IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 6, Issue 11, May 2026
Impact Factor: 8.2

A Review of Environmental and Genetic Determinants of Refractive Errors among School-Going Children

Kishor Bhausaheb Shinde[1], Dr. Pankaj M Gajbhiye[2]
[1]Research Scholar, [2]Assistant Professor
Department of Optometry
Sunrise University, Alwar, Rajasthan

Abstract: *Refractive errors, including myopia, hyperopia, and astigmatism, are among the leading causes of visual impairment in school-going children worldwide. During the last decade, the prevalence of refractive errors has increased rapidly due to changes in lifestyle, educational pressure, and urbanization. While genetic predisposition plays a significant role in ocular development, environmental factors such as prolonged near work, increased digital screen exposure, reduced outdoor activities, and socioeconomic conditions substantially influence the onset and progression of refractive errors. Recent evidence suggests that refractive errors result from complex interactions between genetic susceptibility and environmental exposures rather than from either factor alone. This review summarizes published studies from 2010 to 2022 regarding the environmental and genetic determinants of refractive errors among school-aged children. It also discusses current epidemiological trends, biological mechanisms, and preventive strategies for reducing childhood visual impairment.*

Keywords: Refractive Error, Myopia, Hyperopia, Astigmatism, Genetics, Environment, School Children, Outdoor Activity.

I. INTRODUCTION

Refractive errors are optical defects that prevent light rays from focusing accurately on the retina, resulting in blurred vision. They include myopia (near-sightedness), hyperopia, astigmatism, and anisometropia. According to the World Health Organization, uncorrected refractive errors remain one of the most common causes of avoidable visual impairment among children. During the past decade, the prevalence of childhood myopia has increased dramatically across Asia, Europe, and developing countries including India. Researchers estimate that nearly half of the world's population may become myopic by 2050 if current trends continue.

School-going children represent the most vulnerable population because rapid ocular growth occurs during childhood. Educational demands, increased use of smartphones, reduced outdoor activities, and urban lifestyles have accelerated the progression of refractive errors. Although hereditary factors strongly influence eye development, environmental exposures determine whether genetically susceptible children develop clinically significant refractive errors. Therefore, understanding both environmental and genetic determinants is essential for designing effective prevention strategies.

II. TYPES OF REFRACTIVE ERRORS

Type	Characteristics	Major Risk Factors
Myopia	Distant objects appear blurred	Genetics, near work, low outdoor exposure
Hyperopia	Near objects blurred	Genetics, shorter axial length
Astigmatism	Distorted vision	Corneal curvature abnormalities, hereditary factors
Anisometropia	Unequal refractive power between eyes	Genetic and developmental factors

IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 6, Issue 11, May 2026
Impact Factor: 8.2

III. ENVIRONMENTAL DETERMINANTS

1. Outdoor Activity

Among environmental determinants, time spent outdoors has emerged as the strongest protective factor against childhood myopia.

Natural sunlight stimulates retinal dopamine release, which regulates axial eye growth and prevents excessive elongation responsible for myopia.

Children spending more than two hours daily outdoors show significantly lower myopia incidence than those remaining indoors.

Numerous intervention studies published between 2015 and 2022 consistently demonstrate that increased outdoor exposure delays both onset and progression of myopia.

2. Near Work

Near work includes:

a) Reading
b) Writing
c) Homework
d) Smartphone use
e) Tablet use
f) Computer use

Continuous accommodation during prolonged near work increases visual stress and promotes axial elongation.

Several cohort studies have demonstrated a positive association between excessive near work (>3 hours/day) and childhood myopia, particularly among East Asian populations.

3. Digital Screen Exposure

Following widespread adoption of smartphones and online education, digital screen time has become an important environmental determinant.

Excessive screen exposure causes:

a) accommodative fatigue
b) dry eye
c) reduced blinking
d) prolonged near fixation

Recent evidence suggests that children using digital devices for over 4 hours daily exhibit faster myopic progression than peers with limited exposure.

4. Urbanization

Urban children consistently show higher prevalence of refractive errors compared with rural populations.

Contributing factors include:

a) limited outdoor space
b) intensive education
c) increased indoor lifestyle
d) greater digital exposure

Indian systematic reviews similarly report higher rates of myopia in urban schoolchildren.

IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 6, Issue 11, May 2026
Impact Factor: 8.2

5. Air Pollution

Emerging studies indicate that exposure to PM2.5, NO_2, and other pollutants may contribute indirectly to myopia by increasing ocular inflammation and reducing outdoor activity. Proposed biological mechanisms include oxidative stress, retinal ischemia, and altered dopamine signaling, although further longitudinal evidence is needed.

IV. GENETIC DETERMINANTS

Family history remains one of the strongest predictors of refractive errors.

Children having: -

1. One myopic parent are approximately twice as likely to become myopic,
2. Two myopic parents have an even greater risk.

Twin studies estimate that heritability ranges from 50% to 90%, indicating a substantial genetic contribution to ocular growth.

Genome-wide association studies have identified numerous loci associated with refractive development, including genes involved in extracellular matrix remodeling, retinal signaling, and eye growth. These findings show that refractive errors are polygenic disorders influenced by many variants of small effect.

5. Gene–Environment Interaction

Modern research emphasizes that genes and environment interact.

For example:

a) genetically susceptible children who spend little time outdoors have the greatest risk of developing myopia;
b) Outdoor activity can partially offset inherited susceptibility.

Thus, environmental modification remains beneficial even among high-risk children.

Table 1. Environmental Determinants of Refractive Errors

Environmental Factor	Effect on Refractive Error	Evidence (2010–2022)
Reduced outdoor activity	Strong increase in myopia risk	Strong
Near work	Increased axial elongation	Strong
Screen time	Faster progression	Moderate–Strong
Urbanization	Higher prevalence	Strong
Educational pressure	Increased risk	Moderate
Air pollution	Possible increased risk	Emerging

Table 2. Genetic Determinants

Genetic Factor	Effect
Family history	Major predictor
Twin inheritance	High heritability
GWAS loci	Multiple susceptibility genes

IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 6, Issue 11, May 2026
Impact Factor: 8.2

Axial length genes	Influence eye growth
Retinal signaling genes	Regulate emmetropization

Table 3. Major Review Findings (2010–2022)

Author	Year	Main Finding
Wojciechowski	2011	Myopia has complex genetic inheritance.
Harb & Wildsoet	2019	Refractive errors arise from interactions between genes and environment.
Sheeladevi et al.	2021	Urban Indian children have higher prevalence of refractive errors than rural children.
Dhakal et al.	2022	Outdoor activity is an effective intervention for myopia prevention.
Xu et al.	2022	Air pollution may contribute to myopia through inflammatory and biological pathways.

V. DISCUSSION

Evidence published between 2010 and 2022 indicates that childhood refractive errors are influenced by both inherited and modifiable factors. Genetic susceptibility establishes baseline risk, while environmental exposures such as prolonged near work, excessive screen use, limited outdoor activity, and urban living determine whether refractive errors develop and progress. Public health interventions should therefore focus on school-based vision screening, increasing outdoor play, reducing unnecessary screen exposure, and promoting healthy visual habits. Such strategies may help reduce the burden of preventable visual impairment among school-going children.

VI. CONCLUSION

Refractive errors among school-going children represent a growing global public health concern. The evidence from 2010–2022 consistently demonstrates that environmental and genetic determinants interact in the development of childhood myopia and other refractive errors. While family history remains an important non-modifiable risk factor, modifiable environmental factors—including increased outdoor activity, balanced near work, and reduced screen exposure—offer practical opportunities for prevention. Integrating school vision screening, parental awareness, and lifestyle interventions with ongoing genetic research is essential for reducing the long-term burden of refractive errors and preserving visual health in children.

REFERENCES

1. Charman, W. N. (2010). Peripheral refraction and the development of refractive error: A review. *Ophthalmic and Physiological Optics, 30*(4), 321–338.
2. Harb, E. N., & Wildsoet, C. F. (2019). Origins of refractive errors: Environmental and genetic factors. *Annual Review of Vision Science, 5*, 47–72.
3. Holden, B. A., Fricke, T. R., Wilson, D. A., Jong, M., Naidoo, K. S., Sankaridurg, P., Wong, T. Y., Naduvilath, T. J., & Resnikoff, S. (2016). Global prevalence of myopia and high myopia and temporal trends from 2000 through 2050. *Ophthalmology, 123*(5), 1036–1042.
4. Morgan, I. G., French, A. N., Ashby, R. S., Guo, X., Ding, X., He, M., & Rose, K. A. (2018). The epidemics of myopia: Aetiology and prevention. *Progress in Retinal and Eye Research, 62*, 134–149.
5. Pascolini, D., & Mariotti, S. P. (2012). Global estimates of visual impairment: 2010. *British Journal of Ophthalmology, 96*(5), 614–618.

IJARSCT
International Journal of Advanced Research in Science, Communication and Technology
International Open-Access, Double-Blind, Peer-Reviewed, Refereed, Multidisciplinary Online Journal
ISSN: 2581-9429
Volume 6, Issue 11, May 2026
Impact Factor: 8.2

6. Rose, K. A., Morgan, I. G., Ip, J., Kifley, A., Huynh, S., Smith, W., & Mitchell, P. (2008). Outdoor activity reduces the prevalence of myopia in children. *Ophthalmology, 115*(8), 1279–1285.
7. Sheeladevi, S., Seelam, B., Nukella, P. B., Modi, A., Ali, R., & Keay, L. (2018). Prevalence of refractive errors in children in India: A systematic review. *Clinical and Experimental Optometry, 101*(4), 495–503.
8. Tedja, M. S., Wojciechowski, R., Hysi, P. G., Eriksson, N., Furlotte, N. A., Verhoeven, V. J. M., & Klaver, C. C. W. (2018). Genome-wide association meta-analysis highlights light-induced signaling as a driver for refractive error. *Nature Genetics, 50*(6), 834–848.
9. Wojciechowski, R. (2011). Nature and nurture: The complex genetics of myopia and refractive error. *Clinical Genetics, 79*(4), 301–320.
10. Wu, P. C., Tsai, C. L., Wu, H. L., Yang, Y. H., & Kuo, H. K. (2013). Outdoor activity during class recess reduces myopia onset and progression in school children. *Ophthalmology, 120*(5), 1080–1085.
11. Xiong, S., Sankaridurg, P., Naduvilath, T., Zang, J., Zou, H., Zhu, J., Lv, M., He, X., & Xu, X. (2017). Time spent in outdoor activities in relation to myopia prevention and control: A meta-analysis and systematic review. *Acta Ophthalmologica, 95*(6), 551–566.