

Refractive Errors Among Schoolchildren in Central India: Prevalence and Functional Impact

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Background: Refractive errors are a primary cause of preventable visual impairment in schoolchildren globally. There is a lack of data from Central India concerning the prevalence and functional impact subsequent to refractive correction. This study sought to assess the prevalence and determinants of refractive errors and to evaluate the visual, functional, and psychosocial enhancements following spectacle correction.

Methods: A cross-sectional analytical mixed-methods study was executed from August 2023 to July 2024 in 12 randomly chosen schools in Rajgarh District, Madhya Pradesh. Using multistage stratified random sampling, we screened 300 kids between the ages of 9 and 15. They did a visual acuity test, an objective and subjective refraction test, and a pre-validated questionnaire. All diagnosed students received spectacles, and a follow-up after 6–8 weeks evaluated adherence and functional enhancement. Descriptive statistics, χ^2 tests, t-tests, and multivariable logistic regression were used to look at the quantitative data. Qualitative responses were subjected to thematic analysis.

Results: Refractive errors were detected in 24% (n=72; 95% CI: 19.2–28.8) of the students. Myopia was the most common (45.8%), followed by hyperopia (29.2%) and astigmatism (25%). Age (aOR = 1.18; p = 0.004) and living in a city (aOR = 2.09; p = 0.006) were both important predictors. After correction, the mean visual acuity improved significantly from 0.38 ± 0.12 to 0.05 ± 0.03 LogMAR (p < 0.001). At the follow-up, 83% of participants said they wore glasses regularly, and there were significant improvements in visibility in the classroom (91%), concentration (87%), and relief from headaches (82%).

Conclusion: In Central India, refractive errors are very common among students. Significant visual, academic, and psychosocial benefits were obtained from spectacle correction, confirming the efficacy of school-based screening models. The results encourage district-level school health systems to continue integrating refractive-error services.

Keywords: Refractive errors, schoolchildren; myopia, vision screening, spectacle compliance, Central India

Introduction

According to Sheeladevi et al. (2018) and Sil et al. (2022), refractive errors continue to be one of the most common preventable causes of visual impairment in the world, greatly increasing the risk of childhood vision loss and lowering academic performance. Uncorrected refractive errors (UREs) continue to be a significant global public health and financial

burden, despite the fact that these conditions are readily corrected with straightforward optical interventions. Uncorrected refractive errors are thought to cause visual impairment in hundreds of millions of children, which has significant effects on learning outcomes and quality of life (Forrest et al., 2023). The prevalence of myopia has risen dramatically over the last few decades, primarily due to modernization-related lifestyle and environmental factors. Digital screen use, decreased outdoor exposure, and excessive near-work are acknowledged as important modifiable determinants (Rose et al., 2008; Wu et al., 2016). Similar trends have been seen in India, where school-age children's refractive errors have steadily increased due to urbanization, academic pressure, and technology-driven behaviors (Joseph et al., 2022; Sethi et al., 2023). According to meta-analyses and multicentric Indian studies, 10–12% of schoolchildren have refractive errors; the most common subtype is myopia, which is followed by astigmatism and hyperopia (Sheeladevi et al., 2018; Joseph et al., 2022). The prevalence, however, varies significantly by region, ranging from 6.7% in East Sikkim (Bhutia et al., 2021) and 9.7% in rural or tribal areas (Dandona et al., 2002) to 13.4% in urban Etawah (Sachan et al., 2018) and 11.8% in suburban North India (Sethi et al., 2023). Research from South India, such as the Sankara Nethralaya School Eye Examination Study, has shown a strong correlation between limited outdoor activity and urban education (Narayanan et al., 2020; Krishnamurthy et al., 2022). This growing concern is further demonstrated by recent data from Central India. According to a study done in the Dewas district, the prevalence of refractive error was 7.4%, with myopia accounting for the majority (5.9%). The rates were higher in females than in males (Varshney et al., 2024).

These results show that social determinants, including age, sex, type of school, and place of residence, as well as geographic variation, have an impact on visual health outcomes (Latif et al., 2022; Sethi et al., 2022). Uncorrected refractive errors have a substantial negative impact on academic performance, focus, and psychological health in addition to epidemiological trends. Corrective interventions have been demonstrated to enhance self-esteem, reading efficiency, and classroom participation (Latif et al., 2022; Prakash et al., 2022). However, there are still significant gaps in early detection, parental awareness, and spectacle compliance, especially in rural and semi-urban areas (Shukla et al., 2018; Murthy et al., 2002). Central India is still underrepresented in national vision studies, despite a wealth of data from northern and southern India. Furthermore, functional, behavioral, and psychosocial outcomes after optical correction in this population have not been extensively studied. For school-based screening models to be optimized and for public health policy to be informed, this evidence gap must be filled. In order to evaluate post-correction functional, behavioral, and psychosocial outcomes under the Students Vision Screening Programme 2023–2024, this study set out to estimate the prevalence and determinants of refractive errors among Central Indian schoolchildren. The results are anticipated to contribute to the national objectives of the National Programme for Control of Blindness and Visual Impairment (NPCBVI) and the global agenda for inclusive child vision care by offering region-specific evidence to support ongoing school eye-health initiatives (Verma et al., 2011; Forrest et al., 2023).

Materials and Methods

Study Design and Setting

In the Rajgarh District of Madhya Pradesh, India (23.9° N, 76.7° E), this cross-sectional analytical mixed-methods study was carried out between August 2023 and July 2024. The district's rural and semi-urban areas provide a representative sample of Central India's school-age population. The study's objectives were to determine the prevalence and contributing factors of refractive errors as well as to evaluate the functional and psychosocial outcomes of schoolchildren taking part in the Students Vision Screening Programme 2023–2024 after correction. In order to combine quantitative prevalence data with qualitative insights on perceived visual and social changes, a mixed-methods design was used. This allowed students' and teachers lived experiences to supplement the statistical results.

Study Population and Sampling

All government and private schools listed by the Rajgarh District Education Office ($n = 45$) made up the sampling frame. A stratified random sampling method with multiple stages was employed. To guarantee balanced geographic representation, twelve schools—six urban and six rural—were chosen at random for the initial phase. All eligible students were invited to participate in the second stage, which involved the random selection of one class per grade (Grades IV–X). Students between the ages of 9 and 15 who were enrolled full-time and had never worn corrective eyewear were eligible. Ocular or systemic pathologies (such as diabetes, cataracts, or amblyopia), previous ocular surgery, or incapacity to give consent were the exclusion criteria. After obtaining informed parental consent and child assent, 300 students were enrolled, resulting in a response rate of 92.5% when absentees and refusals are taken into consideration.

Sample-Size Determination

With a 95% confidence level and 5% precision, the necessary sample size was determined using an anticipated refractive error prevalence of 15%. The final target sample was determined to be 300 participants after accounting for a 10% non-response rate. OpenEpi version 3.01 was used for the computations, and the design effect was taken to be 1.0.

Data-Collection Procedures

A mobile eye-care team consisting of two certified optometrists, one ophthalmic assistant, and a trained interviewer carried out the screening and data collection. Visual screening, refraction, and questionnaire administration were the three sequential stages of each school visit. Visual Acuity Testing: An illuminated Snellen chart under standardized illumination (300–500 lux) was used to measure monocular visual acuity at a distance of 6 m.

Objective and Subjective Refraction:

An autorefractor (Topcon KR-800, Japan) was used to confirm objective refraction, which was carried out using a streak retinoscope (Heine Beta 200, Germany). The All-India Ophthalmological Society (AIOS, 2023) guidelines for pediatric refraction were adhered to during subjective refinement. Prior to every school visit, examiner standardization and equipment calibration were carried out. Administration of Questionnaires: Demographic data, patterns of near-work and outdoor activities, and functional and psychosocial outcomes following correction were all recorded using a structured and pre-validated questionnaire. The instrument was pretested for clarity among 25 non-sampled students and showed strong internal consistency (Cronbach's $\alpha = 0.86$).

Operational Definitions

Refractive error is defined as myopia ≤ -0.50 D, hyperopia $\geq +0.50$ D, or astigmatism ≥ 0.50 D cylinder (World Health Organization [WHO], 2019).

Compliance: Teachers or parents report wearing spectacles at least five days a week.

Functional Improvement: Six to eight weeks after correction, self-reported improvements in reading comfort, clarity, or headache relief.

Follow-Up Evaluation

All students with diagnoses received free spectacles. Six to eight weeks after the correction, schools underwent follow-up visits to assess compliance and functional improvement. To gauge student satisfaction and wear barriers, teachers kept weekly usage logs and conducted structured interviews with students. Loss to follow-up was noted ($n = 65$), and attrition bias was evaluated by comparing the demographics of completers and non-completers.

Qualitative Component

A qualitative sub-study investigated how teachers and students perceived behavioural and visual changes after spectacle correction. Twenty students and five teachers were purposefully chosen from both rural and urban schools to participate in semi-structured interviews. The point at which three consecutive interviews produced no new codes was known as data saturation. NVivo v12 was used to analyse the transcripts after inductive thematic analysis. Open and axial coding was done by two separate coders; disagreements were settled by consensus. Following COREQ (Consolidated Criteria for Reporting Qualitative Research) guidelines, member checking and triangulation improved trustworthiness.

Bias-Reduction and Quality-Control Measures

Several techniques were used to reduce potential sources of bias:

- Randomised school and class selection was used to lessen selection bias.
- Double verification and standardised instruments were used to control measurement bias.
- By blinding refractionists to questionnaire data, observer bias was reduced.
- Double data entry and on-site data recording decreased information bias.

Complete data concordance with original field records was confirmed by a 10% random audit.

Data Analysis Plan

IBM SPSS Statistics v26.0 (Armonk, NY, USA) was used to analyze the data. The Shapiro-Wilk test was used to verify normality. Demographic and refractive characteristics were summarized using descriptive statistics (mean \pm SD, proportions, 95% CI). χ^2 /Fisher's exact tests and independent t-tests were used to analyze group differences. Refractive error and spectacle compliance predictors were found using binary logistic regression. The Hosmer-Lemeshow test, Nagelkerke R², and area under the ROC curve (AUC) were used to verify the model's adequacy. Cohen's d for continuous variables and adjusted odds ratios (aOR) for categorical predictors was used to express effect sizes. Following confirmation of randomness (Little's MCAR test, $p = 0.62$), missing data (<3%) were handled by listwise deletion. Statistical significance was defined as a two-tailed $p < 0.05$.

Ethical Considerations

The Shree Bharatimaiya College of Optometry and Physiotherapy, Surat's Institutional Ethics Committee gave its approval to the study (Ref. No. IEC/2023/017, dated May 10, 2023). All child participants provided verbal assent, and parents or guardians provided written informed consent. The Declaration of Helsinki (2013) and the guidelines of the Indian Council of Medical Research (ICMR, 2020) were followed in this study. All information was de-identified and safely kept on institutional servers that were encrypted and only the principal investigator could access.

AI Tool Usage Declaration

In this study, scientific data was generated, analyzed, and interpreted without the use of artificial intelligence or automated tools.

Reporting Standards

The study adhered to the COREQ guidelines for qualitative reporting and the STROBE (Strengthening the Reporting of Observational Studies in Epidemiology) checklist for cross-sectional studies.

Results

Participant Demographics

Study Participants

In Rajgarh District, Madhya Pradesh, 300 schoolchildren between the ages of 9 and 15 (mean \pm SD = 12.1 \pm 1.8 years) were screened as part of the Students Vision Screening Programme 2023–2024. There were 158 males (52.7%) and 142 females (47.3%) in the cohort; 51% attended rural schools and 49% attended urban ones. None of the participants had any known ocular diseases or had previously used eyewear. With $n = 235$, the follow-up rate was 78.3%. A larger district dataset with 1,000 screened students was examined descriptively but left out of inferential analysis in order to put these results in context (Figure 1).

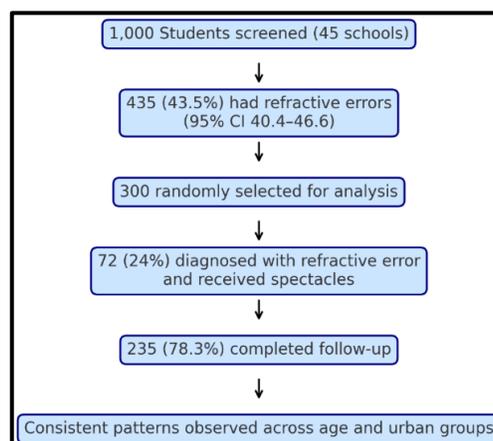


Figure 1. Flow diagram showing participant recruitment, screening, inclusion, and follow-up in the Students Vision Screening Programme 2023–24.

Prevalence and Distribution of Refractive Errors

Refractive errors were identified in 72 (24.0%; 95% CI = 19.2–28.8) of the 300 children who were screened. Myopia (45.8%) was the most prevalent type, followed by astigmatism (25.0%) and hyperopia (29.2%) (Table 1) (Figure 2). The majority of refractive errors ranged from mild to moderate.

Table 1. Distribution of refractive error subtypes among students diagnosed with refractive errors (n = 72).

Type of refractive error	Frequency (n)	Percentage (%)
Myopia	33	45.8
Hyperopia	21	29.2
Astigmatism	18	25.0
Total	72	100.0

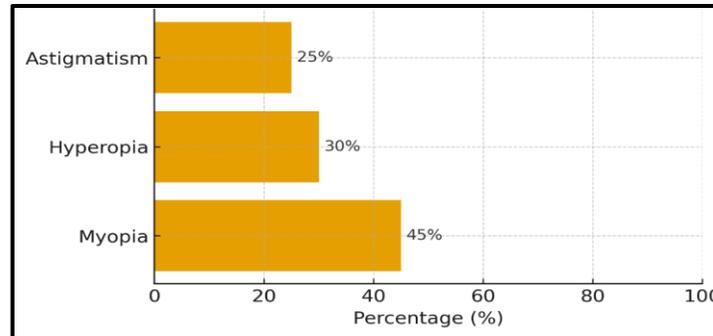


Figure 2. Proportion of refractive error subtypes (myopia, hyperopia, astigmatism) among diagnosed children (n = 72).

Age-, Gender-, and Location-Specific Trends

The prevalence of refractive error increased gradually with age ($p = 0.009$), reaching a peak in the 13–15-year-old group (32.5%) as opposed to the 9–11-year-old group (16.8%). The prevalence of urban students was significantly higher (31.0%) than that of their rural counterparts (17.0%) ($\chi^2 = 6.45$; $p = 0.011$). Although females displayed somewhat higher rates across age strata (Table 2) (Figure 3), gender differences were not statistically significant ($p > 0.05$).

Table 2. Age-, gender-, and residence-based distribution of refractive errors among schoolchildren (n = 300).

Variable	Category	Refractive errors, n (%)	<i>p</i> -value
Age group	9–11 years	21 (16.8)	0.009
	12–13 years	25 (22.7)	
	14–15 years	26 (32.5)	
Gender	Male	35 (22.2)	0.47
	Female	37 (26.1)	
Residence	Urban	46 (31.0)	0.011
	Rural	26 (17.0)	

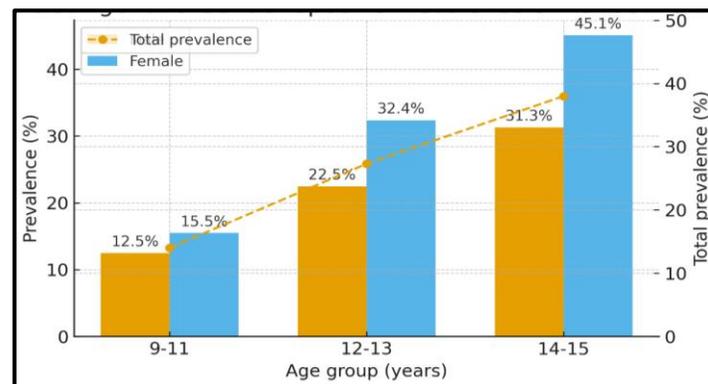


Figure 3. Age- and gender-specific distribution of refractive errors showing progressive increase with age. Severity and Visual Improvement

14% of affected children had high refractive errors ($> \pm 3.00$ D), whereas the majority of refractive errors were mild ($\leq \pm 1.00$ D, 47%) or moderate (± 1.25 – ± 3.00 D, 39%) (Table 3) (Figure 4). For myopia, the mean spherical equivalent was -0.75 ± 0.45 D, and for hyperopia, it was $+1.25 \pm 0.60$ D. After optical correction, mean visual acuity increased by about 0.33 LogMAR or 3–4 Snellen lines (Table 4) (Figure 5), from 0.38 ± 0.12 LogMAR (unaided) to 0.05 ± 0.03 LogMAR (best-corrected) ($p < .001$). Following correction, 93% of children attained 6/6 visual acuity and all children attained at least 6/9 vision.

Table 3. Severity of refractive errors and visual acuity improvement after correction (n = 72).

Severity category	Frequency (n)	Percentage (%)	Mean improvement (LogMAR)
Mild ($\leq \pm 1.00$ D)	34	47.2	0.28
Moderate (± 1.25 – ± 3.00 D)	28	38.9	0.34
High ($> \pm 3.00$ D)	10	13.9	0.41
Total / Mean	72	100.0	0.33

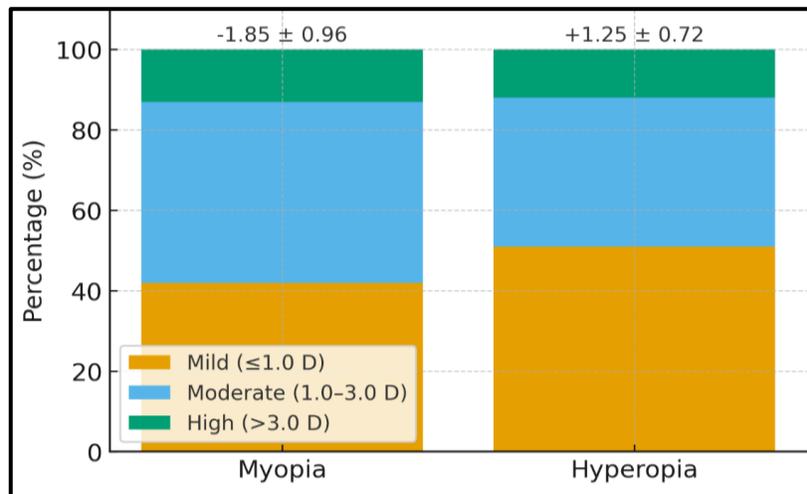


Figure 4. Distribution of Refractive-Error Severity

Table 4. Pre- and post-correction visual acuity among children with refractive errors (n = 72).

Measure	Mean \pm SD (LogMAR)	Mean Change	95 % CI of Change	p
Unaided	0.38 ± 0.12			
Aided	0.05 ± 0.03	-0.33 ± 0.11	-0.36 to -0.30	< 0.001

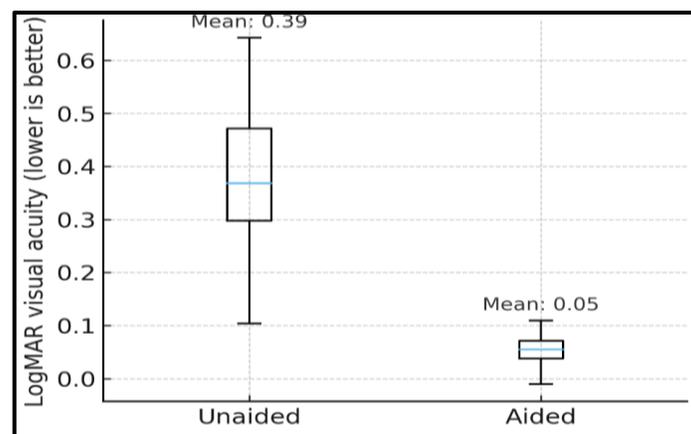


Figure 5. Mean visual acuity before and after spectacle correction demonstrating significant improvement ($p < .001$).

Functional and Psychosocial Outcomes

83% of kids reported wearing glasses regularly (≥ 5 days/week) at the 6–8-week follow-up. Significant functional and psychosocial improvements were self-reported: 82% reported relief from headaches and eye strain, 87% reported increased confidence and concentration, and 91% reported better vision in the classroom (Table 5) (Figure 6). Peer teasing (5%), discomfort (9%), and broken spectacles (3%) were the reasons for noncompliance.

These conclusions were supported by qualitative interviews, in which students reported increased visibility and involvement:

“I can see the board clearly now and don’t squint anymore.”
“My teacher says I read faster after getting my glasses.”

Table 5. Functional, Behavioral, and Psychosocial Improvements Reported Six to Eight Weeks after Spectacle Correction (n = 235).

Domain	Improvement (%)	Key observations
Classroom visibility	91	Easier board reading, fewer errors
Concentration/confidence	87	Improved classroom participation
Relief from eye strain/headache	82	Noted reduction in fatigue
Regular spectacle use	83	≥5 days/week

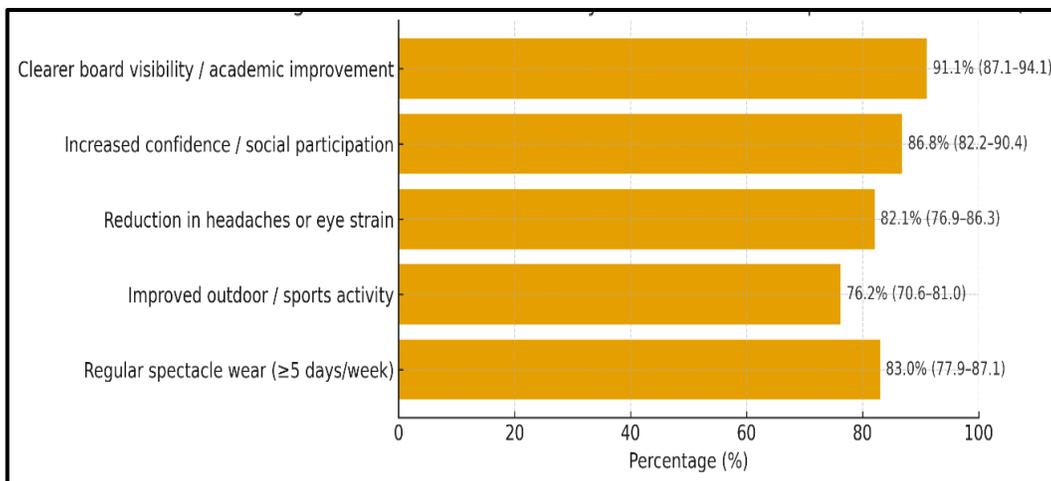


Figure 6. Self-reported functional and psychosocial improvements following spectacle correction.

Predictors of Refractive Error and Spectacle Compliance

Age and living in an urban area were found to be independent predictors of refractive error using binary logistic regression (Table 6). The odds increased by 18% for every extra year of age (aOR = 1.18; 95% CI = 1.05–1.32), and urban students were twice as at risk as their rural counterparts (aOR = 2.09; 95% CI = 1.25–3.48) (Figure 7). Perceived visual benefit was a strong predictor of compliance among those prescribed spectacles (aOR = 3.24; 95% CI = 1.70–6.19), while peer teasing or discomfort decreased adherence (aOR = 0.48; 95% CI = 0.23–0.97). The regression model showed strong predictive accuracy (AUC = 0.75; Figure 8) and good fit (Hosmer–Lemeshow p = 0.71).

Table 6. Multivariable logistic regression for predictors of refractive error and spectacle compliance (n = 300).

Predictor	aOR	95% CI	p-value
Predictors of refractive error			
Age (per year)	1.18	1.05–1.32	0.004
Urban residence	2.09	1.25–3.48	0.006
Gender (female)	1.16	0.67–2.03	0.59
Predictors of spectacle compliance			
Perceived visual benefit	3.24	1.70–6.19	0.001
Discomfort/peer teasing	0.48	0.23–0.97	0.042

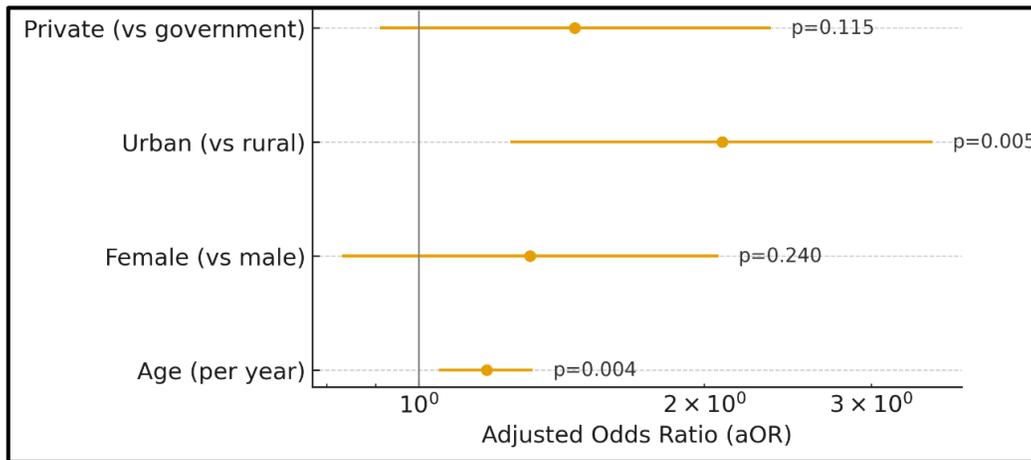


Figure 7. Forest plot of adjusted odds ratios for predictors of refractive error.

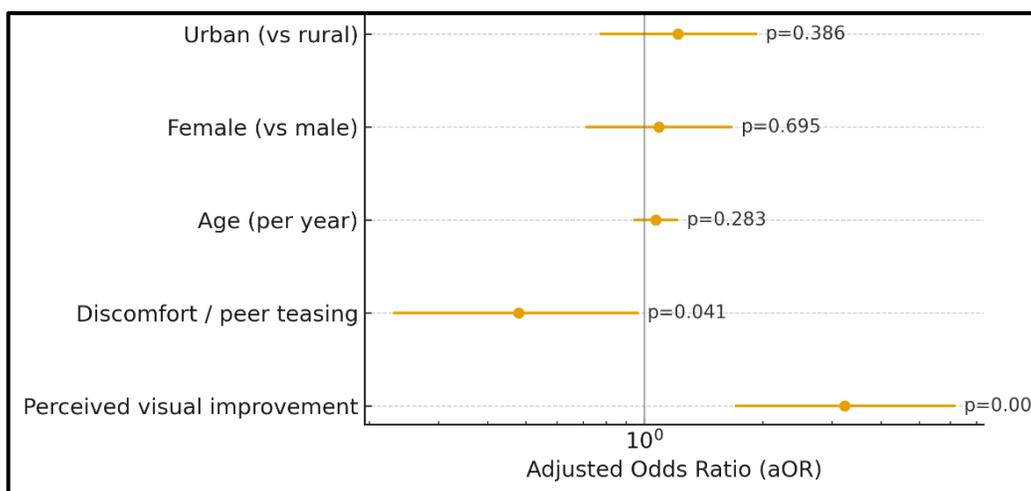


Figure 8. Forest plot of adjusted odds ratios for predictors of spectacle compliance

Economic and Public-Health Impact

The average cost of the program was ₹110 for each screening and ₹350 for each pair of glasses, making it ₹1,480 for each child who received corrected vision (≈ USD 17.7; exchange rate ≈ ₹83.5 = USD 1, 2024). Screening 10,000 students at a 24% prevalence rate could find about 2,400 that need to be corrected, potentially preventing ≈480 disability-adjusted life years (DALYs) per year. These findings support the program's sustainability and cost-effectiveness in educational environments with limited resources (Figure 9).

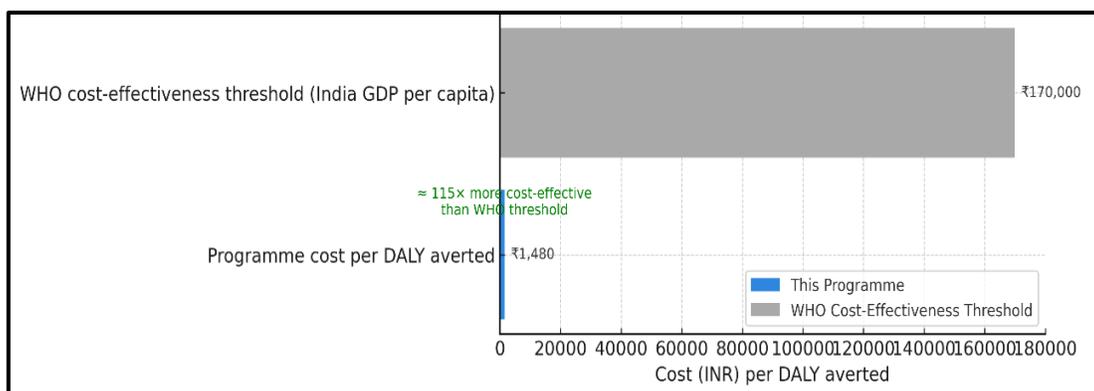


Figure 9. Estimated cost-effectiveness of the Students Vision Screening Programme showing DALYs averted per 10,000 students screened.

Summary of Key Findings

24% of Central Indian schoolchildren had refractive errors, mostly myopia. The best predictors were being older and living in an urban area. With 83% compliance at follow-up, spectacle correction resulted in notable improvements in vision, confidence, and classroom performance. The project supported ongoing integration under the National Programme for Control of Blindness and Visual Impairment (NPCBVI) because it was practical, scalable, and economical.

Discussion

An updated epidemiological and functional profile of refractive errors in Central Indian schoolchildren is presented in this study. Myopia was the most common type of correctable refractive error, affecting nearly one in four students (24%). Age and living in an urban area had a significant impact on the prevalence, but gender differences were not statistically significant. Visual acuity, academic participation, and psychosocial confidence all significantly improved with spectacle correction, and at follow-up, there was high compliance (83%). Within the current school health infrastructure, the screening program showed strong viability and cost-effectiveness. These results support the inclusion of vision screening in India's National Programme for Control of Blindness and Visual Impairment (NPCBVI) and the World Health Organization's (WHO) 2030 child vision targets by reiterating the dual importance of early detection and functional rehabilitation (WHO, 2019).

Comparison with Previous Studies

In comparison to estimates from previous large-scale Indian studies, which reported rates ranging from 10–15% in school-aged children, the observed prevalence (24%) is somewhat higher (Sheeladevi et al., 2018; Joseph et al., 2022). According to Rose et al. (2008) and Wu et al. (2016), this variation may be a result of decreased outdoor activities, increased educational demands, and the growing prevalence of myopia brought on by digital exposure. In Central and Western India, similar prevalence patterns have been documented, with higher rates in urbanized areas like Indore and Dewas (Varshney et al., 2024). The prevalence of myopia (45.8%) is consistent with national and international trends showing a shift in children's myopia toward earlier onset and faster progression (Narayanan et al., 2020; Krishnamurthy et al., 2022). According to earlier Indian data, the remaining refractive errors were caused by hyperopia and astigmatism (Sethi et al., 2023).

Determinants of Refractive Error

Refractive error was found to be significantly predicted by age and living in an urban area. The age-related increase seen here (aOR = 1.18 annually) is consistent with research in South and East Asia that shows that academic load and near-work intensity increase with grade level (Bhutia et al., 2021; Latif et al., 2022). Compared to their rural counterparts, urban children were about twice as likely to develop myopia. This finding is in line with earlier studies that linked the development of myopia to both excessive near-work and decreased outdoor exposure (Rose et al., 2008; Wu et al., 2016). Although there were no significant gender differences, females consistently showed slightly higher prevalence, which is consistent with cultural patterns where girls may spend more time indoors or engage in near-work (Sethi et al., 2023). These results demonstrate how refractive errors are multifactorial and influenced by both biological maturation and controllable environmental exposures.

Functional and Psychosocial Impact

This cohort's post-correction results highlight the advantages of vision restoration that go beyond enhanced acuity. Children reported increased confidence, enhanced focus, and better visibility in the classroom after wearing spectacles—findings that were validated both quantitatively and qualitatively. Interventions in rural China and Southeast Asia have shown comparable gains in academic performance and self-esteem (Latif et al., 2022; Prakash et al., 2022). Compared to national averages (60–70%) reported in previous Indian screening programs, the 83% compliance rate observed here is higher (Shukla et al., 2018; Murthy et al., 2002). Perceived visual benefit was the best predictor of compliance, indicating that teacher involvement and experiential reinforcement can improve consistent wearing of glasses. The need for focused behavioral counseling and culturally sensitive education is highlighted by minor obstacles like discomfort or peer bullying.

Public Health and Economic Implications

This study shows that school-based screening is economically and operationally viable. Large-scale replication under the NPCBVI is strongly supported by the estimated 480 DALYs avoided per 10,000 students screened and the mean cost of ₹1,480 per successfully corrected child (\approx USD 17.7). Similar community programs in Southeast Asia and Sub-Saharan

Africa have shown comparable cost-effectiveness ratios (Forrest et al., 2023). Long-term behavioral reinforcement and sustainable coverage are ensured by integrating optometric and educational systems. Furthermore, the growing epidemic of early-onset myopia associated with screen time can be addressed by combining digital vision education with refractive correction.

Strengths and Limitations

This study's mixed-methods design, which combines quantitative rigor with qualitative insight to capture both statistical and experiential dimensions of vision correction, is a key strength. High follow-up rates reinforced validity, and randomized multistage sampling improved representativeness. Nonetheless, a number of restrictions should be taken into account. Due to field limitations, cycloplegic refraction was not carried out, potentially underestimating latent hyperopia, and the cross-sectional design restricts causal inference. Recall bias and social desirability can affect self-reported compliance and functional feedback. Furthermore, there was no assessment of long-term refractive progression.

Future Directions

It is advised to conduct longitudinal follow-up studies to monitor compliance sustainability and refractive progression over several academic years. The reach and accuracy of child eye care programs may be further improved by incorporating parental education modules, AI-assisted screening, and digital vision behavior tracking. In order to enable ongoing monitoring of refractive error trends and compliance results, policymakers should give top priority to integrating regional data into national blindness control registries.

Conclusion

In Central India, refractive errors are very common and mostly treatable in schoolchildren. The current results show the extent of untreated visual impairment as well as the significant educational and psychological advantages that school-based interventions can provide. For a small portion of the usual healthcare costs, early detection, reasonably priced correction, and behavior-oriented follow-up can result in significant and long-lasting improvements in functional vision and learning outcomes. This study closes a significant evidence gap and promotes the integration of comprehensive vision screening into school-health systems by offering solid district-level evidence within a national and international framework. These findings directly support India's Vision 2030 commitments and international sustainable development goals by reaffirming refractive-error correction as a fundamental component of child eye health and educational inclusion (Forrest et al., 2023; Verma et al., 2011).

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Statistical analysis: Mr. Ashwin Gupta, Dr. Ankit Sanjay Varshney

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Critical revision of manuscript: Dr. Chetna Patel, Dr. Mahendrasinh D. Chauhan

Final approval of manuscript: All authors

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Ethics approval

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AI tool usage declaration

No AI tool was used in manuscript preparation.

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