RESEARCH PAPER

Factors Associated With Myopia Prevalence Among Urban Youth In Mumbai

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Abstract
Aim: To evaluate the influence of parental myopia, residence type, digital exposure, outdoor activities, breaks from near work, and lighting conditions on myopia among youth in Mumbai.
Method: The study is a cross-sectional epidemiological study. 1660 students participated in the survey. The survey collected refractive, behavioural, environmental, and genetic data. Digital time was calculated as a composite variable based on time spent on different digital devices. Variance Inflator Factor was used to test for multicollinearity among variables. Multivariable logistic regression was used on a balanced dataset to analyze the relationship between digital time, parental myopia, outdoor time, breaks in near work, and lighting conditions during near work with myopia. Model performance was assessed using the Hosmer-Lemeshow Test and AUC. Model performance metrics were reported to describe model behaviour rather than to support clinical prediction.
Result: Myopia prevalence in the study population was 29.6%. The mean self-reported age of myopia onset was 13.35±3.46 years. Bivariate analysis revealed noteworthy associations between myopia and digital screen time, parental myopia, and residence type ($p<0.05$). However, only parental myopia (OR=1.59, 95% CI: 1.20-2.11) and residence type (OR=1.39, 95% CI: 1.04-1.86) were associated with myopia in multivariable logistic regression. After adjustment, no significant association was found between digital screen time, outdoor time, breaks in near work, and room lighting and myopia. The model's accuracy was modest at 63% (AUC=0.675). Precision and recall were balanced across groups, and the model showed good calibration (Hosmer-Lemeshow p=0.846).
Conclusion: Parental myopia and residence type were identified as primary factors responsible for myopia onset. With its multifactorial nature, further longitudinal investigations are needed. Public health strategies should emphasize early screening and context-specific preventive measures in urban settings.
Keywords: Myopia, Epidemiology, Urban Youth, Lifestyle Factors, Digital Time, Environmental Exposure, Genetic Factors, Logistic Regression, Mumbai.
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1. Introduction

Myopia, commonly known as near-sightedness, is an ophthalmological condition wherein people can clearly see nearby objects but distant objects appear blurry [1]. The unit of measure for myopia is Diopters (D), denoted by a negative sign. Any person having a measure of at least -0.5D is considered myopic [2]. An increase in the prevalence of myopia also increases the risk of pathological myopia (with a measure of -8D or higher) [2, 3]. Pathological myopia may lead to severe eye diseases, including vision impairment [4].
Several studies have examined different factors responsible for the onset of myopia. Primarily, more near-work and less outdoor time have been identified to play a dominant role in the onset and progression of myopia. The incidence of myopia has particularly increased during and after the COVID-19 pandemic [7]. There is a significant impact of digital device usage on myopia. Outdoor exposure helps in controlling the onset of myopia [8]. The time that children go to sleep and their sleeping patterns affect the occurrence of myopia [9, 10]. Light spectrum, illumination, and variation in brightness are related to the onset of myopia [11]. Myopia rate was found to be higher in children who spend more time on smartphones [12, 13].
Currently, 30% of the global population is myopic. If appropriate corrective measures are not taken, 50% of the global population is estimated to be myopic by 2050 [2], making myopia an epidemic [14]. Myopia prevalence is the highest in the Southeast Asian region. USA has also exhibited substantial myopia prevalence [15]. Figure 1 illustrates the projected rate of myopia worldwide by 2050, based on prevalence trends reported in prior studies [2]. Myopia is increasing rapidly in India, especially in the urban regions [6]. Myopia is not just a global health concern, but also has a burden on the economy [6].

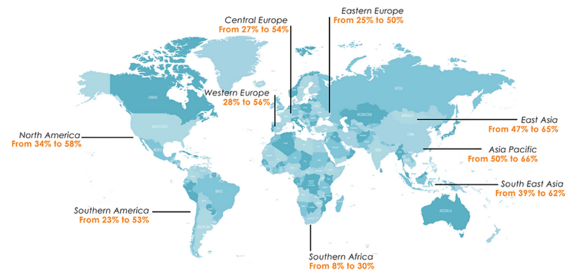

Figure 1: Projected prevalence of myopia by 2050 based on previously published epidemiological models using population-based prevalence estimates.

Mumbai, the commercial and financial capital of India, is a large metropolitan city with a population of around 22 million. 40% Mumbai's population comprises youth [16]. The lifestyle in Mumbai is marked with high academic demands, extensive use of digital devices, prolonged near-work activities, dense housing, and limited outdoor exposure. This is conducive to the risk factors associated with the onset of myopia. Despite these facts, limited data are available to quantify myopia prevalence in Mumbai's youth population. The current literature focuses on broader national or regional trends, leaving a significant research gap. Our study aims to address this gap by examining the myopia prevalence among Mumbai's youth. Precisely, the study aims to estimate the proportion of youth affected by myopia and understand the effects of environmental, genetic, and lifestyle factors on myopia prevalence among Mumbai's youth.
The findings of the study will contribute to the growing body of literature on myopia prevalence, with emphasis on the urban context. This will not only enrich academic research but also assist policymakers and healthcare providers in developing effective management strategies to control myopia in urban settings.

2. Methodology

2.1 Study Design

This cross-sectional epidemiological study was conducted among Mumbai's youth. Data was collected through a structured survey. Colleges were selected using convenience sampling based on accessibility and willingness to participate.

2.2 Participants

Students from selected colleges in the age group of 16-21 years participated in the survey. Information on self-reported age at onset of myopia was collected separately. Exclusion criteria included:

- Incomplete questionnaire data

A total of n=1660 students were included in the final analysis.

2.3 Outcome Variable: Myopia Status

Refractive data was collected through the questionnaire. Following the international epidemiological standard, myopia was classified as:

- **Myopic**: Refractive error ≤ -0.50 D in the higher myopic eye.
- **Non-myopic**: Refractive error > -0.50 D.

2.4 Predictor Variables

2.4.1 Digital Time

Digital_Time was calculated as the total time spent daily on all the digital devices for academic/recreational purposes:

- Mobile phone
- Tablet
- Computer and/or laptop

2.4.2 Outdoor Time

Time spent outdoors daily was recorded as:

- Nil
- Less than 1 hour
- 1-3 hours
- 3-5 hours
- More than 5 hours

2.4.3 Break Frequency

Duration of breaks in near work was recorded as:

- 0 = Never/Rarely
- 1 = Every hour/20 minutes

2.4.4 Parental Myopia

Parents with a history of myopia were categorized as:

- 0 = No myopic parent
- 1 = Either/both parents are myopic

2.4.5 Residence Type

Residence, used as a proxy for environmental exposure, was classified as:

- 0 = Chawl/Independent house
- 1 = Apartment in a building

2.4.6 Lighting Conditions

Room_Lit was classified as

- 0 = Poorly Lit
- 1 = Moderately/Adequately Lit

2.5 Data Cleaning and Pre-processing

The dataset was examined for inconsistent responses (e.g., digital_time >16 hours/day) and missing values. Inconsistent responses were identified through logical checks and excluded. Imputation was not required as there were no missing values. However, median and mode imputation methods were predefined for continuous and categorical variables, respectively, to handle missing data.

2.6 Assessment of Multicollinearity

A correlation matrix was primarily examined to:

- Identify paired relationships between variables.
- Any strong bivariate association indicative of potential multicollinearity.

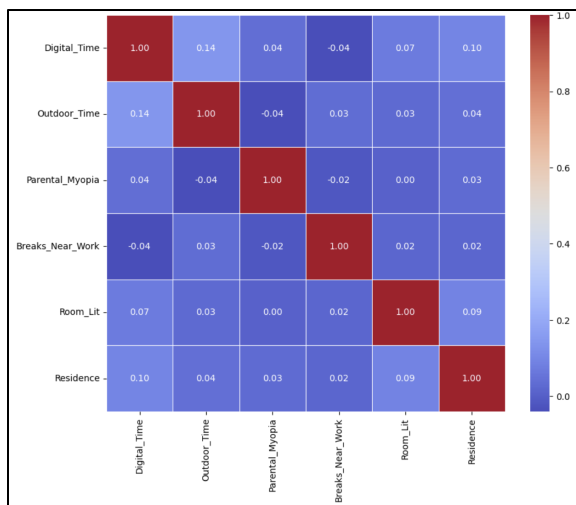

Figure 2: Correlation matrix of the predictor variables

Figure 2 illustrates that all pairwise correlations are very weak (≈ -0.04 to 0.14), confirming the absence of multicollinearity.

Subsequently, Variance Inflator Factor (VIF) analysis was performed to test multicollinearity among the predictors.

Table 1: VIF Values for predictor variables.

Feature	VIF
Digital_Time	1.03
Outdoor_Time	1.02
Parental_Myopia	1.00
Breaks_Near_Work	1.00
Adequate_Room_Light	1.01
Residence	1.02

All VIF values in Table 1 are close to 1, indicating no multicollinearity among the predictors.

2.7 Class Balancing

The dataset was imbalanced towards negative cases. To avoid bias towards the majority class, a balanced subsample was generated before building the model. Retaining all the positive instances (myopia=1), an equal number of random negative instances (myopia=0) were selected from the remaining dataset. This resulted in a 1:1 case-control ratio, enabling stable estimation of model parameters.

2.8 Statistical Analysis

Descriptive statistics were calculated for all the predictor variables. Differences between myopic and non-myopic groups were tested using:

- Mann-Whitney U test for continuous variables (Digital_Time and Outdoor_Time)
- Chi-square test for categorical variables (Parental_Myopia, Breaks_Near_Work, Room_Lit, Residence)

The primary analytical model was **Multivariable Logistic Regression** with myopia status as the dependent variable. The model included:

- Digital_Time
- Outdoor_Time
- Parental_Myopia
- Break_Frequency
- Lighting_Conditions
- Residence_Type

Adjusted Odds Ratios (aOR) with 95% Confidence Intervals (CI) were reported. Model Fitness was assessed using the Hosmer-Lemeshow test, and discrimination using Area Under the ROC Curve (AUC). The analysis is purely associational, not predictive. Performance metrics are used only to describe model behaviour and not for clinical predictions.

All analyses were conducted using Python (pandas, statsmodels, scikit-learn). Significant threshold was set at $p<0.05$.

3. Results

3.1 Participant Characteristics

1660 students were included in the final analysis. The mean age of myopia onset was 13.35±3.46 years. The overall prevalence of myopia was 29.64%, with 57.32% females, 42.48% males, and 0.20% preferred not to reveal their gender.

Table 2: Baseline characteristics of participants by myopia status

Variable	Myopic (n=492)	Non-Myopic (n=1168)	p-value
Digital_Time (Mean±sd)	4.52±1.75	4.27±1.80	0.002
Outdoor_Time (hours/day) (Mean±sd)	1.79±0.96	1.84±0.99	0.509
Parental_Myopia (%)	55.89	43.66	0.000
Breaks_Near_Work (%)	68.50	72.43	0.119
Adequate_Room_Light (%)	96.75	94.52	0.070
Residence_Type (%)	64.23	55.39	0.002

Table 2 displays the baseline environmental and lifestyle characteristics stratified by myopia status. Compared with non-myopic participants, the myopic group had significantly higher digital time and a higher prevalence of parental myopia. Residence type also significantly differed between the two groups. No notable differences were observed for outdoor time, breaks during near work, and adequate room lighting ($p>0.05$).

3.2 Myopia Severity Classification

- Low Myopia (-0.5D to -3D): 73.17% (n=360)
- Moderate Myopia (-3D to -6D): 23.78% (n=117)
- High Myopia (≤ -6D): 3.05% (n=15)

Overall, the distribution indicates a predominance of mild myopia in the dataset, with comparatively fewer cases of high myopia.

3.3 Association between Predictors and Myopia (Bivariate)

Bivariate analysis showed significant associations between myopia and digital screen time, parental myopia, and residence type ($p<0.05$). Outdoor time, breaks in near work, and adequate room lighting were not significantly associated with myopia. All predictors were retained for multivariable analysis.

3.4 Logistic Regression Results

A multivariable logistic regression model was fitted to the balanced dataset to identify independent predictors of myopia after adjusting for potential confounders. The model converged successfully and was statistically significant overall (likelihood ratio test, p=0.00075), indicating that the predictors collectively explained variation in myopia status. The model showed a pseudo R^2 of 0.021, suggesting modest explanatory power, which is typical for behavioural and epidemiological data.

Table 3: Multivariable logistic regression analysis for predictors of myopia

Predictor	β (SE)	Odds Ratio (95% CI)	p-value
Digital_Time	0.053 (0.042)	1.05 (0.97-1.14)	0.211
Outdoor_Time	-0.078 (0.073)	0.93 (0.80-1.07)	0.286
Parental_Myopia	0.464 (0.145)	1.59 (1.20-2.11)	0.001
Breaks_Near_Work	-0.185 (0.162)	0.83 (0.61-1.14)	0.254
Adequate_Room_Light	0.306 (0.374)	1.36 (0.65-2.83)	0.414
Residence_Type	0.331 (0.149)	1.39 (1.04-1.86)	0.026

Table 3 indicates that parental myopia and residence type were significantly associated with myopia. Digital time, outdoor time, breaks in near work, and room lighting were not independently significant. Sensitivity analyses using unbalanced dataset yielded similar directions of associations.

3.5 Model Performance

The model's discrimination ability was evaluated using standard classification metrics on the balanced dataset. The model achieved an overall accuracy of 63%, indicating moderate discriminative ability.

Table 4: Classification performance of the model on the balanced dataset

Class	Precision	Recall	F1-score	Support
Non-myopic (0)	0.62	0.66	0.64	99
Myopic (1)	0.63	0.60	0.62	98
Accuracy			0.63	197

Macro_Average	0.63	0.63	0.63	197
Weighted_Average	0.63	0.63	0.63	197

Model metrics summarized in Table 4 demonstrate comparable precision, recall and F1-scores across both classes, indicating balanced classification performance.

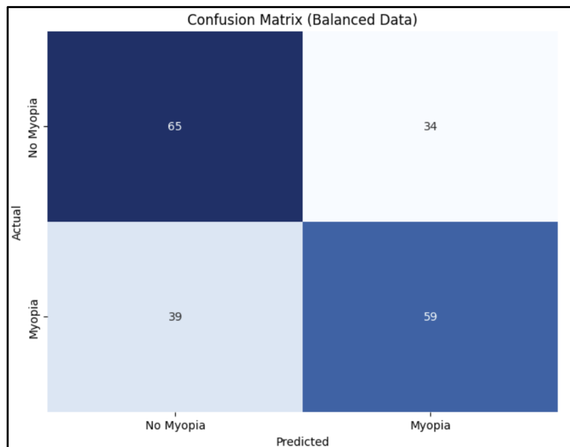

Figure 3: Confusion matrix of the model on the balanced dataset

The confusion matrix in Figure 3 demonstrated a reasonable symmetric distribution of correct and incorrect classifications across both classes.

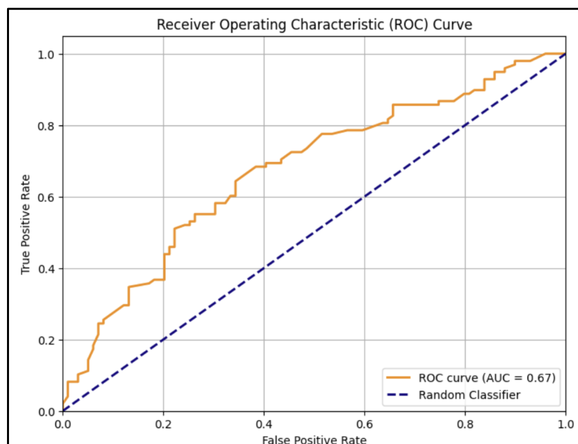

Figure 4: ROC Curve for the model

The ROC curve in Figure 4 indicated moderate discriminative ability, while the Hosmer-Lemeshow test suggested good agreement between observed and predicted outcomes (χ^2=0.81, df=3, p-value=0.846).

4. Discussion

This study examined the relationships among behavioural, environmental, and genetic factors and myopia among Mumbai's youth using a multivariable epidemiological method. The objective of the study was to identify associations between various factors and myopia, rather than building a predictive diagnostic model. The findings underscore that myopia is multifactorial. After adjustment for probable confounders, parental myopia and residence type were found to be significant independent determinants.

The correlation between parental myopia and myopia observed in earlier studies in participants [17, 18] affirms that genetics plays a key role in refractive development. The association remained intact after adjustment for behavioural and environmental factors, indicating that genetics may have an independent influence on myopia risk. This finding is consistent with prior evidence of strong aggregation between heredity and myopia [19] and reinforces the importance of considering family history when assessing individual susceptibility.

Residence type may represent differences in living environments, access to outdoor spaces, or urbanization-oriented factors that affect near-work intensity and exposure to natural light. Similar relationships between residential environment and myopia prevalence have been reported in prior studies [20], supporting the importance of environmental factors in understanding visual health outcomes.

Digital time showed a significant association with myopia in bivariate analysis. However, the relationship did not persist after multivariate adjustment. This attenuation likely reflects shared variance between digital time and other urban lifestyle factors, particularly residence type, which captures broader environmental and behavioural contexts such as housing density, access to outdoor space and daily activity patterns. The weak association after adjustment is consistent with findings of several prior studies indicating that digital use may not independently predict myopia [21, 22, 23, 24]. Instead, screen exposure may work in combination with other behavioural or environmental factors rather than as an independent determinant. Self-reported data on screen exposure may have led to measurement error, reducing the apparent independent association of digital time in multivariate analysis.

Similarly, a protective, but less significant correlation was observed between outdoor time and breaks during near work and myopia in the adjusted model. Previous studies have reported protective effects of increased outdoor exposure [19] and regular breaks [18, 22, 26, 27]. The lack of statistical significance in the present study may be due to reliance on self-reported data or contextual variations in an urban environment. The

possible protective role cannot be ruled out with a weak association. Instead, the effects may be more indirect. Likewise, unlike findings of prior research [28], adequate room lighting did not show an independent association, suggesting that its effect may be modest.

The model's explanatory power and discriminative ability were moderate but meaningful. This level of performance is consistent with epidemiological models aimed at identifying associations rather than making precise individual-level predictions, particularly when based on self-reported behavioural and environmental data [29, 30]. The results indicate that no single factor can be attributed to myopia risk. Behavioural, environmental, and genetic factors together play a decisive role, which is difficult to measure in cross-sectional studies. The dataset was balanced to stabilize coefficient estimation rather than to generate predictive probabilities. The findings should therefore be interpreted as population-level associations rather than clinical predictions.

Considering the public health viewpoint, management strategies should focus on a multimodal approach that integrates behavioural, environmental, and genetic factors rather than focusing on a single factor. The observed association of myopia with genetics and residence type signals the need for early screening, particularly for students living in dense urban environments. School-based vision screening programs could facilitate early detection and management. Urban planning and school policies that encourage outdoor activities may further contribute to long-term preventive efforts.

Despite these findings, it is important to acknowledge the limitations. The use of convenience sampling may limit the generalizability of the results, as the sample may not be representative of the diverse lifestyles and socioeconomic backgrounds of Mumbai youth. Causal conclusions are limited by the cross-sectional design. Self-reported data is always subject to recall bias. The balanced dataset changes the natural prevalence of myopia, and thus, the predicted probabilities cannot be directly interpreted. However, the associations between predictors and myopia remain significant. Sensitivity analyses using unbalanced dataset showed similar directional effects. Class balancing was applied to stabilize coefficient estimation and prevent the dominance of the majority class. The moderate model discrimination also indicates that myopia may be influenced by factors that have not been considered in this study. Further longitudinal studies using objective measurements are needed to clarify causal relationships.

5. Conclusion

This study shows that parental myopia and residence type are important independent factors associated with myopia onset. Digital time, outdoor time, breaks from near work, and room lighting did not portray a significant impact on myopia risk. The model demonstrated moderate discriminative ability with good calibration. This indicates that myopia is multifactorial. The results highlight the importance of genetic and environmental factors in myopia research. To better understand the causal associations, longitudinal studies along with objective exposure measures are necessary.

6. Ethics Statement

The authors used AI tools only for editorial support, such as enhancing the manuscript's readability and clarity. The authors take full responsibility for the content and have performed all analyses, interpretations, and scientific conclusions without the use of AI systems.

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