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Research Article

The Relationship between Long Use of Communication Devices that Emit Blue Light with Sleep Quality

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Abstract

Nowadays communication device usage has already reached an unprecedented level. Based on data provided by Central Statistics Agency (BPS), by 2018, at least 62% of Indonesian had a cellphone or a smartphone, and 20% had a computer. Besides smartphones and computers, many Indonesians choose television (TV) as their entertainment device, as proven by 57% of Indonesian households having a TV, although the number has been reduced in the past decade. Based on research conducted by Zickuhr, in 2011, average adults in the United States spent 7-10 hours using their communication device per day, with the most usage in the young adult population (18-35 years) and decreasing as the age increased. The recent development of computer-based communication devices increased our chances of spending much time staring at the blue light emitting screen. Research about the blue light emission effect has become a significant concern, especially in the last five years. It is due to its effect on sleep quality and eyes well-being. This research is an analytic descriptive, non-experiment cross-sectional study. The research uses a prospective and retrospective approach due to the type of data is primary data collected using a questionnaire distributed through social media. Based on Slovin's formula, the sample needed for this study is 133 respondents. This study showed a significant correlation between the usage of blue light-emitting communication devices, sleep quality (P = 0.000), and a moderate relation (r = 0.425) with the positive pattern.

Keywords: Communication device usage, blue light, sleeps quality

INTRODUCTION

Nowadays communication tools have reached an extensive scale [1; 2]. According to Gadzama et al., in 2015, 4.7 billion people used smartphones worldwide, and it is estimated that it will reach 5.6 billion people by the end of 2020. In Indonesia, based on data from the Central Statistics Agency (BPS), at least 62% of the Indonesian population owns a cellular phone or mobile phone, and 20% have a computer [2]. From the total users of these communication tools, 66% have a connection to the internet network. According to the distribution by age, communication tools users (smartphones and computers) in Indonesia are dominated mainly by users aged 25 years and over (50%). Other than smartphones and computers, TV is still the choice of Indonesian people, with 57% of households owning a television, even though the number of viewers has declined in the past decade. In addition to the communication tools available to all walks of life, the time spent using these communication tools has also increased. According to the research conducted by Sundus, children in the United States can spend up to 8 hours daily using smartphones and watching TV [3]. In Indonesia, according to research conducted by Suhana, children, and adolescents (aged 0-18 years) who should not use communication tools for more than 2 hours, spend up to 5 times the standard recommendation (8-10 hours). 4]. In the adult population, there is also no significant difference regarding the use of communication tools, and according to research conducted by Zickuhr, the average adult spends 7-10 hours a day using communication tools, with the most extended use in the young adult population (age 18 years -35 years) and decreases with age [6].

The development of computer-based communication tools today increases our possibility of seeing a screen that emits light for a long time [6]. The screens on communication devices that we mostly use today have LED (Light Emitting Diode) technology [6;7;8]. We can see this on smartphones, computer monitors, and TVs. LEDs are widely used because they are more environmentally friendly and thinner than their predecessors, such as LCD (Light Crystal Display) and CRT (Cathode Ray Tube)7. The massive use of LED screens does not come without drawbacks. Blue light pollution is often discussed as an adverse effect [6;9]. Research on the effects of blue light pollution has received much attention, especially in the last five years [6; 7]. It is due to its effect on sleep quality and eye health. According to research conducted by Zhao et al., direct exposure to blue light can cause damage to the cornea, lens, and retina due to the nature of blue light, which increases the production of reactive oxidative species (ROS) [7], although according to O'Hagan et al. occurs when there is the extreme exposure to blue light, almost equal to that of midday sunlight (8000-1000lux) [8]. Circadian rhythm-regulating hormones such as melatonin and serotonin are also affected due to exposure to blue light [6; 9]. Exposure to blue light, especially at night, will reduce the secretion of hormones that regulate circadian rhythms, resulting in decreased sleep quality. Although, in various studies, it has been proven that blue light exposure can cause various disorders, blue light exposure therapy can be used to relieve symptoms of seasonal affective disorder (SAD) [9]. In geriatric patients, blue light therapy during the day combined with antipsychotics can help improve sleep quality [10].

In Indonesia, only few studies discuss the effects of blue light exposure on health. Given the large number of users of modern communication tools in Indonesia, such as smartphones, tablets, laptops, and computers, researchers are interested in knowing whether the use of communication tools in Indonesian society can affect sleep quality. Coupled with the current pandemic conditions that make people have to spend time at home, which increases the time they use gadgets for entertainment. Based on the above background, the research problem is formulated as follows: Can the use of communication devices that emit blue light affect sleep quality? The research aims to determine the relationship between communication tools that emit blue light and sleep quality.

LITERATURE REVIEW

Light is an irreplaceable part of our lives. Light can be a source of energy, enabling living things to see and much more. Light can be defined in many contexts, but in general, light can be defined as optical radiation or electromagnetic radiation, which has a wavelength between 10nm to 1mm. It includes ultraviolet, visible, and infrared light [11]. The light that is usually emitted by communication devices is part of the light that can be seen by humans or the visible light spectrum, whose wavelength is between 400-700nm. The human eye will see the colors in this spectrum as red, orange, yellow, green, blue, indigo, and purple; a combination of all these colors with the same intensity can be seen as white. Blue light or blue light is part of this color spectrum with a wavelength of 430-480nm [11].

Blue light can come from a variety of sources. The most significant source of blue light radiation is sunlight, but many things in our daily lives, such as smartphones, televisions, computer screens, LED lights, and fluorescent lights, can also be sources of blue light radiation. The blue light exposure given by these devices is indeed low, but prolonged and repeated exposure times can cause unwanted effects of blue light [6; 11].

In general, light that can be seen by humans based on wavelength can be divided into 3, namely long (red), medium (green), and short (blue). Like other electromagnetic waves, the shorter the wavelength, the more energy the wave will have, and the high energy radiation that can cause abnormalities in the human body [11]. Blue light can have a negative effect if exposed to a significant intensity or long exposure time [6, 7, 8, 9]. In general, the impact of blue light on humans can be divided into 2, namely visual and non-visual effects.

Sleep has many definitions. According to Guyton & Hall, sleep is defined as an unconscious state that can be awakened by giving sensory or other stimuli [16]. Another definition, according to Carley & Farabi, sleep is an active process and is influenced by homeostasis from wakefulness to sleep, which is regulated by circadian rhythms with a cycle of 24 hours a day [17]. Meanwhile, according to WHO, sleep is a physiological state that occurs alternately with awareness, whose duration and quality are equally important for the quality of life. Sleep and wake-up cannot be separated but are related [18]. It can be concluded that sleep is an essential process in life, and sleep is not a passive process but an active process that involves many body functions.

Each individual's sleep needs vary. The factor that has the most significant influence on a person's sleep needs is age. Adults usually need 7-8 hours of sleep, while babies can spend 14-20 hours a day sleeping. In addition to age, several other factors that can also affect a person's sleep needs are the presence or absence of physical illness, lifestyle, environment, and activities carried out while the individual is awake [19; 20].

Not only mammals, sleep can be observed in birds, flies, and lower organisms such as worms [20]. It indicates that sleep is a physiologically important process. The function of sleep is still being debated, but many researchers believe that sleep does not only have one physiological function [20;21].

Although the exact function of sleep remains a mystery, sleep is essential for maintaining an individual's motor, cognitive, and mental balance [16; 18]. It is seen that individuals who experience sleep deprivation will experience a progressive decline in cognitive function, which sometimes can cause abnormal behavior. In addition to cognitive and behavioral disturbances, long periods of awake condition can also cause mental disorders such as being easily irritated and becoming psychotic in intensive awake period [16; 22].

There are two stages of sleep, namely, Non-Rapid Eye Movement (NREM) sleep and Rapid Eye Movement (REM) sleep. NREM sleep is divided into stages 1,2,3 and 4, followed by the REM phase. NREM and REM phases occur alternately, about 4-5 cycles in one night [26]. During the sleep period, NREM and REM change alternately. The function of alternation between these two types of sleep is not yet understood, but irregular cycles and the absence of sleep stages are associated with disturbed sleep. For example, instead of entering sleep via NREM, as usually, individuals with narcolepsy enter sleep directly into REM sleep [26]. The sleep episode begins with a brief period of NREM stage 1 that progresses to stage 2, followed by stages 3 and 4, and finally to REM. However, individuals do not remain in REM sleep throughout the night but instead cycle between NREM and REM stages throughout the night. NREM sleep accounts for about 75 to 80 percent of the total time spent sleeping, and REM sleep accounts for the remaining 20 to 25 percent. The average duration of the first NREM-REM sleep cycle is 70 to 100 minutes. The second cycle, and so on, lasted longer by about 90 to 120 minutes. In normal adults, REM sleep increases as the night progress and is longest, in the last third of the sleep episode. As the repetition of sleep episodes progresses, stage 2 gets longer and becomes mostly NREM sleep, while stages 3 and 4 can sometimes disappear completely [27].

Sleep quality is an individual's ability to stay asleep to get the right amount of REM and NREM sleep. Sleep quality is a person's satisfaction with sleep so that a person does not show feelings of tiredness, easily aroused and restless, lethargic, and apathetic. Sleep quality includes both quantitative and qualitative aspects of sleep, such as the length of sleep, the time it takes to fall asleep, the frequency of awakening, and subjective aspects, such as the depth and wellness of sleep [30]. Several factors affect the quantity and quality of sleep: physiological, environmental, lifestyle, and psychological [29; 32].

Measuring sleep quality using a method called The Pittsburgh Sleep Quality Index (PSQI). The PSQI is an effective instrument to measure sleep quality and sleep patterns in adults. The PSQI was developed to measure and differentiate individuals with good and poor sleep quality [32]. Determination of good and bad sleep quality is seen by measuring seven scores as assessment parameters : sleep quality, sleep latency, sleep duration, sleep habits, sleep disturbances, use of sleeping pills (excessive), and daytime dysfunction during the past month. A global score of 0-5 is considered good sleep quality, whereas a global score > is considered poor sleep disturbance [33].

RESEARCH METHOD

This research is a descriptive-analytic non-experimental research design using a cross-sectional approach. This research was conducted using a questionnaire distributed through social media. This research was conducted from March 2021 – April 2021, including research preparation and reporting the research results. The population of this study was all students from the Faculty of Medicine, Indonesian Christian University, class of 2017. The sample in this study were students of the Faculty of Medicine, Indonesian Christian University, class of 2017, who were screened through inclusion and exclusion criteria. The number of samples was determined based on the Slovin formula. Based on the formula above, the minimum number of samples needed for this research is 122 respondents. Sampling was then carried out by probability sampling using simple random sampling. The sources of this research data are the respondent's identity (name, gender, and age), duration of use of communication devices that emit blue light, and respondents' sleep quality. The data in this study were collected by distributing a questionnaire, namely the PSQI (a questionnaire used to measure the quality and pattern of adult sleep, which can then be categorized as good or bad sleep patterns. This questionnaire contains nine questions that measure seven components : subjective sleeping quality, sleep latency, sleep duration, sleep efficiency, sleep disturbances, the use of sleeping pills, and daytime activity disturbances, which can be seen in the following table:

Table 1: Measuring Components of Quality and Sleep Patterns in Adults

Number	Component	Question Number
1	Subjective sleeping quality	9
2	Sleep latency	Two and 5a
3	Sleep duration	4
4	Sleep efficiency	1,3 and 4
5	Sleep disturbance	5b – 5j
6	Use of sleeping pills	6
7	Disruption of activities during the day	7 and 8

Each question has a score of 0 – 3, with 0 as a marker of no disturbance and three as marker of worst disturbance. The results of each question are then added up as a global score with a maximum of 21. Sleep quality is categorized as good if the global score is 0 – 5, while bad if the global score is 6 – 21 [31; 32]. The PSQI questionnaire has been through a reliability test with a Cronbach Alpha coefficient of 0.69 according to Spira et al. for the English version and = 0.63 according to Sukmawati et al. for the Indonesian version. The results of the validity test conducted by Ratnasari on 18 PSQI questions showed that the calculated r value was more significant than the r table, with a significance of 0.361, while the calculated r value was 0.365 – 0.733, so the PSQI questionnaire could be used as a valid research instrument [32; 33; 34]. The data processing process carried out in this research is editing, coding, and tabulating. Enter the data obtained into the table following the variables that have been studied. The collected data is then processed and analyzed, and the relationship between the independent variable (prolonged use of communication devices that emit blue light) and the dependent variable (sleep quality) is sought. Analysis was performed using the IBM SPSS 25 program for statistical testing. The analysis of this study uses bivariate analysis to find the relationship between the independent variable and the dependent variable.

RESULT AND DISCUSSION

The data for this study were obtained from the previous questionnaire on the use of communication devices that emit blue light on the quality of sleep of students of the Indonesian Christian University medical faculty, which was distributed via social media in April 2021. The number of research samples obtained was 133 respondents.

Table 2: Frequency Distribution of Respondents' Age

Age	Frequency	%
19	1	0.8
20	8	6.0
21	76	57.1
22	22	29.3
23	9	6.8
Total	133	100

Table 2 shows the age distribution of respondents who participated in the research. Based on the table, the age of most respondents is 21 years old with 76 respondents (57.1%), followed by 22 years old as many as 22 respondents (29.3%), then age 23 years, as many as nine respondents (6.8%) and 19 years old as many as one respondent (0.8 %).

Table 3: Frequency Distribution of Respondents' Gender

Gender	Frequency	%
Male	44	33.1
Female	89	66.9
Total	133	100

Table 3 shows the sex distribution of respondents who participated in the study. Based on the table, there are more female respondents than male respondents. Female respondents were 89 (66.9%), while male respondents were 44 (33.1%).

Table 4: Frequency Distribution of Respondents' Usage Duration of Communication Devices that Emit Blue Light

Duration of Use of Communication Devices that Emit Blue Light	Frequency	%
Below average (≤ 9 hours)	42	31.6
Above average	91	68.4
Total	133	100

Table 4 shows the distribution of the duration of the use of communication tools that emit blue light by the respondents. Based on the table, most respondents use communication tools above average. Ninety-one respondents (68.4%) use communication tools above the average, while only 42 (31.6%) use communication tools below the average.

Table 5: Frequency Distribution of Respondents' Sleep Quality

Sleep Quality	Frequency	%
Good (<5)	25	18.8
Poor (5-21)	108	81.2
Total	133	100

Table 5 shows the distribution of respondents sleep quality. Based on the table, most respondents have poor sleeping quality, as many as 108 respondents (81.2%), while only 25 (18.8%) have good sleep quality. Bivariate analysis was conducted to see the relationship between the independent and dependent variables. The independent variable in this study is the duration of use of communication devices that emit blue light on students of the Faculty of Medicine, Christian University of Indonesia. The dependent variable in this research is the sleeping quality of students of the Faculty of Medicine, Christian University of Indonesia. The data obtained were first tested for the normality of the data distribution using the IBM SPSS 25 application. The normality test results for previous data using a communication device that emits blue light on sleeping quality is P=0.000, indicating that the data distribution is not normal because of the P-value <0.005. Using the Spearman rank correlation coefficient test, statistical tests were carried out to determine the relationship between the length of use of communication tools that emit blue light and sleeping quality.

Table 6: Analysis of the Relationship between Usage Duration of Communication Devices that Emit Blue Light with Respondents' Sleep Quality

Sleep Quality	Duration of Use of Communication Devices that Emit Blue Light				Total		P-*value*	r
	Below average		Above average					
	N	%	N	%	N	%		
Good	19	14.3	23	17.3	42	31.6	0.000	0.425
Poor	6	4.5	85	63.9	91	68.4		
Total	25	18.8	108	81.2	133	100		

Table 6 shows an analysis of the relationship between the duration of the use of communication devices that emit blue light and the respondents' sleep quality. Based on the table, out of 133 respondents, 91 people (68.4%) had poor sleeping quality, and 42 respondents had good sleeping quality. The majority of respondents use communication devices that emit blue light above the average that is 108 respondents (81.2%), of which 85 respondents (63.9%) have poor sleeping quality, while 23 respondents (17.3%) have good sleeping quality. In the group that uses communication tools below the average that is 25 respondents (18.8%), 19 respondents (14.3%) of them have good sleeping quality, while six other respondents (4.5%) have poor sleeping quality. Based on statistical tests, there was a significant relationship between the length of time using communication tools that emit blue light and the respondent's sleeping quality (P-value=0.000) and show a positive pattern, meaning that the longer the use of communication devices that emit blue light, the worse the sleeping quality of the respondents.

Bivariate analysis showed a relationship between the duration of use of communication devices that emit blue light and respondents' sleep quality. This relationship was showed by the **evidence** of the p-value (p = 0.000), with a moderate correlation (r = 0.425) and a positive pattern, indicating that as the duration of the use of communication devices that emit blue light increases, the PSQI score will increase, which indicates that the respondent's sleep quality is getting worse, this happens due to the light emitted by communication devices on smartphones, laptops, desktops, or TVs contains much blue light.

The presence of blue light simulates a blue sky during the day, which causes the brain as a regulator of circadian rhythms being "deceived" so that it inhibits the secretion of melatonin and serotonin, hormones essential for the process of drowsiness and sleep. The hormone melatonin has a vital function in the sleep process, and this can be proven through research conducted by Lisa A Ostrin which states that the salivary melatonin levels at night in people who use glasses with blue light filters increased by 58% from 18pg/ml to 25pg/ml. Furthermore, the average length of sleep increased by 24 minutes compared to the control group who did not use the glasses [39]. Serotonin levels can also be disrupted directly by exposure to light. It is evidenced by a study conducted by Takeru Matsumura, which stated that there was a significant decrease in brain serotonin levels in experimental animals (rats) given 6 hours of light and 6 hours of darkness for one month compared to the control group that was given standard lighting for 12 hours of light and 12 hours of darkness [40].

The results are also supported by research conducted by Umi Royanti Koswara, which teenagers with lousy behavior in using gadgets, 79% of them do not have adequate sleep [41]. It is also supported by the research conducted **by** Matthew A. Christensen, which states that the PSQI score go higher along with the increase in smartphone screen time, especially in the young population and non-caucasian race [42]. The pandemic due to Covid-19 also have a bad effect on the use of communication devices that emit blue light. It is showed by research conducted by Abida Sultana, which states that there is an increase in the length of use of gadgets for school-aged children, adults, and the elderly [43].]. This situation followed by the decrease of sleep quality for the people who had never previously experienced sleep disturbances during the pre-pandemic. However, this situation was influenced by many factors such as uncomfortable conditions due to the the lockdown and anxiety feelings due to occurring circumstances. The drastically increased use of gadgets was allegedly also a result, a major factor that play a role in the occurrence of this phenomenon [44].

CONCLUSION

From this study, it can be concluded that 68.4% or 91 respondents use communication devices that emit blue light more than the average. In addition, 108 respondents (81.2%) had poor sleep quality. There is a relationship between the length of use of communication devices that emit blue light and sleep quality, where the longer the use of communication devices that emit blue light, the worse the quality of sleep. Based on this study's results, most respondents had poor sleep quality. Sleep quality can be influenced by many things such as environmental conditions during sleep, health status, the presence or absence of psychological stress, diet, lifestyle, and drugs, but this study shows the use of communication tools that emit blue light, such as smartphones, laptops/desktops, and TVs significantly affect sleep quality. Research respondents are advised to reduce the use of the tools mentioned earlier for recreational needs, especially when many learning activities are carried out online in order to maintain good sleep quality.

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