

Visual Acuity and Refractive Error Profile of Indigenous Schoolchildren in Selangor

Noorsuriawati Mohd Said, B.Optom.^{1,2}, Nurin Syahmina, B.Optom.², Noor Haziq Suliman, Ph.D.², Nurulain Muhamad, M.Sc.², Maryam Amiruddin, MHSc², Sabrina Subri, Ph.D.²

¹Klinik Mata, Hospital Sungai Buloh, 48100 Sungai Buloh, Selangor, Malaysia.

²Department of Health Sciences, Faculty of Optometry, Universiti Teknologi MARA Cawangan Selangor Kampus Puncak Alam, 42300 Bandar Puncak Alam, Selangor, Malaysia.

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Abstract:

Objective: Uncorrected refractive errors are the leading cause of visual impairment in indigenous communities, with hyperopia reported as the most prevalent refractive error among indigenous people in Malaysia. Given the global rise in myopia, this study aimed to determine the visual acuity and current refractive status of indigenous schoolchildren in Selangor.

Material and Methods: This cross-sectional study involved purposively selected 106 indigenous schoolchildren aged from 7 to 12 years in Selangor with no history of ocular surgery, neurodevelopmental disorders, or active ocular diseases. Distance (DVA) and near visual acuity (NVA) were measured using Sonksen LogMAR charts. Refractive assessment was conducted via retinoscopy and subjective refraction. Data were analyzed using Statistical Package for the Social Sciences (SPSS) version 29, with descriptive statistics and the Wilcoxon Signed-Rank test used to compare inter-eye differences.

Results: Among 106 indigenous schoolchildren with a mean age of 9.00 ± 0.137 years, 50.9% were males. Unaided DVA was $0.02 \pm 0.01 \log \text{MAR}$ and $0.01 \pm 0.01 \log \text{MAR}$, and near VA was $0.01 \pm 0.01 \log \text{MAR}$ and $0.00 \pm 0.00 \log \text{MAR}$, for the right and left eye, respectively. Best corrected VA was $0.01 \pm 0.01 \log \text{MAR}$ at distance and $0.00 \pm 0.00 \log \text{MAR}$ at near. Spherical equivalent showed a high prevalence of emmetropia (79.25%), followed by hyperopia (17.92%) and myopia (2.83%). Additionally, 7.55% had astigmatism. Statistically significant inter-eye differences were observed for spherical equivalent (p -value <0.001) but not for the cylindrical power (p -value=0.979).

Conclusion: The refractive profile of Indigenous schoolchildren in Selangor remained dominated by emmetropia and hyperopia, with a low prevalence of myopia, despite the global rise in myopia among children.

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Contact: Sabrina Subri, Ph.D.

Center of Optometry, Faculty of Health Sciences, Universiti Teknologi MARA, UITM Cawangan Selangor, 42300 Bandar Puncak Alam, Selangor, Malaysia.

E-mail: sabrinasubri@uitm.edu.my

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Keywords: emmetropia, hyperopia, indigenous, myopia, refractive error, visual acuity (VA)

Introduction

In Malaysia, indigenous communities known as the Orang Asli represent a minority group that often faces significant healthcare and educational disparities. Characterized by extreme poverty, with an average monthly income of RM437.03, this population faces restricted access to essential services, including primary eye care¹. This raises considerable concern about the prevalence of undetected or untreated visual impairments, which may subsequently compromise the academic achievement of Orang Asli children. This concern is further substantiated by the existing literature, demonstrating a significant association between poor visual health and diminished academic performance in children^{2,3}.

Globally, visual impairment rates in indigenous populations range from 7.15%⁴ to 48%^{5,6}, with uncorrected refractive errors as the primary, treatable cause of visual impairment in this group. A previous study reported that approximately 40.9% of indigenous schoolchildren in Malaysia had visual problems, with refractive errors as the leading cause, accounting for 34.5% of cases⁷. Among different types of refractive errors, hyperopia was the most prevalent among indigenous schoolchildren in Malaysia^{7,8}.

Post-pandemic data reveal a significant shift in the worldwide prevalence of refractive errors. A systematic review has documented a worldwide increase in the progression, prevalence, and incidence of myopia⁹, largely attributed to pandemic-induced lifestyle changes such as prolonged screen time and reduced outdoor activity^{10,11}. Previous studies on indigenous schoolchildren in Malaysia were conducted before the significant environmental and behavioral shifts associated with the 2020 pandemic^{7,8,12}, and it remains unclear whether the refractive error patterns have changed alongside the global increase in

myopia. While these trends are well-documented in the general population, there is a need to evaluate the current refractive status of indigenous schoolchildren in Selangor to understand how these changes may have manifested in this specific, vulnerable population. Therefore, this study aimed to determine the visual profile of the indigenous schoolchildren, with particular emphasis on visual acuity and refractive error. Addressing this gap is essential for a more accurate understanding of the visual health status of this population and may inform future clinical and public health initiatives involving the indigenous community.

Material and Methods

Study design and sampling method

A school-based, cross-sectional study was conducted among Malaysian indigenous primary schoolchildren in Selangor. Schools with predominantly indigenous children in Selangor, using the Ministry of Education Malaysia database, were selected through simple random sampling using digital randomizers to minimize selection bias. Participant recruitment at the schools continued until the required sample size was achieved. The target sample size was reached after recruitment from three out of ten schools; therefore, no additional schools were included. Subsequently, purposive sampling was used to recruit children with the desired criteria: indigenous children born between 2012 and 2017. Children who were proficient in Bahasa Melayu and generally healthy were included to ensure that they could understand instructions. Children with a history of ocular surgery, use of medications affecting binocular function, neurodevelopmental disorders (e.g., ADHD, dyslexia), or active ocular diseases were excluded from this study.

The sample size calculation was determined using the Wan Nor Ariffin online calculator¹³. Based on a report from Kementerian Pendidikan Malaysia (2020), the total number of indigenous primary schoolchildren in Selangor was 2,613. Accounting for a 10% dropout rate, the sample size required was 69 children for a 95% confidence interval. This study was conducted in accordance with the Declaration of Helsinki. Ethical approval was granted by the Universiti Teknologi MARA (UiTM) Research Ethics Committee (Ref. Number: REC/03/2025 [ST/FB/7]). Formal permission secured from the Ministry of Education Malaysia and school administrators. Parental informed consent and child assent were obtained for all children prior to their involvement in the study.

Procedure

Data collection involved measuring monocular visual acuity (VA) and refractive error using standardized optometric protocols, performed by the same optometrist, to determine the visual profile of the indigenous children.

Visual acuity

Monocular VA was assessed using the Sonksen LogMAR chart and a standardized protocol. Each eye was tested individually, beginning with the right eye; the untested eye remained occluded. Children were instructed to identify letters from a crowded Sonksen LogMAR chart at a distance of 3m, beginning from the 0.7logMAR line. Testing continued until the last optotype the child correctly read, and the threshold was recorded as the smallest line of letters the child successfully identified. This procedure was then replicated for the left eye at distance and subsequently for both eyes at a near distance of 40cm, with all final measurements recorded in logMAR units for statistical analysis¹⁴. To minimize cognitive bias in younger or illiterate participants, a matching key card was provided as an alternative to verbal letter naming.

Refractive error

Refractive error was assessed using a two-stage approach: objective refraction followed by subjective refinement, in accordance with established clinical protocols¹⁵. Objective refraction was conducted via static retinoscopy in a dimly illuminated room while the participant fixated on a 6-meter target to relax accommodation. To achieve a neutral reflex, the optometrist evaluated the pupillary reflex across all meridians using a retinoscope at a 50-cm working distance, introducing appropriate spherical or cylindrical lenses until the motion was neutralized. Objective measurements were followed by monocular subjective refinement to determine the best corrected visual acuity (BCVA). Subsequently, subjective refraction was performed under standard room illumination, ranging from 300 to 500 lux, to ensure high-contrast conditions for the participant. The objective findings were refined monocularly using the “Maximum Plus for Best Visual Acuity” approach. Then, followed by the use of the Jackson Cross Cylinder (JCC) to precisely determine the cylindrical power and axis¹⁶. This two-step approach ensured that the refractive error was accurately captured in diopter-sphere (DS) and diopter-cylinder (DC) formats. Finally, the BCVA was recorded in logMAR units.

The classification of refractive error was reported based on the specific spherical equivalent (SE) power (sphere plus half of the cylindrical power)¹⁷, based on the more ametropic eye^{8,18,19} (Table 1). Emmetropia is classified if the case does not fall within any of the specific equivalent ranges. Astigmatism is defined as a power of more than -0.50 DC.

Cycloplegic refraction was not conducted, as this study is embedded within a larger protocol evaluating binocular and accommodative functions that may be altered by cycloplegia. However, the plus lens (+2.00 DS) test was performed on all children to rule out latent hyperopia.

Table 1 Classification of the refractive error based on the spherical equivalent¹⁷

Type of refractive error		Spherical equivalent
Myopia	Mild	-0.50 DS to -3.00 DS
	Moderate	>-3.00 DS to -6.00 DS
	High	>-6.00 DS
Hyperopia	Mild	+1.00 DS to +3.00 DS
	Moderate	>+3.00 DS to +5.00 DS
	High	>+5.00 DS

Statistical analysis

Data were analyzed using Statistical Package for the Social Sciences (SPSS) version 29. Descriptive statistics were used to describe the distributions of demographic, visual acuity, and refractive error. Refractive error was analyzed as continuous numerical values separately for SE. Astigmatism was also categorized according to refractive error type based on SE. Normality testing was conducted using the Shapiro-Wilk test. Results indicated that age, visual acuity, and refractive components were not normally distributed. Consequently, the Wilcoxon Signed-Rank Test was utilized for inter-eye comparisons of the refractive errors.

Results

Demographics

A total of 106 Indigenous primary schoolchildren from Hulu Selangor, Kuala Langat, and Sepang districts participated in this study. The cohort consisted of 50.9% (N=54) males and 49.1% (N=52) females, representing a balanced gender distribution. This study included representatives from two Orang Asli tribes, the Temuan (72.6%) and the Mahmeri (27.4%), with the former constituting the majority of the sample. The children enrolled in this study had a mean age of 9.00 ± 0.14 years, ranging from 7 to 11 years. Within this range, 25.5% (N=27) of the children were 9 years old, followed by 7-year-olds (N=23;

21.7%) and 10-year-olds (N=21; 17.9%), with the smallest proportion (14.2%) being 8-year-olds (N=15).

Visual acuity

Mean unaided and best-corrected visual acuity (VA) values are summarized in Table 2. Overall, both unaided and best-corrected VA were generally within normal range, with no significant inter-eye differences between RE and LE for distance or near acuity (all p -value > 0.05). Only 2.83% of participants had unaided distance VA worse than 0.2 logMAR, while this decreased to 1.88% after correction. Distance BCVA reached a mean of 0.01 ± 0.01 logMAR in both eyes, while BCVA at near achieved a mean of 0.00 ± 0.00 logMAR, signifying normal near acuity.

Refractive error

Based on the spherical equivalent, the refractive error range was 3.38D to -1.50D with a mean of 0.50 ± 0.06 D for RE, and 0.63D to -1.25D with a mean of 0.24 ± 0.03 D for LE. Wilcoxon Signed-Rank test showed a highly significant difference in spherical equivalents between RE and LE ($Z = -6.494$, p -value < 0.001), ranging from -2.75D to +2.50D. Approximately 3.70% (N=4) of the children had a spherical equivalent between RE and LE of more than 0.50D to 1.00D, and 0.9% (N=1) had a spherical equivalent between RE and LE of more than 1.00D. Only 0.9% (N=1) of the children had a spherical equivalent between RE and

Table 2 Visual acuity characteristics of the participants (N=106)

Visual acuity (logMAR)		Right eye (RE) Mean±S.D.	Left eye (LE) Mean±S.D.	Wilcoxon signed-rank test (RE vs LE)
Unaided	Distance VA	0.02±0.01	0.01±0.01	Z =-1.144, p=0.253
	Near VA	0.01±0.01	0.00±0.00	Z =-1.069, p=0.285
Best-corrected	Distance VA	0.01±0.01	0.01±0.01	Z =-0.944, p=0.345
	Near VA	0.00±0.00	0.00±0.00	Z =-0.577, p=0.564

VA=visual acuity

LE of more than $-2.75D$. These indicate that the inter-eye difference in spherical equivalent was statistically significant but not clinically significant for the majority of the sample. Figure 1 shows the distribution of the spherical equivalent on each eye.

Based on refractive error types, 79.25% (N=84) were emmetropic, while the remaining 20.75% (N=22) were ametropic. Hyperopia was the most prevalent refractive error, affecting 17.92% (N=19) of the sample, while myopia was observed in only 2.83% (N=3); 1.89% (N=2) were classified as mild myopia (-0.50 to $3.00D$) and 0.94% (N=1) with moderate myopia (>-3.00 to $6.00D$). Mild hyperopia ($+1.00$ to $+3.00D$) was found in 16.98% (N=18) of the sample, while 0.98% (N=1) presented with moderate hyperopia ($>+3.00$ to $+5.00D$). No cases of high myopia ($>-6.00D$) or high hyperopia ($>+5.00D$) were detected among the sample (Figure 2).

Astigmatism was identified in 8 subjects (7.55%); 3.77% (N=4) of the subjects exhibited astigmatism on the RE, while 6.50% (N=7) had astigmatism on the LE, with values ranging from -0.75 DC to -1.25 DC. The mean cylindrical power was $-0.06\pm 0.02DC$ for the RE and $-0.07\pm 0.02DC$ for the LE. The Wilcoxon Signed Rank test showed no statistically significant difference in cylindrical power between the right and left eyes ($Z=-0.27$, p -value=0.979).

Discussion

This study reported the visual acuity and current refractive error profile of indigenous primary schoolchildren in Selangor. Results showed the children generally had good distance visual acuity (VA), with the majority of the cohort achieving 6/6 best-corrected VA. In accordance with this, the majority of the children were emmetropic, followed by a small percentage of hyperopia and astigmatism. Despite emmetropia and hyperopia remaining the most prevalent refractive categories in this cohort, a slight reduction in hyperopia and a slight increase in emmetropia were observed, compared with previous studies. This pattern may suggest a subtle refractive trend toward myopia compared with the previous study⁷.

Despite myopia being reported to affect 30.2% of schoolchildren in urban areas like Kuala Lumpur¹⁷, the rate of myopia among the indigenous schoolchildren in rural areas remains comparatively low. While the post-pandemic era has been associated with a significant myopic shift due to prolonged home confinement and increased digital dependency²⁰, the refractive profile of the indigenous schoolchildren in the present study was still dominated by emmetropia and hyperopia. Myopia is not yet the predominant refractive condition in this population, potentially due to the lifestyle differences between the indigenous and urban schoolchildren.

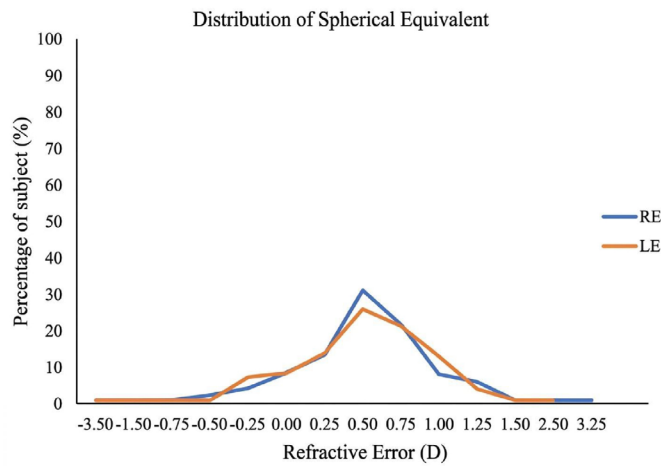


Figure 1 Distribution of the spherical equivalent in each eye (N=106)

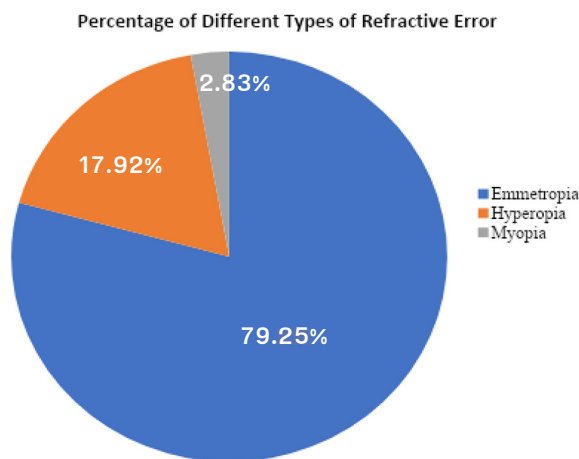


Figure 2 Percentage of different types of refractive error (N=106)

A previous study has suggested that spending 120 to 150 minutes outdoors daily can significantly reduce myopia risk by about 15% to 24%²¹. Given that indigenous children typically spend more time outdoors compared to children living in urban areas, greater outdoor exposure may partially explain the lower rate of myopia observed. This is consistent with previous evidence demonstrating

a higher myopia prevalence in communities with better socioeconomic or urban locations, where near work activities and prolonged screen exposure are more common, alongside reduced outdoor engagement²²⁻²⁴. Rural and indigenous environments may further provide protective conditions against rapid myopic progression. Children in these communities are typically exposed to a higher level of natural outdoor illumination, often exceeding 10,000 lux, which may stimulate retinal dopamine release²⁵. In turn, dopamine may help regulate ocular growth by activating retinal pathways that inhibit excessive axial elongation, thereby reducing myopic progression²⁶.

Despite the overall low myopia prevalence, subtle distributional changes in refractive error were observed in the sample. Compared to Omar et al. (2019), a slight reduction in hyperopia (28.2 % vs 17.92%) accompanied by a slight increase in emmetropia (65.5% vs 79.25%) was noted in this study, which may suggest an emerging refractive shift toward myopia. This observation is important to note in the context of post-pandemic behavioral changes. Although indigenous children’s lifestyle traditionally involves substantial outdoor activities²⁷, the pandemic period has introduced widespread educational and digital adaptations

that have affected children worldwide. Increased screen exposure and altered learning environments may influence the development of refractive error, even in populations previously considered at lower risk.

Although myopia remains a major global concern, hyperopia continues to be clinically significant in pediatric populations. Its association with increased accommodative demand²⁸, amblyopia²⁹, binocular vision anomalies³⁰, and impaired near visual function³¹ may adversely affect academic performance^{2,32}, particularly during sustained near tasks. The higher percentage of hyperopia reported in the current study and in previous studies involving indigenous children warrants further evaluation of binocular function in this population to ensure they maintain good binocular function despite the higher prevalence of hyperopia.

In addition to myopia and hyperopia, astigmatism was found in 7.55% (N=8) of the participants in this study. Similarly, a lower rate of astigmatism compared to urban counterparts was reported among primary schoolchildren on remote islands of the East Coast Peninsular³³ and among children in suburban Kelantan³⁴. Rural and suburban areas demonstrated lower astigmatism prevalence than urban settings, attributed to reduced exposure to near-work activities, such as computer use and video games³⁵. Furthermore, urban environments contribute additional risk through exposure to air pollution, which promotes allergic conjunctivitis³⁶ and a higher prevalence of associated refractive errors, including myopia and hyperopia, all of which are associated with astigmatism^{35,37}.

The results of this study are based on three schools in the Selangor district, which may limit its generalization to all indigenous schoolchildren enrolled in primary school. Another limitation of this study is that refraction was not performed under cycloplegia. Therefore, the maximum plus power of refractive error cannot be revealed. Non-cycloplegic refraction was chosen because the study protocol included a battery of binocular vision assessments, which

would have been rendered unreliable following cycloplegic agent administration due to its pharmacological suppression of accommodative function. Although cycloplegic refraction remains the gold standard for accurately detecting latent hyperopia in pediatric populations, the +2.00 DS test was included as an adjunct screening method to identify potential accommodative influences and partially mitigate underestimation of hyperopic refractive error. Nevertheless, this approach cannot substitute for cycloplegic refraction, although it may still provide valuable insights into visual acuity and refractive error distribution among indigenous schoolchildren in Selangor. Future studies should include a broader population of indigenous primary school children, particularly from different states of the country, and incorporate cycloplegic refraction or an alternative technique to cycloplegic refraction, if possible.

Conclusion

The present findings indicate that while indigenous schoolchildren continue to maintain a predominantly emmetropic and hyperopic refractive status, there is a subtle trend toward myopia observed among the sample compared to the previous literature. In addition, the low myopia rates reported in this study provide empirical evidence potentially linking urban visual stress, such as early intensive near-work and limited outdoor time, to the rise of myopia.

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Conflict of interest

There are no potential conflicts of interest to declare.

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