Digital Photoaging Across Ethnic Groups: Patterns of Skin Changes and Protective Behaviors.

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ABSTRACT:

Objective: To analyze the distinctions between ethnic differences in the expression of premature aging as well as the protective behaviors of those who have been exposed to LED screen devices.

Methodology: This cross-sectional study was carried out at PNS Shifa Hospital, Karachi, between October 2023 and May 2024. A total of 450 participants aged 27 to 40 years were recruited through convenience sampling. Data were collected using a structured questionnaire encompassing demographic details, LED exposure patterns, protective practices, and self-reported indicators of premature aging. Participants were classified into ethnic groups: Punjabi, Sindhi, Muhajir, Pashtun, Balochi, and Others. Statistical analyses, including chi-square tests and logistic regression, were performed using SPSS version 29, with a p-value of <0.05 considered statistically significant

Results: Most of the participants were Punjabis (31.1%), followed by Sindhi (20.2%) and Muhajir (18.2%). Ethnicity was not significantly associated with the use of UV protection (χ^2=5.54, p=0.353) and use of SPF (χ^2=9.23, p=0.100). Similarly, ethnicity did not show a strong relationship with dark circles (p=0.57), decreased elasticity (p=0.68), dry skin (p=0.60), grey hair (p=0.56), or hair fall (p=0.47). However, fine wrinkles showed borderline statistical significance (p=0.05).

Conclusion: Ethnicity does not appear to be a significant determinant of digital photoaging in Pakistan. Instead, exposure to visible light emerges as the primary contributing factor. Universal photoprotective measures are therefore recommended, while further research is warranted to elucidate the underlying mechanisms.

Key words: Ethnicity, digital photoaging, visible light exposure, skin aging.

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Introduction:

Digital technology has been growing at such an amazing pace during the past two decades that it has basically changed the way we are exposed to light in our environment. The light-emitting diode (LED) displays on smartphones, laptops, tablets, and TV sets give off following a type of high-energy visible (HEV) blue light in the wavelength range of 400-500 nm. Ultraviolet (UV) radiation has always been considered the main environmental factor responsible for photoaging, however, a number of studies demonstrate that visible and blue light exposure from digital devices can also cause premature skin aging through oxidative stress-mediated mechanisms.[1,2] In contrast to UV radiation, visible light goes even deeper into the skin dermis causing the generation of reactive oxygen species (ROS), damage to mitochondria, and degradation of the matrix, all of which can contribute to an accelerated skin aging process.[3,4] Digital photoaging is the term used for the cumulative skin changes due to chronic exposure to artificial visible light, mostly from LED screens. Recent experimental and clinical research provides evidence that the expression of matrix metalloproteinases (MMPs) can be elevated by blue light exposure. It also leads to the decrease of type I procollagen synthesis and can cause damage to the extracellular matrix.[3,4] These molecular alterations will finally show up as skin aging signs i.e., wrinkles, hyperpigmentation, reduced skin elasticity and non-uniform skin color. Besides, visible light has been demonstrated to stimulate melanin production by activating melanocytes, resulting in persisting pigmentation, especially in individuals with darker skin types.[3,4] UV-induced tanning has been the conventional understanding for pigmentation changes; however, this pigmentation caused by visible light exposure differs from UV-induced tanning and the effect might be even longer, thereby, unveiling the unique biological impacts of visible light exposure. Besides pigmentary changes, the oxidative stress caused by artificial light may lead to the dysfunction of fibroblasts, a decrease in collagen production and faster cellular aging.[3,4] Damage to mitochondria as well as disruption of the circadian rhythm exacerbate these effects, and both skin healing and hair follicle biology are potentially affected.[5] Studies on living organisms have shown that artificial visible light can lead to cytoskeletal reorganization and cellular stress responses similar to those in photoaged skin.[5] The discovery thus links biological mechanisms with a clinical observation that an extended time of digital screen exposure results in premature aging signs. Although the biological pathways

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for digital photoaging are becoming clearer, the role of ethnicity in determining the extent of susceptibility to these mechanisms has been barely addressed yet. Differences in skin structure, melanin allocation, dermal thickness, and fibroblast activity among ethnicities might be factors in how one reacts to environmental stressors including visible light.[5,6] Pigmentation changes are major in individuals with high Fitzpatrick skin photo types as melanogenic responses to visible light are more intense and thus cause more hyperpigmentation.[7] On the other hand, lighter skin types may face the breakdown of collagen and the appearance of wrinkles at an earlier stage when exposed to oxidative stress.[7] Such variations show that ethnicity could serve as an effect modifier of the LED exposure relation to the aging clinical manifestations. Besides the biological diversity, sociocultural as well as behavioral factors related to ethnicity may have an impact on the occurrence of digital exposure and the employment of protective measures. Investigations into sun-protective behaviors reveal substantial variation across ethnic groups, particularly in sunscreen usage, awareness of photoprotection, and preventive skincare practices.[8] These differences may be carried over to digital photoprotection such as the use of blue-light, filtering screens, iron oxide, involving sunscreens, antioxidants, and behavioral changes like less screen time or more viewing distance. Although there has been an increase in public discussion of blue light and skin health, the data reveals that the awareness and practice of protective behavior are still far apart.[9] It is imperative to know how these protective behaviors differ among various ethnic groups for the purpose of making public health intervention more effective.

In multi-ethnic populations, for example, those in South Asia, along with different genetic backgrounds and skin types there are diverse environmental and occupational exposures. Due to rapid urbanization and digital device usage, screen time has been dramatically increased among all socioeconomic groups. However, the link between ethnicity, digital exposure patterns, and the clinical manifestations of premature aging has not been understood in depth. Most of the literature has focused either on mechanistic laboratory studies or on general associations between screen time and aging indicators, without stratified ethnic analysis.[10] Understanding ethnic variations in digital photoaging will have major dermatological as well as public health consequences. If it is found that certain groups are more susceptible to getting hyperpigmentation, fine wrinkles, decreased elasticity, or hair changes, then evidence may be used for personalized prevention strategies. Moreover, if disparities in photoprotective behaviors are evaluated, then the results may reveal the lack of awareness or unavailability of photoprotective resources. In places with high digital penetration and where different ethnic groups are represented, such data are most valuable.[10]

This research by examining ethnic variations in skin changes and photoprotection practices, may expand our understanding of digital photoaging at the population level and contribute to the development of culturally tailored preventive strategies.

Objective:

This study focuses on premature aging patterns and photoprotective behaviors among individuals of different ethnic backgrounds who regularly use LED screen devices.

Methodology:

This cross-sectional study was conducted at PNS Shifa Hospital, Karachi, Pakistan, between October 2023 and May 2024, following approval from the Institutional Ethics Review Committee (ERC/2023/DERM/45). The present article represents a predefined subgroup analysis of previously collected data exploring the association between LED screen exposure and premature aging. Specifically, this paper focuses on assessing ethnic differences in premature aging manifestations and photoprotective behaviors within the same study population.[10]

The sample size of 450 participants was determined using Open Epi software, based on prevalence estimates from prior studies examining the association between LED exposure and premature aging outcomes.[11] This number was sufficient to ensure 80% statistical power at the 95% confidence level and to detect significant differences across ethnic subgroups using chi-square analysis. The study excluded participants who had conditions or diseases such as polycystic ovarian syndrome (PCOS), thyroid disorders, active dermatological diseases like melasma, dermatitis or erythema, pregnancy or lactation, history of aesthetic or skin procedures, or chronic systemic illnesses that affect the skin or hair, as the above factors independently can impact the skin aging and thus act as confounding variables.[11]

Data were collected through a structured, self-administered online survey specifically designed for this research. The questionnaire comprised four major sections. The first section addressed demographic information, including age (categorized as 27, 30, 31, 35, 36, and 40 years), gender, occupation, and self-reported ethnicity. Based on participants' self-identification, ethnicity was classified into Punjabi, Sindhi, Muhajir, Balochi, Pashtun, and Others. Section two thus dealt with the characteristics of LED exposure and ways of life and behavior that lead to such exposure by asking respondents about what types of LED devices they use, how long on average their daily screen time is (<2 hours, 2-4 hours, 5-7 hours, and >7 hours), how many years full-time they have been using such devices (<1 year, 1-2 years, 2-5 years, and >5 years), how close their eyes are to the screen when they are using the device (10, 20 cm, 21-30 cm, 31-40 cm, and 41-50 cm), and whether they use night mode or UV protection filters. The third part evaluated the respondents' knowledge and use of protection measures related to digital photoaging. For example, if they are aware that LED causes premature aging, are they using sunscreen with SPF, how often do they reapply it, and do they use antioxidants or anti-aging serums.[12] Section 4 focused on the premature aging signs that the participants recognized themselves, such as fine wrinkles, dry skin, hyperpigmentation or dark circles, hair loss, gray hair, and decreased skin firmness or enlarged pores.

The data were entered and statistically analyzed using the Statistical Package for Social Sciences (SPSS) version 29. The descriptive statistics were presented as frequencies/percentages for the categorical variables, while for continuous variables presented as mean and standard deviations. The chi-square test was employed for determining the association between ethnicity and premature aging indicators and also between ethnicity and protective behaviors. In cases where there were significant associations, the post-hoc pairwise comparisons with Bonferroni correction were also used. To further confirm the results of the chi-square test and to test whether the ethnicity can be a predictor of premature aging outcomes, binary logistic regression analysis was performed. Besides, the confounders which are age, gender, average daily screen time, use of SPF sunscreen, and use of antioxidants were taken into account during adjustment. As a result, the 95% confidence inter-

vals for the adjusted odds ratios (AORs) were reported. To examine whether ethnicity has an impact on the association between screen time and premature aging manifestations, the interaction terms were explored. A corresponding p-value <0.05 was deemed to represent statistical significance.

Results:

Overall, a total of 450 participants were enrolled in the study. The largest segment of the participants came from the age group 31-35 years (55.6%) and the gender distribution was almost equal. Punjabis were the major ethnic group forming 31.1% of the total, followed by Sindhi (20.2%), Muhajir (18.2%), Pashtun (11.6%), Balochi (9.8%), and other ethnic groups (9.1%).There was no statistically significant association found between ethnicity and the usage of UV protection ($\chi^2 = 5.54$, $p = 0.353$) or SPF ($\chi^2 = 9.23$, $p = 0.100$) although the level of protective behavior was generally low in all ethnic groups. Likewise, ethnicity was not significantly related to most indicators of premature aging such as dark circles ($p = 0.57$), reduced skin elasticity ($p = 0.68$), dry skin ($p = 0.60$), grey hair ($p = 0.56$), and hair fall ($p = 0.47$). The occurrence of fine wrinkles was nearly statistically significant ($p = 0.05$). Though the Punjab ethnic group participants showed a higher number of aging signs, this is most probably because of their higher number in the sample and not a real ethnic predisposition. In general, ethnic differences were seen descriptively, but no significant ethnic link with digital photoaging results was found.

Table No 1: Ethnic Distribution of Study Participants (n = 450).

Variable	Frequency (n)	Percentage (%)
Age (years)		
27-30	100	22.2%
31-35	250	55.6%
36-40	100	22.2%
Gender		
Male	225	50.0%
Female	225	50.0%
Ethnicity		
Punjabi	140	31.1%
Sindhi	91	20.2%
Balochi	44	9.8%
Pashtun	52	11.6%
Muhajir	82	18.2%

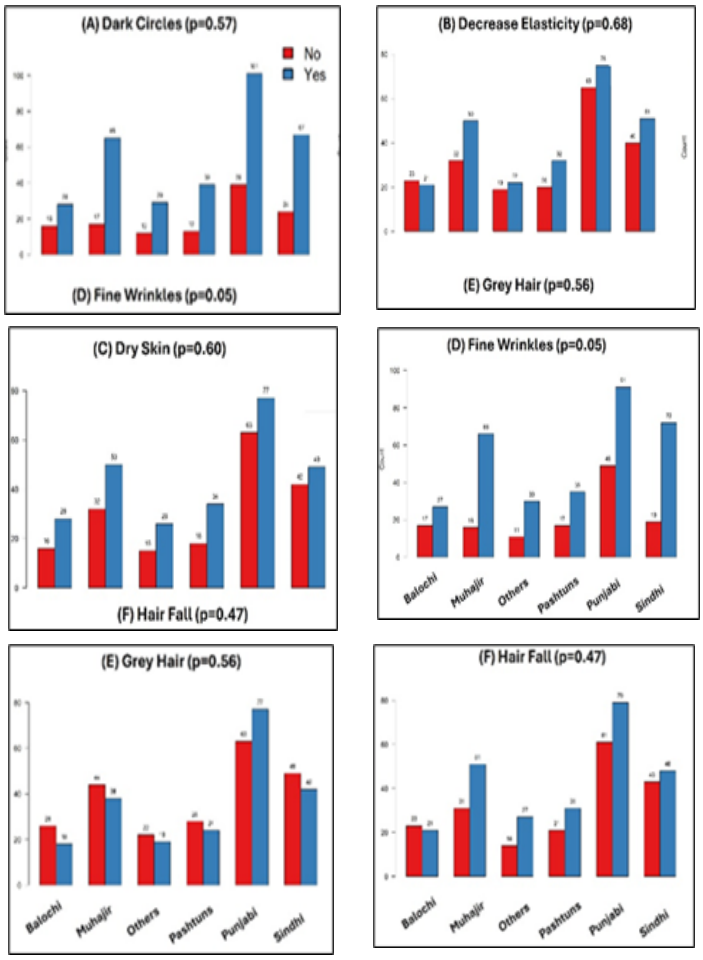
Table No 2: Association Between Ethnicity and UV Protection Use (n = 450).

Ethnicity	No; n(%)	Yes; n(%)	Total (n)
Punjabi	99 (70.7%)	41 (29.3%)	140
Sindhi	56 (61.5%)	35 (38.5%)	91
Balochi	32 (72.7%)	12 (27.3%)	44
Pashtun	35 (67.3%)	17 (32.7%)	52
Muhajir	48 (58.5%)	34 (41.5%)	82
Others	25 (61.0%)	16 (39.0%)	41
Total	295 (65.6%)	155 (34.4%)	450

Table No 3: SPF Use Across Ethnic Groups (n = 450).

Ethnicity	No (n)	Yes (n)	Total (n)
Punjabi	90	50	140
Sindhi	58	33	91
Balochi	30	14	44
Pashtun	44	8	52
Others	88	35	123
Total	310	140	450

Figure 1: Comparative Analysis of Premature Aging Indicators Among Ethnic Groups.



Discussion:

The findings of the present study indicate that although certain ethnic groups reported a higher frequency of specific skin and hair concerns, ethnicity was not significantly associated with most early aging indicators. This suggests that digital photoaging is likely influenced more by behavioral and environmental factors than by cultural practices alone.[12] The majority of participants in this study were between 31 and 35 years of age (55.6%), with an equal representation of males and females. Punjabi respondents comprised the largest ethnic group (31.1%), followed by Sindhi (20.2%) and Muhajir (18.2%). The higher frequency of complaints observed among Punjabi participants may partly reflect their greater representation in the study population rather than a genuine ethnic predisposition. Overall, protective measures against light-induced skin damage

were generally inadequate. Only 34.4% of participants reported practicing UV protection. Similarly, sunscreen use was suboptimal, with just 31.1% indicating regular SPF application. Among ethnic groups, Muhajir participants demonstrated comparatively better UV protection practices (41.5%), followed by Sindhi participants (38.5%), whereas Punjabi and Balochi participants reported the lowest usage. These findings align with previous studies highlighting poor public awareness and limited adoption of sun-protective behaviors across many populations.[13-16] The lower prevalence of UV protection and SPF use in this study population may predispose individuals to cumulative oxidative stress and compromise of the skin barrier.[15,16] Emerging evidence indicates that visible light, particularly blue light emitted from LED screens, contributes to oxidative stress, melanogenesis, and skin aging.[12,17-19] AlGhamdi et al.[20] further noted that although awareness of sun exposure risks exists, consistent sunscreen use and adequate photoprotective practices remain insufficient. Pourang A et al.[12] reported that visible light exposure can induce reactive oxygen species production and activate pigmentation pathways through oxidative stress mechanisms. Similarly, Kaltchenko MV et al.[19] demonstrated that visible light stimulates melanogenesis and promotes persistent pigmentation, especially in susceptible skin types. These mechanisms may help explain the pigmentation-related complaints and other aging signs observed among participants in the present study. Dark circles were not significantly associated with ethnicity ($p = 0.57$). Instead, they appear to be more strongly linked to sleep disturbances and digital eye strain resulting from prolonged screen exposure. Rabiei et al.[13] demonstrated that blue light filter applications can improve sleep outcomes by reducing circadian disruption induced by blue light. Likewise, Dong et al.[18] reported that blue light exposure disrupts circadian rhythm and causes cellular damage in skin tissues. Poor sleep quality has also been correlated with altered skin appearance and periorbital darkening.[14] Decreased skin elasticity ($p = 0.68$) and dry skin ($p = 0.60$) also showed no significant association with ethnicity. Jang et al.[14] reported that poor sleep resulting from excessive smartphone use was linked to deterioration in skin hydration and elasticity. In addition, Paculová V et al.[17] observed that short-term blue light exposure can impair skin barrier function and induce transient pigmentation changes. Collectively, these findings support the hypothesis that prolonged LED exposure may contribute to dryness and reduced elasticity irrespective of ethnic background. Fine wrinkles demonstrated borderline statistical significance across ethnic groups ($p = 0.05$), suggesting potential ethnic variation in wrinkle formation. Punjabi and Sindhi participants exhibited higher frequencies of fine wrinkles. Ethnic differences in melanin content, dermal thickness, and collagen architecture may contribute to these variations in wrinkle patterns. Visible light–induced oxidative stress is known to accelerate collagen degradation and photoaging changes.[12,18] Individuals with lighter skin phenotypes may develop wrinkles earlier due to reduced natural photoprotection, whereas darker skin types may experience delayed wrinkling but show a greater tendency toward pigmentary changes.[19] Grey hair ($p = 0.56$) and hair fall ($p = 0.47$) were not significantly associated with ethnicity. These findings suggest that factors such as stress, nutritional deficiencies, hormonal influences, and oxidative stress may play a more prominent role than ethnic background. Oxidative stress induced by prolonged visible light exposure may indirectly contribute to follicular damage and premature hair aging.[12,16]

Punjabi participants consistently exhibited the highest absolute frequencies of dark circles, reduced elasticity, dry skin, fine wrinkles, grey hair, and hair loss. However, given that Punjabis represented the largest ethnic group in the sample, these findings may be influenced by sample size rather than reflecting a true ethnic predisposition. In contrast, Balochi participants consistently reported the lowest symptom counts, though this may reflect smaller representation or potential underreporting. Muhajir participants demonstrated relatively greater awareness and protective practices, including higher use of UV protection, and reported moderate frequencies of aging manifestations. This suggests that preventive behaviors may mitigate certain features of digital photoaging. In contrast, Pashtun participants exhibited comparatively lower SPF use and modest frequencies of skin complaints, reflecting potential gaps in awareness or access to skincare practices. The absence of statistically significant associations for most indicators may partly reflect reliance on self-reported symptoms. Participants' perceptions of wrinkles, pigmentation, loss of elasticity, and hair changes are inherently subjective and may vary depending on individual awareness and cosmetic concerns. Incorporating objective dermatological examinations or imaging-based assessment tools would enhance the reliability and validity of future studies.

Overall, the present findings reinforce the concept that digital photoaging is multifactorial, driven by cumulative screen exposure, oxidative stress, sleep disturbances, and protective behaviors rather than ethnicity alone.[12-19] Greater awareness of photoprotection, blue light filters, antioxidants, and regular SPF use may help reduce the burden of premature aging associated with prolonged LED exposure.[13-20]

Several factors strengthen the credibility of this study. First, Pakistan's ethnically diverse population—including Punjabi, Sindhi, Muhajir, Pashtun, Balochi, and other groups—provides a robust basis for exploring ethnic differences. Second, the relatively large sample size of 450 participants and the narrow age range (27–40 years) minimize the confounding influence of age-related factors. Third, the detailed assessment of multiple aging markers and protective behaviors enabled a comprehensive evaluation of digital photoaging patterns.

Nonetheless, the analytical framework and its alignment with existing evidence must be considered when interpreting these results. The same perspective should guide future research on long-term consequences and inform the broader goals outlined in the study's summary.

Conclusion:

Ethnicity does not appear to be a significant determinant of digital photoaging among LED screen users in Pakistan; rather, environmental visible light exposure emerges as the primary driver. Despite certain study limitations, the findings support the adoption of universal photoprotective strategies, including reduced screen time, use of blue-light filters, and antioxidant-based skincare. Future longitudinal and biomarker-driven studies are warranted to elucidate underlying mechanisms and to identify subtle variations that may otherwise remain understated.

References:

1. Kumari J, Das K, Babaei M, Rokni GR, Goldust M. The impact of blue light and digital screens on the skin. J Cosmet Dermatol. 2023 Apr;22(4):1185-1190. doi: 10.1111/jocd.15576. Epub 2023 Jan 3. PMID: 36594795.
2. Christensen T, Johnsen BJ, Bruzell EM. Violet-blue light exposure of the skin: is there need for protection? Photochem Photobiol Sci. 2021 May;20(5):615-625. doi: 10.1007/s43630-021-00043-9. Epub 2021 Apr 24. PMID: 33893982.
3. Kim S, Rainer BM, Qi J, Brown I, Ogurtsova A, et al. Clinical and molecular change induced by repeated low-dose visible light exposure in both light-skinned and dark-skinned individuals. Photodermatol Photoimmunol Photomed. 2023 May;39(3):204-212. doi: 10.1111/phpp.12819. Epub 2022 Aug 1. PMID: 35861041; PMCID: PMC9859939.
4. Tao Zhang, Malyn Ungsurungsie, Liu Yue, Junxiang Li, Baoxia Zhuang, et al. Skin photobiological effect induced by BL: Clinical manifestation, mechanisms, and protection against photodamages, Journal of Dermatologic Science and Cosmetic Technology.2024; 1 (3).doi: 10.1016/j.jdsct.2024.100042.
5. Rascalou A, Lamartine J, Poydenot P, Demarne F, Bechetoille N. Mitochondrial damage and cytoskeleton reorganization in human dermal fibroblasts exposed to artificial visible light similar to screen-emitted light. J Dermatol Sci. 2018 May 5:S0923-1811(18)30213-5. doi: 10.1016/j.jdermsci.2018.04.018. Epub ahead of print. PMID: 29764717.
6. McNish H, Mathapathi MS, Figlak K, Damodaran A, Birch-Machin MA. The Effect of Blue Light on Mitochondria in Human Dermal Fibroblasts and the Potential Aging Implications. FASEB J. 2025 Jun 15;39 (11):e70675. doi: 10.1096/fj.202500746R. PMID: 40421626; PMCID: PMC12107506.
7. Paculová V, Lenobel R, Prasad A, Pospíšil P. Oxidative modification of skin collagen. Int J Biol Macromol. 2026 May;363:152174. doi: 10.1016/j.ijbiomac.2026.152174. Epub 2026 Apr 21. PMID: 42025729.
8. McKenzie C, Nahm WJ, Kearney CA, Zampella JG. Sun-protective behaviors and sunburn among US adults. Arch Dermatol Res. 2023 Aug;315(6):1665-1674. doi: 10.1007/s00403-023-02547-z. Epub 2023 Feb 15. PMID: 36790452; PMCID: PMC9930066.
9. Neal Bhatia, Natasha Atanaskova Mesinkovska, Nancy Samolitis, Seaver Soon, Tyler Steele, et al. Knowledge, Perceptions and Photoprotective Behaviors Against the Damaging Effects of Direct, Indirect, and Blue Light: There Are No “Cheat Days”. J Clin Aesthet Dermatol. 2022;15(8):E61-E66. Available from: https://jcadonline.com/photoprotective-direct-indirect-blue-light/
10. Haykal D. Screens, Blue Light, and Epigenetics: Unveiling the Hidden Impact on Skin Aging. Aesthet Surg J Open Forum. 2024 Oct 9;6:ojae088. doi: 10.1093/asjof/ojae088. PMID: 39497903; PMCID: PMC11532803.
11. Liebel F, Kaur S, Ruvolo E, Kollias N, Southall MD. Irradiation of skin with visible light induces reactive oxygen species and matrix-degrading enzymes. J Invest Dermatol. 2012 Jul;132(7):1901-7. doi: 10.1038/jid.2011.476. Epub 2012 Feb 9. PMID: 22318388.
12. Pourang A, Tisack A, Ezekwe N, Torres AE, Kohli I, Hamzavi IH, Lim HW. Effects of visible light on mechanisms of skin photoaging. Photodermatol Photoimmunol Photomed. 2022 May;38(3):191-196. doi: 10.1111/phpp.12736. Epub 2021 Oct 8. PMID: 34585779.
13. Rabiei M, Masoumi SJ, Haghani M, Nematolahi S, Rabiei R, et al. Do blue light filter applications improve sleep outcomes? A study of smartphone users' sleep quality in an observational setting. Electromagn Biol Med. 2024 Apr 2;43(1-2):107-116. doi: 10.1080/15368378.2024.2327432. Epub 2024 Mar 10. PMID: 38461462.
14. Jang SI, Jung Y, Lee M, Kim J, Kim BJ, et al. Evaluation of changes in skin characteristics due to the poor quality of sleep caused by smartphone usage. J Cosmet Dermatol. 2022 Apr;21(4):1656-1665. doi: 10.1111/jocd.14265. Epub 2021 Jun 18. PMID: 34062052.
15. Francois-Newton V, Kolanthan VL, Mandary MB, Philibert EG, Soobramaney V, Petkar G, Sokeechand BN, Hosenally M, Cavagnino A, Baraibar MA, Ng SP. The protective effect of a novel sunscreen against blue light. Int J Cosmet Sci. 2022 Aug;44(4):464-476. doi: 10.1111/ics.12794. Epub 2022 Aug 1. PMID: 35689421.
16. Yeh, W.-J., Yan, C., & Wu, C.-H. Photoprotective Effects of Phytochemicals on Blue Light-Induced Retinal Damage: Current Evidence and Future Perspectives. Nutrients.2025; 17(2), 331. doi:10.3390/nu17020331
17. Paculová V, Prasad A, Pospíšil P. Oxidative Fragmentation of Collagen in Skin: Relevance to Skin Aging and Skin Diseases. J Invest Dermatol. 2026 Feb;146 (2):550-554.e2. doi: 10.1016/j.jid.2025.08.005. Epub 2025 Aug 19. PMID: 40840842.
18. Dong K, Goyarts EC, Pelle E, Trivero J, Pernodet N. Blue light disrupts the circadian rhythm and create damage in skin cells. Int J Cosmet Sci. 2019 Dec;41 (6):558-562. doi: 10.1111/ics.12572. PMID: 31418890.
19. Kaltchenko MV, Chien AL. Photoaging: Current Concepts on Molecular Mechanisms, Prevention, and Treatment. Am J Clin Dermatol. 2025 May;26(3):321-344. doi: 10.1007/s40257-025-00933-z. Epub 2025 Mar 12. PMID: 40072791.
20. AlGhamdi KM, AlAklabi AS, AlQahtani AZ. Knowledge, attitudes and practices of the general public toward sun exposure and protection: A national survey in Saudi Arabia. Saudi Pharm J. 2016 Nov;24(6):652-657. doi: 10.1016/j.jsps.2015.04.002. Epub 2015 Apr 27. PMID: 27829807; PMCID: PMC5094427.

Authors’ contribution	
Sadia Rehman	Principal Investigator
Seemab Khan	Clinical supervision, final approval
Sassi Kanwal	Data collection, Interpretation of results
Shazia Shakoor	Literature review, analysis and interpretation findings.
Zara Sami	Statastical analysis
Muniba Abid	Write up, Literature review, data collection