

# Prevalence of Refractive Errors Among School-Age Children and Adolescents in Saudi Arabia: A Systematic Review and Meta-Analysis

Abdulmajeed Al Khathami<sup>1,\*</sup>, Mohamed Baklola<sup>2,\*</sup>, Anwar Ali Alshehri<sup>3</sup>, Lujain Hussain Alnasser<sup>4</sup>, Razan Saleh Alshehri<sup>5</sup>, Mohammed A Salawi<sup>6</sup>, Rahaf Hussain Alwadai<sup>7</sup>, Mohammed Al Ghazwi<sup>8</sup>, Amira Ahmed Qadim Alanazi<sup>9</sup>, Asayel Mojidea Alshammari<sup>10</sup>, Naji Al-bawah<sup>11,\*</sup>, Mayas Hafez<sup>12</sup>, Abdullah Abu Melha<sup>1</sup>

<sup>1</sup>Department of Ophthalmology, King Fahad Hospital, Al Baha Health Cluster, Al Baha, Saudi Arabia; <sup>2</sup>Faculty of Medicine, Mansour University, Mansoura, Egypt; <sup>3</sup>College of Medicine, University of Bisha, Bisha, Saudi Arabia; <sup>4</sup>College of Medicine, University of Hail, Hail, Saudi Arabia; <sup>5</sup>Imam Abdulrahman Bin Faisal University, College of Medicine, Dammam, Saudi Arabia; <sup>6</sup>College of Medicine, Taif University, Taif, Saudi Arabia; <sup>7</sup>College of Medicine, Najran University, Najran, Saudi Arabia; <sup>8</sup>Batterjee Medicine college, Jeddah, Saudi Arabia; <sup>9</sup>College of Medicine, Northern Border University, Arar, Saudi Arabia; <sup>10</sup>College of Medicine, Aljouf University, Aljouf, Saudi Arabia; <sup>11</sup>Faculty of Medicine, Sana'a University, Sana'a, Yemen; <sup>12</sup>Qatif Central Hospital, Al Qatif, 32654, Saudi Arabia

\*These authors contributed equally to this work

Correspondence: Naji Al-bawah; Mohamed Baklola, Email Najjalbawah@gmail.com; Mohamedbaklola2000@gmail.com

**Background:** Refractive errors, including myopia, hyperopia, and astigmatism, are a leading cause of visual impairment among children worldwide. In Saudi Arabia, the prevalence of these conditions among school-age children and adolescents remains poorly understood, with significant variations reported across studies. This systematic review and meta-analysis aimed to provide a comprehensive estimate of the pooled prevalence of refractive errors in this population and explored factors influencing their distribution.

**Methods:** A systematic search of PubMed, Scopus, Web of Science, and ScienceDirect was conducted in accordance with PRISMA 2020 guidelines. Observational studies reporting the prevalence of refractive errors among Saudi school-aged children and adolescents were included. Data extraction and quality assessment were conducted using the Newcastle-Ottawa Scale. Pooled prevalence estimates with 95% confidence intervals (CIs) were calculated using a random-effects model, and heterogeneity was assessed with the  $I^2$  statistic.

**Results:** Nine studies including over 15,000 participants were analyzed. The pooled prevalence of myopia was 6.7% (95% CI: 3.0% to 14.2%), hyperopia was 3.6% (95% CI: 1.3% to 9.8%), and astigmatism was 7.7% (95% CI: 2.5% to 20.9%). Subgroup analysis revealed regional disparities, with the highest myopia prevalence reported in Taif (33.3%) and Bisha (22.5%), and the lowest in Medina (1.6%). Studies conducted after 2018 showed a significantly higher pooled myopia prevalence (16.4%, 95% CI: 8% to 30.5%) compared to those published before 2018 (3.3%, 95% CI: 1.4% to 7.5%) ( $p < 0.001$ ). While studies using cycloplegic refraction reported a slightly higher myopia prevalence (7.2%, 95% CI: 4.7% to 11%) than those using non-cycloplegic methods (6.7%, 95% CI: 2.4% to 17.5%), the difference was not statistically significant ( $p = 0.9$ ). No significant difference was observed between studies with smaller or larger sample sizes, although high heterogeneity persisted across all subgroups.

**Conclusion:** Refractive errors, particularly astigmatism, represent a significant and growing public health issue among Saudi school-aged children and adolescents. The findings underscore the urgent need for standardized diagnostic protocols, including the use of cycloplegic refraction, and the implementation of school-based vision screening programs.

**Keywords:** myopia, hyperopia, astigmatism, refractive errors, children

## Introduction

Refractive errors, primarily including myopia (nearsightedness), hyperopia (farsightedness), and astigmatism, are among the most prevalent ocular disorders affecting populations globally.<sup>1</sup> These visual impairments result from irregularities in the eye's ability to focus light on the retina, leading to blurred vision and, if uncorrected, can cause functional limitations and

educational disadvantages in children.<sup>2</sup> Among these, myopia has emerged as a major global public health concern due to its rapidly increasing prevalence and potential for sight-threatening complications such as myopic maculopathy, retinal detachment, and glaucoma.<sup>2</sup> The global prevalence of myopia is projected to rise dramatically, from approximately 22.9% in 2020 to nearly 50% by 2050, highlighting the urgent need for early detection and effective management strategies.<sup>1,3</sup>

This trend is not merely a biological inevitability; rather, it reflects a complex interplay of genetic predispositions and environmental exposures, particularly lifestyle factors.<sup>1,3,4</sup> Modern risk factors, such as increased screen time, excessive near-work activities (eg, prolonged use of digital devices), reduced time spent outdoors, and early educational pressures, have been strongly associated with the onset and progression of myopia in children.<sup>5,6</sup> These risk factors are particularly concerning in high-income countries undergoing rapid urbanization, where behavioral and environmental patterns have shifted significantly in recent decades.<sup>7</sup>

Epidemiological studies reveal that the prevalence and distribution of refractive errors vary considerably by geographic region, ethnicity, and socioeconomic conditions. For instance, cross-sectional studies from Australia have demonstrated that myopia affects 42.7% of 12-year-old Asian children compared to 8.3% in their European Caucasian peers. By age 17, these figures rise to 59.1% and 17.7%, respectively, reflecting both ethnic and environmental influences.<sup>5,6</sup> Similar findings are reported in the U.S.-based Multi-Ethnic Pediatric Eye Disease Study, which documented a myopia prevalence of 3.98% in Asian children compared to 1.2% in Non-Hispanic White children. Hyperopia was more prevalent in NHW children (25.65%) than in Asian children (13.47%), while astigmatism showed less variation (6.33% vs 8.29%).<sup>8</sup>

However, these international comparisons, while informative, may not directly translate to the Saudi Arabian context due to differences in population structure, educational systems, urbanization rates, and cultural practices.<sup>9,10</sup> While global studies are valuable in identifying overarching trends, localized data are crucial for tailoring public health strategies that address specific risk profiles and healthcare infrastructure.

In Saudi Arabia, the current literature on refractive errors in children and adolescents remains fragmented and inconsistent. Previous studies vary widely in methodology, sampling strategies, diagnostic criteria, and regional coverage, making it difficult to draw reliable national-level conclusions.<sup>11</sup> Moreover, few reviews have attempted to consolidate existing findings or assess the heterogeneity in reported prevalence rates across Saudi regions.<sup>11</sup> The lack of a comprehensive synthesis of data not only limits our understanding of the burden of refractive errors in the Kingdom but also hampers efforts to implement standardized screening and early intervention programs.

Given these gaps, a systematic review and meta-analysis focused specifically on Saudi school-aged children and adolescents is warranted. This review aims to provide a pooled estimate of the prevalence of myopia, hyperopia, and astigmatism in this demographic and to explore regional differences, temporal trends, and methodological inconsistencies in the available literature.

## Methods

### Study Design

This research employed a systematic review and meta-analysis to synthesize available evidence on the prevalence of refractive errors among children and adolescents aged 3 to 18 years in Saudi Arabia. The study was structured using the PICO framework as follows:

- Population (P): School-aged children and adolescents residing in Saudi Arabia.
- Intervention/Exposure (I): Diagnosis of refractive errors (myopia, hyperopia, or astigmatism).
- Comparison (C): Not applicable, as the objective was to assess prevalence without comparative analysis.
- Outcome (O): Reported prevalence rates of the specified refractive errors.

The methodology followed the standards set by the Cochrane Handbook for Systematic Reviews of Interventions and conformed to the PRISMA 2020 reporting guidelines, ensuring a transparent and rigorous review process.<sup>12,13</sup> This review was prospectively registered in PROSPERO (registration number: CRD420251006138).

## Search Strategy

A comprehensive search was performed in PubMed, Scopus, Web of Science, and ScienceDirect for articles published from January 2000 to January 2025. The search was performed using Medical Subject Headings (MeSH) terms and relevant keywords, including “myopia”, “hyperopia”, “astigmatism”, “refractive errors”, “prevalence”, “children”, “adolescents”, “students”, “school”, and “Saudi Arabia”, combined using Boolean operators (AND/OR) to optimize the retrieval of relevant studies. Although our search was limited to studies published in English, this approach is justified by the context of healthcare research in Saudi Arabia. English is the official language of medical education and scientific publication in the country, and nearly all peer-reviewed medical and epidemiological research, including that indexed in major databases, is published in English. As such, excluding non-English sources is unlikely to have significantly impacted the comprehensiveness of our review.

## Eligibility Criteria

We included observational studies (cross-sectional, prospective, or retrospective) reporting the prevalence of refractive errors in children and adolescents aged 3–18 years in Saudi Arabia. Studies were included if prevalence data were explicitly stated or could be inferred from raw data (eg, numerator and denominator provided). Studies reporting a broader age range were included only if data for the 3–18 age group were separately reported or could be extracted.

## Inclusion and Exclusion Criteria

Studies were included if they met the following criteria: (1) involved school-aged children and adolescents within the specified age range; (2) employed any diagnostic method for refractive error, including cycloplegic and non-cycloplegic refraction; and (3) reported prevalence data on myopia, hyperopia, or astigmatism. All levels of refractive error severity were eligible for inclusion, and no restrictions were placed based on participant gender, school setting (public or private), or geographical region within Saudi Arabia.

Exclusion criteria encompassed non-primary research articles such as reviews, editorials, commentaries, case series, and conference abstracts. Studies were also excluded if they did not report refractive error prevalence or if such data could not be derived from the presented results. Articles that were not accessible in full text or published in languages other than English were omitted.

## Study Selection and Screening

The selection of studies followed a structured and methodical approach. All identified records were imported into Rayyan, a web-based platform designed to facilitate the screening process in systematic reviews.<sup>14</sup> Duplicate entries were automatically identified and removed. Title and abstract screening was independently conducted by eight reviewers based on the predefined eligibility criteria. To assess the consistency of reviewer judgments during this phase, inter-rater reliability was evaluated using Cohen’s kappa statistic, which yielded a value of 0.78, indicating substantial agreement.<sup>15</sup> Disagreements were resolved through discussion. Articles deemed eligible or requiring further evaluation underwent full-text screening, which was performed by four reviewers. References were then managed using EndNote for full-text handling and citation organization. Final inclusion decisions were made by consensus to ensure that all selected studies adhered to the established criteria.

## Quality Assessment

To evaluate the methodological quality of the included studies, the Newcastle-Ottawa Scale (NOS) was applied. This tool assesses non-randomized studies across three key domains: selection of study participants, comparability of groups, and outcome assessment.<sup>16</sup> Each study received a score between 0 and 9. Based on these scores, studies were classified as high quality (scores of 7 to 9), moderate quality (scores of 4 to 6), or low quality (scores of 0 to 3). The NOS has been widely adopted in large-scale systematic reviews on epidemiological studies, supporting its validity and reliability in assessing methodological rigor.<sup>17</sup> Four reviewers independently assessed the studies. In cases where their evaluations differed, the reviewers first discussed the discrepancies in an attempt to reach agreement. If a consensus could not be

achieved, two additional reviewers were consulted to provide a final judgment. This process ensured consistency and rigor in the quality assessment.

## Data Extraction and Management

To maintain consistency throughout the data collection process, a standardized extraction form was developed and implemented. Four reviewers independently extracted relevant information from each included study. This included general study details such as author names, year of publication, study design, geographical location, and sample size. Information related to participant demographics, including age range and gender distribution, was also recorded. Additionally, the extracted data included prevalence estimates for myopia, hyperopia, and astigmatism, details on myopia severity (mild, moderate, high), hyperopia classification, and astigmatism thresholds, and information on diagnostic methodologies (cycloplegic vs non-cycloplegic refraction, auto-refractometer, subjective refraction tests). All extracted data were compiled and organized using Microsoft Excel to prepare for statistical analysis. The extraction form was pilot tested to ensure it captured all necessary variables comprehensively and consistently. Any discrepancies between reviewers were addressed through discussion. If consensus could not be reached, two additional authors were consulted to ensure the reliability and accuracy of the final dataset.

## Statistical Analysis

All statistical analyses were conducted using R software (version 4.2.2), utilizing the metafor and meta packages. To synthesize prevalence estimates for myopia, hyperopia, and astigmatism, random-effects models were employed, accounting for between-study variability due to expected clinical and methodological heterogeneity. Proportion estimates were presented with 95% confidence intervals (CIs), and the Freeman–Tukey double arcsine transformation was applied to stabilize variance, particularly in studies reporting very high or low prevalence values. Heterogeneity was assessed using both Cochran’s Q test and the I<sup>2</sup> statistic. A Q test p-value of <0.10 or an I<sup>2</sup> value exceeding 50% was considered indicative of substantial heterogeneity.

Where applicable, subgroup analyses were conducted to explore sources of heterogeneity, including geographic region, refractive error classification methods (cycloplegic vs non-cycloplegic), and age group stratifications. Meta-regression analyses were pre-specified to evaluate the influence of continuous variables such as publication year and sample size on prevalence estimates.<sup>18</sup> In cases where overlapping datasets from similar populations were identified, the study with the larger sample size or more comprehensive data was prioritized to avoid duplication. To assess the robustness of the pooled estimates, leave-one-out sensitivity analyses were performed. Publication bias was evaluated using contour-enhanced funnel plots and Egger’s regression test. In addition, Doi plots were generated and examined using the Luis Furuya-Kanamori (LFK) index, where LFK values between –1 and +1 were interpreted as indicating symmetry, values between ±1 and ±2 as minor asymmetry, and values exceeding ±2 as evidence of major asymmetry.<sup>19,20</sup>

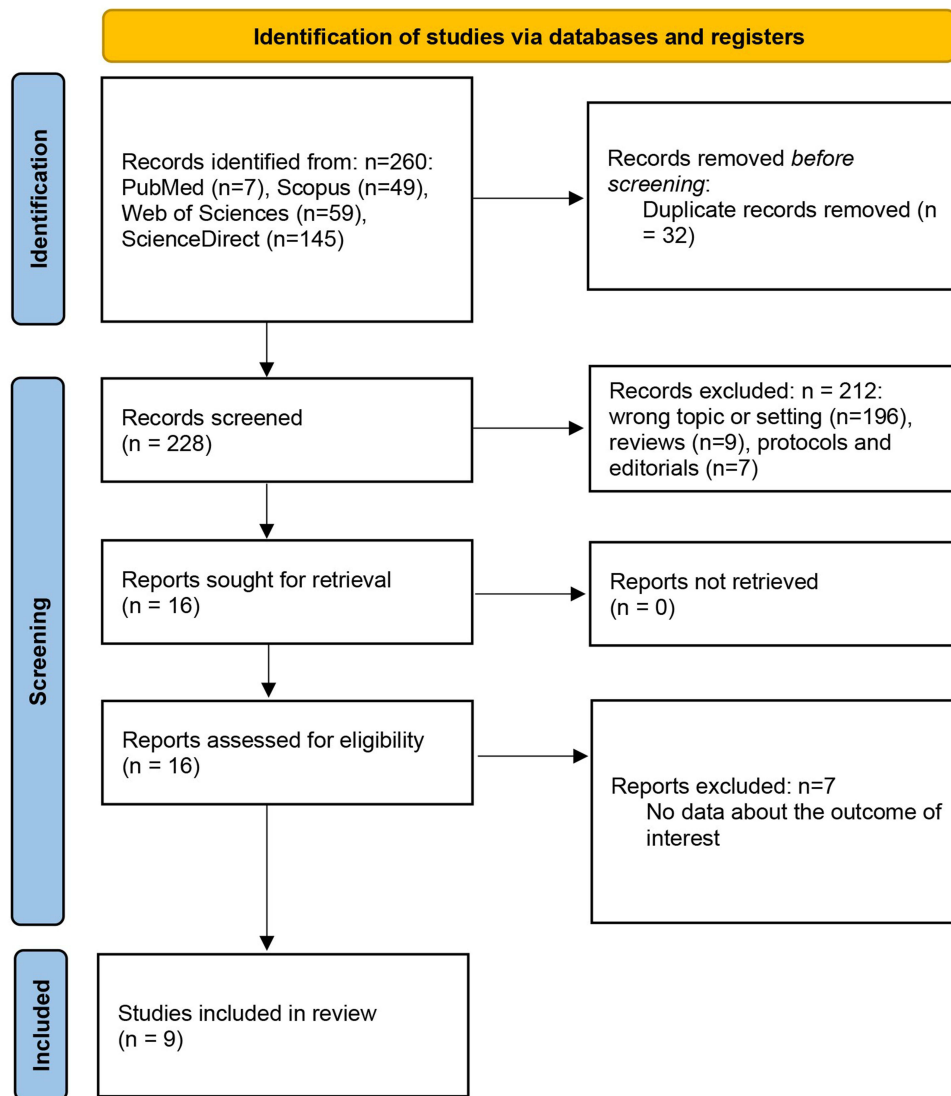
## Results

### Search Results

A comprehensive search of four electronic databases (PubMed, Scopus, Web of Science, and ScienceDirect) yielded 260 records published between January 2000 and January 2025 (Figure 1). After eliminating 32 duplicate entries, 228 unique records remained for screening. Titles and abstracts were reviewed, leading to the exclusion of 212 records based on criteria such as irrelevance to the research question or setting (n = 196), review articles (n = 9), and protocols or editorials (n = 7). The full texts of the remaining 16 articles were then assessed in detail. Following this evaluation, 7 articles were excluded due to the absence of specific prevalence data on refractive errors. As a result, 9 studies were deemed eligible and included in the final systematic review and meta-analysis.<sup>21–29</sup>

### Description of Included Studies

The nine studies included in this review were published between 2010 and 2023 and investigated the prevalence of myopia among school-aged children across different regions in Saudi Arabia (Table 1). All studies utilized a cross-



**Figure 1** PRISMA flow diagram for study selection.

sectional design. Sample sizes varied, ranging from 360 participants in the study by Alkhathami et al (2023) to 5,176 participants in the study by Aldebasi (2014). Altogether, these studies encompassed more than 15,000 children, making this one of the most extensive systematic reviews to date on the prevalence of refractive errors among Saudi schoolchildren.

The age range of participants spanned from 3 to 18 years, encompassing children in kindergarten, primary, and secondary school. All studies used visual screening techniques, but only 2 studies employed cycloplegic refraction, the gold standard for pediatric refractive error assessment, while 7 studies used non-cycloplegic techniques, such as autorefraction, visual acuity tests, or retinoscopy.

## Prevalence of Myopia

The analysis estimated the overall prevalence of myopia among school-aged children in Saudi Arabia at 6.7% (95% CI: 3.0% to 14.2%). This estimate was accompanied by a substantial heterogeneity among the included studies, as indicated by an  $I^2$  value of 99.5% and a  $\tau^2$  value of 1.59 (Figure 2). The reported prevalence varied considerably, ranging from 0.7% (Alrahili et al, 2017) to 33.3% (AlThomali et al, 2022). The lowest prevalence was reported by Alrahili et al (2017) in a sample of 1,893 children, while the highest prevalence was documented by AlThomali et al (2022) in

**Table 1** Summary of Included Studies

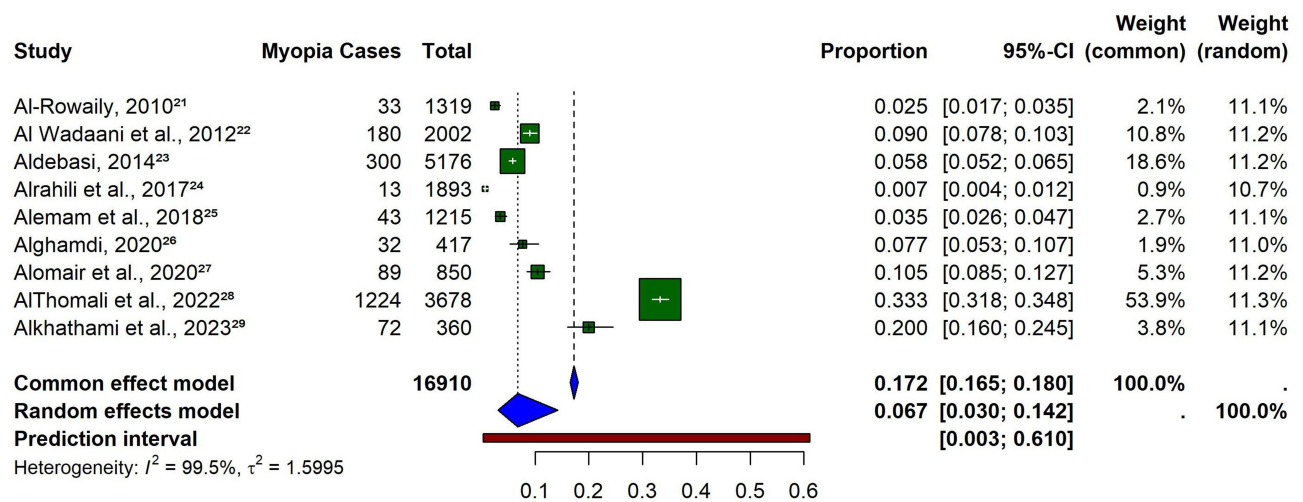
Study	Location	Study Design	Sample Size	Population	Age Range (years)	Method of Diagnosis	Prevalence of Myopia (%)	Grades of Myopia	Prevalence of Hyperopia (%)	Prevalence of Astigmatism (%)	Refraction Technique
<b>Al-Rowaily, 2010<sup>21</sup></b>	Riyadh	Cross-sectional study	1319 Boys: 577 Girls: 742	Pre-school children (kindergarten and primary school entrants)	4–8 years	Visual acuity test, auto refractometer, non-cycloplegic retinoscopy	2.5% (95% CI: 1.7–3.3%)	Mild Myopia: 1.9% (95% CI: 1.2–2.6%) Moderate Myopia: 0.3% (95% CI: 0.0–0.6%) High Myopia: 0.3% (95% CI: 0.0–0.6%)	2.1% (95% CI: 1.3–2.9%)	2.5% (95% CI: 1.7–3.3%)	Non-cycloplegic
<b>Al Wadaani et al, 2012<sup>22</sup></b>	Al Hassa	Cross-sectional study	2002 Boys: 966 Girls: 1036	Primary school children	6–14 years	Snellen chart, auto refractometer, cycloplegic refraction (1% cyclopentolate)	9.0% (CI =7.7–10.2%) Boys: 7.0% Girls: 10.3%	NR	1.4% (CI= 0.80–1.9%)	1.7% (CI=1.1% to 2.2%)	Cycloplegic
<b>Aldebasi, 2014<sup>23</sup></b>	Qassim	Cross-sectional study	5176 Boys: 2573 Girls: 2603	Primary school children	6–13 years	LogMAR protocol, cycloplegic autorefractometer, spherical equivalent classification	5.8% (CI =5.2–6.4%)	Mild Myopia: 87% Moderate Myopia: 10.9% High Myopia: 2.1%	0.7% (CI =0.5–0.9%) Mild hyperopia: 36.4% Moderate hyperopia: 52.4% High hyperopia: 11.4%	Myopic astigmatism 5.4% hyperopic astigmatism (2.7%) mixed astigmatism (1.7%)	Cycloplegic

<b>Alrahili et al, 2017</b> <sup>24</sup>	Medina	Cross-sectional study	1893 Boys: 947 Girls: 946	Kindergarten and primary school children	3–10 years	Handheld auto refractometer, non-cycloplegic autorefraction	0.7% Boys: 0.5% Girls: 0.9%	NR	1.5% Boys: 2.3% Girls: 0.7%	25.3% myopic astigmatism; n = 13 (2.7% of all astigmatism cases). Boys: 25.1% Girls: 25.5%	Non-cycloplegic
<b>Alemam et al, 2018</b> <sup>25</sup>	Medina	Cross-sectional study	1215 Boys: 525 Girls: 690	Children attending a pediatric ophthalmology clinic	3–14 years	Retinoscopy, subjective refraction, spherical equivalent	3.54% Boys: 4.0% Girls: 3.1%	Mild Myopia: 87% Moderate Myopia: 10.9% High Myopia: 2.1%	NR	NR	Non-cycloplegic
<b>Alghamdi, 2020</b> <sup>26</sup>	Oyoun Al Jawa	Cross-sectional study	417 All are males	Primary school children	6–13 years	Non-cycloplegic refraction, ocular alignment, stereo-acuity, Ishihara plates	7.7%	NR	8.9%	3.1%	Non-cycloplegic
<b>Alomair et al, 2020</b> <sup>27</sup>	Riyadh	Cross-sectional study	850 Boys: 475 Girls: 375	School children	6–15 years	Auto refractometer, full visual assessment (RESC protocol)	10.48%	NR	2.12%	8.48% Myopic and astigmatic 31 (3.65) Hyperopic and astigmatic 34 (4)	NR

(Continued)

Table I (Continued).

Study	Location	Study Design	Sample Size	Population	Age Range (years)	Method of Diagnosis	Prevalence of Myopia (%)	Grades of Myopia	Prevalence of Hyperopia (%)	Prevalence of Astigmatism (%)	Refraction Technique
<b>AlThomali et al, 2022<sup>28</sup></b>	Taif	Cross-sectional study	3678 Males: 1837 Females: 1841	School children	7–18 years	American Academy criteria, various refractive error calculations	33.28% Males: 31.3% Females: 35.1%	Low Myopia: 28.6% Moderate Myopia: 3.7% High Myopia: 0.9%	17.63% Males: 17.2% Females: 18% Levels: Low and Moderate Hyperopia: 16.3% High Hyperopia: 1.3%	Overall: 50.14% Males: 47.7% Females: 52.6% Levels: Low and Moderate astigmatism: 47.0% Severe astigmatism: 3.1% Simple myopic and cylinder: 16.6% Simple hyperopic and cylinder: 10.3% Compound myopic: 13.5% Compound hyperopic: 5.9% Mixed astigmatism: 3.8%	Non-cycloplegic
<b>Alkhathami et al, 2023<sup>29</sup></b>	Bisha, Saudi Arabia	Cross-sectional study	360 Males: 214 Females: 146	School children	7–14 years	Auto refractometer, visual acuity test, questionnaire-based clinical data	Right eye: 20% Left eye: 22.5%	NR	Right eye: 21% Left eye: 23%	NR	NR



**Figure 2** Forest plot of myopia prevalence among school-age children and adolescents in Saudi Arabia.

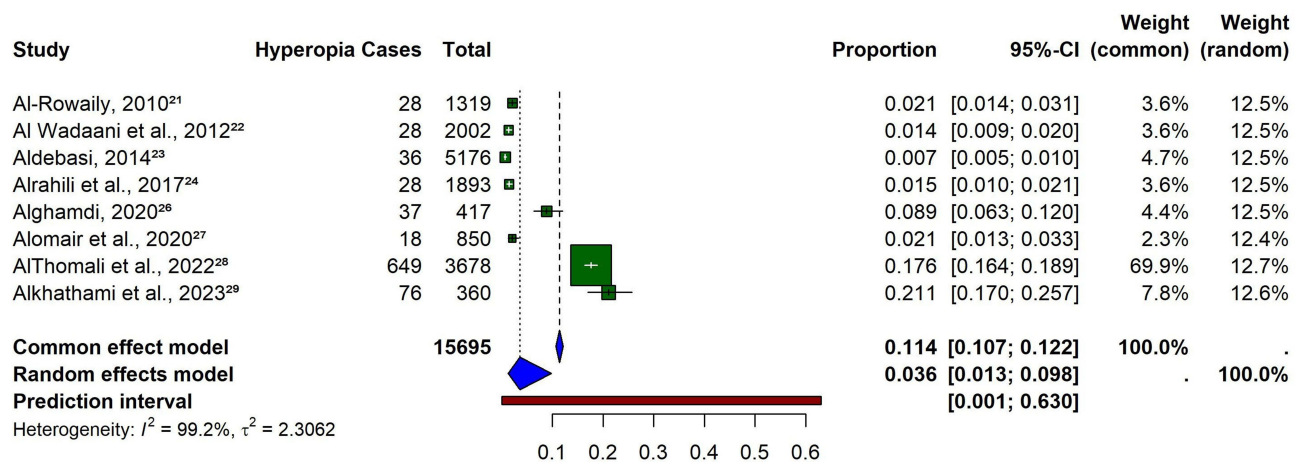
a large cohort of 3,678 participants. Notably, Alkhathami et al (2023) also reported a high prevalence of 20% among 360 children.

The severity of myopia varied between studies (Table 1). Mild myopia was the most frequently observed category, with Aldebasi (2014) reporting that 87% of myopic children had mild myopia, while AlThomali et al (2022) reported a slightly lower percentage of 28.6%. Moderate myopia accounted for 3.7% to 10.9% of cases, while high myopia was less common, ranging from 0.3% to 2.1% in the included studies.

### Prevalence of Hyperopia

The pooled prevalence of hyperopia across the included studies was 3.6% (95% CI: 1.3–9.8%), with marked heterogeneity ( $I^2=99.2\%$ ,  $\tau^2=2.3062$ ) (Figure 3). The reported prevalence varied substantially, ranging from 0.7% (Aldebasi, 2014) to 21.1% (Alkhathami et al, 2023).

The prevalence and severity of hyperopia varied across studies (Table 1). Mild hyperopia was the most frequently observed category, with Aldebasi (2014) reporting that 36.4% of hyperopic children had mild hyperopia, while AlThomali et al (2022) noted that low and moderate hyperopia accounted for 16.3% of cases. High hyperopia was less common, ranging from 1.3% to 11.4% in the studies included. The overall prevalence of hyperopia ranged from 0.7% to 17.63%, with some studies reporting higher rates in females compared to males.



**Figure 3** Forest plot of hyperopia prevalence among school-age children and adolescents in Saudi Arabia.

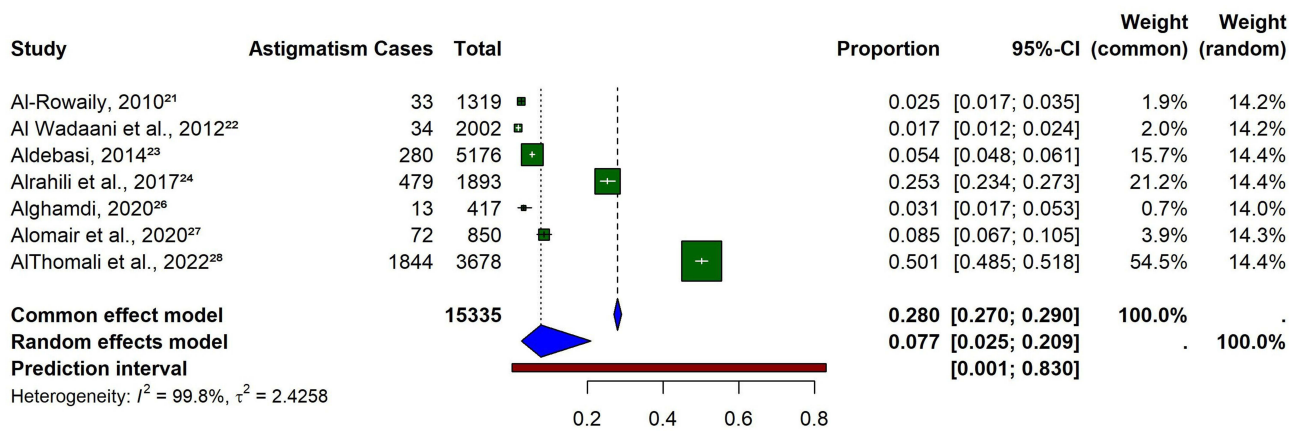


Figure 4 Forest plot of astigmatism prevalence among school-age children and adolescents in Saudi Arabia.

### Prevalence of Astigmatism

The pooled prevalence of astigmatism was 7.7% (95% CI: 2.5–20.9%), with extremely marked heterogeneity ( $I^2=99.8\%$ ,  $\tau^2=2.4258$ ) (Figure 4). The reported prevalence varied widely, with AlThomali et al (2022) documenting the highest prevalence at 50.1%, while Al-Rowaily (2010) and Al Wadaani et al (2012) reported the lowest prevalences (2.5% and 1.7%, respectively).

AlThomali et al (2022) reported the highest prevalence, with low and moderate astigmatism accounting for 47% of cases, while severe astigmatism was less common at 3.1% (Table 1). Myopic astigmatism was frequently observed, with rates ranging from 2.7% to 16.6%, while hyperopic astigmatism and mixed astigmatism were less prevalent, ranging from 1.7% to 10.3%. Some studies, such as Alrahili et al (2017), noted similar astigmatism rates between boys and girls, while others, like AlThomali et al (2022), reported slightly higher rates in females (52.6%) compared to males (47.7%).

### Sensitivity and Subgroup Analyses

A meta-influence analysis was conducted to examine whether any single study significantly affected the pooled prevalence of myopia. It is provided in Table S1. The results show that removing individual studies did not lead to major changes in the overall prevalence estimates, indicating that no single study disproportionately influenced the meta-analysis findings.

Subgroup analysis results are presented in Table 2, highlighting variations in the estimated prevalence of myopia based on specific study characteristics. While studies utilizing cycloplegic refraction reported a marginally higher pooled

Table 2 Subgroup Analysis of Pooled Prevalence of Myopia Among School-Aged Children and Adolescents in Saudi Arabia

Subgroup Variable	Category	No. of Studies	Pooled Prevalence (95% CI)	I² (%)	Between-Group p-value
Refraction technique	Cycloplegic	2	7.21% (4.7–11)	95.7	0.9
	Non-cycloplegic	7	6.72% (2.4–17.5)	99.3	
Geographic region	Riyadh	2	5.22% (1.2–19.6)	98.1	<0.001*
	Al Hassa	1	8.99% (7.8–10.3)	—	
	Qassim	1	5.80% (5.2–6.5)	—	
	Medina	2	1.59% (0.3–7.7)	96.4	
	Oyoun Al Jawa	1	7.67% (5.5–10.6)	—	
	Taif	1	33.28% (31.8–34.8)	—	
	Bisha	1	22.50% (18.5–27.1)	—	

(Continued)

**Table 2** (Continued).

Subgroup Variable	Category	No. of Studies	Pooled Prevalence (95% CI)	I <sup>2</sup> (%)	Between-Group p-value
Year of publication	Before 2018	5	3.27% (1.4–7.5)	97.0	<0.001*
	After 2018	4	16.36% (8.0–30.5)	98.7	
Sample size	< 1500	5	7.16% (3.2–15.2)	97.7	0.9
	≥ 1500	4	6.42% (1.2–27.6)	99.8	

Note: \*Significant values at  $p < 0.05$ .

prevalence (7.21%, 95% CI: 4.7–11) than those using non-cycloplegic techniques (6.72%, 95% CI: 2.4–17.5), this difference was not statistically significant ( $p = 0.9$ ). Notable differences were observed across geographic regions. Taif and Bisha reported the highest prevalence estimates at 33.28% and 22.50%, respectively, while Medina had the lowest prevalence at 1.59%. The test for subgroup differences across regions was statistically significant ( $p < 0.001$ ), indicating meaningful regional variation. Studies published after 2018 showed a significantly higher pooled prevalence (16.36%, 95% CI: 8.0–30.5) compared to those before 2018 (3.27%, 95% CI: 1.4–7.5) ( $p < 0.001$ ). No significant difference was found when comparing studies with sample sizes below 1500 to those with larger samples ( $p = 0.9$ ), though both groups showed substantial heterogeneity.

## Meta-Regression

Meta-regression analysis revealed that the year of publication significantly contributed to the observed heterogeneity in myopia prevalence ( $p = 0.038$ ), suggesting that studies published more recently tended to report higher prevalence rates. In contrast, sample size did not appear to account for a meaningful portion of the heterogeneity ( $p = 0.624$ ), indicating that variations in the number of participants across studies did not significantly influence the differences in reported prevalence estimates (see [Table 3](#)).

## Publication Bias

To assess potential publication bias, both Doi plots and funnel plots were examined for asymmetry in the prevalence estimates of myopia, hyperopia and astigmatism ([Figures S1– S6](#), respectively). For myopia, the funnel plot appeared symmetrical, and the Doi plot showed an LFK index of 0.09, indicating no evidence of publication bias. The distribution of studies was balanced around the pooled prevalence estimate, suggesting that smaller studies did not systematically report higher or lower prevalence rates. The plot shape and central clustering reinforce the robustness of the pooled estimate.

In contrast, the funnel plot for hyperopia showed noticeable asymmetry, with a skewed distribution of studies. This visual asymmetry was confirmed by the Doi plot, which had an LFK index of 3.31 indicating major asymmetry and potential publication bias. For astigmatism, the Doi plot showed no asymmetry (LFK = 0.47), and similar funnel plot assessments suggested a balanced distribution of prevalence estimates, reinforcing confidence in the pooled findings.

**Table 3** Meta-Regression Analysis Results for Pooled Prevalence of Myopia Among School-Age Children and Adolescents in Saudi Arabia

Variables	Coefficient	p value
Sample size	0.00126	0.624
Year of publication	2.190	0.038

**Table 4** Quality Assessment of Included Studies Using the Newcastle-Ottawa Scale (NOS)

Study	Selection (Max: 4)	Comparability (Max: 2)	Outcome/Exposure (Max: 3)	Total Score	Quality Rating
Al-Rowaily, 2010 <sup>21</sup>	4	2	3	9	High Quality
Al Wadaani et al, 2012 <sup>22</sup>	3	2	3	8	High Quality
Aldebasi, 2014 <sup>23</sup>	3	2	3	8	High Quality
Alrahili et al, 2017 <sup>24</sup>	4	2	3	9	High Quality
Alemam et al, 2018 <sup>25</sup>	4	2	3	9	High Quality
Alghamdi, 2020 <sup>26</sup>	3	1	2	6	Moderate Quality
Alomair et al, 2020 <sup>27</sup>	2	1	3	6	Moderate Quality
AlThomali et al, 2022 <sup>28</sup>	3	1	3	7	High Quality
Alkhathami et al, 2023 <sup>29</sup>	2	2	2	6	Moderate Quality

## Quality Assessment of Included Studies

The quality of the studies included in this review was evaluated using the Newcastle-Ottawa Scale (NOS), as summarized in Table 4. Seven studies achieved scores between 7 and 9, indicating high methodological quality. These studies demonstrated rigorous participant selection processes, appropriate comparison groups, and reliable methods for measuring outcomes. Notable examples include those conducted by Al-Rowaily (2010), Al Wadaani (2012), Aldebasi (2014), Alrahili (2017), Alemam (2018), and AlThomali (2022), all of which employed sound research designs that support the credibility of their findings. The remaining three studies were rated as having moderate quality, each receiving a score of 6. These ratings were primarily due to issues such as relatively small sample sizes, use of non-cycloplegic refraction methods, or potential selection bias, which may affect the generalizability or precision of their results.

## Discussion

This systematic review and meta-analysis offers a detailed overview of the prevalence of refractive errors among school-aged children and adolescents in Saudi Arabia, drawing on data from nine studies that collectively involved more than 15,000 participants. The findings identify astigmatism as the most prevalent refractive error, with a pooled estimate of 7.7%, followed by myopia at 6.7% and hyperopia at 3.6%. These results highlight the substantial burden of uncorrected refractive errors in this population and point to an important area for public health intervention. Although all included studies reported data on myopia, the prevalence varied widely across regions, ranging from 0.7% to 33.3%. The consistently higher prevalence of astigmatism, however, may indicate that this condition has not received adequate attention in either clinical practice or research agendas.

The pooled prevalence of myopia in Saudi Arabia (6.7%) is higher than that reported in Ethiopia (5.26%)<sup>30</sup> and other African countries (4.7%)<sup>31</sup> but lower than rates observed in East Asia (31%).<sup>32</sup> This disparity may be attributed to differences in genetic predisposition, lifestyle factors, and levels of urbanization.<sup>33</sup> For instance, increased near-work activities, reduced outdoor time, and technological advancements have been linked to higher myopia prevalence globally.<sup>34–37</sup> In Saudi Arabia, the rising prevalence may also reflect improved diagnostic capabilities and increased awareness of refractive errors.<sup>38</sup>

The diagnostic methodology significantly influenced the prevalence estimates of myopia across the included studies. Studies employing cycloplegic refraction, such as Al Wadaani et al (2012)<sup>22</sup> and Aldebasi (2014),<sup>23</sup> reported higher myopia prevalence rates of 9% and 5.8%, respectively. In contrast, studies using non-cycloplegic methods, such as Al-Rowaily (2010)<sup>21</sup> and Alrahili et al (2017),<sup>24</sup> reported lower prevalence rates ranging from 0.7% to 7.7%. This discrepancy suggests that cycloplegic refraction, which paralyzes the ciliary muscle and eliminates accommodation, may provide a more accurate detection of myopia, particularly in younger children.<sup>39</sup> Non-cycloplegic methods, on the other hand, may underestimate myopia due to the influence of accommodation.<sup>40</sup> These findings underscore the importance of standardized diagnostic approaches, with cycloplegic refraction remaining the gold standard for reliable pediatric refractive error assessment.

The pooled prevalence of astigmatism in this review was 7.7%, though individual study estimates ranged widely from 1.7% to 50.1%. Myopic astigmatism emerged as the most frequently reported subtype, aligning with global trends documented in previous research.<sup>41–43</sup> Several factors may contribute to the relatively high prevalence of astigmatism observed in Saudi Arabia, including hereditary influences, environmental exposures, and lifestyle changes such as increased screen time among children.<sup>44</sup> One study conducted in Jeddah among participants attending an amblyopia awareness campaign reported a notably high prevalence of astigmatism at 41.5%. Within this group, 40.6% of children without a prior diagnosis were found to have astigmatism incidentally.<sup>45</sup> However, because the study recruited attendees from a vision health event, the findings may reflect a degree of selection bias, potentially inflating the prevalence estimate. This underscores the importance of conducting well-designed, population-based studies to generate more representative data and to clarify the factors contributing to the burden of astigmatism across different regions and age groups in Saudi Arabia.

Although hyperopia had the lowest pooled prevalence (3.6%), its detection is especially important in early childhood, when uncorrected farsightedness can lead to amblyopia and delayed visual development.<sup>46,47</sup> Mild hyperopia was the most common form, but even low levels can significantly affect reading fluency and school performance. Current findings reinforce the importance of incorporating hyperopia detection into routine early childhood vision screening to support cognitive and educational development.

Gender-specific analysis revealed a slightly higher prevalence of both myopia and astigmatism among females. This aligns with global literature, where differences may stem from hormonal, anatomical, or behavioral factors, including higher rates of near-work activity among girls.<sup>48</sup> Policymakers and educators could consider targeted interventions for girls, such as vision-friendly classroom environments and awareness campaigns that emphasize early screening and eye health education.

The findings of this study align with regional and global trends in the prevalence of refractive errors. For instance, a meta-analysis conducted in the Middle East reported a myopia prevalence of 5.2%, which is slightly lower than our estimate of 10%.<sup>49</sup> Similarly, our results are consistent with studies from India (5.3%) and Nepal (7.1%),<sup>50,51</sup> indicating shared risk factors such as urbanization, increased educational demands, and lifestyle changes. These parallels suggest that environmental and socio-cultural factors, including prolonged near-work activities and limited outdoor exposure, may contribute to the rising burden of refractive errors across diverse populations.<sup>37,52</sup> The consistency in findings underscores the importance of addressing these modifiable risk factors through targeted public health interventions to mitigate the growing prevalence of refractive errors among children globally.<sup>53</sup>

Given the rising prevalence and consequences of uncorrected refractive errors, particularly myopia and astigmatism, school-based screening programs should be expanded and standardized. Programs should prioritize the use of cycloplegic refraction, especially for younger children, and integrate follow-up pathways to ensure timely correction. Public health campaigns should also raise awareness among parents and educators about the importance of limiting near-work activities and encouraging outdoor play.

This review has several notable limitations. First, none of the studies included reported the prevalence of high myopia, a severe and vision-threatening condition. The absence of this data limits the understanding of the full spectrum of refractive errors and the potential long-term burden of uncorrected high myopia in the pediatric population. Second, many studies did not clearly report the refraction techniques used, particularly whether cycloplegic or non-cycloplegic methods were applied. This may have contributed to variability and potential bias in prevalence estimates. Future

research should consistently specify the refraction methodology to improve comparability and diagnostic accuracy. Third, the analysis focused solely on prevalence and did not include multivariate analysis to explore risk factors such as age, gender, urban or rural residence, screen time, or genetic predisposition. This limits the ability to identify significant predictors of refractive errors. Finally, the substantial heterogeneity across studies reflects differences in sampling methods, diagnostic protocols, and population characteristics. This underscores the need for consistent and standardized protocols in future epidemiological vision research.

## Conclusion

This study demonstrates that refractive errors are a significant public health issue among school-aged children and adolescents in Saudi Arabia. Astigmatism emerged as the most common refractive error, followed by myopia and hyperopia. Notable regional variations were observed, with especially high rates of myopia in cities such as Taif and Bisha. Additionally, studies conducted after 2018 reported markedly higher myopia prevalence compared to earlier research, reflecting an upward trend over time. These findings highlight the urgent need for standardized diagnostic methods, particularly the consistent use of cycloplegic refraction, to improve accuracy in screening and diagnosis. To address the growing burden of refractive errors, national school-based vision screening programs should be implemented. These programs should include regular eye examinations by trained personnel, integration with school health services, and referral pathways for children needing corrective treatment. Policymakers should also promote preventive strategies such as increasing outdoor activities and managing screen time as part of broader child health initiatives. Implementing these measures is essential to reducing visual impairment and supporting the academic and developmental success of Saudi children.

## Data Sharing Statement

The datasets analyzed during this study are not publicly available; however, they can be obtained from the corresponding author upon reasonable request.

## Author Contributions

All authors made a significant contribution to the work reported, whether in the conception, study design, execution, acquisition of data, analysis and interpretation, or in all these areas. All authors took part in drafting, revising, or critically reviewing the article; gave final approval of the version to be published; have agreed on the journal to which the article has been submitted; and agree to be accountable for all aspects of the work.

## Funding

There is no funding to report.

## Disclosure

The authors declare that they have no competing interests in this work.

## References

1. Foster PJ, Jiang Y. Epidemiology of myopia. *Eye*. 2014;28(2):202–208. doi:10.1038/eye.2013.280
2. Schaeffel F. Myopia - What is old and what is new? *Optometry Vision Sci*. 2016;93(9):1022–1030. doi:10.1097/OPX.0000000000000914
3. Grzybowski A, Kanclerz P, Tsubota K, Lanca C, Saw SM. A review on the epidemiology of myopia in school children worldwide. *BMC Ophthalmol*. 2020;20(1):1–11. doi:10.1186/S12886-019-1220-0/TABLES/2
4. Hashemi H, Fotouhi A, Yekta A, Pakzad R, Ostadimoghaddam H, Khabazkhoob M. Global and regional estimates of prevalence of refractive errors: systematic review and meta-analysis. *J Curr Ophthalmol*. 2017;30(1):3–22. doi:10.1016/J.JOCO.2017.08.009
5. Ohno-Matsui K. What is the fundamental nature of pathologic myopia? *Retina*. 2017;37(6):1043–1048. doi:10.1097/IAE.0000000000001348
6. Medina A. The cause of myopia development and progression: theory, evidence, and treatment. *Surv Ophthalmol*. 2022;67(2):488–509. doi:10.1016/J.SURVOPHTHAL.2021.06.005
7. Ip JM, Saw SM, Rose KA, et al. Role of near work in myopia: findings in a sample of Australian school children. *Invest Ophthalmol Vis Sci*. 2008;49(7):2903–2910. doi:10.1167/IOVS.07-0804
8. Wen G, Tarczy-Hornoch K, McKean-Cowdin R, et al. Prevalence of myopia, hyperopia and astigmatism in non-Hispanic white and Asian children: multi-ethnic pediatric eye disease study. *Ophthalmology*. 2013;120(10):2109. doi:10.1016/J.OPHTHA.2013.06.039

9. Alobaisi S, Alromaih AI, Aljulayfi AS, Alanazi SM, Knowledge AS. Attitude, and Practice among parents of strabismic children in Saudi Arabia: a cross-sectional study. *Cureus*. 2022;14(12). doi:10.7759/CUREUS.33120
10. Alanazi SRG, Alanazi HWH, Alanazi WG, et al. Parents' knowledge and attitudes toward pediatric ophthalmic disorders in Saudi Arabia: a cross-sectional study. *Pediatric Reports*. 2024;16(4):902–920. doi:10.3390/PEDIATRIC16040077
11. Alghamdi W. Prevalence of refractive errors among children in Saudi Arabia: a systemic review. *Open Ophthalmol J*. 2021;15(1):89–95. doi:10.2174/1874364102115010089
12. Cumpston M, Li T, Page MJ, et al. Updated guidance for trusted systematic reviews: a new edition of the Cochrane Handbook for Systematic Reviews of Interventions. *Cochrane Database Syst Rev*. 2019;10(10):ED000142. doi:10.1002/14651858.ED000142
13. Page MJ, McKenzie JE, Bossuyt PM, et al. The PRISMA 2020 statement: an updated guideline for reporting systematic reviews. *BMJ*. 2021;372. doi:10.1136/BMJ.N71.
14. Ouzzani M, Hammady H, Fedorowicz Z, Elmagarmid A. Rayyan-a web and mobile app for systematic reviews. *Syst Rev*. 2016;5(1):1–10. doi:10.1186/S13643-016-0384-4/FIGURES/6
15. Landis JR, Koch GG. An application of hierarchical kappa-type statistics in the assessment of majority agreement among multiple observers. *Biometrics*. 1977;33(2):363. doi:10.2307/2529786
16. Stang A. Critical evaluation of the Newcastle-Ottawa scale for the assessment of the quality of nonrandomized studies in meta-analyses. *Eur J Epidemiol*. 2010;25(9):603–605. doi:10.1007/S10654-010-9491-Z
17. Baklola M, Terra M, Elsehrawy MG, et al. Epidemiology of surgical site infections post-cesarean section in Africa: a comprehensive systematic review and meta-analysis. *BMC Pregnancy Childbirth*. 2025;25(1):1–18. doi:10.1186/S12884-025-07526-Y/FIGURES/5
18. Geissbühler M, Hincapié CA, Aghlmandi S, Zwahlen M, Jüni P, da Costa BR. Most published meta-regression analyses based on aggregate data suffer from methodological pitfalls: a meta-epidemiological study. *BMC Med Res Methodol*. 2021;21(1):123. doi:10.1186/S12874-021-01310-0
19. Cheema HA, Shahid A, Ehsan M, Ayyan M. The misuse of funnel plots in meta-analyses of proportions: are they really useful? *Clin Kidney J*. 2022;15(6):1209–1210. doi:10.1093/CKJ/SFAC035
20. Furuya-Kanamori L, Barendregt JJ, Doi SAR. A new improved graphical and quantitative method for detecting bias in meta-analysis. *Int J Evid Based Healthc*. 2018;16(4):195–203. doi:10.1097/XEB.0000000000000141
21. Al-Rowaily MA. Prevalence of refractive errors among pre-school children at King Abdulaziz Medical City, Riyadh, Saudi Arabia. *Saudi J Ophthalmol*. 2010;24(2):45–48. doi:10.1016/J.SJOPT.2010.01.001
22. Al Wadaani FA, Amin TT, Ali A, Khan AR. Prevalence and pattern of refractive errors among primary school children in Al Hassa, Saudi Arabia. *Glob J Health Sci*. 2012;5(1):125–134. doi:10.5539/GJHS.V5N1P125
23. Aldebasi YH. Prevalence of correctable visual impairment in primary school children in Qassim Province, Saudi Arabia. *J Optim*. 2014;7(3):168–176. doi:10.1016/J.OPTOM.2014.02.001
24. Alrahili NHR, Jadidy ES, Alahmadi BSH, et al. Prevalence of uncorrected refractive errors among children aged 3-10 years in western Saudi Arabia. *Saudi Med J*. 2017;38(8):804–810. doi:10.15537/SMJ.2017.8.20412
25. Mohammed Alemam A, Aldebasi MH, Rehmatullah A, Alsaidi R, Tashkandi I. Prevalence of myopia among children attending pediatrics ophthalmology clinic at Ohud Hospital, Medina, Saudi Arabia. *J Ophthalmol*. 2018;2018. doi:10.1155/2018/3708409.
26. Alghamdi W. Refractive errors and binocular anomalies in primary schools in uyoun aljawa: a small Urban Town in Saudi Arabia. *Glob J Health Sci*. 2020;12(10):p116. doi:10.5539/GJHS.V12N10P116
27. Alomair R, Alghnam S, Alnasser B, et al. The prevalence and predictors of refractive error among school children in Riyadh, Saudi Arabia. *Saudi J Ophthalmol*. 2021;34(4):273–277. doi:10.4103/1319-4534.322621
28. Althomali TA, Alqurashi M, Alghamdi AS, Ibrahim A, Alswailmi FK. Prevalence of refractive errors in school-going children of Taif region of Saudi Arabia. *Saudi J Ophthalmol*. 2022;36(1):70–74. doi:10.4103/SJOPT.SJOPT\_46\_21
29. Alkhathami A, Alqarni SAM, Aljuaid AT, et al. Prevalence and patterns of refractive error among school-age children in Bisha, Saudi Arabia. *Cureus*. 2023;15(12). doi:10.7759/CUREUS.50530
30. Lorato MM, Yimer A, Kebede Bizueneh F. Prevalence of myopia in school-age children in Ethiopia: a systematic review and meta-analysis. *SAGE Open Med*. 2023;11. doi:10.1177/20503121231200105
31. Oveneri-Ogbomo G, Osuagwu UL, Ekpenyong BN, et al. Systematic review and meta-analysis of myopia prevalence in African school children. *PLoS One*. 2022;17(2):e0263335. doi:10.1371/JOURNAL.PONE.0263335
32. Duthel F, Oueslati T, Delamarre L, et al. Myopia and near work: a systematic review and meta-analysis. *Int J Environ Res Public Health*. 2023;20(1):875. doi:10.3390/IJERPH20010875/S1
33. Martínez-Albert N, Bueno-Gimeno I, Gené-Sampedro A. Risk factors for myopia: a review. *J Clin Med*. 2023;12(18):6062. doi:10.3390/JCM12186062
34. Russo A, Boldini A, Romano D, et al. Myopia: mechanisms and strategies to slow down its progression. *J Ophthalmol*. 2022;2022:1004977. doi:10.1155/2022/1004977
35. Lanca C, Saw S-M. The association between digital screen time and myopia: a systematic review. *Ophthalmic Physiol Opt*. 2020;40(2):216–229. doi:10.1111/OPO.12657
36. Rudnicka AR, V KV, Wathern AK, et al. Global variations and time trends in the prevalence of childhood myopia, a systematic review and quantitative meta-analysis: implications for aetiology and early prevention. *Br J Ophthalmol*. 2016;100(7):882–890. doi:10.1136/BJOPHTHALMOL-2015-307724/-DC1
37. Biswas S, El Kareh A, Qureshi M, et al. The influence of the environment and lifestyle on myopia. *J Physiol Anthropol*. 2024;43(1):7. doi:10.1186/S40101-024-00354-7
38. Alanazi MK, Almutleb ES, Badawood YS, Kudam MA, Liu M. Perspectives and clinical practices of optometrists in Saudi Arabia concerning myopia in children. *Int J Ophthalmol*. 2023;16(2):267–273. doi:10.18240/IJO.2023.02.14
39. Ho M, Morjaria P. Cycloplegic refraction in children. *Community Eye Health*. 2024;37(122):14.
40. Yuexin W, Yu Z, Yifei Y, Yan L, Yueguo C. The impact of accommodation function on the difference between noncycloplegic and cycloplegic refraction in adult myopes. *Acta Ophthalmol*. 2024;102(5):e727–e735. doi:10.1111/AOS.16632
41. Eslayah AH, Omar R, Fadzil NM. Refractive amblyopia among children aged 4–12 years in a hospital-based setting in Gaza Strip, Palestine. *Med Hypothesis Discov Innov Ophthalmol*. 2021;10(3):107. doi:10.51329/MEHDIOPTHAL1428

42. At R, Farzana Ghouse N. A study on prevalence of refractive errors, strabismus and amblyopia in paediatric age group in a tertiary care hospital. *Original Research Article J Evid Based Med Healthc.* 2018;5. doi:10.18410/jebmh/2018/144
43. Abd Elkhaliq RM, El-Bassiouny OM, El Nahass HS, Farghaly RM. Pattern of errors of refraction among children attending ophthalmic outpatient clinic in Suez Canal University Hospital. *Suez Canal University Med J.* 26(10):2023.
44. Read SA, Collins MJ, Carney LG. A review of astigmatism and its possible genesis. *Clin Exp Optom.* 2007;90(1):5–19. doi:10.1111/j.1444-0938.2007.00112.x
45. Basheikh A, Howldar S, Basendwah M, Baqais R, Bamakrid M, Alhibshi N. Astigmatism among children in Jeddah, Saudi Arabia: prevalence and associated factors. *World Family Med J.* 2021;19(2). doi:10.5742/MEWFM.2021.93976
46. Öner V, Bulut A, Büyüktarakçı S, Kaim M. Influence of hyperopia and amblyopia on choroidal thickness in children. *Eur J Ophthalmol.* 2016;26(6):623–626. doi:10.5301/EJO.5000703
47. Pascual M, Huang J, Maguire MG, et al. Risk factors for amblyopia in the vision in preschoolers study. *Ophthalmology.* 2014;121(3):622–629.e1. doi:10.1016/J.OPHTHA.2013.08.040
48. Wajuihian SO, Mashige KP. Gender and age distribution of refractive errors in an optometric clinical population. *J Optom.* 2021;14(4):315. doi:10.1016/J.OPTOM.2020.09.002
49. Khoshhal F, Hashemi H, Hooshmand E, et al. The prevalence of refractive errors in the Middle East: a systematic review and meta-analysis. *Int Ophthalmol.* 2020;40(6):1571–1586. doi:10.1007/S10792-020-01316-5
50. Sheeladevi S, Seelam B, Nukella PB, Modi A, Ali R, Keay L. Prevalence of refractive errors in children in India: a systematic review. *Clin Exp Optom.* 2018;101(4):495–503. doi:10.1111/CXO.12689
51. Bist J, Kandel H, Paudel N, et al. Prevalence of refractive errors in Nepalese children and adults: a systematic review with meta-analysis. *Clin Exp Optom.* 2023;106(2):119–132. doi:10.1080/08164622.2022.2153582
52. Li D, Min S, Li X. Is spending more time outdoors able to prevent and control myopia in children and adolescents? a meta-analysis. *Ophthalmic Res.* 2024;67(1):393–404. doi:10.1159/000539229
53. Saxena R, Dhiman R, Gupta V, et al. Prevention and management of childhood progressive myopia: national consensus guidelines. *Indian J Ophthalmol.* 2023;71(7):2873–2881. doi:10.4103/IJO.IJO\_387\_23

## Clinical Ophthalmology

### Publish your work in this journal

Clinical Ophthalmology is an international, peer-reviewed journal covering all subspecialties within ophthalmology. Key topics include: Optometry; Visual science; Pharmacology and drug therapy in eye diseases; Basic Sciences; Primary and Secondary eye care; Patient Safety and Quality of Care Improvements. This journal is indexed on PubMed Central and CAS, and is the official journal of The Society of Clinical Ophthalmology (SCO). The manuscript management system is completely online and includes a very quick and fair peer-review system, which is all easy to use. Visit <http://www.dovepress.com/testimonials.php> to read real quotes from published authors.

Submit your manuscript here: <https://www.dovepress.com/clinical-ophthalmology-journal>

**Dovepress**

Taylor & Francis Group