

Prevalence and Pattern of Refractive Errors and Presbyopia in an Islamic Boarding School Community in Cirebon, Indonesia

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Abstract

Introduction: Uncorrected refractive errors and presbyopia remain significant public health concerns, particularly in understudied Islamic boarding schools.

Objective: This study assessed refractive errors, presbyopia, and ocular abnormalities at Pesantren Buntet, Indonesia. **Method:** A community-based cross-sectional study involved 422 participants undergoing Snellen visual acuity testing, subjective refraction, and near vision assessment. **Results and Discussion:** Visual problems affected 63.03% ($n = 266$) of participants. Myopia was most prevalent (48.34%, $n = 204$), followed by astigmatism (23.70%, $n = 100$) and hyperopia (4.27%, $n = 18$). Participants under 18 years comprised 60.66% of the sample. Presbyopia affected all participants aged ≥ 40 years (19.91%, $n = 84$), with a mean reading addition of $+1.75 \pm 0.54$ D. Suspected ocular pathologies occurred in 6.64% ($n = 28$). Intensive near-work and limited outdoor exposure were potential, unmeasured risk factors.

Conclusion: These findings highlight substantial visual health needs and support routine screening and accessible optometric services in boarding schools

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Introduction

Uncorrected refractive errors (URE) and unaddressed presbyopia remain the primary global contributors to visual impairment and avoidable blindness. Worldwide estimates indicate that over 2.2 billion people live with distance or near vision impairment, with at least 1 billion having conditions that could have been prevented or are yet to be adequately addressed (World Health Organization [WHO], 2021). The socioeconomic repercussions of untreated visual impairment are severe, generating an estimated global annual productivity loss exceeding USD 410 billion (Flaxman et al., 2021). This public health challenge is particularly acute across Asia, where shifting demographics, rapid urbanization, and intensified educational demands have coincided with a dramatic surge in myopia prevalence among children and young adults (Holden et al., 2021); (Morgan et al., 2021).

In Indonesia, vision loss and uncorrected refractive conditions present a major health policy challenge. According to national health surveys, visual disability affects a significant portion of the population across various age brackets (Kementerian Kesehatan Republik Indonesia, 2018). Official health mapping underscores that refractive errors account for a high proportion of preventable visual impairment among school-aged children and productive-age individuals nationwide (Pusat Data dan Informasi Kementerian Kesehatan RI, 2020). Recent empirical studies in urban Indonesian centers report that the prevalence of refractive errors among school children has reached 28%, influenced by increasing digital device usage and indoor routines (Darusman et al., 2023). Furthermore, occupational eye health assessments in Indonesian educational institutions demonstrate that uncorrected refractive errors and unaddressed presbyopia affect up to 44.2% and 66.4% of school staff and teachers, respectively (Ehrlich et al., 2013). Despite the availability of cost-effective corrective solutions such as eyeglasses, access remains restricted due to systemic barriers, including limited optical services in sub-urban regions, low public eye health literacy, and financial constraints (Bourne et al., 2021); (Keel et al., 2021).

Islamic Boarding Schools, locally known as *pesantren*, constitute a unique, high-density residential and educational ecosystem in Indonesia, housing millions of students (*santri*), religious teachers (*ustadz/ustadzah*), and administrative personnel. From an environmental health perspective, the routine of a *pesantren* typically involves structured indoor study sessions, classical text reading (*kitab kuning*), text memorization (*hafalan*), writing, and religious activities. In the ophthalmic literature, prolonged near-work activities and limited exposure to ambient outdoor sunlight are widely recognized as potential environmental risk factors associated with myopia development and progression (Lingham et al., 2021); (Morgan et al., 2021); (Xiong et al., 2020). However, while these factors represent scientifically plausible hypotheses for residential educational settings, individual behavioral exposures (such as exact daily hours of near-work, reading distance, and actual outdoor light lux levels) are variable and were not directly quantified in the present screening design. Therefore, environmental exposures within the *pesantren* should be conceptualized as potential contextual risk factors rather than uniform baseline characteristics assumed for all participants. Concurrently, older community members inevitably encounter age-related near vision decline (presbyopia), which directly impacts daily reading and instructional performance (Lawrenson et al., 2023).

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Despite the high concentration of individuals undergoing daily academic and visual tasks in these religious institutions, visual health within the *pesantren* setting remains substantially understudied. Existing epidemiological literature in Indonesia primarily focuses on general public schools, clinical hospital cohorts, or broad urban populations (Darusman et al., 2023); (Ehrlich et al., 2013). Consequently, a critical empirical research gap exists regarding the comprehensive prevalence, diagnostic patterns, and age-related distribution of both distance refractive errors (myopia, hyperopia, astigmatism) and presbyopia across multi-generational populations coexisting within a single *pesantren* environment

To address this gap, this study investigated the prevalence and clinical patterns of refractive errors and presbyopia within the Islamic Boarding School community of Pesantren Buntet in Cirebon, Indonesia. By evaluating distance and near visual function across diverse age groups and genders, this research provides baseline empirical evidence on the epidemiological burden of uncorrected vision problems in a religious boarding school setting, establishing a foundation for future analytical studies measuring specific environmental risk factors.

Method

This study employed a descriptive, observational cross-sectional design to investigate the prevalence, clinical patterns, and demographic distribution of refractive errors and presbyopia during a community-based eye health screening and spectacle distribution program at Pesantren Buntet, Cirebon Regency, West Java, Indonesia. The study population included students (*santri*), teaching staff (*ustadz/ustadzah*), administrative personnel, and local residents. Participants were recruited through convenience sampling based on voluntary attendance and informed consent. Individuals with severe ocular trauma or acute anterior segment infections preventing safe refraction were excluded.

Clinical examinations were conducted by trained eye care professionals using standardized procedures. Uncorrected distance visual acuity (UDVA) was assessed monocularly at 6 meters using a Snellen chart. Participants with UDVA worse than 6/6 underwent subjective refraction using trial lenses to determine best-corrected visual acuity (BCVA). Refractive errors were classified as myopia (spherical equivalent ≤ -0.50 D), hyperopia ($\geq +0.50$ D), and astigmatism (cylindrical power ≥ 0.75 D). Near vision was assessed at 40 cm using a reading card, while presbyopia was identified based on impaired near vision (worse than N6/J1) that improved with positive spherical lens addition. Basic anterior segment examinations identified suspected ocular abnormalities requiring referral. Demographic characteristics, visual acuity, refractive diagnoses, and spectacle prescriptions were recorded using standardized forms.

Data were analyzed using IBM SPSS Statistics version 26.0. Descriptive statistics summarized demographic characteristics and refractive diagnoses as frequencies and percentages, while cross-tabulations described the distribution of refractive errors and presbyopia across age and sex categories. The study followed the ethical principles of the Declaration of Helsinki. Informed consent was obtained from adult participants and from parents or legal guardians of underage students before examination, with participant confidentiality maintained throughout the study

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Result and Discussion

1. Result

A total of 422 participants from the Pesantren Buntet community were examined during the eye health screening program. The baseline demographic features and overall clinical parameters of the study population are summarized in Table 1.

Table 1
Characteristics of the Respondents

No	Variable	Mean / Median	Standard Deviation	Min	Max
1	Age (years)	24.50	14.82	8	68
2	Uncorrected Visual Acuity (OD)	0.38	0.32	0.00	1.30
3	Uncorrected Visual Acuity (OS)	0.36	0.31	0.00	1.30
4	Spherical Equivalent Power OD (Diopters)	-1.25	1.85	-8.00	+3.50
5	Spherical Equivalent Power OS (Diopters)	-1.18	1.78	-7.50	+3.00
6	Cylindrical Refractive Power OD (Diopters)	-0.68	0.82	-4.00	0.00
7	Cylindrical Refractive Power OS (Diopters)	-0.62	0.79	-3.75	0.00
8	Presbyopia Reading Addition Power (Diopters)*	+1.75	0.54	+1.00	+3.00

*Calculated specifically for participants aged ≥ 40 years requiring near vision correction (n = 84)

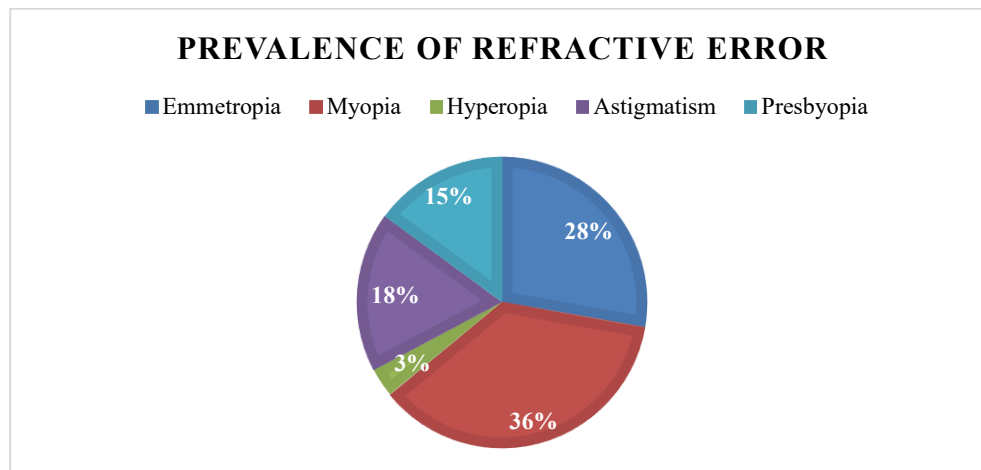
The baseline characteristics presented in Table 1 highlight a diverse study population spanning from young children to older adults, with a mean/median age of 24.50 ± 14.82 years (range: 8–68 years). On average, respondents exhibited mild distance visual impairment, as indicated by mean LogMAR uncorrected visual acuity values of 0.38 ± 0.32 in the right eye (OD) and 0.36 ± 0.31 in the left eye (OS), reaching maximum deficits up to 1.30 LogMAR. The ocular refraction profile reveals a predominant trend toward myopic error, characterized by negative mean spherical equivalents of $-1.25 \pm 1.85D$ in OD (ranging from -8.00 to +3.50 D) and $-1.18 \pm 1.78 D$ in OS (ranging from -7.50 to +3.00 D), accompanied by mild astigmatic components with mean cylindrical powers of $-0.68 \pm 0.82 D$ (OD) and $-0.62 \pm 0.79 D$ (OS). Additionally, among the subgroup of older participants aged 40 years and above (n=84), there was a distinct requirement for near vision correction, demonstrating a mean presbyopic reading addition power of $+1.75 \pm 0.54 D$ (range: +1.00 to +3.00 D).

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Table 2
Distribution of Refractive Errors, Presbyopia, and Ocular Conditions by Age and Gender

Category	Age Group (Years)	Male (n = 188)	Female (n = 234)	Total (n = 422)	Prevalence (%)
Demographics	< 18 (Pediatric/Youth <i>Santri</i>)	112	144	256	60.66
	18 – 39 (Young Adults/Staff)	38	44	82	19.43
	≥ 40 (Seniors/Educators)	38	46	84	19.91
Refractive Profile	Emmetropia (Normal Distance Vision)	74	82	156	36.97
	Myopia (Simple/Compound)	86	118	204	48.34
	Hyperopia	8	10	18	4.27
	Astigmatism (Isolated/Combined)	42	58	100	23.70
Near Vision	Presbyopia (Aged ≥ 40 years)	38	46	84	19.91
Other Conditions	Suspected Organic Ocular Pathology	12	16	28	6.64

The demographic and clinical distribution in Table 2 shows a predominantly young cohort, with pediatric and youth *santri* (< 18 years) comprising the majority of participants (60.66%, $n = 256$), followed by senior educators/staff aged ≥ 40 years (19.91%, $n = 84$) and young adults (19.43%, $n = 82$), with females consistently outnumbering males across all age groups (55.45% vs. 44.55%). Clinically, myopia emerged as the most prevalent distance refractive error, affecting nearly half of the population (48.34%, $n = 204$), while astigmatism was detected in 23.70% ($n = 100$) and hyperopia in only 4.27% ($n = 18$), leaving 36.97% ($n = 156$) with emmetropia. Furthermore, age-related near-vision impairment (presbyopia) affected all respondents in the ≥ 40 age bracket (19.91%, $n = 84$), and non-refractive ocular abnormalities were identified in 6.64% ($n = 28$) of the total population, highlighting a dual burden of uncorrected refractive error in younger individuals and presbyopia alongside organic pathologies in older community members.



Diagrams 1. Proportion and distribution of refractive errors and presbyopia among the Islamic Boarding School community of Pesantren Buntet Cirebon.

Diagram 1 illustrates the overall visual health profile of the Pesantren Buntet community, revealing that myopia is the predominant refractive error, affecting nearly half of the examined population (48.3%), followed by astigmatism at 23.7% and hyperopia at a much lower frequency of 4.3%. Meanwhile, normal distance visual acuity (emmetropia) accounts for 37.0% of participants, indicating that more than six out of ten individuals in this community require distance vision correction. Additionally, age-related near-vision difficulty (presbyopia) represents a significant proportion at 19.9%, corresponding directly to the senior population segment (≥ 40 years). Taken together, these findings demonstrate a high overall burden of uncorrected visual conditions within the boarding school ecosystem, driven primarily by myopia among younger *santri* and presbyopia among older staff and educators.

2. Discussion

Epidemiological Burden of Myopia

The principal empirical finding of this study is the high prevalence of myopia (48.34%, $n = 204$) among the Pesantren Buntet community, characterized by mean spherical equivalent powers of -1.25 ± 1.85 D in the right eye and -1.18 ± 1.78 D in the left eye. This rate substantially exceeds national rural baseline estimates for uncorrected refractive errors in Indonesia and aligns closely with post-pandemic figures observed in urban primary school populations (Darusman et al., 2023); (Kementerian Kesehatan RI, 2020). To interpret these clinical findings accurately and avoid methodological overreach, a rigorous distinction must be maintained between the empirical observations recorded during screening and the theoretical biological mechanisms described in external literature:

- 1) Empirical Observations of This Study: Cross-sectional screening confirmed that myopia is the predominant distance refractive error in this community, heavily concentrated within the pediatric and youth *santri* cohort (<18 years, representing 60.66%, $n = 256$ of the total sample). However, specific behavioral exposures such as the exact daily hours spent reading classical texts (*kitab kuning*), continuous screen usage, reading distances, and

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individual daily lux levels of outdoor sunlight exposure were not measured or quantified among participants in this screening design. Consequently, high indoor study loads should be conceptualized strictly as potential environmental risk factors associated with residential boarding school ecosystems, rather than uniform exposures experienced equally by all respondents.

2) **Biological Mechanisms Supported by External Literature:** Ophthalmic and epidemiological research globally has established several pathophysiological models for myopia onset and progression:

- a) *Hyperopic Defocus and Accommodative Stress:* Sustained near-visual tasks induce lag of accommodation and hyperopic retinal blur, which stimulates biochemical cascades in the retina and sclera, ultimately driving axial eyeball elongation (Morgan et al., 2021); (Yam et al., 2022).
- b) *Retinal Dopamine Signaling:* High-intensity natural daylight (typically >10,000 lux) stimulates the synthesis and release of retinal dopamine, an inhibitory neurotransmitter that restricts excessive axial scleral expansion (Lingham et al., 2021); (Xiong et al., 2020).
- c) *Environmental Interactions:* Reduced outdoor time combined with intensive educational activities creates a permissive environment for myopic shifts during early ocular development (Gifford et al., 2021); (Jonas et al., 2021).

While these biological models provide a scientifically plausible theoretical framework to contextualize the elevated myopia rates among younger *santri*, they represent external hypotheses rather than mechanisms proven by the empirical data of this study. This study establishes the epidemiological baseline of visual impairment; subsequent analytical cohort studies utilizing objective biometry (e.g., optical low-coherence interferometry for axial length) and environmental sensors (e.g., wearable light meters) are required to test these biological pathways directly within Islamic boarding schools.

Astigmatism Profiles, Gender Variance, and Visual Acuity Loss

Astigmatism affected nearly a quarter of the examined cohort (23.70%, $n = 100$), with mean cylindrical refractive powers of -0.68 ± 0.82 D (OD) and -0.62 ± 0.79 D (OS). The presence of uncorrected astigmatism, either as isolated cylindrical refractive error or in combination with spherical myopia (compound myopic astigmatism), directly accounts for the observed degradation in baseline distance visual acuity, which averaged 0.38 ± 0.32 LogMAR in OD and 0.36 ± 0.31 LogMAR in OS, with severe cases reaching 1.30 LogMAR. Uncorrected astigmatic optics create asymmetrical focal points along different ocular meridians, triggering chronic accommodative fatigue, asthenopia, frontal headaches, and reduced reading comprehension during intensive study sessions (Lawrenson et al., 2023); (World Health Organization [WHO], 2021).

Demographically, female participants exhibited a higher absolute count and proportion of refractive errors compared to males across all age categories (55.45% vs. 44.55%). Gender discrepancies in refractive profiles have been documented across Asian pediatric populations (Bourne et al., 2021); (Sankaridurg et al., 2023). In global literature, these differences are frequently attributed to earlier pubertal growth spurts accelerating

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axial length expansion in females, alongside behavioral variations in indoor versus outdoor leisure preferences (Morgan et al., 2021). In the context of *pesantren* life, while female *santri* may participate in different indoor study or recreational routines, these behavioral factors remain observational hypotheses within this cross-sectional framework.

Universal Presbyopia and Ocular Co-Morbidities in Senior Educators

Among older community members (≥ 40 years, $n = 84$), presbyopia was detected at a universal prevalence (100% within this age group, representing 19.91% of the total study population), with a mean required reading addition power of $+1.75 \pm 0.54$ D (range: $+1.00$ to $+3.00$ D). Presbyopia is an inescapable, progressive physiological aging process of the visual system, resulting from loss of crystalline lens elasticity and declining ciliary muscle accommodative amplitude (Bourne et al., 2021); (Fricke et al., 2023). Despite its physiological predictability, uncorrected presbyopia in academic and religious institutions causes significant functional disability, severely hindering teachers (*ustadz/ustadzah*) ability to review fine print, grade assignments, read classical Arabic scripts, and perform administrative duties (Ehrlich et al., 2013; Resnikoff et al., 2024).

Furthermore, suspected organic ocular pathologies such as nuclear cataracts, pterygium, and corneal opacities were identified in **6.64% ($n = 28$)** of the screened population, concentrated almost exclusively among older adults. In tropical agricultural regions like Cirebon, cumulative lifetime exposure to ultraviolet (UV) radiation combined with age-related nuclear lens sclerosis drives the formation of pterygium and senile cataracts (Flaxman et al., 2021); (Marmamula et al., 2022). The coexistence of physiological near-vision decline (presbyopia) and organic ocular diseases underscores a dual burden of eye care needs among senior *pesantren* staff.

Public Health Implications and Institutional Recommendations

The overarching clinical finding that 63.03% ($n = 266$) of screened participants required optical correction or tertiary medical referral reveals a critical unmet eye care need within this residential educational community. The persistence of unaddressed refractive errors stems from well-documented structural barriers, including the absence of routine institutional vision screening, low eye health literacy regarding subtle refractive symptoms, optical cost constraints, and geographical distance from primary optometric services (Bourne et al., 2021); (Keel et al., 2021). To mitigate the burden of uncorrected visual impairment in *pesantren* ecosystems, integrated public health strategies should be implemented:

- 1) Institutionalized Vision Screening: Establishing mandatory visual acuity screening for all newly admitted *santri* and annual optometric checks for teaching and administrative staff.
- 2) Promoting Environmental Hygiene and Outdoor Activity: Encouraging structured daily outdoor breaks during daylight hours (e.g., 120 minutes daily), which global consensus guidelines recommend as a safe, cost-effective intervention to support visual development and slow myopic progression in children (Gifford et al., 2021); (WHO, 2021); (Xiong et al., 2020).
- 3) Ergonomic Reading Standards: Improving ambient artificial illumination in study halls, enforcing proper working distances (>30 cm), and raising awareness about visual fatigue.

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- 4) Ergonomic Reading Standards: Improving ambient artificial illumination in study halls, enforcing proper working distances (>30 cm), and raising awareness about visual fatigue.

Study Limitations

This study has several limitations that should be considered when interpreting its findings. First, the descriptive cross-sectional design provides information on refractive errors and presbyopia at a single point in time, preventing conclusions about causal relationships or disease progression. Second, convenience sampling and voluntary participation may introduce selection bias, as individuals experiencing visual problems may have been more likely to attend screening. Consequently, the findings from 422 participants may not represent the entire Pesantren Buntet community or other Islamic boarding schools in Indonesia. Third, environmental factors potentially associated with myopia, including daily reading duration, digital screen exposure, reading distance, and outdoor light exposure, were not directly measured. Therefore, their contributions to refractive errors could not be evaluated. Fourth, the examination relied primarily on visual acuity testing and subjective refraction without cycloplegic refraction or ocular biometry, potentially affecting diagnostic accuracy, particularly among younger participants. Additionally, suspected ocular pathologies were identified through basic examinations without comprehensive ophthalmological confirmation. Future studies should employ larger, representative samples, longitudinal designs, standardized environmental assessments, and comprehensive eye examinations to strengthen epidemiological evidence and guide preventive eye health programs

Conclusion

In conclusion, this study demonstrates a substantial burden of uncorrected visual conditions within the Islamic Boarding School community of Pesantren Buntet, where 63.03% (n = 266) of the examined population presented with distance refractive errors, presbyopia, or suspected organic ocular pathologies. Myopia emerged as the predominant distance refractive error, affecting 48.34% (n = 204) of respondents heavily concentrated among pediatric and youth *santri* (<18 years) followed by astigmatism in 23.70% (n = 100) and hyperopia in 4.27% (n = 18). Universal presbyopia was observed among all senior community members aged ≥ 40 years (19.91%, n = 84) with a mean reading addition of $+1.75 \pm 0.54$ D, while suspected organic ocular pathologies were identified in 6.64% (n = 28) of participants. Environmental exposures characteristic of *pesantren* life such as intensive indoor reading routines and limited outdoor light exposure were contextualized as potential environmental risk factors supported by external ophthalmic literature, rather than causal mechanisms directly verified by the cross-sectional data of this study. Overall, these empirical findings confirm a high prevalence of unaddressed visual deficits and highlight the critical need for institutionalized, routine eye health screening programs alongside accessible optometric interventions in residential religious educational settings across Indonesia.

Declaration of AI Assistance

AI Tools including Chat GPT, Gemini, Claude AI were used during the preparation of this manuscript. The AI Tools were used for grammar checking, paraphrasing and translating. The Authors have checked the output of the tools

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