

Trend and Distribution of Refractive Errors Among Children Attending a Private Optometry Practice in Northern Malaysia

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ABSTRACT

Background: Childhood myopia is escalating worldwide, increasing lifetime risks of ocular diseases and affecting educational and psychosocial outcomes. In Malaysia, practice-based evidence from private optometry is limited, constraining planning for screening and myopia-control services. **Objective:** To describe the trend and distribution of refractive errors among children attending a private optometry practice in northern Malaysia, and to examine associations with age and gender. **Methods:** This retrospective, cross-sectional review of electronic health records for 700 first-visit pediatric patients (<18 years) at a private optometry clinic in Ipoh, northern Malaysia, between April 2021 and June 2025. Refractive status was classified by spherical equivalent (SE) in the more ametropic eye as myopia (≤ -0.50 D), high myopia (≤ -5.00 D), hyperopia ($\geq +0.50$ D), or emmetropia (-0.50 D < SE < +0.50 D). Age-stratified prevalence was summarized descriptively, and associations with age group and gender were tested using chi-square analysis ($\alpha = 0.05$). **Results:** Myopia predominated, affecting 76.4% (n=535 from 700) of children, with 10.7% (n=75/535) classified as high myopia. Hyperopia followed, affecting 14.6% (n=102/700), and emmetropia accounted for 9.0% (n=93/700). The association between age group and refractive error type was significant (χ^2 , $p < 0.001$): myopia increases from 54.9% in preschoolers (5–6 years) to 73.6% (7–9), 74.4% (10–12), 86.8% (13–15), and 83.5% in upper-secondary students (16–17 years). Hyperopia declined across age groups, whereas emmetropia remained relatively stable. Myopia was slightly more frequent in males (80.1%) than in females (73.5%), while hyperopia was more frequent in females (18.3%) than in males (10.0%) (χ^2 , $p = 0.008$). **Conclusion:** In this northern-Malaysian private-practice cohort, myopia was highly prevalent and increased sharply across school years, with nearly one in ten children exhibiting high myopia. Hyperopia predominated in early childhood, whereas emmetropia remained relatively stable. These practice-based findings support early pediatric vision screening and integration of evidence-based myopia-control strategies within community and private care pathways. Future research should include cycloplegic refraction, axial-length monitoring, and evaluation of environmental and behavioral risk factors, as well as cost-effectiveness analyses of clinic-integrated interventions in Malaysian settings.

Keywords:

Myopia; high myopia; children; private optometry; Malaysia

INTRODUCTION

Refractive errors are the most common visual disorders in children worldwide and a leading cause of visual impairment when left uncorrected (World Health Organization [WHO], 2019). Among them, myopia has drawn particular attention due to its rising prevalence, early onset, and potential to progress into high myopia. High myopia not only impairs vision but also increases the lifetime risk of sight-threatening ocular complications, including retinal detachment, myopic maculopathy, glaucoma, and cataract (Tideman et al., 2016).

Globally, the burden of myopia has grown at an alarming pace. It is estimated that by 2050, nearly half of the world's population will be myopic, and 10% will have high myopia

(Holden et al., 2016; Foster & Jiang, 2014). The prevalence is especially pronounced in East and Southeast Asia, where urban school-leaving populations have reported rates exceeding 80% (Morgan et al., 2018). This "myopia epidemic" has led to significant public health concern, with myopia now recognized as one of the leading causes of preventable visual impairment in children (Holden et al., 2016; World Health Organization, 2019).

In Malaysia, available data suggest that the prevalence of pediatric myopia is increasing in parallel with regional trends (Goh et al., 2005; Saw et al., 2006). However, most published studies have been school-based (Hussin, 2021; Ismail & Sukumaran, 2022) or hospital-based (Knight et al., 2018), which may not fully represent refractive error patterns seen in routine community optometry practice.

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Children attending hospital clinics often have more severe visual conditions, while school-based surveys provide only single-time-point data without long-term follow-up. Furthermore, substantial regional variation exists: Goh et al. (2005) reported myopia in 9.8% of children aged 7 years and 34.4% of those aged 15 years in the Gombak District; Hashim et al. (2008) found a 7.7% prevalence of refractive error among Malay primary school children in suburban Kelantan; and more recently, an urban school-based study in Wangsa Maju, Kuala Lumpur, found that nearly half (47.8%) of students exhibited refractive errors, with myopia being the most common (Ismail & Sukumaran, 2022). These findings underscore the clear urban–rural disparity in childhood myopia and highlight the absence of real-world evidence from private optometry settings.

Private optometry practices play a critical role in primary eye care delivery in Malaysia, often serving as the first point of contact for parents seeking vision assessment for their children, and are therefore uniquely positioned to provide real-world data on refractive errors across a wide spectrum of pediatric patients; however, despite this important role, published studies from private practice settings are scarce, leaving their contribution to the national myopia landscape under-documented. Understanding refractive error prevalence in such contexts is particularly relevant in urban populations, where children may experience higher educational pressures, greater near-work demands, and reduced outdoor exposure, factors identified as significant risks for myopia development and progression (Wu et al., 2018; Rose et al., 2008). Given that most existing Malaysian evidence is derived from school- or hospital-based studies, which may not reflect the true distribution of refractive errors in children presenting voluntarily for care, the present study addresses this knowledge gap by analyzing pediatric refractive data from a private optometry practice in Ipoh, an urban center in northern Malaysia.

Another important knowledge gap concerns the distribution of high myopia among Malaysian children. High myopia is not only more difficult to manage clinically (Shah et al., 2024; Eppenberger et al., 2024) but also associated with a disproportionate risk of irreversible vision loss (Haarman et al., 2020; Chung, 2025). Early detection of high myopia and its age- and gender-related distribution is therefore essential to inform prevention strategies and identify children at greatest risk.

The present study addresses these gaps by analyzing pediatric refractive error data from an urban private optometry practice in northern Malaysia. The findings are intended to inform early screening initiatives, guide clinical myopia control programs, and contribute to a more

comprehensive understanding of refractive error patterns among Malaysian children.

MATERIALS AND METHODS

Study Design and Setting

A retrospective cross-sectional study was conducted at a private optometry practice in Ipoh, an urban area in northern Malaysia, which provides comprehensive primary eye care services for children and adults. Data were extracted from the clinic’s electronic health record (EHR) system covering all first-visit pediatric encounters between April 2021 and June 2025. EHR-based studies have been increasingly adopted to estimate prevalence and clinical patterns in real-world practice settings (Wang et al., 2012; Schneeweiss et al., 2017). All refractions were performed by qualified optometrists using a Nidek ARK-1 binocular autorefractor, followed by subjective refinement. Ethical approval for this retrospective review was obtained from the IIUM Research Ethics Committee (IREC 2025-391).

Accommodation Control and Refraction Protocol

Cycloplegic refraction is widely regarded as the reference standard for pediatric refractive assessment because pharmacologic cycloplegia suppresses accommodation and reduces the risk of over-minus prescriptions and “missed” latent hyperopia. However, non-cycloplegic refraction remains common in primary optometry settings when cycloplegia is impractical due to regulatory restrictions, parental acceptance, time, or workflow considerations. In such situations, non-cycloplegic measurements are known to yield slightly more myopic and less hyperopic spherical equivalents, especially in younger children with active accommodation (Guo et al., 2022; StatPearls, 2024).

In this study, refraction was performed without cycloplegia, consistent with standard Malaysian private-practice procedures. Objective refraction was obtained using a binocular autorefractor (Nidek ARK-1) equipped with an internal fogging system to relax accommodation. This was followed by subjective refinement using the “maximum-plus/least-minus for best visual acuity” endpoint, prescribing the most plus power (or least minus) that maintained optimal clarity. This fogging-and-maximum-plus approach is a widely accepted method to minimize accommodative effort and avoid over-minusing when pharmacologic cycloplegia cannot be performed (Review of Myopia Management, 2023; Guo et al., 2022). Despite these measures, the absence of cycloplegic agents may result in a modest underestimation of hyperopia and

an overestimation of mild myopia. This limitation, consistent with findings from comparative studies, is acknowledged and discussed later in this manuscript (Guo et al., 2022; StatPearls, 2024).

Participants

The study population comprised 700 consecutive pediatric patients (<18 years) who attended their first eye examination during the study period. Only first-visit records were included to avoid duplication. Patients with missing refraction data, prior ocular surgery, or known ocular pathology (e.g., keratoconus, congenital cataract) were excluded. Demographic variables (age, gender, and ethnicity) were obtained from the EHR and analyzed descriptively.

Data Collection and Eye Selection

Sphere and cylinder values were extracted from the EHR, and spherical equivalent (SE) was calculated as:

$$SE = Sphere + \frac{1}{2} Cylinder$$

The more ametropic eye (the eye with the greater absolute SE) was used to classify refractive status, following standard epidemiologic practice to avoid interocular correlation bias (Saw et al., 2006; Verkicharla et al., 2020).

Definitions of Refractive Error

Refractive error categories were defined according to international standards (Morgan et al., 2018; WHO, 2019):

- Myopia: $SE < -0.50 D$
 - High Myopia: $SE \leq -5.00 D$
- Hyperopia: $SE \geq +0.50 D$
- Emmetropia: $-0.50 D < SE < +0.50 D$

Age Grouping

Participants were classified into school-age groups to correspond with Malaysian educational stages:

- Preschool: 5–6 years
- Lower Primary: 7–9 years
- Upper Primary: 10–12 years
- Lower Secondary: 13–15 years
- Upper Secondary: 16–17 years

This grouping allows clinically meaningful interpretation of refractive error trends across developmental and educational stages (French et al., 2013; Wu et al., 2018).

Statistical Analysis

Data were analyzed using IBM SPSS Statistics for Windows, Version 23.0 (IBM Corp., Armonk, NY, USA). Descriptive statistics were computed for demographic and refractive variables. Prevalence rates of myopia, high myopia, hyperopia, and emmetropia were calculated overall and stratified by age group and gender. Associations between refractive-error type and both age group and gender were examined using chi-square (χ^2) tests. Statistical significance was set at $\alpha = 0.05$. Ninety-five percent confidence intervals (CIs) for prevalence estimates were computed using the binomial approximation formula:

$$CI = p \pm 1.96 \frac{\sqrt{p - (1 - p)}}{n}$$

where p represents the observed prevalence and n the sample size.

RESULTS

A total of 700 pediatric patients under the age of 18 years were included in the analysis. The mean \pm SD age was 10.77 ± 3.3 years (range: 5–17 years). Of these, 389 (55.6%) were females and 311 (44.4%) were males. Participants were distributed across educational-age categories as follows: preschool, 51 (7.3%); lower primary, 242 (34.6%); upper primary, 176 (25.1%); lower secondary, 152 (21.7%); and upper secondary, 79 (11.3%).

Myopia was the predominant refractive error, affecting 535 (76.4%) children. Of these, 75 (14.0%) met the criteria for high myopia ($SE \leq -5.00 D$), corresponding to 10.7% of the total sample. Hyperopia and emmetropia were observed in 102 (14.6%) and 63 (9.0%) children, respectively (Table 1, Figure 2).

Table 1. Distribution of refractive errors in the study sample.

Refractive Error	Proportion (%)	n
Myopia	76.4%	535
*High Myopia	10.7%	75
Hyperopia	14.6%	102
Emmetropia	9.0%	63

*High myopia ($SE \leq -5.00 D$) is a subset of the myopic group; it represents 14.0% of all myopic children and 10.7% of the total sample.

Age-related variations are summarized in Table 2 and illustrated in Figure 1. The trend showed a marked increase in myopia proportion with age, from 54.9 % in preschoolers (5–6 years) to 83.5 % in upper-secondary students (16–17 years). Among the myopic children, 75 (14.0 %) had high myopia ($SE \leq -5.00 D$). Hyperopia declined sharply with age, while emmetropia remained relatively stable. High myopia rose progressively from 11.8% in preschoolers to 21.7% in lower-secondary

students. A chi-square analysis revealed a significant association between age group and refractive error type (χ^2 , $p < 0.001$).

Table 2. Age-related distribution of refractive errors. L represents lower, and U represents upper. The high myopia subgroup is reported within, not in addition to, the total myopic category.

Age Group	Myopia % (n)	High Myopia % (n)	Hyperopia % (n)	Emmetropia % (n)
Preschool	54.9% (28)	11.8% (6)	33.3% (17)	11.8% (6)
L/Primary	73.6% (178)	6.6% (16)	18.2% (44)	8.3% (20)
U/Primary	74.4% (131)	6.8% (12)	14.8% (26)	10.8% (19)
L/Secondary	86.8% (132)	21.7% (33)	7.9% (12)	5.3% (8)
U/Secondary	83.5% (66)	10.1% (8)	3.8% (3)	12.7% (10)

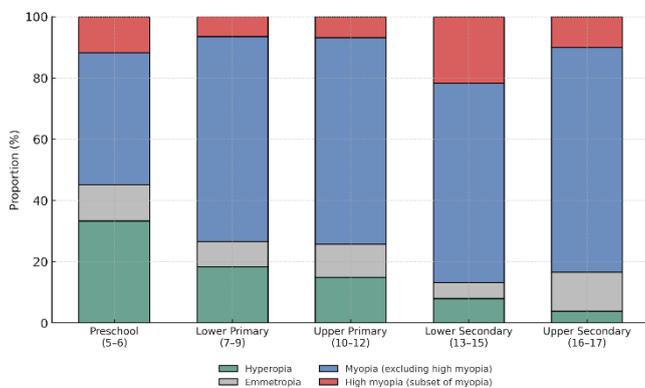


Figure 1. Age-related distribution of refractive errors

Gender differences are shown in Table 3 and Figure 2. Myopia was slightly more common in males (80.1%) than in females (73.5%). High myopia is presented as a subset of total myopia, affecting 12.9% of males and 9.0% of females. Hyperopia was more frequent among females (18.3 %) than males (10.0 %), while emmetropia proportions were similar between sexes. The overall association between gender and refractive-error type was significant (χ^2 , $p = 0.008$).

Stratified analysis of age and gender combined revealed that the gender differences in myopia and hyperopia persisted across most age groups, with males consistently showing higher proportion of myopia and females showing a higher proportion of hyperopia. The proportion of high myopia increased with age in both genders, but no statistically significant difference was observed between males and females within individual age groups ($p > 0.05$).

Table 3. Gender distribution of refractive errors. The high myopia subgroup is reported within, not in addition to, the total myopic category.

Gender	Myopia % (n)	High Myopia % (n)	Hyperopia % (n)	Emmetropia % (n)
Male	80.1% (249)	9.9% (31)	10.0% (31)	10.0% (31)
Female	73.5% (286)	9.1% (35)	18.3% (71)	8.2% (32)

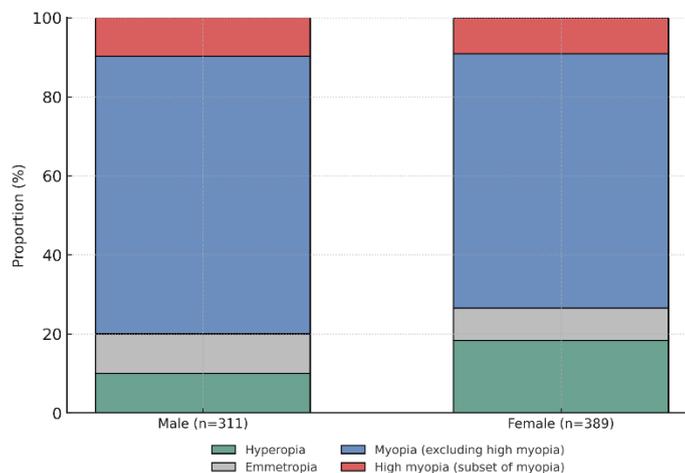


Figure 2. Gender distribution of refractive errors

DISCUSSION

This study provides practice-based epidemiological evidence on the distribution of refractive errors among Malaysian children attending a private optometry practice. Myopia was the predominant refractive error (76.4%), with high myopia present in 14.0% of myopic children (75/535) and 10.7% of the total sample. The proportion of children with myopia was higher in older age groups, ranging from 54.9% among preschoolers to 86.8% in lower-secondary students and 83.5% in upper-secondary students, while hyperopia declined correspondingly. These findings indicate a clear age-related trend and mirror patterns reported in other East and Southeast Asian cohorts (Morgan et al., 2018; Wu et al., 2018).

Comparison with previous studies

The overall prevalence in this cohort is higher than that reported in earlier Malaysian population-based studies. The National Eye Survey 1996 documented a low overall myopia prevalence (Zainal et al., 2002), but subsequent decades have shown a steady rise paralleling urbanization and educational intensification. Early regional studies, such as those by Chung et al. (1996), which found substantial rates of refractive errors among Chinese schoolchildren in Kuala Lumpur, already signaled a shift toward higher prevalence in urban areas. Goh et al. (2005) later quantified this pattern, reporting myopia in 9.8% of 7-year-olds and 34.4% of 15-year-olds in Gombak, while

Hashim et al. (2008) found a 7.7% prevalence of refractive error in suburban Kelantan. More recent urban data by Ismail and Sukumaran (2022) demonstrated that nearly half (47.8%) of schoolchildren in Kuala Lumpur exhibited refractive errors, consistent with this upward trajectory.

By contrast, studies involving rural and indigenous children consistently report far lower prevalence. Omar et al. (2019) observed only 2.4% myopia among Orang Asli children in rural Pahang, Hanisah et al. (2024) reported similar low figures among children on remote East Coast islands, and Bakar et al. (2012) found a marked difference between the more urbanized Malay and the native Iban groups. Together, these findings reveal a clear urban–rural and ethnic gradient in childhood myopia patterns in Malaysia, which aligns with differences in educational demands, near-work exposure, and outdoor activity. The markedly higher proportion observed in our urban private-practice cohort may therefore reflect both environmental and behavioural risk factors that accompany modern lifestyles.

The higher myopia trend observed here may also partly reflect self-selection bias: children attending private optometry practices typically present for symptomatic visual concerns rather than routine screening. This differs from school-based or population-level surveys (e.g., Goh et al., 2005; Ismail & Sukumaran, 2022), which include asymptomatic children. Therefore, the elevated proportion observed here likely represents the clinical burden among those actively seeking care, rather than the population prevalence.

The gender difference observed in this study, with a slightly higher proportion of myopia among males (80.1%) compared to females (73.5%), contrasts with reports from several regional studies that found a higher prevalence in females (He et al., 2004; Lin et al., 2004). This reversal may be related to sample variability or demographic differences in clinic attendance and should be examined further in population-based research.

Possible explanations and mechanisms

The age-related increase in myopia observed supports evidence that sustained near work, intensive schooling, and limited outdoor exposure accelerate the onset and progression of myopia (French et al., 2013; Wu et al., 2018; Lan et al., 2022). Environmental and behavioural influences act synergistically with biological susceptibility, resulting in excessive axial elongation and scleral remodelling (Tkatchenko et al., 2022). The proportion of high myopia (14.0% within myopia; 10.7% overall) in this sample is worrisome, as it predisposes children to retinal

detachment, myopic maculopathy, and glaucoma (Tideman et al., 2016). These findings echo reports from regional cohorts (He et al., 2004; Lin et al., 2004) and are consistent with the broader epidemiologic model described by Foster and Jiang (2014), in which urbanization and educational intensity drive both the onset and progression of myopia.

Given that nearly one in ten children in this cohort had high myopia, early identification and control are crucial. Private optometry settings can play a pivotal preventive role by implementing evidence-based optical and behavioural strategies to slow progression, as supported by recent systematic reviews (Walline et al., 2020; Saw et al., 2019). Early screening before the start of primary education, parental education on outdoor activity, and myopia-control interventions (e.g., defocus spectacle lenses, orthokeratology, or low-dose atropine) are essential to mitigate progression.

Strengths and limitations

The use of electronic health records from a private optometry practice provides valuable real-world evidence rarely captured in Malaysian epidemiological literature. It complements school- and hospital-based data by reflecting children who seek primary eye care. The inclusion of a large, age-diverse sample enhances the reliability of observed trends.

However, several limitations should be acknowledged. Non-cycloplegic refraction may slightly underestimate hyperopia and overestimate mild myopia (Guo et al., 2022). Despite using internal fogging and maximum-plus endpoints, residual accommodation cannot be excluded. As this analysis was based on retrospective clinical data from a single private optometry practice, the findings represent local distribution trends rather than population prevalence. Important confounders, such as parental myopia, screen time, and outdoor duration, were unavailable in the retrospective records. Future studies incorporating cycloplegia and biometric measures will help clarify true refractive status.

Implications for practice and future directions

Despite these limitations, the findings have important implications for paediatric vision care in Malaysia. The high prevalence of myopia and its early onset emphasize the importance of routine childhood vision screening and the introduction of myopia-control interventions such as low-dose atropine, orthokeratology, and peripheral-defocus spectacle lenses in community practice. Collaboration between private practitioners and public-health services

may strengthen early detection and management, particularly in urban populations.

The escalating myopia prevalence in this and prior Malaysian cohorts underscores the need for comprehensive, multi-sectoral myopia-control strategies. Private optometrists, being the primary contact point for paediatric eye care, should be empowered to implement evidence-based interventions consistent with current management frameworks (Eppenberger et al., 2024; Shah et al., 2024; Saw et al., 2019). Integrating private practice with public health screening, promoting outdoor activities, and expanding parental awareness can help curb the trend. Longitudinal, nationwide studies incorporating cycloplegic refraction and axial length tracking are warranted to evaluate the long-term outcomes and cost-effectiveness of interventions in the Malaysian context.

Future research should include cycloplegic refraction and axial-length measurement, evaluate environmental and behavioural risk factors, and examine the longitudinal outcomes of myopia-control programmes delivered in private optometry settings. Cost-effectiveness and scalability analyses will also be essential to support sustainable national strategies for the prevention and control of myopia.

CONCLUSION

Myopia was highly prevalent among Malaysian children attending private optometric care, with rates increasing sharply across school years, and nearly one in ten were affected by high myopia. The pattern mirrors urbanization-related lifestyle changes observed across East and Southeast Asia and underscores the urgent need for early detection and intervention.

Private optometrists play a critical role in mitigating this growing public-health concern by integrating evidence-based myopia-control strategies into routine paediatric eye care. Strengthening early vision screening, promoting outdoor activity, and expanding collaboration between private and public sectors are essential steps toward sustainable myopia control in Malaysia.

DECLARATIONS

Funding

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

Conflict of Interest

The authors declare that there are no conflicts of interest regarding the publication of this paper.

AI Usage Declaration

Portions of this manuscript were prepared with assistance from *ChatGPT (GPT-5, OpenAI)* under the supervision and full intellectual direction of the corresponding author. The AI tool was used solely to refine language, structure, and clarity of writing. All scientific content, analyses, and interpretations were conceived, verified, and approved by the authors.

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