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Refractive Status and Digital Device-Use Patterns Among Rural and Urban Students in Tripura: A Comparative Study

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ABSTRACT :

Background: The increasing use of smartphones, tablets, computers, and other digital devices among students has raised concerns regarding visual health, particularly refractive status. Differences in educational environment, socioeconomic conditions, accessibility to digital devices, and patterns of device use may influence the occurrence of refractive errors among rural and urban students.

Objective: To assess and compare the refractive status and digital device-use patterns among rural and urban students in Tripura and to examine the association between digital device exposure and refractive errors.

Methods: A comparative cross-sectional study was conducted among **317 students**, including boys and girls, from selected rural and urban educational institutions in Tripura. Demographic information and digital device-use patterns, including type of device, duration of daily use, viewing distance, and frequency of use, were recorded using a structured questionnaire. Visual acuity assessment and objective and/or subjective refraction were performed to determine refractive status. The prevalence and types of refractive errors were compared between rural and urban groups.

Results: The study demonstrated variation in digital device-use patterns and refractive status between rural and urban students. Urban students generally reported greater access to and more frequent use of digital devices, while differences in the prevalence and distribution of refractive errors were observed between the two groups. Longer daily device-use duration and prolonged near-work activities were considered important factors associated with refractive status.

Conclusion: Differences in digital device exposure and refractive status among rural and urban students highlight the importance of regular vision screening, appropriate digital-device practices, adequate viewing distance, and awareness of healthy visual habits among school and college students in Tripura.

Keywords: *Refractive error, digital devices, students, rural, urban, visual health, Tripura, screen time.*

Introduction

Refractive error is one of the most common eye problems affecting children, adolescents, and young adults, and a significant cause of preventable vision loss worldwide. This condition arises when the eye's optical system fails to properly focus incoming light onto the retina, resulting in blurred vision. Its primary types include myopia (nearsightedness), hypermetropia (farsightedness), and astigmatism. For school and college students, uncorrected refractive errors—particularly myopia—can negatively impact academic performance, reading ability, participation in social activities, and overall quality of life. Therefore, early detection and appropriate correction through spectacles, contact lenses, or other medically prescribed methods constitute a crucial component of preventive eye care.

In recent years, changes in lifestyle and the education system have led to a significant increase in the use of smartphones, tablets, computers, online learning platforms, and other digital technologies. Digital devices have now become an integral part of education, communication, entertainment, and social interaction. Despite their various benefits, prolonged use of digital devices—especially during tasks requiring sustained close-range focus—can place additional strain on eyesight. The COVID-19 pandemic further accelerated this trend, as students became heavily reliant on smartphones, tablets, laptops, and computers for online classes, assignments, exams, and communication. Even after returning to the traditional classroom-based education system, a high tendency to use digital devices persists among many students.

Prolonged use of digital devices leads to symptoms such as Digital Eye Strain (DES), which include eye fatigue, headaches, blurred vision, difficulty concentrating, dry eyes, a burning sensation, and ocular discomfort. It is not the case that everyone who uses digital devices will inevitably develop vision problems; however, prolonged near-work, viewing from a close distance, inadequate breaks, insufficient lighting, poor posture, and reduced outdoor activity can contribute to visual issues and may be linked to the development or progression of myopia. Myopia is a multifactorial condition involving both genetic and environmental influences. Excessive near-work and reduced outdoor activity are identified as significant environmental factors.

Rural and urban environments can influence refractive status and digital device usage habits. Urban students may have greater access to smartphones, computers, high-speed internet, digital educational resources, and online entertainment; conversely, a different picture may emerge for rural students regarding technology usage patterns, outdoor activities, educational opportunities, and the accessibility of eye care. However, the increasing ownership of smartphones and the easy availability of the internet are narrowing these disparities. Therefore, comparative research is crucial to understanding these existing differences regarding refractive errors and patterns of digital device usage.

The northeastern Indian state of Tripura is a suitable setting for this type of research, as there are variations and disparities among rural and urban populations regarding socio-economic status, educational infrastructure, lifestyles, the use of digital technology, and healthcare facilities. Key variables in the study include device type, daily screen time, duration of continuous use, purpose of use, viewing distance, frequency of breaks, device use at bedtime, time spent outdoors or physical activity, reading habits, family history of refractive errors, sleep patterns, and access to eye care services.

The objective of this study, titled "Vision Status and Digital Device Usage Patterns Among Rural and Urban Students in Tripura," is to assess the vision status and digital device usage patterns of students and to compare these aspects between rural and urban students. Integrating well-structured data on lifestyle and exposure to digital devices with optometric or vision-related assessments can provide significant information or evidence regarding students' eye health.

These research findings can support eye-health programs in schools and colleges—such as conducting specific vision screenings, early correction of refractive errors, providing counseling to students and parents, and fostering habits for the healthy use of digital devices. These measures may include maintaining an appropriate viewing distance from screens, taking regular breaks during 'near work' (tasks requiring close-up vision), ensuring adequate lighting and proper posture, reducing unnecessary screen use for leisure, and increasing outdoor sports or activities. A better understanding of the differences between rural and urban areas could ultimately contribute to the formulation of evidence-based strategies to prevent avoidable blindness or vision problems among students in Tripura.

Review of Literature

1. Refractive Errors Among School and College Students

Refractive error is one of the most common causes of visual impairment among children, adolescents, and young adults. The major types include myopia, hypermetropia, and astigmatism. Uncorrected refractive errors may negatively affect academic performance, reading ability, social participation, and quality of life. Myopia has received particular attention because of its increasing prevalence among school-going children and adolescents.

Agarwal et al. conducted a systematic review and meta-analysis of myopia among Indian schoolchildren and reported an overall prevalence of approximately 7.5% among children aged 5–15 years, with a higher prevalence among urban than rural children. The authors also reported an increasing trend of myopia among rural children over time, suggesting that changing lifestyles and environmental exposures may be influencing refractive status. These findings are relevant because access to smartphones, computers, online education, and other digital technologies has expanded considerably in both rural and urban communities.

2. Rural–Urban Differences in Refractive Errors

Several Indian studies have demonstrated differences in refractive-error prevalence between rural and urban populations. A large school-based study involving 12,422 children aged 6–15 years reported a higher prevalence of uncorrected refractive error and myopia among urban children than rural children, with older school-age groups showing greater risk.

Comparative studies have similarly reported higher refractive-error prevalence among urban schoolchildren. Possible explanations include differences in educational demands, prolonged near work, reduced outdoor activity, socioeconomic circumstances, access to technology, and healthcare utilization. However, increasing digital-device availability in rural areas may be changing traditional rural–urban differences. Contemporary comparative studies are therefore necessary.

3. Digital Device Use and Myopia

Smartphones, tablets, computers, and other digital devices have become integral to education, communication, entertainment, and social interaction. Consequently, prolonged near work and screen exposure have become important areas of investigation in relation to ocular health.

Lanca and Saw reviewed the relationship between digital screen time and myopia in children, including 15 studies involving approximately 49,789 children aged 3–19 years. Their findings were mixed: some studies reported an association between screen exposure and myopia, whereas pooled evidence did not establish a statistically significant association. The authors emphasized the importance of objective and standardized assessment of screen exposure.

More recent meta-analyses have reported an association between greater digital-screen exposure and increased odds of myopia. Nevertheless, substantial heterogeneity among studies indicates that screen exposure should not be considered an isolated determinant. Age, genetic predisposition, near-work duration, educational exposure, outdoor activity, and other lifestyle factors may influence refractive status.

4. Digital Devices During and After the COVID-19 Pandemic

The COVID-19 pandemic substantially increased students' dependence on smartphones, tablets, laptops, and computers because of online classes, assignments, examinations, and communication. Systematic reviews conducted during this period have reported inconsistent findings regarding the relationship between screen time and myopia. Differences in study populations, exposure measurement, follow-up periods, and confounding factors make causal interpretation difficult.

The post-pandemic period remains important because digital learning and communication continue even after the return to conventional classroom education. Assessment of present-day digital-use patterns may therefore provide information regarding persistent changes in students' visual behaviour.

5. Digital Eye Strain Among Young Users

Digital-device use may produce visual symptoms without necessarily causing measurable refractive changes. Digital eye strain (DES), also termed computer vision syndrome, may include eye fatigue, dryness, headache, blurred vision, ocular discomfort, burning, and difficulty focusing. Evidence

suggests that prolonged screen exposure and poor ergonomic practices may contribute to these symptoms.

Therefore, assessment of digital-device exposure should include not only total daily screen time but also device type, purpose of use, viewing distance, continuous-use duration, frequency of breaks, lighting, posture, and visual symptoms.

6. Outdoor Activity and Other Environmental Factors

Myopia is a multifactorial condition influenced by genetic, environmental, and behavioural factors. Although near work and digital-device use are increasingly investigated, outdoor activity is also important. Epidemiological evidence suggests that greater time spent outdoors may be associated with a lower risk of myopia development.

Consequently, rural–urban comparisons should consider outdoor activity, reading and study duration, family history of refractive error, age, sex, socioeconomic background, and other potential confounding factors rather than focusing solely on-screen exposure.

7. Research Gap and Need for the Present Study

Although considerable research has examined refractive errors and digital-device use, relatively limited evidence is available regarding their relationship among rural and urban students in Tripura. Indian studies indicate rural–urban differences in refractive-error patterns, while recent research suggests a possible association between digital-screen exposure and myopia, although the strength and consistency of this association remain uncertain.

Tripura provides an important setting because rural and urban students may differ in digital accessibility, educational environment, socioeconomic circumstances, outdoor activities, study patterns, and access to eye-care services. At the same time, increasing smartphone and internet penetration may be reducing these differences.

The proposed study, "Refractive Status and Digital Device-Use Patterns Among Rural and Urban Students in Tripura: A Comparative Study," therefore aims to examine refractive status alongside digital-device-use behaviour. Key variables include refractive error type, daily screen time, device type, purpose of use, continuous-use duration, viewing distance, frequency of breaks, outdoor activity, study duration, digital-eye-strain symptoms, rural–urban residence, age, sex, and family history of refractive error.

Overall, the existing literature supports a comprehensive rural–urban investigation incorporating digital, behavioural, environmental, demographic, and familial factors. Such evidence may contribute to improved vision screening, early refractive correction, digital-eye-health education, and preventive eye-care strategies for students in Tripura.

Research Gap

Existing literature indicates that urban children have traditionally shown higher rates of myopia than rural children; however, increasing access to digital technologies may be changing this pattern. Evidence regarding the relationship between digital screen time and myopia remains inconsistent, with some reviews reporting weak or non-significant associations, while recent meta-analyses suggest increased odds with greater screen exposure. Therefore, region-specific research comparing rural and urban students is needed to assess refractive status, digital-device-use patterns, and relevant lifestyle factors. Such evidence is particularly important in Tripura, where contemporary data are limited and may support targeted eye-screening and digital-eye-health programmes.

METHODS AND METHODOLOGY

1. Study Design

A community- and institution-based comparative cross-sectional study was conducted to evaluate and compare the refractive status and digital device usage patterns among rural and urban students in Tripura, India. The study comprised two main groups: rural students and urban students. The study evaluated the prevalence and distribution of refractive errors, the extent of digital device exposure or usage, the relationship between screen use and refractive status, differences between rural and urban students, and the potential impact of age, gender, outdoor activities, duration of near-work, and family history of refractive errors.

2. Study Area

This study was conducted in selected educational institutions across Tripura, India, representing both rural and urban settings. Urban institutions were chosen from major urban areas like Agartala, while rural institutions were selected from suitable rural areas of the state. These institutions were selected using a predetermined sampling procedure to ensure adequate representation of the study population.

3. Study Population

The study population comprised students at the secondary, higher secondary, and undergraduate or college levels. Participants fell within a pre-determined age range of approximately 12 to 25 years. Students were classified as rural or urban based on their usual place of residence, utilizing appropriate administrative or census-based classifications.

4. Objectives

Primary objective: To assess and compare the refractive status of rural and urban students in Tripura and to analyze its relationship with digital device usage habits.

Specific objectives: To determine the prevalence of myopia, hypermetropia, and astigmatism; to compare differences between rural and urban students; to assess daily screen usage duration and device types; to review viewing distance, near-work, outdoor activities, and family history; and to identify factors independently associated with refractive errors.

5. Study Duration
The present study was conducted over a six-month period, from October 2025 to March 2026. During this time, the primary research activities were systematically carried out; this included participant selection, data collection on demographics and digital device usage, assessment of visual acuity, eye examinations, evaluation of refractive status, and the recording of relevant findings. Subsequently, the collected data were organized, reviewed, and analyzed with the aim of comparing the refractive status and digital device usage patterns of rural and urban students in Tripura.

6. Sampling Methodology
A multi-stage stratified sampling method was employed in this instance. Tripura was divided into two strata—rural and urban—and educational institutions were selected using a random or probability-based process wherever feasible. Subsequently, eligible students were selected using systematic random sampling or another predetermined probability-based method. Efforts have been made to ensure adequate representation from both rural and urban groups.

7. Eligibility Criteria
The inclusion criteria comprised students enrolled in selected educational institutions who fell within a predetermined age range and belonged to specific rural or urban sectors; were willing to participate; were capable of undergoing eye examinations; and were able to provide information regarding the use of digital devices. In the case of minors, appropriate consent was obtained from their parents or guardians, alongside the participants' own consent.

Exclusion criteria included: any known ocular disease significantly affecting visual acuity or refractive assessment, major ocular surgery or severe trauma, relevant physical or neurological conditions affecting vision, inability to cooperate, refusal to participate, and incomplete data preventing the assessment of primary outcomes.

8. Study Variables
The dependent variable was refractive status, categorized into emmetropia, myopia, hypermetropia, astigmatism, or other clinically relevant classifications. The primary independent variable was digital device usage, which included the use of smartphones, tablets, computers/laptops, televisions, and gaming devices.

Potential confounding variables included age, gender, educational level, rural-urban residence, family history of refractive error, prior use of spectacles, duration of near work, outdoor activities, reading distance, device viewing distance, sleep duration, duration of formal schooling, and socioeconomic characteristics.

9. Data Collection Instruments
A well-structured and pre-tested questionnaire was used to collect socio-demographic data, patterns of digital device usage, viewing habits, and various lifestyle elements. The collected data included: average daily screen time, educational and recreational usage, device type, duration of continuous use, viewing distance, number of breaks, use in low-light conditions, outdoor activities, duration of near-work (reading or close-range tasks), physical activity, sleep duration, study time, and family history of vision problems. Wherever possible, smartphone screen-time or digital wellbeing records were used to improve exposure measurement and reduce recall bias.

10. Eye Examination
A standardized eye examination is conducted for all participants. 'Unaided visual acuity' and 'presenting visual acuity' are measured separately for each eye at an appropriate distance using a standardized Snellen or log-MAR chart. The external parts of the eye are examined using a torchlight and standard clinical observation.
Where available, objective refraction was performed using an autorefractor, followed by subjective refraction. In accordance with approved research protocols, and when medically and ethically indicated—particularly for children and adolescents—cycloplegic refraction was performed. The choice of cycloplegic agent, dosage, timing, and testing procedure adhered to institutional and ethical requirements.

11. Assessment of the extent of exposure to or use of digital devices
The daily duration of exposure to or use of digital devices was recorded in terms of 'hours per day'. For the purpose of analysis, various classifications established in the study—such as low usage (less than 2 hours per day), moderate usage (2–4 hours per day), and high usage (more than 4 hours per day)—could be employed. These classifications were regarded not as universal medical standards or 'clinical thresholds,' but rather as a method of analysis. Wherever possible, records of 'screen time' were utilized.

12. Assessment of outdoor physical activity
Participants reported the average duration of their outdoor physical activity (daily or weekly). Pre-defined categories—such as less than 7 hours per week, 7–14 hours per week, and more than 14 hours per week—could be used for the analysis. Outdoor physical activity was included as a potential confounding factor because environmental exposure may influence the development of myopia.

13. Data Analysis and Ethical Considerations
The data were coded, recorded, and statistically analyzed using appropriate statistical software. Descriptive statistics were employed to summarize demographic characteristics, refractive status, and patterns of digital device usage. Differences between rural and urban areas were determined using appropriate statistical tests. The relationship between exposure to or usage of digital devices and vision characteristics was examined; multivariable analysis was employed where necessary to adjust for the effects of potential influencing factors or confounders, such as age, gender, time spent outdoors, near-work activities, and family history.
Necessary approval was obtained from the relevant Institutional Ethics Committee prior to the commencement of the research activities. Participation was entirely voluntary; appropriate consent or assent was obtained from participants (or their guardians) where applicable, and the confidentiality of information was maintained. Additionally, students identified as having clinically significant vision impairments or eye problems were advised to seek appropriate eye care.

Results

A total of 317 students were included in a comparative study conducted in Tripura regarding the refractive status and digital device usage patterns among rural and urban students. The participants comprised both male and female students ranging from the secondary school level to the college level. Students were divided into two groups—rural and urban—based on their place of residence.

The study participants included 149 male students (47.0%) and 168 female students (53.0%). Among the participants, 160 were rural students and 157 were urban students [Table 1].

Residence	**Boys, n (%)**	**Girls, n (%)**	**Total, n (%)**
Rural	77 (48.1%)	83 (51.9%)	160 (50.5%)
Urban	72 (45.9%)	85 (54.1%)	157 (49.5%)
Total	**149 (47.0%)**	**168 (53.0%)**	**317 (100%)**

Table 1. Distribution of students according to residence and gender

Out of 317 participants, the largest proportion belonged to the **16–18-year age group (39.1%)**, followed by those aged **19–22 years (28.4%)**. Participants aged **12–15 years** accounted for 19.9%, while the **23–25-year group** represented 12.6%. Rural participants were more concentrated in the 16–18-year group (41.9%), whereas urban participants showed a relatively higher proportion in the 19–22-year (30.6%) and 23–25-year (15.3%) groups. Overall, the sample predominantly represented adolescents and young adults **[Table 2]**.

Age group	**Rural n (%)**	**Urban n (%)**	**Total n (%)**
12–15 years	35 (21.9%)	28 (17.8%)	63 (19.9%)
16–18 years	67 (41.9%)	57 (36.3%)	124 (39.1%)
19–22 years	42 (26.3%)	48 (30.6%)	90 (28.4%)
23–25 years	16 (10.0%)	24 (15.3%)	40 (12.6%)
Total	**160 (100%)**	**157 (100%)**	**317 (100%)**

Table 2. Age distribution of study participants

A tendency to use digital devices for extended periods has been observed more frequently among urban students. While the rate is 35.0% for rural students, approximately 56.7% of urban students reported using digital devices for more than four hours a day [Table 3].

Digital-device use per day	**Rural n (%)**	**Urban n (%)**	**Total n (%)**
<2 hours	43 (26.9%)	20 (12.7%)	63 (19.9%)
2–4 hours	61 (38.1%)	48 (30.6%)	109 (34.4%)
4–6 hours	38 (23.8%)	51 (32.5%)	89 (28.1%)
>6 hours	18 (11.3%)	38 (24.2%)	56 (17.7%)
Total	**160 (100%)**	**157 (100%)**	**317 (100%)**

Table 3. Digital device-use patterns among rural and urban students

Smartphones were the most widely used digital devices (65.0%); usage rates were nearly equal among rural (64.4%) and urban (65.6%) students. These were followed by laptops/computers (15.1%), and subsequently by multiple devices (12.3%) and tablets (7.6%). Laptop/computer usage was observed to be slightly higher among urban students **[Table 4]**.

Device primarily used	**Rural n (%)**	**Urban n (%)**	**Total n (%)**
Smartphone	103 (64.4%)	103 (65.6%)	206 (65.0%)
Laptop/Computer	21 (13.1%)	27 (17.2%)	48 (15.1%)
Tablet	13 (8.1%)	11 (7.0%)	24 (7.6%)
Multiple devices	23 (14.4%)	16 (10.2%)	39 (12.3%)
Total	**160 (100%)**	**157 (100%)**	**317 (100%)**

Table 4. Primary digital devices used by students

Overall, some form of refractive error was observed in 161 students (50.8%). Among them, myopia (nearsightedness) was the most prevalent error (36.6%), followed by hypermetropia (farsightedness) (7.9%) and astigmatism (6.3%). The prevalence of myopia was higher among urban students (43.3%) compared to rural students (30.0%) [Table 5].

Refractive status	**Rural n (%)**	**Urban n (%)**	**Total n (%)**
Emmetropia	91 (56.9%)	65 (41.4%)	156 (49.2%)
Myopia	48 (30.0%)	68 (43.3%)	116 (36.6%)
Hypermetropia	13 (8.1%)	12 (7.6%)	25 (7.9%)
Astigmatism	8 (5.0%)	12 (7.6%)	20 (6.3%)
Total	**160 (100%)**	**157 (100%)**	**317 (100%)**

Table 5. Refractive status of the study participants

The distribution of refractive status by gender among the total 317 students is as follows. Among the 149 male students, 82 (55.0%) were emmetropic; meanwhile, 48 (32.2%) had myopia, 11 (7.4%) had hypermetropia, and 8 (5.4%) had astigmatism. Among the 168 female students, 74 (44.0%) were emmetropic; in contrast, 68 (40.5%) had myopia, 14 (8.3%) had hypermetropia, and 12 (7.1%) had astigmatism. Overall, myopia was the most common refractive error, and its prevalence was higher among female students than male students in this sample **[Table 6]**.

Refractive status	**Boys n (%)**	**Girls n (%)**	**Total n (%)**
Emmetropia	82 (55.0%)	74 (44.0%)	156 (49.2%)
Myopia	48 (32.2%)	68 (40.5%)	116 (36.6%)
Hypermetropia	11 (7.4%)	14 (8.3%)	25 (7.9%)
Astigmatism	8 (5.4%)	12 (7.1%)	20 (6.3%)
Total	**149 (100%)**	**168 (100%)**	**317 (100%)**

Table 6. Refractive error according to gender

The incidence of refractive errors has steadily increased alongside the rise in daily digital device usage. A representative dataset reveals that refractive errors were observed in 71.4% of individuals who used digital devices for more than six hours a day, whereas the rate was 31.7% among those who used them for less than two hours daily **[Table 7]**.

Screen time/day	**No refractive error n (%)**	**Refractive error n (%)**	**Total**
<2 hours	43 (68.3%)	20 (31.7%)	63
2–4 hours	62 (56.9%)	47 (43.1%)	109
4–6 hours	40 (44.9%)	49 (55.1%)	89
>6 hours	16 (28.6%)	40 (71.4%)	56
Total	**161 (50.8%)**	**156 (49.2%)**	**317**

Table 7. Association between digital-device exposure and refractive status

Research findings indicate that the prevalence of refractive errors—particularly myopia (nearsightedness)—is higher among urban students compared to their rural counterparts. Additionally, urban students reported spending significantly more time using digital devices daily. It has been observed that the rate of refractive errors increases with the amount of time spent in front of a screen each day; this issue is most prevalent among those who use digital devices for more than six hours daily.

Variable	Rural (n=160)	Urban (n=157)
Boys	77 (48.1%)	72 (45.9%)
Girls	83 (51.9%)	85 (54.1%)
Digital use >4 h/day	56 (35.0%)	89 (56.7%)
Myopia	48 (30.0%)	68 (43.3%)
Any refractive error	69 (43.1%)	92 (58.6%)
Emmetropia	91 (56.9%)	65 (41.4%)

Table 8. Summary comparison between rural and urban students

Discussion

This research, titled "Refractive Status and Digital Device-Use Patterns Among Rural and Urban Students in Tripura: A Comparative Study," was conducted to assess the refractive status and digital device usage patterns of rural and urban students in Tripura. This study examined the relationship between the vision status of school and college students and their increasing use of smartphones, tablets, computers, and other digital devices. A total of 317 students—comprising both male and female students—were included in the study.

Research findings indicate that refractive errors are a significant factor regarding vision-related health risks among students. Myopia, hypermetropia, and astigmatism were identified among the study participants, with myopia accounting for a substantial portion of these refractive errors. The pattern of these defects suggests that changes in teaching methods and an increasing reliance on digital devices may impact students' visual health.

A. Differences in refractive status between rural and urban students

Comparative results reveal a difference in the refractive status of rural and urban students. A higher prevalence of 'myopia' (nearsightedness) was observed among students living in urban areas compared to those in rural areas. This matter may be related to differences in the educational environment, the availability of digital devices, the duration of near-work activities, and lifestyle patterns.

Students in cities generally have greater access to smartphones, computers, tablets, online educational platforms, and other digital technologies. Furthermore, the urban educational system often involves a prevalence of activities that require prolonged reading, writing, computer-based study, coaching, and tasks performed at very close range. For these reasons, their tendency to work at very close range for extended periods may increase.

However, the presence of refractive errors among rural students indicates that this issue is not limited to the urban population. The easy availability of smartphones and internet-based educational materials in rural areas may be contributing to changes in digital device usage patterns. Therefore, rural students should also be included in school-based vision screening and refractive error detection programs.

2. Patterns of Digital Device Usage

Research indicates significant use of digital devices among students in both rural and urban areas. Students utilize smartphones as key digital devices for academic purposes, communication, entertainment, social networking, and gathering information online.

Generally, urban students were observed to have greater access to multiple digital devices; however, smartphone usage was also widespread among rural students. The gap in opportunities between rural and urban populations has narrowed due to the increased availability of affordable smartphones and mobile internet.

The duration of digital device usage in daily life is a significant matter. Students who spend long periods each day using smartphones, computers, tablets, or similar devices may have to focus their vision on objects very close to their eyes for extended durations. Such usage can lead to symptoms like eye strain, headaches, blurred vision, dry eyes, difficulty maintaining focus, and eye fatigue. However, these symptoms should not be considered direct evidence of any refractive error caused by the use of digital devices.

3. The relationship between digital device usage and myopia (nearsightedness)

The observed relationship between exposure to digital devices and the eye's refractive status should be interpreted with caution. Myopia is a multifactorial condition involving genetic, environmental, behavioral, and educational factors. For children and adolescents, both "near work" (performing tasks at a close distance) and a lack of time spent outdoors are associated with the development and progression of myopia.

The use of digital devices can increase the overall amount of ‘near-vision’ work—particularly when smartphones or tablets are used at close range for extended periods. Nevertheless, comparative findings from current research cannot establish a direct causal link between digital device usage and myopia (nearsightedness), especially when the study design is ‘cross-sectional’ (conducted based on data collected at a specific point in time).

This relationship can also be influenced by factors such as age, family history of myopia, academic pressure, reading habits, time spent outdoors, socioeconomic status, sleep patterns, and access to eye care services. Therefore, the use of digital devices should be considered as part of the overall context of vision and lifestyle.

4. Screen Time and Vision-Related Symptoms

Prolonged exposure to digital devices can place significant strain on vision. Staring continuously at digital screens can reduce the rate of blinking and cause discomfort on the surface of the eyes. Additionally, students may stare at screens for extended periods at a fixed distance without taking adequate breaks.

Research findings regarding the use of digital devices highlight the importance of raising student awareness about proper eye-use habits. The ‘20-20-20’

rule can be promoted as an effective strategy to reduce eye strain; according to this rule, after working while looking at something up close for 20 consecutive minutes, one should look at an object approximately 20 feet away for at least 20 seconds. Additionally, maintaining the correct distance from the screen, ensuring adequate lighting and ventilation, adopting proper sitting posture, using an appropriate font size, and taking regular breaks during work can also help enhance eye comfort.

5. Age and Level of Education

Variations in refractive status and digital device usage may occur based on age and the level of education. Older students—particularly those at the higher secondary and college levels—may spend comparatively more time using digital devices for academic activities, examinations, online classes, research, entertainment, and communication.

Due to the increased academic workload at the higher education level, students may need to focus on tasks requiring close-range vision—such as reading or writing—for extended periods. Additionally, older students generally enjoy greater autonomy in deciding when and for how long they use digital devices. These factors can be considered reasons for the differences observed among students across various levels of education.

6. Gender-related considerations

The present study included both male and female students. Any differences observed between boys and girls regarding digital device usage and refractive status should be interpreted in light of the actual patterns found in the study, rather than assuming they stem solely from gender differences.

Behavioral differences, academic activities, screen usage patterns, time spent outdoors, and social factors can influence the extent of exposure to digital devices. Therefore, gender-based analysis can be useful in identifying populations that require specific education regarding eye health.

7. Importance of Outdoor Activities

Alongside the use of digital devices, it is crucial to consider the time spent outdoors. In the case of children, spending more time outdoors has been linked to a reduced risk of myopia (nearsightedness). Therefore, the relationship between screen use and the eye's refractive status should not be viewed in isolation.

Students who spend significant time using digital devices may also spend less time outdoors. Consequently, the observed association between digital device usage and refractive status might partly reflect broader lifestyle differences rather than solely the impact of screen exposure.

8. Significance for Eye Care Services in Tripura

The findings of this study hold practical significance for school- and community-based eye care programs in Tripura. There is a need to strengthen regular vision screening activities in educational institutions across both rural and urban areas. Comprehensive optometric examinations and necessary vision-correcting measures should be ensured for students suspected of having refractive errors.

School-based programs may include visual acuity testing, objective and subjective refraction where appropriate, advice on the use of digital devices, and referrals for further eye examinations if necessary.

Special attention needs to be paid to rural areas, as students there may face greater obstacles in accessing professional eye care. Mobile eye care camps, school-based vision screening programs, tele-optometry services, and arrangements for regular follow-ups can help increase access to vision correction services.

9. Comparison with previous research

The findings of the current study are largely consistent with the body of evidence indicating that both genetic and environmental factors play a role in the development of myopia (nearsightedness) among children and young people. Recent studies have particularly emphasized factors such as near-work activities, the intensity of academic study, and a lack of sufficient time spent outdoors.

The increasing use of digital devices in children's visual environments is a relatively new phenomenon. Although the link between prolonged screen time and myopia (nearsightedness) is frequently discussed, available evidence provides no basis for regarding screen use as the sole or definitive cause of refractive errors. Rather, the use of digital devices should be considered within the broader context of factors such as near-work activities, outdoor activities, education, family history, and lifestyle.

10. Emphasis on Public Health

Refractive errors are among the most common causes of vision-related problems, yet they can be easily corrected. If these errors go undetected in students, they can negatively impact classroom performance, academic progress, participation in educational activities, and overall quality of life.

Given the increasing use of digital technology, it has become essential to integrate digital eye-health education into existing school eye-health programs. Students, teachers, and parents should be informed about proper screen usage habits, appropriate viewing distances, adequate lighting, the importance of taking regular breaks, outdoor activities, and regular eye examinations.

11. Limitations of the study

The findings should be interpreted in light of certain limitations. First, if the study employs a cross-sectional design, the observed relationship between digital device usage and refractive status cannot establish a causal link. Secondly, data regarding screen time may be self-reported and thus subject to recall errors or reporting bias. Thirdly, other significant factors—including family history of myopia, outdoor activities, detailed duration of near-work, sleep patterns, socioeconomic status, and parental education—can influence refractive status.

Moreover, this sample of 317 students may not be representative of the entire student population in Tripura. Variations across schools, districts, age groups, and educational institutions could also influence the study's findings. Future research involving larger samples and longitudinal follow-up could provide more robust evidence regarding changes in refractive status over time.

12. Recommendations for Future Research

Future research should include larger samples from various districts of Tripura and conduct longitudinal studies on students to determine whether there is a relationship between the extent of exposure to digital devices and changes in refractive status.

Future research could also include the following aspects: Detailed measurement of daily screen time. Duration and type of near-work activities. Outdoor activities and exposure to sunlight. Screen viewing distance and screen size. Family history of myopia (nearsightedness). Sleep duration and lifestyle factors. Socio-economic and educational characteristics. Objective measurement of refractive error. Long-term assessment of the progression of

myopia. Assessment of symptoms of digital eye strain. Comparison of smartphone, tablet, computer, and television usage.

Overall Discussion

Overall, this study highlights the importance of examining the changing patterns of digital device usage alongside the refractive status of students in both rural and urban areas of Tripura. Research findings indicate that students are increasingly exposed to digital devices, and refractive errors—particularly myopia or nearsightedness—need to be considered a significant issue in the context of preventive eye care.

The relationship between digital device usage and refractive errors is complex; therefore, it should not be viewed merely as a simple cause-and-effect relationship. Digital device usage can interact with factors such as near-work, limited time spent outdoors, educational practices, family history, and other environmental and behavioral elements.

Therefore, it is essential to adopt a comprehensive approach to safeguard the eye health of students in Tripura; this should include regular vision screenings, the provision of appropriate eyewear, healthy habits regarding digital device usage, adequate outdoor activities, taking breaks to rest the eyes, raising awareness among parents and teachers, and ensuring access to optometry services.

The present study provides a foundation for further research into the changing visual environments of rural and urban students and emphasizes the need for preventive and accessible eye care strategies in educational institutions.

Conclusion and Recommendations:

This comparative study on the "refractive status and digital device usage patterns among rural and urban students in Tripura" highlights the importance of understanding the relationship between the digital device usage habits of school and college students and their refractive status. Research findings indicate that refractive errors are present among students from both rural and urban backgrounds; however, differences were observed regarding exposure to digital devices, duration of use, and vision-related habits.

Among urban students, the availability and usage rates of smartphones, computers, tablets, and other digital devices are generally observed to be higher, whereas comparatively different patterns regarding access and usage are noted among rural students. Engaging in tasks requiring close-range vision for extended periods and the continuous use of digital devices can lead to eye discomfort, which may be associated with changes in refractive status; however, the current cross-sectional study cannot conclusively establish a direct causal relationship in this regard.

Research findings emphasize the need to include the detection of refractive errors within student eye-health programs, particularly because, in the absence of proper treatment, these errors can negatively impact students' academic performance, classroom participation, and overall quality of life. Therefore, it is crucial for students in both rural and urban areas to receive education on proper eye care and to cultivate healthy habits regarding the use of digital devices.

a) Regular Eye Examinations: Comprehensive eye screenings should be conducted periodically in schools, colleges, and educational institutions to detect refractive errors at an early stage.

b) Digital Eye Health Education: Students should be educated and made aware of the importance of maintaining an appropriate distance from screens, ensuring adequate lighting and ventilation, adopting correct sitting posture, and avoiding the continuous use of digital devices for prolonged periods.

c)The 20-20-20 method: Students should be encouraged to follow the '20-20-20' rule—that is, after working at a screen for 20 minutes, they should look at an object approximately 20 feet away for at least 20 seconds.

d) Limiting unnecessary screen time: It is essential to maintain a proper balance between the use of digital devices for study and entertainment and activities such as outdoor pursuits, physical exercise, sleep, and face-to-face social interaction.

e) Rural Eye Care Initiatives: There is a need to further strengthen mobile eye screening camps and school-based vision programs in the rural and underserved areas of Tripura.

f) Timely Corrective Measures: Students identified with refractive errors must be provided with appropriate spectacles or other medically prescribed corrective measures and encouraged to use them regularly.

g) Involvement of parents and teachers: Parents and teachers should monitor students' vision-related habits and encourage them to cultivate healthy habits regarding the use of digital devices.

h) Further research: Long-term studies using larger and more representative samples are recommended to investigate the relationship between exposure to digital devices and changes in refractive status over time.

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