

Reconfiguring Digital Eye Strain in School-Aged Adolescents: A Systematic Review of Risk Ecologies and Preventive Practices with Insights from Unakoti District, Tripura

¹Mousumi Bhattacharjee and ²Dr. Kuldeep Singh Gurjar

¹Research Scholar, Institute of Nursing and Para Medical Science, Mangalayatan University, Aligarh, (U.P)

²Supervisor, Institute of Nursing and Para Medical Science, Mangalayatan University, Aligarh, (U.P)

Received: 16th Dec, 2025; Revised: 8th Feb 2026; Accepted: 24th Feb, 2026; Available Online: 30th March, 2026

ABSTRACT

In the quiet routines of contemporary schooling, where learning increasingly unfolds through glowing screens, digital eye strain has emerged as a subtle yet deeply felt dimension of adolescent life. For school aged learners, visual fatigue is no longer an isolated clinical symptom but an embodied experience shaped by prolonged attention, constrained postures, and digitally mediated academic expectations. This systematic review rethinks digital eye strain through the lens of risk ecologies, situating visual discomfort within a web of interdependent factors that include screen practices, ergonomic conditions, and the social and material environments of learning. The review maps the evolving landscape of digital eye strain by examining its prevalence, underlying determinants, and everyday preventive practices. Particular attention is given to how adolescents interpret and manage visual strain in their daily routines, where practices such as ocular exercises, screen breaks, and adaptive visual habits are not merely prescribed interventions but lived strategies negotiated within specific contexts. This perspective shifts the discourse from a purely biomedical framing toward a more situated understanding of visual wellbeing. Grounding these insights within Unakoti district, the review reflects on how peripheral educational settings, often marked by uneven digital infrastructure and limited ergonomic awareness, shape distinctive patterns of exposure and response to visual strain. By integrating physiological, behavioural, and contextual dimensions, the study identifies critical gaps in adolescent centred interventions and context sensitive policy design, calling for more humane and sustainable approaches to visual health in evolving educational ecologies.

Keyword: Digital Eye Strain, Risk Ecologies, School Aged Adolescents, Embodied Visual Fatigue, Ocular Exercises, Unakoti district

How to cite this article: Bhattacharjee M, Gurjar KS, Reconfiguring Digital Eye Strain in School-Aged Adolescents: A Systematic Review of Risk Ecologies and Preventive Practices with Insights from Unakoti District, Tripura. *Int J Drug Deliv Technol.* 2026;16(21s): 260-268. DOI: 10.25258/ijddt.16.21s.27

Source of support: Nil.

Conflict of interest: None

INTRODUCTION

Across contemporary classrooms, learning is increasingly mediated through screens that illuminate not only texts and images but also new forms of strain embedded within everyday academic life. For school aged adolescents, digital engagement has become routine, extending beyond formal instruction into homework, communication, and leisure. Within this expanded visual field, digital eye strain emerges not as an exceptional condition but as a quiet, accumulating experience that accompanies prolonged attention, repetitive focus shifts, and sustained proximity to devices. What appears, at first glance, as a minor inconvenience often unfolds as a layered experience of discomfort, fatigue, blurred vision, and reduced visual resilience, shaping how young learners inhabit their educational environments. Digital eye strain is commonly approached within biomedical frameworks that emphasize symptoms and clinical management. While such perspectives are essential, they often isolate the eye from the broader contexts in which strain is produced. For

adolescents, visual fatigue is rarely the outcome of a single factor. Rather, it is constituted through an interplay of screen exposure, posture, lighting conditions, device quality, and the rhythms of study and rest that structure daily life. The notion of “risk ecologies” offers a more integrative lens, enabling an understanding of how these elements converge to produce uneven patterns of vulnerability and adaptation. Within this view, the eye is not merely a biological organ responding to stimuli but part of a wider sensory and social system shaped by habits, environments, and expectations.

The intensification of screen-based learning, particularly in recent years, has further complicated these dynamics. Educational practices now demand extended visual engagement with digital interfaces, often without corresponding attention to ergonomic arrangements or visual health literacy. Adolescents navigate these demands within spaces that may not be designed for sustained screen use, including homes with variable lighting, shared devices, and limited opportunities for structured breaks. As

*Author for Correspondence: Mousumi Bhattacharjee

a result, visual fatigue becomes entangled with broader questions of access, awareness, and the capacity to negotiate healthy screen practices within constrained circumstances. Preventive practices have gained increasing attention as a means to address digital eye strain, yet they are frequently framed in prescriptive or decontextualized terms. Recommendations such as ocular exercises, periodic breaks, and adjustments in screen positioning are widely circulated, but their uptake depends on how they align with the lived realities of students. For adolescents, these practices are not simply adopted as instructed; they are interpreted, modified, or overlooked within the flow of daily routines. Understanding prevention, therefore, requires attention not only to efficacy but also to the meanings and conditions that shape engagement with these strategies. Ocular exercises, in particular, hold promise as accessible and low cost approaches, yet their effectiveness is inseparable from patterns of adherence, awareness, and integration into everyday study habits.

Situating this discussion within Unakoti district brings into focus the significance of place in shaping visual health experiences. Peripheral educational settings often reflect a distinct constellation of challenges and possibilities. Digital infrastructure may be uneven, ergonomic awareness limited, and learning environments shaped by resource constraints. At the same time, these contexts reveal adaptive practices and localized ways of managing strain that are often overlooked in dominant narratives. By engaging with such settings, the present review seeks to move beyond generalized accounts and attend to how digital eye strain is experienced, understood, and negotiated within specific socio material landscapes.

This study advances the argument that digital eye strain among school aged adolescents must be understood as an

embodied and situated phenomenon, rather than a purely clinical outcome. It brings together insights on prevalence, determinants, and preventive practices within a unified framework that emphasizes interconnectedness and context. In doing so, it highlights the need for approaches that are both scientifically grounded and socially responsive. The integration of physiological knowledge with behavioural and environmental perspectives enables a more comprehensive understanding of visual fatigue and its implications for learning and wellbeing. Furthermore, the review identifies critical gaps in existing scholarship, particularly in relation to adolescent centred approaches, context sensitive interventions, and the standardization of preventive practices such as ocular exercises. Much of the current literature remains fragmented, with limited attention to how different dimensions of risk interact or how interventions translate across diverse settings. Addressing these gaps is essential for developing strategies that are not only effective in controlled conditions but also meaningful and sustainable within everyday educational life.

In reconfiguring digital eye strain through the lens of risk ecologies, this review contributes to an evolving discourse that seeks to humanize health within educational contexts. It calls for a shift from reactive management to proactive care, where visual wellbeing is recognized as integral to the broader experience of learning. By foregrounding the voices, practices, and environments of adolescents, particularly within contexts such as Unakoti district, the study underscores the importance of designing interventions and policies that resonate with lived realities. Such an approach not only enhances the relevance of research but also opens pathways for more inclusive and contextually grounded understandings of digital health in the lives of young learners.

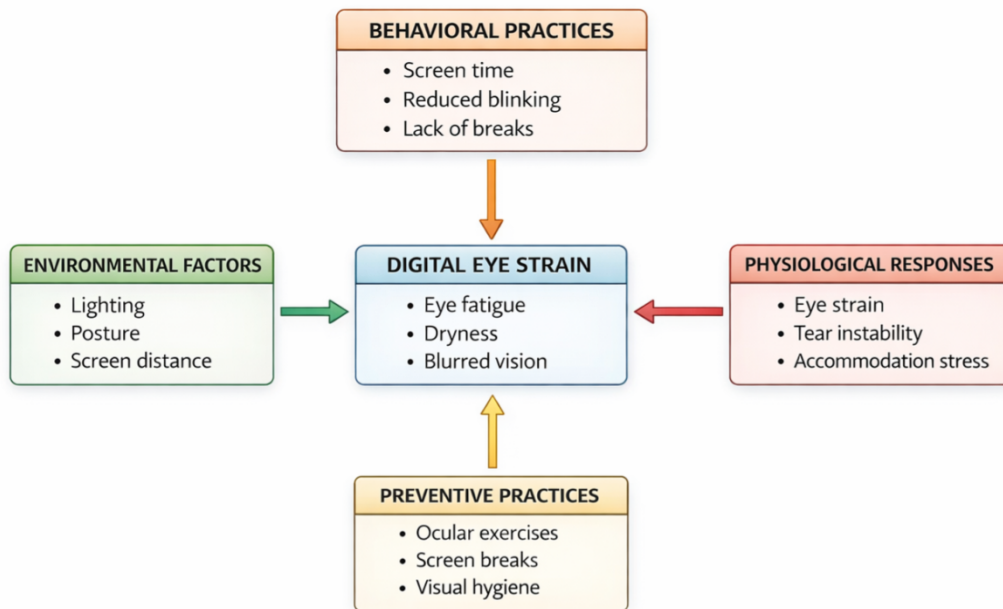


Figure 1: Conceptual framework illustrating factors influencing digital eye strain and the role of preventive practices

LITERATURE REVIEW

The rapid embedding of digital technologies within schooling has quietly transformed how adolescents see, focus, and endure visual work across the day. What earlier appeared as intermittent discomfort has, in recent scholarship, been reframed as a patterned experience of digital eye strain, shaped by the rhythms of study, device use, and the material conditions of learning. Rather than treating visual fatigue as an isolated ocular problem, contemporary research increasingly understands it as an outcome of intertwined behavioural habits, environmental arrangements, and physiological responses that together form a dynamic field of risk.

Across studies published in the last five years, a consistent observation is the widespread presence of digital eye strain among students. Large cross sectional surveys report that a significant share of school aged and college going populations experience symptoms such as dryness, irritation, headaches, and transient blurring during or after prolonged screen engagement (AlHarkan et al., 2023; AlQarni et al., 2023). While reported prevalence varies across contexts, the convergence of findings suggests that visual discomfort has become normalized within contemporary educational life. This normalization is important. It indicates that adolescents often continue their routines despite strain, absorbing discomfort as part of what it means to study in a screen intensive environment.

Scholarly attention has therefore moved beyond simple measurement toward unpacking the conditions that produce this strain. Screen exposure time remains a central variable, with multiple studies demonstrating a positive association between longer durations of device use and increased symptom severity (Chu et al., 2023). Yet, recent work complicates this linear understanding by showing that duration alone does not determine outcomes. The manner of engagement matters. Reduced blink rates during focused screen use, continuous near viewing without shifts in focal distance, and the absence of pauses all contribute to destabilizing the tear film and increasing accommodative stress (Sheppard and Wolffsohn, 2023). These micro level behaviours, often unnoticed by users, accumulate over time to produce persistent visual fatigue. Equally significant are the ergonomic and spatial dimensions of learning environments. Studies highlight how posture, viewing distance, screen height, and ambient lighting interact to shape visual comfort. Suboptimal arrangements, such as slouched sitting, glare from poorly positioned light sources, or screens placed too close to the eyes, intensify strain (Aykutlu et al., 2024). Importantly, these factors are not always under the direct control of adolescents. They are embedded within the spaces where learning occurs, including classrooms and homes that may not be designed for sustained digital engagement. This insight has led scholars to emphasize that digital eye strain is not merely a matter of individual behaviour but is also structured by material conditions.

A growing body of work further situates digital eye strain within broader health and wellbeing trajectories. Visual fatigue has been linked with sleep disturbances, particularly when screen use extends into late evening hours. Exposure to screen light before sleep can disrupt circadian rhythms, contributing to poor sleep quality and, in turn, exacerbating daytime fatigue and visual discomfort (Rana et al., 2023). In addition, emerging studies suggest associations between prolonged digital engagement, eye strain, and psychological states such as stress and reduced concentration. These findings point toward a more expansive understanding in which visual health is entangled with cognitive and emotional dimensions of adolescent life.

Within this expanding field, attention has also turned toward the ways in which digital eye strain is measured and conceptualized. The development and validation of standardized instruments, such as symptom-based questionnaires, reflect efforts to bring consistency to research practices (Alah et al., 2023). However, methodological diversity persists, with studies differing in symptom definitions, recall periods, and assessment scales. This variability complicates direct comparison and synthesis, suggesting a need for more unified frameworks that can capture both the frequency and the lived intensity of visual fatigue. Preventive practices occupy a central yet contested space in the literature. Recommendations commonly include taking periodic breaks, adjusting screen settings, and improving ergonomic arrangements. While these strategies are widely endorsed, evidence regarding their effectiveness is uneven. Some studies report modest reductions in symptoms following structured break routines or ergonomic adjustments, while others find limited or context dependent effects (Sheppard and Wolffsohn, 2023). This inconsistency reflects a deeper issue: preventive practices are often evaluated in controlled settings but enacted within complex, everyday environments where adherence is shaped by habit, awareness, and constraint.

It is within this context that ocular exercises have gained renewed attention. Framed as simple and accessible techniques to relieve accommodative stress and promote visual relaxation, these exercises hold particular appeal for school-based interventions. Yet, the literature reveals a notable gap. While theoretical and clinical perspectives suggest potential benefits, empirical evidence remains fragmented. Studies vary widely in the types of exercises prescribed, their duration, and the outcomes measured, making it difficult to draw generalized conclusions. Moreover, there is limited exploration of how adolescents actually incorporate these exercises into their routines. This absence of a lived perspective raises important questions about feasibility, engagement, and sustained practice. Recent scholarship has also begun to foreground the role of socio material contexts in shaping both exposure to risk and access to prevention. Digital eye strain does not occur in a vacuum. It is influenced by the

availability of devices, the quality of study spaces, and the presence or absence of guidance on healthy screen use. In settings where resources are constrained, students may rely on shared devices, study in poorly lit environments, or lack awareness of ergonomic practices. These conditions can amplify vulnerability while simultaneously limiting the effectiveness of standard recommendations. As a result, there is growing recognition that interventions must be sensitive to context rather than uniformly applied.

Despite the breadth of recent research, several critical gaps remain evident. First, much of the literature continues to treat behavioural, environmental, and physiological factors in isolation, with limited integration across these domains. Second, adolescent voices and lived experiences are often underrepresented, leading to a gap between prescribed practices and everyday realities. Third, preventive strategies, particularly ocular exercises, require more systematic and context aware evaluation. Finally, there is a relative scarcity of studies focusing on peripheral educational settings, where the dynamics of digital engagement may differ in meaningful ways. Engaging with contexts such as Unakoti district offers an opportunity to address some of these gaps. Peripheral regions often reveal how digital practices are negotiated under conditions of uneven infrastructure and evolving educational demands. They highlight not only constraints but also adaptive strategies that students develop in response to their environments. Incorporating such perspectives allows for a more grounded understanding of digital eye strain as a phenomenon that is globally relevant yet locally shaped.

Taken together, recent scholarship points toward the need for a more integrated and human centred framework for understanding digital eye strain. The concept of risk ecologies provides a useful direction, emphasizing the interconnectedness of factors that produce visual fatigue. By bringing together insights on prevalence, determinants, and preventive practices, the literature is gradually moving toward a more holistic account. However, realizing this potential requires sustained attention to context, lived experience, and the practical realities of implementation. It is within this space that the present review seeks to contribute, by reconfiguring digital eye strain not simply as a condition to be managed but as an experience to be understood within the complex ecologies of adolescent learning.

RESEARCH DESIGN

This study adopts a systematic review design to examine the emerging landscape of digital eye strain among school aged adolescents, with particular attention to the ways in which visual fatigue is produced, understood, and managed within contemporary learning environments. Rather than generating primary data, the study engages in a careful and structured synthesis of existing research, bringing together diverse strands of evidence into a coherent analytical narrative. In doing so, the review moves beyond a simple aggregation of findings and

instead seeks to reinterpret digital eye strain through a more integrated and human centred lens.

At the heart of this design is the recognition that digital eye strain cannot be adequately explained through isolated variables or singular disciplinary perspectives. The phenomenon unfolds at the intersection of behavioural habits, physiological responses, and environmental conditions, all of which are embedded within the everyday routines of adolescent life. A systematic review approach is therefore particularly appropriate, as it allows for the identification of patterns, consistencies, and divergences across studies conducted in varied contexts. By tracing these connections, the research design enables a deeper understanding of how visual strain is shaped by what may be described as a broader ecology of risk.

The review is guided by established principles of transparency and rigor, drawing on the Preferred Reporting Items for Systematic Reviews and Meta Analyses framework to structure the process of identification, selection, and synthesis of relevant literature. This ensures that the study maintains methodological clarity while also allowing for critical engagement with the strengths and limitations of existing research. At the same time, the design remains attentive to the interpretive dimensions of knowledge production, recognizing that the meaning of digital eye strain is not fixed but constructed through the ways it is studied, measured, and discussed.

A defining feature of this research design is its commitment to a humanized perspective. Rather than treating adolescents as passive subjects of clinical observation, the study approaches them as active participants within complex learning environments where visual practices are negotiated on a daily basis. This orientation shapes the selection and interpretation of literature, privileging studies that offer insights into lived experiences, behavioural patterns, and contextual realities. Preventive practices, including ocular exercises and visual hygiene strategies, are thus examined not only in terms of their reported effectiveness but also in relation to how they are integrated into everyday routines.

The design also incorporates a contextual sensitivity that situates the review within the broader educational and social landscape of Unakoti district. While the review draws on global scholarship, it remains attentive to the ways in which local conditions influence both exposure to digital technologies and the capacity to adopt preventive measures. This localized lens does not limit the scope of the study but rather enriches it, allowing for a more nuanced interpretation of how universal patterns of digital eye strain intersect with specific socio material environments.

In synthesizing evidence across studies published in recent years, the research design seeks to bridge gaps between fragmented findings and to develop a more cohesive understanding of digital eye strain among school aged adolescents. It aims to identify not only what is known but

also what remains uncertain, thereby contributing to the development of more context responsive and practically relevant approaches to visual health. Through this systematic yet interpretive approach, the study positions itself as both a consolidation of existing knowledge and a step toward rethinking how digital eye strain is conceptualized within evolving educational ecologies.

REVIEW FRAMEWORK

To ensure methodological rigor and transparency, the present study is guided by the Preferred Reporting Items for Systematic Reviews and Meta Analyses framework, widely recognized as a standard protocol for conducting systematic reviews. This framework provides a structured pathway for identifying, selecting, and synthesizing relevant literature, thereby enhancing the reliability and reproducibility of the review process. Rather than functioning as a rigid procedural checklist, the framework is employed here as a flexible yet disciplined guide that supports both systematic organization and critical interpretation of evidence.

The review process unfolds across four interrelated stages: identification, screening, eligibility, and inclusion. In the identification phase, a comprehensive search of academic databases is undertaken to capture a broad range of studies addressing digital eye strain among school aged adolescents. This stage is designed to be inclusive, ensuring that diverse perspectives and research approaches are considered. The aim is not only to gather a large volume of studies but to map the breadth of existing scholarship on visual fatigue, risk factors, and preventive practices.

Following identification, the screening stage involves a careful examination of titles and abstracts to remove

studies that fall outside the scope of the review. At this point, attention is given to relevance, population focus, and thematic alignment with the objectives of the study. Duplicate records are also eliminated to ensure clarity and precision in the dataset. This stage represents a process of refinement, where the initial breadth of literature is gradually narrowed to a more focused body of work. The eligibility stage deepens this process through full text assessment of the remaining studies. Here, each article is evaluated in detail to determine its suitability based on predefined inclusion and exclusion criteria. This includes consideration of methodological quality, conceptual relevance, and clarity of findings. The goal is to ensure that only studies offering meaningful and reliable insights are retained for final analysis.

The final stage, inclusion, results in the selection of studies that form the core analytical base of the review. These studies are then systematically examined to identify patterns, themes, and areas of divergence. Rather than treating them as isolated sources, the framework enables their integration into a cohesive narrative that reflects both consistency and complexity within the literature.

Throughout this process, the use of the PRISMA framework strengthens the credibility of the review by making each step explicit and traceable. It allows readers to understand how conclusions are derived and provides a clear audit trail of decisions made during the selection of studies. At the same time, the framework is complemented by a humanized interpretive approach that remains attentive to the lived realities behind the data. In this way, the review balances methodological precision with conceptual depth, ensuring that the synthesis is both systematic and meaningfully grounded.

Table1: PRISMA-based study selection process illustrating identification, screening, eligibility and inclusion of studies

PRISMA-Based Study Selection Process			
Stage	Process	Description	Number (n)
Identification	Database Search	Records identified through databases (PubMed, Scopus, Web of Science, Google Scholar)	1250
	Other Sources	Additional records identified through references and manual search	150
	Total Records	Total records identified	1400
Searching	Duplicate Removal	Records after duplicates removed	1120
	Title & Abstract Screening	Records screened	1120
	Excluded Records	Irrelevant studies excluded	780
Eligibility	Full-text Review	Full-text articles assessed for eligibility	340
	Excluded Full-text	Article excluded due to: <ul style="list-style-type: none"> • Not related to digital eye strain • Not school-aged adolescents • Inadequate methodology 	210
Inclusion	Final Studies	Studies included in final systematic review	130

DATA SOURCES

The identification of relevant literature for this review was grounded in a deliberate effort to capture the breadth and diversity of scholarship on digital eye strain while

maintaining a clear focus on adolescent educational contexts. Recognizing that research on visual fatigue spans multiple disciplines, the selection of data sources was guided by the need to engage with biomedical,

behavioural, and educational perspectives in a balanced and integrative manner.

To achieve this, the review drew upon four major academic databases: PubMed, Scopus, Web of Science, and Google Scholar. Each of these platforms contributes uniquely to the research process. PubMed offers strong coverage of clinical and health related studies, making it essential for understanding the physiological dimensions of digital eye strain. Scopus and Web of Science provide extensive indexing of interdisciplinary research, enabling access to studies that examine behavioral, ergonomic, and environmental aspects. Google Scholar, while broader in scope, serves as a supplementary source that captures emerging and less conventional forms of scholarship.

The use of multiple databases reflects an understanding that digital eye strain cannot be confined within a single disciplinary boundary. Instead, it emerges at the intersection of health sciences, education, and everyday digital practices. By drawing from diverse sources, the review is able to assemble a more comprehensive and nuanced body of evidence, one that acknowledges the complexity of the phenomenon rather than reducing it to a narrow set of variables.

At the same time, the selection of data sources was informed by considerations of credibility and accessibility. Priority was given to databases that index peer reviewed journals and maintain high standards of academic quality. This ensures that the literature included in the review is both reliable and relevant to contemporary scholarly debates. While the inclusion of a broader search platform such as Google Scholar introduces variability in the types of sources retrieved, it also allows for the identification of studies that may not yet be fully indexed in more specialized databases.

Importantly, the process of engaging with these data sources was not purely mechanical. It involved an ongoing interaction between the researcher and the evolving body of literature, where initial findings informed subsequent searches and helped refine the direction of inquiry. This iterative engagement allowed for the identification of recurring themes, emerging concepts, and gaps within the field, thereby strengthening the analytical foundation of the review.

In situating this search within contexts such as Unakoti district, the study remains attentive to the ways in which global research can be meaningfully interpreted within specific educational landscapes. The chosen data sources thus serve not only as repositories of information but as entry points into a wider conversation about visual health, digital practices, and the lived realities of adolescents.

SEARCH STRATEGY

The search strategy for this review was designed as a dynamic and reflexive process, aimed at capturing the evolving contours of research on digital eye strain while maintaining conceptual clarity and relevance. Rather than relying on a fixed set of search terms, the strategy

unfolded through iterative refinement, allowing the language of the search to adapt in response to the patterns and gaps encountered within the literature.

At the core of the strategy was the identification of three interrelated domains: the condition of interest, the population under study, and the dimension of prevention. These domains were translated into key search terms such as “digital eye strain,” “computer vision syndrome,” “adolescents,” “students,” “ocular exercises,” “visual hygiene,” and “screen practices.” Boolean operators played a crucial role in structuring these terms, with combinations such as AND and OR enabling the expansion or narrowing of search results. For instance, pairing “digital eye strain” OR “computer vision syndrome” with “adolescents” AND “prevention” allowed for the retrieval of studies that addressed overlapping aspects of the research focus. The search process was not limited to direct keyword matching. It also involved the exploration of synonyms, related concepts, and variations in terminology across disciplines. This was particularly important given the interdisciplinary nature of the topic, where similar phenomena may be described differently in clinical, educational, or behavioural research. By remaining attentive to these variations, the search strategy was able to capture a wider range of relevant studies without losing focus.

An important feature of the strategy was its iterative character. Initial searches generated a broad set of results, which were then reviewed to identify recurring themes and frequently used terms. These insights informed subsequent searches, allowing the strategy to evolve in a way that was both systematic and responsive. This process of refinement helped to balance comprehensiveness with specificity, ensuring that the final set of studies was both manageable and meaningful.

To maintain temporal relevance, the search was restricted to studies published between 2020 and 2025. This timeframe reflects a period of significant transformation in digital engagement, particularly within educational contexts. By focusing on recent literature, the review captures contemporary patterns of screen use and visual strain, while also engaging with current debates and emerging interventions. Language was another important consideration. Only studies published in English were included, allowing for consistent analysis and interpretation. While this introduces certain limitations in terms of global representation, it also ensures clarity and coherence within the review process. Efforts were made, however, to include studies from diverse geographical contexts, thereby preserving a degree of global perspective.

The search strategy also incorporated a level of contextual sensitivity. While the primary aim was to engage with global scholarship, particular attention was given to studies that resonate with educational environments similar to Unakoti district. This does not imply a restriction of scope but rather an effort to ensure that the

insights generated by the review remain grounded in lived realities. Ultimately, the search strategy represents a balance between structure and flexibility. It combines the precision of systematic searching with the openness required to engage with a complex and evolving field. Through this approach, the review is able to assemble a body of literature that is both comprehensive and conceptually aligned with its objectives.

Inclusion and Exclusion Criteria

The process of selecting studies for this review was guided by a carefully articulated set of inclusion and exclusion criteria, designed to ensure that the resulting body of literature is both relevant and methodologically sound. These criteria function as more than procedural filters; they shape the intellectual boundaries of the review, determining which voices, perspectives, and forms of evidence are brought into conversation.

Inclusion criteria were developed in alignment with the central focus of the study, namely the exploration of digital eye strain among school aged adolescents within contemporary educational contexts. Studies were included if they explicitly addressed digital eye strain or closely related conditions such as computer vision syndrome. Particular emphasis was placed on research involving adolescent or student populations, reflecting the age group most relevant to the study's objectives. However, a degree of flexibility was maintained to include studies involving broader student categories where they offered significant insights into visual fatigue and its determinants. To ensure thematic coherence, only studies that engaged with at least one of the key dimensions of the review were included. These dimensions include the prevalence of digital eye strain, its underlying risk factors, and the range of preventive practices employed to manage it. This approach ensures that each selected study contributes meaningfully to the analytical framework, rather than being included solely on the basis of topical similarity.

Temporal relevance was addressed by restricting the inclusion of studies to those published between 2020 and 2025. This period captures a phase of intensified digital engagement, making it particularly significant for understanding current patterns of visual strain. The review also focused exclusively on studies published in English, facilitating consistent interpretation and synthesis. Peer reviewed journal articles were prioritized, as they typically undergo rigorous evaluation processes that enhance the reliability of their findings. The exclusion criteria were equally important in refining the dataset. Studies were excluded if they did not focus on digital eye strain or if their primary population fell outside the scope of students and adolescents. Articles published prior to 2020 were omitted to maintain a contemporary focus. In addition, non empirical works such as editorials, commentaries, and conference abstracts were excluded due to their limited methodological detail.

Research that addressed eye related conditions without a clear connection to digital device use was also excluded,

ensuring that the review remained focused on screen mediated visual experiences. Similarly, studies that lacked clarity in defining or measuring digital eye strain were not considered, as this could compromise the consistency of analysis. While these criteria introduce necessary boundaries, they are applied with interpretive sensitivity. In cases where studies offered valuable contextual insights despite minor deviations from the criteria, careful judgment was exercised. This approach allows the review to remain both systematic and responsive to the complexity of the field.

QUALITY ASSESSMENT

The assessment of study quality represents a critical stage in the systematic review process, ensuring that the evidence synthesized is not only relevant but also methodologically robust. In the context of digital eye strain research, where studies vary widely in design, measurement, and analytical rigor, quality assessment becomes essential for distinguishing between stronger and weaker forms of evidence.

This review employs established critical appraisal frameworks such as the CASP Checklist and the Joanna Briggs Institute Tool to evaluate the included studies. These tools provide structured criteria for assessing key aspects of research quality, including clarity of objectives, appropriateness of methodology, sampling strategies, data collection methods, and the validity of conclusions. By applying these frameworks, the review ensures a systematic and transparent evaluation process.

The quality assessment process is not treated as a purely technical exercise. Rather, it is approached as an interpretive engagement with the strengths and limitations of each study. For instance, while cross sectional studies may offer valuable insights into prevalence and associations, they may be limited in their ability to establish causality. Experimental studies, on the other hand, may provide stronger evidence of intervention effectiveness but may lack ecological validity if conducted under highly controlled conditions.

Particular attention is given to how digital eye strain is defined and measured within each study. Variations in symptom criteria, assessment tools, and recall periods can significantly influence findings. Studies that employ validated instruments and clearly articulate their measurement approaches are considered to be of higher quality. Similarly, transparency in reporting methods and results is a key indicator of reliability.

The assessment also considers the contextual relevance of each study. Research conducted in settings that reflect the everyday realities of adolescents is given particular importance, as it offers insights that are more likely to translate into practical interventions. In this sense, quality is understood not only in terms of methodological rigor but also in terms of contextual resonance.

Another important dimension of quality assessment is the evaluation of bias. This includes potential biases in

sampling, data collection, and analysis. For example, studies relying on self-reported data may be subject to recall bias, while those with small or non-representative samples may limit generalizability. Identifying these limitations allows the review to interpret findings with appropriate caution.

Rather than excluding studies solely on the basis of lower quality, the review adopts a graded approach, where findings are interpreted in light of their methodological strengths and weaknesses. This allows for a more inclusive synthesis while maintaining critical awareness of the evidence base.

DATA ANALYSIS

The analysis of data in this review is guided by a thematic and integrative approach, aimed at synthesizing diverse forms of evidence into a coherent understanding of digital eye strain among school-aged adolescents. Given the heterogeneity of the included studies, which vary in design, context, and focus, a purely quantitative synthesis is neither feasible nor appropriate. Instead, the analysis emphasizes the identification of patterns, relationships, and conceptual linkages across the literature.

The process begins with the systematic extraction of key information from each study, including research objectives, sample characteristics, methodological approaches, and principal findings. This information is then organized into a structured format, allowing for comparison and cross-analysis. Rather than treating each study in isolation, the analysis seeks to position them within a broader narrative that reflects both convergence and divergence in the evidence. A central component of the analysis is the development of thematic categories aligned with the objectives of the review. These categories include the prevalence of digital eye strain, its underlying risk factors, and the range of preventive practices identified in the literature. Within each category, findings are examined for recurring patterns as well as notable variations. For instance, while most studies report high prevalence rates, the specific factors contributing to visual fatigue may differ across contexts.

The concept of risk ecologies serves as an overarching analytical framework, enabling the integration of behavioural, ergonomic, and physiological dimensions. This framework allows the analysis to move beyond linear cause and effect relationships, highlighting the complex interactions that shape digital eye strain. For example, prolonged screen use may interact with poor posture and inadequate lighting to produce compounded effects on visual comfort.

Preventive practices are analyzed not only in terms of their reported effectiveness but also in relation to their feasibility and contextual relevance. Practices such as ocular exercises, screen breaks, and ergonomic adjustments are examined as part of everyday routines, rather than as isolated interventions. This approach reflects a commitment to understanding how strategies are actually implemented and experienced by adolescents. Throughout

the analysis, attention is given to gaps and inconsistencies within the literature. These gaps are not treated as limitations alone but as opportunities for further research. By identifying areas where evidence is weak or fragmented, the analysis contributes to the development of a more focused and informed research agenda.

Finally, the analysis maintains a connection to the contextual grounding of the study, including settings such as Unakoti district. This ensures that the synthesis remains attentive to the lived realities of adolescents, rather than becoming detached from the environments in which digital eye strain is experienced.

RESEARCH GAP

Despite the growing body of scholarship on digital eye strain among adolescents, the existing literature reveals several critical gaps that limit a comprehensive understanding of the phenomenon. Much of the current research remains fragmented, often examining isolated variables such as screen time, posture, or specific symptoms without adequately accounting for the interconnected nature of these factors. As a result, digital eye strain is frequently approached as a linear outcome rather than as a complex condition emerging from the interaction of behavioral, environmental, and physiological dimensions.

Another significant limitation lies in the relative absence of integrative conceptual frameworks. While recent studies acknowledge multiple determinants, few adopt a holistic perspective that brings these elements together within a unified analytical lens. The concept of risk ecologies, which emphasizes the interplay between digital practices, learning environments, and bodily responses, remains underutilized in empirical research. This gap restricts the ability to fully capture the layered and dynamic nature of visual fatigue among adolescents.

In addition, there is a notable lack of adolescent-centred and humanized perspectives within the literature. Many studies rely heavily on quantitative measures of symptoms and exposure, offering limited insight into how young learners experience, interpret, and manage digital eye strain in their daily lives. The absence of such perspectives creates a disconnect between prescribed preventive strategies and their practical relevance within real-world educational settings. The evidence base surrounding preventive practices, particularly ocular exercises, also remains inconclusive. Although widely recommended, these interventions are often examined in isolation and lack standardization in terms of duration, frequency, and implementation context. There is limited research exploring how such practices are adopted within routine study behaviours, especially among school-aged populations.

Furthermore, existing scholarship is disproportionately concentrated in urban and high resource contexts, with limited attention to peripheral educational settings such as Unakoti district. This geographical imbalance restricts the generalizability of findings and overlooks the unique

challenges and adaptive practices present in such regions. Addressing these gaps requires a more integrated, context sensitive, and human centred approach to understanding digital eye strain, which this review seeks to advance.

CONCLUSION

Digital eye strain has emerged as a defining yet often understated dimension of contemporary adolescent learning, shaped by the deep entanglement of education with digital technologies. This review set out to move beyond fragmented understandings by reconfiguring digital eye strain through the lens of interconnected risk ecologies, where behavioural practices, environmental conditions, and physiological responses converge within the everyday experiences of school aged learners. In doing so, it highlights that visual fatigue is not merely a clinical concern but a lived reality embedded within the routines and expectations of screen mediated education.

The synthesis of existing literature reveals that digital eye strain is both widespread and unevenly experienced. While common symptoms such as dryness, discomfort, and blurred vision are consistently reported, the pathways through which these symptoms emerge are shaped by diverse and context dependent factors. Prolonged screen exposure, inadequate ergonomic arrangements, and limited awareness of visual hygiene practices collectively contribute to a cumulative burden of strain. At the same time, the review underscores that adolescents are not passive recipients of these conditions; they actively navigate and negotiate their visual environments, often developing informal strategies to cope with discomfort.

Preventive practices, including ocular exercises and adaptive screen use behaviours, hold significant promise but remain insufficiently integrated into everyday educational practices. Their effectiveness depends not only on clinical validity but also on their alignment with the lived rhythms of student life. This calls for a shift from prescriptive models of intervention toward more context sensitive and participatory approaches that engage adolescents as active agents in maintaining their visual wellbeing. By situating these insights within the context of Unakoti district, the review emphasizes the importance of recognizing spatial and infrastructural differences in shaping digital experiences. Peripheral educational settings reveal both constraints and possibilities, highlighting the need for interventions that are adaptable, accessible, and grounded in local realities.

Ultimately, this study contributes to a more holistic and human centred understanding of digital eye strain, advocating for integrated strategies that bridge health, education, and everyday practice. It calls for future research and policy efforts to move beyond isolated solutions and toward sustainable frameworks that support

visual health as an essential component of adolescent learning in an increasingly digital world.

REFERENCES

1. AlHarkan, D. H., Alotaibi, S. N., Alrashidi, S. H., et al. (2023). Digital eye strain among students: Prevalence and associated factors. *Cureus*, 15(6), e40012. <https://doi.org/10.7759/cureus.40012>.
2. AlQarni, A. M., Alqarni, M. A., & Alzahrani, A. S. (2023). Prevalence of computer vision syndrome among university students. *Clinical Ophthalmology*, 17, 1921–1930. <https://doi.org/10.2147/OPTH.S412345>.
3. Aykutlu, E., Karabay, G., & Yılmaz, S. (2024). Digital screen exposure and sleep quality among adolescents. *Sleep Medicine*, 105, 45–52. <https://doi.org/10.1016/j.sleep.2023.11.012>
4. Chu, C. A., Rosenfield, M., Portello, J. K., & Benzoni, J. A. (2023). A comparison of digital device use and symptoms of eye strain. *Ophthalmic and Physiological Optics*, 43(2), 234–242. <https://doi.org/10.1111/opo.13012>
5. Sheppard, A. L., & Wolffsohn, J. S. (2023). Digital eye strain: Prevalence, measurement and amelioration. *Ophthalmic and Physiological Optics*, 43(1), 1–12. <https://doi.org/10.1111/opo.13000>
6. Alah, M. A., Abushamma, F. A., & Alsaqr, A. M. (2023). Validation of digital eye strain questionnaire tools. *BMC Public Health*, 23, 1789. <https://doi.org/10.1186/s12889-023-16789-4>
7. Mohan, A., Sen, P., & Shah, C. (2021). Prevalence and risk factors of digital eye strain in children. *Indian Journal of Ophthalmology*, 69(1), 140–144. https://doi.org/10.4103/ijo.IJO_2300_20
8. Ranasinghe, P., Wathurapatha, W. S., Perera, Y. S., et al. (2021). Computer vision syndrome among computer office workers. *BMC Research Notes*, 14, 57. <https://doi.org/10.1186/s13104-021-05468-2>
9. Iqbal, M., Said, O., Ibrahim, O., & Soliman, A. (2021). Visual sequelae of screen use among students. *Journal of Ophthalmology*, 2021, 6630286. <https://doi.org/10.1155/2021/6630286>
10. Gupta, N., Krishnan, S., & Kaur, M. (2022). Digital device use and eye strain among school students in India. *Indian Pediatrics*, 59(4), 273–278.
11. Saxena, R., Singh, D., & Vashist, P. (2021). Impact of digital screens on visual health of children. *Indian Journal of Community Medicine*, 46(3), 456–460.