

Covid-19 pandemic, sleep quality, and emotional tone of dreams: A model to look into how psychological stress affects sleep quality, dream and emotionality

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Summary. The outbreak of coronavirus disease (Covid-19) has impacted the health and welfare of people globally. Given the fundamental role of sleep in health and wellbeing, it is important to study the impact of Covid-19 on sleep quality, dream content and emotionality. This has not been studied among Indian population. The present study was carried out to understand the state of sleep quality, dream contents and the relation between sleep quality and emotionality in people during the Covid-19. Based on previous studies, we expected to find differences among individuals based on how much they were affected by Covid-19, which may be because of pandemic-related stressors (like altered family dynamics, economic stability, etc.). We used Mannheim Dream questionnaire (MADRE), Pittsburgh Sleep Quality Index (PSQI), Positive Affect Negative Affect Schedule (PANAS). We used robust statistics and resampling-based estimates to quantify differences and associations for hypothesis testing. The findings indicate that during pandemic, sleep quality deteriorated with increase in negative affect and improved with increase in positive affect. Sleep quality also deteriorates with an increase in the intensity of emotionally charged dreams. Furthermore, correlation analysis revealed a negative relationship between age and negative affect (NA) suggesting that the younger the age, higher the negative affective state. Subjects who reported to be Covid-19 affected had an increased frequency of nightmares and were more distressed by nightmares, compared to those reporting not affected. This supports the notion that sleep, dreams, and affective states were disrupted during the pandemic. Subjects infected with Covid-19 had dreams of relatives or friends suffering from coronavirus and this shows the strong effect of the pandemic on the dream contents. Our study highlights the impact of psychological stress on human sleep, and emotionality. According to the study findings, we suggest that monitoring sleep, dreams, and emotions may help in developing effective interventions to restore sleep quality, prevent sleep disorders, and manage affective behaviour in pandemic like situations.

Keywords: Dreams, sleep, affective states, Covid-19 pandemic

1. Introduction

The rapid spread of Covid-19 severely impacted both psychological and social life of people around the globe. Compromised sleep is one of the chief contributing factors that worsens psychological wellbeing and emotional stability (Dey et al., 2021; Majumdar et al., 2020, Verma, 2020, Brooks et al., 2020, Casagrande et al., 2020; Rasskazova et al., 2020; Ong et al., 2011, Dai et al., 2021; Guadagni et al., 2020). Moreover, poor sleep quality is related to emotion-

ally negative dreams and increased number of nightmares (Levin, 1994; Simor et al., 2012, Bulkeley & Kahan, 2008; Pesonen et al., 2020; Schredl & Bulkeley, 2020). Worsening of sleep quality, increase in frequency of negative dreams and negativity of dream contents, and diminishing mental and emotional health have been reported in disasters like disease outbreak, wars, 9/11 terrorists' attack, (Barrett, 2001; Hartmann & Basile, 2003; Hartmann & Brezler, 2008, Chew et al., 2020; Datta & Tripathi, 2021; Franceschini et al., 2020; Huang & Zhao, 2020; Innocenti et al., 2020; Schredl & Bulkeley, 2020; Tan et al., 2020; Verma, 2020; Zhou et al., 2020). It is assumed that increase in distress and traumatic experiences gets reflected in dreams especially as nightmares and in disturbances of sleep patterns (Barrett, 2001; Bulkeley & Kahan, 2008). Poor sleep quality was observed in the Chinese population at the beginning of the Covid-19 outbreak and individuals were at risk of mental illness such as depressive symptoms, anxiety and acute post-traumatic stress symptoms (Fofana et al., 2020; Huang & Zhao, 2020; Sun et al., 2020). Similarly, a study from Finland reported an increase in pandemic related dreams, especially increase in nightmares and self-reported perceived stress (Pesonen

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et al., 2020). One of our previous studies, during Covid-19 pandemic reported poor sleep quality, high day time impairments, and negative emotionality among vulnerable people (Radhakrishnan et al., 2021). The present study examined sleep quality in relation to dreams, dream content and affective states in an Indian population sample, comparing people who were affected versus those who were not affected by the pandemic. Health professionals were also included as their work was more related to the sufferings of Covid-19. Studies report that an individual's affective states during the day influence the sleep quality of the subsequent night and this compromised sleep quality will in turn impact affective states in the following day (Konjarski et al., 2018, Kalmbach et al., 2014). As affective states impact dreams and sleep quality, a strong association among sleep quality, sleep mentation, and affective states have been reported (Levin et al., 2011; Ong et al., 2011; Hobson, 2009; Hobson et al., 1998). Waking life events during day time impact our dreams and sleep which in turn facilitate adaptation to waking experiences. In order to study dream contents elaborately, we have used sensitive dream content-based questions in the study. Such an approach is important to analyse dreams and dream contents related to pandemic or threatening situations etc. We have undertaken this study with the hypothesis that individuals who have been affected by Covid-19 would experience more negative emotions during the day and will have more negative pandemic-related dreams with reduced sleep quality, intense emotional dreams with negative tone, and increased frequency of nightmares.

2. Method

A web-based cross-sectional survey was conducted from October to November 2020. Participant recruitment was done through online platforms mainly through Twitter, Reddit and WhatsApp. The link for the survey was active from the 31st of October to the 30th of November 2020. Before the start of the survey, an online electronic consent was obtained for the willingness to participate. To maintain anonymity of the participants, we refrained from collecting their names, phone numbers, and email addresses. However, participants were free to contact us via phone and email for any clarification regarding the survey. One response was limited to one web account address so as to avoid any repetition of responses. Data were anonymised when stored online. Subjects were free to withdraw from the study at any time. The total time to fill out the survey was approximately 10-15 minutes.

The survey received a total of 961 responses. 15 were duplicate entries and were excluded. Thus we had 946 responses worldwide, of which 776 were residing in India and 170 from other countries. The current study focused only on Indian residents and therefore the final sample size of the study is 776. The study was conducted in accordance with the declaration of Helsinki. The study is undertaken as a part of the ongoing study on Neurophysiology of dreams and Institute ethics committee approval was obtained (NIMH/DO/ETHICS SUB-COMMITTEE (BS & NS; 11th MEETING/19).

The primary objective of this study was to explore the effects of the pandemic on the Indian sample. We adopted a questionnaire-based approach to evaluate quantitative and qualitative features of sleep patterns, emotional health, and dreaming experience in different groups of the same sample whose lives were affected by the pandemic. Individuals were grouped on the basis of reported gender. The

study participants were also grouped as the: 'High Recallers' (HR) (who reported "several times a week", "almost every morning" dreams) versus 'Low Recallers' (LR) (who reported "two or three times a month", "more than once a month", or "never" dreams); individuals having a history of Covid-19 infection vs no history of infection; individuals with nearby relative, neighbours, or friends infected vs those with no nearby infected people; individuals in healthcare profession vs those not in healthcare; and lastly, individuals whose life is affected by Covid-19 pandemic vs those whose life is not affected by Covid-19. On the basis of the study's objectives, we explored the socio-demographic details, Mannheim Dream questionnaire, Pittsburgh Sleep Quality Index, Positive Affect Negative Affect Schedule and dream content-based questions.

Socio-demographic (DG) details include age (DG1), gender (DG2), healthcare professional (DG3), level of education (DG4), current residence "country" (DG5), history of infection with Covid-19 (DG6), Covid-19 infected relatives, neighbours, or friends (DG7), to what extent has the ongoing Covid-19 pandemic affected your life (DG8). For DG8, participants who answered "moderately affected", "quite a lot affected" or "severely affected" were categorised under "Covid-19 affected life", whereas those who answered "not at all affected" or "slightly affected" were put under "not Covid-19 affected life".

2.1. Mannheim Dream Questionnaire (MADRE)

The current study used the English version of MADRE, a questionnaire with 20 self-reported items (Schredl et al., 2014). MADRE covers dream recall frequency, lucid dream recall frequency, the intensity of dreams, frequency of recent nightmares, and different aspects of dream content. Since this questionnaire provides many variables, we focused on selected items for the analysis as per our hypothesis. These include dream recall frequency (MD1), intensity of dreams emotionally (MD2), emotional tone of dreams (MD3), frequency of recent nightmares (MD4), and distress caused by nightmares (MD5). Dream recall ability was obtained by MADRE questionnaire from item number 1 i.e., "How often have you recalled your dreams recently" (MD1).

2.2. Pittsburgh Sleep Quality Index (PSQI)

PSQI score is used to measure the overall sleep quality. It is a 19-items scale and has seven components which indicate various sleep problems over the past month (Buysse et al., 1989). These components are subjective sleep quality (PQC1), sleep latency (PQC2), sleep duration (PQC3), sleep efficiency (PQC4), sleep disturbance (PQC5), use of sleep medication (PQC6), and daytime dysfunction (PQC7). The global PSQI score is obtained by summing up scores (0-3 range) of all the components. The global PSQI score ranges from 0 to 21 and indicates that a higher score is associated with worse sleep quality.

2.3. Positive Affect Negative Affect Schedule (PANAS)

PANAS is a 20 items scale and is used to assess affective states over a variable time frame (e.g. present moment, past few days, past week, past month). In the current study, participants were asked to respond to the items that are rated on a 5-point Likert-type scale ranging from 1 (very slightly or not at all) to 5 (extremely) over the past few weeks. PANAS

consists of 10 words (interested, enthusiastic, inspired, excited, strong, proud, alert, determined, attentive, active) that assess positive affect (PA) and 10 words (scared, nervous, upset, distressed, guilty, irritable, hostile, ashamed, jittery, afraid) that assess negative affect (NA). PANAS scale scores ranges between 10 and 50 were calculated (Crawford & Henry, 2004).

2.4. Dream Content (DC) based questions

To examine the content of dreams, we asked the participants 10 questions which gives information about dream content related to Covid-19 pandemic. Dream Content Questions for the present study related to aggression and friendliness were derived from the literature (Bernstein & Roberts, 1995; Bruni et al., 1999). Dream content questions related to sufferings associated with covid-19 were added in this study to gain further details of the dream content. These questions are: “How are your dreams typically during Covid-19 pandemic? (DC1)”, “How often do you find yourself friendly and calm while dreaming? (DC2)”, “How often do you find aggressive or cruel characters in your dreams? (DC3)”, “How often have you seen yourself suffering from a disease or trauma in dreams? (DC4)”, “How often have you seen yourself recovering from a disease or trauma in dreams? (DC5)”, “How often have you seen people in your immediate social environment (family, relatives, or neighbours) suffering from diseases or trauma in dreams? (DC6)”, “How often have you seen people in your immediate social environment (family, relatives, or neighbours) recovering from diseases or trauma in dreams? (DC7)”, “Have you seen yourself suffering from coronavirus in dreams? (DC8)”, “Have you dreamt of your relatives or friends suffering from coronavirus? (DC9)”, and “What are the spatial settings (places) of your dreams in the last several months? (DC10)”. Questions DC2 to DC7 were responded on Likert scale (Always, Often, Sometimes, Rarely, Never) whereas questions DC8 and DC9 were answered with YES or NO options. Questions DC1 and DC10 were not included for analysis.

2.5. Statistics

Robust correlations and Chi-squared tests were done using open-source statistical packages (Pingouin version 0.5.0, Vallat, 2018) and python libraries (NumPy, Pandas). Between-group differences were evaluated using Yuen’s test for trimmed means based on bootstrap samples (20% trimming and 5000 bootstrap samples) (Wilcox, 2011; Yuen, 1974). Corrections for multiple comparisons were done for correlations, Chi-squared tests as well as Yuen’s test using Holm’s method (Holm, 1979). Comparisons using Chi-squared and Yuen’s tests were grouped per hypothesis and corrections were carried out for controlling the family-wise error rate at 0.05, whereas corrections for all correlations were applied globally. A corrected p-value < 0.05 was considered statistically significant, although we also report uncorrected p-values that were less than 0.05 to highlight

trends. Detailed statistical results for all comparisons are provided in supplementary.

Effect sizes: We appreciate that due to the large sample size any statistical tests may be over-sensitive to the slightest differences. However, we point out that three ways in which we have already addressed this issue. Firstly, we use robust estimators throughout – Yuen’s test which compares 20% trimmed means between two groups, and the Shepherd’s pi estimator for correlation, which handles bivariate outliers effectively. Our usage of these estimators makes our estimates more reliable and robust to outliers and deviations from normality, thereby reducing type I error while maintaining adequate power. Secondly, we use resampling-based procedures using these robust statistical estimators for inference and hypothesis testing for each pre-defined hypothesis. This further minimizes the effect of outliers and deviations from normality. And lastly, we use a strict control of family-wise type I error rate using Holm’s correction for variables grouped under each pre-defined hypothesis. The key findings presented in the main paper are now restricted to only those variables which were significant after applying Holm’s correction for multiple comparisons. We point out that these approaches are widely used across scientific domains, and we argue that our usage of these three methods permits very sensitive detection of effects with adequate power, while keeping the type I error rate under control.

While we have computed effect sizes ahead of submission, we did not present them in the main paper. We believe that effect sizes estimated based on our usage of robust statistics are not directly interpretable in the same way as more commonly used measures such as Cohen’s d. Given that the presented work is geared towards discovery of effects, we have not highlighted the strength of these effects and we have instead presented important variables that can guide further studies. We ultimately recognize the importance of effect sizes, and therefore we provide these along with full statistical results in the supplementary. The effect size measure used follows Algina et al 2005.

3. Results

A brief summary of age demographics is summarized in table 1. The overall results showed that individuals affected by Covid-19 had an increased incidence of recent nightmares and were also distressed by nightmares. We found that females were more distressed by nightmares during the pandemic than males. After dividing individuals based on dream recall ability, we found that individuals with a ‘High Recall’ reported lesser overall sleep quality, reduced sleep durations and increased daytime dysfunction compared to individuals with ‘Low Recall’. Individuals in healthcare reported shorter sleep latency than individuals those who weren’t in healthcare. We also found a positive correlation between overall sleep quality (PSQI score) and negative affect. Our findings showed that life affected by Covid-19 is positively associated with an increase in dream intensity as well as an increase in the frequency of nightmares.

3.1. Individuals affected by Covid-19 and their sleep, dreams and affective state.

We found increased daytime dysfunction ($p_{holm}=0.01$) in individuals who reported being affected by Covid-19 individuals. They also experienced more nightmares ($p_{holm}<0.001$), which were more Covid distressing to them than those who

Table 1. Distribution of Age.

| | Valid | Median | Mean | Std. Dev. | Minimum | Maximum |
|---------|-------|--------|--------|-----------|---------|---------|
| Females | 242 | 26 | 29.558 | 9.854 | 18 | 63 |
| Males | 534 | 33 | 34.534 | 9.901 | 18 | 65 |

Table 2. Individuals affected by Covid-19 and their sleep, dreams and affective state. (Covid Affected Life (N_{no}=236, N_{yes}=540)).

| Dependent variables | Est. difference | t-statistic | p _{uncorrected} | p _{holm} | |
|---|-----------------|-------------|--------------------------|--------------------------|-------------------|
| Overall sleep quality (PSQI score) | -0.75 | -2.96 | 0.00 | 0.06 | |
| Subjective sleep quality (PQC1) | -0.15 | -2.63 | 0.02 | 0.23 | |
| Daytime dysfunction (PQC7) | -0.25 | -3.44 | 0.00 | 0.01* | |
| Find yourself friendly and calm while dreaming (DC2) | 0.16 | 2.05 | 0.04 | 0.29 | |
| Find aggressive or cruel characters in your dreams (DC3) | -0.28 | -3.03 | 0.01 | 0.10 | |
| Seen yourself suffering from diseases or trauma in dreams (DC4) | -0.29 | -2.68 | 0.01 | 0.12 | |
| Seen yourself recovering from diseases or trauma in dreams (DC5) | -0.15 | -1.94 | 0.05 | 0.38 | |
| Seen nearby people suffering from a disease or trauma in dreams (DC6) | -0.32 | -2.89 | 0.00 | 0.06 | |
| Seen nearby people recovering from a disease or trauma in dreams (DC7) | -0.22 | -2.04 | 0.06 | 0.38 | |
| Intensity of dreams emotionally (MD2) | -0.22 | -2.19 | 0.03 | 0.28 | |
| Frequency of recent nightmares (MD4) | -0.64 | -3.65 | 0.00 | 0.00*** | |
| Distress caused by nightmares (MD5) | -0.55 | -5.07 | 0.00 | 0.00*** | |
| Negative Affect (NA) | -2.18 | -2.59 | 0.01 | 0.15 | |
| Chi-square variables | x ² | DoF | Cramer's V | p _{uncorrected} | p _{holm} |
| Covid Affected Life vs emotional tone of dreams (MD3) | 21.39 | 4 | 0.17 | 0.00 | 0.00** |
| Covid Affected Life vs seen yourself suffering from coronavirus in dreams (DC8) | 0.29 | 1 | 0.02 | 0.59 | 1.00 |
| Covid Affected Life vs dreamt of your relatives or friends suffering from coronavirus (DC9) | 1.33 | 1 | 0.04 | 0.25 | 1.00 |

were not affected by the pandemic ($p_{holm} < 0.001$). The emotional tone of dreams in Covid-19 affected versus those who were not affected by the pandemic differed significantly (chi-squared=21.39, $p < 0.001$, $p_{holm} < 0.001$). Find more details in table 2.

Further findings show a trend towards a decrease in subjective sleep quality ($p = 0.02$, $p_{holm} = 0.23$) and overall sleep quality ($p < 0.01$, $p_{holm} = 0.06$) (these trends are not statistically significant after correcting for multiple comparisons) in individuals whose lives were affected by the Covid-19 pandemic. These individuals also found themselves less friendly and calm in dreams ($p = 0.04$, $p_{holm} = 0.29$) and encountered more aggressive or cruel characters in their dreams ($p < 0.01$, $p_{holm} = 0.10$) but these effects were not significant after corrections for multiple comparisons. They had a higher incidence of dreams involving relatives, neighbours, or friends ($p < 0.01$, $p_{holm} = 0.06$) and themselves ($p = 0.01$, $p_{holm} = 0.12$) suffering from diseases or trauma than individuals who were not affected by Covid. They also found themselves recovering

from disease or trauma in their dreams ($p = 0.05$, $p_{holm} = 0.38$), and experienced more emotionally intense dreams ($p = 0.03$, $p_{holm} = 0.28$). They also showed increased negative mood during day time ($p = 0.01$, $p_{holm} = 0.15$) but results were insignificant after corrections for multiple comparisons.

3.2. Dreams and affective states of females and males

From a demographic perspective, female individuals were younger than male individuals ($p < 0.001$, $p_{holm} < 0.001$). We found that females were more distressed because of nightmares ($p < 0.001$, $p_{holm} < 0.001$) than males (detailed in Table 3).

We also observed weaker trends which did not survive corrections for multiple comparisons. For instance, females reported a greater tendency to dream about people in their immediate social environment (family, relatives, or neighbours) suffering illness or trauma ($p = 0.03$, $p_{holm} = 0.48$). More-

Table 3. Dreams and affective states of females and males (Gender (N_{female} =242, N_{male} =534)).

| Dependent variables | Est. difference | t-statistic | p _{uncorrected} | p _{holm} |
|---|-----------------|-------------|--------------------------|-------------------|
| Find aggressive or cruel characters in your dreams (DC3) | 0.12 | 1.85 | 0.06 | 0.66 |
| Seen nearby people suffering from a disease or trauma in dreams (DC6) | 0.23 | 2.10 | 0.03 | 0.48 |
| Intensity of dreams emotionally (MD2) | 0.31 | 2.98 | 0.00 | 0.06 |
| Frequency of recent nightmares (MD4) | 0.42 | 2.12 | 0.04 | 0.50 |
| Distress caused by nightmares (MD5) | 0.47 | 4.54 | 0.00 | 0.00*** |
| Age | -6.14 | -7.03 | 0.00 | 0.00*** |
| Negative Affect (NA) | 2.08 | 2.70 | 0.01 | 0.14 |

Table 4. Sleep, dreams and affective states of Higher Recallers (HR) and Low Recallers (LR) (Dreamers (N_{HR}=309, N_{LR}=467)).

| Dependent variables | Est. difference | t-statistic | p _{uncorrected} | p _{holm} | |
|---|-----------------|-------------|--------------------------|--------------------------|-------------------|
| Overall sleep quality (PSQI score) | 0.86 | 3.60 | 0.00 | 0.00** | |
| Subjective sleep quality (PQC1) | 0.20 | 3.74 | 0.00 | 0.01** | |
| Sleep latency (PQC2) | 0.26 | 3.32 | 0.00 | 0.01* | |
| Daytime dysfunction (PQC7) | 0.29 | 3.81 | 0.00 | 0.01** | |
| Find yourself friendly and calm while dreaming (DC2) | -0.22 | -2.70 | 0.01 | 0.07 | |
| Find aggressive or cruel characters in your dreams (DC3) | 0.42 | 4.39 | 0.00 | 0.01** | |
| Seen yourself suffering from diseases or trauma in dreams (DC4) | 0.32 | 3.10 | 0.00 | 0.01** | |
| Seen yourself recovering from diseases or trauma in dreams (DC5) | 0.21 | 2.51 | 0.02 | 0.07 | |
| Seen nearby people suffering from a disease or trauma in dreams (DC6) | 0.30 | 2.94 | 0.00 | 0.03* | |
| Seen nearby people recovering from a disease or trauma in dreams (DC7) | 0.23 | 2.32 | 0.03 | 0.07 | |
| Intensity of dreams emotionally (MD2) | 0.84 | 10.29 | 0.00 | 0.00*** | |
| Frequency of recent nightmares (MD4) | 1.54 | 7.44 | 0.00 | 0.00*** | |
| Distress caused by nightmares (MD5) | 0.47 | 4.65 | 0.00 | 0.00*** | |
| Positive Affect (PA) | 1.57 | 2.45 | 0.01 | 0.07 | |
| Negative Affect (NA) | 3.54 | 4.60 | 0.00 | 0.00*** | |
| Age | -4.79 | -5.71 | 0.00 | 0.00*** | |
| Chi-square variables | x ² | DoF | Cramer's V | p _{uncorrected} | p _{holm} |
| Covid Affected Life vs emotional tone of dreams (MD3) | 17.59 | 4 | 0.15 | 0.00 | 0.02* |
| Covid Affected Life vs seen yourself suffering from coronavirus in dreams (DC8) | 4.18 | 1 | 0.07 | 0.04 | 0.49 |
| Covid Affected Life vs dreamt of your relatives or friends suffering from coronavirus (DC9) | 10.38 | 1 | 0.12 | 0.00 | 0.02* |

over, their dreams featured more aggressive and cruel characters ($p=0.06$, $p_{holm}=0.66$). During daytime activities, their affective states were more negative ($p<0.01$, $p_{holm}=0.14$) than males but not significantly. Females also reported having more emotionally intense dreams ($p<0.01$, $p_{holm}=0.06$) and more nightmares than males ($p=0.04$, $p_{holm}=0.50$) but these effects were not significant after corrections for multiple comparisons.

3.3. High Recallers and Low Recallers dreamers

We found that individuals who had a high dream recall rate (HR, 39.8% of all individuals) had a reduced overall sleep quality ($p=0.001$, $p_{holm}<0.01$), reported subjective sleep quality ($p=0.001$, $p_{holm}<0.01$) and increased sleep latency ($p=0.001$, $p_{holm}<0.01$) than individuals with a low dream recall rate (LR). Daytime dysfunction was also higher in HR than LR ($p=0.001$, $p_{holm}<0.01$). HR reported more aggressive or cruel characters ($p=0.001$, $p_{holm}<0.01$) in their dreams, and reported having seen nearby people ($p<0.01$, $p_{holm}=0.03$)

and themselves ($p=0.001$, $p_{holm}<0.01$) suffering from disease or trauma in dreams more than LR. HR had greater incidence of intense dreams ($p<0.001$, $p_{holm}<0.001$) and experienced more nightmares recently ($p<0.001$, $p_{holm}<0.001$) than LR. These nightmares were also distressing during the pandemic ($p<0.001$, $p_{holm}<0.001$). HR also showed a more negative mood ($p<0.001$, $p_{holm}<0.001$) and surprisingly, also reported a weaker effect of increased positive affect than LR ($p=0.013$; $p_{holm}=0.071$). Statistical comparisons by chi-squared test showed that there was a significant difference in the emotional tone of dreams of HR and LR (chi-squared = 17.59; $p<0.001$, $p_{holm}=0.02$), with more negative tone for HR. We also found a difference in the dreams of HR and LR when they dreamt of their relatives or friends suffering from Covid (chi-squared = 10.38; $p<0.001$, $p_{holm}=0.02$), with higher incidence of such dreams in HR. These findings are detailed in table 4.

Additionally, weaker effects that did not survive correction for multiple comparisons include fewer friendly and calm

Table 5. Sleep and dreams of individuals whose relatives, neighbours, or friends had Covid-19 (Covid-19 Nearby) (Covid-Nearby (N_{no}=269, N_{yes}=507)).

| Dependent variables | Est. difference | t-statistic | p _{uncorrected} | p _{holm} |
|--------------------------------------|-----------------|-------------|--------------------------|-------------------|
| subjective sleep quality (PQC1) | -0.14 | -2.60 | 0.02 | 0.31 |
| sleep latency (PQC2) | -0.24 | -2.31 | 0.02 | 0.32 |
| frequency of recent nightmares (MD4) | -0.39 | -1.98 | 0.05 | 0.77 |

Table 6. Dreams of individuals who suffered Covid-19 infection (Covid Self) (Covid Self (N_{yes}=62, N_{no}=714).

| Chi-square variables | χ^2 | DoF | Cramer's V | $p_{uncorrected}$ | p_{holm} |
|---|----------|-----|------------|-------------------|------------|
| Covid Affected Life vs emotional tone of dreams (MD3) | 3.55 | 4 | 0.07 | 0.47 | 1.00 |
| Covid Affected Life vs seen yourself suffering from coronavirus in dreams (DC8) | 5.53 | 1 | 0.08 | 0.02 | 0.24 |
| Covid Affected Life vs dreamt of your relatives or friends suffering from coronavirus (DC9) | 14.27 | 1 | 0.14 | 0.00 | 0.00*** |

characters in dreams for HR than LR ($p=0.01$, $p_{holm}=0.07$), and increased occurrence of nearby people ($p=0.03$, $p_{holm}=0.07$) and themselves ($p=0.02$, $p_{holm}=0.07$) recovering from disease or trauma in dreams.

3.4. Sleep and dreams of individuals whose relatives, neighbours, or friends had Covid-19

We found that reported subjective sleep quality was reduced ($p=0.02$, $p_{holm}=0.31$) and sleep latency was increased ($p=0.02$, $p_{holm}=0.32$) in individuals whose relatives, neighbours, or friends suffered from Covid-19, but neither of these effects survived corrections for multiple comparisons, as documented in table 5.

3.5. Individuals who suffered Covid-19 infection (Covid Self)

We observed a difference in the contents of dreams of individuals who had been infected with Covid-19 with respect to those who hadn't been infected, where the former reported a higher incidence of dreams featuring their relatives or friends suffering from Covid-19 (chi-squared = 14.27; $p<0.001$, $p_{holm}<0.001$). However, such a difference in occurrence of dreams featuring themselves was not statistically significant after correcting for multiple comparisons (chi-squared = 5.53; $p=0.02$, $p_{holm}=0.24$). We also found that individuals who reported having suffered from Covid-19 did not show any significant differences in sleep parameters and affective changes compared to those who did not. All statistically significant outcomes for these comparisons are detailed in table 6.

3.6. Individuals who work in healthcare

We found that individuals who were in healthcare reported reduced sleep latency ($p=0.001$, $p_{holm}=0.02$) in comparison to those who were not in healthcare. (Table 7)

We also noted weaker effects which were not statistically significant after corrections for multiple comparisons. These

include improved sleep quality ($p<0.01$, $p_{holm}=0.07$), and decreased emotional intensity of dreams ($p=0.01$, $p_{holm}=0.19$) in individuals in healthcare. Their dreams also featured more characters of people in their nearby environment who were suffering from disease or trauma ($p=0.04$, $p_{holm}=0.66$).

3.7. Correlation of sleep, dreams and affective state

Our correlation analyses based on robust statistics found that there is a negative correlation between age and negative affect (NA) ($r=-0.21$; CI 95%= -0.28 to -0.14; $p<0.001$, $p_{holm}<0.001$). We observed a positive correlation between overall sleep quality (PSQI score) and negative affect ($r=0.39$; CI 95%= 0.33 to 0.45; $p<0.001$, $p_{holm}<0.001$) but a negative correlation between overall sleep quality (PSQI score) and positive affect ($r=-0.21$; CI 95%= -0.28 to -0.14; $p<0.001$, $p_{holm}<0.001$). We also observed a positive correlation between overall sleep quality (PSQI score) and intensity of dreams emotionally indicating that poorer sleep quality is associated with more emotionally intense dreams ($r=0.28$; CI 95%= 0.22 to 0.35; $p<0.001$, $p_{holm}<0.001$). Poorer sleep quality is positively correlated with the extent to which life was affected by Covid-19 ($r=0.17$; CI 95%= 0.10 to 0.24; $p<0.001$, $p_{holm}<0.001$). Table 8 shows the results of correlation analysis between different variables.

Further, we found that negative affect is positively correlated with emotional intensity of dreams ($r=0.34$; CI 95%= 0.27 to 0.40; $p<0.001$, $p_{holm}<0.001$), and with the number of recent nightmares ($r=0.31$; CI 95%= 0.25 to 0.38; $p<0.001$, $p_{holm}<0.001$). Negative affect is also correlated positively to the distress caused by nightmares ($r=0.29$; CI 95%= 0.22 to 0.35; $p<0.001$, $p_{holm}<0.001$).

On the other hand, we found that positive affect negatively correlated with number of nightmares ($r=-0.10$; CI 95%= -0.17 to -0.03; $p<0.01$, $p_{holm}=0.03$) and the extent to which they were distressing ($r=-0.19$; CI 95%= -0.26 to -0.12; $p<0.001$, $p_{holm}<0.001$). We also found that the extent to which life was affected by Covid-19 is positively associated with intensity of dreams ($r=0.16$; CI 95%= 0.09 to 0.23; $p<0.001$, $p_{holm}<0.001$), number of nightmares ($r=0.20$; CI 95%= 0.13 to 0.26; $p<0.001$, $p_{holm}<0.001$) and distress relat-

Table 7. Subjects who work in healthcare (InHealthcare (N_{no}=624, N_{yes}=152)).

| Dependent variables | Est. difference | t-statistic | $p_{uncorrected}$ | p_{holm} |
|---|-----------------|-------------|-------------------|------------|
| Overall sleep quality (PSQI) | 0.86 | 2.98 | 0.00 | 0.07 |
| Subjective sleep quality (PQC1) | 0.15 | 2.32 | 0.06 | 0.82 |
| Sleep latency (PQC2) | 0.43 | 3.61 | 0.00 | 0.02* |
| Seen nearby people suffering from a disease or trauma in dreams (DC6) | -0.25 | -2.01 | 0.04 | 0.66 |
| Intensity of dreams emotionally (MD2) | 0.21 | 2.48 | 0.01 | 0.19 |

Table 8. Correlation of sleep, dreams and affective state.

| Correlation between variables | Shepherd's pi | 95% CI | $p_{uncorrected}$ | p_{holm} |
|---|---------------|----------------|-------------------|------------|
| Age and overall sleep quality (PSQI) | -0.08 | (-0.16, -0.01) | 0.02 | 0.09 |
| Age and Positive Affect (PA) | 0.02 | (-0.05, 0.1) | 0.55 | 1.00 |
| Age and Negative Affect (NA) | -0.21 | (-0.28, -0.14) | 0.00 | 0.00*** |
| Overall sleep quality (PSQI) and Positive Affect (PA) | -0.21 | (-0.28, -0.14) | 0.00 | 0.00*** |
| Overall sleep quality (PSQI) and Negative Affect (NA) | 0.39 | (0.33, 0.45) | 0.00 | 0.00*** |
| Overall sleep quality (PSQI) and intensity of dreams emotionally (MD2) | 0.28 | (0.22, 0.35) | 0.00 | 0.00*** |
| Overall sleep quality (PSQI) and to what extent has the ongoing Covid-19 pandemic affected your life (DG8) | 0.17 | (0.10, 0.24) | 0.00 | 0.00*** |
| Negative Affect (NA) and intensity of dreams emotionally (MD2) | 0.34 | (0.27, 0.4) | 0.00 | 0.00*** |
| Negative Affect (NA) and frequency of recent nightmares (MD4) | 0.31 | (0.25, 0.38) | 0.00 | 0.00*** |
| Negative Affect (NA) and distress caused by nightmares (MD5) | 0.29 | (0.22, 0.35) | 0.00 | 0.00*** |
| Negative Affect (NA) and To what extent has the ongoing Covid-19 pandemic affected your life (DG8) | 0.19 | (0.12, 0.26) | 0.00 | 0.00*** |
| Positive Affect (PA) and intensity of dreams emotionally (MD2) | -0.03 | (-0.10, 0.04) | 0.43 | 1.00 |
| Positive Affect (PA) and frequency of recent nightmares (MD4) | -0.10 | (-0.17, -0.03) | 0.01 | 0.03* |
| Positive Affect (PA) and distress caused by nightmares (MD5) | -0.19 | (-0.26, -0.12) | 0.00 | 0.00*** |
| Positive Affect (PA) and To what extent has the ongoing Covid-19 pandemic affected your life (DG8) | 0.02 | (-0.05, 0.10) | 0.52 | 1.00 |
| To what extent has the ongoing Covid-19 pandemic affected your life (DG8) and intensity of dreams emotionally (MD2) | 0.16 | (0.09, 0.23) | 0.00 | 0.00*** |
| To what extent has the ongoing Covid-19 pandemic affected your life (DG8) and frequency of recent nightmares (MD4) | 0.20 | (0.13, 0.26) | 0.00 | 0.00*** |
| To what extent has the ongoing Covid-19 pandemic affected your life (DG8) and distress caused by nightmares (MD5) | 0.24 | (0.18, 0.31) | 0.00 | 0.00*** |

ed with nightmares ($r=0.24$; CI 95%= 0.18 to 0.31; $p<0.001$).

We observed a weak trend in PSQI scores, which decreased with age ($r=-0.08$; CI 95%= -0.16 to 0.-0.01; $p=0.02$, $p_{holm}=0.09$), indicating that younger individuals had more sleep problems during the pandemic. However, this effect did not survive correction for multiple comparisons.

4. Discussion

The study evaluated sleep health in terms of sleep duration, sleep latency, and sleep quality along with emotionality and dreaming experience among Indian individuals who were either healthcare professionals or had a history of Covid-19 infection. In line with our hypothesis, the findings from this study suggest that the pandemic indeed severely impacted sleep health with participants reporting disturbed sleep, poor sleep quality, long sleep onset latency, reduced sleep duration, and more negative dream contents. As a consequence of heightened fear, anxiety, distress, and irritability among people due to the Covid-19 pandemic, people were highly prone to stress and mood changes to a variable extent.

In agreement with our hypothesis, dreams were strongly influenced by the pandemic outbreak in terms of negative emotions and featured increased incidence of contents related to disease and sufferings. We also found a significant association between sleep disturbances and negative emotions during dreaming. Distressing dreams, when one is suffering from anxiety and stress, influence the quality of sleep (Vandekerckhove & Cluydts, 2010). Several studies have demonstrated that bad dreams, nightmares, and negatively charged dreams are related to poor sleep quality (Simor et

al., 2012; Spoomaker et al., 2006). This is largely attributed to emotionally negative dreams and nightmares, which lead to frequent nocturnal awakenings and prolonged wake after sleep onset due to fear of falling asleep (Avci, 2022; Siclari et al., 2020; Simor et al., 2012; Spoomaker et al., 2006). We have used PSQI and MADRE questionnaires to assess sleep disturbances and dreaming respectively, and our findings suggest a three-way association between sleep quality, frequency of nightmares and intensity of dreams. We observed a strong association between increased intensity and negativity of dreams, increased incidence of nightmares and reduction in sleep quality. While impaired sleep quality impacts emotional processing during wakefulness (Konjarski et al., 2018) as REM sleep is important for ensuring proper social functioning. Social functioning impairment is associated with dysregulation of dopamine function and emotional processes (Norris et al., 2004; Skuse & Gallagher, 2009). It has been argued that changes occur in dopamine synthetic pathways in Covid-19 infection due to significant similarities of gene co-expression, co-regulation between Angiotensin I Converting Enzyme 2 (ACE2, encoding the main receptor to SARS-CoV-2) and Dopa Decarboxylase (catalyses the biosynthesis of dopamine) (Attademo & Bernardini, 2021; Nataf, 2020). As dopamine has significant influence on regulation of sleep-wake cycle, stress, emotions, its dysregulation leads to anhedonia, apathy, disturbances of sleep, and deterioration in social functioning. Furthermore, sleep quality is associated with emotional regulation strategies and negative affect is positively correlated with poor sleep quality (Latif et al., 2019).

In the present study, reports of negative dreams with aggressive or cruel characters are in agreement with previous

studies (William Domhoff & Schneider, 2008). More often, dreaming involves the dreamer as a victim than an aggressor (Domhoff, 1996; Hall & Van De Castle, 1966; Revonsuo, 2000) and as the pandemic outbreaks were perceived as a threat to life, during dreams, the dreamer succumbs to more negative dreams with aggressive and cruel characters where the dreamer acts like a victim suffering from coronavirus and recovering from it (Skancke et al., 2014). As per the threat stimulation theory (Revonsuo, 2000), in situations like the pandemic, people perceive stress in life when they see people's sufferings in real life and accordingly, their dreams involve such suffering and miseries that subsequently disturb their sleep. It may also be stated that in most conditions, waking life events are incorporated into the dreams as brain areas which are active during waking states are reactivated during REM sleep especially during dreams (Hobson, 2009; Hobson et al., 1998). Negative emotions associated with nightmares and the intensity of dreams reported by the participants highlight such correlation with emotions and thoughts in addition to waking life events (Schredl & Bulkeley, 2020). As participants had poor sleep quality which correlated positively with negative emotions of waking activities, such reciprocal relationship between poor sleep quality and increased negative affect during the subsequent day or increased negative affect during daytime might cause poor sleep quality in turn in the subsequent night. Furthermore, it was also observed that poor sleep quality is associated with dream recall frequency (DRF) (van Wyk et al., 2019). In the present study, high dream recallers reported poor sleep quality as well as dreams involving aggressive and cruel characters. Increased dream recall frequency along with abnormal sleep has been explained in previous studies with the help of the arousal-retrieval model of dream recall (Koulack & Goodenough, 1976; Schredl, 1999). According to this model, a dream recall happens if awakening occurs immediately after the dream so that arousal facilitates the conversion of short-term memory trace into long term memory storage. Poor sleep quality and increased dream frequency have been observed in many recent Covid-19 pandemic related studies. It is important to note that HR also showed increased number of nightmares that cause distress during the daytime. Such findings are associated with both anxiety and depressive symptoms during pandemics (Scarpelli, Alfonsi, Gorgoni, et al., 2021; Sikka et al., 2018). We observed that females had more intense dreams, higher emotional tone, and increased number of nightmares when compared to males, which was in line with other studies (Gorgoni et al., 2021; Schredl & Reinhard, 2008). Nightmares were also more distressing in females as the content of dreams were of more suffering from disease or trauma in their immediate environment than that of males. These findings indicate that increased frequency of nightmares and more intense dreams could be related to sufferings with less friendly characters. Stressful immediate environments such as those seen in pandemic or traumatic situations may cause changes in dream contents, especially among females (Pagel et al., 1995).

Surprisingly, participants who had contracted Covid-19 showed no differences in any parameters of sleep or dreaming. We suspect that after recovering from the disease, Covid-19 infected individuals likely considered the pandemic less threatening to life. But subjects whose family members (immediate environment) suffered from a Covid-19 infection reported higher impact on sleep disturbance

as they had increased nightmares and disturbed subjective sleep quality. In the case of health care workers, we found that sleep quality was better when compared with non-healthcare workers which is contrary to the findings of other studies (Huang & Zhao, 2020). One possibility is that as the survey was conducted 10 months from the start of the pandemic, the psychological distress would have been managed adequately, thereby leading to improved sleep quality. But at the same time, they dreamt of people suffering from Covid-19 in their immediate vicinity. This suggests that waking life events are incorporated in their dreams according to the continuity hypothesis (Domhoff, 1996; Schredl, 2006). According to Freud, unconscious forces are so strong that the frightening nature during waking life appears as a disguised version in dreams (Freud, 1900). Freud also believed that our recent waking life experience and part of it called day residue comes in our dreams. In line with this, many studies confirmed that there is a relationship between waking life events and sleep mentation.

Our study provides important insights into the significance of sleep health in preserving emotions and quality of life in human subjects. Adult humans require about 18-25% of REM sleep during night sleep. During REM sleep, the mesolimbic dopaminergic system (MDA) is highly active and is important for regulating REM sleep, memory consolidation, and prioritise the processing of emotional and motivational content of dreams (Dzirasa et al., 2006; Qiu et al., 2019; Smith et al., 2004). REM sleep maintains affective brain homeostasis and prepares the organism for a proper social and emotional functioning on subsequent waking (Goldstein & Walker, 2014; van der Helm & Walker, 2012). Our study reemphasises such relation between sleep and emotionality as those who had sleep disturbances that affected sleep quality had experienced negative dreams and emotionality. The present study has helped us to delineate many aspects of disturbed sleep, social and emotional functioning, and evidences of relationship among sleep, dreams, and affective brain regulation. There are many studies that show links between sleep, stress, depression, anxiety and affect (Amaral et al., 2018; Casagrande et al., 2020; Salari et al., 2020). At the biological level, it has been observed that psychological stress induces sleep difficulties, anxiety, depression and negative affect (Chiba et al., 2012; Locci & Pinna, 2017; Nollet et al., 2020). Behaviorally, the psychological impact of the Covid-19 outbreak stress on the general population can be seen in sleep abnormalities, negative affect, nightmares, more negative dreams, elevated levels of anxiety and depression. Our study is consistent with similar findings and suggests a model where variables such as sleep, affect, dreams, and psychological stress are related to each other and act as determinants of overall well-being in stressful situations such as pandemics. Taking all of the findings into account, the Indian sample reported sleep problems, pandemic-related dream content, and compromised emotional health during the pandemic outbreak, especially when they were affected by the pandemic.

5. Limitations

One of the main limitations of this study is that it is a cross-sectional design and assessed sleep, dream content, and affective state at one-time point only. The study did not inquire about retrospective assessments of pre-Covid-19 sleep parameters as implicit thinking of participants may create retrospective biases. Online recruitments of partici-

pants could have introduced significant bias in the study sample because online surveys might be mostly responded by the participants who were interested in sleep and dreams or having sleep, dreams or mood-related problems. Since India is a vast country, data collected were from different regions which had different percentages of Covid-19 infected people, which might have influenced psychological stress in participants to a variable extent and might not represent the population uniformly. Another factor which poses difficulty in generalizing the findings is that an unbalanced sample of males and females participated in the survey. While we did use robust statistical estimators in an attempt to minimize the risk of bias due to this, such methods are not guaranteed to address these problems entirely.

6. Conclusion

The findings of the present study indicate that the Covid-19 pandemic has impacted day-to-day life and can be reflected in sleep patterns, emotions, and sleep mentation. It gives us information to understand the psychological impact of pandemic outbreaks in the Indian population. Significant results based on robust statistical methods indicate that people were suffering from sleep problems, pandemic-related dreams, and negative emotions. Many studies across the world consistently found similar results. Disturbed dream phenomenology and impaired sleep features seem to have a relationship with the negative affect phenomenon. Future studies are needed to ascertain the neurobiological, physiological, and psychopathological mechanisms which can explain the relationship between sleep, dreams, and emotions. In summary, our study suggests that there is a need to address the sleep problems and compromised emotional wellbeing of people affected by the pandemic.

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Supplement - Table

| method | n | outliers | r | p-val | power | Ci95%_lower | Ci95%_upper | var_x | var_y | p-val_holm |
|--------|----------|----------|----|--------------|-------------|-------------|-------------|-------|-------|-------------|
| 0 | shepherd | 776 | 45 | -0,08370515 | 0,023621077 | 0,619897598 | -0,16 | Age | PSQI | 0,09448431 |
| 1 | shepherd | 776 | 52 | 0,022424719 | 0,546894172 | 0,092502654 | -0,05 | Age | PA | 1 |
| 2 | shepherd | 776 | 35 | -0,212443541 | 5,21947E-09 | 0,99952746 | -0,28 | Age | NA | 6,26337E-08 |
| 3 | shepherd | 776 | 46 | -0,212534174 | 6,67539E-09 | 0,999944004 | -0,28 | PSQI | PA | 7,34293E-08 |
| 4 | shepherd | 776 | 38 | 0,391171113 | 2,1433E-28 | 1 | 0,33 | PSQI | NA | 3,85794E-27 |
| 5 | shepherd | 776 | 35 | 0,279410346 | 9,34178E-15 | 0,999999997 | 0,21 | PSQI | MD2 | 1,30785E-13 |
| 6 | shepherd | 776 | 28 | 0,167388228 | 4,16737E-06 | 0,996036025 | 0,1 | PSQI | DG8 | 2,91716E-05 |
| 7 | shepherd | 776 | 26 | 0,336559153 | 2,55251E-21 | 1 | 0,27 | NA | MD2 | 4,33927E-20 |
| 8 | shepherd | 776 | 22 | 0,312151259 | 1,67277E-18 | 1 | 0,25 | NA | MD4 | 2,67643E-17 |
| 9 | shepherd | 776 | 36 | 0,285682531 | 2,30007E-15 | 0,999999999 | 0,22 | NA | MD5 | 3,4501E-14 |
| 10 | shepherd | 776 | 23 | 0,194448259 | 7,51601E-08 | 0,999706184 | 0,12 | NA | DG8 | 6,76441E-07 |
| 11 | shepherd | 776 | 35 | -0,029217248 | 0,427103004 | 0,124812523 | -0,1 | PA | MD2 | 1 |
| 12 | shepherd | 776 | 35 | -0,101862806 | 0,005513716 | 0,793485818 | -0,17 | PA | MD4 | 0,027568582 |
| 13 | shepherd | 776 | 52 | -0,194535702 | 1,32136E-07 | 0,999572666 | -0,26 | PA | MD5 | 1,05708E-06 |
| 14 | shepherd | 776 | 27 | 0,023700146 | 0,517224264 | 0,09926765 | -0,05 | PA | DG8 | 1 |
| 15 | shepherd | 776 | 13 | 0,163162804 | 5,89954E-06 | 0,995080856 | 0,09 | DG8 | MD2 | 3,53972E-05 |
| 16 | shepherd | 776 | 16 | 0,19617774 | 4,96911E-08 | 0,99977509 | 0,13 | DG8 | MD4 | 4,96911E-07 |
| 17 | shepherd | 776 | 38 | 0,244253767 | 1,74E-11 | 0,999999218 | 0,18 | DG8 | MD5 | 2,262E-10 |