

Assessing the Critical Imperative for Optometric Care and Professional Education Expansion in Peri-Urban and Rural Ecosystems: A Cross-Sectional Analysis of the Nabadwip-Mayapur Corridor, Nadia District, West Bengal

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Abstract: *Uncorrected refractive error (URE) and unaddressed presbyopia remain the primary etiologies of avoidable moderate-to-severe visual impairment globally, disproportionately disabling productive populations in rural and peri-urban zones. This study investigates the institutional necessity for primary optometric infrastructure, refractive services, and formal optometric education within the Nabadwip-Mayapur corridor of Nadia District, West Bengal. This geographic region presents a unique socio-epidemiological cross-section: an indigenous agro-artisan populace-predominantly the traditional handloom (tant) weaving clusters of Nabadwip- intersecting with a massive floating and permanent international/domestic pilgrimage community situated across the Bhagirathi River in Mayapur. Utilizing a population-based, cross-sectional descriptive design, structured clinical evaluations and visual acuity assessments were conducted among 850 individuals aged ≥ 15 years across four representative clusters. The overall prevalence of presenting visual impairment ($<6/18$ in the better eye) was 23.4% ($n=199$). Uncorrected refractive errors accounted for 58.8% of these impairments ($n=117$), followed by operable cataracts (28.1%, $n=56$). Presbyopic blur afflicted 68.2% of participants aged ≥ 40 years, yet functional spectacle coverage among artisanal weavers was critically depressed at 21.4%. Occupational analysis revealed that untreated presbyopia and uncorrected astigmatism led to severe asthenopia, elevated fabric defect rates, and a 20% to 35% decline in weavers' monthly earnings. Geographic isolation imposed by riverine transit, reliance on uncalibrated over-the-counter reading glasses, and a lack of qualified optometrists represent primary systemic barriers. We argue that establishing institutionalized Diploma (D.Optom) and Bachelor's Degree (B.Optom) education programs within the district provide a crucial dual-impact remedy: eradicating avoidable visual morbidity while offering stable, professional, and self-sustaining healthcare employment for local youth.*

Keywords: Optometry, community eye health, uncorrected refractive errors, Nabadwip, Mayapur, Nadia, handloom weavers, presbyopia, public health optometry, allied health education, employment

1. Introduction

Avoidable visual impairment (VI) and preventable blindness represent significant, often neglected public health and socioeconomic burdens across low- and middle-income countries (Bourne et al., 2021; World Health Organization [WHO], 2019). The Lancet Global Health Commission on Global Eye Health highlighted that more than 1.1 billion individuals worldwide live with untreated visual impairment, with upwards of 90% residing in resource-constrained agrarian and peri-urban environments (Burton et al., 2021). Uncorrected refractive error (URE) remains the leading worldwide cause of moderate-to-severe distance visual impairment, while unmanaged presbyopia degrades near-vision performance for hundreds of millions of working adults (Fricke et al., 2018).

In India, although public frameworks such as the National Programme for Control of Blindness and Visual Impairment (NPCB&VI) have established notable surgical intervention systems for senile cataracts, human resources for vision care remain starkly skewed toward tertiary urban hospitals (Murthy et al., 2008; National Blindness and Visual Impairment Survey, 2019). Consequently, comprehensive primary refraction and allied visual rehabilitation are

practically unavailable in rural peripheries, leaving substantial populations in structural "vision-care deserts."

1.1 Regional Context: The Nabadwip–Mayapur Corridor

Nadia District, located within the lower Gangetic delta of southern West Bengal, exhibits notable socio-occupational and demographic heterogeneity. At the geographical center of this district lies the Nabadwip–Mayapur axis, divided by the Bhagirathi River:

- 1) **The Artisanal and Agrarian Cohort (Nabadwip):** A historical municipality and educational cradle of Bengal, Nabadwip functions today as an intensive micro-industrial hub for manual Jacquard and pit-loom cotton and silk weaving (*tant*). Handloom weaving and allied sizing operations demand sustained, high-precision stereopsis and near-vision accommodation under suboptimal, dim interior illumination.
- 2) **The Pilgrimage and Geriatric Cohort (Mayapur):** Situated directly on the eastern bank of the Bhagirathi within Bamanpukur Gram Panchayat, Mayapur is the global spiritual center of ISKCON. The region houses permanent monastics, elderly spiritual retirees, and attracts millions of domestic and international transit visitors every year.

Despite this high occupational and demographic demand, primary eye care delivery remains severely fragmented. The riverine boundary imposes substantial transit friction. Public community health centers (CHCs) and primary health centers (PHCs) lack diagnostic refractive instruments and qualified optometric personnel. As a result, the population depends heavily on informal, non-certified street vendors dispensing poorly centered, over-the-counter reading glasses.

1.2 Study Objectives

This investigation addresses four primary objectives:

- Quantify the baseline prevalence and clinical etiologies of visual impairment, URE, and presbyopia within the Nabadwip–Mayapur corridor.
- Characterize the occupational and economic penalty of uncorrected near and distance visual deficits among the artisanal handloom weavers of Nabadwip.
- Identify the spatial, logistical, and financial barriers driving low spectacle coverage rates.
- Formulate an actionable public health and vocational framework demonstrating how expanding diploma- and degree-level optometric education can simultaneously eliminate avoidable vision loss and generate local allied healthcare employment.

2. Materials and Methods

2.1 Study Design and Sampling Framework

A population-based, cross-sectional epidemiological investigation was conducted over a six-month period across four stratified territorial clusters in the Nabadwip–Mayapur corridor:

- **Cluster A:** Municipal wards of Nabadwip town, characterized by dense concentrations of handloom weaving cottages.
- **Cluster B:** Mayapur rural belt, encompassing Bamanpukur-I and Bamanpukur-II Gram Panchayats.
- **Cluster C:** Riverine ferry transit nodes (Hularghat, Swarupganj, and Nabadwip Ghats).
- **Cluster D:** Peripheral agrarian hamlets adjacent to Babladanga and Teghori.

Sample size calculations were based on an anticipated rural visual impairment prevalence of 18% ($P=0.18$) from comparable Eastern Indian surveys (Dandona et al., 2001), a 3% absolute margin of error ($d=0.03$), a 95% confidence interval ($Z=1.96$), and a design effect (DEFF) of 1.5 to account for multi-cluster variation:

$$n = \frac{Z^2 \cdot P \cdot (1 - P)}{d^2} \cdot DEFF$$

$$n = \frac{(1.96)^2 \cdot (0.18) \cdot (0.82)}{(0.03)^2} \cdot 1.5 \approx 945$$

Accommodating a 10% non-response or examination refusal rate, a target cohort of 1,000 individuals aged ≥ 15 years was framed. A multistage stratified cluster sampling approach was executed, yielding an analyzed final cohort of $N=850$

participants (85.0% completion rate).

2.2 Clinical and Optometric Protocols

Screenings and examinations were conducted by qualified optometric personnel utilizing calibrated portable diagnostic instruments:

- **Visual Acuity (VA):** Monocular and binocular presenting visual acuity (PVA) and pinhole-corrected acuity were evaluated at 3 meters using retro-illuminated LogMAR tumbling-E charts.
- **Refraction:** Objective static retinoscopy (Heine BETA 200 streak retinoscope) corroborated with automated desktop autorefraction, followed by meticulous subjective trial-frame refraction to determine best-corrected visual acuity (BCVA).
- **Near Visual Acuity:** Evaluated at a standard working distance of 40 cm (and cross-checked at the participant's specific occupational distance) using standard tumbling-E and N-point near-vision reading cards under standardized focal illumination (≥ 300 lux).
- **Anterior Segment and Ocular Media Examination:** Portable hand-held slit lamp biomicroscopy (Keeler PSL One) was utilized to examine corneal clarity, anterior chamber depth, and crystalline lens status for cataract grading.
- **Posterior Segment Evaluation:** Direct ophthalmoscopy and non-mydratic indirect evaluations were conducted to screen for diabetic retinopathy signs, glaucomatous optic disc cupping, and maculopathies.

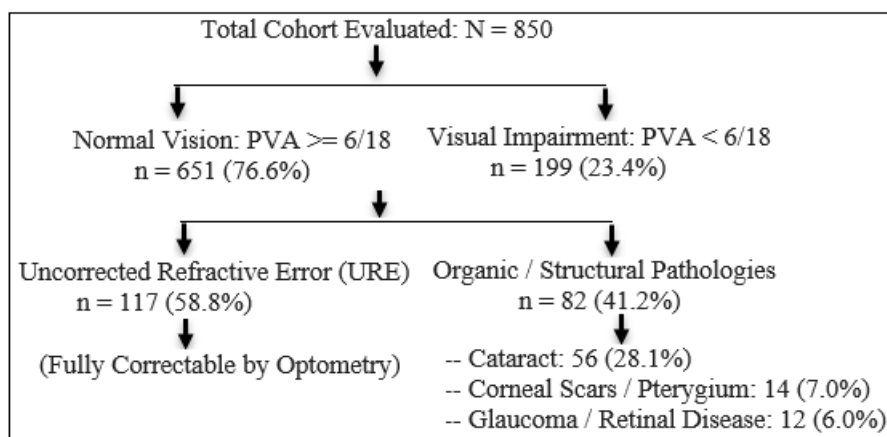
2.3 Diagnostic Classifications (WHO / ICD-11 Alignment)

- **Normal Vision:** $PVA \geq 6/18$ in the better eye.
- **Visual Impairment (VI):** $PVA < 6/18$ in the better eye.
- **Moderate Visual Impairment:** $PVA < 6/18$ to $\geq 6/60$.
- **Severe Visual Impairment:** $PVA < 6/60$ to $\geq 3/60$.
- **Blindness:** $PVA < 3/60$ or a central visual field restricted to $< 10^\circ$.
- **Uncorrected Refractive Error (URE):** Presenting VA $< 6/18$ improving to $\geq 6/18$ through refractive spectacle correction.
- **Presbyopia:** Inability to read N8 at 40 cm with presenting distance correction in individuals aged ≥ 35 years, improving by at least one optotype line with positive spherical addition ($\geq +1.00D$)

3. Results

3.1 Sociodemographic Characteristics

Among the 850 participants examined, 53.4% were male ($n=454$) and 46.6% were female ($n=396$). The mean age was 46.8 ± 16.2 years (range: 15–88 years). Stratification by primary occupation revealed that 34.1% ($n=290$) were traditional handloom textile weavers and allied artisans, 28.5% ($n=242$) were agrarian laborers, 14.7% ($n=125$) worked in the temple-hospitality and retail sectors, and 22.7% ($n=193$) were homemakers, retired persons, or resident monastics.



3.2 Prevalence and Clinical Etiologies of Visual Impairment

Overall, 199 individuals (23.4%) presented with bilateral visual impairment ($<6/18$) in the better eye). Table 1 presents the clinical etiologies underlying this impairment.

Table 1: Etiological Breakdown of Presenting Distance Visual Impairment (N= 199)

Clinical Etiology	Affected Individuals (n)	Percentage (%)	Primary Corrective / Clinical Intervention
Uncorrected Refractive Error (URE)	117	58.80%	Primary Optometric Refraction & Spectacle Dispensing
Operable Senile Cataract	56	28.10%	Surgical Referral (SICS / Phacoemulsification)
Pterygium / Corneal Opacity	14	7.00%	Therapeutic Management / Anterior Segment Surgery
Posterior Segment Pathology / Glaucoma	12	6.00%	Referral to Tertiary Vitreoretinal / Glaucoma Specialist
Total	199	100.00%	

Note. Approximately 59% of presenting visual impairment was due entirely to uncorrected refractive errors, indicating that simple, non-invasive optometric intervention could resolve the majority of vision loss across the corridor.

3.3 Presbyopic Prevalence and Occupational Impact Among Handloom Weavers

Among participants aged ≥ 40 years ($n = 532$), the clinical prevalence of presbyopia reached 68.2% ($n = 363$). However, the **Spectacle Coverage Rate (SCR)** for presbyopia was critically deficient at only 23.4% ($n = 85$).

Within the handloom weaver subgroup ($n = 290$)

- **Focal Working Demand:** Weavers operate at continuous, fixed focal planes between 35 and 50 cm to monitor warp tension, pass shuttles, tie broken threads, and track complex Jacquard card patterns.
- **Uncorrected Visual Strain:** 61.4% ($n = 178$) of working weavers suffered from untreated presbyopic or astigmatic blur while working at the loom.
- **Economic Consequences:** 72.5% of weavers experiencing untreated near blur reported frequent eye

fatigue (asthenopia), headaches, slower picking speeds, and an increased incidence of weaving defects (*khot*). This resulted in an estimated **20% to 35% reduction in net daily piece-rate earnings** compared to fully corrected weavers.

Occupational Trajectory of Untreated Presbyopia:

[Uncorrected Presbyopia / Astigmatism]

- Severe Asthenopia & Saccadic Eye Strain
- Thread Breakage Misidentification & Slower Pick Rates
- Fabric Rejection & 20-35% Daily Wage Loss

3.4 Disparities in Local Eye Health Infrastructure

A geospatial analysis of infrastructure highlighted clear disparities across the Bhagirathi River:

Table 2: Eye Care Infrastructure and Resource Distribution: Nabadwip vs. Mayapur

Parameter	Nabadwip Municipality & Periphery	Mayapur (Bamanpukur GP & Environs)
Estimated Population (2024–2026)	~	~ (+ major floating pilgrim influx)
Government Primary Eye Care Centers (PECCs)	0 (Only general OPD at State General Hospital)	0 (Limited to sub-center level care)
Certified Optometrists (B.Optom / M.Optom)	4 (primarily commercial retail dispensaries)	0 (No permanent full-time practitioner)
Informal Optical Sellers / Street Quacks	18+ (footpath and weekly market vendors)	6+ (ferry ghats and religious haats)
Average Travel Time to District Hospital	Direct roadway access to Krishnanagar (20km)	River ferry transit +25km rural roadways

Participant surveys identified the primary barriers to obtaining corrective spectacles:

- 1) **Financial Cost / Non-Affordability (44.2%):** Commercial retail optical outlets charge prices that are prohibitive for daily piece-rate weavers and marginal farm laborers.
- 2) **Geographical Friction / Ferry Transit (31.8%):** Residents of rural Mayapur, Swarupganj, and Teghori face complex river crossings and lost working days to reach optometrists in Krishnanagar or Nabadwip.

- 3) **Dependence on Counterfeit Readymade Spectacles (18.5%):** Widespread reliance on uncalibrated, symmetric-power readymade magnifiers purchased from open markets. These devices lack proper centration, fail to correct astigmatism, introduce induced prismatic distortion, and exacerbate eye strain.

4. Discussion

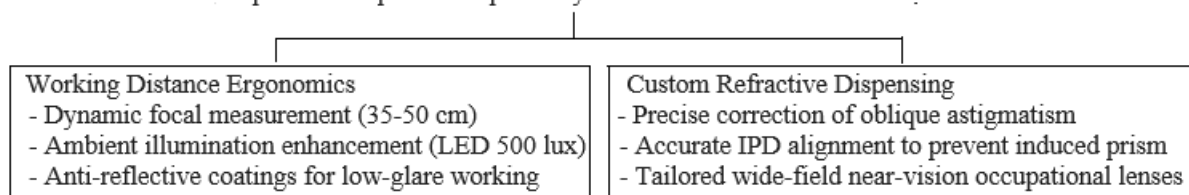
4.1 Occupational Optometry and Rural Industrial Viability

The handloom sector in Nabadwip represents a culturally and economically vital craft industry. However, manual weaving places immense physical demands on the human visual system. The continuous fine motor coordination required to manage thousands of warp yarns at 35–50 cm working

distances requires precise accommodation, binocular convergence, and optimal visual acuity.

When weavers reach their fourth decade, uncorrected presbyopia directly threatens their livelihood. Due to the lack of community-based optometric services, these artisans frequently purchase cheap + 2.00D or + 3.00D readymade reading glasses from weekly village markets (*haats*). Because these glasses have arbitrary optical centers that do not match the weaver's interpupillary distance (IPD), they induce continuous prismatic effects, leading to asthenopia, diplopia, and chronic headaches. Incorporating targeted occupational optometry- providing individualized refractive assessments matched to loom working distances, proper pupillary centration, and customized wide-field lenses- would immediately restore working precision, preserve product quality, and extend artisanal careers.

Proposed Occupational Optometry Model for Handloom Clusters



4.2 The Pilgrimage Demography and Rural Isolation in Mayapur

East of the Bhagirathi River, Mayapur exhibits an atypical demographic pattern: a high-density rural Bengali population living alongside an expansive, international spiritual community. While primary dispensaries operate within institutional monastic campuses, the surrounding rural populations across Bamanpukur, Swarupganj, and Teghori have virtually no access to formal optometric refraction.

The physical barrier of the Bhagirathi River amplifies this vulnerability. For an elderly resident from rural Mayapur, obtaining a complete eye examination requires crossing the river by boat to Nabadwip Ghat, followed by local vehicle transit to Nabadwip town or bus transit to Krishnanagar District Hospital. This multi-stage transit incurs direct financial costs, lost daily wages, and physical fatigue. Consequently, progressive ocular conditions—such as primary open-angle glaucoma, diabetic retinopathy, and early cataracts—often remain undiagnosed until irreversible visual impairment occurs.

4.3 The Role of Modern Optometry Beyond Refraction

Historically, eye health policy in India has viewed visual impairment primarily through a surgical lens, focusing on high-volume cataract camps (Murthy et al., 2008). While cataract surgery remains vital—accounting for 28.1% of visual impairment in our cohort- surgical interventions alone

cannot resolve refractive deficits. Refraction and visual care require ongoing, accessible, and community-embedded clinical services.

A fully qualified optometrist fills several essential gaps identified in the Nabadwip–Mayapur corridor:

- 1) **Precision Comprehensive Refraction:** Providing accurate distance and near spectacle prescriptions tailored to individual ocular and occupational profiles.
- 2) **Pediatric and Amblyopia Screening:** Detecting refractive amblyopia, high uncorrected myopia, and binocular vision anomalies in rural schools early in childhood development.
- 3) **Primary Pathology Triaging:** Utilizing slit-lamp biomicroscopy and non-mydratic fundus cameras to identify diabetic retinopathy, elevated intraocular pressure, and early cataracts, directing complex cases systematically to tertiary ophthalmology centers.
- 4) **Community Rehabilitation and Education:** Advising on ocular hygiene, diabetic lifestyle risks, and proper eye protection for industrial workers.

5. Strategic Policy and Educational Recommendations

To resolve the systemic shortages identified in this study, we propose an integrated public health, clinical, and educational framework:

[Tier 1: Community Grassroots]

ASHA and Anganwadi Workers trained in Tumbling E (6/12) and Near Vision Presbyopia Screening



[Tier 2: Primary Optometric Vision Hubs & Education Centers]

Permanent Vision Centers at Nabadwip State General Hospital & Mayapur Bamanpukur PHC

- Comprehensive Refraction, Slit-Lamp, Non-Mydriatic Fundus, Low-Cost Spectacle Lab

- Integration with D.Optom and B.Optom Clinical Training Programs



[Tier 3: Secondary and Tertiary Ophthalmic Links]

Krishnanagar District Hospital & Regional Medical Colleges (Cataract Surgery, Glaucoma, Vitreoretinal Care)

- 1) **Establishment of Permanent Primary Eye Care Centers (PECCs):** The Department of Health and Family Welfare, Government of West Bengal, should partner with regional institutions to open two fully equipped PECCs: one adjacent to the Nabadwip Handloom Industrial Cluster, and another within the Bamanpukur-Mayapur Health Block.
- 2) **Expansion of Formal Optometric Education (D. Optom/ B. Optom):** Regional polytechnics, paramedical institutions, and allied health colleges in Nadia should establish accredited Diploma (D.Optom) and Bachelor's (B.Optom) programs. This intervention addresses two challenges at once:
 - It trains a local workforce of licensed optometrists who understand regional languages, cultural context, and occupational visual needs.
 - It provides stable, specialized healthcare career pathways for rural and peri-urban youth, fostering self-employment through local, ethical vision centers.
- 3) **Mobile Optometry Units for Artisans:** Fully equipped mobile refraction vans with onboard lens-edging capabilities should visit weaving clusters weekly, providing on-site examinations and affordable, durable spectacles with minimal interruption to work schedules.
- 4) **Regulation of Counterfeit Ready-Made Spectacles:** Regulatory bodies should curb the distribution of uncalibrated, over-the-counter reading glasses sold by unlicensed vendors, while public fair-price medicine dispensaries provide subsidized, custom-measured spectacles.

6. Conclusion

The Nabadwip– Mayapur corridor illustrates the pronounced imbalance between community visual needs and available optometric infrastructure in rural and peri-urban India. Uncorrected refractive error and presbyopia account for nearly 60% of all visual impairment in this region, lowering the economic productivity of traditional handloom weavers and leaving rural and pilgrim populations without access to care.

Relying exclusively on episodic cataract surgical camps cannot solve this ongoing public health issue. A sustainable solution requires decentralized, institutionalized optometry integrated with professional educational opportunities. Establishing accredited Diploma (D.Optom) and Bachelor's Degree (B.Optom) programs in the district provides a clear **dual-impact solution**:

- **Clinical & Public Health Impact:** Deploying certified

optometrists into permanent primary vision centers brings high-quality, preventative refractive care directly to rural communities, protecting residents from the harms of uncalibrated eyewear and unmanaged eye disease.

- **Socio-Economic & Employment Impact:** It opens respected, professional healthcare careers for local youth, driving employment and self-reliance throughout the region.

Integrating accessible optometric services with localized professional education offers a practical, scalable model for eliminating avoidable visual impairment while strengthening the socioeconomic fabric of the Eastern Gangetic delta.

Declarations

Ethical Approval: This study was conducted in accordance with the ethical principles of the Declaration of Helsinki and approved by the Institutional Ethics Committee. Informed written and verbal consent was obtained from all adult participants and the legal guardians of minor participants prior to clinical examination.

Conflict of Interest: The author declares that there are no personal, commercial, or financial conflicts of interest related to this manuscript.

Data Availability Statement: De-identified clinical and demographic datasets generated during this study are available from the corresponding author (optom.sahaanindya@gmail.com) upon reasonable academic request.

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Author Profile

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