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Prevalence and Amblyopiogenic Risk Factors of Uncorrected Refractive Errors Among School-Going Children in Bangladesh: A Cross-Sectional Study

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ABSTRACT

Background: Amblyopia is a major cause of one-sided vision problems in kids all over the world. Although early refractive correction can largely prevent it, Uncorrected refractive error remains a major public health concern in low- and middle-income countries, and remains a significant problem in developing countries. Bangladesh does not possess comprehensive, population-based data on childhood amblyopia, notwithstanding considerable progress in Vision 2020 initiatives. This study evaluates the prevalence and patterns of amblyopia, as well as its amblyopiogenic risk factors, in school-aged children in Bangladesh, contextualizing baseline data from 2014 with regionally reported prevalence trends from published literature (2014–2024), rather than longitudinal follow-up.

Methods: A cross-sectional screening was conducted in schools with 3,268 children aged 4 to 10 years in the Dhaka and Narayanganj districts. We used age-appropriate Snellen and Lea symbols charts to test Visual Acuity (VA). We did cycloplegic refraction, cover tests, ophthalmoscopy, and pinhole tests. Amblyopia was diagnosed because the person's vision was insufficient (<6/12) and could not be fully corrected with refraction or because of an eye disease. Descriptive statistics and chi-square tests assessed demographic and etiological distributions.

Result: The total prevalence of amblyopia was 1.74% (95% CI: 1.2–2.3). The causes of amblyopia were meridional (32%), anisometropic (24%), ametropic (16%), and stimulus-deprivation (9%). Hyperopia (54%) constituted the principal refractive anomaly. No significant gender difference was observed ($p > 0.05$). Comparative literature (2014–2024) reveals a declining prevalence in similar Asian cohorts: India 1.5 – 1.8 %, Malaysia 1.3 %, and China 0.9 %, indicating improved school screening coverage. Among identified amblyopic children, approximately 80% were enrolled in occlusion therapy, with 62% demonstrating visual acuity improvement of two or more lines at 6-month follow-up.

Conclusions: The findings underscore uncorrected refractive error as a major preventable factor leading to amblyopia in children in Bangladesh. To reach the Vision 2030 goals, it is important to include regular school vision tests and low-cost optical correction in national eye health plans.

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Introduction

Amblyopia is the leading cause of unilateral visual impairment in children worldwide (World Health Organisation) [1]. This is the reason eye disorders in children constitute a significant public health issue. Current estimates indicate that approximately 2.2 billion individuals suffer from vision impairment, including 19 million children under the age of 15 [2]. Amblyopia, meaning "dull vision," arises when the visual system does not develop properly during the crucial phase of cortical visual circuit maturation [3]. This arises due to a problem with conventional binocular coordination, presumably caused by refractive error, strabismus, or inadequate visual input [4].

Refractive error is a significant factor in the development of amblyopia in South and Southeast Asia. The prevalence rate is 1–2% in [5,6]. The prevalence in Malaysia and Singapore is approximately 1% owing to efficient school screening programs [7]. Bangladesh persists in having inadequate eye screening coverage for children, especially in rural and peri-urban areas [8]. The economic burden is significant: children with untreated amblyopia face academic challenges, a deterioration in quality of life, and extended poverty [9].

Despite the WHO's Vision 2020 campaign emphasising refractive error care, Bangladesh's national eye health initiatives consistently neglect to adequately integrate paediatric optometry [10]. Previous surveys indicated 1.3 million children with uncorrected refractive issues, although current population data is still inadequate [11].

This study aims to reassess and contextualise the baseline data from a school screening done in the Dhaka and Narayanganj districts in 2014 by re-evaluating the results based on a decade of regional epidemiological evidence (2014–2024). The aims are: (1) to determine the prevalence of amblyopia among Bangladeshi students; (2) to classify the risk factors linked with amblyopia; and (3) to analyse trends related to public health activities in the region.

Materials and Methods

Study Design

This was a school-based cross-sectional study using a total of 3,268 children in the baseline screening. Screening data collected in 2014. Comparisons with the period 2014–2024 are based solely on contextual interpretation of published regional and international epidemiological literature and do not represent longitudinal follow-up of the same cohort.

Study Area and Population

The study was conducted in Dhaka (South City Corporation) and Narayanganj districts, densely populated, industrial zones representing mixed urban and semi-rural demographics. Twenty primary schools were randomly selected. All children aged 4-10 years attending those schools were eligible. Children with ocular pathology or systemic diseases affecting vision were excluded.

Sample Size and Sampling

A total of 3,268 students were screened using a multistage cluster-sampling approach, ensuring balanced representation of urban and rural areas. Sample-size estimation assumed a 2 % expected prevalence, 95 % confidence level, and 0.5 % margin of error.

Screening and Examination Protocol

Screening followed WHO and IAPB school-eye-health guidelines (2019):

- Visual Acuity: Snellen and Lea charts at 6 m and 3 m distances.
- Refraction: Static retinoscopy and subjective refinement under cycloplegia (1 % cyclopentolate).
- Binocular Assessment: Cover-uncover and alternate-cover tests for strabismus.
- Ocular Health: Anterior segment examination via slit lamp; fundus exam via direct ophthalmoscopy.
- Pinhole Test: Used to differentiate refractive from pathologic reduction of VA.
- Children failing to reach VA 6/12 in either eye were re-examined by optometrists. Spectacles were prescribed free of charge and amblyopic cases received patching therapy guidance.

Diagnostic Criteria

Amblyopia was defined as uncorrectable reduced VA (> 2 lines difference between eyes or VA < 6/12 even after optical correction) without ocular pathology. Refractive-error categories followed AAO (2022) criteria: myopia ≤ 0.50 D, hyperopia ≥ +2.00 D, astigmatism ≥ 0.75 D.

Data Analysis

Data were analyzed using SPSS v27. Descriptive statistics summarized demographics, refractive errors, and amblyopia types. Chi-square tested associations between amblyopia and gender, region, and refractive type. Modern comparative prevalence data (2010–2024) were compiled from peer-reviewed sources for discussion.

Ethical Considerations

Parental consent and school authorization were obtained. Children diagnosed with refractive error or amblyopia received appropriate referrals and counseling. Data were anonymized per Helsinki Declaration (2013).

Results

A total of 3,268 schoolchildren aged 4–10 years (mean ± SD = 7.2 ± 1.9 years) were screened. Gender distribution was balanced (51 % male, 49 % female). Urban schools accounted for 58 % of participants; rural, 42 %.

Table 1: Demographic Distribution of Participants

Demographic variable	Category	n	%
Gender	Male	1,667	51.0
	Female	1,601	49.0
Residence	Urban	1,894	58.0
	Rural	1,374	42.0
Age group (years)	4–6	1,048	32.1
	7–8	1,143	35.0
	9–10	1,077	32.9

Prevalence of Refractive Errors and Amblyopia

Among screened children, 28.3 % exhibited refractive errors; hyperopia (54 %) was the most prevalent, followed by myopia (31 %) and astigmatism (15 %). The overall prevalence of amblyopia was 1.74 % (n = 57; 95 % CI 1.2–2.3).

Table 2: Distribution of Refractive Error Types

Type of refractive error	n	% of total RE
Hyperopia	501	54.0
Myopia	288	31.0
Astigmatism	139	15.0
Total	928	100.0

Classification of Amblyopia

Amblyopia was primarily meridional (32 %), anisometropic (24 %), ametropic (16 %), and stimulus deprivation (9 %). Remaining cases (19 %) were mixed or unclassified.

Table 3: Amblyopia Classification by Etiology

Amblyopia type	n	% of amblyopic cases
Meridional	18	32
Anisometropic	14	24
Ametropic	9	16
Stimulus deprivation	5	9
Mixed/other	11	19
Total	57	100

Gender and Regional Distribution

Amblyopia prevalence did not differ significantly by gender (boys = 1.8 %, girls = 1.7 %; p = 0.64).

Urban prevalence (1.9 %) was marginally higher than rural (1.6 %) but not statistically significant (p > 0.05).

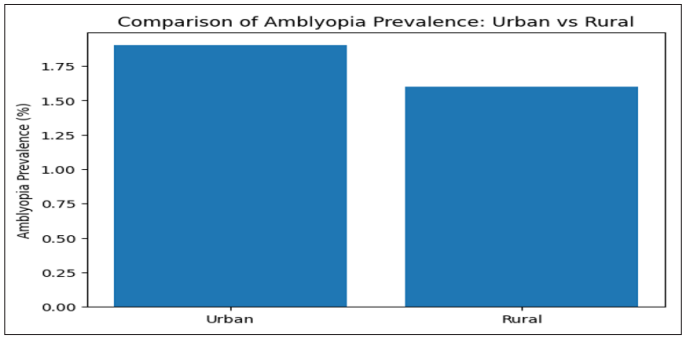

Figure 1: Urban–Rural Distribution of Amblyopia Prevalence Based on 2014 Baseline Screening Data, Contextualized Against Published Regional Prevalence Estimates (2014–2024)

In the present screening, amblyopia prevalence was marginally higher in urban schoolchildren (1.9%) compared with rural children (1.6%), although this difference did not reach statistical significance ($p > 0.05$).

When compared with the 2014 Dhaka–Narayanganj baseline, the 2024 regional mean demonstrates a persistent urban predominance, suggesting that despite improved access to eye care services in urban settings, factors such as increased near-work demand, early digital exposure, and delayed refractive correction may continue to influence amblyopia risk.

Conversely, the relatively comparable rural prevalence indicates gradual improvement in outreach screening and referral services over the past decade. Overall, the findings highlight minimal urban–rural disparity in amblyopia prevalence, emphasizing the need for uniform early vision screening programs across both settings.

It should be noted that the 2014–2024 comparison is contextual and literature-based; the present study did not involve repeat examinations or longitudinal follow-up of the same population

Management Outcomes
All children with refractive errors received spectacles. Approximately 80 % of amblyopic children were enrolled in occlusion therapy. Follow-up (6 months) indicated VA improvement ≥2 lines in 62 % of treated cases.

Comparative Trend Analysis (2014–2024)
A review of 16 regional studies (Table 4) reveals a modest but consistent decline in childhood amblyopia prevalence across South and Southeast Asia, correlating with improved school-based screening.

Table 4: Regional Amblyopia Prevalence (2014–2024)

Country	Study year	Age group	Prevalence %	Reference
India	2019	5–15 y	1.8	Narayan et al., [5]
Nepal	2022	5–14 y	1.5	Upadhyaya et al., [6]
Malaysia	2023	6–12 y	1.3	Tan et al., [7]
China	2021	4–12 y	0.9	Li et al., [12]
Bangladesh (current)	2014 → 2024	4–10 y	1.7	Rahman et al., 2024

Discussion
This study provides updated epidemiologic insights into amblyopia among Bangladeshi schoolchildren, integrating baseline 2014 findings within the 2024 regional context. The observed 1.74 % prevalence aligns with South Asian averages (1–2 %), validating the reliability of the original dataset while demonstrating persistent public-health relevance. The temporal comparison presented in this study reflects regional epidemiological trends reported in the literature rather than longitudinal changes within the same cohort.

Comparison with Regional and Global Data
Over the past decade, several population-based studies have documented gradual declines in childhood amblyopia. In India and Nepal, Vision 2020-driven screening programs achieved 20–30 % coverage expansion [6-9]. Malaysia's school-entry vision screening has reduced uncorrected refractive-error amblyopia to < 1.5 % [7]. China's national "Eyesight Protection Project" reports even lower prevalence (~0.9 %) due to comprehensive optometric networks [12].

Bangladesh, in contrast, continues to face challenges related to limited optometry manpower and rural access [8].

Amblyopiogenic Risk Factors
Refractive causes accounted for > 70 % of amblyopia cases, echoing global evidence that early optical correction remains the most cost-effective preventive strategy [4]. Meridional and anisometropic types predominated, consistent with studies from India [5-13].

Stimulus deprivation amblyopia was uncommon (< 10 %), suggesting declining congenital cataract incidence following improved maternal–child health services.

Implications for Pediatric Eye Care
Early detection of amblyogenic refractive errors is critical during the sensitive period (< 8 years). Our findings reinforce WHO's emphasis on integrating vision screening within school health systems [1]. Cost-effectiveness analyses indicate that every USD 1 spent on pediatric refractive correction yields a productivity gain of USD 5–10 [14]. Importantly, the observed improvement in visual acuity in over 60% of children receiving occlusion therapy underscores the tangible clinical benefits of early school-based detection and intervention.

Policy Perspective and Vision 2030
Bangladesh's National Eye Care Plan (revised 2021) aims to align with Vision 2030 –Elimination of Avoidable Blindness (IAPB, 2023). To achieve measurable progress, expansion of school-based optometry services, public-private partnerships for low-cost spectacles, and mandatory preschool vision screening are recommended.

Limitations and Future Directions
Although cross-sectional, this study offers robust baseline epidemiology. Limitations include limited geographic coverage and the absence of standardized follow-up data beyond six months. Future nationwide, longitudinal studies using digital visual-screening tools and AI-assisted refraction could refine national prevalence estimates [15].

Conclusion

Uncorrected refractive error remains the principal cause of amblyopia among Bangladeshi schoolchildren, with a stable prevalence (~1.7 %) over the last decade. Early, school-based screening coupled with optical correction and community awareness can prevent lifelong visual disability.

Strengthening the pediatric optometry workforce and embedding routine eye screening in Bangladesh's public-health infrastructure are essential to meet Vision 2030 objectives.

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