ORIGINAL ARTICLE

Prevalence of Refractive Errors in the Indonesian Paediatric Population at a Tertiary Eye Centre

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ABSTRACT

Introduction: Visual impairment occurs when the visual system and vision functions are affected due to an eye condition. Visual impairment among the paediatric population is a significant public health issue due to the long-term impact on life-years. **Methods:** A cross-sectional study was conducted at Island Hospital in Penang, Malaysia, a medical tourism facility, enrolling Indonesian school-aged children aged 5–12 years. The study included interviews, uncorrected distance visual acuity measurements using the Snellen chart, cycloplegic refraction with a streak retinoscope refined subjectively, and detailed slit-lamp examinations of the anterior and posterior segments. **Results:** In this study, 229 children aged 5 to 12 years who attended the Ophthalmology Clinic at Island Hospital in Penang were assessed for refractive errors. The average age of the participants was 8.82 years (standard deviation: 2.37), with a gender distribution of 118 males (51.5%) and 111 females (48.5%). The overall prevalence of refractive errors was 70.7%, comprising 15.7% hyperopia, 55% myopia, and 29.3% emmetropia. Mann-Whitney tests indicated significant differences in SE values across ethnicities and age groups for both eyes, with a p-value of <0.05, while no significant differences were found between genders. Age showed a weak negative correlation with SE in the right eye (r = -0.172, p = 0.009) and left eye (r = -0.183, p = 0.005). **Conclusion:** Refractive errors are highly prevalent among Indonesian paediatric patients, with myopia being the most common at 55%. Early detection and interventions are crucial, particularly for high-risk groups such as Indonesian Chinese children.
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Keywords: Prevalence, Refractive error, Indonesian children, Paediatric, Myopia

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INTRODUCTION

Ametropia, or refractive error, is a common ocular condition caused by a disrupted emmetropization, in which a mismatch between the axial length and the optical power results in defocused retinal images. Notably, refractive errors, particularly in the paediatric population, have been recognized as a global public health concern. In response, initiatives such as the SPECS 2030 program aim to address refractive error coverage and tackle the global burden of visual impairment. Uncorrected refractive error is ranked as the leading cause of visual impairment and the second leading cause of blindness (1). Although solutions for refractive errors, such as prescription glasses, are relatively straightforward, significant barriers to accessing these healthcare services persist, particularly in developing countries (2).

The global distribution of childhood ametropia exhibits distinct patterns across countries and continents. For instance, countries in East and Southeast Asia, such as Taiwan, Singapore, Shanghai, and Malaysia, have been documented to have the highest prevalence of myopia among children (3). According to global estimates, both myopia and astigmatism are highly prevalent in Southeast Asia, with environmental factors such as prolonged near work being significant contributors (4). However, while several studies have documented the prevalence of refractive errors in Southeast Asia, the definitions of refractive errors were often not clearly established. The International Myopia Institute (IMI) has emphasized the need for clarification of terminologies to promote standardization in myopia management (5). Similarly, other types of ametropia, including emmetropia, hyperopia, and astigmatism, should be standardized to enhance confidence among practitioners in delivering evidence-based vision care (4).

Indonesia, the largest archipelagic nation in the world and the fourth most populous country, has one of the highest global prevalences of visual impairment (6). According to Indonesia's first population-based study on blindness and severe visual impairment, refractive error is the leading treatable cause of childhood visual impairment (7). In recent years, this issue has become particularly evident post-pandemic, as increased screen time and shorter working distances have contributed to a rise in refractive errors among schoolchildren (8). Despite being preventable, refractive errors remain a significant cause of visual impairment in children. Nonetheless, the prevalence of refractive errors and visual impairment in the Indonesian population, particularly among children, remains underexplored, with limited available data. Gaining a clearer understanding of the magnitude of these conditions is crucial, as they can profoundly impact educational attainment and social development.

Given the barriers to accessing tertiary eye care services in Indonesia, many Indonesian families choose to seek treatment overseas in countries like Malaysia, Thailand, and Singapore, where quality eye care is more readily available. Since the 1980s, Malaysia has reformed its medical systems, becoming one of the top destinations for high-quality care at reasonable costs and with closer proximity to Indonesia (9). In the context, the rise of medical tourism presents a unique opportunity to study refractive errors among Indonesian children within a private tertiary care hospital setting that is increasingly sought after by these families for specialized treatment. Accordingly, this study aims to assess the prevalence of refractive errors and visual impairment among children attending a tertiary eye center in Penang, including the Indonesian paediatric population. The findings will provide valuable insights to enhance early detection and intervention strategies.

By investigating this critical issue within a sample of Indonesian paediatric patients, our findings can potentially guide targeted outreach initiatives and influence health policy development in Indonesia. Such efforts could enhance access to paediatric vision care within the country and reduce the dependency on cross-border medical tourism. Furthermore, the study's results will underpin evidence-based interventions, driving improvements in paediatric eye care services and shaping health policies tailored to the specific needs of Indonesian children. Ultimately, the goal is to ensure that every child receives the care and support necessary to achieve optimal vision and fully engage in their education and social development.

MATERIALS AND METHODS

A cross-sectional study was conducted at Island Hospital in Penang, Malaysia, a flagship medical tourism hospital, to evaluate refractive errors among Indonesian school children aged 5–12 years. The study received ethical approval by the Island Hospital Ethics Committee (Approval Number: RSCH ID-22-02173-JML) on October 3, 2023. Prior to participation, informed consent was obtained from the parents or legal guardians of all participants. The research was carried out between November 2023 and March 2024, and all data were collected by a single trained optometrist to ensure consistency and minimize inter-examiner variability.

The inclusion criteria for the study focused on literate Indonesian school children who could cooperate and follow instructions throughout the examination. Conversely, participants were excluded if they had ocular pathologies, a history of ocular surgery or trauma, systemic disorders, accommodative or vergence anomalies, strabismus, use of ocular or systemic medications, oculomotor dysfunction, neurological or psychiatric conditions, learning difficulties, or were unable to cooperate during assessments.

A comprehensive medical, ocular, and family history was recorded for each participant. Clinical assessments began with the measurement of uncorrected distance visual acuity using a Snellen chart (Nikon Chart Projector NP-3S). Additional evaluations included stereopsis testing, cover testing, pupillary examination, and measurements of the near point of accommodation and near point of convergence.

Autorefraction and intraocular pressure were assessed using the Topcon Auto Kerato-Refracto-Tonometer TRK-2P. Objective refraction was performed using a Neitz streak retinoscope (RX-RC, Japan), followed by cycloplegic refraction using the “CTC” method. This approach involved administering 1% cyclopentolate hydrochloride (Cyclogyl 1%, Alcon Laboratories Inc., Fort Worth, TX, USA) and 1% tropicamide (Mydriacyl 1%, Alcon Laboratories Inc., Fort Worth, TX, USA) into the conjunctival sac at 15-minute intervals to ensure adequate cycloplegia.

Subsequently, subjective refinement of refraction was then carried out to determine the best-corrected visual acuity (BCVA) for each eye. Refractive error data were

collected and analyzed for both the right and the left eyes. Statistical comparisons by age and ethnicity were performed separately for each eye to explore potential interocular variation.
Finally, anterior and posterior segment evaluations were conducted using a slit-lamp biomicroscope (Zeiss SL800, Germany), and fundus photographs were captured using the Topcon NW-400 imaging system for both eyes.

Refractive error classification was based on the spherical equivalent (SE), calculated as the spherical power plus half of the cylindrical power. Myopia was defined as SE ≤ -0.50D, emmetropia as -0.50D < SE ≤ +0.50D, and hyperopia as SE > +0.50D under cycloplegia. This threshold reflects the classification used in large epidemiological studies of school-aged populations (10), enabling comparison across studies and capturing the full spectrum of hyperopia, including mild cases that may still affect the visual function and academic performance. Myopia was further categorized based on SE as follows: mild myopia is ≤ -3.00 D, moderate myopia is between -3.00 D to -6.00 D, and high myopia > -6.00 D (11).

Data collection and statistical analysis were performed using IBM SPSS Statistics for Windows (version 25.0; IBM Corp., Armonk, NY, USA). The normality of the data distribution was assessed using the Kolmogorov-Smirnov test. Descriptive statistics were applied to evaluate demographic data and the prevalence of refractive errors, with results expressed as mean, standard deviation (SD), frequency, and percentage. For non-normally distributed variables, the Mann-Whitney U test was used to compare SE and LogMAR visual acuity between genders, age groups, and ethnicities. A P-value less than 0.05 was considered statistically significant.

The prevalence of refractive error was calculated and tabulated in both eyes, however, the prevalence of the right eye was taken due to the standardization of using the right eye in most prevalence studies. Furthermore, based on the statistical test conducted using Spearman's correlation, there is a high correlation between the spherical equivalent for both eyes (r=0.904, p<0.001), meaning that both eyes have similar refractive errors. Therefore, taking the prevalence of the right eye will simplify analysis because including the left eye will overestimate the prevalence of refractive error.

Overall, this study presents a detailed and standardized approach to evaluating refractive errors in Indonesian school children, aiming to contribute to the understanding of refractive error distribution and its associated determinants in this population.

RESULTS

I. Demographic Analysis

The study population included 229 children aged 5 to 12 years, with a mean age of 8.82 years (SD: 2.37). There was a slight male predominance, with 118 males (51.5%) and 111 females (48.5%). Indonesian Chinese participants comprised 127 (55.5%) of the study population, while Pribumi/Javanese children made up 102 (44.5%). The substantial representation of Indonesian Chinese participants highlights the relevance of ethnicity in refractive error patterns.

II. Prevalence of Refractive Errors

Table I: Distribution of Refractive Errors by Age

Age (Years)	Frequency	Percentage (%)
5	23	10.0
6	27	11.8
7	30	13.1
8	27	11.8
9	19	8.3
10	31	13.5
11	29	12.7
12	43	18.8
Total	229	100.0

The overall prevalence of refractive errors was 70.7%. Myopia was the most common type, affecting 55% of participants, followed by emmetropia (29.3%) and hyperopia (15.7%), as defined by SE. Age-specific analysis showed an increasing trend in refractive error prevalences with age, peaking at 18.8% among 12-year-olds and lowest (10%) among 5-year-olds. This trend underscores the age-related progression of refractive errors.

III. Spherical Equivalent (SE)

Table II: Spherical Equivalent (SE) of Refractive Errors for the Right Eye and Left Eye

Refractive Error	Right Eye		Left Eye	
	Frequency	Percent	Frequency	Percent
Hyperopia	36	15.7	33	14.4
Myopia	126	55	124	54.1
Emmetropia	67	29.3	72	31.4
Total	229	100	229	100

Myopia was the most prevalent refractive error in both eyes, affecting 55% of right eyes and 54.1% of left eyes. This finding emphasizes the increasing prevalence of myopia among children and its significance as a public health concern.

IV. Refractive Errors by Gender and Ethnicity

Table III: Mean and Standard Deviation for Spherical Equivalent (SE) and LogMAR VA by Gender

Gender	Parameters	SE Right	SE Left	LogMarVA Right	LogMarVA Left
Male	Mean	-2.1698	-2.0042	0.0703	0.0610
	N	118	118	118	118
	Std. Deviation	3.74839	3.54820	0.12897	0.11623
Female	Mean	-1.7354	-1.5604	0.0459	0.0432
	N	111	111	111	111
	Std. Deviation	3.21391	3.17536	0.08397	0.08594
Total	Mean	-1.9592	-1.7891	0.0585	0.0524
	N	229	229	229	229
	Std. Deviation	3.49869	3.37261	0.10994	0.10284

There were no statistically significant differences in SE or LogMAR visual acuity (VA) between males and females ($p > 0.05$), indicating that gender was not a significant factor in refractive error prevalence or severity.

Table IV Mean and Standard Deviation for Spherical Equivalent (SE) and LogMAR VA by Ethnicity

Gender	Parameters	SE Right	SE Left	LogMar VA Right	LogMar VA Left
Indonesian Chinese	Mean	-3.7031	-3.2348	0.0795	0.0654
	N	127	127	127	127
	Std. Deviation	3.64521	3.44927	0.12931	0.11977
Pribumi / Javanese	Mean	0.2120	0.0110	0.0324	0.0363
	N	102	102	102	102
	Std. Deviation	1.57209	2.22129	0.07198	0.07418
Total	Mean	-1.9592	-1.7891	0.0585	0.0524
	N	229	229	229	229
	Std. Deviation	3.49869	3.37261	0.10994	0.10284

Significant differences were noted between ethnic groups, with Indonesian Chinese children exhibiting more severe myopia than Pribumi/Javanese children ($p < 0.001$), highlighting ethnicity as a key determinant in refractive error development.

V. Refractive Errors by Age Group

Table V: Mean and Standard Deviation for Spherical Equivalent (SE) by Age group

Parameter	Age group	N	Mean	Std. Deviation	Std Error Mean
SE Right	8 years	107	-1.7675	3.79689	0.36706
	9-12 years	122	-2.1274	3.22103	0.29162
SE Left	5-8 years	107	-1.6297	3.82678	0.36995
	9-12 years	122	-1.9289	2.92607	0.26491

Children aged 9–12 years had significantly more severe myopia than those aged 5–8 years ($p < 0.05$), supporting the notion of progressive myopia with age.

VI. Statistical Analysis

Table VI: Mann-Whitney Test for Spherical Equivalent (SE) Refractive Errors and LogMAR VA by Gender, Ethnicity and Age group

Characteristics	Parameters	SE Right	SE Left	LogMAR VA Right	LogMAR VA Left
Gender	Mann-Whitney U	6299	6077	6136.5	6123
	Z	-0.499	-0.942	-1.008	-1.072
	P value	0.618	0.346	0.313	0.284
Ethnicity	Mann-Whitney U	1837	2405.5	5167.5	5755
	Z	-9.316	-8.175	-3.217	-1.827
	P value	<0.001	<0.001	0.001	0.068
Age group	Mann-Whitney U	5511.5	5526	6020	6050
	Z	-2.031	-2.002	-1.241	-1.202
	P value	0.042	0.045	0.215	0.229

The Mann-Whitney U test showed no statistically significant differences in SE or LogMAR VA between male and female participants ($p > 0.05$), indicating that gender may not be a major factor influencing refractive error in this population.

The Mann-Whitney U test revealed significant differences in SE and LogMAR VA in the right eyes between Indonesian Chinese and Pribumi/Javanese participants. These findings suggest that ethnicity plays a significant factor influencing refractive error development, with Indonesian Chinese children are more likely to exhibit higher degrees of myopia than to Pribumi/Javanese children.

Additionally, a significant differences in SE was observed between the 5-8-year-old and 9-12-year-old age groups. This supports the notion that myopia severity increases with age, highlighting the progressive nature of refractive error in childhood.

VII. Correlation Between Age and SE

Table VII: Correlations between Age and Spherical Equivalent (SE)

Spearman Correlation	SE Right	SE Left
Age	r= -0.172 p= 0.009	r= -0.183 p= 0.005

** Correlation is significant at the 0.01 level (2-tailed)

Spearman correlation analysis demonstrated a weak but statistically significant negative correlation between age and SE, indicating that as age increases, myopia severity also tends to increase.

DISCUSSION

Visual impairment occurs when the visual system and its functions are compromised due to an eye condition (12), with uncorrected refractive error identified as the leading cause globally (13, 14). An estimated 2.2 billion people are affected by distance or near visual impairment worldwide. Among the paediatric population, visual impairment is a major public health concern due to its substantial impact on developmental years and overall life-years lost.

In response to the growing burden of visual impairment, the World Health Organization (WHO) launched the VISION 2020: The Right to Sight campaign, which identified uncorrected, reversible refractive error as a top global priority. Among children, vision impairment is closely associated with a decline in health-related quality of life (15). Furthermore, while comprehension may remain intact, children with visual impairment often exhibit slower reading speeds compared to their sighted peers, which can negatively affect academic performance. (16).

In this study, the overall prevalence of refractive errors was 70.7%, with myopia accounting for 55%, hyperopia for 15.7%, and emmetropia for 29.3%. We adopted a SE threshold of $\geq$ +0.50 D to define hyperopia, consistent with large epidemiological studies in school-aged populations (10). Although some researchers advocate for a higher threshold, such as SE $\geq$ +2.00 D, to identify clinically significant hyperopia, our inclusive approach aimed to capture milder forms that may still impact visual function, learning, and quality of life(17).

The Mann-Whitney tests revealed significant differences in SE between ethnicities and age groups for both the right and left eyes ($p < 0.05$), highlighting demographic influences on ametropia. Similar demographic variations have been reported in previous studies. For instance, Harrington reported the prevalence of myopia ($\leq$-0.50 D), hyperopia ($\geq$+2.00 D), and astigmatism ($\geq$1.00 DC) among Irish children aged 6–7 as 3.3%, 25.0%, and 19.2%, respectively, and among 12–13-year-olds as 19.9%, 8.9%, and 15.9% (18). These age-related differences in SE are consistent with our findings. Interestingly, the lower prevalence of myopia in younger children aligns with findings by Yahya in Malaysia (19). Within the Indonesian demographic, our results are supported by Setyowati et al., who found a 63.2% prevalence of myopia among schoolchildren aged 6–12 years (20). In contrast, Yahya et al. reported a much lower overall prevalence of refractive error at 9.56%, with myopia comprising 43.59% of cases (21). This stark difference may be attributed to variations in target populations. Yahya's study focused on rural areas, whereas our participants likely represent urban, higher socioeconomic groups, families who can afford cross-border medical treatment in Malaysia.

Age showed a weak but statistically significant negative correlation with SE in both the right eye ($r = -0.172$, $p = 0.009$) and left eye ($r = -0.183$, $p = 0.005$), indicating that as age increases, SE shifts toward the negative direction, reflecting increased myopia prevalence. This trend aligns with broader epidemiological data: countries in East and Southeast Asia, such as Taiwan (36.4%), Singapore (30.8%), Shanghai (30.8%), and Malaysia (14.0%), report the highest prevalence of myopia among children aged 8 years (3). Among ethnic groups, myopia is more prevalent among Chinese children compared to other ethnicities, a trend observed in multi-ethnic studies from Singapore and Malaysia (21, 22). This disparity may be influenced by cultural emphasis on academic achievement to improve socioeconomic status and accumulating cultural capital (23). The impact of pediatric refractive errors, particularly in the context of modern societal demands, should not be underestimated or ignored. Darusman et al. reported a 40% prevalence of ametropia among Indonesian schoolchildren in grades 4 through 6 following the COVID-19 pandemic, yet only 4% of affected students wore prescription eyeglasses (24). Clinically, the rising prevalence of myopia in East Asian countries, including Indonesia, should be considered a significant global public health concern. Addressing this growing burden of disease requires integrated efforts at national and international levels.

Moreover, myopia increases the risk of developing sight-threatening ocular complications, including cataract, myopic maculopathy, peripheral retinal degeneration, retinal detachment, and open-angle glaucoma (25). High myopia, in particular, is strongly associated with a greater risk of open-angle glaucoma (26). Comparatively, the prevalence of myopia is significantly higher in Asian countries, where the pressure to excel academically is intense, than in European contexts.

This has been attributed to long hours of near work and limited outdoor exposure (27). Urbanization and higher socioeconomic status are linked to more indoor time, longer study hours, and less outdoor activity (28). The growing use of digital devices especially smartphones and tablets introduces unique visual stressors, such as blue light exposure and reduced blink rate, which may affect ocular growth differently than traditional reading. Conversely, daily outdoor activity has consistently been shown to be protective, even in genetically predisposed children (29).

In terms of gender differences, there were no significant differences in SE between males and female in this study. This aligns with findings by Nunes et al., who also reported no statistically significant differences in the distribution of anisometropia between genders (30). However, Yahya et al. observed that females had a higher risk of ametropia compared to males among Malaysian children aged 6–36 months (21). Similarly, Logwill et al. found a significant proportion of females with a higher risk of myopia in Irish populations, which they attributed to the larger proportion of females pursuing advanced education compared to males (31, 32). Yahya et al. also reported comparable findings among Indonesian schoolchildren aged 6 to 19 years (21). The discrepancy between our findings and those of previous studies may be attributed to the smaller sample size in our study.

Overall, the findings of this study highlight the importance of early detection and management of refractive errors in children. Regular eye examinations can help identify and address refractive errors early on, preventing potential vision problems and improving quality of life. Vision screening in preschool children allows for the early detection of amblyopia and refractive errors, which are the most common causes of visual impairment in childhood. Early treatment during this critical developmental stage can preserve visual function and improve long-term quality of life (33, 34). In the absence of timely correction, refractive errors may lead to visual impairment that limits occupational opportunities and can reduce the effective working lifespan (35). These findings emphasize the need for integrated early screening programs to prevent lifelong socioeconomic and health consequences.

Nevertheless, this study had some limitations. It may not fully represent the entire Indonesian paediatric population due to regional, socioeconomic, or cultural differences, which could affect the generalizability of the results. While age and ethnicity were identified as significant factors, other possible influences, such as environmental conditions, genetic factors, or access to eye care services, were not explored in detail. Additionally, the use of an SE threshold of +0.50 D to define hyperopia may have contributed to a higher reported prevalence compared to studies using a ≥ +2.00 D definition (4, 36); however, this inclusive threshold reflects a deliberate choice to capture early hyperopic shifts relevant to pediatric visual function and public health planning.

Looking ahead, future studies should investigate the factors contributing to the high prevalence of myopia, especially in the Indonesian Chinese population. This could include examining genetic predisposition, environmental influences, and lifestyle habits linked to myopia. Additionally, further research is needed to determine effective strategies for preventing and managing myopia, such as reducing near work and promoting outdoor activities. A larger study is also recommended to provide a more accurate understanding of refractive error prevalence in this population. Although the current analysis focused on spherical refractive errors, future work using this dataset will also explore the prevalence and clinical impact of astigmatism and anisometropia, given their importance as amblyogenic risk factors.

CONCLUSION

Visual impairment in children is a significant public health concern, affecting their development, education, and quality of life. This study found a high prevalence (70.7%) of refractive errors among Indonesian children attending a tertiary eye clinic, with myopia being the most common (55%), followed by hyperopia at 15.7% and emmetropia at 29.3%. The results align with global trends, emphasizing the increasing burden of myopia.

Early detection and interventions, such as routine vision screenings and access to corrective measures, are crucial in mitigating the impact of refractive errors. Additionally, preventive strategies like encouraging outdoor activities and limiting near work may help curb the rising prevalence of myopia, ultimately improving children's educational opportunities and overall well-being. While this study focused on spherical refractive errors, future work will explore astigmatism and anisometropia given their importance as amblyogenic risk factors. Routine preschool vision screening should be prioritized as a preventive measure, not only to protect visual development but also to reduce future barriers to employment and productivity.

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