



# Impact of the novel coronavirus (COVID-19) pandemic on sleep

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**Background:** The COVID-19 pandemic has led to significant changes in daily routines and lifestyle worldwide and mental health issues have emerged as a consequence. We aimed to assess the presence of sleep disturbances during the lockdown in the general population.

**Methods:** Cross-sectional, online survey-based study on adults living through the COVID-19 pandemic. The questionnaire included demographics and specific questions assessing the impact of the pandemic/lockdown on sleep, daytime functioning and mental health in the general population. Identification of sleep pattern changes and specific sleep-related symptoms was the primary outcome, and secondary outcomes involved identifying sleep disturbances for predefined cohorts (participants reporting impact on mental health, self-isolation, keyworker status, suspected COVID-19 or ongoing COVID-19 symptoms).

**Results:** In total, 843 participants were included in the analysis. The majority were female (67.4%), middle aged [52 years (40–63 years)], white (92.2%) and overweight to obese [BMI 29.4 kg/m<sup>2</sup> (24.1–35.5 kg/m<sup>2</sup>)]; 69.4% reported a change in their sleep pattern, less than half (44.7%) had refreshing sleep, and 45.6% were sleepier than before the lockdown; 33.9% had to self-isolate, 65.2% reported an impact on their mental health and 25.9% were drinking more alcohol during the lockdown. More frequently reported observations specific to sleep were 'disrupted sleep' (42.3%), 'falling asleep unintentionally' (35.2%), 'difficulties falling'/'staying asleep' (30.9% and 30.8%, respectively) and 'later bedtimes' (30.0%). Respondents with suspected COVID-19 had more nightmares and abnormal sleep rhythms. An impact on mental health was strongly associated with sleep-related alterations.

**Conclusions:** Sleep disturbances have affected a substantial proportion of the general population during the COVID-19 pandemic lockdown. These are significantly associated with a self-assessed impact on mental health, but may also be related to suspected COVID-19 status, changes in habits and self-isolation.

**Keywords:** Insomnia; virus; mental health; survey; sleep disruption

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## Introduction

In December 2019, an outbreak of the novel strain severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) emerged in China, and rapidly spread worldwide. The new condition was named coronavirus disease 2019 (COVID-19) by the World Health Organization (WHO) and was declared a pandemic on the 11<sup>th</sup> of March 2020 (1). Millions of cases were confirmed with hundreds of thousands of deaths. This unprecedented situation and the finding that the virus was highly contagious (person-to-person transmission) (2), required the adoption of non-vaccination public health measures aiming to reduce further spreading of SARS-CoV-2 (2). These measures included track-and-tracing, self-isolation, quarantine, social distancing and community containment, as well as nationwide lockdowns (3). Lockdown measures were implemented in many countries, including the UK, leading to significant social and lifestyle changes. In addition to any direct effects of COVID-19 on people's health the lockdown had an impact on the perception of confinement, caused worries about livelihood, family or friends, and had indirect effects on the health and wellbeing of non-infected people. The psychological consequences of isolation in epidemics or during quarantine have previously been addressed (4,5), however, with scarce focus on their effects on sleep (6).

In the current pandemic, the effects of isolation have been described in cohorts from China and Italy (7,8), with poor quality sleep and comorbid psychological disturbances being identified as significant issues (9-11). We therefore hypothesised that the COVID-19 pandemic and the public lockdown significantly impacted on sleep in the general population. We compared suspected COVID-19 with non-COVID-19, and tested whether there was an association with mental health impact. In order to survey current sleep problems, the British Sleep Society (BSS) initiated the National Early Detection Screening for the COVID-19 pandemic.

We present this article in accordance with the "Strengthening the Reporting of Observational Studies in Epidemiology" (STROBE) reporting checklist (available at <http://dx.doi.org/10.21037/jtd-cus-2020-015>).

## Methods

### Study design

The BSS Research and Executive Committee approved this prospective, cross-sectional, survey-based study. The UKRI/

MRC and the NHS Health Research Authority (HRA) confirmed that ethical approval was not required owing to the screening survey design (<https://cdn.amegroups.cn/static/application/04712039f3b0c07e77f3c779c14d1a17/JTD-CUS-2020-015-1.pdf>). The study conformed to the provisions of the Declaration of Helsinki (as revised in 2003). An online survey was available to the general public from May 12<sup>th</sup> to June 2<sup>nd</sup>, 2020 (<https://cdn.amegroups.cn/static/application/1778ae9dd49ffd9dfb1da63b65421e93/JTD-CUS-2020-015-2.pdf>). Eligible participants were adults aged 18 years or older, living through the 2020 COVID-19 pandemic and under national lockdown regulations. Subjects required literacy and access to the Internet. Participants were excluded if they were not living under national lockdown regulations or were underage.

### Questionnaire items

Respondents were asked to answer multiple choice questions or provide a free-text response regarding baseline characteristics, and the impact of the pandemic/lockdown including COVID-19 infection history, self-isolation, key-working, mental health, alcohol and sleep medication use, and a sleep profile (current quality/quantity, change in sleep pattern and specific sleep symptoms) (<https://cdn.amegroups.cn/static/application/1778ae9dd49ffd9dfb1da63b65421e93/JTD-CUS-2020-015-2.pdf>; Supplementary material).

A total of 24 different sleep symptoms were grouped into six sleep symptom categories for analysis (*Table S1*): (I) insomnia/disrupted sleep, (II) daytime symptoms, (III) abnormal behaviours in sleep, (IV) sleep-disordered breathing, (V) restless legs, (VI) sleep phase disturbance.

### Primary and secondary outcomes

The primary outcomes were to identify sleep disturbances related to the COVID-19 pandemic lockdown in the general population. Secondary outcomes included subgroup analyses for pre-defined cohorts within the population: reported suspected COVID-19, self-isolation, keyworker and mental health impact.

### Statistical analysis

Continuous variables were presented as median [interquartile range, IQR], due to non-normally distributed data. Mann-Whitney U and Chi-squared analyses were

**Table 1** Baseline characteristics of total study participants (n=843)

| Characteristics          | Category          | N    | % or range |
|--------------------------|-------------------|------|------------|
| Gender                   | Female            | 568  | 67.4%      |
|                          | Male              | 266  | 31.6%      |
|                          | Prefer not to say | 3    | 0.4%       |
|                          | Other             | 6    | 0.7%       |
| Age (years)              |                   | 52   | 40–63      |
| Age                      | 10–19             | 5    | 0.6%       |
|                          | 20–29             | 40   | 4.7%       |
|                          | 30–39             | 154  | 18.3%      |
|                          | 40–49             | 190  | 22.5%      |
|                          | 50–59             | 189  | 22.4%      |
|                          | 60–69             | 182  | 21.6%      |
|                          | 70–79             | 81   | 9.6%       |
|                          | 80–89             | 2    | 0.2%       |
| Ethnicity                | White             | 778  | 92.2%      |
|                          | Black             | 11   | 1.3%       |
|                          | Asian             | 32   | 3.8%       |
|                          | Other             | 23   | 2.7%       |
| Weight (kg)              |                   | 83.5 | 69.0–101.6 |
| Height (cm)              |                   | 167  | 160–175    |
| BMI (kg/m <sup>2</sup> ) |                   | 29.4 | 24.1–35.5  |

Data presented as count (percentage) or median [interquartile range].

performed for comparison of continuous and categorical variables, respectively, in *a priori* subgroup comparison. A main-effects multiple logistic regression was used to identify the strength of association between the six symptom categories or a reported sleep pattern change and factors relating to the pandemic. Further multiple logistic regression modelling was reported as odds ratios where significant associations were found between sleep symptoms and pandemic-related factors (Supplementary material).

‘Yes’ and ‘maybe’ responses regarding COVID-19 infection were grouped into ‘suspected COVID-19’ for analysis due to global limited availability of polymerase chain reaction (PCR) swab testing. “Don’t know” answers were not included in the modelling as they were non-binary.

Data were collected on Google Forms (accessed online May 2020, Google Ireland Limited, Dublin, Ireland) and analysed with SPSS version 24 (IBM Corporation, New

York, USA) and Prism version 8 (GraphPad Software, San Diego, California, USA). A P value of  $\leq 0.05$  was considered statistically significant. Missing data were not imputed.

## Results

### *Demographics and descriptive characteristics*

844 participants completed the online survey, one underage participant was excluded, and 843 datasets were included in the final analysis. Respondents were mostly female (67.4%), middle aged [52 years (40–63 years)], predominantly white (92.2%), and overweight to obese [BMI 29.4 kg/m<sup>2</sup> (24.1–35.5 kg/m<sup>2</sup>)] (Table 1).

A proportion of 21.1% of respondents had suspected COVID-19 and 286 participants (33.9%) had to self-isolate. 550 participants (65.2%) reported an impact of the pandemic on their mental health. 296 participants (35.1%)

were keyworkers; 219 participants (25.9%) reported drinking more alcohol during the pandemic (Table S2).

### **Impact on sleep**

Less than half of the participants (47.5%) felt satisfied with their current sleep quantity or felt refreshed from sleep (44.7%), with 27.0% reporting to sleep 6–7 [5; 8] hours; 585 participants (69.4%) noticed a change in their sleep pattern during the pandemic, 45.6% felt sleepier than before the lockdown and 7.4% reported the use of sleep medication during the lockdown compared to 5.2% before the lockdown (Table S3); 264 (31.3%) participants reported sleep restriction, with <6 hours of sleep. These were older [55 years (42–64 years) *vs.* 50 (39–62 years),  $P=0.007$ ], had higher BMI [31.3 (25.7–37.6) *vs.* 28.3 (23.6–34.4)  $\text{kg}/\text{m}^2$ ,  $P<0.001$ ], and were more likely to report shielding due to vulnerability (31.1% *vs.* 22.8%,  $P=0.038$ ), disability (30.3% *vs.* 20.0%,  $P=0.001$ ) and an impact on their mental health (71.2% *vs.* 62.5%,  $P=0.049$ ) (Table S4).

The most commonly reported specific sleep symptoms were disrupted sleep (42.3%), falling asleep unintentionally (35.2%), difficulty falling and staying asleep (30.9% and 30.8%, respectively) and going to bed later (30.0%) (Table 2). Regarding ‘other’ symptoms, a small number of respondents stated that their sleep had improved (1.9%) (Table S5).

### **Effect of self-isolation and keyworker status**

A positive answer to household self-isolation status question was assumed to report the participants self-isolating themselves. Five cases were excluded from keyworker group comparison due to “don’t know” responses.

Participants who self-isolated reported significantly more insomnia/disrupted sleep (60.8% *vs.* 51.7%,  $P=0.012$ ), daytime symptoms (53.8% *vs.* 46.0%,  $P=0.030$ ), abnormal behaviours in sleep (27.3% *vs.* 20.1%,  $P=0.018$ ) and restless legs (23.4% *vs.* 16.2%,  $P=0.01$ ) (Table 3); specifically, these reported more sleep disruption (49.3% *vs.* 38.8%,  $P=0.003$ ), nightmares (24.1% *vs.* 16.5%,  $P=0.008$ ), abnormal movements of the limbs/trunk (8% *vs.* 3.1%,  $P=0.001$ ), restless legs (18.2% *vs.* 11.1%,  $P=0.005$ ), falling asleep unintentionally (40.6% *vs.* 32.5%,  $P=0.02$ ) and abnormal sleep rhythm (9.1% *vs.* 4.8%,  $P=0.016$ ) (Table S6). Keyworkers described significantly fewer sleep-related and daytime disturbances than others, namely choking/gasping at night (1.7% *vs.* 5.4%,  $P=0.010$ ), daytime naps (14.9% *vs.* 23.7%,  $P=0.003$ ), falls/injuries (0.3% *vs.* 2.2%,  $P=0.035$ )

and getting up later (17.6% *vs.* 23.8%,  $P=0.035$ ) (Table S7).

### **Suspected COVID-19 status**

The most reported COVID-19 infection symptoms in the total study participants were dry cough and breathlessness (4.5% each), followed by headache (3.7%) and muscle pain (3.6%) (Table S8). Participants with suspected COVID-19 had significantly more nightmares (25.8% *vs.* 17.3%,  $P=0.010$ ) and abnormal sleep rhythm (11.2% *vs.* 5.0%,  $P=0.002$ ) (Table S9). Ongoing COVID-19 symptoms were associated with sleep disruption (OR 2.810, 95% CI, 1.632 to 4.867,  $P<0.001$ ) (Figure 1).

### **Mental health**

Forty “don’t know” responses were excluded from mental health impact group comparison. Participants reporting an impact of the pandemic on their mental health also had significantly more sleep symptoms {5 [2–7] *vs.* 0 [0–3],  $P<0.001$ } and were more concerned about their sleep {6 [5–8] *vs.* 4 [1–6] out of 10 points,  $P<0.001$ } (Table 3). A multiple logistic regression analysis demonstrated that reported mental health impact was a predictor of sleep pattern change during the pandemic ( $\beta=0.969$ , 95% CI, 0.663 to 1.281,  $P<0.001$ , Table S10). In a further regression analysis, an impact on mental health was significantly predicted by the presence of difficulty falling asleep (OR 3.600, 95% CI, 2.317 to 5.752,  $P<0.001$ ), sleep disruption (OR 2.523, 95% CI, 1.696 to 3.794,  $P<0.001$ ), excessive sleepiness (OR 3.488, 95% CI, 2.050 to 6.264,  $P<0.001$ ), falling asleep unintentionally (OR 3.810, 95% CI, 2.588 to 5.726,  $P<0.001$ ) and nightmares (OR 7.005, 95% CI, 3.951 to 13.600,  $P<0.001$ ) (Figure 2). An impact on mental health was associated with both increased alcohol intake (OR 1.529, 95% CI, 1.074 to 2.203,  $P=0.02$ ) and sleep medication use (OR 1.634, 95% CI, 1.036 to 2.644,  $P=0.039$ ).

### **Predictors of a change in sleep pattern**

A multiple logistic regression model including ‘change in sleep pattern’ as the categorical outcome variable with baseline demographics and pandemic-related factors as predictor variables was performed (Table S10). No collinearity was found between predictor variables. A change in sleep pattern was overall most strongly associated with reported sleep medication use during the pandemic ( $\beta=1.276$ , 95% CI, 0.140 to 2.578,  $P=0.039$ ), ongoing

**Table 2** Reported specific sleep symptoms and within categories by total study participants (n=843)

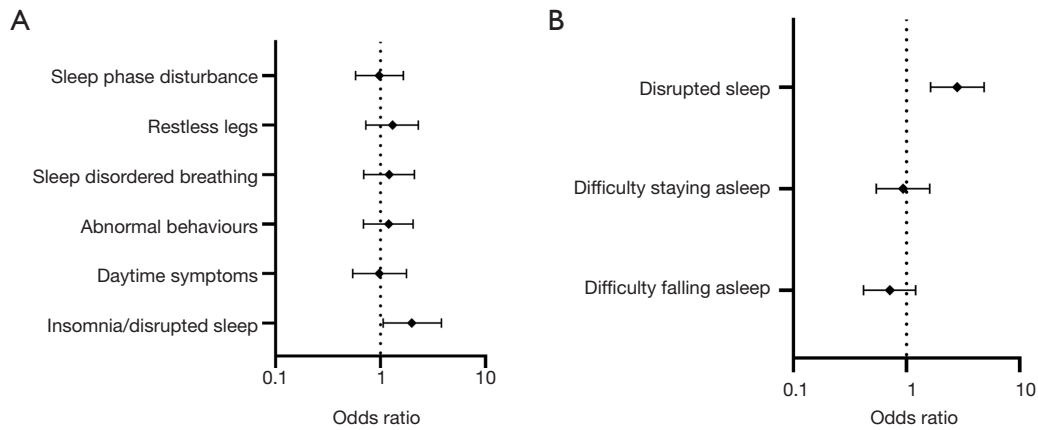
| Variables                                      | N   | % or range |
|--|-----|------------|
| Number of sleep symptoms                       | 3   | 0–6        |
| Insomnia/disrupted sleep                       | 462 | 54.8%      |
| Disrupted sleep                                | 357 | 42.3%      |
| Difficulty falling asleep                      | 261 | 30.9%      |
| Difficulty staying sleep                       | 260 | 30.8%      |
| Sleep phase disturbance                        | 440 | 52.3%      |
| Going to bed later                             | 253 | 30.0%      |
| Getting up later                               | 183 | 21.7%      |
| Getting up earlier                             | 133 | 15.8%      |
| Going to bed earlier                           | 104 | 12.3%      |
| Abnormal sleep rhythm (advanced/delayed)       | 53  | 6.3%       |
| Daytime symptoms                               | 410 | 48.6%      |
| Falling asleep unintentionally                 | 297 | 35.2%      |
| Daytime naps                                   | 173 | 20.5%      |
| Excessive sleepiness                           | 168 | 19.9%      |
| Falls/injuries                                 | 13  | 1.5%       |
| Sleep-disordered breathing                     | 223 | 26.5%      |
| Morning headaches                              | 179 | 21.2%      |
| Breathlessness during the night                | 47  | 5.6%       |
| Choking/gasping at night                       | 34  | 4.0%       |
| Breath-holding                                 | 30  | 3.6%       |
| Abnormal behaviours in sleep                   | 190 | 22.5%      |
| Nightmares                                     | 161 | 19.1%      |
| Sleep talking                                  | 27  | 3.2%       |
| Sleep paralysis                                | 22  | 2.6%       |
| Sleepwalking                                   | 6   | 0.7%       |
| Eating while asleep                            | 6   | 0.7%       |
| Restless legs                                  | 157 | 18.6%      |
| Restless legs                                  | 114 | 13.5%      |
| Cramps   | 51  | 6.0%       |
| Abnormal movements (limbs or trunk)            | 40  | 4.7%       |
| How concerned are you about your sleep? (0–10) | 6   | 4–7        |

Data presented as count (percentage) or median [interquartile range].

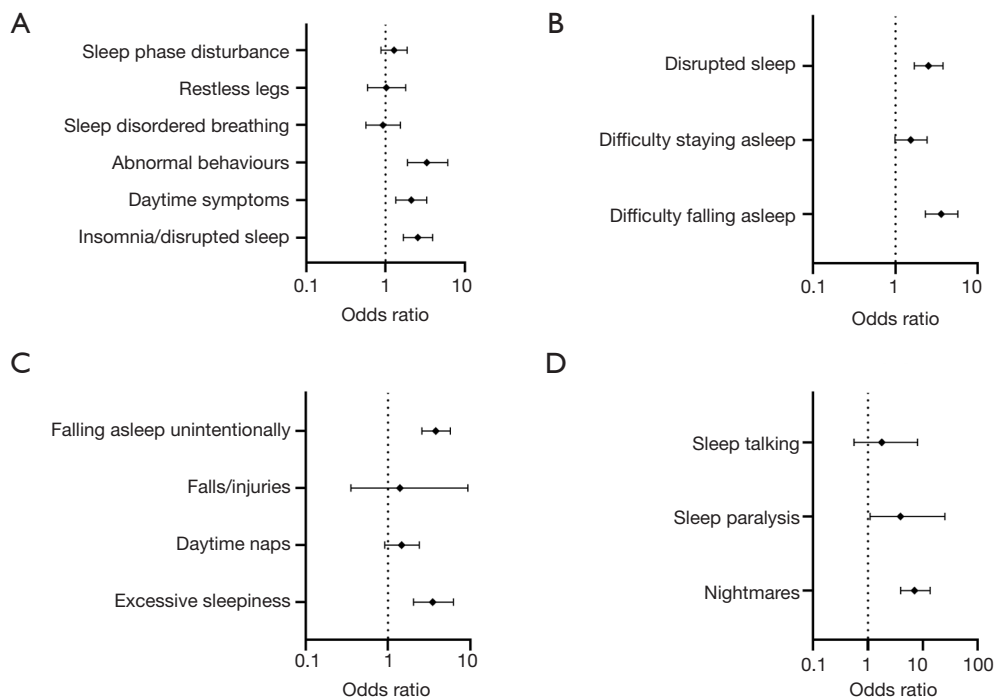
**Table 3** Sleep symptom categories reported by study participants within subgroups

| Groups             | Category                                       | No  |            | Yes |            | $\chi^2$ or MWU | P value |
|--------------------|--|-----|------------|-----|------------|-----------------|---------|
|                    |  | N   | % or range | N   | % or range |                 |         |
| Suspected COVID-19 | Number of sleep symptoms                       | 3   | 0–6        | 4   | 0–6        | 56,821          | 0.406   |
|                    | Insomnia/disrupted sleep                       | 354 | 53.2%      | 108 | 60.7%      | 3.139           | 0.076   |
|                    | Daytime symptoms                               | 320 | 48.0%      | 90  | 50.6%      | 0.335           | 0.563   |
|                    | Abnormal behaviours in sleep                   | 143 | 21.5%      | 47  | 26.4%      | 1.932           | 0.165   |
|                    | Sleep-disordered breathing                     | 181 | 27.2%      | 42  | 23.6%      | 0.947           | 0.330   |
|                    | Restless legs                                  | 125 | 18.8%      | 32  | 18.0%      | 0.062           | 0.803   |
|                    | Sleep phase disturbance                        | 353 | 53.1%      | 88  | 49.4%      | 0.748           | 0.387   |
|                    | How concerned are you about your sleep? (0–10) | 6   | 4–7        | 6   | 4–8        | 21330           | 0.326   |
| Self-isolation     | Number of sleep symptoms                       | 3   | 0–6        | 4   | 1–7        | 70,651          | 0.006   |
|                    | Insomnia/disrupted sleep                       | 288 | 51.7%      | 174 | 60.8%      | 6.365           | 0.012   |
|                    | Daytime symptoms                               | 256 | 46.0%      | 154 | 53.8%      | 4.704           | 0.030   |
|                    | Abnormal behaviours in sleep                   | 112 | 20.1%      | 78  | 27.3%      | 5.557           | 0.018   |
|                    | Sleep-disordered breathing                     | 143 | 25.7%      | 80  | 28.0%      | 0.513           | 0.474   |
|                    | Restless legs                                  | 90  | 16.2%      | 67  | 23.4%      | 6.588           | 0.010   |
|                    | Sleep phase disturbance                        | 291 | 52.2%      | 150 | 52.4%      | 0.003           | 0.955   |
|                    | How concerned are you about your sleep? (0–10) | 6   | 4–7        | 6   | 4–8        | 26965           | 0.115   |
| Keyworkers         | Number of sleep symptoms                       | 3   | 0–6        | 3   | 0–6        | 74,972          | 0.123   |
|                    | Insomnia/disrupted sleep                       | 292 | 54.0%      | 166 | 56.1%      | 0.686           | 0.558   |
|                    | Daytime symptoms                               | 273 | 50.5%      | 134 | 45.3%      | 2.069           | 0.151   |
|                    | Abnormal behaviours in sleep                   | 131 | 24.2%      | 56  | 18.9%      | 5.683           | 0.079   |
|                    | Sleep-disordered breathing                     | 157 | 29.0%      | 64  | 21.6%      | 5.530           | 0.020   |
|                    | Restless legs                                  | 109 | 20.1%      | 48  | 16.2%      | 3.334           | 0.164   |
|                    | Sleep phase disturbance                        | 291 | 53.8%      | 147 | 49.7%      | 1.319           | 0.253   |
|                    | How concerned are you about your sleep? (0–10) | 6   | 4–7        | 6   | 4–7        | 27,592          | 0.369   |
| Mental health      | Number of sleep symptoms                       | 0   | 0–3        | 5   | 2–7        | 34,296          | <0.001  |
|                    | Insomnia/disrupted sleep                       | 72  | 28.3%      | 377 | 68.4%      | 118.238         | <0.001  |
|                    | Daytime symptoms                               | 60  | 23.6%      | 338 | 61.3%      | 104.778         | <0.001  |
|                    | Abnormal behaviours in sleep                   | 16  | 6.3%       | 170 | 30.9%      | 63.810          | <0.001  |
|                    | Sleep-disordered breathing                     | 34  | 13.4%      | 181 | 32.8%      | 34.783          | <0.001  |
|                    | Restless legs                                  | 23  | 9.1%       | 127 | 23.0%      | 22.599          | <0.001  |
|                    | Sleep phase disturbance                        | 89  | 35.0%      | 336 | 61.1%      | 49.360          | <0.001  |
|                    | How concerned are you about your sleep? (0–10) | 4   | 1–6        | 6   | 5–8        | 11,789          | <0.001  |

Suspected COVID-19: no (n=665), yes (n=178); self-isolation: no (n=557), yes n=286; keyworkers: no (n=541), yes n=296; mental health: no (n=254), yes (n=549). Data presented as count (percentage) and median [interquartile range].  $\chi^2$  = Chi-squared values presented for categorical variables. MWU = Mann-Whitney U values presented for scale variables.



**Figure 1** Forest plot displaying associations between ongoing COVID-19 symptoms and reported sleep symptoms (for all sleep symptom categories and specific symptoms within insomnia/disrupted sleep category). (A) Odds ratios for sleep symptom categories. (B) Odds ratios for specific sleep symptoms within insomnia/disrupted sleep category.



**Figure 2** Forest plots displaying significant associations between mental health impact and sleep symptoms (by symptom category, and specific sleep symptoms reported within insomnia/disrupted sleep, daytime symptoms and abnormal behaviours in sleep categories). (A) Odds ratios for the six sleep symptom categories. (B) Odds ratios for insomnia/disrupted sleep. (C) Odds ratios for daytime symptoms. (D) Odds ratios for abnormal behaviours in sleep. Sleepwalking and eating while sleeping excluded due to perfect separation.

COVID-19 symptoms ( $\beta=1.124$ , 95% CI, 0.368 to 1.937,  $P=0.005$ ) and reported mental health impact ( $\beta=0.969$ , 95% CI, 0.663 to 1.281,  $P<0.001$ ), displaying a negative association with age ( $\beta=-0.026$ , 95% CI,  $-0.040$  to  $-0.012$ ,  $P<0.001$ ), male gender ( $\beta=-0.350$ , 95% CI,  $-0.658$  to  $-0.040$ ,  $P=0.026$ ) and general health rating ( $\beta=-0.244$ , 95% CI,  $-0.343$  to  $-0.149$ ,  $P<0.001$ ) (Tjur's  $R^2=0.177$ , adjusted  $R^2=0.165$ ).

### *Association between sleep symptom categories and pandemic factors*

Insomnia/disrupted sleep was significantly associated with mental health impact (OR 2.435, 95% CI, 1.821 to 3.281,  $P<0.001$ ), ongoing COVID-19 symptoms (OR 2.232, 95% CI, 1.159 to 4.385,  $P=0.018$ ) and sleep medication use during the pandemic (OR 5.933, 95% CI, 2.142 to 20.030,  $P=0.002$ ). Daytime symptoms were significantly associated with an impact on mental health (OR 2.332, 95% CI, 1.741 to 3.145,  $P<0.001$ ) and sleep medication use during the pandemic (OR 3.450, 95% CI, 1.425 to 9.285,  $P=0.009$ ). Abnormal behaviours in sleep were significantly associated with mental health impact (OR 2.198, 95% CI, 1.522 to 3.212,  $P<0.001$ ) and reported disability (OR 1.504, 95% CI, 1.002 to 2.253,  $P=0.048$ ). Sleep-disordered breathing was significantly associated with ongoing COVID-19 symptoms (OR 3.405, 95% CI, 1.610 to 7.450,  $P=0.002$ ) and an impact on mental health (OR 1.725, 95% CI, 1.232 to 2.430,  $P=0.002$ ). Restless legs symptoms were significantly associated with ongoing COVID-19 symptoms (OR 2.530, 95% CI, 1.143 to 5.388,  $P=0.024$ ), an impact on mental health (OR 1.933, 95% CI, 1.318 to 2.862,  $P=0.001$ ) and reported disability (OR 1.566, 95% CI, 1.029 to 2.364,  $P=0.034$ ). Sleep phase disturbance was significantly associated with an impact on mental health (OR 1.669, 95% CI, 1.254 to 2.212,  $P<0.001$ ), increased alcohol intake (OR 1.510, 95% CI, 1.080 to 2.121,  $P=0.017$ ) and sleep medication use during the pandemic (OR 2.553, 95% CI, 1.084 to 6.713,  $P=0.041$ ) (Figure 3).

## **Discussion**

### *Summary of main findings*

The pandemic lockdown had a major impact on the population. The majority of respondents described an altered sleep pattern and almost half of the studied population felt sleepier than prior to the lockdown.

Reported problems included dozing off unintentionally in the day, disrupted sleep, difficulties falling/staying asleep and later bedtimes. Over a quarter of all respondents reported an increased alcohol intake during the lockdown. Furthermore, those self-isolating reported more insomnia/disrupted sleep, daytime symptoms, abnormal behaviours in sleep and symptoms of restless legs compared to those not self-isolating. Keyworkers reported fewer sleep alterations than others. In those with suspected COVID-19, nightmares and abnormal sleep rhythm were more common. A reported impact on mental health was most strongly associated with more difficulties falling asleep, sleep disruption, nightmares and daytime sleepiness. A change in sleep pattern was associated with medication use, ongoing COVID-19 symptoms and mental health impact, and it was negatively associated with age, male gender and general health.

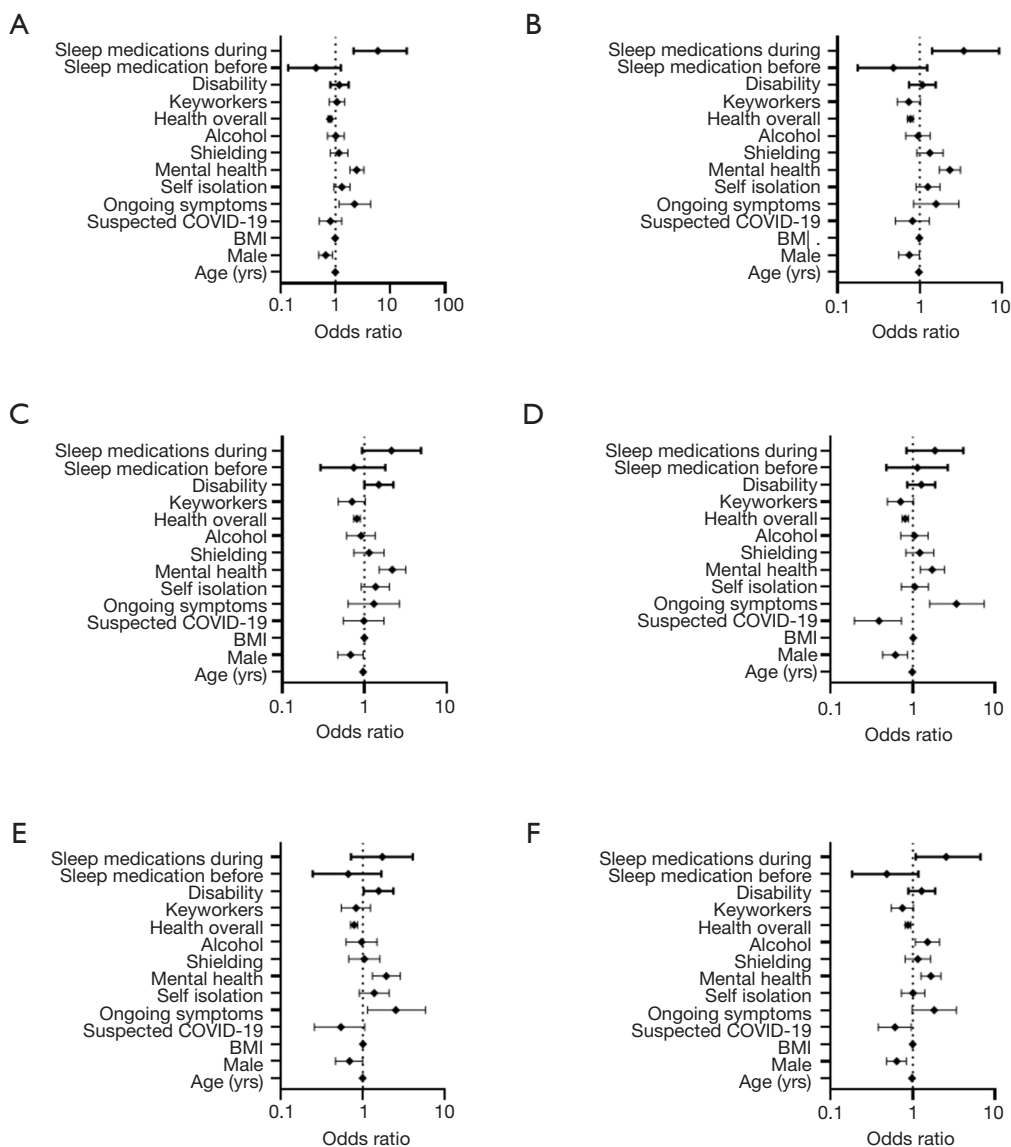
### *Assessing lockdown impact on sleep and clinical significance of findings*

Home confinement and isolation procedures have required modifications in lifestyle, leading to the loss of daily routines and habits. Resultant issues such as work, family and financial problems, limited exposure to natural light, and restricted opportunities to exercise may have negative effects on sleep (5). Insufficient sunlight, physical inactivity, dietary changes, weight gain, increased digital screen time, as well as the risk of alcohol use and developing addictions, are associated with prolonged lockdown (12). Additionally, sleep deprivation may lead to immunological alterations and it would therefore seem pertinent to consider the effects of altered sleep on COVID-19 susceptibility (13). Notably, almost a third of participants in our study reported sleeping less than 6 hours, and these were of older age, had higher BMI, reported more vulnerability/disability and mental health impact during the pandemic compared to respondents getting more than 6 hours of sleep.

### **Reported change in sleep pattern and specific sleep symptoms**

Less than half of our study participants were feeling refreshed or felt that they were sleeping enough during the pandemic, and almost half of them felt sleepier than before the lockdown (Table S3). The most commonly reported specific sleep symptoms included disrupted sleep, difficulty falling and staying asleep, later bedtimes and falling asleep unintentionally in the day (Table 2). A majority





**Figure 3** Forest plots displaying association of each sleep symptom category (insomnia/disrupted sleep, daytime sleepiness, abnormal behaviours in sleep, sleep-disordered breathing, restless legs, sleep phase disturbance) with demographics and pandemic-related factors. (A) Odds ratios for insomnia/disrupted sleep. (B) Odds ratios for daytime symptoms. (C) Odds ratios for abnormal behaviours in sleep. (D) Odds ratios for sleep-disordered breathing. (E) Odds ratios for restless legs symptoms. (F) Odds ratios for sleep phase disturbance.

of respondents reported a change in sleep pattern, and this was predicted by the presence of ongoing COVID-19 symptoms, mental health impact, sleep medication use in the pandemic, younger age and worse general health rating (Table S10). Similarly, a recent Italian survey including young adults demonstrated a significantly delayed bed and rise times during lockdown, spending overall more time in bed, but reporting a poor sleep quality (8). Also, an increased

prevalence of insomnia during the outbreak was found in a Chinese survey-based study (9). Of note, a UK survey showed that half of the respondents experienced more disturbed sleep than usual; 39% of the participants reported sleeping fewer hours than before the lockdown; and 29% reported sleeping longer hours but still felt less rested (14). Consistent with our findings, only a minority of respondents reported improved sleep during the lockdown (14).

### Effect of alcohol

Although frequently used by people who suffer from insomnia to try and help sleep (15), alcohol actually disrupts sleep architecture, possibly exacerbates sleep pathologies (such as sleep-disordered breathing and NREM parasomnias), and worsens daytime sleepiness (16). Almost 26% of our study population reported increased alcohol intake during the lockdown (*Table S2*). This is in line with previous evidence showing that, despite the decrease in social gathering, only a third of drinkers have reduced or stopped their alcohol intake, while 21% drink more frequently (17). Stress further contributes to alcohol seeking behaviour (18), and alcohol is also used to alleviate negative emotions (19). In our study, the presence of a sleep phase disturbance was predicted by an increased alcohol intake, reported mental health impact and sleep medication use during the pandemic (*Figure 3*).

### Impact on mental health

The potential effect of mood alterations on sleep is relevant in the pandemic. The link between sleep and mood disturbances has previously been demonstrated in circumstances similar to the current lockdown (4,5). Confinement and quarantine have negative psychological consequences (4,5), which can have an impact on sleep. Worsened insomnia symptoms and psychological reactions attributed to the outbreak were demonstrated in the general population using online questionnaires reflecting the situation prior to and following the lockdown (9). Insomnia was associated with being female, mental illness, increased severity of anxiety and depression, COVID-19-related stress and prolonged time in bed (9). In a Chinese study the prevalence of insomnia was at 26%, and over 20% of patients with pre-existing mental health conditions reported a deterioration of these (11). Stronger changes in sleep quality in those with higher scores of depression, anxiety and stress were reported as well. Additionally, a longitudinal study investigating whether sleep quality depends on the social situation found an association between social isolation and poor sleep quality in older adults (20). Of note, over 65% of the population involved in our study reported an impact of the pandemic or lockdown on their mental health (*Table S2*), and this cohort reported more sleep-related symptoms and concerns about their sleep (*Table 3*). Importantly, an impact on mental health was one of the significant predictors for a reported change in sleep pattern (*Table S10*). On regression analysis, reported mental health impact was significantly associated with difficulties

falling asleep, disrupted sleep, daytime sleepiness and nightmares (*Figure 2*).

### Self-isolation status, keyworkers and sleep

Compared to those who did not self-isolate, self-isolators more frequently reported disrupted sleep, nightmares, abnormal movements, restless legs, falling asleep unintentionally and abnormal sleep rhythm (*Table S6*). Higher rates of difficulties to fall asleep or early awakenings in medically isolated versus self- or non-isolated individuals in the outbreak have been previously demonstrated (7). A subgroup of the population that deserves special attention in the current circumstances are keyworkers. Healthcare workers account for a proportion of these; they have not only suffered the stress of being directly involved in the care of patients, but also faced the consequences of working long hours during the pandemic. Sleep disruption, poor quality of sleep, insomnia, and mood disturbances have all been reported in healthcare workers under pandemic circumstances (21-23). Although our study did not find an association between sleep disturbances and keyworker status, notably this group also included non-healthcare workers (postal workers, truck driver, police officer and others) (*Table S7*). Possibly keyworkers, considered as a wider group, experienced fewer changes in their routines during the lockdown, as they were allowed to leave the house to continue working.

### Suspected COVID-19

There may be additional factors affecting sleep directly when considering individuals who suspect they have had COVID-19. Pre-existing sleep disorders, such as obstructive sleep apnoea, may also be present in COVID-19 patients (24), and might further impact on sleep quality and shortness of breath following the infection. In our study, the presence of symptoms associated with sleep-disordered breathing was significantly associated with ongoing COVID-19 symptoms (*Figure 3*).

Furthermore, potential neuropathogenic mechanisms of SARS-CoV-2 and a range of neurological symptoms have been reported in patients with COVID-19 (25). It could be hypothesised that involvement of structures controlling sleep-wake cycles in the central nervous system play a role in the presence of sleep-related symptoms in COVID-19 patients. We found a significant association between the presence of ongoing COVID-19 symptoms and insomnia/disrupted sleep (*Figure 3*). Moreover, participants with suspected COVID-19 had a higher frequency of nightmares

and abnormal sleep rhythm (Table S9). Additionally, our regression analysis showed that restless legs symptoms were significantly associated with ongoing COVID-19 symptoms, mental health impact, and disability (Figure 3).

### Limitations to the study

A selection bias may be expected in the study, as subjects with affected sleep may have been more interested in completing the survey. Also, as the survey was widely distributed among the population, this could have included subjects living in different countries, with different levels of lockdown measures. Additionally, the self-reported status with regards to having suspected COVID-19 was subjective and affirmatory responses did not require positive formal testing. Moreover, no formal objective assessments of specific sleep disorders were undertaken. Finally, there was limited diversity in the respondents' ethnicity which did not permit assessing the impact of the pandemic on sleep in ethnic minorities.

Despite these limitations, and although it is clear that public health measures are required in such unprecedented circumstances, the potential effects of confinement and isolation on sleep should be screened for, and support needs to be provided for adequate management of sleep disturbances (6). Early identification of sleep disturbances and associated impact on mental health is crucial for timely intervention and support (26,27). Future studies could include formal assessments of subjective and objective measurements of sleep disorders, with more specific focus on subgroups according to infection, keyworker status and ethnicity.

### Conclusions

Altered sleep patterns and specific sleep-related symptoms are common in the general population during the pandemic lockdown. These are mainly associated with mental health impact, self-isolation, suspected COVID-19 infection and ongoing symptoms. The potential consequences of the lockdown on sleep should not be overlooked, as they can have an impact on the future wellbeing of society. Sleep issues may be addressed early with appropriate guidance and/or counselling to avoid the longer-term impact of these on a public health scale.

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screening survey design (<https://cdn.amegroups.com/static/application/04712039f3b0c07e77f3c779c14d1a17/JTD-CUS-2020-015-1.pdf>). The study conformed to the provisions of the Declaration of Helsinki (as revised in 2003).

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