

Original article

Prevalence and Association of Dry Eye Disease with the Increased Use of Electronic Devices Among University Students in Libya

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ABSTRACT

The increasing reliance on personal electronic devices for higher education has raised significant public health concerns regarding visual safety and digital eye strain. Dry eye disease (DED), an ocular surface condition characterized by a loss of tear film homeostasis and chronic discomfort, is increasingly affecting young adults. Prolonged screen immersion induces mechanistic blink reflex suppression, accelerating tear film evaporation and triggering localized ocular surface inflammation. This multi-institutional study investigated the prevalence and clinical severity of DED symptoms among university students across Libya, while isolating independent socio-demographic, behavioral, and digital ergonomic risk factors. A descriptive cross-sectional study was carried out between September and December 2025. Data collection and coordination through the Faculty of Pharmacy, Attahadi University (Tripoli, Libya). A total of 652 university students completed a self-administered digital survey (Google Forms) comprising socio-demographic profiles, screen behavior tracking arrays, and the validated 12-item Ocular Surface Disease Index (OSDI) questionnaire. Bivariate distributions and categorical risk markers were evaluated using Pearson's Chi-square tests in SPSS Version 26.0. The mean population OSDI score was critically high at 42.01 ± 24.6 , with an overall active DED symptom prevalence of 83.3% ($n = 543$). Clinical stratification revealed that an overwhelming majority of the entire cohort suffered from advanced manifestations, with 67.9% ($n = 443$) meeting the diagnostic criteria for severe DED. Bivariate inferential analysis isolated the regular use of eyeglasses ($p = 0.038$) as a highly significant marker for ocular distress. Crucially, students utilizing eyeglasses exclusively dedicated to electronic screen viewing exhibited a heightened symptom prevalence of 89.9% ($p = 0.038$), contrasting with an 80.2% rate among general medical prescription wearers. Traditional demographic markers, including biological sex ($p = 0.364$), age distribution ($p = 0.865$), and bedtime device interactions ($p = 0.523$), did not demonstrate statistically significant associations with symptom development, illustrating a uniform risk trajectory across student blocks. A critically high prevalence of severe, screen-induced DED exists among Libyan university students. The data indicate that intense academic digital workloads override generic demographic variables. The unexpected risk peak among specialized eyeglass wearers warns against a false sense of security that leads to decreased blinking awareness. Institutional, campus-level public health interventions—such as digital hygiene orientations, ergonomic workstation filters, and the structured promotion of the 20-20-20 resting rule—are urgently required to protect student vision from chronic ocular surface damage.

Introduction

The global landscape of higher education has experienced an exponential reliance on personal electronic devices—including laptops, smartphones, tablets, and institutional computers—for academic learning, data tracking, and clinical referencing [1–3]. While these digital display terminals (DDTs) provide instant educational utility, prolonged exposure to artificial screens poses a significant physiological challenge to the human visual system [4]. Extensive screen viewing has been heavily linked to Digital Eye Strain (DES), also known as Computer Vision Syndrome (CVS), which presents as a complex cluster of internal ocular fatigue, blurred vision, and extraocular musculoskeletal discomfort [4–6]. Among these manifestations, Dry Eye Disease (DED) has emerged as the most prevalent, clinically significant ocular complication affecting modern student cohorts experiencing unmitigated daily screen time [4,7].

DED is a multifactorial disorder of the ocular surface characterized by a loss of tear film homeostasis and neurosensory ocular discomfort [8]. The underlying pathology associated with digital device use is primarily driven by altered, incomplete, or severely impaired blinking patterns, which dramatically accelerate the evaporation of the tear film's lipid layer [7,9,10]. Concentration on digital interfaces reduces the natural human blink rate by up to 66%, dropping from an average of 15–20 blinks per minute to as few as 3–7 blinks [11]. Furthermore, screen users frequently exhibit "partial or incomplete blinks," where the eyelids fail to close fully [10]. This mechanical suppression of the blink reflex disrupts the lacrimal functional unit,

prevents the meibomian glands from evenly distributing lipids across the cornea, and accelerates the evaporation of the tear film's watery layer [10,12]. Left unmanaged, this chronic evaporative stress triggers a complex pathological cascade on the ocular surface. The continuous loss of tear film homeostasis leads to localized hyperosmolarity, inflammation, epithelial damage, and potential neurosensory abnormalities [8,13]. To systematically screen populations at risk and measure the frequency and severity of these symptoms, validated clinical tools such as the Ocular Surface Disease Index (OSDI) questionnaire are widely utilized in research settings.

Epidemiological metrics from global literature establish that DED etiology among university students is highly prevalent and driven by continuous digital strain, environmental triggers, and behavioral habits. In Southeast Asia, studies from Malaysia documented an exceptionally high symptom prevalence of 92.1% paired with a severe mean OSDI score of 43.15 ± 19.3 [15], matching data from Thailand, which revealed a 70.8% prevalence among medical curricula [16]. Within Eastern Europe and the Middle East, this public health trend remains consistently elevated; Turkish student cohorts showed an overall DED prevalence of 86.1%, with 53.8% meeting the criteria for severe clinical disease [17]. Similarly, studies in Saudi Arabia, Palestine, and Jordan reported prevalence rates of 84.5%, 69.4%, and 74.2%, respectively, highlighting a widespread baseline risk profile across the Arab region [18–20].

Conversely, shifts to hybrid or remote online learning settings within Spain and Poland revealed lower yet significant clinical thresholds ranging between 51.8% and 57.1% [21], while African baselines from Ethiopia and Ghana show a broad prevalence window between 44.3% and 50.5% [22,23]. Mechanistic trials confirm that close-range digital screen focus suppresses the standard human blink rate by up to 60–66% [10], compounding the dose-response screen threshold where accumulating more than 6 to 7 hours of daily screen time represents a critical clinical cutoff that exponentially increases the odds of developing severe evaporative DED [16,18]. Additionally, late-night device interaction disrupts sleep architecture (< 6–7 hours), triggering low-grade systemic inflammatory responses that impair normal lacrimal gland fluid secretion [22]. Furthermore, high academic workloads common to health science fields cause autonomic nervous system imbalances and psychological stress, which suppress aqueous tear production [16,19]. Pharmacy students represent a uniquely high-risk demographic within this context, enduring rigorous academic workloads that demand dense reading, intensive laboratory data tracking, and continuous electronic assessment modules [14].

While global literature highlights this critical surge, baseline epidemiological data regarding digital eye strain and DED among students in Libya remains severely limited. This lack of localized data is particularly critical given that regional environmental stressors in North Africa—such as arid climates, high ambient temperatures, and dust exposure—could heavily compound tear film instability. Therefore, this cross-sectional study was conducted to obtain quantitative baseline data on the prevalence and clinical severity of DED symptoms among pharmacy students at Attahadi University (Tripoli, Libya) using the OSDI scale, while isolating the independent socio-demographic and device-related risk factors contributing to this public health concern.

Materials and Methods

Study Design and Setting

A descriptive, multi-institutional cross-sectional study was conducted to determine the prevalence, clinical severity, and associated behavioral risk factors of screen-induced dry eye disease (DED) among university students across Libya. The study operations, screening coordination, and database management were centralized at the Faculty of Pharmacy, Attahadi University in Tripoli, Libya. The study's operational field phase spanned a consecutive four-month period from September to December 2025.

Target Population and Sample Size

The target population for this study comprised undergraduate and postgraduate university students enrolled across public and private higher education institutions in Libya. A total sample size of 652 participants was successfully recruited for final analysis using a non-probability convenience sampling method. The minimum sample size required to ensure sufficient statistical power was verified using standard epidemiological parameters for cross-sectional surveys. Assuming a conservative dry eye disease prevalence estimate (p) of 50% to yield the maximum variance, a 95% confidence interval ($Z = 1.96$), and a 5% margin of error ($d = 0.05$), a baseline target sample size of approximately 384 respondents was calculated using Cochran's formula:

$$n = \frac{Z^2 \cdot p \cdot (1 - p)}{d^2}$$

The final acquired cohort of 652 completed responses exceeded this statistical threshold by 69.7%, providing the study with a robust sample size to reliably evaluate bivariate demographic subgroups and isolate independent behavioral risk factors. Inclusion criteria required participants to be currently registered university students in Libya, active users of digital display terminals (DDTs) for academic or personal purposes, and willing to provide electronic informed consent. Exclusion criteria

applied to individuals with a self-reported history of recent refractive or corneal surgery (such as LASIK within the past year), active ocular infections, or incomplete survey submissions.

Data Collection Instrument and Survey Protocol

Data collection was executed using a self-administered, multi-component digital questionnaire hosted on Google Forms and distributed through electronic networks across multiple Libyan institutions. The structured survey instrument was divided into three independent functional blocks:

Section I: Socio-demographic Profiles

This segment gathered participant background characteristics, including biological sex, age, and specific vision correction history, such as the regular use of eyeglasses.

Section II: Digital Device Usage Behaviors

This portion recorded specific exposures and operational habits concerning digital interfaces, capturing data parameters detailed across behavioral tracking frameworks. Key variables included daily hours of continuous screen configuration, screen brightness variations, and late-night device interaction before bedtime.

Section III: Clinical Symptom Stratification

Objective measurement of dry eye symptom frequency and structural severity was evaluated via the standard 12-item Ocular Surface Disease Index (OSDI) questionnaire developed by Schiffman et al. [24].

OSDI Scoring and Disease Classification

The 12 clinical assessment items of the OSDI questionnaire were graded using a 5-point Likert scale to gauge frequency (0 = none of the time; 1 = some of the time; 2 = half of the time; 3 = most of the time; 4 = all of the time). The total composite OSDI diagnostic score was derived mathematically for each respondent using the standard established formula:

$$\text{OSDI Score} = \frac{\text{Sum of scores for all answered questions} \times 25}{\text{Total number of questions answered}}$$

The continuous outcome matrix generated a final score ranging from 0 to 100 points, where higher values indicate progressive ocular surface dysfunction and localized visual discomfort. To ensure standard clinical alignment, diagnostic outcomes were grouped into four distinct operational severities based on validation cut-offs:

- **Normal Ocular Surface (Negative for DED):** Scores from 0 to 12 points.
- **Mild DED:** Scores from 13 to 22 points.
- **Moderate DED:** Scores from 23 to 32 points.
- **Severe DED:** Scores from 33 to 100 points.

Based on these defined thresholds, university students were classified as clinical symptom-positive for dry eye disease if they scored ≥ 13 points, while scores below 13 points were considered negative for active DED symptoms.

Statistical Analysis

Raw database repositories exported from Google Forms were processed, coded, and entered directly into IBM SPSS Statistics for Windows, Version 26.0 (IBM Corp., Armonk, NY, USA). Initial data cleaning steps verified completeness across all parameters. Descriptive statistical algorithms mapped the baseline socio-demographic values and behavioral habits using absolute frequencies and percentages, which were visualized using graphs and tables. Bivariate distribution comparisons were evaluated using Pearson's Chi-square (χ^2) tests to establish cross-tabulated associations between categorical socio-demographic characteristics, digital display device usage behaviors, and categorized DED severity indices. Statistical significance cutoffs for all comparative tests were maintained at a standard two-tailed (p -value < 0.05).

Results

Socio-Demographic Characteristics of the Study Cohort

A total of 652 university students across Libya completed the standardized digital questionnaire. The baseline socio-demographic features and bedtime device usage trends are compiled in (Table 1). The study population demonstrated a relatively balanced gender distribution with a slight male predominance, consisting of 338 males (51.8%) and 314 females (48.2%). In terms of age stratification, the majority of the surveyed students belonged to the 21–25 years old cohort ($n = 350$, 53.8%), followed by students aged ≤ 20 years ($n = 226$, 34.6%), while a minor segment was older than 25 years ($n = 76$,

11.6%). Behavioral habits before sleep structures showed that an overwhelming majority of the student population (n = 544, 83.4%) reported active usage of digital display devices at bedtime, whereas only 16.6% (n = 108) abstained. Analysis of visual correction histories demonstrated that 63.0% of the students (n=411) regularized the use of eyeglasses. Within this eyeglass-wearing subset (n = 411), 55.7% (n = 229) utilized them for medically prescribed refractive errors, while 44.3% (n = 182) utilized them strictly for viewing electronic screen interfaces.

Table 1. Socio-Demographic characteristics and Bedtime Screen Behaviors of the Student Cohort (N = 652)

Baseline Metrics & Subgroups	Frequency (n)	Percentage (%)
1. Gender		
Male	338	51.8
Female	314	48.2
2. Age Category (Years)		
≤ 20years	226	34.6
21–25 years	350	53.8
>25 years	76	11.6
3. Digital Device Use at Bedtime		
Yes	544	83.4
No	108	16.6
4. Regular Use of Eyeglasses		
Yes	411	63.0
No	241	37.0
5. Primary Indication for Eyeglasses (n = 411)*		
Medically Prescribed	229	55.7
Electronic Screen Dedicated	182	44.3

*Note: Percentage values for Subsection 5 are computed using the denominator of active eyeglass users (n = 411).

Digital Display Terminal (DDT) Usage Patterns and Application Profiles

The comprehensive behavioral characteristics and operational habits concerning digital display terminals (DDTs) among the surveyed university students (N = 652) are visually summarized in (Figure 1). The baseline exposure metrics revealed a long-standing history of digital device interaction, with a clear majority of the student cohort (55.2%, n = 360) reporting active utilization of digital screens for a duration of 5 to 10 years. This was followed by a substantial segment of long-term users exceeding 10 years of exposure (27.2%, n = 177), while a smaller minority reported less than 5 years of usage history (17.6%, n = 115). Quantifying the daily workload, more than half of the study population (55.1%, n = 359) exhibited an extensive dose-response screen threshold that exceeded 6 hours of continuous daily screen time. In contrast, 30.8% (n = 201) engaged with screens for 3 to 6 hours per day, and only a minimal proportion of 14.1% (n = 92) maintained a daily device exposure of less than 3 hours. Regarding hardware preferences, the mobile smartphone emerged as the single most heavily utilized electronic interface, preferred by an overwhelming 67.8% (n = 442) of the respondents. Other digital platforms were vastly secondary, including computer laptops (17.2%, n = 112), tablets/iPads (8.1%, n = 53), television displays (4.1%, n = 27), and dedicated digital gaming consoles (2.8%, n = 18).

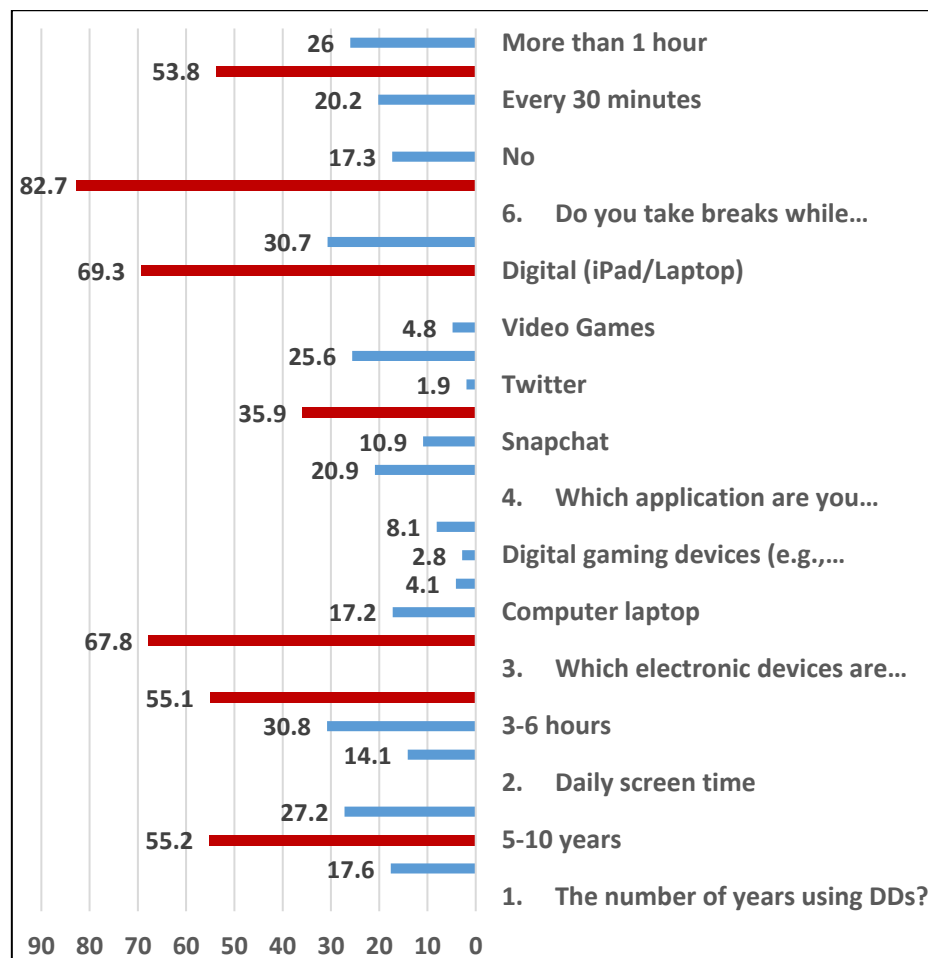


Figure 1. Digital device exposure profiles and application tracking metrics across the university student cohort (N = 652)

Application tracking paradigms demonstrated a dual configuration between social engagement and academic workflows. The most frequently accessed applications among students were Instagram (35.9%, $n = 234$) and specialized educational/studying software (such as Notability, OneNote, or programming platforms), which accounted for 25.6% ($n = 167$) of active engagement. These were followed by TikTok (20.9%, $n = 136$), Snapchat (10.9%, $n = 71$), video games (4.8%, $n = 31$), and Twitter (1.9%, $n = 13$). Consistent with these application profiles, the primary driving force behind screen interaction was academic preparation; 69.3% of the cohort ($n = 452$) reported adopting exclusive digital studying modalities (iPads/laptops), outperforming traditional physical paper media (30.7%, $n = 200$). To counter screen-induced visual distress, an encouraging 82.7% of students ($n = 539$) reported taking regular intervals or breaks while operating DDTs, whereas 17.3% ($n = 113$) confessed to continuous device usage without rest periods. However, the micro-frequency of these rest periods remained sub-optimal; among the subset who practiced break-taking behaviours ($n = 539$), over half (53.8%, $n = 290$) only paused their screen configurations every hour, while 26.0% ($n = 140$) extended continuous usage beyond one hour, and a minor group of 20.2% ($n = 109$) integrated proactive breaks every 30 minutes.

Ocular Ergonomics, Environmental Lighting, and Anti-Glare Preventative Measures

The descriptive statistical parameters and structural percentages regarding ocular ergonomics, ambient environmental lighting, and protective filtration measures adopted by the student cohort ($N = 652$) are visually mapped in (Figure 2). Among the subset of students who actively implement intervals while operating digital display terminals (DDTs) ($n = 539$), micro-rest strategies were heavily centered around short micro-breaks. More than half of these active break-takers (54.6%, $n = 294$) maintained an average break duration of 5 to 10 minutes. A smaller segment restricted their resting periods to brief intervals of less than 5 minutes (21.7%, $n = 117$), while 23.7% ($n = 128$) extended their breaks beyond 15 minutes. To proactively manage localized visual fatigue during extended screen configurations, the student population demonstrated widespread reliance on individual physical habits. A substantial majority (68.3%, $n = 445$) reported intentionally closing their eyes during active usage periods to alleviate sensory strain. Similarly, an overwhelming majority (80.5%, $n = 525$) of the total surveyed population engaged in active parameter management by manually adjusting the screen brightness of their devices. In sharp contrast to these widespread active adjustments, the objective utilization of defensive optical barriers

remained severely inadequate. Two-thirds of the studied cohort (67.0%, n = 437) documented constant exposure to screen glare during daily device operations. Despite this prominent optical stressor, a vast majority of the students rejected external protective measures: only 29.9% (n = 195) reported regular integration of a physical anti-glare filter, and just 32.1% (n = 209) implemented targeted screen filters or blue-light-blocking software tools. This deficiency in filtering defenses was further compounded by high-intensity display and environmental luminescence configurations. More than half of the university students (58.6%, n = 382) operated their digital devices with a "bright" screen configuration, while 17.8% (n = 116) utilized "very bright" displays, leaving only 23.6% (n = 154) who limited their tasks to a dim display. Concurrently, ambient illumination settings matched this high-luminescence trend; 53.1% (n = 346) of the respondents characterized their surrounding room lighting as "bright" and 7.5% (n = 49) as "very bright," while 39.4% (n = 257) performed their academic tasks under dim conditions. Finally, significant clinical vulnerabilities were observed regarding physical viewing proximities. Although a baseline majority of 54.5% (n = 355) maintained a relatively standard viewing distance between 40 cm and 76 cm (approximately an arm's length away), a deeply concerning 39.4% (n = 257) of the students operated their digital interfaces at a hazardous close visual proximity of less than 40 cm. Only a minimal minority of 6.1% (n = 40) reported an extended viewing distance exceeding 76 cm.

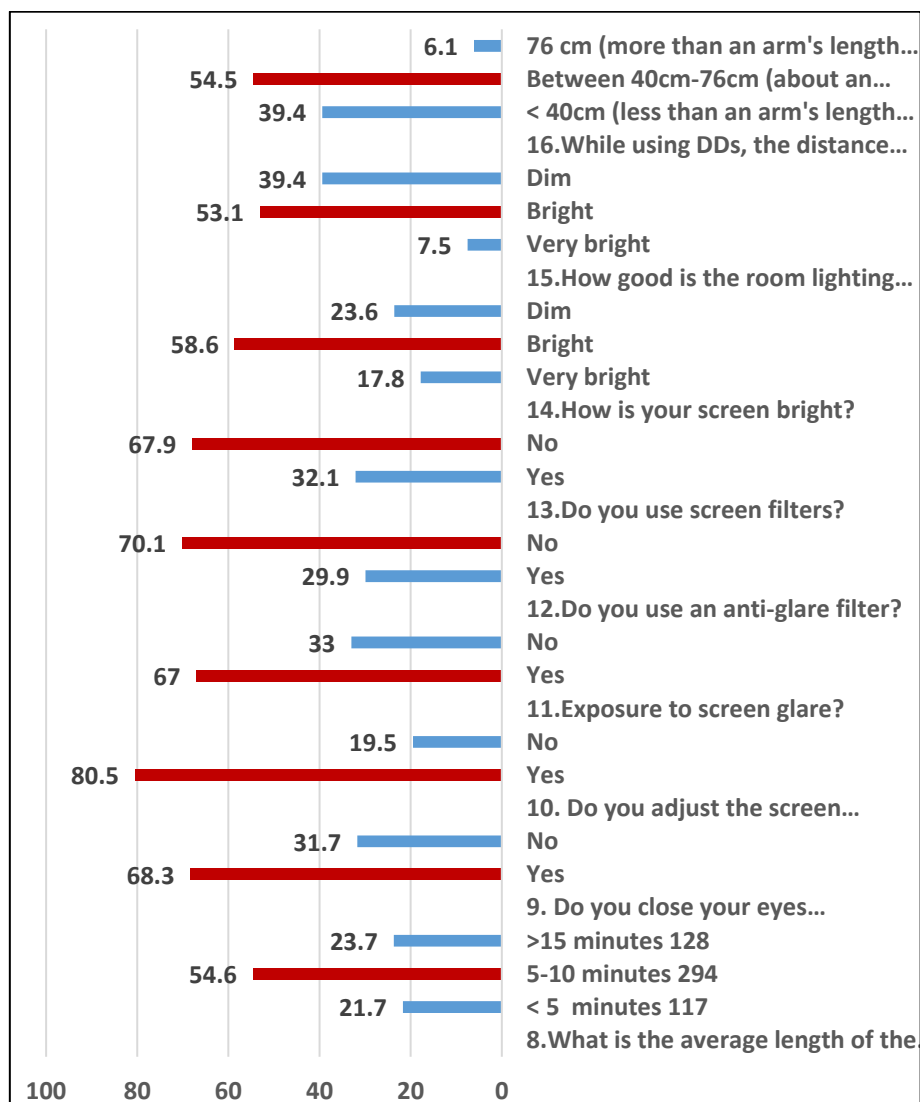


Figure 2. Ocular ergonomics, display luminance, and optical filtration barriers across the student cohort (N = 652)

Item-Level Analysis of the Ocular Surface Disease Index (OSDI)

To evaluate the specific clinical presentations of ocular distress within the student cohort (N = 652), an item-level frequency distribution of the 12-item Ocular Surface Disease Index (OSDI) questionnaire was conducted. In alignment with standardized ophthalmic research protocols, clinically significant symptom frequency was established by pooling responses representing substantial clinical thresholds, specifically those indicating symptom manifestation "half of the time," "most of the time," or "all of the time." The comprehensive response distribution matrix is detailed in (Table 2).

Profiling Specific Ocular Symptoms

Subjective evaluation of localized ocular surface dysfunction indicated severe physical distress among the students, as visually quantified across the discrete response spectrum in (Figure 3). The most prevalent manifestation was painful or sore eyes, documented by more than half of the study population (54.0%, $n = 352$) within the positive clinical threshold (comprising 6.9% all of the time, 18.3% most of the time, and a dominant 28.8% half of the time). Gritty ocular sensations (feeling of sand or foreign body in the eye) were reported with high frequency by 42.8% ($n = 279$) of the respondents. Visual quality was heavily compromised, with 42.0% ($n = 274$) of the students positive for persistent blurred vision and 30.5% ($n = 199$) presenting with clinical thresholds for low vision. Additionally, abnormal ocular surface sensitivity to light (photophobia) was also verified in 40.0% ($n = 261$) of the surveyed cohort.

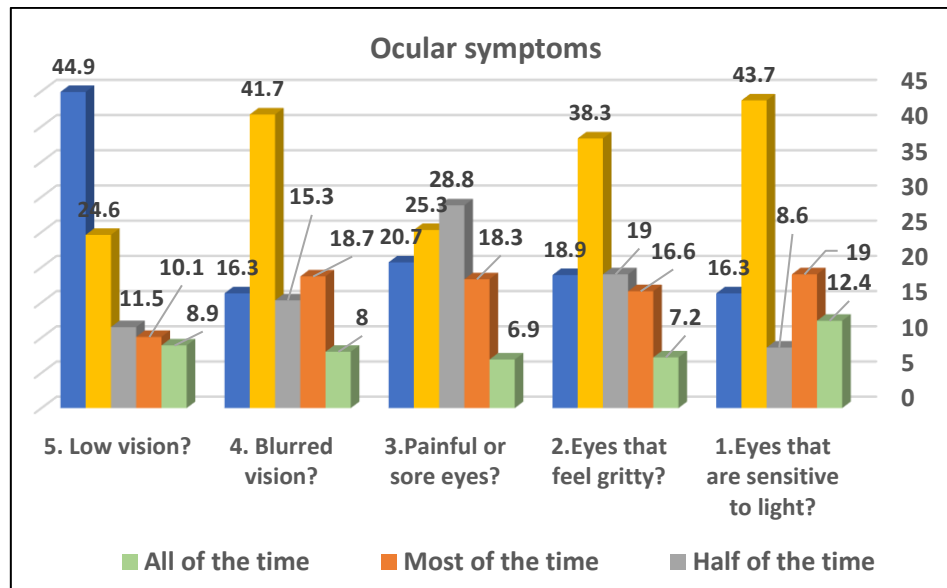


Figure 3. Frequency distribution of student responses regarding the 5-item ocular symptoms subscale of the OSDI (N = 652)

Impact on Vision-Related Daily Functions

The chronic presence of evaporative ocular distress induced severe functional limitations during standard academic and daily operations, as visually tracked in (Figure 4). Structural demands involving close-range focus and digital interaction yielded the highest restriction metrics:

- **Reading Disruptions:** A prominent 58.1% ($n = 379$) of the student cohort reported significant problems while reading, with 11.0% experiencing this all of the time and 25.9% most of the time.
- **Computer Work Limitations:** Consistent with the high exposure rates to screens, 54.6% ($n = 356$) of the students experienced functional impairment while working with a computer or digital interface.
- **Night Driving Vulnerability:** Over half of the cohort (50.9%, $n = 332$) documented functional difficulties during night driving tasks.
- **Television Viewing Constraints:** A total of 39.4% ($n = 257$) confirmed functional problems while watching television displays.

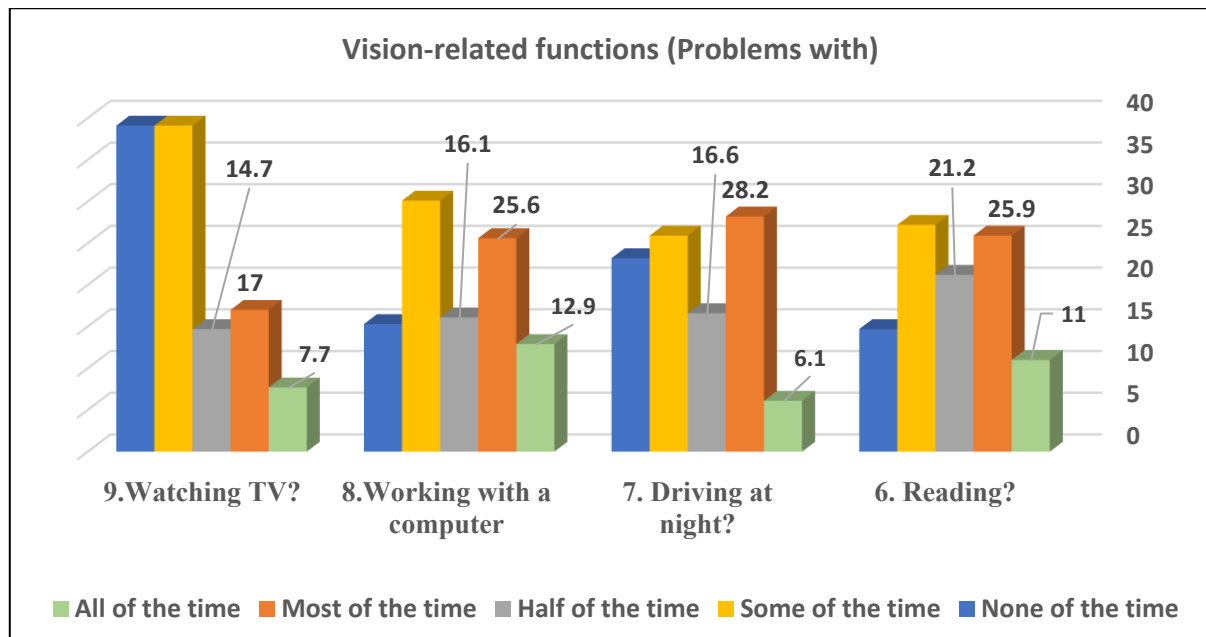


Figure 4. Frequency distribution of student responses regarding the 4-item vision-related functions subscale of the OSDI (N = 652)

Micro-Environmental Aggravating Triggers

Evaluation of secondary external stress factors highlighted a profound vulnerability to specific indoor and regional atmospheric conditions, as detailed in (Figure 5). The single most powerful external environmental driver was exposure to air-conditioned areas, which triggered or exacerbated dry eye symptoms in 65.6% (n = 428) of the student population (with an exceptional 40.6% reporting this distress most of the time). Atmospheric factors typical to North African geographical regions further compounded this baseline instability; 58.9% (n = 384) of the students suffered from significant ocular surface aggravation under windy conditions, and 46.6% (n = 304) documented immediate exacerbation when exposed to places or areas characterized by low humidity.

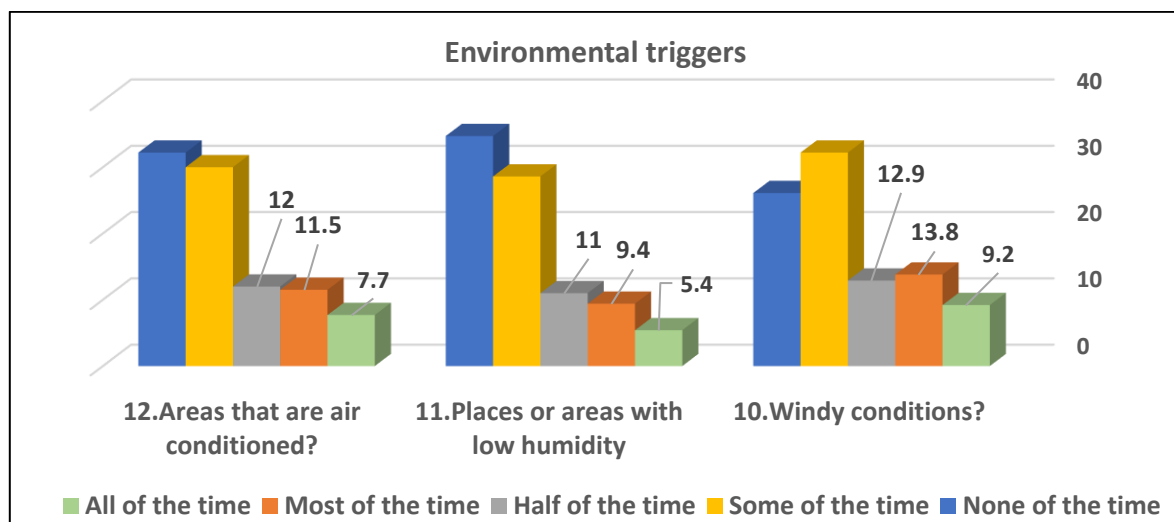


Figure 5. Frequency distribution of student responses regarding the 3-item environmental triggers subscale of the OSDI (N = 652)

Table 2. Detailed Responses of the University Students on the 12-Item Ocular Surface Disease Index (N = 652)

Diagnostic Item / Statement	All of the time n (%)	Most of the time n (%)	Half of the time n (%)	Some of the time n (%)	None of the time n (%)
Ocular Symptoms					
1. Eyes sensitive to light?	81 (12.4)	124 (19.0)	56 (8.6)	285 (43.7)	106 (16.3)
2. Eyes that feel gritty?	47 (7.2)	108 (16.6)	124 (19.0)	250 (38.3)	123 (18.9)
3. Painful or sore eyes?	45 (6.9)	119 (18.3)	188 (28.8)	165 (25.3)	135 (20.7)
4. Blurred vision?	52 (8.0)	122 (18.7)	100 (15.3)	272 (41.7)	106 (16.3)
5. Low vision?	58 (8.9)	66 (10.1)	75 (11.5)	160 (24.6)	293 (44.9)
Vision-Related Functions					
6. Problems with reading?	72 (11.0)	169 (25.9)	138 (21.2)	177 (27.2)	96 (14.7)
7. Problems with night driving?	40 (6.1)	184 (28.2)	108 (16.6)	169 (25.9)	151 (23.2)
8. Working with a computer?	84 (12.9)	167 (25.6)	105 (16.1)	196 (30.1)	100 (15.3)
9. Problems watching TV?	50 (7.7)	111 (17.0)	96 (14.7)	255 (39.1)	140 (21.5)
Environmental Triggers					
10. Windy conditions?	63 (9.7)	114 (17.5)	207 (31.7)	130 (19.9)	138 (21.2)
11. Areas with low humidity?	73 (11.2)	147 (22.5)	84 (12.9)	221 (33.9)	127 (19.5)
12. Air-conditioned areas?	69 (10.6)	265 (40.6)	94 (14.4)	91 (14.0)	133 (20.4)

Prevalence and Severity Profile of Dry Eye Disease (DED)

The diagnostic assessment based on the composite continuous Ocular Surface Disease Index (OSDI) scores revealed a profound burden of ocular surface dysfunction within the university student population (N = 652). The mean overall OSDI score for the studied cohort was 42.01 ± 24.6 = points, positioning the average student baseline well into the clinically severe category. The overall diagnostic prevalence and categorical stratification of DED severity are systematically compiled in (Table 3). Based on the established validation cut-offs, an overwhelming majority of the university students (83.3%, n = 543) presented with positive clinical symptoms for dry eye disease (OSDI ≥ 13). When stratified by progressive pathological severities, the vast majority of symptomatic individuals met the structural criteria for severe DED, accounting for 67.9% (n = 443) of the entire study population. Conversely, intermediate clinical tracks were less frequent, with mild DED documented in 7.4% (n = 48) of the cohort and moderate DED observed in 8.0% (n = 52). Only a minor segment of 16.7% (n = 109) maintained a normal ocular surface profile completely free of active disease symptoms.

Table 3. Overall Prevalence and Severity Categorization of Dry Eye Disease (N = 652).

Dry Eye Disease Severity Category	OSDI Score Range	Frequency (n)	Percentage (%)	Clinical Diagnostic Status
Normal Ocular Surface	0 – 12	109	16.7	Symptom-Negative
Mild DED	13 – 22	48	7.4	Symptom-Positive
Moderate DED	23 – 32	52	8.0	Symptom-Positive
Severe DED	33 – 100	443	67.9	Symptom-Positive

Bivariate Associations between Risk Factors and OSDI Outcomes

To identify the independent socio-demographic parameters, environmental factors, and digital display habits driving ocular surface dysfunction, comprehensive Pearson's Chi-square (χ^2) cross-tabulations were evaluated against categorical DED positivity.

Socio-Demographic Correlates

Bivariate analysis of student background features demonstrated a uniform distribution of clinical symptoms across standard biological brackets (Table 4). Neither biological sex (p = 0.364) nor age stratification (p = 0.865) shared a statistically significant relationship with DED positivity, indicating that demographic orientation alone does not alter baseline clinical risk. Similarly, the prevalence of DED among bedtime device users (85.5%) compared to non-users (72.2%) did not reach statistical significance (p = 0.523). In contrast, vision correction variables emerged as critical indicators of ocular distress. A highly significant association was established between the regular use of eyeglasses and DED positivity (p = 0.038), with spectacle-wearing students presenting a higher prevalence of symptoms (85.6%) than non-spectacle wearers (79.3%). Furthermore, specific indications for lens use revealed a prominent risk shift; students who wore eyeglasses strictly dedicated to electronic screen viewing exhibited a significantly higher symptom prevalence of 89.9% compared to those utilizing corrective lenses for general medical/refractive indications (80.2%; p = 0.038).

Table 4. Bivariate Associations Between Student Socio-Demographic Profiles and DED Prevalence Indices (N = 652)

Baseline Factor / Variable Subgroup	DED Positive n (% within factor)	DED Negative n (% within factor)	Prevalence of Symptoms (% Positive)	Pearson χ^2 p-value
1. Biological Sex				0.364
Male (n = 338)	286 (84.6)	52 (15.4)	84.6%	
Female (n = 314)	257 (81.8)	57 (18.2)	81.8%	
2. Age Category (Years)				0.865
≤20 years (n = 226)	186 (82.3)	40 (17.7)	82.3%	
21–25 years (n = 350)	294 (84.0)	56 (16.0)	84.0%	
>25 years (n = 76)	63 (82.9)	13 (17.1)	82.9%	
3. Bedtime Screen Interaction				0.523
Active Bedtime Users (n = 544)	465 (85.5)	79 (14.5)	85.5%	
Abstaining Users (n = 108)	78 (72.2)	30 (27.8)	72.2%	
4. Regular Use of Eyeglasses				0.038*
Yes (n = 411)	352 (85.6)	59 (14.4)	85.6%	
No (n = 241)	191 (79.3)	50 (20.7)	79.3%	
5. Lens Indication Profile (n = 411)				0.038*
General Medical/ Refractive (n = 182)	146 (80.2)	36 (19.8)	80.2%	
Screen Dedicated Filters (n = 229)	206 (89.9)	23 (10.1)	89.9%	

*Statistically significant at standard threshold ($p < 0.05$).

Behavioral Habits and Ergonomic Device Exposures

Bivariate distribution metrics concerning hardware configurations and operational habits revealed powerful correlations with accelerated tear film instability (Table 5): The analysis revealed that cumulative lifetime exposure, measured in total years of device use, did not demonstrate a significant association with symptom prevalence ($p = 0.443$). In contrast, daily screen time exposure was highly significant ($p < 0.001$), with students exceeding six hours of daily use exhibiting a striking 90.0% prevalence of positive clinical symptoms, thereby confirming a clear dose–response relationship. The modality of academic media also emerged as a critical determinant of ocular health outcomes. Students who relied on continuous digital study platforms such as iPads and laptops demonstrated a markedly elevated prevalence of dry eye disease (DED) at 92.3%, compared with a substantially lower rate of 63.0% among those who primarily used traditional paper-based media ($p = 0.0001$). Hardware characteristics further influenced symptom development, with device geometry and display size showing significant associations ($p = 0.041$). The highest prevalence rates were observed among active users of digital gaming systems (94.4%) and laptop computers (91.1%).

Screen luminescence was identified as a dominant external stressor, as operating on very bright displays was strongly correlated with DED development ($p < 0.0001$), producing an exceptionally high symptom rate of 95.7%. Variations in ambient room illumination also proved significant ($p = 0.012$), underscoring the importance of environmental lighting conditions. Optical barriers and environmental traps contributed meaningfully to symptom progression. The presence of screen glare was significantly associated with clinical outcomes ($p = 0.006$), and the absence of defensive optical accessories such as anti-glare filters ($p = 0.006$) or software-based screen filters ($p = 0.001$) was linked to elevated prevalence indices ranging between 84.9% and 86.7%. Rest micro-intervals presented a paradoxical effect: although break-taking behavior was statistically significant ($p = 0.006$), students who incorporated short pauses still reported high symptom scores (85.2%). This paradox likely reflects the tendency of severely affected high-intensity users to adopt micro-rest strategies that remain insufficient to disrupt the chronic evaporative cascade. By contrast, intentional eye closure did not yield significant relief ($p = 0.887$). Finally, mechanical proximities were found to be significant ($p = 0.046$), with hazardous close viewing distances of less than 40 cm associated with an 87.2% prevalence of active clinical symptoms. Collectively, these findings highlight the multifactorial nature of digital eye strain, demonstrating that behavioral, ergonomic, and environmental variables interact to shape ocular surface outcomes in student populations.

Table 5. Bivariate associations between student device behaviors and DED prevalence (N = 652)

Baseline Factor / Variable Subgroup	DED Positive n (% within factor)	DED Negative n (% within factor)	Prevalence of Symptoms (% Positive)	Pearson χ^2 p-value
6. Number of Years Using Devices				0.443
< 5 years (n = 115)	93 (17.1)	22 (20.2)	80.9%	
5–10 years (n = 360)	303 (55.8)	57 (52.3)	84.2%	
> 10 years (n = 177)	147 (27.1)	30 (27.5)	83.1%	
7. Daily Screen Time Duration				< 0.001*
< 3 hours (n = 92)	61 (11.2)	31 (28.4)	66.3%	
3–6 hours (n = 201)	159 (29.3)	42 (38.5)	79.1%	
> 6 hours (n = 359)	323 (59.5)	36 (33.1)	90.0%	
8. Core Study Medium / Modality				0.0001*
Digital (iPads /Laptops) (n=452)	417 (92.3)	35 (7.7)	92.3%	
Traditional Papers (n = 200)	126 (63.0)	74 (37.0)	63.0%	
9. Most Frequently Used Hardware				0.041*
Mobile Smartphone (n = 442)	363 (66.9)	79 (72.5)	82.1%	
Computer Laptop (n = 112)	102 (18.8)	10 (9.2)	91.1%	
Television Screen (n = 27)	18 (3.3)	9 (8.2)	66.7%	
Digital Gaming Devices (n = 18)	17 (3.1)	1 (0.9)	94.4%	
Tablet / iPad (n = 53)	43 (7.9)	10 (9.2)	81.1%	
10. Active Breaks Scheduling				0.006*
Yes (n = 539)	459 (84.5)	80 (73.4)	85.2%	
No (n = 113)	84 (15.5)	29 (26.6)	74.3%	
- Break Frequency (n = 539)				0.006*
Every 30 minutes (n = 109)	89 (19.4)	20 (25.0)	81.7%	
Every hour (n = 290)	230 (50.1)	60 (75.0)	79.3%	
More than 1 hour (n = 140)	140 (30.5)	0 (0.0)	100.0%	
- Break Duration (n = 539)				0.006*
< 5 minutes (n = 117)	104 (22.7)	13 (16.3)	88.9%	
5–10 minutes (n = 294)	227 (49.5)	67 (83.8)	77.2%	
> 15 minutes (n = 128)	128 (28.1)	0 (0.0)	100.0%	
11. Intentional Eye Closure Habit				0.887
Yes (n = 445)	370 (68.1)	75 (68.8)	83.1%	
No (n = 207)	173 (31.9)	34 (31.2)	83.6%	
12. Interface Manual Brightness				0.101
Yes (n = 525)	437 (80.5)	88 (71.6)	83.2%	
No (n = 127)	106 (19.5)	21 (28.4)	83.5%	
13. Interface Brightness Intensity				< 0.0001*
Very Bright (n = 116)	111 (20.4)	5 (4.6)	95.7%	
Bright (n = 382)	321 (59.1)	61 (56.0)	84.0%	
Dim (n = 154)	111 (20.4)	43 (39.4)	72.1%	
14. Ambient Room Illumination				0.012*
Very Bright (n = 49)	46 (8.5)	3 (2.8)	83.9%	
Bright (n = 346)	288 (53.0)	58 (53.2)	83.2%	
Dim (n = 257)	209 (38.5)	48 (44.0)	81.3%	
Baseline Factor / Variable Subgroup	DED Positive n (% within factor)	DED Negative n (% within factor)	Prevalence of Symptoms (% Positive)	Pearson χ^2 p-value
15. Exposure to Screen Glare				0.006*
Yes (n = 437)	358 (65.9)	79 (72.5)	81.9%	
No (n = 215)	185 (34.1)	30 (27.5)	86.0%	
16. Use of Anti-Glare Filter				0.006*
Yes (n = 195)	155 (28.5)	40 (36.7)	79.5%	
No (n = 457)	388 (71.5)	69 (63.3)	84.9%	

17. Use of Screen Software Filters				0.001*
Yes (n = 209)	159 (29.3)	50 (45.9)	76.1%	
No (n = 443)	384 (70.7)	59 (54.1)	86.7%	
18. Operational Viewing Distance				0.046*
< 40 cm (n = 257)	224 (41.2)	33 (30.3)	87.2%	
40 cm – 76 cm (n = 355)	287 (52.9)	68 (62.4)	80.8%	
>76 cm (n = 40)	32 (5.9)	8 (7.3)	80.0%	
*Statistically significant at standard thresholds (p < 0.05).				

Discussion

Prevalence and Severity of Dry Eye Disease (DED)

This study evaluated the epidemiological burden, clinical severity, and behavioral risk factors of screen-induced DED among university students in Libya. Using the validated OSDI questionnaire, the overall prevalence of DED within the studied cohort was exceptionally high at 83.3% (n = 543), featuring a critically elevated mean continuous OSDI score of 42.01 ± 24.6 points. When stratified by progressive pathological severities, intermediate clinical categories were less prominent—with mild DED documented in 7.4% (n = 48) and moderate DED observed in 8.0% (n = 52)—while an overwhelming majority of the total population met the structural criteria for severe DED (67.9%, n = 443). This high active prevalence matches international data patterns for healthcare and health science students subjected to intensive academic screen workloads. The 83.3% prevalence closely mirrors the landmark findings of Stejar et al., who documented an identical overall DED prevalence of 83.6% among Romanian medical students [25]. Similarly, regional baseline metrics from Saudi Arabia identified a symptom prevalence of 84.5% [18], while recent epidemiological surveys in the Philippines and Vietnam reported comparably high thresholds of 82.2% [26] and 88.6% [27], respectively. Similarly, the heavy concentration of advanced clinical indices aligns with the high rates of severe DED reported among healthcare blocks in Palestine (78.4%) [19] and separate regional Saudi cohorts (74.9%) [28], where severe manifestations accounted for 40.4% and 30.4% of cases, respectively. This trend is further supported by Choi et al. [29], who documented a 78.1% DED prevalence among student populations, with severe cases making up 33.5% of the sample. While certain undergraduate medical landscapes, such as in Malaysia, report even higher clinical limits reaching 92.1% [15], the baseline documented across Libyan institutions is significantly elevated when contrasted with historical data. For instance, Supiyaphun et al. [16] recorded a baseline symptom rate of just 8.15% with a low 5.5% severe threshold in their cohort. These wide operational variances confirm that university populations face a significantly higher risk of developing homeostatic tear film imbalances compared to general populations. This vulnerability is primarily driven by prolonged screen focus and heavy e-learning schedules that cause serious blink reflex suppression. The intense academic workload typical of university settings requires prolonged visual focus on digital display terminals (DDTs). This behavior directly compromises the lacrimal functional unit through mechanistic blink suppression. Continuous near-work and screen exposure reduce the natural human blink frequency by up to two-thirds, dropping from a baseline of 15–20 blinks per minute to fewer than 3–7 blinks [10]. This mechanical suppression disrupts the normal secretion of meibum from the meibomian glands, resulting in a deficient or unstable lipid layer [12]. Without a proper lipid coating, the underlying aqueous layer evaporates rapidly, leading to the high rates of severe DED observed in this study.

Inferential Analysis of Significant Behavioral and Ergonomic Risk Factors

Inferential testing identified multiple behavioral habits and workplace setups as significant risk factors for DED within this cohort. Daily exposure duration showed an extremely significant correlation (p < 0.001), with students using screens for more than six hours daily reaching a 90.0% symptom prevalence rate. This dose-response threshold is highly comparable to the landmark epidemiological models of Logaraj et al. [30], which positioned acute daily duration as the primary driver of screen-induced eye strain. It also aligns with contemporary tracking by Gawlik et al. [21], who validated a 4-to-6-hour daily screen threshold as a key independent predictor of severe DED. A highly interesting finding in this study was the significant risk correlation with vision correction profiles (p = 0.038). Students using eyeglasses exhibited a higher DED prevalence (85.6%) than non-users (79.3%). Crucially, within this group, students relying on glasses *exclusively dedicated to electronic screen viewing* reached a massive 89.9% symptom rate, compared to 80.2% among general prescription wearers (p = 0.038). This finding is directly corroborated by Almalki et al. [18] and Altinbas et al. [17], who documented a similarly high risk among young adults wearing optical correction tools while managing digital tasks. This paradox suggests that students using specialized or unprescribed blue-light glasses may experience a false sense of visual security. This psychological cushion often leads to reduced blinking awareness and poor screen ergonomics, which worsens evaporative tear film loss. In contrast, Abdulmannan et al. [31] noted that contact lens use was the primary optical risk variable driving mechanical friction and localized hypoxia on the ocular surface. Environmental setup and digital ergonomics were also highly significant. Transitioning from physical books to digital study methods (i.e., tablets or laptops) increased DED prevalence from 63.0% to 92.3% (p = 0.0001), supporting the findings of Almalki et al. [18] regarding the clinical strain caused by

academic digitalization. In line with the findings of Ranasinghe et al. [32] and Alluwihan [33], environmental configurations like screen glare ($p = 0.006$) and the lack of protective filters ($p \leq 0.006$) significantly worsened symptom presentations. High screen luminance ($p < 0.001$) and close viewing ergonomics (< 40 cm; $p = 0.046$) were also identified as primary triggers. Bright screen displays paired with improper ambient room lighting force the ciliary muscles into continuous accommodation strain. At the same time, a closer viewing distance increases the vertical line of sight and widens the palpebral fissure. This broader palpebral opening exposes a larger surface area of the cornea to ambient air currents, accelerating tear evaporation, tear film hyperosmolarity, and localized inflammation. Unexpectedly, taking breaks was positively associated with symptoms ($p = 0.006$). Rather than indicating that resting harms the eyes, this trend reveals a common behavioral bias: university students under intense academic pressure typically employ manual adjustments or short breaks only as a *reactive response* after severe, painful physical eye strain has already set in.

Inferential Analysis of Insignificant Associations

In contrast to the behavioral triggers, this study identified several socio-demographic and lifestyle parameters that shared no statistically significant relationship with DED positivity ($p > 0.05$), including biological sex, age stratification, bedtime device usage, cumulative years of device exposure, intentional eye closure, and the manual adjustment of screen brightness settings. This study found no significant associations between DED symptoms and biological sex ($p = 0.364$), age distribution ($p = 0.865$), or the cumulative number of years using devices ($p = 0.443$). While global population studies frequently report a female predominance due to hormonal factors, our findings match the cross-sectional data of Aćimović et al. [34] in Serbia and Páez et al. [35] in Argentina. Both studies noted that within demanding health science tracks, the uniform digital load and environmental demands completely override generic demographic variables. The narrow age range typical of university students also explains the lack of age-related differences, a trend supported by Gawlik et al. [21]. Furthermore, several behavioral adjustments failed to show statistical significance. Bedtime device usage ($p = 0.523$) did not significantly predict symptom progression, mirroring the conclusions of Alluwihan [33] that high daytime academic screen loads are a much stronger predictor of DED than specific late-night habits. The lack of significance for manual brightness adjustments ($p = 0.101$) and intentional eye closure ($p = 0.887$) further supports this idea. These micro-adjustments are simple reactive behaviors that cannot fix the tear film instability caused by long hours of intense study. As emphasized by Gawlik et al. [21], occasional intentional blinking is insufficient to protect the ocular surface; instead, students require highly structured, preventive ergonomic workflows, such as the 20-20-20 rule, to truly reduce screen-related dry eye.

Study Limitations

While this study provides a robust epidemiological sample ($N = 652$) across multiple student networks in Libya, certain limitations must be acknowledged. First, the cross-sectional study design prevents the establishment of a direct causal relationship between specific screen behaviors and the long-term development of DED. Second, clinical staging relied entirely on the subjective, patient-reported metrics of the OSDI survey. Due to logistical constraints in regional university settings, survey data could not be validated against objective ophthalmic tests, such as Schirmer's moisture tests, Tear Break-Up Time (TBUT) tracking, or objective fluorescein corneal staining. Finally, because the survey was distributed online using a convenience sampling method, the sample may be subject to participation bias, as students already experiencing dry eye symptoms might have been more motivated to complete the survey.

Conclusion

This study provides critical baseline epidemiological data on the profound burden of screen-induced Dry Eye Disease (DED) among university students in Libya. The clinical findings reveal an exceptionally high active symptom prevalence of 83.3% ($n = 543$), with an alarming 67.9% ($n = 443$) of the entire cohort exhibiting advanced, severe manifestations based on validation Ocular Surface Disease Index (OSDI) criteria. Inferential statistical modeling demonstrates that intensive academic workloads and poor digital ergonomics override traditional baseline demographic indicators. Specifically, daily digital screen exposure exceeding 6 hours ($p < 0.001$), exclusive reliance on digital studying modalities ($p = 0.0001$), high screen brightness settings ($p < 0.0001$), and hazardous close viewing distances of less than 40 cm ($p = 0.046$) significantly correlate with severe ocular surface distress. Furthermore, this study isolates a critical "eyeglass paradox" ($p = 0.038$), where students utilizing eyeglasses exclusively dedicated to electronic screen viewing exhibited a heightened symptom prevalence of 89.9%. This finding indicates that specialized computer filters may induce a false sense of security, inadvertently causing students to neglect voluntary blinking awareness and active ergonomic hygiene. Compounded by localized regional environmental drivers—such as continuous exposure to indoor air-conditioning (65.6%) and windy atmospheric conditions (58.9%)—unmitigated screen immersion triggers a continuous evaporative cascade that severely compromises tear film homeostasis. To protect student vision from chronic ocular surface damage, a series of targeted institutional and individual public health guidelines are strongly recommended:

1. Incorporate mandatory digital hygiene orientations and ergonomic training presets into the university curricula for health science tracks.
2. Mandate technical lab modifications, including blue-light software filtering overrides, fixed 40–76 cm hardware display mounts, and microclimatic humidity optimization to disrupt indoor evaporative airflows.
3. Establish continuous campus campaigns and visible anchors pushing the 20-20-20 rule (resting the eyes every 20 minutes by focusing on a point 20 feet away for 20 seconds).
4. Advocate for regular clinical screening blocks coupled with the early adoption of preservative-free artificial tear formulations to sustain precocular homeostasis during heavy electronic assessment modules.

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