Changes in sleep pattern and sleep quality during COVID-19 lockdown

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Introduction: To mitigate the spread of the pandemic coronavirus infection (COVID-19), governments across the world have adopted “lockdowns” which have confined many individuals to their homes. This disrupts normal life routines, elements of which are important circadian cues. The pandemic is also associated with new stressors, altered roles, and uncertainties about health and economic security, which are also likely to affect sleep. The current study is an online survey of sleep experience, routines, physical activity, and symptoms of anxiety and depression, to study the alterations associated with the lockdown.

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Materials and Methods: The survey was conducted in early May 2020 using a questionnaire circulated through social media platforms. Questions related to demographic characteristics, current and previous sleep schedules, routine, and working patterns. Insomnia (Insomnia Severity Index - 4), Stress (Perceived Stress Scale - 4), anxiety and depressive symptoms (Patient Health Questionnaire - 4) and physical activity (International Physical Activities Questionnaire) were assessed using standardized instruments.

Results: A total of 958 valid responses were received. Compared to the prelockdown period, there was a shift to a later bedtime and waking time, with a reduction in night-time sleep and an increase in day-time napping. These effects were visible across occupational groups, but mostly affected working individuals except health professionals. Sleep quality deteriorated across groups. Reductions in sleep duration were associated with depressive symptoms.

Conclusions: The COVID-19 lockdown is associated with changes in sleep schedule and in the quantity and quality of night-time sleep. Although these changes are associated with elevated rates of emotional symptoms, it is unclear from these cross-sectional results, whether sleep deterioration produces psychological distress, or vice versa.

Key words: Coronavirus, COVID-19, home-confinement, lockdown, pandemic, sleep

INTRODUCTION

The lockdown during the recent COVID-19 pandemic has resulted in a changed lifestyle for many of us.[1] These changes were mostly restrictive in terms of social interaction, creativity, opportunities, and positive relationships.[1] The restriction was also extended to physical activity, mobility, and availability of nutritional food.[1,2] In effect, these have disrupted chronobiological rhythms as these are influenced by not only the light but also other zeitgebers such as meal, social interaction, and physical activity.[1,3] Thus, a structured routine can help in improving sleep duration and quality through multiple intrinsic and extrinsic factors.

Most people are confined to their homes. This confinement is stressful in itself as individuals are sharing the limited space for a prolonged period with few close contacts. In addition, they experience a lack of novel stimuli, disruptions of routine activity, increased parenting responsibilities, especially for women, and altered productivity expectations for those engaged in professional duties from home.[4] In addition to the ever-present fear of contracting COVID-19 as it spreads across the country, uncertainty about jobs, economic situation, and the health and safety of loved ones. The pandemic has also been described as an information epidemic, as most people have constant access to news about negative consequences, much of it through electronic media and consequent increase in “screen time.” In short, lockdown resulted in home confinement during prevailing anxiety and reduction of positive stimuli.[5] Stress, in general, but not always, has an inverse relationship with sleep. The effect of stress on sleep quality, timing, and duration is influenced by sleep reactivity.[6] Persons with high reactivity develop insomnia during stressful situations while those without do not. Thus, home-confinement resulting from lock-down increases the chances of disturbed sleep and insomnia through stress.

Initiation and maintenance of sleep-wake cycle are explained by two-process models, whereby circadian factors and homeostatic factors interact constantly to induce and maintain sleep.[5] This model posits that owing to circadian factors, human have higher chances to fall asleep at night as we are designed to behave as a diurnal species by nature.[5] Sleep pressure represents the homeostatic factor, which is proportional to the time awake. In other words, longer the time awake, higher the sleep pressure, and higher the chances of falling asleep.[5] Being a diurnal species, human stay awake during the day and accumulate sleep pressure, which reaches maximum at night, where it interacts with circadian factors to induce sleep.[5] Confinement to home can disrupt circadian rhythms as well as homeostatic process (reduced sleep pressure) due to opportunities for extending sleep in the morning and taking naps during the day.

The present COVID-19 epidemic is a rare situation where a sizable population is confined to the home and are not compelled to follow a structured routine. Earlier studies that have assessed the effect of confinement on sleep have been done in astronauts preparing for Mars mission, incarcerated women, and seafarers.[6-8] However, the results of these studies cannot be extrapolated to home confinement during COVID-19 lockdown as the nature of confinement is different. First, data from the Mars mission simulation involved only six members of different nationalities, limited space for physical activity, active engagement in training, and prolonged confinement, i.e., 520 days.[6] Although the study among incarcerated women had a larger sample size, it cannot be extended to the general population as stressors, and sleep environments were different from those in home confinement.[7] The third study included seafarers who were on the ship and engaged in a normal routine. Besides that, the study population in these studies did not have responsibilities other than the profession related, had little opportunities for leisure activities and were not anticipating any threat to life. As discussed, these factors play a role in sleep quality and quantity.

Considering the paucity of literature, the present study was planned under the aegis of the Research, Education, and
Training sub-Committee of the Indian Psychiatric Society to assess the proportion of subjects with insomnia and poor sleep-quality during lockdown. In addition, we wanted to compare sleep patterns and changes in sleep duration after lockdown compared to the prelockdown period. Finally, we wanted to analyze the effect of occupation on insomnia, sleep quality, sleep duration, and sleep pattern after considering confounders that affect any of these sleep parameters.

**MATERIALS AND METHODS**

This online survey using the Survey Monkey platform among the general population was done after obtaining approval from the ethics committee of the institute of the first author and the Indian Psychiatric Society. The survey tool was made available in four languages, i.e., English, Hindi, Odiya, and Bengali, with translations being carried out by the authors who were fluent in the language, and consultant psychiatrists (Hindi– SKP, Bengali– AB). The survey went online on April 28, 2020, and the last response was collected on May 10, 2020. All participants above the age of 18 years, regardless of gender, were invited by sending them a link through E-mail or groups on social media (e.g., WhatsApp) and their consent was taken. The participants who completed the survey were asked to forward the survey further if they felt so, to have a snowballing effect.

However, participants who had memory troubles, those taking sleeping pills, pregnant women, and individuals who have self-identified as having COVID-19 infection were excluded from the study. A semi-structured performa was developed to gather information about sociodemographic data, work responsibilities, sleep patterns, screen time, other medical comorbidities, and medication intake.

Sociodemographic data included age, gender, residence, occupation, educational qualifications, years of education, and marital status.

**Occupational responsibilities**

Participants were asked if they were going outside the home for professional activity during lockdown; if yes, does their profession require changing shifts. Two items enquired about work from home and whether participants had to follow a structured time schedule for work from home or left to work as per convenience.

**Sleep pattern**

They were asked to provide usual bedtime, time to fall asleep, usual wake time, mode of awakening in the morning (self/alarm/other), quality of sleep and daytime naps with duration, total time spent in sleep in a given day before and after lockdown. Although multiple subjective and objective measures are available to assess sleep patterns and sleep patterns longitudinally, for example, sleep diary and actigraphy, use of recall method for sleep pattern has a moderate correlation with objective methods.[9,10] Moreover, methods of objective estimation of sleep pattern and duration amount for only 20% variation. Thus, the recall method can reliably be used to estimate the sleep pattern over short periods.

**Sleep quality**

Sleep quality in this study was assessed based on the subjective report of nighttime sleep after waking up in the morning on a single item. It asked about their subjective feeling of nighttime sleep quality. Single item has been found to have a good correlation with a score of Pittsburgh Sleep Quality Index.[11]

**Screen time**

Participants were asked about time spent on screen before and after lockdown each day in hours. Screens involved computers, laptops, smartphones, tablets, and television.

**Daily schedule**

Participants responded to a question “whether you are following a structured routine after lock-down?” in either yes or no. This question was used to assess the effect of lockdown on the daily routine.

**Substance use**

Participants were asked if they had used addictive substances such as tobacco, alcohol, cannabis, hypnotics, or any other substance during the past 6 months. They were also asked about changes in the pattern of substance use in the lockdown period.

**Other medical comorbidities**

Participants were asked if they had any other medical morbidity such as systemic hypertension, diabetes mellitus, cardiac illness, chronic obstructive pulmonary disease, asthma, or any other medical disorders. In addition, they were asked to provide information regarding medications that they were taking.

**Diagnosis of insomnia**

Insomnia was assessed using the Insomnia Severity Index (ISI).[12,13] It has seven items that enquire about nighttime sleep as well as daytime functioning and quality of sleep. Each item is scored on a five-point Likert scale with scores ranging between 0 and 28. Score >14 denotes clinical insomnia.[14] As this instrument was available only in English and Hindi, only scores in these languages are analyzed.

**Mood**

Depression and anxiety were diagnosed using four-item patient health questionnaire (PHQ-4).[15] PHQ-4 has been found to have two factors—depression and anxiety (84% variance). Increasing the PHQ-4 score correlates with the use of health-care resources, functional impairment,
and disability. It is an ultra-brief questionnaire to assess depression and anxiety.

Perceived stress scale
To assess the impact of prevailing conditions in emotions, four-item perceived stress scale-4 was used.[16] It has been validated as a measure of perceived stress among various populations and its score moderately correlates with anxiety and depression scale. It has an internal consistency of 0.74.[16]

International Physical Activity Questionnaire
A brief version of the International Physical Activity Questionnaire (IPAQ) was used.[17] This instrument asks the subject to provide information on time spent on exercise in the last 7 days, as well as time spent each day on categories of vigorous physical activity, moderate physical activity, walking, and sitting. This instrument has been shown to generate comparable scores to the longer IPAQ, which has been validated extensively.

Statistical analysis
Statistical analysis was performed using R v 3.6.2, with Standard Packages for the statistical analysis.[18] Before analysis, participants who had the same IP address were assessed for similarities in demographic characteristics, to exclude duplicates. Categorical responses to multiple-choice questions were summarized with frequency tables, and numerical responses (in relation to age, as well as total sleep time, screen time, and responses to IPAQ questions relating to types of exercise) were summarized using their mean and standard deviation. To study factors associated with changes in routine and sleep measures, these parameters were analyzed across subgroups with a net increase, reduction, or maintenance of sleep schedule. To do so, responses on current and previous bedtimes and waking times were used. These responses were collected on an ordinal scale of 1-hour intervals (between 4 AM and 8 AM for waking time, and between 10 PM and 12 AM for sleeping time). Differences in responses for the current and previous sleeping and waking times were used to identify individuals with later, earlier, and similar schedules. This was then used to recategorize individuals as those with an overall reduction in sleep times (those who had later sleeping times with the same or earlier waking times, or earlier waking times with the same sleep time), an increase in sleep time (an earlier sleeping time and later waking time, or either of these with no change in the other measure). Those individuals who maintained the same sleeping and waking times, or who had a similar direction of change in both were classified as having the same sleep time. Data on various parameters were analyzed across these three groups. The analysis was also conducted by changes in sleep quality between the prelockdown and lockdown periods, with four categories—those with preexisting poor quality sleep that persisted, those with good sleep quality in both periods, and those whose sleep worsened or improved between these time points.

Data were also compared across groups of occupational categories, namely, health-care workers (doctors and nurses) who were expected to be continuing to work as previously, housewives (who were presumed to be working mostly at home even before the lockdown), and those who did not belong to either of these categories. Bonferroni correction was applied for multiple testing and based on the number of variables, \( P < 0.002 \) was considered statistically significant.

RESULTS
A total of 1024 completed responses were received during the survey. Out of this, 60 responses were excluded for various reasons, for example, pregnancy, COVID-19 positivity, memory problems, taking sleeping pills and age of participants being <18 years. Nine hundred and thirty-eight participants were from IP addresses in India, with the remaining participants belonging to the USA (n = 7), UK and UAE (n = 4 each), Canada (n = 3), Singapore (n = 2), and one each from Australia, Germany, Kuwait, Oman, Qatar, and Saudi Arabia. The Indian respondents were spread across 25 states and from all regions of the country. Although most of the participants responded on all items, responses on some items were missing in some of the forms. However, after ensuring that all missing responses were not localized to some specific respondents, all 958 responses were included in the analysis. Due to missing values on the outcome measure, 958 individuals were included in the analysis on sleep duration, 935 for occupation groups, and 923 for sleep quality assessment.

The average age of participants in the study was 37.32 (±13.09) years. Two fifths (41.2%) group comprised women, 67% were married and living with their spouse. The rest were either unmarried or living alone. Three-fourth (75.9%) respondents were graduate and 35.9% were health-care workers. Nearly half (47%) of the subjects were working from home and 35.9% were going outside the home for work during lockdown. Nearly half (55%) participants were working as per their convenience while remaining were following daytime shift work. About 16.4% reported that they were engaged in changing shift-work. Nearly 9% were nicotine users, 10.8% were using alcohol and 1.1% reported use of cannabis. Nearly 14% reported that their substance use had reduced during lockdown, while 3.1% reported an increase.

Just over 10% of the group met the criteria for clinically significant insomnia according to ISI, 11.7% reported anxiety and 11.1% reported depression. Other medical disorders were also reported in the group with varying frequency, for example, hypertension (12.3%), 9.4%
diabetes mellitus, 7.2% hypothyroidism, 4.2% had asthma, 1.2% reported coronary artery disease, and chronic obstructive pulmonary disease, each. However, many subjects had more than one disorder.

A change has been noticed in sleep time and wake time after lockdown. Based on bedtime and wake time before and after home confinement, subjects were categorized into three groups-whose sleep duration at night has reduced (16.1%), increased (18.1%), and last, where it remained unchanged [Figure 1a]. These groups were comparable with regard to gender \((P = 0.57)\), education \((P = 0.29)\), physical activity, working outside home \((P = 0.17)\), working from home \((P = 0.13)\), shift working after lockdown \((P = 0.62)\), screen time before \((P = 0.90)\) and after lockdown \((P = 0.67)\), waking up with alarm before \((P = 0.08)\), and after lockdown \((P = 0.89)\), use of alcohol \((P = 0.28)\), tobacco \((P = 0.92)\) or any other addictive substance \((P = 0.38)\). Other comparing variables are shown in Table 4. Change in sleep quality compared to pre-lockdown state among these groups is depicted in Figure 1b and c shows a comparison of perceived stress among these groups. Figure 1d depicts the change in sleep onset latency after lockdown compared to prelockdown period.

As seen in Table 1, About a quarter (23.4%) reported that sleep quality worsened, in 8.4% it improved and in others remained similar to prelockdown state (pre-lockdown good = 46.9%; pre-lockdown poor = 20.7%) \((\chi^2 = 64.03; P < 0.001)\). These groups were comparable with regard to gender \((P = 0.007)\), education \((P = 0.07)\), occupation \((P = 0.33)\), daytime napping before \((P = 0.23)\) and after \((P = 0.30)\) lockdown. Similarly, working from home \((P = 0.26)\) or outside home \((P = 0.91)\), regularity of work from home \((P = 0.10)\), and shift work \((P = 0.09)\) were not different among groups. Physical activity was also comparable among these groups. Table 2 illustrates distribution of other factors in these groups.

Table 3 represents a comparison of demographic, sleep pattern, insomnia, mood, and physical activity among groups based on occupation-health-care workers, homemakers, and others. These groups were comparable with regard to education level \((P = 0.31)\), screen time before lock-down, sleep-onset latency before \((P = 0.43)\) and after \((P = 0.93)\) lockdown, sleep quality before \((P = 0.43)\) and after lockdown \((P = 0.52)\), and physical activity before and after lockdown.

### Table 1: Change in sleep schedule before and during lockdown \((n=938)\)

| Sleep pattern                        | Before lockdown | During lockdown | Test statistic | \(P\)  |
|--------------------------------------|-----------------|-----------------|----------------|--------|
| Bedtime                              |                 |                 |                |        |
| After 11 PM                          | 451 (48.4)      | 610 (65.2)      | 52.98          | <0.001 |
| Before 11 PM                         | 480 (51.6)      | 325 (34.8)      |                |        |
| Sleep onset latency                  |                 |                 |                |        |
| <30 min                              | 741 (79.4)      | 523 (56.6)      | 132.8          | <0.001 |
| >60 min                              | 36 (3.8)        | 157 (16.99)     |                |        |
| 30-60 min                            | 156 (16.7)      | 244 (26.4)      |                |        |
| Waking time                          |                 |                 |                |        |
| After 6 AM                           | 686 (73.6)      | 748 (80.3)      | 11.55          | 0.001  |
| Before 6 AM                          | 246 (26.4)      | 183 (19.7)      |                |        |
| Mode of waking                       |                 |                 |                |        |
| By myself                            | 504 (54.0)      | 611 (65.7)      | 80.27          | <0.001 |
| Somebody wakes me up                 | 54 (5.8)        | 113 (12.2)      |                |        |
| With alarm                           | 375 (40.2)      | 206 (22.2)      |                |        |
| Daytime napping                      |                 |                 |                |        |
| <60 min                              | 290 (31.1)      | 354 (38.0)      | 129            | <0.001 |
| >60 min                              | 86 (9.2)        | 237 (25)        |                |        |
| No naps                              | 556 (59.7)      | 340 (37)        |                |        |
| Refreshed sleep on waking            | Nonrefreshed    | 276 (30)        | 44.88          | <0.001 |
| Refreshed                            | 657 (70)        | 515 (55)        |                |        |
| Screen time (h)                      | 3.77±2.752      | 5.52±2.371      | <0.001*        |        |

*Chi-square test; *Mann-Whitney U-test

### Table 2: Comparison of variables associated with change in nighttime sleep after lockdown \((n=935)\)

| Variable                  | Change in Nighttime sleep from pre-lockdown | Test statistic | \(P\)  |
|---------------------------|--------------------------------------------|----------------|--------|
|                          | Reduced \((n=151)\)                        | Same \((n=614)\) | Increased \((n=170)\) | |
| Age (years)              | 37.42±12.6                                | 37.77±13.18    | 36.12±12.93 | 30.14 | <0.001* |
| Occupation (%)           |                                            |                |                |       |
| Health-care worker       | 55 (36.42)                                | 247 (40.22)    | 63 (37.05)    | 3.93  | 0.41    |
| Home-maker               | 13 (8.60)                                 | 47 (7.65)      | 8 (4.70)      |       |        |
| Other                    | 82 (54.30)                                | 317 (51.62)    | 99 (58.23)    |       |        |
| Working outside the home after lockdown (%) | 61 (40.39) | 250 (40.71) | 56 (32.94) | 3.47 | 0.18    |
| Sleep-onset latency <30 min before lockdown (%) | 123 (81.45) | 499 (81.27) | 124 (72.94) | 6.25 | 0.04    |
| Sleep-onset latency <30 min after lockdown (%) | 74 (49) | 351 (57.16) | 106 (62.35) | 5.95 | 0.05    |
| Refreshing sleep after lockdown (%) | 111 (73.50) | 444 (72.31) | 105 (61.76) | 8.01 | 0.01    |
| Refreshing sleep after lockdown (%) | 68 (45.03) | 344 (56.02) | 106 (62.35) | 10.39 | 0.005   |
| Daytime napping before lockdown (%) | 56 (37.08) | 257 (41.85) | 66 (38.82) | 1.49 | 0.48    |
| Daytime napping after lockdown (%) | 93 (61.5) | 400 (65.14) | 98 (57.64) | 2.82 | 0.24    |
| Anxiety reported (%)     | 19 (12.58)                                | 75 (12.21)     | 13 (7.64)     | 2.97  | 0.23    |
| Depression reported (%)  | 26 (17.21)                                | 66 (10.74)     | 10 (5.88)     | 10.62 | <0.001  |
| Insomnia (%)             | 36 (9.92)                                 | 6 (8.82)       | 47 (10.17)    | 0.122 | 0.941   |

*Kruskall-Wallis test; Others were Chi-square tests*
These findings contrast with those of a recent study from a Greek population, which reported that nearly 38% of participants had clinical insomnia after the COVID-19 outbreak. However, proportion to clinical insomnia was lower during the present study compared to the Greek population and remained at the level of pre-COVID-19 period. Voitsidis et al. showed that insomnia in the Greek population was a function of loneliness, uncertainty, depression, and COVID-19-related worries with a major contribution from two factors—depression and uncertainty. Perception of uncertainty and depressive feelings are influenced by a number of factors, for example, age, religious beliefs, availability of family support, to name a few. The study population in this study was younger compared to that included in the present study. Available literature suggests that resilience increases with age and is positively associated with spiritual beliefs and support of...
Most of the subjects included in the present study were married and living with a spouse (though does not always translate in positive emotional support) that could have resulted in lesser perceived stress and insomnia. It is further strengthened by the finding that perceived stress was comparable among groups with reduced, increased and “no-change” in nighttime duration of sleep after lock-down [Figure 1c].

Lockdown also affected sleep patterns and screen time [Table 3]. Bedtime was delayed, sleep onset latency prolonged, and the proportion of daytime napping increased. A sizable number of subjects were confined to home in the present study, and home confinement is known to produce such effects due to disruption in circadian rhythm. [5] Daytime napping also reduces the sleep pressure, thus, delays the bedtime and prolongs sleep-onset latency. [5] Thus, circadian and homeostatic factors regulating sleep are mutually influential and interact to determine the timing and latency of sleep onset. [5] Moreover, delayed sleep also reduces the amount of slow-wave sleep owing to circadian factors, and this may result in poor sleep quality, as was seen in the present study. [5] Other factors that could influence sleep patterns could be screen time, which increased after lock-down. Longer time on screen is associated with shorter sleep and lesser sleep efficiency. [21]

Owing to the shift of sleep pattern, reduced nighttime sleep compared to prelockdown sleep was observed in 16.1% and longer nighttime sleep in 18.1% [Table 4]. However, the reduction was related to delayed bedtime and prolongation to delayed waking up [Figure 1a]. Shorter sleep duration after lockdown was associated with an increased proportion of longer sleep onset latency and depression after lockdown. In addition, shorter nighttime sleep duration was associated with worsening of sleep quality after lockdown [Table 2]. Although not systematically assessed in the present study, shorter nighttime sleep duration could have resulted in sleep deprivation. This is further reiterated by the fact

**Figure 1:** (a-d) Sleep-related variables in subjects during home confinement during COVID-19

| Change in bedtime and wake time after lockdown (%) (N=935) |
|-----------------------------------------------------------|
| Waking Earlier (n=92) Waking same time (n=437) Waking Later (n=406) |
| Bedtime Earlier (n=78) 3.10 2.78 2.46 |
| Bedtime Same (n=478) 3.64 34.55 12.94 |
| Bedtime Later (n=379) 3.10 9.41 28.02 |

**Category Indicators:**
- Nighttime sleep reduced
- Nighttime sleep remained same
- Nighttime sleep increased

Change in sleep duration during home confinement (N subjects)

**Comparison of perceived stress among groups**

| Perceived Stress Scale |
|------------------------|
| Reduced Same Increased |

**Change in sleep onset latency before and after home confinement (%)**

| < 30 min before confinement | > 30 min before confinement |
|-----------------------------|-----------------------------|
| 15.63 25.30                | 15.63 10.59                |

| 30 min after confinement | < 30 min after confinement |
|--------------------------|-----------------------------|
| 5.00                     | 15.63                       |

| 30 min after confinement | < 30 min after confinement |
|--------------------------|-----------------------------|
| 8.00                     | 15.63                       |
that the proportion of poor-quality sleep and daytime napping has also increased in this group [Table 4]. Sleep deprivation is known to produce depressive symptoms, daytime fatigue, and daytime sleepiness. Moreover, the optimal treatment of insomnia also improves depressive symptoms. A dose-response relationship between the proportion of depression with the change in sleep-duration, sleep-quality, and comparable proportions of insomnia supports this notion [Table 2 and 4]. However, in the present study, change in nighttime sleep duration was not affected by physical activity, occupation, working from home, or going outside home and perceived stress. These findings are contradictory to proposals in a recent paper that suggested plausible mechanisms of sleep changes during home confinement. It was put forth that confinement may lead to increased stress owing to a multitude of factors, namely, available space, lack of social interaction, absence of work and reduction in physical activity, which ultimately culminates in sleep disruption. This was not seen in the present study as nearly half of the study population was working from home after lockdown, and social interaction through social media could have been maintained to prelockdown state as depicted by the increment in screen-time after lock-down.

This study indicated that nearly a quarter of participants reported worsening of sleep quality after lockdown. In addition, nearly 21% of participants had poor sleep quality even before the lockdown.

Both proportions are greater than the fraction of poor sleep quality among the Indian population reported earlier. A number of factors could explain the difference. First, an earlier Indian study was conducted in a limited geographical population using face to face interviews with a validated questionnaire. On the other hand, the present study was a self-reported survey sent through social media and was dependent on recall-based response. Moreover, sleep quality was determined through a single item rather than using a structured questionnaire. Though single item has been found to have optimal concurrent validity to assess sleep quality, there is a possibility that persons with poor sleep quality have preferred to respond to survey over persons with good sleep quality. Finally, the prevalence of poor sleep quality was greater than insomnia in the present study because both are different constructs. Considering that sleep quality may be affected by a number of other sleep disorders, besides insomnia, poor sleep quality has been removed from the diagnostic criteria of insomnia disorder.

In the present study, groups based on occupation were comparable with regard to sleep quality and delayed in bed-time and wake time compared to prelockdown [Table 1]. Some of the home-makers responded that they were working from home during lock-down, which could be attributed to part-time home-based professional activities in this group. Home-makers had a maximal shift in sleep-time and wake-time after lockdown. Although increment in the proportion of daytime napping was observed in health-care workers and other professionals, it was not seen in home-makers. Moreover, comparable shifting of sleep schedule and proportion of working after lockdown among three groups also challenge the possibility that work-load could result in stress and consequent sleep problems. However, interaction among the place of work (from home and outside home) and mood (anxiety and depression) could have influenced sleep quality, which could not be examined in the present study. Health-care workers had the lowest proportions of anxiety and depression compared to the other two groups. This could have resulted from a better understanding of COVID-19 in this group compared to the other two groups.

This study had certain methodological limitations that are inherent to Internet-based surveys. First, all inclusion and exclusion criteria were assessed on the basis of self-report, and therefore some participants who were unaware of their status (e.g., for memory problems or pregnancy) may have been included. Second, cross-sectional collection of data has a recall bias, especially for patterns of sleep and activity assessed for the prelockdown period. Third, as already discussed, response bias could not be ruled out. Fourth, some data was missing in all variables, though the magnitude was limited to 1%-2% of the total number of subjects. As responses were solicited by requests across social media platforms by a snowballing strategy, the subjects recruited may belong to groups that belong to similar strata of society, besides being more likely to be known to each other. This is made evident by the large proportion of health-care workers amongst the respondents (n = 379; 39.3%), Internet access, motivation to respond, and comfort with self-reporting emotional and behavioral symptoms, may all have influenced both participation rates, and the responses elicited. Moreover, stresses related to the lockdown are unlikely to be uniformly distributed in the community and are likely to affect those with limited material resources, more than the wealthy. Taken together, these factors affect the generalizability of the results. Fifth, although data is based on self-report on standardized assessment tools wherever available, these have mostly been short screening instruments rather than comprehensive evaluations, as these might limit participation. Finally, it is difficult to ascertain how many individuals received the survey link but did not participate, and thus a response rate could not be ascertained.

CONCLUSIONS

This survey showed that COVID-19 lockdown was associated with poor sleep quality, shift in sleep cycle to delayed phase,
sleep-deprivation based on nighttime sleep, and depressive symptoms in a sizable number of population.

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**Conflicts of interest**

There are no conflicts of interest.

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