Review Article Pol J Public Health, Vol. 135 (2025): 49-56

ANNA BLAZHKOVA[1], MAGDALENA CZAJA[1], DOMINIKA REHAN[2], KATARZYNA RZYM[3], HANNA SITKA[1], SVEN SOLISCH[4], ANNA SUSŁOW[1], EWA SZCZĘSNA[2]

Blue light from screen and depression – A review

Abstract

Introduction. The growing prevalence of screen time in modern societies has significantly increased exposure to blue light, especially from smartphones and computers. While blue light is crucial for circadian rhythm regulation and mood enhancement during the day, its excessive evening exposure may negatively impact sleep quality and emotional stability. Recent studies have pointed toward its potential link with the development of depressive symptoms.

Aim. This review aims to explore the relationship between exposure to blue light particularly from screen-based devices and the development or exacerbation of depressive symptoms, with a focus on biological mechanisms, epidemiological data, and the therapeutic potential of light in mood disorders.

Material and methods. A narrative review of 113 articles retrieved from PubMed and open-access sources (published up to May 2025) was conducted. The included literature covered neurobiological mechanisms (e.g., melanopsin, ipRGCs), circadian rhythm alterations, clinical trials on light therapy, and epidemiological studies linking screen time with depression. Emphasis was placed on studies investigating adolescent and adult populations, blue light wavelength sensitivity, and melatonin suppression.

Conclusions Blue light influences human physiology through melanopsin-expressing retinal ganglion cells, affecting melatonin secretion and circadian rhythms. While daytime exposure supports mood and cognitive performance, evening exposure is associated with sleep disturbances and an increased risk of depressive symptoms. Bright light therapy shows promising efficacy in treating seasonal affective disorder and may support mood regulation in broader populations.

Keywords: Blue light, depression, circadian rhythm, melatonin, screen exposure, light therapy.

DOI: 10.12923/2083-4829/2025-0010

INTRODUCTION

The average European spends as much as 2 to 3 hours per day on screen-related activities outside work [1]. The global pandemic of COVID-19 only exaggerated this trend, due to social requirements as well as psychological needs, for example excessive use of smartphones to cope with negative emotions. In general, our daily screen time varies from 5-7 hours. This means that we spend about 70-98 days every year exposed to a blue light produced by screens [2]. In Poland specifically, the national NASK Nastolatki 3.0 statistic report shows that adolescents spend on average 5 h 36 min online on school days and 6 h 16 min on non-school days [3]. Recent PISA 2022 analyses show that approximately 1 in 3 polish 15-years-old spend more then 7 h/day on non-school days with digital devises [4].

According to the definition, light is defined as electromagnetic radiation composed of photons. Visible light for humans ranges from 380 to 750 nm wavelength, which is a very narrow window of the electromagnetic spectrum. Blue light is the highest energy band of the visible spectrum (380-500 nm), moreover it is omnipresentand its main source emitting is the sun [5]. Blue light plays an essential role in synchronisation of circadian rhythms in humans, controlled by hypothalamus. Bright light is responsible for the modulation of brain function, the elevation of body temperature and heart rate, as well as the reduction of sleepiness [6]. Nowadays people are widely exposed to artificial sources of blue light, mostly from LED (light emitting-diodes) technology in computers, smartphones and television. Studies suggest that blue light exposure might influence sleep quality and duration. Insufficient sleep was declared by the Center of Disease Control and Prevention (CDC) a "public health problem". In Poland, the national statistical data shows that sleep problems are common. A recent study by Nowicki et al. shows that 50.5 per cent of adults reported subjective sleep problems [7]. Public health data aligns with this finding, noting that 20-30 per cent of adults experience sleep problems and additionally sleep disturbances affect around 80 % of people with depression [8].

Sleep disorders have been linked not only to negative health effects but also social outcomes. Poor sleep quality causes daytime sleepiness, which decreases the likelihood of engaging in social activities, isolation and deters social-emotional

[1] T. Marciniak Lower Silesian Specialist Hospital – Emergency Medicine Centre, Wrocław, Poland
[2] Lower Silesian Center for Oncology, Pulmonology and Hematology, Plac Ludwika Hirszfelda 12, 53-413 Wrocław, Poland
[3] Jan Biziel University Hospital No. 2 in Bydgoszcz, Poland
[4] University Clinical Hospital in Opole, Poland

processing [9]. Additional evidence indicates that sleep deprivation contributes to the deterioration of cognitive function and workplace productivity, resulting in more traffic accidents, industrial accidents, medical errors and loss of work productivity. Moreover, people sleeping on average less than six hours per night has a 13 per cent higher mortality risk than individuals sleeping between seven and nine hours. Workers who sleep less than seven hours per day exhibit a productivity loss, approximately 1.5 to 2.4 percentage points, due to absenteeism or presenteeism, in relation to those sleeping seven to nine hours. It is estimated that in the year 2020 the U.S. lost between $299 billion to $433 billion due to insufficient sleep [10]. In Poland, the estimated cost of insufficient sleep is approximately PLN 8-9 billion per year (these figures derive from UCE Research calculations) [11]. Inadequate sleep quality results in substantial economic losses to the modern economic, as well as social burden.

Nevertheless, in clinical practice blue light phototherapy is widely used to lower serum bilirubin level in patients with neonatal jaundice. Numerous studies report that blue light therapy can help to reduce major depression symptoms, as well as cognitive brain activity [12].

Depressive disorders can be characterised as a mood disorder that causes a persistent feeling of sadness, loss of interest, emptiness, irritable mood and simultaneously somatic and cognitive changes, which affect an individual's capacity to function. The fifth edition (DSM-5) of the Diagnostic and Statistical Manual of Mental Disorders of American Psychiatric Association distinguishes depressive disorders into: disruptive mood dysregulation disorder, major depressive disorder, persistent depressive disorder (dysthymia), premenstrual dysphoric disorder, depressive disorder due to another medical condition [13]. Depression affects more than 300 million people worldwide [14]. The average prevalence of chronic depression in 2019 among EU citizens was 7,2%, higher share was reported for women [15].

Seasonal affective disorder (SAD) is a subtype of major depressive disorder and bipolar disorder with fluctuation of symptoms. In fall and winter, we observe aggravation of depressive signs and alleviation by the spring and summer. The manifestation of seasonal depression is like atypical depression, therefore apart from classical major depressive symptoms there is observed excessive sleep and food intake. The occurrence of SAD is more frequent in temperate climates, where deficiency in light during fall-winter season is observed [13]. The incidence of SAD depends on geographic location; individualswho live in northern latitudes, farther from the equator, are more vulnerable. In clinical practice, we can use screening tools that assist in identifying patients with SAD, in particular Seasonal Pattern Assessment Questionnaire (SPAQ) [16].

Treatment of depressive disorders requires a comprehensive approach. It can be divided into pharmacological and non-pharmacological. The second one contains psychotherapy, transcranial magnetic stimulation (TMS), electroconvulsive therapy (ECT), deep brain stimulation (DBS). Recent studies suggest that blue light therapy may be useful as a part of complex treatment of depression.

STATE OF KNOWLEDGE

Blue light from screen and depression

A review of the available scientific literature reveals a complex relationship between exposure to blue light emitted by screens and the occurrence of depressive symptoms. Studies suggest a bidirectional mechanism of action—while daytime exposure to blue light may exert antidepressant effects, excessive exposure in the evening is associated with mood disturbances, primarily through disruption of the circadian rhythm and suppression of melatonin secretion [17].

Neurobiological mechanisms triggered by blue light exposure – the melanopsin pathway and intrinsically photosensitive retinal ganglion cells (ipRGCs)

The identification of melanopsin provided definitive evidence that photoreceptive functions underlying circadian, neuroendocrine and neurobehavioral responses to light are not exclusively mediated by rods and cones. In the year 1998 Provencio et al. identified an opsin in photosensitive dermal melanophores of African clawed frog (Xenopus laevis) – melanopsin [18]. Melanopsin is expressed in intrinsically photosensitive retinal ganglion cells (ipRGCs), which retain their photosensitivity even when signals from rods and cones are blocked pharmacologically [19]. These specialised retinal cells exhibit peak sensitivity to short-wavelength blue light at approximately 480 nm and are primarily involved in non-image-forming functions, including circadian rhythm regulation and mood modulation [20]. Light signals transmitted by ipRGCs reach brain regions outside the visual system that are responsible for mood and cognitive functions, leading to immediate alterations in emotional state [21]. This holds fundamental significance for understanding the effects of blue light on mood. Melanopsin is involved not only in the regulation of melatonin production by the suprachiasmatic nucleus (SCN) but also influences the activity of brain regions associated with emotional processing, such as the lateral habenula and frontal cortical areas [17,22]. Ziółkowska et al. in experimental studies on Brown Norway rats revealed that exposure to blue light may lead to downregulation of melanopsin expression in ipRGCs [23]. In this study it has been demonstrated that continuous exposure for two days to blue light-emitting diodes (LED) light with a wavelength of 463 nm significantly reduces the number of melanopsin-positive cells and induces structural damage to these cells, including dendritic vacuolisation and mitochondrial impairment. Although it is well established that blue LEDs pose a greater risk to retinal integrity compared to white or green light [24], the specific impact of monochromatic blue light exposure on ipRGCs in rats remains unexplored. These cells may be particularly vulnerable to blue light-induced damage due to the absence of myelin sheaths around their axons and the high density of mitochondria within them [25]. Blue light can interfere with mitochondrial enzymes, promoting the generation of reactive oxygen species and potentially impairing axonal transport as well as the viability of ipRGCs [26]. However, existing studies on long-term blue light exposure have focused exclusively on its effects on photoreceptors, while overlooking ipRGCs. Therefore, there is a clear need for further long-term investigations using appropriate animal models.

Effects on the circadian rhythm and melatonin secretion

Findings from multiple long-term studies consistently indicate that blue light exerts the strongest suppressive effect on melatonin secretion compared to other wavelengths within the visible light spectrum. The action spectrum for melatonin suppression shows peak sensitivity in the range of 459-464 nm, which corresponds precisely to blue light. In a controlled study by Thapan et al. 22 volunteers underwent 215 light exposures using monochromatic light at various wavelengths (424, 456, 472, 496, 520, and 548 nm). The order of effectiveness in melatonin suppression was as follows: 424 ≈ 456 nm > 472 nm > 496 nm > 520 nm > 548 nm. The most pronounced suppressive effects were observed at the shortest wavelengths within the blue light range, while efficacy declined sharply with the transition to longer green and yellow wavelengths [27].

Fundamental evidence for the predominant role of blue light in melatonin suppression originates from comprehensive action spectrum studies conducted by a research team in the United States. In a landmark study by Brainard et al. involving 72 healthy volunteers, the first spectral sensitivity map of the human melatonin-regulating system was developed [28]. The researchers exposed participants to monochromatic light at various wavelengths (ranging from 440 to 600 nm) and measured the percentage of melatonin suppression. The results clearly demonstrated that the most pronounced suppression occurred at a wavelength of 464 nm, with a very high correlation coefficient (R^2=0.91) when fitted to a vitamin A_1 retinaldehyde-based photopigment template. Similar results were obtained in more recent research published in Proceedings of the National Academy of Sciences, in which 99 young, healthy participants (mean age 22.9 years) were exposed to 6.5 hours of continuous monochromatic light at various wavelengths [29]. This study confirmed previous findings by identifying peak spectral sensitivity at 481 nm, with a significant contribution of melanopsin (81%) to the circadian phase-shifting response.

Biological mechanisms and the role of melanopsin

Information about blue light intensity is transmitted from melanopsin-containing retinal ganglion cells (ipRCGs) to the suprachiasmatic nucleus (SCN) of the hypothalamus via the retinohypothalamic tract. Melatonin (5-methoxy-N-acetyltryptamine) is produced and secreted by the pineal gland, as well as locally within the retina, in a circadian manner – remaining low throughout daylight hours and rising significantly during the night. Melatonin exerts its effects on sleep regulation, circadian rhythm disturbances, and mood disorders by binding to two high-affinity G protein-coupled receptors, known as MT1 and MT2 [30]. The suppression of melatonin secretion in response to light is mediated by melanopsin, which conveys photic signals to the pineal gland, resulting in the inhibition of melatonin synthesis. This process is directly dependent on both the intensity and wavelength of light, with blue light exerting the strongest effect.

RESULTS

Effects of Bright Light on mood depend on various factors such as light intensity, wavelength spectrum, illumination duration, time of the day, and individual circadian rhythms [31]. Blue wavelengths are beneficial during daylight hours. They improve attention, alertness, reaction times, and also mood, but during the nighttime they appear to be the most disruptive. The excessive use of smartphones, laptops as well as energy-efficient lighting, is increasing our exposure to blue light, especially after sundown [32].

Prolonged exposure to blue light can negatively impact sleep patterns and delays the circadian rhythm.

Exposure to light inhibits the secretion of melatonin, a hormone that is crucial for the circadian rhythm. Even a weak light can disrupt the human circadian rhythm and melatonin secretion. Even a light level of eight lux, which is a level of brightness that exceeds most table lamps and is about twice as much as a bedside lamp, affects our sleep. Exposure to light at night is one of the reasons why so many people don't sleep long enough. As a result too little sleep is associated with an increased risk of depression, as well as diabetes and cardiovascular problems [33,34].

Studies suggest that exposure to a bright display and light from electronic devices affects sleep latency and REM sleep but that a bright display does not affect sleep variables. Sleep latency was significantly longer, and REM sleep was significantly shorter. All these physiological changes due to the exposure to the light source generated from electronic devices cause a sleep phase shift to later hours [35-37].

Retrospective analysis of the studies showed that higher levels of smartphone use and poor sleep quality predicted depression/anxiety. Excessive use of smartphones and exposure to the blue light they emit can cause various health problems, both physical and mental. According to reports, problematic Internet use can affect sleep structure, for example by reducing REM sleep, slow-wave sleep, and sleep efficiency [38]. One study suggested several mechanisms for the relationship between electronic media use and poor sleep, one of which appears to be key: the light emitted from the screens of devices can affect sleep. Other mechanisms are: using electronic media may displace sleep, using electronic devices may be associated with cognitive, emotional, or physiological arousal, and using a cell phone in the bedroom may disrupt sleep because incoming messages may awaken adolescents at night [39]. Exposure to blue light during the day is essential for inhibiting the secretion of melatonin, a hormone produced by the pineal gland that plays a key role in regulating and synchronisation of the circadian rhythm. That is why exposure to blue light is important during the day to maintain a good mood, alertness, and mental function throughout the day. However, prolonged exposure to low-energy blue light, especially just before bedtime, can have serious consequences for sleep quality, circadian rhythm phase, and cycle length.

Moreover, the insufficient sleep quality has been associated with harmful effects on both health and daily functioning, potentially contributing to the development of depression. Since sleep plays a crucial role in regulating mood, individuals whose rest is disturbed due to the use of technology may be at greater risk of experiencing symptoms of depression, including fatigue, difficultiesin concentrating , and excessive tiredness during the day.

Light therapy has become an alternative form of treatment for depression and can be effective for some people. The greatest effectiveness of mood regulation with light has been proven especially in the context of seasonal affective disorder (SAD) – a condition characterised by recurrent depressive symptoms that worsen during months with less light and improve with the increase in daylight in spring and summer. The primary treatment for SAD involves daily exposure to bright light

in the morning, usually with a lamp that emits 2,500 to 10,000 lux for 30 minutes to 2 hours [40]. Generally, the higher the light intensity, the shorter the exposure time can be to achieve satisfactory and comparable benefits. Research shows that at least half of people with SAD have experience of significant improvement in their mood thanks to light therapy, often within a few days. Meta-analyses indicate that regular exposure to daylight can lead to a significant reduction in symptoms of depression. Light therapy produces quick results and minimal side effects compared to pharmacological treatment, which gives us more therapeutic options for many people with depression [31].

Light affects mood through various mechanisms, and the most reports are about the circadian system. This system is regulated by a network of cellular clocks, which are synchronised daily by exposure to light. This process begins when the photosensitive retinal ganglion cells (ipRGCs), which are different from the photoreceptors that form the image, detect light, especially in the blue band (~470 nm). These cells transmit information to the suprachiasmatic nucleus (SCN) in the hypothalamus, the central biological clock, which in turn regulates melatonin production through the pineal gland.

Bright light, especially in the morning hours, inhibits melatonin production and changes its rhythm, which causes the sleep-wake cycle to shift depending on the time of exposure. Morning light shortens the cycle, which promotes early bedtime and melatonin secretion, while evening light lengthens the cycle. Regular exposure to light during the day helps synchronise the circadian rhythm, which allows for earlier and more effective sleep. This connection and alignment on the circadian rhythm is associated with the improvement of both seasonal and non-seasonal depression symptoms [40].

Another way that light can affect mood is by stimulating the monoaminergic systems that influence arousal and alertness. Research clearly shows a strong connection between mood and alertness. Functional magnetic resonance imaging studies have shown that exposure to blue light for as little as 30 minutes increases activity in the rostral anterior cingulate cortex (rACC), a brain area involved in the reward system that is often smaller in people with depression. Light appears to rapidly activate neural circuits associated with positive emotions and cognitive arousal, suggesting that the direct stimulation of the cerebral cortex may be another mechanism by which light improves mood and reduces symptoms of depression [35,41].

Bright Light Therapy (BLT) affects many physiological processes, including regulation of the circadian rhythm, increased alertness through the homeostatic system, and modulation of serotonin and other monoaminergic neurotransmitters. The effect of BLT on the mood improvement depends on numerous factors, such as intensity of light, spectral composition, exposure time, administration time, and individual circadian rhythm. Research has shown that low-intensity light with a blue addition (750 lux) can have the same therapeutic effects as traditional high-intensity light (10,000 lux) in treating Seasonal Affective Disorder (SAD) [42].

Treatment with Bright Light can improve quality of sleeping, increase alertness, and regulate circadian rhythm disorders such as Delayed Sleep Phase Syndrome, which is often associated with mood disorders. This effect can minimise the risk of early recurrence of symptoms and episodes of depression.

Working the night shift disrupts the cortisol and melatonin cycles, the secretion of which is associated with white light also from screens, which directly affects the quality of sleep. In the year 2023, Salman M Alreshidi et al. conducted a study examining the sleep quality of nurses [43]. The study found that nurses who worked the night shift had poorer sleep quality than their colleagues working the day shift. Furthermore, sleep deprivation negatively impacts their health. Thestudy was conducted between March and April of 2023 in Medical City, Riyadh Province, central Saudi Arabia. The sleep quality of 191 nurses was assessed using the Arabic version of the Pittsburgh Sleep Quality Index (PSQI). The PSQI is a 19-item, psychometrically validated measure of sleep quality and disturbances, rated on a scale from 0 to 21. A score of <5 indicates good sleep quality, while a score >5 indicates poor sleep quality. The Arabic version of the Hospital Anxiety and Depression Scale (HADS) was used to measure depressive symptoms. Participants were asked to respond to each question on a questionnaire regarding their well-being over the past week using a 4-point Likert scale ranging from 0 (normal) to 3 (severe). The study results showed that 73.3% of the nurses surveyed suffered from depressive symptoms.

DISCUSSION

The current study shows the connection between exposure to blue light from electronic devices and the incidence of depression, which is dominantly conducted through circadian rhythm disturbance and melatonin inhibition. The findings are in accordance with the existing literature, which highlights the double-sided impact of blue light on human physiology and overall mood. During the day, exposure to blue light has been linked to the promotion of alertness and cognitive functioning. According to study by Cajochen et al., which showed how exposure to light with a color temperature of 6500K not only suppressed the onset of melatonin more strongly but also promoted better individual alertness and cognitive performance than exposures with lower color temperatures [44]. This suggests the advantages of blue-enriched light in the day on mood and cognitive functions, while the exposure during night time has an ability to disrupt and dysregulate the brown adipose tissue, sleep, and mood regulation. Research indicates that even low-intensity blue light can delay melatonin onset, leading to disruptions in sleep architecture [45]. Such disruptionshave serious consequences , as there has been a proven association between the disturbance of sleep and the onset of depressive symptoms. The intrinsically photosensitive retinal ganglion cells (ipRGCs) and the involvement of melanopsin in the action of blue light on circadian rhythms have been established. Melanopsin-ipRGCs are maximally sensitive to light at around 480 nm, the same as the maximum sensitivity for the suppression of melatonin. These ipRGCs project into the suprachiasmatic nucleus (SCN), the central circadian clock, therefore affecting mood regulation and the sleep-wake response. What is interesting is that the effect was significantly greater in adolescence, which points out the susceptibility of this population group to the negative effects of excess screen exposure. Additionally, the timing and duration of screen exposure plays important role in shaping its effect on mental health. Evening use of electronic devices has been identified as a major cause of delayed onset of sleep and shorter duration of sleep, both of which are significant contributors to mood disturbance.

The reduction of screen use during the evening and the rapid development of technologies aimed at reducing its negative impact on circadian rhythms and mental health is underway. Future research should primarily assess the effectiveness of various protective solutions, including blue light filtering glasses, special screen coatings, and night modes in devices. Such solutions could contribute not only to improve sleep quality and reduce likelihood of developing mood disorders such as depression, but also to the overall well-being of people who use blue light-emitting devices [46,47]. In addition to research on blue light reduction technologies, it is also worth to consider the potential benefits and risks of phototherapy - an important clinical aspect, as its appropriate use can improve the condition of patients with mental disorders such as insomnia or depression [48]. Determining the specific exposure conditions and parameters of light used in the treatment of the conditions, including intensity, wavelength and time of application, seems crucial in the context of phototherapy's safety and effectiveness. This approach will enable to identify situations in which the therapeutic benefits outweigh the potential harmful effects, for example, leading to sleep disturbances or nervous system hyperexcitability. Therefore, further research involving large, diverse populations is necessary to develop appropriate therapeutic methods using light for various conditions.

The important fact is that poor sleep quality is associated with symptoms of depression. Shorter sleep duration over a six-month period is associated with more severe depression in those who experienced a depressive episode [49]. One possible explanation for the results of a study on sleep quality in night shift nurses is that night shifts disrupt the nurses' circadian rhythm, negatively impacting sleep and thus triggering depressive symptoms [50]. Other studies have shown a correlation between circadian rhythm disruptions, sleep quality and depressive symptoms. This phenomenon may result from abnormal cortisol secretion patterns [51]. Individuals who experience symptoms of depression secrete more cortisol, which disrupts the rhythm found in healthy individuals, whereby cortisol secretion peaks in the morning and gradually decreases throughout the day, reaching its lowest level in the evening [52]. It is worth to add here information from another study demonstrating a link between melatonin and cortisol. Claustrat et al. conducted a chronobiological study of melatonin and cortisol secretion in depressed subjects [53]. The temporal organisation of plasma melatonin and cortisol secretion was examined in healthy control participants and in depressed patients from the study group. Eleven patients with primary affective disorders (10 women, 1 man) and 8 men from the control group were examined over a 24-hour period. The study involved blood sampling every 2 hours during the day and every hour at night. Plasma melatonin and cortisol concentrations were determined using a radioimmunoassay. Additionally, plasma melatonin was measured at 3:00 AM in older men from the control group (n=8) and in women (n=10) at the time of ovulation. The study results showed that the control group produced low or undetectable circadian plasma melatonin levels and a very pronounced nocturnal rhythm. No significant difference was observed in the nocturnal melatonin peak at 3:00 AM among the three control groups. Patients with depression also demonstrated a significant melatonin rhythm, but at a lower level. In nine of the eleven patients, nocturnal melatonin secretion was less pronounced and often associated with hypercortisolemia. Additional episodic melatonin secretion in the late afternoon was observed in only two patients. Patients with depression showed an increase in mean cortisol secretion. However, research findings in this area are inconsistent. For example, a study conducted among nurses in Norway found no significant correlation between sleepiness and night shift work [54]. However, it should be noted that differences in national healthcare systems, work environments, and workload may be partially responsible for these contradictory results. However, these studies suggest a relationship between cortisol and melatonin, whose secretion is influenced by bright light also emitted by screens, and their level, which influence sleep quality and disturbances and, consequently, the incidence of depression.

Older adults represent another high-risk group in whom disturbances of sleep and circadian rhythm are strongly associated with depressive symptoms. Epidemiological data indicate that up to 50% of older adults report chronic sleep problems, which frequently co-occur with late-life depression. In community studies, insomnia is not simply a benign feature of aging but is a significant predictor of depressive symptoms and functional decline [55,56].

With advancing age, biological mechanisms further increase vulnerability to the disorder. A decline in nocturnal melatonin secretion and phase shifts of circadian rhythms are common in older adults, resulting in difficulties initiating and maintaining sleep [57]. Moreover, flattening of the diurnal cortisol slope has been described in depressed older adults, which is associated with worse health outcomes [58]. These neuroendocrine changes underline the importance of circadian misalignment as a driver of late-life mood disorders.

As a conclusion, older adults,like shift workers,represent a particularly vulnerable population, in whom circadian rhythm disruption, poor sleep hygiene, and psychosocial stressors converge to significantly increase the risk of depression.

Several limitations of the present study should be considered. Most of the reports are about cross-sectional correlation studies, which means that it is difficult to determine the causal direction. In the studies discussed in this work, researchers reported mostly correlations between variables (screen time and depression), but not evidence that screen time causes depression, rather than its converse, or that the correlation is confounded by other variables. The cross-sectional design restricted our understanding of the long-term effect of screen time changes on depression. To establish causality, other research methods are needed, such as longitudinal studies (tracking changes over time), controlled experiments or advanced statistical analyses that remove the effect of confounding variables. It is likely that the relationship between screen time and depressive symptoms is bidirectional, but this cannot be addressed without longitudinal or interventional studies. Furthermore, studies are characterised by considerable methodological heterogeneity: questionnaires and criteria used to measure screen use and depression vary, and populations from different age groups and socioeconomic backgrounds are included. Most of the results are based on self-reports regarding their sleep-wake history and light exposure rather than more objective measurements. In addition, most studies only accounted for the quantitative level of screen use (duration), not the qualitative nature of media content. It remains unclear which types of social media, types/genres of television, and content are associated with depression. Different social media use, internet activities, or TV genres may have varied, and even opposite,

associations with mental health. The research used in this work comes from various countries and cultures. Therefore, there is a possibility of differences because there are cultural differences in the available technology. Additionally, there is a wide variability in the overlap between the data collection period and the COVID-19 pandemic, which makes it difficult to determine the possible effect of the pandemic. These discrepancies in study designs and measurement instruments lower compatibility and make it difficult to synthesize the results.

Recommendations and practice guidlines

Guidelines from major public health organisations recommend reducing sedentary evening screen exposure, especially in children and adolescents, and prioritising healthy sleep and physical activity. The World Health Organisation recommends no sedentary screen time for infants <1 year old. Sedentary screen time is also not recommended for 1-year-olds. For children age 2 years, ≤1 h/day (less is better). For children ages 3-4 years old, ≤1 h/day (less is better) [59]. In children and adolescents 5-17 years old the WHO guideline from 2022 recommends limiting sedentary behavior, in particular recreational screen-based time (no specific hourly limit) , while maintaining ≥60 min/day moderate to vigorous physical activity. This WHO guideline for adults recommends reducing sedentary time, including screen time (no specific hourly limit), and increasing physical activity [60]. Given the circadian phase delaying effect of evening exposure to short-wavelength light, several major sleep organisations advise screen-time restrictions before bedtime.

1. Occupational sleep safety guidance recommends dimming light and stopping use of back-lit devices 1-2 h before sleep. NHS guidelines advise ≥1 h of screen-free time before sleep [61,62].
2. Pediatric and sleep health organisations recommend device-free bedrooms and regular sleep-wake schedules [63].
3. As a supportive measure blue light reducing settings can be enabled on electronic devices. Blue-blocking lenses before sleeping improved sleep in an RCT of insomnia patients, notably with variable effect by individual and content.
4. Morning light supports circadian absorption and earlier melatonin onset. Prioritising exposure to morning or daytime light is recommended.

Preventive practices for implementation in education, workplaces and public campaigns. Below we provide several examples of preventive practices that aim to improve general population life and sleep quality.

1. Introduction of phone usage restrictions policies in schools. The UNESCO Global Monitoring Report from 2023 argues for electronic devices in classrooms only when it demonstrably supports learning [64].
2. Integration into school health education programmes and communication with parents od standard messages promoting evening “digital curfews and device-free bedrooms [63].
3. Encourag outdoor breaks in schools that priorities exposure to daylight, to support circadian alignment and mental health, as well as physical activity [59].
4. EU/UK guidelines recommend periodic short breaks from display screen equipment (DSE) users [65,66].
5. Provid fatigue management education (sleep and light exposure scheduling) for shift workers and minimizing quick rotations [67].

CONCLUSION

This paper presents a review of the literature on how blue light exposure impacts circadian rhythm physiology, sleep, and depressive symptoms development, especially among young people. The topic is gaining both health and social importance as time spent in front of the screens has been increasing through recent years, especially since the COVID-19 pandemic. Blue light with wavelength 380–500 nm, is present in daylight and it regulates the circadian rhythm. It contributes to mood enhancement, cognitive functioning, and the regulation of melatonin secretion. However, its artificial sources, such as screens of mobile devices or energy-efficient lighting, can lead to physiological disturbances, especially when they are used in the evening. Cells called intrinsically photosensitive retinal ganglion cells (ipRGCs), act as central players for blue light effects. They contain melanopsin, which is most sensitive to light around 480 nm wavelength. These cells transmit light signals toward the suprachiasmatic nucleus (SCN), influencing circadian rhythms and mood regulation. Blue light is the strongest inhibitor of melatonin secretion, the hormone responsible for sleep. During the day, this inhibition has a physiological purpose to keep the body in an alert state. However, in the evening, even small amounts of blue light can suppress melatonin production. Inhibition of melatonin leads to difficulty in falling asleep, reduced sleep quality, and dysregulation of the circadian rhythm, which is directly linked to the development of depressive symptoms. Evening exposure to screen light and following sleep disturbances are strong predictors of both depression and anxiety. Exposure to blue light in the evening not only delays sleep onset and shifts the REM phase but also reduces overall sleep quality and efficiency. Consequently, this leads to excessive daytime sleepiness and fatigue, which in turn can cause problems with concentration. As has been shown , all of those factors result in increased risk of developing depression, anxiety, and other emotional disorders. On the other hand, light can also bring therapeutic benefits. Bright light therapy (BLT), used mainly in the treatment of seasonal affective disorder (SAD), involves morning exposure to strong light, which supports circadian rhythm synchronisation and improves mood, giving better treatment outcomes. Therefore, light therapy is a promising addition to depression treatment, particularly in the context of circadian rhythm disturbances. Limiting electronic device use before bedtime, preferably a few hours before sleep, combined with using blue light filters and the promotion of sleep hygiene, plays a critical role in supporting good sleep quality. It is important to note that blue light has both beneficial and negative effects on our health. The time of exposure is crucial, and reducing evening screen time may help prevent its impacts on health and circadian rhythms.

REFERENCES

1. European Commission (Eurostat). Are Europeans glued to their screens? [https://ec.europa.eu/eurostat/web/products-eurostat-news/-/ddn-20180507-1] (access: 10.08.2025).
2. Comparitech. Screen Time Statistics: Average Screen Time by Country. [https://www.comparitech.com/tv-streaming/screen-time-statistics/] (access: 10.08.2025).
3. Nastolatki 3.0 (edycja 2022): zachowania młodzieży online – główne wyniki. NASK; 2022. [https://www.nask.pl/magazyn/nastolatki-3-0-raport-z-ogolnopolskiego-badania-uczniow-i-rodzicow] (access: 10.08.2025).

4. Polscy piętnastolatkowie w perspektywie międzynarodowej. Wyniki badania PISA 2022. IBE (PISA); 2022.
5. Cougnard-Gregoire A, Merle BMJ, Aslam T, et al. Blue light exposure: ocular hazards and prevention-a narrative review. Ophthalmol Ther. 2023;12(2):755-88.
6. Wahl S, Engelhardt M, Schaupp P, et l. The inner clock-Blue light sets the human rhythm. J Biophotonics. 2019;12(12):e201900102.
7. Nowicki Z, Grabowski K, Cubała WJ, et al. Prevalence of self-reported insomnia in general population of Poland. Psychiatr Pol. 2016;50(1):165-173.
8. Sen. Dużo śpij, długo żyj. Akademia NFZ; 2025.
9. Holding BC, Sundelin T, Schiller H, et al. Sleepiness, sleep duration, and human social activity: An investigation into bidirectionality using longitudinal time-use data. Proc Natl Acad Sci USA. 2020;117(35):21209-17.
10. Hafner M, Stepanek M, Taylor J, et al Why sleep matters-the economic costs of insufficient sleep: a cross-country comparative analysis. Rand Health Q. 2017;6(4):11.
11. Polacy mają problem ze snem – gospodarka traci na tym mld zł rocznie (2024-2025 update). UCE Research; 2024.
12. Silvani MI, Werder R, Perret C. The influence of blue light on sleep, performance and wellbeing in young adults: A systematic review. Front Physiol. 2022;13:943108.
13. Diagnostic and Statistical Manual of Mental Disorders, 5th ed. APA. DSM-5. [https://dn790004.ca.archive.org/0/items/APA-DSM-5/DSM5.pdf] (access:11.08 2025).
14. Arias-de la Torre J, Vilagut G, Ronaldson A, et al. Prevalence and variability of depressive symptoms in Europe. Lancet Public Health. 2023;8(11):889-98.
15. 7.2% of people in the EU suffer from chronic depression (statistic). European Commission/Eurostat; 2025.
16. Chang CE, Chen HC, Chen IM, et al. Evaluation of seasonal variations for the seasonal pattern assessment in mood disorder patients and healthy controls. BMC Psychiatry. 2025;25(1):458.
17. Burge MT, Lumapas RL, Lander AC, et al. Blue light influences negative thoughts of self. Sleep. 2025;48(7).
18. Provencio I, Jiang G, De Grip WJ, et al. Melanopsin: An opsin in melanophores, brain, and eye. Proc Natl Acad Sci USA. 1998;95(1):340-5.
19. Gooley JJ, Lu J, Chou TC, et al. Melanopsin in cells of origin of the retinohypothalamic tract. Nat Neurosci. 2001;4(12):1165.
20. Hattar S, Liao HW, Takao M, et al. Melanopsin-containing retinal ganglion cells: Architecture, projections, and intrinsic photosensitivity. Science. 2002;295:1065-70.
21. LeGates TA, Fernandez DC, Hattar S. Light as a central modulator of circadian rhythms, sleep and affect. Nat Rev Neurosci. 2014;15(7):443-54.
22. Alkozei A, Dailey NS, Bajaj S, et al. Exposure to blue wavelength light is associated with increases in bidirectional amygdala-dlpfc connectivity at rest. Front Neurol. 2021;12:625443.
23. Ziólkowska N, Chmielewska-Krzesinska M, Vyniarska A, et al. Exposure to blue light reduces melanopsin expression in intrinsically photoreceptive retinal ganglion cells and damages the inner retina in rats. Invest Ophthalmol Vis Sci. 2022;63(1):26.
24. Krigel A, Berdugo M, Picard E, et al. Light-induced retinal damage using different light sources, protocols and rat strains reveals LED phototoxicity. Neuroscience. 2016;339:296-307.
25. Bristow EA, Griffiths PG, Andrews RM, et al. The distribution of mitochondrial activity in relation to optic nerve structure. Arch Ophthalmol. 2002;120(6):791-6.
26. Osborne NN, Li GY, Ji D, Mortiboys HJ, Jackson S. Light affects mitochondria to cause apoptosis to cultured cells: possible relevance to ganglion cell death in certain optic neuropathies. J Neurochem. 2008;105(5):2013-2028.
27. Thapan K, Arendt J, Skene DJ. An action spectrum for melatonin suppression: evidence for a novel non-rod, non-cone photoreceptor system in humans. J Physiol. 2001;535(Pt 1):261-267.
28. Brainard GC, Hanifin JP, Greeson JM, et al. Action spectrum for melatonin regulation in humans: evidence for a novel circadian photoreceptor. J Neurosci. 2001;21(16):6405-6412.
29. St Hilaire MA, Ámundadóttir ML, Rahman SA, et al. The spectral sensitivity of human circadian phase resetting and melatonin suppression to light changes dynamically with light duration. Proc Natl Acad Sci USA. 2022;119(51):e2205301119.
30. Liu J, Clough SJ, Hutchinson AJ, et al. MT1 and MT2 melatonin receptors: a therapeutic perspective. Annu Rev Pharmacol Toxicol. 2016;56:361-83.
31. Maruani J, Geoffroy PA. Bright light as a personalized precision treatment of mood disorders. Front Psychiatry. 2019;10:85.
32. Vandewalle G, Balteau E, Phillips C, et al. Daytime light exposure dynamically enhances brain responses. Curr Biol. 2006;16(16):1616-21.
33. Impacts of Blue Light Exposure From Electronic Devices on Circadian Rhythm and Sleep Disruption in Adolescent and Young Adult Students Chronobiol Med. 2024;6(1):10-4.
34. Blazhkova A, Rehan D, Rzym K, et al. The Impact of sleep disorders on cardiovascular risk. J Educ Health Sport. 2025;81:59851.
35. Higuchi S, Motohashi Y, Liu Y, et al. Effects of VDT tasks with a bright display at night on melatonin, core temperature, heart rate, and sleepiness. J Appl Physiol. 2003;94(5):1773-6.
36. Chen YL, Gau SS. Sleep problems and internet addiction among children and adolescents: a longitudinal study. J Sleep Res. 2016;25(4):458-65.
37. Duffy JF, Czeisler CA. Effect of light on human circadian physiology. Sleep Med Clin. 2009;4(2):165-77.
38. Dworak M, Schierl T, Bruns T, Strüder HK. Impact of singular excessive computer game and television exposure on sleep patterns and memory performance of school-aged children. Pediatrics. 2007;120(5):978-85.
39. Cain N, Gradisar M. Electronic media use and sleep in school-aged children and adolescents: A review. Sleep Med. 2010;11(8):735-42.
40. Tao L, Jiang R, Zhang K, et al. Light therapy in non-seasonal depression: An update meta-analysis. Psychiatry Res. 2020;291:113247.
41. Killgore WDS. Lightening the mood: evidence for blue light exposure in the treatment of post-concussion depression. Expert Rev Neurother. 2020;20(11):1081-3.
42. Meesters Y, Dekker V, Schlangen LJ, et al. Low-intensity blue-enriched white light (750 lux) and standard bright light (10,000 lux) are equally effective in treating SAD. A randomized controlled study. BMC Psychiatry. 2011;11:17.
43. Alreshidi SM, Rayani AM. The correlation between night shift work schedules, sleep quality, and depression symptoms. Neuropsychiatr Dis Treat. 2023;19:1565-71.
44. Chellappa SL, Steiner R, Blattner P, et al. Non-visual effects of light on melatonin, alertness and cognitive performance: can blue-enriched light keep us alert? PLoS One. 2011;6(1):16429.
45. Heo JY, Kim K, Fava M, et al. Effects of smartphone use with and without blue light at night in healthy adults: A randomized, double-blind, crossover, placebo-controlled comparison. J Psychiatr Res. 2017;87:61-70.
46. Ostrin LA, Abbott KS, Queener HM. Attenuation of short wavelengths alters sleep and the ipRGC pupil response. Ophthalmic Physiol Opt. 2017;37(4):440-50.
47. Shechter A, Kim EW, St-Onge MP, et al. Blocking nocturnal blue light for insomnia: A randomized controlled trial. J Psychiatr Res. 2018;96:196-202.
48. Terman M, Terman JS. Light therapy for seasonal and nonseasonal depression: efficacy, protocol, safety, and side effects. CNS Spectr. 2005;10(8):647-72.
49. Perlman CA, Johnson SL, Mellman TA. The prospective impact of sleep duration on depression and mania. Bipolar Disord. 2006;8(3):271-4.
50. H-S KIM, Choi K-S, Eom M, et al. Role of circadian types and depressive mood on sleep quality of shift work nurses. Korean J Psychopharmacol. 2011;2011:96-104
51. Peeters F, Nicolson NA, Berkhof J. Levels and variability of daily life cortisol secretion in major depression. Psychiatry Res. 2004;126(1):1-13.
52. Cervantes P, Gelber S, Kin FN, et al. Circadian secretion of cortisol in bipolar disorder. J Psychiatry Neurosci. 2001;26(5):411-6.
53. Claustrat B, Chazot G, Brun J, et al. A chronobiological study of melatonin and cortisol secretion in depressed subjects: plasma melatonin, a biochemical marker in major depression. Biol Psychiatry. 1984;19(8):1215-28.
54. Øyane NM, Pallesen S, Moen BE, et al. Associations between night work and anxiety, depression, insomnia, sleepiness and fatigue in a sample of Norwegian nurses. PLoS One. 2013;8(8):e70228.
55. Foley DJ, Monjan AA, Brown SL, et al. Sleep complaints among elderly persons: an epidemiologic study of three communities. Sleep. 1995;18(6):425-32.
56. Almeida OP, Pfaff JJ. Sleep complaints among older general practice patients: association with depression. Br J Gen Pract. 2025;55(520):864-6.
57. Hood S, Amir S. The aging clock: circadian rhythms and later life. J Clin Invest. 2017;127(2):437-46.
58. Adam EK, Quinn ME, Tavernier R, et al. Diurnal cortisol slopes and mental and physical health outcomes: A systematic review and meta-analysis. Psychoneuroendocr. 2017;83:25-41.
59. World Health Organization. Guidelines on physical activity, sedentary behaviour and sleep for children under 5 years of age. Geneva: WHO; 2019.
60. World Health Organization. WHO Guidelines on physical activity and sedentary behaviour. Geneva: WHO; 2020.
61. Tips for reducing fatigue during long hours/shift work. CDC; 2025.
62. NHS. Fall asleep faster and sleep better – Every Mind Matters. [https://www.nhs.uk/every-mind-matters/mental-wellbeing-tips/how-to-fall-asleep-faster-and-sleep-better/] (access: 07.08.2025).

63. Where We Stand: Screen Time. HealthyChildren.org (AAP); 2025. [https://www.healthychildren.org/English/family-life/Media/Pages/Where-We-Stand-TV-Viewing-Time.aspx] (access: 07.08.2025).
64. Technology in education – A tool on whose terms? Key messages on restricting classroom smartphone use unless it supports learning. UNESCO GEM Report; 2023.
65. HSE (UK). Working safely with display screen equipment – work routine and breaks. [https://www.hse.gov.uk/msd/dse/work-routine.htm] (access: 07.08.2025).
66. Council Directive 90/270/EEC on minimum safety and health requirements for work with display screen equipment. EUR-Lex; 2025.
67. Light – Coping with night/evening shifts (manipulating light exposure for circadian adaptation). CDC/NIOSH; 2025. [https://www.cdc.gov/niosh/centers/fatigue.html] (access: 07.08.2025).

Corresponding author
Dominika Rehan
Lower Silesian Center for Oncology, Pulmonology and Hematology
12 Plac Ludwika Hirszfelda St., 53-413 Wrocław
e-mail: dominikarehan3@gmail.com