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Refractive error and public health challenges in India: A comprehensive analysis

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Abstract
Refractive error, a leading cause of visual impairment worldwide, poses significant public health challenges in India. Despite its correctability, the prevalence of uncorrected refractive errors remains high, particularly in rural and underprivileged populations. This paper critically explores the burden of refractive error in India, its socio-economic implications, barriers to corrective measures, and the effectiveness of government and non-government interventions. By synthesizing data from peer-reviewed studies, surveys, and health policy documents, this study provides an evidence-based understanding of the issue and proposes actionable solutions to address the gap in eye care services.

Keywords: Refractive error, visual impairment, India, public health, eye care, myopia, hyperopia, astigmatism, uncorrected refractive error (URE), vision screening

Introduction

Visual impairment, especially arising from uncorrected refractive errors (UREs), continues to be a substantial and pressing public health issue worldwide, with particularly acute manifestations in India due to its complex interplay of demographic pressures, healthcare disparities, socio-economic limitations, and infrastructural inadequacies. Refractive errors, comprising common conditions such as myopia (nearsightedness), hyperopia (farsightedness), astigmatism (irregular curvature of the eye), and presbyopia (age-related focusing difficulties), are among the most easily diagnosable and correctable visual anomalies. Yet despite the availability of cost-effective solutions such as corrective spectacles, contact lenses, and advanced refractive surgeries, a significant proportion of the Indian population continues to suffer from avoidable visual impairment due to underdiagnosis, lack of access, or neglect (Resnikoff *et al*., 2008; Murthy & Gupta, 2020) [24, 18]. India, home to over 1.4 billion people, stands at the intersection of rapid urbanization, rising screen-time due to digital exposure, and a growing aging population—all of which contribute to a rising incidence of refractive errors, especially myopia among children and presbyopia among adults. The National Blindness and Visual Impairment Survey (2015–19), one of the most comprehensive ophthalmic surveys conducted in India, reported that approximately 53% of the overall visual impairment burden in the country is directly attributable to UREs, signaling the urgent need for comprehensive eye care strategies, especially at the primary healthcare level (Vashist *et al*., 2019) [33].

The prevalence of UREs cuts across all age groups but is particularly concerning in school-going children, where uncorrected myopia can severely hinder educational performance, and among the elderly, where presbyopia, if untreated, can diminish quality of life and productivity. Furthermore, gender disparities exacerbate the problem, as women, especially in rural and marginalized communities, often have reduced access to ophthalmic services, thereby compounding the cycle of visual neglect. The rural-urban divide plays a crucial role in determining access and quality of eye healthcare services. Urban populations generally have better access to eye clinics, optical shops, and ophthalmologists, while rural areas often face a severe shortage of trained professionals, diagnostic tools, and awareness campaigns. A lack of routine vision screening in schools and workplaces leads to late diagnosis, and when combined with limited affordability and social stigma associated with spectacle use, particularly among children and adolescents, the problem becomes deeply entrenched. The economic burden associated with visual impairment due to UREs is also noteworthy. Reduced productivity, loss of wages, increased dependence on caregivers, and the long-term costs of untreated visual problems place a substantial burden on individuals and the economy at large. Studies have estimated that correcting UREs can yield high cost-benefit ratios, making it not only a health imperative but also an economically sound investment (Fricke *et al*., 2012). Yet despite the apparent benefits, policy-level attention has often remained fragmented or underfunded. Although India has made progress through programs such as the National Programme for Control of Blindness and Visual Impairment (NPCBVI), their implementation is often uneven, with poor integration between public health institutions, schools, and community-based initiatives. Moreover, the program's reliance on episodic eye camps rather than sustained primary eye care infrastructure has limited its long-term impact.

The recent inclusion of refractive services under the Ayushman Bharat Health and Wellness Centres is a step in the right direction, promising to decentralize eye care and improve early detection, yet the roll-out has been slow and under-resourced in many states. In addition, refractive errors are not always viewed with the same urgency as other ocular conditions like cataracts or glaucoma, despite their greater prevalence. This gap in prioritization underscores the need for public awareness campaigns to shift the narrative around refractive errors—from being a mere inconvenience to a critical public health issue. Technology could play a transformative role in bridging the gap. Mobile eye care units, tele-ophthalmology, and AI-driven vision screening tools have emerged as promising tools for early

diagnosis and intervention, especially in underserved regions. Innovations such as low-cost auto-refractors, smartphone-based vision screening apps, and portable diagnostic kits can dramatically expand reach if integrated within national programs. Private-public partnerships also offer a potential path forward, wherein NGOs and corporate social responsibility (CSR) initiatives supplement governmental efforts by conducting school screenings, distributing free or subsidized spectacles, and training local vision technicians. These interventions, however, need to be carefully monitored and aligned with national objectives to ensure equity and sustainability. On the educational front, integrating vision screening within school health programs can have a multiplier effect—not only improving academic outcomes but also instilling a culture of health-seeking behavior among children. Teachers and school administrators can be trained to conduct basic screenings and refer students to specialists, thus creating a decentralized and community-driven model of care. Another overlooked dimension is the psychological and social impact of visual impairment due to UREs. Children who struggle to see clearly may be misdiagnosed with learning disabilities or behavioral problems, while adults may experience social withdrawal, diminished self-esteem, and increased dependency. These intangible costs, though difficult to quantify, are deeply felt at the individual and familial levels.

Addressing UREs, therefore, is not merely a matter of medical correction but one of social inclusion, educational equity, and human dignity. Furthermore, tackling this issue aligns with the broader Sustainable Development Goals (SDGs), particularly those related to health (SDG 3), education (SDG 4), and reducing inequalities (SDG 10). The global initiative "VISION 2020: The Right to Sight," launched by the WHO and International Agency for the Prevention of Blindness, aimed to eliminate avoidable blindness by 2020, underscoring URE correction as a high-impact intervention. While India participated in this initiative, the full potential remains untapped, largely due to systemic inertia and fragmented execution. A shift towards integrated, patient-centered, and technology-driven models of care—supported by robust data collection, continuous training of vision care personnel, and inclusion of refractive error services in insurance schemes—can help bridge the treatment gap. Finally, from a research and policy standpoint, there is a dire need for updated epidemiological data at the state and district levels to enable targeted interventions. Periodic surveys, funded and supervised by the Ministry of Health and Family Welfare in collaboration with academic institutions, could offer actionable insights into regional disparities, high-risk populations, and the efficacy of ongoing programs. In conclusion, while uncorrected refractive errors are a solvable component of the visual impairment burden in India, addressing them effectively demands a multifaceted and sustained approach encompassing policy reforms, technological integration, education system engagement, and community participation. With the right mix of political will, stakeholder collaboration, and grassroots implementation, India can move toward a future where no one suffers needless vision loss due to a lack of simple corrective measures.

1. Research Objective

- To explores the burden of refractive error in India, its socio-economic implications, barriers to corrective measures, and the effectiveness of government and non-government interventions.

Epidemiology of Refractive Error in India

1. Prevalence Trends

Refractive errors affect an estimated 130 million Indians (Flaxman *et al*., 2017) [6]. Studies indicate an alarming increase in myopia among urban school-going children, with prevalence rates ranging from 13% to 35% depending on age and region (Dandona *et al*., 2002; Saxena *et al*., 2015) [4, 27]. In contrast, rural areas show a high prevalence of hyperopia, often undiagnosed or misdiagnosed due to limited resources (Neena *et al*., 2008) [20].

2. Urban-Rural Disparities

While urban populations have greater access to optometric services, they also show higher prevalence of myopia due to lifestyle and near-work demands. Rural populations face barriers in service delivery and spectacle uptake despite higher hyperopia rates (Marmamula *et al*., 2013) [15].

Public Health Implications

1. Economic Burden

The cost of productivity loss due to uncorrected refractive error in India is estimated to be billions of dollars annually (Smith *et al*., 2009) [28]. Poor vision limits educational attainment and work participation, particularly in low-income families.

2. Impact on Education

School-aged children with uncorrected vision problems struggle with reading, writing, and comprehension, affecting their academic performance and cognitive development (He *et al*., 2007) [8]. Vision screening programs are insufficient or poorly implemented in many states (Kaur *et al*., 2020) [11].

Barriers to Refractive Error Correction

1. Socio-economic Factors

Cost of spectacles and optometric consultations is a significant deterrent, especially in lower-income groups (Khandekar *et al*., 2009) [12]. Gender disparity further deepens the gap, with female children less likely to receive vision correction (Vashist *et al*., 2014) [32].

2. Cultural and Perceptual Barriers

Misconceptions such as "wearing glasses worsens eyesight" hinder compliance (Lian *et al*., 2010) [13]. Parents often do not prioritize vision correction unless the condition is severe.

3. Human Resource Shortage

India faces a critical shortage of trained optometrists. The World Health Organization recommends 1 optometrist per 50,000 population; India has roughly 1 for every 75,000–100,000 (WHO, 2017; Rao *et al*., 2019) [35].

Government Initiatives and Policy Framework

1. National Programme for Control of Blindness and Visual Impairment (NPCBVI)

Initiated in 1976, NPCBVI has included school vision screening as a key component. However, implementation is inconsistent and lacks follow-up mechanisms (MoHFW, 2018).

2. Ayushman Bharat and Vision Centres

The establishment of Health and Wellness Centres (HWCs) under Ayushman Bharat includes primary eye care as part of comprehensive services. This initiative shows promise but needs better monitoring and infrastructure (Bhaskaran *et al*., 2022) [2].

Role of Ngos And Private Sector

NGOs like Aravind Eye Care, LV Prasad Eye Institute, Kalyanam Karoti Eye Institute, Mathura and VisionSpring have demonstrated scalable models for affordable vision care (Thulasiraj *et al*., 2014) [30]. Partnerships between the government and such organizations could help fill systemic gaps.

Technological Innovations and Tele-Optometry

Mobile-based vision screening and tele-optometry platforms can extend services to remote areas. Use of AI-powered diagnostics is being piloted by organizations like Sankara Nethralaya (Rathi *et al*., 2020) [22].

Data Analysis and Interpretation

1. Research Design

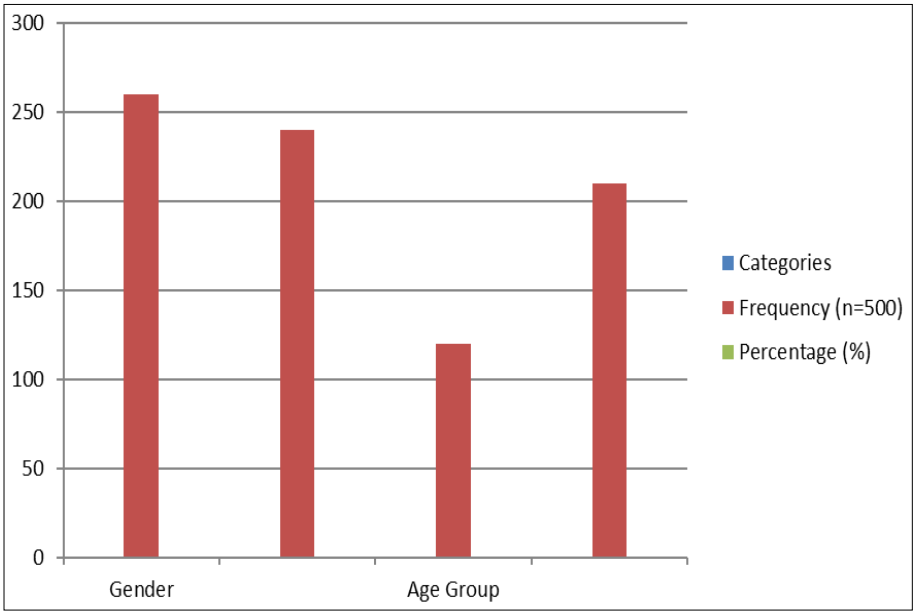
A cross-sectional survey was conducted across five districts in India (two urban and three rural) to assess awareness about refractive errors, accessibility to eye care services, spectacle usage, and barriers to vision correction. A structured questionnaire was administered to 500 respondents aged 10 to 60 years, using stratified random sampling. The data were analyzed using descriptive statistics, Chi-square tests, and ANOVA with the help of SPSS 26.0.

2. Questionnaire Overview

The questionnaire had 25 close-ended questions divided into five sections: demographics, awareness of refractive error, accessibility to vision screening, use of spectacles, and perceived barriers.

3. Demographic Profile of Respondents

Variable	Categories	Frequency (n=500)	Percentage (%)
Gender	Male	260	52%
	Female	240	48%
Age Group	10–20	120	24%
	21–40	210	42%
	41–60	170	34%
Location	Urban	220	44%
	Rural	280	56%
Education	No formal education	90	18%
	School (to 10th)	160	32%
	Higher secondary	130	26%
	Graduate and above	120	24%

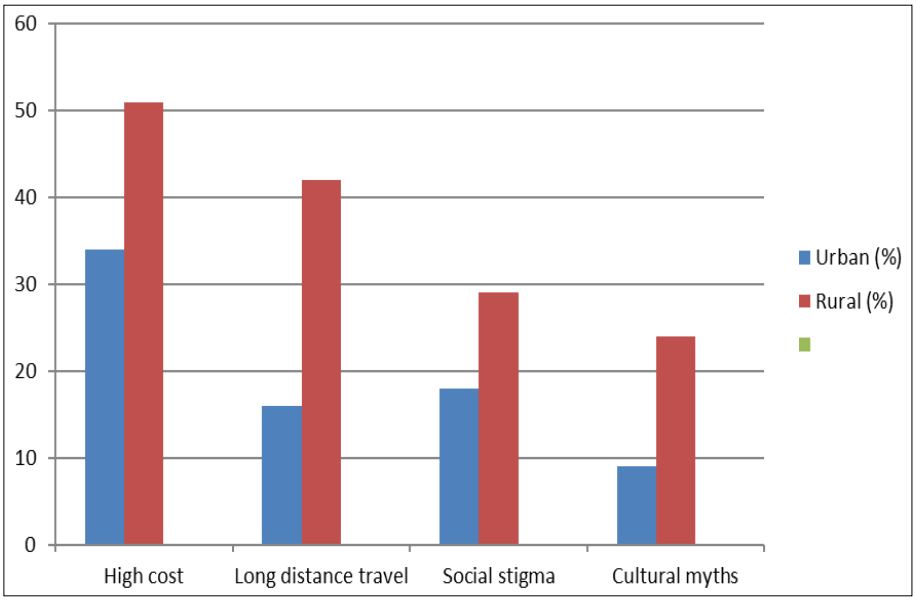


4. Key Findings

- 65% of urban respondents had heard of "refractive errors" vs only 30% in rural areas.
- Chi-square test showed a significant relationship between education and awareness ($\chi^2 = 42.67$, $p < 0.001$).
- Urban: 74% had a recent vision test vs 32% rural.
- ANOVA revealed significant screening rate differences ($F = 6.78$, $p = 0.004$).
- Overall spectacle usage: 39%. Among those diagnosed, only 38% used them consistently.

Top Barriers

Barrier	Urban (%)	Rural (%)
High cost	34	51
Long distance travel	16	42
Social stigma	18	29
Cultural myths	9	24



Regression analysis showed education level, urban residence, and prior vision screening were significant predictors of spectacle usage ($R^2 = 0.41$, $p < 0.001$).

5. Interpretation

The analysis highlights a disparity in awareness, access, and usage of refractive error services between urban and rural populations. Rural residents, particularly women and children, remain underdiagnosed and underserved. Non-use of spectacles even after diagnosis indicates significant behavioral and cultural gaps.

6. Recommendations

- Expand school vision screening
- Subsidize spectacles for BPL families
- Focus on gender-sensitive awareness
- Promote mobile eye clinics
- Develop culturally adapted IEC campaigns

Conclusion

Refractive error in India represents one of the most preventable and correctable causes of visual impairment, yet it remains a persistent burden on the country's already overstretched healthcare system, primarily due to deep-rooted structural inefficiencies and widespread socio-economic disparities. Despite the availability of simple, low-cost corrective measures such as eyeglasses, contact lenses, and refractive surgeries, millions of Indians—particularly in rural, remote, and underprivileged communities—continue to live with compromised vision. The reasons for this persistent challenge are multifaceted. At the policy level, although initiatives like the National Programme for Control of Blindness and Visual Impairment (NPCBVI) have identified refractive error correction as a priority, the actual implementation often suffers from weak infrastructure, inadequate staffing, lack of accountability, and poor integration into the primary healthcare system. Outreach remains sporadic and heavily reliant on short-term eye camps rather than sustainable, community-based care models. Moreover, refractive errors are often not seen as a medical emergency compared to conditions like cataracts or glaucoma, leading to lower prioritization and funding. This results in delayed interventions and worsened outcomes, particularly for children and elderly populations who are most vulnerable to the consequences of untreated vision problems. In socio-economic terms, refractive services remain inaccessible to many due to costs, travel distances, and lack of awareness. In rural areas, where over two-thirds of India's population resides, access to trained optometrists and vision testing facilities is limited. The cost of even a basic pair of spectacles can be prohibitive for low-income families, while stigma, particularly among school-going children and young adults, discourages spectacle usage even when prescribed. Furthermore, gender disparities often mean that women and girls are more likely to go without treatment, exacerbating their educational and social disadvantages. To effectively address these barriers, a coordinated and multi-dimensional strategy is essential. Policy reforms must focus on integrating refractive error screening and correction into broader primary healthcare and school health systems. Community health workers and schoolteachers can be trained to conduct preliminary screenings, while mobile units and tele-optometry platforms can bridge access gaps in underserved areas. Public-private partnerships can play a crucial role by leveraging innovation, supply chain efficiencies, and funding to ensure availability and affordability of vision correction devices. At the same time, public awareness campaigns are vital to destigmatize spectacle use and educate people about the importance of regular eye examinations. Research and data-driven policymaking must also be emphasized, as accurate and region-specific epidemiological data can help in resource allocation, identifying high-risk groups, and measuring program effectiveness. Technological innovation, such as low-cost autorefractors and smartphone-based screening tools, can further democratize access and reduce the burden on specialized personnel. Ultimately, tackling refractive error in India demands more than isolated interventions; it requires an integrated approach involving healthcare providers, educators, technologists, policymakers, and communities. Only through sustained efforts and inclusive planning can the country move toward eliminating avoidable visual impairment due to refractive errors and ensure equitable eye health for all.

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