the percentages in the brackets represent the proportion of the variable to the study population

Table II: Dry Spot autorefraction of study subjects

n =1287	4-year old	5-year old	6-year old	CI	OR	p
VA RE (LogMar)	0.18(SD: 0.10)	0.16(SD: 0.12)	0.13(SD:0.11)	-2.652, -0.704	-1.678	0.001
Mean sphere RE (DS)	0.70(SD: 2.65)	0.60(SD: 0.61)	0.60(SD:0.54)	-0.021, 0.390	0.009	0.561
Mean cylinder RE (DC)	-0.78(SD: 0.66)	-0.54(SD: 8.29)	-0.37(SD:9.07)	-0.056, 0.093	0.019	0.623
Cylinder Axis RE						
With the rule	243	377	316	-0.001, 0.002	0.001	0.336
Against the rule	40	56	31	-0.089, 0.382	0.147	0.644
Oblique	80	88	56	-0.382, 0.089	-0.147	0.222
Mean SE RE (DS)	0.17(SD: 0.49)	0.21(SD: 0.58)	0.18(SD: 0.49)	-0.355, 0.002	-0.179	0.047
Anisometropia						
Yes	5	19	14			
No	358	502	389	-0.725, 0.606	-0.06	0.861

CI, 95% confidence interval; OR, odds ratio; VA, visual acuity; RE, right eye; SD, standard deviation

Table III: Visual impairment and amblyopia among study subjects

n=1287	4-year old	5-year old	6-year old	CI	OR	p
Formal assessment						
Yes	65(28.0%)	89(38.4%)	78(33.6%)			
No	298(23.2%)	432(40.9%)	325(30.8%)	-1.020,1.147	0.063	0.909
VI present						
Yes	44(27.7%)	64(40.3%)	51(32.1%)			
No	308(27.7%)	452(40.7%)	351(31.6%)			
Unable to do VA screening	11(64.7%)	5(29.4%)	1(5.9%)	-1.483,2.964	0.741	0.514
VI laterality (n=159)						
Unilateral	10(16.1%)	28(45.2%)	24(38.7%)			
Bilateral	34(35.1%)	37(38.1%)	26(26.8%)	-3.469,1.786	-0.842	0.530
Type of VI (n=159)						
Mild	17(27.4%)	24(38.7%)	21(33.9%)			
Moderate	25(26.6%)	40(42.6%)	29(30.9%)			
Severe	1(33.3%)	1(33.3%)	1(33.3%)			
VI prevalence (%)	12.1	12.3	12.7			
Amblyopia						
Yes	19(19.6%)	44(45.4%)	34(35.1%)			
No	327(28.7%)	461(40.5%)	350(30.8%)	-1.980,0.018	-0.918	0.054
Amblyopia prevalence (%)	5.23	8.45	8.44			
Amblyopia laterality (n=97)						
Unilateral	4(11.8%)	17(50.0%)	13(38.2%)			
Bilateral	15(19.0%)	27(34.2%)	22(27.8%)	-1.080,4.058	1.483	0.256

CI, 95% confidence interval; OR, odds ratio; VI, visual impairment; VA, visual acuity

Table IV: Cycloplegic refraction and ocular findings in formal eye assessment subjects

n=170	4-year old	5-year old	6-year old	CI	OR	p
Mean sphere RE (DS)	2.11(SD: 12.55)	0.58(SD: 1.26)	0.53(SD: 1.11)			0.307
Mean cylinder RE (DC)	-0.93(SD: 0.97)	-1.16(SD: 0.97)	-1.19(SD: 1.08)			0.266
Mean SE RE (DS)	0.07(SD: 0.70)	0.00(SD: 1.19)	-0.07(SD: 1.09)			0.719
Astigmatism (n=121)	28(23.1%)	47(38.8%)	46(38.0%)	0.033,0.463	0.123	0.002
With-the-rule	26(23.0%)	44(38.9%)	43(38.1%)	0.142,5.793	0.907	0.918
Against-the-rule	2(25%)	3(37.5%)	3(37.5%)	0.196,5.352	1.023	0.978
Myopia (n=13)	2(15.4%)	8(61.5%)	3(23.1%)	0.015,1.176	0.133	0.070
Hypermetropia (n=10)	2(20.0%)	2(20.0%)	6(60.0%)	0.020,2.033	0.200	0.174
Diagnosis (n=151)						
Refractive error	33(22.9%)	59(41.0%)	52(36.1%)			
Exotropia	0	1	1	-3.783, -0.416	-2.144	0.015
Esotropia	1	0	0			
Allergic conjunctivitis	0	1	0			
NLDO	0	1	1			

CI, 95% confidence interval; OR, odds ratio; RE, right eye; SD, standard deviation; SE, spherical equivalent; NLDO, nasolacrimal duct obstruction

Table V: Subjects visual acuity and dry Spot auto-refraction based on ethnicity

n=1287	Malay	Chinese	Indian	Orang Asli	CI	OR	p
RE VA (LogMar)	0.15(SD:0.12)	0.16(SD:0.11) 0.483	0.14(SD: 0.10)	0.23(SD:0.19)	-2.733,1.292	-0.720	
Mean sphere RE (DS)	0.63(SD:0.55)	0.67(SD:2.69)	0.57(SD:0.56)	0.40(SD:0.41)	-0.033,0.240	0.104	0.136
Mean cylinder RE (DC)	-0.33(SD:9.88)	-0.84(SD:0.72)	-0.82(SD:0.63)	-0.82(SD:0.94)	-0.026,0.069	0.022	0.371
Mean axis RE (Degrees)	80.34(SD:73.16)	79.98(SD:71.14)	69.56(SD:68.50)	69.08(SD:69.06)	-0.002,0.003	0.001	0.831
Mean SE RE (DS)	0.24(SD:0.49)	0.12(SD:0.56)	0.16(SD:0.57)	-0.01(SD:0.56)	-0.695,0.117	-0.406	0.006
VI							
Yes	82(51.6%)	48(30.2%)	23(14.5%)	6(3.8%)			
No	614(55.3%)	300(2.7%)	178(16.0%)	19(1.7%)	-2.830,3.740	0.455	0.786
VI prevalence	11.8%	13.8%	16.4%	11.4%			
Anisometropia							
Yes	22(57.9%)	10(26.3%)	5(13.2%)	1(2.6%)	-0.720,1.079	0.155	0.743
No	683(54.7%)	346(27.7%)	196(15.7%)	24(1.9%)			
Amblyopia							
Yes	51(52.6%)	24(24.7%)	17(17.5%)	5(5.2%)			
No	630(55.3%)	311(27.3%)	179(15.7%)	20(1.8%)	-0.529,1.281	0.376	0.415
Amblyopia prevalence	7.23%	6.74%	8.46%	20.0%			

CI, 95% confidence interval; OR, odds ratio; RE, right eye; VA, visual acuity: SD, standard deviation; SE, spherical equivalent; VI, visual impairment

Orang Asli subjects had worse presenting VA (p=0.007), had more myopic spherical equivalent (p=0.001) and higher amblyopia prevalence (p=0.030) in comparison to other ethnicities. VI prevalence was similar in all ethnicities. There was no significant difference between the prevalence of anisometropia between all ethnicities (Table V).

DISCUSSION

The population of Malaysia is estimated to be 28.334 million, with 17.2% of the population aged nine years and below.[12] The 4 major Malaysia ethnicities are Malay (50.4%), Chinese (24.6%), Indian (7.1%) and Orang Asli (11%).[12] Our study had good representation of all races with a slightly lower proportion of Orang Asli. This was expected as our study was conducted in Peninsular Malaysia whereas Orang Asli predominates in East Malaysia.

Our study used Spot as it was lightweight, portable and had a sensitivity of 89.0% to 93.8% and specificity of 88.0% to 92.9% for amblyopia risk factors.[8,9] Our subject Spot response rate was higher compared to VA response rate (99.3% vs. 98.7%). This confirmed the observation that instrument-based vision screening by trained personnel was faster and easier to perform than visual acuity testing, especially in young children.[13] We noted that older children had better presenting VA. This was consistent with the development of linguistic neural pathways in children, which improved with age.[16]

Out of the 221 subjects who came for formal eye assessment, 88.8% required treatment and 99.3% of the ocular conditions diagnosed were potentially treatable. This highlighted the need for early detection of ocular risk factors in preschool children to prevent the development of amblyopia. Our formal eye assessment default rate of 23.1% exposed potential barriers to ophthalmic care, which were beyond the scope of our study.

Astigmatism represented 84% of refractive errors detected in our study, which was higher compared to other literature which reported astigmatism rates of 35% to 72%.[10,17,18] This

could be explained by ethnicity variation as it was noted that South East Asian children had higher rates of astigmatism.[19] Our myopia prevalence of 9% corresponded to previously reported regional rates of preschool children myopia of 8.6%.[20] We had an anisometropia prevalence of 2.8%. This was similar to Lai YH et al's study where the prevalence of anisometropia was 2%.[21] Though our Orang Asli population was small, we noted that Orang Asli subjects had poorer presenting visual acuity, had a spherical equivalent that was more myopic and had a higher prevalence of amblyopia in comparison to other ethnicities. This could be due to socio-economic differences and access to health care as our Orang Asli population lived in very remote areas.

Studies have reported VI to range from 0.038%[22] to 7.5%.[23] Our VI prevalence of 12.5% was higher, with 59.1% of subjects having moderate VI. This differed from the MEPED study where 61% to 80% of the subjects with visual impairment had mild visual impairment.[10] We reported an amblyopia prevalence of 5.23% to 8.44%. This differed from other studies that reported amblyopia to range from 0.8% to 1.9%.[17,18,24] Our higher VI and amblyopia prevalence, though possibly reflective of ethnic differences, emphasized the necessity for preschool vision screening as in comparison to the other countries, Malaysian children only have formal vision assessment at 7 years of age and older.

Limitations of our study were that we did not perform cycloplegic refraction for all subjects and demographic data collected was minimal. Our study, however, is still representative of the Malaysian preschool population as it was a large, population-based study with a good ethnic representation of all Malaysian major races. Furthermore, this study had standardized visual assessments by qualified medical personnel and automated refraction performed for all subjects to look for amblyopia risk factors, which may be undetected by VA screening alone.

CONCLUSION

In summary, our study highlights an urgent need for initiation of preschool vision screening in Malaysia as the majority of the ocular abnormalities detected were potentially treatable. More research also needs to be carried out to ensure that any preschool vision screening will address the potential barriers to ophthalmic care especially in the rural populations in Malaysia.

ACKNOWLEDGMENTS

The authors would like to thank the Director General of the Ministry of Health Malaysia for his kind permission to publish this article.

The authors thank Professor Daniel Reidpath, Professor Pascale Allotey and all staff of SEACO (South East Asia Community Obeservatory) for allowing access and providing logistic support to the preschools in their sub-districts of Segamat, Johor.

FUNDING

This study was supported by a grant from the Malaysian Ministry of Health Research Grant (Grant number: :-00249.) The study sponsor had no involvement in study design; in the collection, analysis and interpretation of data; in the writing of the report; and in the decision to submit the paper for publication.

REFERENCES

1. Xiao O, Morgan IG, Ellwein LB, He M. Prevalence of Amblyopia in School-Aged Children and Variations by Age, Gender, and Ethnicity in a Multi-Country Refractive Error Study. Ophthalmology 2015; 122(9): 1924-31.
2. Aldebasi YH. Prevalence of correctable visual impairment in primary school children in Qassim Province, Saudi Arabia. J Optom 2014; 7(3): 168-76.
3. US Preventive Services Task Force. Vision screening for children 1 to 5 years of age: US Preventive Services Task Force Recommendation statement. Pediatrics 2011; 127(2): 340-346.
4. Solebo AL, Cumberland PM, Rahi JS. Whole-population vision screening in children aged 4–5 years to detect amblyopia. Lancet 2015; 385(9984): 2308-19.
5. Nurul FAB, Chen AH, Abdul RMN, Goh PP. Pilot Study: A Review of Personnel Involved in School Vision Screening and the Training Module in Betong, Malaysia. International Medical Journal Malaysia 2012; 11(2): 23-7.
6. Hussin DA, Omar R, Knight VF. Causes of visual impairment among Pre-school Children in Sitiawan District, Perak, Malaysia. Sains Malays 2009; 38(6): 959-64.
7. Premsenthil M, Manju R, Thanaraj A et al. The screening of visual impairment among preschool children in an urban population in Malaysia; the Kuching pediatric eye study: a cross sectional study. BMC Ophthalmol 2013;13:16. [Cited May 2016] Available from: www.biomedcentral.com/1471-2415/13/16
8. Garry GA and Donahue SP. Validation of Spot screening device for amblyopia risk factors. J AAPOS 2014; 18(5): 476-80.
9. Mendez M, Arguello L, Martinez J, Salas Vargas M, Alvarado Rodriguez AM, Papa CE et al. Evaluation of the Spot Vision Screener in young children in Costa Rica. J AAPOS 2015; 19(5): 441-4.
10. Multi-Ethnic Pediatric Eye Disease Study (MEPEDS) Group. Prevalence and Causes of Visual Impairment in African-American and Hispanic Preschool Children: the Multi-Ethnic Pediatric Eye Disease Study. Ophthalmology 2009; 116(10): 1990–2000.
11. United Nations Children's Fund (UNICEF). Economic planning unit. Prime Minister's Department, Malaysia. Profile of Children in Malaysia. Implementation of Children's Right with Equity. November 2013. Page 10. [Cited January 2016] Available from: www.unicef.org/malaysia/Unicef-ProfileOfChildrenInMalaysia
12. Department of Statistics Malaysia. Population Distribution and Basic Demographic Characteristic Report 2010 (Updated: 05/08/2011).[Cited Jan 2016] Available from: www.statistics.gov.my/index.php?r=column/ctheme&menu_id=L0pheU43NWJwRWVSZklWdzQ4TlhUUT09&bul_id=MDMxdHZjWTk1SjFzTzNkRXYzcVZjdz09
13. Miller JM, Lessin HR, American Academy of Pediatrics Section on Ophthalmology, Committee on Practice and Ambulatory Medicine, American Academy of Ophthalmology, American Association for Pediatric Ophthalmology and Strabismus, American Association of Certified Orthoptists. Instrument-Based Pediatric Vision Screening Policy Statement. Pediatrics 2012; 130(5): 983-6.
14. Donahue SP, Arthur B, Neely DE et al. Guidelines for automated preschool vision screening: A 10-year, evidence-based update. J AAPOS 2013; 17(1): 4-8.
15. Dye MWG, Bavelier D. Differential development of visual attention skills in school-age children. Vis Res 2010;50(4): 452–9.
16. Siéroff E, Riva M. Attention and the identification of parafoveal words in school-age children and adults. J Neurolinguist 2011; 24(4): 420-34.
17. Pai ASI, Wang JJ. Prevalence and Risk Factors for Visual Impairment in Preschool Children. The Sydney Paediatric Eye Disease Study. Ophthalmology 2011; 118(8): 1495–500.
18. Al-Rowaily MA. Prevalence of refractive errors among pre-school children at King Abdulaziz Medical City, Riyadh, Saudi Arabia. Saudi J Ophthalmol 2010; 24(2): 45-8.
19. Huynh SC, Kifley A, Rose KA, Morgan I, Heller GZ, Mitchell P. Astigmatism and Its Components in 6-Year-Old Children. Invest Ophthalmol Vis Sci 2006; 47(1): 55-64.

20. Dirani M, Chan YH, Gazzard G, Hornbeak DM, Leo SW, Selvaraj P et al. Prevalence of Refractive Error in Singaporean Chinese Children: The Strabismus, Amblyopia, and Refractive Error in Young Singaporean Children (STARS) Study. Invest Ophthalmol Vis Sci 2010; 51(3): 1348–55.
21. Lai YH, Tseng HY, Hsu HT, Chang SJ, Wang HZ. Uncorrected Visual Acuity and Noncycloplegic Autorefraction Predict Significant Refractive Errors in Taiwanese Preschool Children. Ophthalmology 2013; 120(2): 271-6.
22. Lu Q, Zheng Y, Sun B, Cui T, Congdon N, Hu A et al. Population-based Study of Visual Impairment Among Pre-school Children in Beijing: The Beijing Study of Visual Impairment in Children. Am J Ophthalmol 2009; 147(6): 1075-81.
23. Mehravaran S, Duarte PB, Brown SI, Mondino BJ, Hendler K, Coleman AL. The UCLA preschool vision program, 2012-2013. J AAPOS 2016; 20(1): 63-7.
24. Tarczy-Hornoch K, Cotter SA, Borchert M, McKean-Cowdin R, Lin J, Wen G, Kim J et al. Prevalence and Causes of Visual Impairment in Asian and Non-Hispanic White Preschool Children. Multi-Ethnic Pediatric Eye Disease Study. Ophthalmology 2013; 120(6): 1220-26.