Original Article

Prevalence of Refractive Error in Malay Primary School Children in Suburban Area of Kota Bharu, Kelantan, Malaysia

Syaratul-Emma Hashim,[1] *MBBS, M Med,* Hui-Ken Tan,[1] *MBBS*, Wan-Hazabbah WH,[1] *MD, M Med*, Mohtar Ibrahim,[1] *MD, MMed*

Abstract

Introduction: Refractive error remains one of the primary causes of visual impairment in children worldwide, and the prevalence of refractive error varies widely. The objective of this study was to determine the prevalence of refractive error and study the possible associated factors inducing refractive error among primary school children of Malay ethnicity in the suburban area of Kota Bharu, Kelantan, Malaysia. Materials and Methods: A school-based cross-sectional study was performed from January to July 2006 by random selection on Standard 1 to Standard 6 students of 10 primary schools in the Kota Bharu district. Visual acuity assessment was measured using logMAR ETDRS chart. Positive predictive value of uncorrected visual acuity equal or worse than 20/40, was used as a cut-off point for further evaluation by automated refraction and retinoscopic refraction. Results: A total of 840 students were enumerated but only 705 were examined. The prevalence of uncorrected visual impairment was seen in 54 (7.7%) children. The main cause of the uncorrected visual impairment was refractive error which contributed to 90.7% of the total, and with 7.0% prevalence for the studied population. Myopia is the most common type of refractive error among children aged 6 to 12 years with prevalence of 5.4%, followed by hyperopia at 1.0% and astigmatism at 0.6%. A significant positive correlation was noted between myopia development with increasing age (P <0.005), more hours spent on reading books (P <0.005) and background history of siblings with glasses (P <0.005) and whose parents are of higher educational level (P <0.005). Malays in suburban Kelantan (5.4%) have the lowest prevalence of myopia compared with Malays in the metropolitan cities of Kuala Lumpur (9.2%) and Singapore (22.1%). Conclusion: The ethnicity-specific prevalence rate of myopia was the lowest among Malays in Kota Bharu, followed by Kuala Lumpur, and is the highest among Singaporean Malays. Better socio-economic factors could have contributed to higher myopia rates in the cities, since the genetic background of these ethnic Malays are similar.

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Key words: Children, Myopia, Refractive error

Introduction

Refractive error remains one of the primary causes of visual impairment in children worldwide.[1-3] Prevalence of visual impairment in children, is defined as uncorrected vision equal to or worse than 20/40, and it varies from as low as 2.72% in South Africa[4] to as high as 15.8% in Chile.[3] To address the issue of blindness in children, the World Health Organisation (WHO) recently launched a global initiative, VISION 2020-The Right to Sight, to eliminate avoidable blindness among children.[5] Myopia is the most common refractive error in children. High myopia is associated with potentially blinding conditions such as retinal tear, retinal detachment, macular degeneration, cataract and glaucoma. The economic costs of correction for myopia with spectacles, contact lens or LASIK in optometry and ophthalmology centres amount to billions of dollars.[6] Therefore, understanding the prevalence and underlying aetiological factors is important to reduce the prevalence of refractive errors.

In children, the prevalence of refractive errors varies widely. Less than 1% prevalence of refractive errors was reported in primary school children in rural Tanzania,[7] 8.1% in Katmandu,[2] 14.8% in Malaysia,[8] 36.7% in Hong Kong,[9] and more than 50% in Singapore.[10] The wide

[1] Department of Ophthalmology, School of Medical Sciences, Health Campus University Sains Malaysia, Kelantan, Malaysia
Address for Correspondence: Dr Hui-Ken Tan, Department of Ophthalmology, School of Medical Sciences, Health Campus, Universiti Sains Malaysia, 16150 Kubang Kerian, Kelantan, Malaysia.
Email: tan_huiken@yahoo.com

variations of reported prevalence of refractive error could be attributed to several factors, including the targeted study population (population-based or school-based), methods of measurement (cycloplegia or non-cycloplegia), ethnicity and definition of terms such as the degrees of myopia, hyperopia and astigmatism.

Refractive error, particularly myopia, is a major issue in Asian countries.[6,11] Furthermore, the prevalence of myopia has also increased among young Asian adult populations, as reported in a longitudinal 13 years study on students aged between 3 and 17 years by Hiroomi Matsumura et al.[12] The progression of myopia was also noted to be more prevalent in older children, and was much higher than those reported in Western countries. In Taiwan, 2 studies involving school children aged 6 to 18 years showed a prevalence of more than 80% by the age of 18.[13] Another study in a Japanese student population showed an overall prevalence of approximately 50%.[14] A study in Hong Kong showed that myopia was not only at its highest prevalence as compared to other countries, but myopia has also occurred in younger age groups.[9]

In Malaysia, studies on refractive error are scare, and these studies were all conducted in the West Coast of Peninsula Malaysia.[8,15,16] In the East Coast of Peninsula Malaysia, a relatively rural area, there has yet to be any reported prevalence of refractive error in children. This study would provide informative figures for better planning in the national health programme, and provide useful data on refractive error among primary school children, specifically in Kota Bharu. This study is in line with the WHO campaign of Vision 2020, where children have the right to good sight.

Materials and Methods

This study was approved by the Research and Ethical Committee, School of Medical Sciences, Universiti Sains Malaysia. Inclusion criteria for this study encompassed all randomly selected primary school Malay children from Standard 1 until Standard 6 in the district of Kota Bharu, and with consent given by parents or guardians. Exclusion criteria included students who were already on ophthalmology follow-up for known ocular conditions, were absent from school on the examination day, refused visual acuity assessment or eye examination, and were inconsistent in visual acuity assessment after 3 attempts.

Sampling Procedure

Sample size was calculated using a single proportion formula. It was calculated to estimate an anticipated 14.8% prevalence of refractive error[8] with 95% confidence interval. The sample size calculated was 840 students with non-respondent rate of 20%. The sample of 840 students was equally distributed among the 6 standards of children. A total of 140 students were randomly selected in each standard.

This study was carried out from January to July 2006, among primary school children in the suburban area of Kota Bharu, Kelantan. In the first stage, a total of 96 registered primary schools were selected from the Education Council list in which 10 schools were randomly selected. The second random selection involved the selection of students. Lists of Standard 1 to Standard 6 students from each selected school were obtained 2 weeks prior to the examination day. Random selection of the students was then carried out by using a simple table of randomisation. Both processes of random selection were performed by an independent observer. Questionnaires were distributed to parents or guardians to obtain information regarding the socio-economic background and family history of refractive errors.

Ocular Examination in Schools

Visual acuity assessments were performed by a trained optometrist. Visual acuity was taken using an alphabetical or tumbling E logMAR ETDRS chart (Fig. 1a). Students who were unable to recognise alphabets were assessed using Tumbling E logMAR charts, while the remaining students were assessed using alphabetical logMAR chart.

Visual acuity assessments (presenting, uncorrected and best-corrected) were done at 3 metres. Students who were assessed by Tumbling E charts were requested to indicate the direction of the E optotype either by pointing with his or her finger, or by calling out the direction. Students who were assessed by alphabetical charts were asked to call out the alphabets shown. The lowest line read successfully was assigned as the visual acuity for the eye undergoing testing. The right eye was tested first followed by the left eye, each time occluding the fellow eye. A pinhole test was carried out if the visual acuity was equal to or worse than 20/40.

Students who were suspected of having refractive errors, using a referral criterion of uncorrected visual acuity equal to or worse than 20/40 (or an equivalent logMAR value of 0.3), was sent for further evaluation using autorefraction (Fig. 1b) and retinoscopy techniques.

Statistical Analysis

Data entry and analysis were implemented by utilising SPSS version 12. In assessing the factors associated with types of refractive errors, these students were divided into 2 groups. The first group (or Level 1) comprised students from Standard 1 to Standard 3, while the second group (or Level 2) comprised students from Standard 4 to Standard 6. Analysis of the sociodemographic factors associated with the types of refractive error was carried out. The

Fig. 1a. Student holding spectacle occluder during visual acuity assessment.

Fig. 1b. Portable handheld autorefractor.

Table 1. Distribution of Visual Impairment (According to Age Group)

Age (y)	No of students with visual impairment	Total no. of students	Prevalence (%)
6	1	55	0.1
7	7	96	1.0
8	4	100	0.6
9	6	127	0.9
10	9	130	1.3
11	10	101	1.4
12	17	96	2.4
Total	54	705	7.7

association of myopia with the level of schooling, parental education, family income or family history of refractive error was investigated using logistic regression.

Results

Response Rate

A total of 840 students were enumerated from the 10 selected schools. Thirty-five were absent from school on the day of examination and 93 students failed to provide their consent forms during the day of screening. Hence, with a 85% response rate (15% non-respondents), a total of 712 students were examined. Seven students, whose visual acuity assessments were unreliable, were excluded from this study. Therefore, 705 students were eligible for this study, with 51.91% male and 48.09% female. All the respondents (100%) were of Malay ethnicity.

Visual Impairment

Visual impairment was detected in at least one eye in 54 students, giving a 7.7% prevalence in our population. From Table 1, the highest prevalence was seen in Standard 6 students with a prevalence of 2.4%.

The main cause of visual impairment was due to refractive error, contributing 49 out of 54 cases of visual impairment (90.7%). Other causes of visual impairment were not common, namely corneal disease (3.7%), congenital anomaly with phthisis bulbi (2%), bilateral macular scarring secondary to congenital toxoplasmosis (2%) and amblyopia secondary to uncorrected congenital ptosis (2%).

Refractive Error

Refractive error was detected in 49 students (7%). There was an exponential relationship observed in our population

Table 2. Distribution of Types of Refractive Error (According to Age Group)

	Myopia (Spherical ≥-0.5 D)		Hyperopia (Spherical ≥+2.0 D)		Astigmatism (Cylindrical ≥0.75)		Total	
Age (y)	n	(%)	n	(%)	n	(%)	n	(%)
6	0	(0.0)	0	(0.0)	1	(2.0)	1	(2.0)
7	3	(6.1)	4	(8.3)	0	(0.0)	7	(14.3)
8	1	(2.0)	1	(2.0)	2	(4.2)	4	(8.1)
9	5	(10.2)	0	(0.0)	0	(0.0)	5	(10.2)
10	8	(16.3)	1	(2.0)	0	(0.0)	9	(18.4)
11	8	(16.3)	0	(0.0)	1	(2.0)	9	(18.4)
12	13	(26.6)	1	(2.0)	0	(0.0)	14	(26.6)
Total	38	(77.5)	7	(14.3)	4	(8.2)	49	(100.0)

Table 3. Distribution of Types of Refractive Error (According to Gender)

	Myopia (Spherical ≥-0.5 D)		Hyperopia (Spherical ≥+2.0 D)		Astigmatism (Cylindrical ≥0.75)		Total	
Gender	**n**	**(%)**	**n**	**(%)**	**n**	**(%)**	**n**	**(%)**
Male	12	(24.5)	1	(2.0)	2	(4.1)	15	(30.6)
Female	26	(53.1)	6	(12.3)	2	(4.1)	34	(69.4)
Total	38	(77.5)	7	(14.3)	4	(8.2)	49	(100.0)

Table 4. Association of Myopia and Socio-demographic Factors using Univariate Analysis

Variables	**Myopia**				**Odds ratio**	***P* value***
	Yes: n (%)		**No: n (%)**			
Level in primary school						
Level 1	7	(18.4)	324	(48.6)		
Level 2	31	(81.6)	343	(51.4)	4.2	0.001
Gender						
Male	12	(31.6)	354	(53.1)		
Female	26	(68.4)	313	(46.9)	2.4	0.120
Hours reading books						
Less 2 h	23	(60.5)	537	(80.5)		
More 2 h	15	(39.5)	130	(19.5)	2.7	0.004
Siblings on glasses						
Yes	16	(42.1)	73	(10.9)		
No	22	(57.9)	594	(89.1)	5.9	0.000
Parents on glasses						
Yes	8	(21.0)	566	(84.8)		
No	30	(79.0)	101	(15.2)	0.0	0.420
Parental education level						
No formal education	0	(0.0)	17	(2.5)		
Primary education	2	(5.2)	101	(15.1)		
Secondary education	15	(39.5)	403	(60.4)		
Tertiary education	21	(55.3)	146	(22.0)	3.4	0.000
Household income						
Less than RM 500	1	(2.6)	101	(15.1)		
>RM 500-2000	12	(31.6)	304	(45.6)		
>RM 2000-5000	21	(55.3)	201	(30.1)		
>than RM 5000	4	(10.5)	61	(9.2)	1.7	0.004

**P* value <0.005: chi-square test

between refractive error and increasing age (Table 1). Myopia was the most common type of refractive error, detected in 38 students, contributing 77.5% of the total refractive error. The prevalence of myopia was 5.4% in the study population. Hyperopia was detected in 7 students (1%), followed by astigmatism in 4 students (0.6%) (Table 2 and 3).

Uncorrected Refractive Error

Twenty-four (3.3%) students wore glasses on the day of examination. These students with glasses had uncorrected visual acuity of worse than 20/40. Among students who had refractive errors, 48% of them were wearing corrective lenses, while more than half of them with uncorrected refractive error.

Table 5. Association of Myopia and Socio-demographic Factors using Multivariate Analysis

Variables	Myopia				Odds ratio	*P* value*
	Yes (n = 35)		No (n = 879)			
Level in primary school						
Level 1	7	(18.4)	324	(48.6)		
Level 2	31	(81.6)	343	(51.4)	4.14	0.001
Hours reading books						
Less than 2 h	23	(60.5)	537	(80.5)		
More than 2 h	15	(39.5)	130	(19.5)	2.71	0.008
Siblings on glasses						
Yes	16	(42.1)	73	(10.9)		
No	22	(57.9)	94	(89.1)	5.02	0.000
Parents education level						
No formal education	0	(0)	17	(2.5)		
Primary education	2	(5.2)	101	(15.1)		
Secondary education	15	(39.5)	403	(60.4)		
Tertiary education	21	(55.3)	146	(22.0)	2.99	0.001

**P* value <0.005: chi-square test

Analysis of Factors Influencing Myopia Development

Univariate analysis: Of the variables studied in the univariate analysis of logistic regression models (Table 4), 5 variables were identified to have a statistical association with the development of myopia. There was a statistically significant association of students in the upper primary group, longer hours spent for reading books, background history of siblings with glasses, parent's educational level and household income in the development of myopia. More girls were noted to have myopia, approximately with a ratio of 2:1. However by univariate analysis, this finding was not statistically significant. There was no significant association between myopia development and the history of parents with glasses.

Multivariate analysis: Interpretation of final association of variables in the development of myopia was carried out using multivariate analysis of logistic regression models. These factors were levels of primary education, hours spent on reading books, siblings with glasses, parent's educational levels and household income, which were found to have a significant association with the development of myopia by univariate analysis. Using multivariate analysis, each of the factors was analysed by controlling the other factors.

From Table 5, children in the Level 2 (Standard 4 to Standard 6) cohort have nearly 4 times higher risk of developing myopia, after controlling for the other 3 variables. Those who spend time reading for more than 2 hours a day also have increased risk of myopia. Children whose siblings wear glasses have nearly 5 times higher risk of developing myopia compared to those who do not. Those students who had parents with higher degrees of education had 3 times increased risk of myopia compared to those whose parents had lower educational levels.

Discussions

Primary school education is the most crucial educational years since children acquire the most learning during this particular period. Thus, good visual acuity in children is important to ensure optimum educational potential. Subjects selected for this study represented both urban and suburban areas, a near-equal gender distribution, and all subjects were of Malay ethnicity. The prevalence of visual impairment was 7.7% in this study, which compares favourably to the Gombak Study where the prevalence of uncorrected visual impairment was 17.1%, reduced to less than 1.5% with best correction.[8] Although refractive error was the prime cause of visual impairment in RESC studies, there was a major difference in the prevalence among the different population. It is clear that the rural population has consistently low prevalences of refractive error compared to their urban counterparts.[1,17,18] Similarly, Kota Bharu is considered less developed as compared to the urban community of Gombak in Kuala Lumpur (the capital city of Malaysia), although Kota Bharu is the state capital of Kelantan.

Table 6. Table of Comparison Showing Prevalence Rates of Refractive Errors in Children

Country	Visual impairment	Refractive error	Myopia (%)	Hyperopia (%)	Age (y)	Criteria (Dioptre)	Method of assessment
Hong Kong Fan et al, 2004 (n = 7560)[9]	NA	NA	36.7	4.0	5-11	M ≤-0.5 H >+2.0	CAR
Singapore Saw et al, 2006 (n = 1962)[21]	NA	NA	36.3 22.1*	1.7 3.4*	7-9	M <-0.5	CAR
Australia Junghans et al, 2005 (n = 1936)[23]	NA	NA	8.4	6.2	4-12	M < -0.5	NCRS
Chile Maul et al, 2000 (n = 5303)[3]	15.8	8.8	3.4-18.7	7-22	5-15	M < -0.5 H >+2.0	CAR, CRS
New Delhi Murthy et al, 2002 (n = 6447)[24]	6.4	5.2	4.9-10.8	15.6-3.9	5-15	M <-0.5 H >+2.0	CAR, CRS
Nepal Pokharel etal, 2000 (n = 5067)[22]	2.9	2.6*	1.2	1.4	5-15	M <-0.5 H >+2.0	CAR, CRS
Shunyi, China Zhao et al, 2000 (n = 5884)[17]	12.8	11.3	36-43	10	5-15	M <-0.5 H >+2.0	CAR, CRS
Kathmandu Nepal et al, 2003 (n = 1100)[2]	11.0(#)	8.1	4.3	1.3	5-16	NA	NCRS
West Malaysia Saw et al, 2006 (n = 1752)[21]	NA	NA	1.34 9.2*	2.9 1.7*	7-9	M ≤-0.5 H >+2.0	CAR
East Malaysia current study,2006 (n = 795)	7.7	7.0	5.4	1.0	6-13	M ≤-0.5 H ≥+2.0	NCAR, NCRS

* prevalence in Malay population; # ocular morbidity

CAR: cycloplegic autorefraction; CRS: cycloplegic retinoscopy; H: hyperopia; M: myopia; NA: not applicable; NCAR: non-cycloplegic autorefraction; NCRS: non-cycloplegic retinoscopy

Myopia was the most common type (77.5%) of refractive error in this study, with a prevalence rate of 5.4%. Associations between development of myopia and demographic or social factors were well studied. With multivariate modelling, the strongest association of myopia in this study was related to the older age of children, more time spent on reading books and the presence of siblings with glasses. In this study, the odds ratio for development of myopia in children who read more than 2 hours per day was 2.69 (multivariate-adjusted odds ratio was 2.71). A positive association was also seen between a high prevalence rate of myopia with larger housing types, increased family incomes and higher educational levels of parents. In addition, genes were also important in the development of refractive error, with inheritability of 84% to 86% for myopia or hyperopia.[19,20] A significant correlation of myopia development with parental education and household income was seen in the current study by univariate analysis. However after controlling for all factors, multivariate regression showed no significant association between household incomes and the development of myopia.

The prevalence rates of myopia among ethnic Malay living in the suburban area of Kota Bharu (5.4%) was lower than the Malay populations in the metropolitan cities of Kuala Lumpur (9.2%) and Singapore (22.1%).[21] The prevalence rate of hyperopia in this study was 1.0%, which was lower than Kuala Lumpur (2.9%) and Singapore (3.4%). The prevalence rate of astigmatism was also the lowest (0.6%) in Malay children in Kota Bharu, compared with Kuala Lumpur (18.7%) and Singapore (44.3%). The genetic backgrounds of Malays in Kelantan, Kuala Lumpur and Singapore are similar. As such, the differences in the

refractive error prevalence rates were unlikely to be due to genetic factors, and may be primarily environmental in nature. This could be attributed to better socio-economic conditions in Kuala Lumpur and Singapore, in the form of better educational levels, higher parental incomes, reading habits of children, more vigorous educational systems and the greater use of information technology for learning.

The prevalence rate of myopia in Malay children in Kota Bharu was considerably lower compared with countries such as Hong Kong (36.7%),[9] China (36-43%),[17] and Singapore (36.3%).[21] Countries such as Nepal (2.1%),[22] rural area Tanzania (less than 1%),[7] Australia (5.3%),[23] and Katmandu (8.1%)[2] have lower prevalence rates of myopia (Table 6). The wide variations of reported prevalence rates of refractive errors could be attributed to several factors. These include the definition of study populations (population-based or school-based), methods of measurement (cyclopegia or non-cyclopegia), populations ethnicities, definitions of myopia, hyperopia and astigmatism, and the types of environmental factors considered.

In this study, the prevalence rates for all 3 types of refractive errors were much lower than the other reported studies from Malaysia and Singapore. However, as only students with visual acuity of 20/40 (equivalent logMAR value of 0.3) were picked, a proportion of students with a low degree of refractive error may have gone undetected. Hyperopic children may compensate by accommodation while some myopic children may squint, masking the actual level of poor visual acuity.

The prevalence of refractive error and uncorrected refractive error would provide a useful and informative figure for further planning in the national health programme. Many factors would need to be considered when deciding whether to introduce eye-screening programmes in primary schools. These factors include the prevalence of myopia, the impact of poor eyesight in children on their studies, human and financial resources needed for screening and referral, as well as availability and compliance of any treatment offered.

Conclusion

This study was conducted to provide baseline data on the prevalence rate of refractive errors among ethnic Malay children in the suburban area of Malaysia, and compare the prevalence rates among ethnic Malay children populations from Kuala Lumpur and Singapore. The ethnicity-specific prevalence rate of myopia in children was the lowest in Kota Bharu, followed by Kuala Lumpur and the highest in Singapore. Better socio-economic factors are likely to contribute to higher prevalence rates of myopia in the major cities compared with suburban area, controlling for the genetic background of the populations.

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