International Journal for Multidisciplinary Research (IJFMR)
E-ISSN: 2582-2160 ● Website: www.ijfmr.com ● Email: editor@ijfmr.com

A Clinical Study of Refractive Errors in School-Aged Children Between the Age (8–17 Years): A Comprehensive Review

Mohd. Tahseen Raja khan[1], Mr. Sukhdev Singh[2], Mr. Ashish Dhar Dwivedi[3], Dr. Prashant Gupta[4]

[1]PG, Research Scholar Shri Ram Murti Smarak Institute of Paramedical Sciences, ABVMU Lucknow U.P
[2,3]Assistant Professor, Shri Ram Murti Smarak Institute of Paramedical Sciences, ABVMU Lucknow U.P
[4]Principal Cum Professor, Faculty of Paramedical Sciences, Bareilly International University Bareilly U.P

Abstract

Refractive errors remain a leading cause of visual impairment in children worldwide, particularly in school-aged groups (8–17 years). Myopia, hyperopia, and astigmatism often go uncorrected, negatively impacting a child's education, psychological development, and quality of life. This review discusses the global prevalence, risk factors, classification, clinical diagnosis, and current management strategies for refractive errors in this population. The paper also underscores the importance of school-based vision screening and interventions to reduce the public health burden of childhood visual impairment. Several national and international studies have contributed to the understanding of REs in children. The Refractive Error Study in Children (RESC) conducted in multiple countries under WHO guidelines provided a standardized methodology to evaluate the burden of refractive errors. The findings consistently emphasized the need for school-based vision screenings, early correction, and public education programs. In India, regional studies from Delhi, Chennai, Hyderabad, and rural North India have provided valuable insights into the regional variation in RE prevalence and associated risk factors. This review article therefore aims to bridge the knowledge gap by providing a detailed and up-to-date synthesis of the epidemiology, risk factors, clinical presentation, diagnostic methodologies, treatment options, and preventive strategies for refractive errors in children aged 8–17 years. It is designed to serve as a resource for clinicians, researchers, public health professionals, and educators in formulating strategies and interventions to tackle this pervasive issue. Ultimately, it advocates for a collaborative, multidisciplinary approach to ensure that no child is left behind due to a correctable visual disability.

Keywords: Refractive error, myopia, hyperopia, astigmatism, pediatric vision, school screening, visual impairment

Introduction

Vision is one of the most vital senses for human development, and its proper functioning is crucial for a

child's learning, development, and quality of life. Among all ocular disorders, refractive errors (REs) are the most commonly encountered visual impairments, particularly in children. Refractive errors are optical abnormalities that result in improper focusing of light rays on the retina, leading to blurred or distorted vision. The primary forms of REs include myopia (nearsightedness), hyperopia (farsightedness), and astigmatism. These errors often begin during childhood and can progress significantly if left uncorrected, leading to complications such as amblyopia, strabismus, or even long-term visual disability.The prevalence of refractive errors among children has surged globally, emerging as a significant public health issue. A combination of genetic predisposition and changing environmental factors, such as reduced time spent outdoors and increased near work (reading and screen usage), has accelerated this trend. The age group of 8 to 17 years represents a critical period of visual and cognitive development. During this phase, academic demands rise substantially, and children are exposed to more near-vision tasks, which potentially exacerbate the risk of developing REs, especially myopia. If uncorrected, these visual impairments can hinder academic achievement, reduce self-esteem, and impact overall psychological well-being. Globally, uncorrected refractive errors are the leading cause of visual impairment and the second leading cause of blindness, according to the World Health Organization (WHO). It is estimated that over 2.5 billion people globally require vision correction, of which more than 1 billion have unmet needs. Children are a vulnerable segment in this statistic. In developing countries, the burden is particularly high due to lack of awareness, limited access to eye care services, and economic constraints preventing the procurement of corrective eyewear. School-based screenings are often the first and only opportunity for early diagnosis of REs in many low-income and middle-income countries.In India, multiple studies have shown that the prevalence of refractive errors among school-aged children ranges from 5% to 25%, with significant variation based on geographical location, socioeconomic status, urban-rural divide, and age. Urban areas tend to have higher prevalence rates of myopia, which may be attributed to increased exposure to digital screens, lower levels of outdoor activity, and higher academic pressures. Meanwhile, hyperopia is more prevalent in younger children and tends to decrease with age due to the natural growth and elongation of the eyeball. Astigmatism may remain stable or progress depending on ocular and genetic factors. The Indian government's efforts, such as the Rashtriya Bal Swasthya Karyakram (RBSK), have aimed at integrating vision screening within school health programs to combat this growing concern. The early identification and management of refractive errors are essential to avoid preventable visual impairment. This includes routine vision screening, comprehensive eye examinations, and timely intervention through spectacles, contact lenses, or other appropriate corrective methods. With advancements in pediatric ophthalmology, newer interventions like orthokeratology, low-dose atropine therapy, and customized optical solutions have shown promise in myopia control and vision correction. Despite these innovations, access to care remains a bottleneck in many resource-limited settings.Technological developments and artificial intelligence (AI) are now aiding in accurate and early diagnosis. Portable autorefractors, mobile screening vans, and AI-powered vision tests are increasingly being deployed, especially in rural and underserved areas. Public-private partnerships have also contributed to the expansion of vision care services across the country. Nevertheless, challenges such as low awareness among parents and teachers, social stigma around spectacle use, and poor follow-up compliance continue to impede progress.The psychological and social implications of uncorrected refractive errors are also significant. Children with vision problems may face difficulties in reading, writing, participating in class, and engaging in extracurricular activities. They may develop a negative self-image, avoid social interactions, or perform poorly academically. Early correction not only improves visual acuity but also enhances educational

outcomes, mental health, and future career prospects.The importance of evidence-based research in understanding the epidemiology, risk factors, and treatment outcomes of refractive errors in children cannot be overstated. This review aims to comprehensively analyze the clinical characteristics, diagnostic approaches, and management strategies of refractive errors in children aged 8 to 17 years. By synthesizing current literature, the review highlights global and Indian trends in pediatric refractive errors, identifies gaps in eye care delivery, and emphasizes the role of integrated public health strategies in mitigating this growing burden.Furthermore, the role of parents, educators, and pediatricians in recognizing early signs of visual impairment is pivotal. Symptoms such as squinting, eye rubbing, frequent headaches, holding objects too close, or declining academic performance should prompt immediate vision evaluation. Educating caregivers about these signs, coupled with regular eye check-ups, forms the backbone of preventive pediatric eye care.The digital age has further complicated the visual environment of children. With the advent of online education, smartphones, and digital learning tools, children are exposed to screens for extended periods, often in poorly lit environments or with inadequate breaks. This shift has been correlated with an alarming rise in myopia incidence, termed "school myopia" or "digital myopia." Strategies such as the 20-20-20 rule (every 20 minutes, look at something 20 feet away for 20 seconds), encouraging outdoor play, and promoting ergonomic study habits are simple yet effective tools to curb this trend.

2. Types of Refractive Errors

Refractive errors are the most common visual disorders, occurring when the eye cannot properly focus light onto the retina, resulting in blurred vision. They are caused by anomalies in the eye's length, curvature of the cornea, or lens flexibility. In children, timely detection of these conditions is crucial because the developing visual system is more susceptible to permanent visual impairment if left untreated. The three primary types of refractive errors are myopia, hyperopia, and astigmatism, with presbyopia occurring later in life. Each of these has distinct clinical characteristics, underlying mechanisms, and management approaches.

2.1 Myopia (Nearsightedness)

Myopia is characterized by the ability to see nearby objects clearly while distant objects appear blurry. It occurs when the axial length of the eye is too long or the cornea has excessive curvature, causing light rays to focus in front of the retina rather than directly on it. Myopia typically develops during childhood and may progress until early adulthood.

Classification:

1. **Simple Myopia:** Most common type; generally mild and correctable with spectacles.
2. **Pathological (Degenerative) Myopia:** Severe, progressive, and associated with degenerative changes in the retina, choroid, and sclera.
3. **Night Myopia:** Difficulty seeing in low light conditions due to a lack of accommodation.
4. **Pseudo-myopia:** Temporary form caused by overuse of accommodation, such as prolonged near work.

Etiology:

- **Genetic Factors:** Children with myopic parents are at higher risk.
- **Environmental Factors:** Reduced time spent outdoors, increased screen time, and extensive near work contribute to early onset.
- **Growth and Development:** Rapid eye growth in school-age children may lead to increased axial length.

- Blurred distance vision
- Squinting
- Eye strain
- Headaches
- Difficulty seeing the board in school

Diagnosis:

- Visual acuity test
- Retinoscopy
- Autorefraction
- Cycloplegic refraction

Management:

- **Corrective Lenses:** Glasses and contact lenses are the most common.
- **Pharmacological Intervention:** Low-dose atropine eye drops (0.01%) are used to slow progression.
- **Orthokeratology:** Special contact lenses worn overnight to temporarily reshape the cornea.
- **Refractive Surgery:** Laser-assisted in situ keratomileusis (LASIK) or photorefractive keratectomy (PRK) – rarely used in children.

Complications:

- Increased risk of retinal detachment
- Macular degeneration
- Glaucoma

Early-onset **Symptoms:**

cataract

2.2 Hyperopia (Farsightedness)

Hyperopia is a refractive error in which distant objects may be seen more clearly than near objects. It results from an eyeball that is too short or a cornea that is too flat, causing light rays to focus behind the retina.

Classification:

Simple Hyperopia: Most common, seen in all age groups, particularly in early childhood.

Pathological Hyperopia: Caused by abnormal eye structure due to genetic or developmental anomalies.

Functional Hyperopia: Associated with lens rigidity or paralysis of accommodation.

Etiology:

- Short axial length
- Flattened corneal curvature
- Genetic predisposition
- Small globe size (microphthalmia)

Symptoms:

- Blurred near vision
- Eye fatigue with reading
- Headaches, especially after near work
- In young children, may present as accommodative esotropia (inward turning of the eye)

Diagnosis:

- Visual acuity testing (especially near vision)

- Cycloplegic refraction (essential for accurate measurement in children)
- Retinoscopy and autorefractor readings

Management:

- **Eyeglasses:** Convex lenses (+ diopters) to aid focusing light on the retina.
- **Vision Therapy:** To improve accommodative function in children with symptoms.
- **Monitoring:** Many children outgrow mild hyperopia; regular follow-up is key.

Complications:

- Amblyopia (lazy eye)
- Strabismus
- Learning difficulties due to uncorrected visual strain

2.3 Astigmatism

Astigmatism occurs when the cornea or lens has an irregular shape, leading to light rays focusing on multiple points in the eye instead of a single point. It can occur with myopia or hyperopia, resulting in distorted or blurred vision at all distances.

Types of Astigmatism:

Regular Astigmatism: The principal meridians are perpendicular. Can be corrected with cylindrical lenses.

With-the-rule: Vertical meridian is steeper.

Against-the-rule: Horizontal meridian is steeper.

Oblique: Principal meridians lie obliquely.

Irregular Astigmatism: Meridians are not perpendicular. Typically caused by corneal scarring, keratoconus, or surgery.

Etiology:

- Hereditary
- Trauma or surgery to the eye
- Keratoconus (progressive thinning of the cornea)
- Uneven pressure on the cornea (e.g., from eyelids or habitual eye rubbing)

Symptoms:

- Blurred or distorted vision
- Ghost images
- Eye strain
- Headaches
- Squinting

Diagnosis:

- Keratometry and corneal topography to map corneal curvature
- Astigmatic fan chart
- Retinoscopy and autorefractor

Management:

- **Corrective Lenses:** Cylindrical glasses or toric contact lenses.
- **Refractive Surgery:** LASIK or PRK in selected cases (mostly adults).
- **Rigid Gas Permeable (RGP) Lenses:** Especially effective for irregular astigmatism.

Complications:

- Visual distortion
- Reduced visual acuity
- Potential amblyopia in children if untreated

2.4 Presbyopia (Age-related Farsightedness)

While not typically seen in children, presbyopia deserves mention as a refractive error that results from the natural aging process. It is due to the gradual loss of accommodation by the lens, making it difficult to focus on near objects. It usually begins in the early to mid-40s.

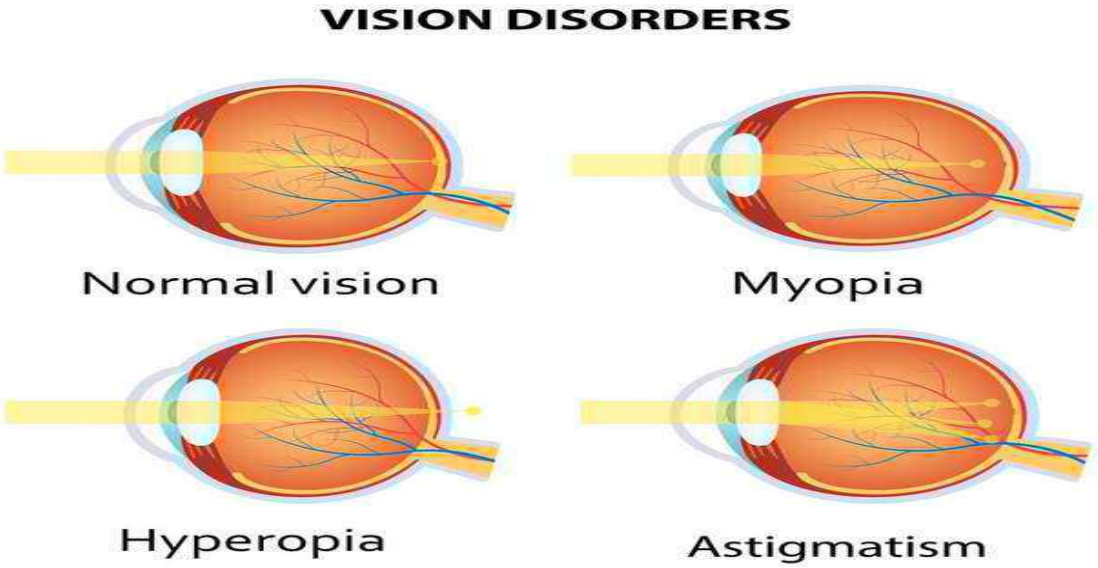
2.5 Compound and Mixed Refractive Errors

Compound Myopic Astigmatism: Both focal points are in front of the retina, but at different distances.

Compound Hyperopic Astigmatism: Both focal points are behind the retina.

Mixed Astigmatism: One focal point lies in front and the other behind the retina.

These forms require complex lens prescriptions and careful evaluation to achieve optimal correction.



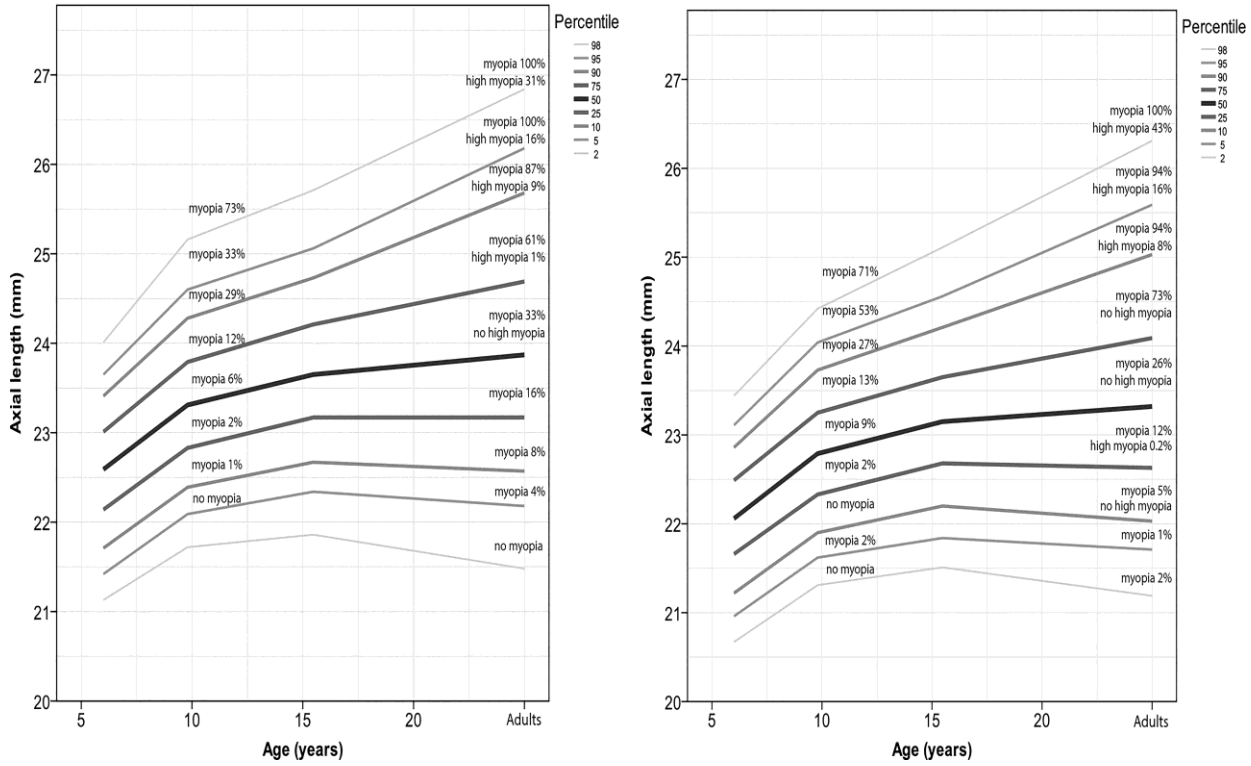
3. Epidemiology of Refractive Errors in Children (8–17 Years)

Refractive errors are the leading cause of visual impairment globally, especially in school-aged children. The World Health Organization (WHO) estimates that over 2.2 billion people worldwide suffer from vision impairment or blindness, with at least 1 billion cases due to unaddressed refractive errors. Among these, a significant proportion occurs in children aged 8 to 17 years, a critical period for academic learning and psychosocial development.The global prevalence of refractive errors in children varies widely depending on geographic location, ethnicity, socioeconomic status, and environmental factors. According to the Refractive Error Study in Children (RESC) conducted by WHO in countries like China, India, Chile, Nepal, and South Africa, the prevalence of uncorrected refractive errors among school children ranges from 5% to 20%. Myopia is the most prevalent type, especially in urban and East Asian populations, while hyperopia and astigmatism show more variable patterns.In East Asia, particularly countries like China, Singapore, South Korea, and Japan, myopia has reached epidemic proportions. Studies have shown prevalence rates of myopia as high as 70–90% among teenagers. This rise is attributed to intense educational pressure, increased screen time, and reduced outdoor activities. In India, the prevalence of refractive errors among children varies between 5% and 15%, with urban areas generally showing higher

rates due to lifestyle factors. A multicentric study by Murthy et al. (2002) reported a prevalence of 7.4% in school-going children aged 5–15 years. More recent studies indicate a rising trend of myopia in school-aged children, particularly in metropolitan cities like Delhi, Mumbai, and Chennai. Rural versus urban disparities also play a significant role in epidemiology. Urban children have higher rates of myopia, likely due to lifestyle differences, while hyperopia is more common in younger rural children and may go unnoticed due to the eye's accommodative ability. Astigmatism, although less commonly studied, affects around 10–20% of children globally and often coexists with other refractive errors.

Gender differences in prevalence have been inconsistent across studies. Some research indicates a slightly higher incidence of myopia in females, potentially due to earlier pubertal development and educational demands. However, the difference is not universally significant.

Age is another critical factor. Refractive errors, particularly myopia, tend to manifest and progress during the school years. The age group of 8 to 17 years represents a phase of rapid ocular growth and increasing academic workload, which may contribute to the onset or progression of myopia. Hyperopia, common in early childhood, typically decreases with age as the eye grows. Socioeconomic status impacts access to vision care, timely diagnosis, and correction. Children from low-income families are less likely to receive eye examinations or wear corrective lenses. This inequity contributes significantly to the burden of visual impairment .In summary, refractive errors in children aged 8–17 years are a growing public health issue. Their epidemiology is influenced by genetic, environmental, behavioral, and socioeconomic factors. Understanding these patterns is essential for developing effective prevention, screening, and treatment strategies to reduce the burden of childhood visual impairment.



4. Management of Refractive Errors in Children (8–17 Years)

The effective management of refractive errors in children is crucial for ensuring optimal visual development, academic performance, and quality of life. Children aged 8–17 years are at a critical developmental stage where untreated refractive errors can lead to learning difficulties, reduced self-

esteem, and in severe cases, irreversible visual impairment such as amblyopia. Management strategies encompass diagnosis, corrective interventions (optical, pharmacological, and surgical), vision therapy, and public health initiatives.

4.1 Early Detection and Diagnosis

The first step in managing refractive errors is early detection through comprehensive eye examinations. Children often do not report vision problems due to unawareness or adaptation. Hence, school screening programs are essential to identify asymptomatic cases. A detailed diagnostic process includes:

- Visual acuity testing (distance and near)
- Retinoscopy and auto-refractor assessments
- Cycloplegic refraction for accurate diagnosis in children (to eliminate accommodation) Keratometry and corneal topography in suspected cases of astigmatism or keratoconus

Early and accurate diagnosis helps determine the type and extent of refractive error, guiding the choice of management.

4.2 Optical Correction

Spectacles remain the most common and effective modality for managing refractive errors in children. The appropriate lens prescription depends on the type of refractive error:

- Myopia: Concave (minus) lenses
- Hyperopia: Convex (plus) lenses
- Astigmatism: Cylindrical lenses tailored to the axis of refractive error
- Mixed errors: Combination lenses

Key considerations include:

- Use of lightweight, impact-resistant lenses for safety
- Full-time wear recommendation in moderate to high refractive errors
- Regular follow-up to adjust prescription with growth and progression
- Contact lenses may be prescribed for older children or those with high refractive errors, anisometropia, or sports-related needs. However, proper hygiene, motivation, and parental supervision are critical to avoid complications like corneal infections.

4.3 Pharmacological Management

Pharmacological intervention has emerged as a valuable tool, particularly in myopia control. One of the most promising agents is:

- Atropine Eye Drops (Low-dose):
- Used in concentrations of 0.01%, 0.025%, or 0.05%
- Proven to slow myopia progression by 50–60%
- Minimal side effects at low doses (slight photophobia, near blur)
- Long-term safety and rebound effects under investigation
- Other emerging pharmacological options include:
- Pirenzepine gel (muscarinic antagonist)
- Methylxanthine (experimental oral agent) These medications are typically reser
- ved for progressive myopia in children and require regular ophthalmic monitoring.

4.4 Orthokeratology (Ortho-K)

Orthokeratology is a non-surgical intervention that uses rigid gas-permeable contact lenses worn overnight to reshape the cornea temporarily. Indications include:

- Moderate myopia (−1.00 D to −5.00 D)
- Early onset or rapidly progressing myopia
- Contact lens intolerance during daytime

Benefits:

- Freedom from glasses or lenses during the day
- Documented reduction in axial elongation and myopia progression

Challenges:

- High cost
- Strict lens hygiene and compliance needed
- Risk of microbial keratitis

4.5 Vision Therapy and Visual Hygiene

For functional vision problems associated with refractive errors (e.g., accommodative insufficiency, binocular dysfunction), vision therapy may be recommended. It includes exercises and structured programs to:

- Improve eye focusing and coordination
- Reduce eyestrain during near work
- Enhance reading efficiency
- Visual hygiene education is equally important:
- Encouraging the 20-20-20 rule (20 seconds break every 20 minutes of near work)
- Promoting outdoor activities (2+ hours/day shown to reduce myopia risk)
- Limiting screen time

4.6 Refractive Surgery (Rare in Children)

- Refractive surgery is not routinely performed in children due to:
- Ongoing ocular development
- Risks of complications
- Ethical concerns
- However, in special circumstances (e.g., high anisometropia not correctable with glasses or contact lenses), laser-assisted surgeries like LASIK or PRK may be considered in older adolescents (≥16 years) with stable refraction, under expert supervision.

4.7 Management of Specific Refractive Errors

Myopia:

- Spectacles are first-line
- Low-dose atropine for progression control
- Orthokeratology or bifocal/multifocal lenses as adjuncts
- Regular axial length monitoring

Hyperopia:

- Often under corrected unless symptomatic
- Full correction in cases of esotropia or high hyperopia
- Cycloplegic refraction essential for accurate diagnosis

Astigmatism:

- Cylindrical lenses for regular astigmatism

- Rigid contact lenses for irregular types
- Consider keratometry for monitoring corneal changes

Anisometropia:

- Unequal refractive error between eyes
- Leads to amblyopia if uncorrected
- Spectacles or contact lenses (better binocular correction)
- Amblyopia therapy (patching or atropine penalization)

4.8 Amblyopia Prevention and Management

- Uncorrected refractive errors are a leading cause of refractive amblyopia. Management involves:
- Full-time optical correction
- Occlusion therapy (patching the dominant eye)
- Pharmacologic penalization
- Vision therapy to stimulate the weaker eye
- Early intervention ensures better visual prognosis.

4.9 Parental and School Involvement

- Educating parents and teachers plays a pivotal role in:
- Recognizing early signs (e.g., squinting, poor academic performance)
- Ensuring spectacle compliance
- Encouraging routine eye exams
- Reducing stigma associated with glasses
- School-based vision screening programs and referral systems improve early detection and correction.

4.10 Public Health and Policy Interventions

Refractive error correction is one of the most cost-effective public health strategies. WHO's "VISION 2020" and the "World Report on Vision (2019)" emphasize:

- Integration of refractive services in primary eye care
- Training of school health workers
- Distribution of affordable spectacles
- Surveillance of visual impairment in children
- Mobile eye clinics, tele-optometry, and NGO-led initiatives can expand reach in underserved communities.
- Emerging Trends and Future Directions

The field of pediatric refractive error management is rapidly evolving with advancements in technology, pharmacology, and public health strategies. With the global rise in the prevalence of myopia and other vision disorders among children, researchers and clinicians are focusing on innovative approaches that go beyond traditional correction methods. These emerging trends and future directions offer promising solutions for early detection, myopia control, personalized care, and long-term visual health.

5.1 Technological Advancements in Detection and Monitoring

One of the most notable trends is the use of artificial intelligence (AI) and machine learning algorithms in diagnosing and predicting refractive errors. AI-integrated devices can now screen large populations with high accuracy, even in remote or resource-limited settings. AI-powered retinal image analysis and axial length tracking help in early detection and monitoring of progressive myopia, allowing for timely interventions.Portable autorefractors and smartphone-based vision screening tools are gaining popularity in school screening programs, especially in underserved areas. These tools offer cost-effective, scalable solutions for mass detection, enabling early treatment and reducing the burden of uncorrected refractive errors.

5.2 Advances in Myopia Control Therapies

- The future of refractive error management lies in myopia control rather than just correction. Recent studies have demonstrated the efficacy of novel optical designs such as:
- Peripheral defocus-modifying contact lenses (e.g., MiSight)
- Multifocal spectacle lenses
- Orthokeratology (Ortho-K) lenses
- These modalities not only correct vision but also slow down myopia progression by influencing eye growth and refractive development.
- On the pharmacological front, low-dose atropine eye drops (0.01%–0.05%) remain the most researched and recommended agents. New pharmacologic agents like pirenzepine gel and methylxanthine are under investigation and may offer alternatives in the coming years.

Advances in Myopia Control Therapies

- The future of refractive error management lies in myopia control rather than just correction. Recent studies have demonstrated the efficacy of novel optical designs such as:
- Peripheral defocus-modifying contact lenses (e.g., MiSight)
- Multifocal spectacle lenses
- Orthokeratology (Ortho-K) lenses

- These modalities not only correct vision but also slow down myopia progression by influencing eye growth and refractive development.
- On the pharmacological front, low-dose atropine eye drops (0.01%–0.05%) remain the most researched and recommended agents. New pharmacologic agents like pirenzepine gel and 7-methylxanthine are under investigation and may offer alternatives in the coming years.

References

1. Holden BA, Fricke TR, Wilson DA, et al. Global prevalence of myopia and high myopia and temporal trends from 2000 through 2050. Ophthalmology. 2016;123(5):1036-1042.
2. World Health Organization. World report on vision. Geneva: WHO; 2019.
3. Resnikoff S, Pascolini D, Mariotti SP, et al. Global magnitude of visual impairment caused by uncorrected refractive errors in 2004. Bull World Health Organ. 2008;86(1):63–70.
4. He M, Zeng J, Liu Y, et al. Refractive error and visual impairment in urban children in southern China. Invest Ophthalmol Vis Sci. 2004;45(3):793-799.
5. Naidoo KS, Jaggernath J. Uncorrected refractive errors. Indian J Ophthalmol. 2012;60(5):432–437.
6. Saw SM, Katz J, Schein OD, et al. Epidemiology of myopia. Epidemiol Rev. 1996;18(2):175-187.
7. Murthy GV, Gupta SK, Ellwein LB, et al. Refractive error in children in an urban population in New De8. Dandona R, Dandona L. Refractive error blindness. Bull World Health Organ. 2001;79(3):237–243.
8. Czepita D, Zejmo M, Mojsa A. Prevalence of myopia and hyperopia in a population of Polish schoolchildren. Ophthalmic Physiol Opt. 2007;27(1):60-65.
9. Morgan IG, Ohno-Matsui K, Saw SM. Myopia. Lancet. 2012;379(9827):1739-1748.
10. Dolgin E. The myopia boom. Nature. 2015;519(7543):276-278.
11. Saxena R, Vashist P, Tandon R, et al. Prevalence of myopia and its risk factors in urban school children in Delhi. Ophthalmic Physiol Opt. 2015;35(5):500-507.
12. Rose KA, Morgan IG, Ip J, et al. Outdoor activity reduces the prevalence of myopia in children. Ophthalmology. 2008;115(8):1279–1285.
13. Guggenheim JA, Northstone K, McMahon G, et al. Time outdoors and physical activity as predictors of incident myopia in childhood: a prospective cohort study. Invest Ophthalmol Vis Sci. 2012;53(6):2856-2865.
14. Jones LA, Sinnott LT, Mutti DO, et al. Parental history of myopia, sports and outdoor activities, and future myopia. Invest Ophthalmol Vis Sci. 2007;48(8):3524-3532.
15. Walline JJ, Jones LA, Sinnott LT, et al. A randomized trial of the effect of soft contact lenses on myopia progression in children. Invest Ophthalmol Vis Sci. 2008;49(11):4702-4706.
16. Chia A, Lu QS, Tan D. Five-year clinical trial on atropine for the treatment of myopia 2. Ophthalmology. 2016;123(2):391-399.
17. Cooper J, Schulman E, Jamal N. Current status on the development and treatment of myopia. Optometry. 2012;83(5):179-199.
18. Chen Y, Zhang J, Morgan IG, et al. Atropine for the treatment of childhood myopia: effect on myopia progression after cessation of atropine. Ophthalmology. 2016;123(3):391-399.
19. Smith EL, Kee C, Ramamirtham R, et al. Peripheral vision can influence eye growth and refractive development in infant monkeys. Invest Ophthalmol Vis Sci. 2005;46(11):3965-3972.

20. Hiraoka T, Kakita T, Okamoto F, et al. Long-term effect of overnight orthokeratology on axial length elongation in childhood myopia: a five-year follow-up study. Invest Ophthalmol Vis Sci. 2012;53(7):3913-3919.
21. Huang J, Wen D, Wang Q, et al. Efficacy comparison of 16 interventions for myopia control in children: a network meta-analysis. Ophthalmology. 2016;123(4):697-708.
22. Lam CSY, Tang WC, Tse DY, et al. Defocus incorporated multiple segments (DIMS) spectacle lenses slow myopia progression: a 2-year randomized clinical trial. Br J Ophthalmol. 2020;104(3):363-368.
23. Sankaridurg P, Holden B, Smith E 3rd, et al. Decreasing rate of myopia progression with increasing age in schoolchildren. Invest Ophthalmol Vis Sci. 2011;52(3):936-941.
24. Wu PC, Chuang MN, Choi J, et al. Update in myopia and treatment strategy of atropine use in myopia control. Eye. 2019;33(1):3-13.
25. Siatkowski RM, Cotter SA, Crockett RS, et al. Randomized trial of amblyopia treatment in children aged 7 to 17 years. Arch Ophthalmol. 2008;126(4):437-447.
26. Scheiman M, Mitchell GL, Cotter S, et al. A randomized clinical trial of vision therapy/orthoptics versus pencil push-ups for the treatment of convergence insufficiency in young adults. Optom Vis Sci. 2005;82(7):583-595. 28. Verkicharla PK, Ohno-Matsui K, Saw SM. Current and predicted demographics of high myopia and its associated complications. Br J Ophthalmol. 2015;99(6):821-825.
27. Holden BA, Sankaridurg P, Smith EL, et al. Myopia, an underrated global challenge to vision: where the current data takes us on myopia control. Eye. 2014;28(2):142-146.
28. Liu HH, Xu L, Wang YX, et al. Prevalence and progression of myopic retinopathy in Chinese children and adolescents. Invest Ophthalmol Vis Sci. 2019;60(9):2878-2883.
29. Morgan IG, Iribarren R, Fotouhi A, et al. Myopia. Lancet. 2012;379(9827):1739–1748.
30. Wen G, Tarczy-Hornoch K, McKean-Cowdin R, et al. Prevalence of amblyopia and associated risk factors in the multi-ethnic pediatric eye disease study. Ophthalmology. 2011;118(11):2044-2051.
31. Kandel H, Khadka J, Sapkota YD, et al. Uncorrected refractive error in school children in Nepal. Optom Vis Sci. 2012;89(1):124-130.
32. Guo L, Yang J, Mai J, et al. Prevalence and associated factors of myopia among school children in Guangzhou, China. Optom Vis Sci. 2016;93(4):379-385.
33. Ip JM, Saw SM, Rose KA, et al. Role of near work in myopia: findings in a sample of Australian school children. Invest Ophthalmol Vis Sci. 2008;49(7):2903-2910.
34. Mutti DO, Mitchell GL, Moeschberger ML, et al. Parental myopia, near work, school achievement, and children's refractive error. Invest Ophthalmol Vis Sci. 2002;43(12):3633-3640.
35. Li SM, Li SY, Kang MT, et al. Near work related parameters and myopia in Chinese children: the Anyang Childhood Eye Study. PLoS One. 2015;10(8):e0134514.
36. Ngo CS, Tan NW, Lim GY, et al. Visual impairment and refractive errors in Singaporean children aged 6 to 72 months. Ophthalmology. 2013;120(7):1479-1486.
37. Sankaridurg P, Naduvilath TJ, Chen X, et al. Myopia control with novel central and peripheral plus contact lenses and extended depth of focus contact lenses: 2-year results from a randomized clinical trial. Invest Ophthalmol Vis Sci. 2019;60(8):2732.
38. Bullimore MA. The safety of soft contact lenses in children. Optom Vis Sci. 2017;94(6):638-646.
39. Walline JJ, Lindsley K, Vedula SS, et al. Interventions to slow progression of myopia in children. Cochrane Database Syst Rev. 2020;1:CD004916.

40. Tideman JW, Snabel MC, Tedja MS, et al. Association of axial length with risk of uncorrectable visual impairment for Europeans with myopia. JAMA Ophthalmol. 2016;134(12):1355-1363.
41. Lou L, Yao C, Jin Y, et al. Global patterns in health burden of uncorrected refractive error. Invest Ophthalmol Vis Sci. 2016;57(14):6271-6277.
42. Foster PJ, Jiang Y. Epidemiology of myopia. Eye. 2014;28(2):202–208.
43. Holden BA, Jong M, Davis S, et al. Nearly 1 billion people have a vision impairment that could have been prevented or has yet to be addressed. Lancet Glob Health. 2019;7(10):e1319-e1321.
44. Fricke TR, Tahhan N, Resnikoff S, et al. Global cost of correcting vision impairment from uncorrected refractive error. Bull World Health Organ. 2012;90(10):728-738.
45. American Academy of Ophthalmology. Preferred Practice Pattern® Guidelines: Pediatric Eye Evaluations. 2022.
46. Gifford K, Gifford P. The future of myopia control contact lenses. Cont Lens Anterior Eye. 2020;43(3):234-241.
47. Williams KM, Bertelsen G, Cumberland P, et al. Increasing prevalence of myopia in Europe and the impact of education. Ophthalmology. 2015;122(7):1489-1497.
48. Chen M, Wu A, Zhang L, et al. The increasing prevalence of myopia and high myopia among high school students in Fenghua city, eastern China: a 15-year population-based survey. BMC Ophthalmol. 2018;18(1):159.