



# IMPACT OF COVID-19 PANDEMIC LOCKDOWNS ON CIRCADIAN RHYTHMS: A STUDY IN HYDERABAD CITY

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## **ABSTRACT**

### **BACKGROUND**

The relationship between circadian rhythms and pandemics remains poorly understood. Prolonged poor regulation can cause sleep disorders, cardiovascular diseases, diabetes, obesity, mental health disorders such as depression, anxiety and other adverse health outcomes. Currently, there are limited therapies and no early intervention or prevention strategies readily available. This study gives the Indian population data during COVID-19 for circadian rhythm research.

### **MATERIALS AND METHODS**

A general survey was conducted to analyse the prevalence of poor sleep habits and mental health in Indian population during the COVID-19 pandemic lockdowns.

### **RESULTS**

The research data presented here is in agreement with current literature and highlights the complexity of pandemics, sleep cycles and the convergence of unregulated sleep habits and mental health including lifestyle and psychosocial stressors causing symptom manifestation in Indians.

### **CONCLUSION**

An effective long-term intervention should reduce negative health outcomes. This goal has not been achieved and current solutions reduce symptoms only temporarily and fail to provide help for every group in the population affecting psychological wellbeing and the quality of life. Further needs exist for public awareness, determination of risk factors and initiation of preventive measures, in addition to development of new and easily accessible options for the vulnerable population providing better quality of life.

## **INTRODUCTION**

Humans evolved as diurnal species to function during the day and rest at night following the rotation of the Earth. This influences a multitude of biological processes; during an entire day, cognitive abilities and alertness tend to peak and fall at various times depending on an individual, ultimately affecting productivity, multitasking ability, task performance and memory. (Duguay and Cermakian 2009) These are handled by specific pathways in the brain that have an intricate time-keeping system like an internal clock; the circadian rhythm. This complex biochemical machinery is encoded in the DNA as CLOCK genes. It is exhibited in variable complexities by all living organisms on Earth.

In the 21st century, with great advancements in technology, there is a conscious control of light exposure during nights due to students and employees of various fields working within 24-hour periods through night shifts, night-outs and heavy usage of light-emitting devices. (Snyder and Chang 2019) These lead to the desynchronization of the rhythm from environmental cues causing grogginess, poor performance, microsleep, irritability and extreme fatigue during the day. Although light acts as the main zeitgeber, over the years, studies have shown that environmental factors like temperature, exercise, diet, social interaction, anxiety and stress can greatly alter the cycle.

### **Pandemic lockdowns**

Since the dawn of time, humans have faced several brutal outbreaks like Influenza, SARS, MERS, bubonic plague, smallpox and HIV/AIDS which caused drastic paradigm shifts. The novel coronavirus, Covid-19 is no different, it began in December 2019, already wreaking havoc globally in a matter of 3 months. When we look at how the human race survived previous outbreaks, people practiced confinement and isolation long before quarantine and lockdowns came into the picture. Lockdowns are implemented by authorities for public health safety against dangers like terrorism, wars, nuclear activities and outbreaks.

Covid-19 lockdowns across the world are being dealt with unpredictability of the virus which has largely impacted the lifestyle of the people including social interactions, mental health, physical activities, sanitization, diet and sleep patterns. It has changed the routine normalcy due to the substantial "social distancing" and "work-from-home" rules.

One of the more extreme issues being impaired food accessibility which surprisingly caused excessive consumption of food by most people in Italy. (Scarmozzino and Visioli 2020) In India, food has been an obvious struggle for the people of lower classes, migrants, labourers and farmers. Moreover, the constant mental stress, depression and anxiety created by the internet with regular updates and misinformation of the macabre situation has heavily created a panic among adults being worried about their futures, financial security, families and jobs. (Silva, Da Silva, and Toledo, n.d.)

The lack of routine has led to people having dire variable sleep patterns especially among the younger generation glued to digital media at nights. The students now have to face an entirely new educational environment through online classes as well as the people working from home. With these comforts, people end up going to bed at different times of the day. A study done in Italy reported people losing track of time and higher decrease in sleep quality for those with existing mental health conditions. (Cellini et al. 2020) In India, a general online survey conducted by wakefit.co, a sleep solutions start-up in Bangalore, showed that there is a 40% rise in late night sleepers and 49% of them accounted for staying up due to anxiety in lockdown.

The scenario for the front-line shift workers is alarming. It was reported that there is an excessive caffeine consumption, daytime napping and drastic change in sleep hygiene making them the most sleep-vulnerable population in these unprecedented times. (Shriane et al. 2020) Further data on epidemiological studies suggests that shift workers in general are at dangerously higher risk for cardiovascular diseases, obesity and cancer, especially breast cancer in rotating female workers due to sleep deprivation, impaired immune system and melatonin hormone suppression by exposure to light at night. (Haus and Smolensky 2013)

These sudden unexpected fluctuations in the accustomed lives of the people for a rather prolonged period has been having a silent but a direct impact on the internal circadian clocks on a grand scale. The following study desires to explore and contribute to this area of research.

### What are circadian rhythms?

The word 'circadian' comes from the Latin words, "circa dian" meaning "about a day". Circadian rhythms are internal biological clocks that follow an entrained oscillation of approximately 24 hours during which they govern most of the basic cellular mechanisms in the body. It has been observed in various species ranging from unicellular organisms (eg. *Gonyaulax*) to highly complex mammals (eg. *Homo sapiens*). (Vitaletta, Takahashi, and Turek 2001)

It was first discovered by French geophysicist, astronomer and a chronobiologist Jean Jacques-d'ortous de Mairan in 1729 in the plant; *Mimosa pudica*. He noticed that the leaves of mimosa continued to open and close even when it was kept in the dark for 24 hours. Although his observation was indecisive, it was verified in 1832 by French-Swiss botanist, Alphonse de Candolle. Scientists later worked on several species to understand the ubiquitous nature of circadian rhythms for many years. An important breakthrough occurred during 1970's when the molecular basis of this process was observed as mutant strains in *Drosophila melanogaster* and *Neurospora crassa*. The first mammalian CLOCK genes were identified in mice. These contributions laid the foundation as model organisms to study molecular genetics of circadian rhythms. (Dunlap 1999)

In recent years, several advances have been made to better understand the evolution of this immaculate system and to find ways to treat sleep related disorders. In the event of a disruption, the cycle itself becomes "free-running" i.e., self-sustaining, controlled by the Suprachiasmatic Nucleus (SCN) of the Hypothalamus. Although the circadian clock is nycthemeral, the SCN is said to have an average of 24.2-hour cycle.

The SCN is a pair of nuclei above the optic chiasm that contain up to 20,000 neurons which fire together orchestrating the various interconnected mechanisms throughout the body. Hence, SCN is called the "Master Clock". (Silver 2018) When light enters the eye, it is absorbed by photoreceptors; rod and cone cells that are responsible for vision and photosensitive retinal ganglion cells (ipRGCs) that contain melanopsin, a photopigment that absorbs wavelengths up to 480nm which falls under blue light spectrum. This information is carried to the SCN by Retinohypothalamic tract. SCN coordinates with the pineal gland for the release of melatonin hormone that controls the sleep-wake cycle by inducing sleep in darker hours and its concentration decreases during the day giving alertness.

Circadian rhythms are known to directly control the immune system, homeostasis, behaviour, brain wave activity, DNA and protein synthesis, telomerase activity (Chen et al. 2014), cell cycle, cell regeneration, hormone production, cardiac and respiratory rate, metabolism, thermoregulation and gut microbiome. (Voigt et al. 2016)

People with eye impairment, certain mental disorders and melatonin imbalance, exhibit severely disturbed sleep patterns resulting in Circadian Rhythm Sleep Disorders (CRSDs).

### Hypothesis and objectives of this study

For a normal person, if there is a sudden change in the circadian cycle, it results in dangerously lack of energy and drowsiness during the day. This can be treated by simply resetting the clock that is; resuming back to the normal schedule. For a prolonged period, it leads to major health risks like sleep disorders, depression, cardiovascular diseases, diabetes, obesity, dementia, Alzheimer's disease (Wu et al. 2019) and cancer.

It is hypothesized that if the rhythms of otherwise normal individuals are desynchronised for a prolonged period, like in case of a forced nation-wide lockdown during a global pandemic that has drastically changed the lifestyle norm of the society, then it will have unfavourable effects on overall health.

The purpose of the study is to find out how the lockdowns have directly impacted the circadian rhythms of different groups in a third world country like India, predicting their state post lockdown, and to suggest recovery methods accordingly.

This study aims to provide public awareness but more importantly, a better understanding to the government and authorities on how critical it is to ensure the proper health and livelihood of the people that are the backbone of a country's economy.

Research is still being carried out by experts on how to better manage an unascertained global situation like this. Many theories and models have been proposed and improved to a great extent compared to previous outbreaks. That being said, further research is required to collect more data and deeply study the analytics in order to bring in better solutions for the future.

## MATERIALS AND METHODS

### Participants and study design:

To avoid the spread of COVID-19, taking into account the precautionary protocol given by World Health Organisation (WHO), a general survey of the Indian population was conducted with verbal consent and appropriate data collection was done online.

The sociodemographic variables include age, sex, and mode (offline/online) of work and education. The variables taken are between change in lifestyle and habits in lockdown and the change in circadian rhythm.

The questions were framed in relation to the hypothesis of the study. The time period applied for this study is the consecutive Nationwide COVID-19 lockdowns that occurred between March 25, 2020 and May 31, 2020 (4 phases) and the gradual Unlock phases that started from June 1, 2020 as per Government of India. Participants were requested to complete a self-report questionnaire through Google Forms maintaining their anonymity. The form was circulated via various means of social media communication systems (E.g., WhatsApp, Instagram, Facebook). The 15-item questionnaire that examined their general and sleep habits during this period was prepared from previous studies ([Ellis et al. 1981](#) and Stanford Health Care sleep questionnaire). All data collection was done from December 1, 2020 to February 1, 2021.

Inclusion criteria: different age groups ranging from 15 to 65 in India. In total, 125 volunteers participated in this study. The survey took approximately 15 minutes to complete and collected data in a number of categories: demographics, personal details, aspects of sleep habits and patterns, effect on mental health, lifestyle and quality of life. Those Indians, who reside in Hyderabad, India during lockdown phases form the sleep population in this study. Missing response items were not imputed.

## RESULTS AND DISCUSSION

From the people that participated in this study, 125 responses were received. Missing response items and the ones that did not meet the inclusion criteria were not imputed. The final survey population used in data analysis comprised of 115 people aged 15-65 years. All variables were analysed using simple statistical methods, giving the number of non-missing observations and frequency counts for categorical variables. The statistical analyses were performed using Microsoft Excel software.

The survey also included questions about existing health conditions, income and occupation. These responses were not considered in this study due to COVID-19 lockdown constraints but they may be useful for further research.

### Sleep habits

A sleep deprived society faces the increased burden of COVID-19 economic and psychosocial problems, substance abuse, and suicide. Disordered sleep is cannot disappear with control of infection, making interventions extremely important. Good sleep habits are necessary when it comes to maintaining circadian rhythm.

Under this section of the survey, the general sleep habits (use of electronics before bedtime, work/study in bed, consumption of alcohol/cigarettes, eating snacks before bedtime/during the night, consumption of caffeinated beverages) were assessed. People were asked about the severity of their habits not restricted to lockdown on a 4-point scale, where 1 was defined as "No" and 4 as "Yes".

The highest score reported is for the use of electronics before bedtime – 72.17% followed by work/study in bed – 26.95% and consumption of caffeinated beverages – 25.21%. The least scores were seen in eating snacks before bedtime/during the night – 11.30% and consumption of alcohol/cigarettes – 3.47%. [shown in figure 1]

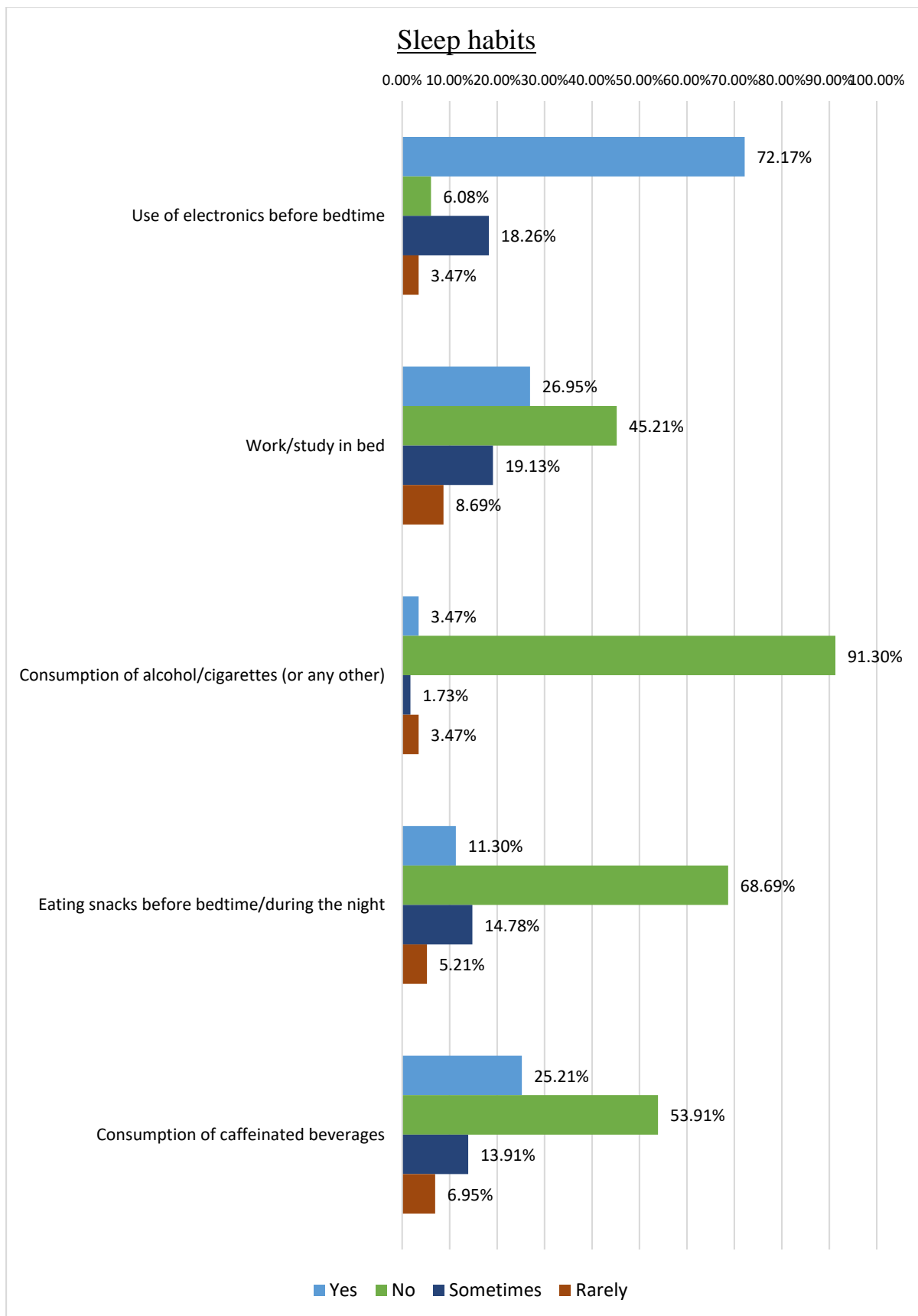


Figure 1. Graph depicting the sleep habits of the given population not restricted to lockdowns.

Since majority of the participants were young adults, these results were expected. It is important to note the highest use of electronics before bedtime has a dire impact on quality of sleep (Rainville et al. 2019), (Chang et al. 2015).

Worsened	Improved	Not much	No change
19.1%	14.8%	40%	26.8%

Table 1. Percentage of people whose above habits were affected during lockdown.

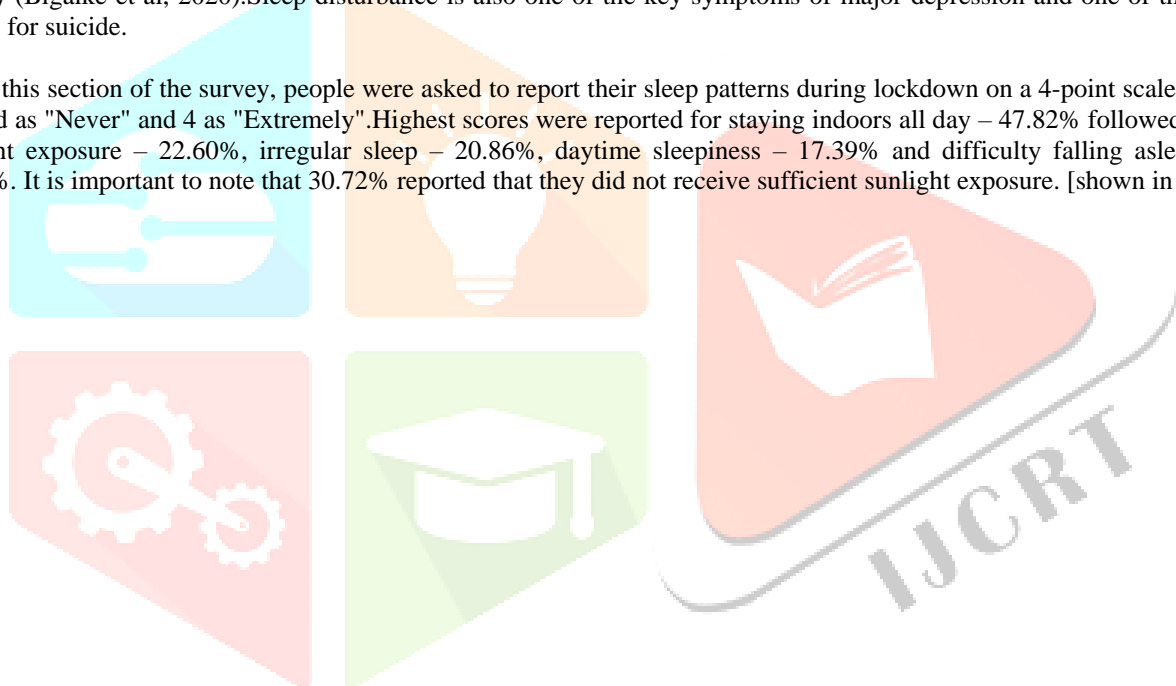
When asked about the change in sleep habits during lockdown, 19.1% reported that it worsened and 14.8% reported that their habits have improved. [shown in table 1]

### Sleep patterns

Unhealthy sleep pattern can indicate poor regulation of circadian rhythm. The pandemic disrupted normal life routines which are important circadian cues. It is also caused new stressors, altered roles, and uncertainties about health and economic security, which affect sleep. Considering the importance of sleep for a healthy life and for immune function, efforts should be made to improve awareness on this matter and to offer assistance to affected individuals.

A study reported higher anxiety and reduced sleep quality during pandemic with a stronger association in women with respect to anxiety (Bigalke et al, 2020). Sleep disturbance is also one of the key symptoms of major depression and one of the proven risk factors for suicide.

Under this section of the survey, people were asked to report their sleep patterns during lockdown on a 4-point scale, where 1 was defined as "Never" and 4 as "Extremely". Highest scores were reported for staying indoors all day – 47.82% followed by sufficient sunlight exposure – 22.60%, irregular sleep – 20.86%, daytime sleepiness – 17.39% and difficulty falling asleep at night – 16.52%. It is important to note that 30.72% reported that they did not receive sufficient sunlight exposure. [shown in figure 2]



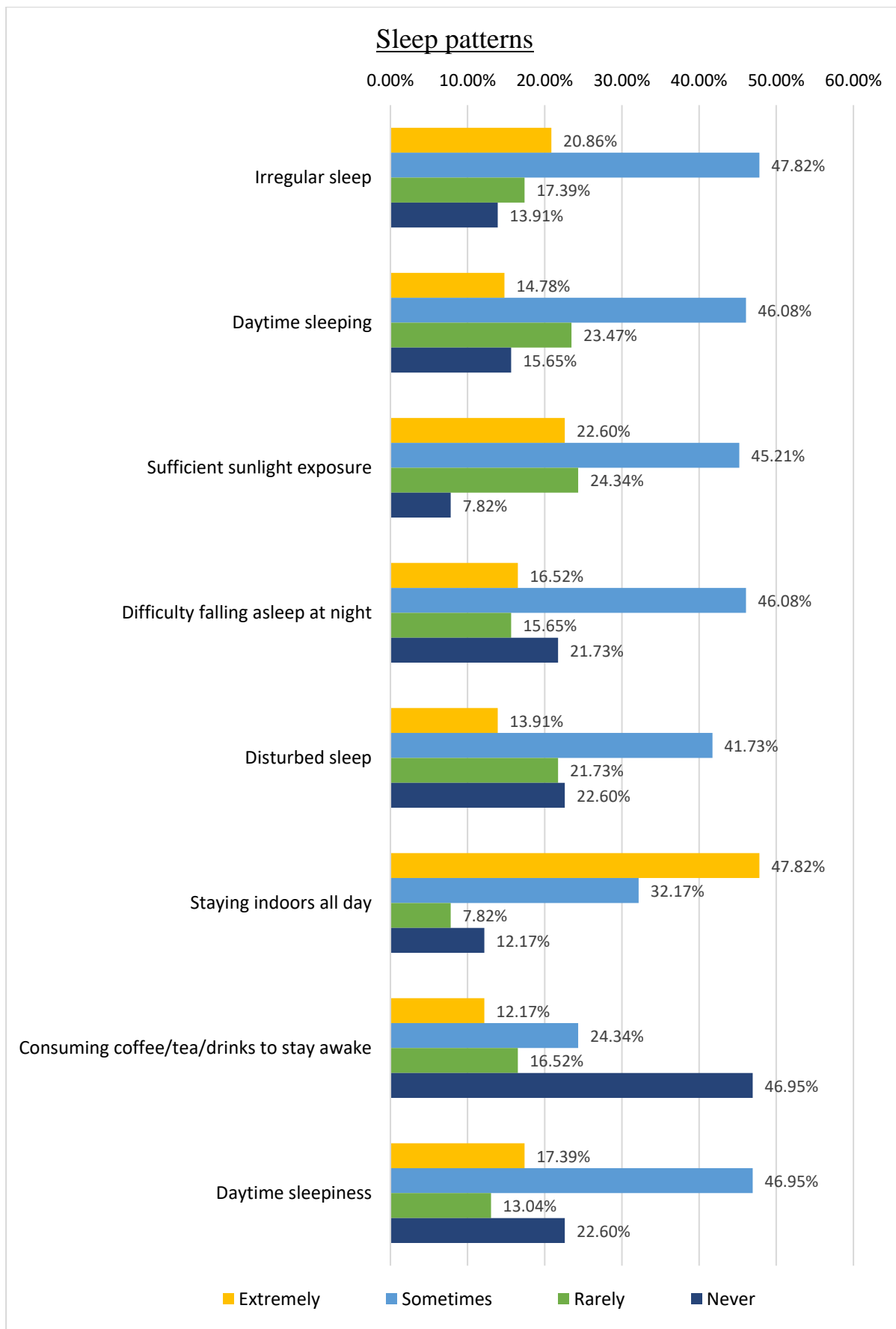


Figure.2. Graph showing sleep patterns of the given population during lockdowns.

## Mental health

Research suggests that the relationship between sleep and mental health is a lot more complicated than we thought. While sleep has been known to be a symptom of many psychiatric conditions, more recent views suggest that sleep can also play a causal role in both the development and maintenance of different mental health problems (Scott et al, 2017).

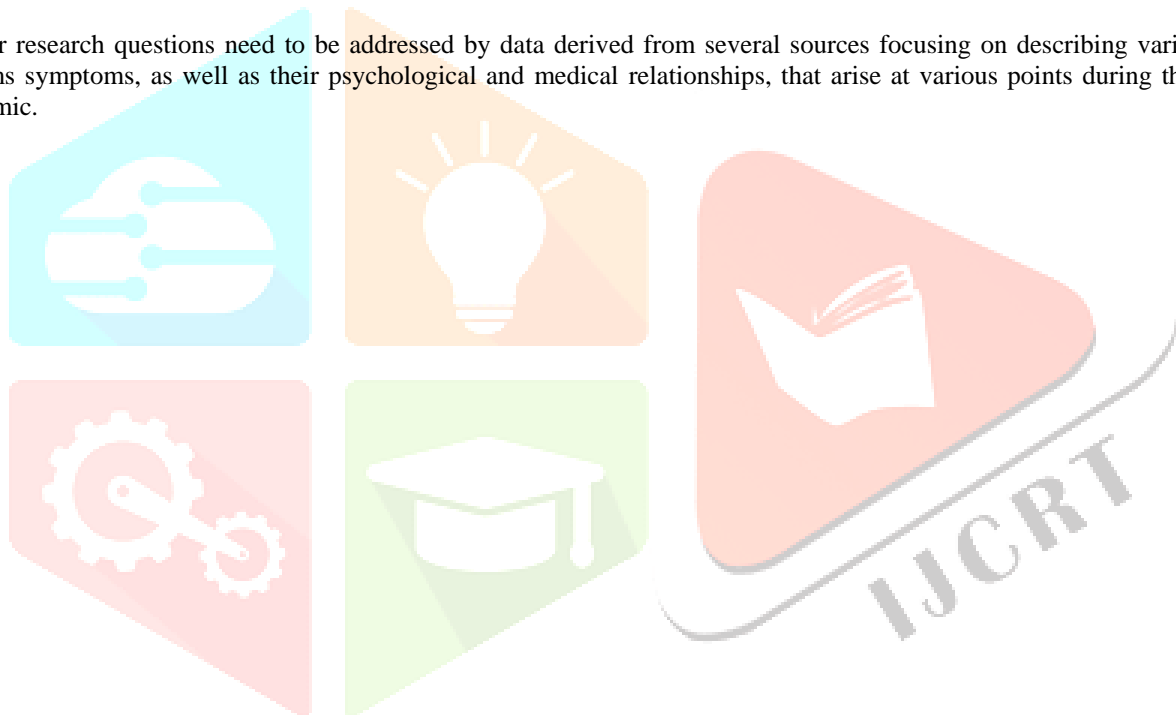
In a review of mental health in India during COVID-19 pandemic, the major mental health issues reported were stress, anxiety, depression, insomnia, denial, anger and fear. Children, older people, frontline workers, people with existing mental health illnesses were the most vulnerable in this context. COVID-19 related suicides have also been increasingly common. (Roy et al, 2021)

The mental health impact of the COVID-19 crisis may differ from previously studied stressful events in terms of psychological aspects, risk factors, and symptom severity across geographic regions worldwide. Thorough and continuous assessment of health and outcomes in mental health practice is crucial for defining which practices should be further developed and which discontinued.

In this section, people were asked to report their mental state during lockdown on a 4-point scale, where 1 was defined as "Never" and 4 as "Extremely". Severity in scores was seen mainly for constant worry about future/family/job/health/finances – 36.52%, keep checking the news updates often – 30.43% and, too afraid to leave the house in the fear of contracting COVID-19 – 20.86%. [shown in figure 3]

It is important to note that in almost all options, the average response of "Sometimes" was high indicating most people definitely experienced some form of mental stress. From these results, it is apparent that people were heavily stressed during the lockdowns.

Further research questions need to be addressed by data derived from several sources focusing on describing various circadian rhythms symptoms, as well as their psychological and medical relationships, that arise at various points during the COVID-19 pandemic.



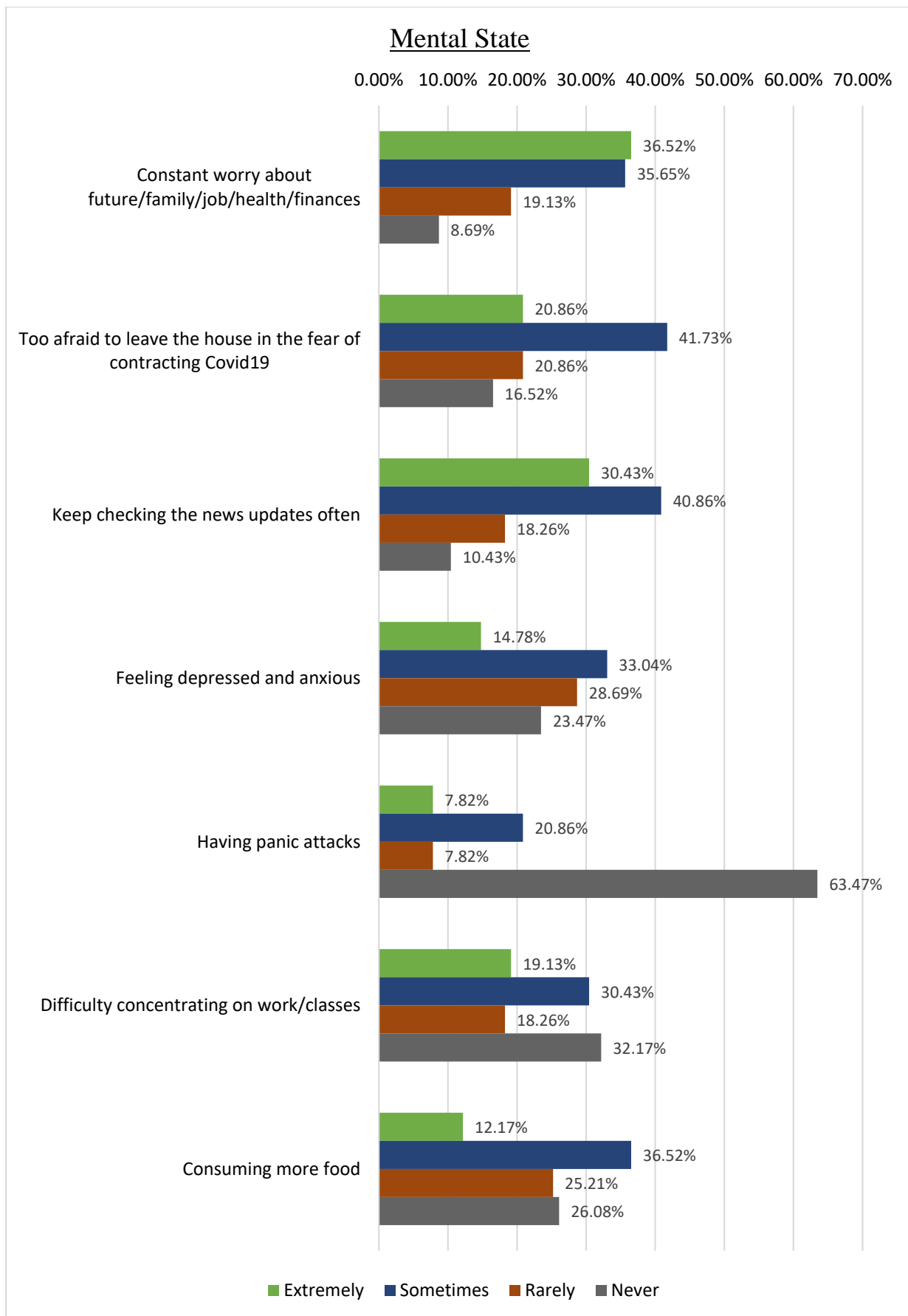


Figure 3. Graph showing mental state of the given population during lockdowns.



## Students during the pandemic

Students are another group of individuals whose lifestyle drastically shifted during the lockdowns. These sudden changes can impact a young developing brain differently than adults.

A survey conducted by Lucknow-based Spring Dale College (SDC) chain of schools in July involving 4,454 respondents revealed several health issues that included eyesight problems, backache, headache, fatigue, irritability, strain, obesity and insomnia. Students felt loss of confidence and low motivation which otherwise was possible in normal school days, the survey indicated. The more positive effects reported were that over 60% said they got more leisure time for their hobbies and spending more time at home strengthened their familial relationships. (Source: Times of India, Hindustan times)

From this survey, 43.30% reported being more comfortable online, 41.70% said it reduced their performance followed by 33.30% who said they were more stressed than before and 20% who reported that their mental health has deteriorated. [shown in figure 4]

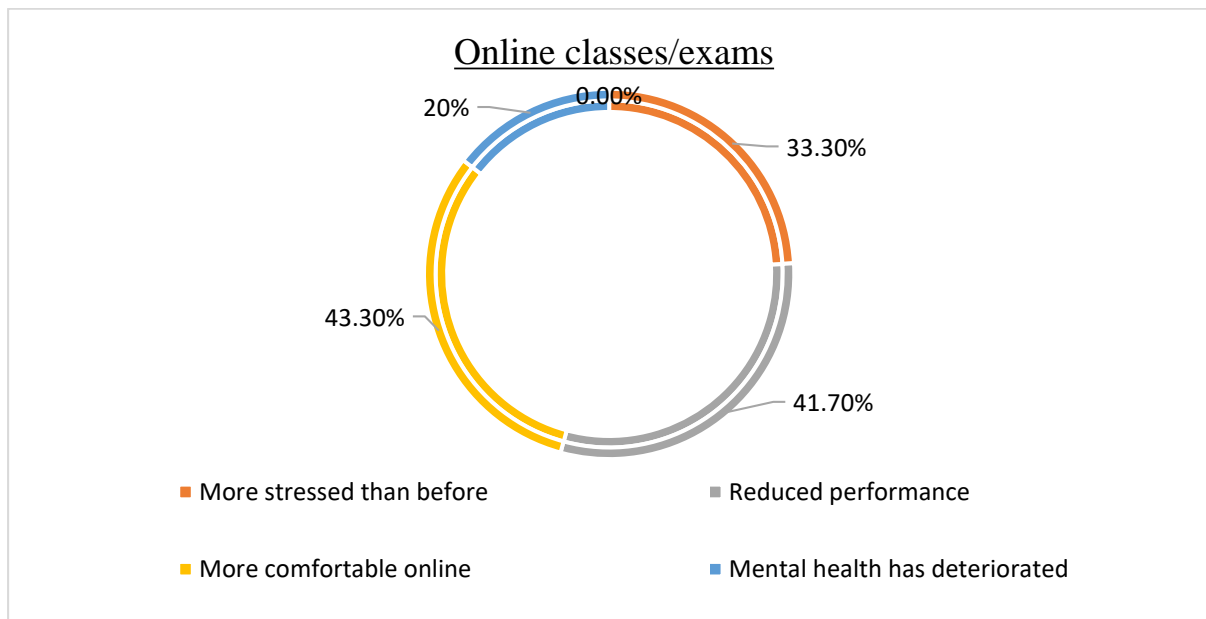


Figure 4. Chart depicting impact of online mode of education on students during lockdowns.

Youth Risk Behaviour Surveillance System data and the Centre for Disease Control and Prevention's (CDC) 2019 Youth Risk Behaviour Survey show that US adolescents continue to suffer from poor mental health and suicidality at alarming rates. This data alone must be cause for concern, but the COVID-19 pandemic has the potential to further erode adolescent mental health, particularly for those whose mental health was poor prior to the pandemic (Hertz et al, 2021). If this is alarming in US, it indicates a cause for concern in a second most populated country, i.e., India.

## Discussion:

In this survey, the relationship of sleep problems during COVID-19 pandemic in India are presented in the light of the literature. Stress levels skyrocketed during the pandemic for many reasons, including loneliness, anxiety, economic hardships, juggling work and school, future uncertainty and fearmongering by media. Psychosocial stressors seem to have affected the pattern of sleep and worsened sleep quality in individuals. Sleep disturbances during pandemic have been referred as COVID-somnia (Inönü, 2021). Being isolated due to work from home policy can also cause complications in our sleeping patterns disrupting the light-based cues for wakefulness. Sunlight and light exposure help keep circadian rhythm on schedule.

All of this stress and lack of sleep can have big, negative impacts on overall health. One concern that's specific to the pandemic is the effect on immune system. Chronically sleep-deprived people tend to have lowered immunity and that makes their susceptibility to viruses higher. Sleep deprivation is associated with altering of innate and adaptive immune parameters, leading to a chronic inflammatory state and an increased risk for infectious/inflammatory pathologies, including cardiometabolic, neoplastic, autoimmune and neurodegenerative diseases (Garbarino et al, 2021). This may also be the cause for the high number of breakthrough cases in fully vaccinated groups.

A recent study found that there was a significant increase in the incidence of stress cardiomyopathy during the COVID-19 pandemic when compared with pre-pandemic periods (Jabri et al, 2020). Another study showed that the prevalence of sleep disturbance was 17.65–81% in the general population. Physiologic and social-psychological factors contributed to sleep disturbance of the general population during pandemic (Lin et al, 2021).

Available data suggest that the mental health sequelae of COVID-19 will mirror previous pandemics. Clinicians and mental health leaders should focus on the negative effects of isolation, particularly anxiety and distress. So far, some places and institutions have addressed mental health concerns by adapting mental health services, focusing on controlling infection, modifying accessibility to diagnosis and treatment. The COVID-19 pandemic should be an opportunity to improve mental health services everywhere.

With use of effective programs treating sleep problems, psychological distress may be reduced. Vice versa, with use of effective programs treating psychological distress, sleep problems may be reduced.

In conclusion, this paper suggests the following recovery methods to help maintain circadian rhythm for a healthy life. This information is collected from several published data sources online. This is not a cure for existing illnesses or sleep disorders.

#### Suggested recovery methods to maintain a healthy sleep schedule:

**Create a sleep schedule** - While six or nine hours can be appropriate for some adults, most need seven to eight hours of sleep per day.

**Limit screen time at night** - Turn off all devices one hour before bedtime.

**Structure your daytime schedule** - Commit to daily activities (e.g., exercise, meals, socializing) at certain times to build structure to the days. This supports a regular bedtime and wake time. Set cell phone reminders to anchor the schedule, and as a reminder to turn off screens an hour before bedtime.

**Find time for relaxation** - Avoid electronics before bedtime. Instead, take a hot bath, play soothing music, try meditation and read a book.

**Minimize naps** - Daytime sleep must be less than 30 minutes and before 2 p.m. If you have trouble falling asleep at night, avoid napping.

**Try breathing exercises** - Take ten slow deep breaths to fall asleep. Slowly inhale through your nose for 3 to 4 seconds and a slowly exhale through your mouth for 3 to 4 seconds.

**Enhance your sleep environment** - Make sure the bedroom environment is conducive to sleep. Keep the room temperature cool and dark.

**Stress management** - Due to less access to the usual coping strategies because of the pandemic, try new activities and hobbies — painting, writing, photography, indoor exercise videos, etc. Find ways to stay connected with friends and family through technology. Consider going for therapy if the stress feels unmanageable.

**Avoid consuming caffeine/alcohol/beverages regularly** - Drinking occasionally and having coffee minimum 1 cup a day is advisable. Do not drink at least 4-6 hours before bedtime. Consume plenty of water instead to avoid feeling sleepy during the day.

**Maintain healthy eating habits** - There are plenty of healthy food items that are good for proper sleep hygiene. Not only the type of food, but eating them at the right time is also crucial.

## CONCLUSION

Sleep is affected during COVID-19 pandemic in families, students, health-care workers, population in isolation and quarantine. Limited literature exists with subjective data to study sleep in COVID-19 pandemic.

As awareness builds for people's health agenda in India, evidence on high rate of health problems during a pandemic highlights the critical need for interventional services for people of different groups. Government, NGO's and physicians must actively work together in spreading awareness and help in providing correct information and solution for people especially in rural areas. Corporations and educational institutions should enforce more lenient rules. Management of sleep troubles and mental health is particularly needed in frontline health care workers. Continuous tracking of the psychological consequences for outbreaks should become routine as part of preparedness efforts worldwide.

Most interest and importance are those investigations that include both rural and urban populations, their income and occupation, providing a balanced perspective from which to explore trends in healthcare and intervention in India. Given the recent volume of such articles due to COVID-19, it is worth considering how this research can be used to facilitate change to create better outcomes. New research should shape and expand our basic understanding of importance of sleep and innovative methodologies. Although the existing data is impressive, many challenges still remain and further research is absolutely warranted.

### Limitations of this study

A general survey of this kind is subject to certain limitations which need to be carefully considered. The results rely solely on individual's subjective self-reports. This is especially an area of concern regarding the data on their experiences because the results were not completely validated by medical records. Their experience can be biased as respondents may have recall bias.

The study is conducted in the selected region and with a very small population; therefore, generalizing must be done with care. The findings are not representative of the sleep characteristics in whole India. Moreover, the study and the results are related to an urban area, so it is not a good representative for rural areas.

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