


## RESEARCH ARTICLE

# Sleep in adults from the UK during the first few months of the coronavirus outbreak

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## Summary

The coronavirus disease 2019 (COVID-19) outbreak emerged at the end of 2019 and quickly spread around the world. Measures to counter COVID-19, including social distancing and lockdowns, created an unusual situation that had the potential to impact a variety of behaviours, including sleep, which is crucial for health and well-being. Data were obtained through an online survey. The total sample comprised 19,482 participants from the UK. Participants were asked several questions regarding sleep quality and quantity. Each participant completed the questionnaires once during a data collection period spanning January 20 to March 31, 2020. Data provided by different participants during different weeks (spanning time-periods just before COVID-19 was identified in the UK and during the early weeks following its arrival) were compared using analysis of variance tests and regressions. Regression analyses controlling for age, sex and ethnicity revealed significant associations of small magnitude between date of survey completion and sleep quality, sleep latency, number of awakenings and composite score of poor sleep quality. These analyses also indicated small increases in eveningness tendency as the study progressed. There was no change in sleep duration or time spent awake at night. The COVID-19 outbreak did not appear to impact negatively sleep in a substantial manner during the early stages in the UK. The small increases in sleep quality variables (except for time spent awake at night and sleep duration) and eveningness are nonetheless of interest. Further research is needed to understand how best to provide support to those most in need of a good night's sleep during this unprecedented time.

## KEYWORDS

chronotype, coronavirus, COVID-19, pandemic, sleep duration, sleep quality

The study was performed at the Goldsmiths University of London.

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## 1 | INTRODUCTION

The coronavirus outbreak emerged at the end of 2019 (Palacios Cruz, Santos, Velázquez Cervantes, & León Juárez, 2020) resulting in worldwide restrictive measures that were introduced in most countries in 2020. This period provided novel challenges and uncertainties. There was a rise in stress, anxiety, depression, time spent using electronic devices, isolation and sleep problems (Beaunoyer, Dupéré, & Guitton, 2020; Luo, Guo, Yu, Jiang, & Wang, 2020; Sher, 2020; Wang et al., 2020).

Changes in lifestyle accompanying concerns surrounding coronavirus disease 2019 (COVID-19) could potentially impact sleep patterns. Some studies have already considered links between different aspects of the COVID-19 pandemic and sleep (Robillard et al., 2021; Wang et al., 2020; Zhou et al., 2020). In a study carried out in Spain, where COVID-19 had a large impact on the health system, healthcare workers on the frontline developed more sleep disturbances than non-healthcare professionals (Herrero San Martin et al., 2020).

For some, the arrival of COVID-19 could have had a negative association with sleep, but it is also possible that other factors, including a reduction in commuting time, more flexible work/social schedules and, for some, a greater opportunity for physical activity, could have provided positive benefits for sleep. Indeed, lifestyle changes linked to COVID-19 could be both positive and negative. For example, one report using a general population from China suggested that the arrival of COVID-19 was associated with a greater time spent looking at screens but also a greater consumption of fruits and vegetables as compared to before the outbreak (Hu, Lin, Chiwanda Kaminga, & Xu, 2020). Another study found that people tended to do more exercise during lockdown, especially when considering previously inactive adults (Constandt et al., 2020).

Insomnia and poor sleep quality appear to have been common worries during lockdowns as indicated by the number of internet searches for insomnia, which increased by 58% during the first 5 months of 2020 compared with previous years (Zitting et al., 2020). Some studies have found that sleep length increased during the COVID-19 pandemic but that sleep quality decreased (Blume, Schmidt, & Cajochen, 2020; Wright et al., 2020).

Despite these important findings, there is a scarcity of studies with data collected prior to and during the COVID-19 with adequate sample sizes. Therefore, the present study aimed to investigate sleep characteristics before and during the earliest stages of the COVID-19 pandemic in a large sample from the UK. Cross-sectional questionnaire data regarding sleep quality and quantity were collected among the UK population before and during the earliest stages of the pandemic in the context of a wider study focussed on touch (commissioned by the Wellcome Collection and performed in collaboration with BBC Radio 4). Data collected each week during the earliest stages of the pandemic were compared.

The first cases of COVID-19 were confirmed in the UK during the second week of the study (January 31, 2020). During the seventh week of the study (March 5) the first death was confirmed, and the number of cases had exceeded 100. The number of cases increased

each week throughout the course of the study. The Prime Minister made an announcement about lockdown in the UK during the last week of the study (on March 23, 2020), which was enforced a few days later (March 26). Less restrictive measures were implemented earlier, such as closing pubs and gyms, and people were urged to maintain social distance, to regularly wash their hands, and to avoid touching their faces.

This study pre-registered (<https://osf.io/fs6w9>) the following hypothesis: (1) Sleep quality will decrease over time; (2) Sleep quantity will remain stable or increase over time; and (3) Diurnal preference will not show substantial changes across the study. The hypotheses were proposed due to the uncertainty, stress and lifestyle changes associated with COVID-19 that we thought would impact sleep quality in particular. For the first two hypotheses, we particularly expected changes during the last 2 weeks of the study when the COVID-19 situation got worse, and more measures were implemented to stop the spread of the disease.

## 2 | METHODS

The “Touch Test” was an online self-reported survey that explored attitudes to touch in a worldwide sample. The survey comprised various measurements, including several sleep variables, and was part of a wider public engagement project (see <https://osf.io/9e7ru/> for full survey). Participants were recruited through broadcasts on BBC Radio 4 and other social media and were required to have internet access on a computer, smart phone, or tablet in order to complete the survey. Data collection spanned January 20 to March 31, 2020; each participant completed the survey only once. After providing consent, participants were able to complete the survey at any point during the following 7 days (87% of the sample answered the survey the same day that it was started). Participation was voluntary and those taking part did not receive any monetary reward. The total sample included here (i.e. those who answered at least one sleep item and were UK residents) comprised 19,482 participants. In all, 24 participants were excluded, as they stated in a comment box that their answers reflected the period before COVID-19 or they noted that their responses could be biased by the COVID-19 situation. One more participant was excluded, as they stated being confused about the questions. Therefore, the total sample comprised 19,457 participants. The mean (*SD*, range) age was 57.1 (14.1, 18–99) years. The sample was 74.2% female, 24.3% male, 0.5% non-binary, 0.4% preferred not to say, and 0.5% preferred to self-describe.

The following questions were used to assess sleep quality; most of them (except D and E) were adapted from the Pittsburgh Sleep Quality Index (Buysse, Reynolds, Monk, Berman, & Kupfer, 1989) and were asked regarding sleep: (A) “How would you rate your sleep quality for the majority of nights during the past month?”, with four response options (i.e. “very good”, “fairly good”, “fairly bad”, and “very bad”); (B) “During the majority of the days and nights in the past month how many hours of actual sleep did you get at night? This may be different to the number of hours you spent in bed”, with five response

options (i.e. >9, 8–9, 7–8, 6–7, 5–6 and <5 hr); (C) “Thinking about a typical night in the last month... How long does it take you to fall asleep?”, with five response options (i.e. 0–15, 16–30, 31–45, 46–60, and 61 min or more); (D) “If you then wake up during the night, how long are you awake in total (add up all the time when you are awake)?”, with five response options (i.e. 0–15, 16–30, 31–45, 46–60, and 61 min or more); (E) “How many times did you wake up between the time you first fell asleep and your final awakening?”, with five response options (i.e. none, 1, 2, 3, 4 or more). A further item came from the Morningness and Eveningness Questionnaire (Horne & Ostberg, 1976) and measured diurnal preference. Participants were asked (F) “One hears about ‘morning’ and ‘evening’ types of people. Which one of these do you consider yourself to be?”, with four response options (i.e. 1 = Definitely a morning type, 2 = rather more a morning type than an evening type, 3 = rather more an evening type than a morning type, and 4 = definitely an evening type).

Additionally, a composite score of poor sleep quality comprised all of these items (except chronotype) and was made in order to provide a broad measure of sleep quality. The following coding was used to build the composite: *sleep quality* (1 = very good; 2 = fairly good; 3 = fairly bad; 4 = very bad), *sleep duration* (1 = 7 to >9 hr; 2 = 6–7 hr; 3 = 5–6 hr; 4 = <5 hr), *latency* (1 = 0–15 min, 2 = 16–30 min; 3 = 31–45 min, 4 = 46–60 min, 5 = >60 min) *time awake* (1 = 0–15 min, 2 = 16–30 min; 3 = 31–45 min, 4 = 46–60 min, 5 = >60 min) and *awakenings* (0 = 0 awakenings; 1 = 1 awakening, 2 = 2 awakenings, 3 = 3 awakenings, 4 = 4 or more awakenings). Overall, scores could range from 4 to 22, where higher scores represent poorer sleep quality.

## 2.1 | Statistical analysis

This study and analyses were pre-registered on the Centre for Open Science Website (<https://osf.io/fs6w9>). All the tests were performed on raw (untransformed) data. One-way analysis of variance (ANOVA)s and Bonferroni (Games–Howell if equal variances were not assumed) post hoc tests were performed to examine differences across weeks for each sleep variable and the composite score of poor sleep quality. Additionally, regression analyses were performed using day of completion (instead of week) as a continuous variable and controlling for age, sex, and ethnicity in order to examine linear associations between day of completion (independent variable) and the sleep variable (dependent variable). As >87% of the sample endorsed their ethnicity as “White English/Welsh/Scottish/Northern Irish/British”, and the other categories (including Asian, Asian British, African, Caribbean among others) were endorsed infrequently this variable was dichotomised.

## 2.2 | Deviations from the protocol

We largely followed the pre-registered analysis plan; however, there were a few deviations from protocol. Specifically, a composite score

of poor sleep quality was added in order to provide a broad measure of sleep quality and test possible differences across weeks. In the pre-registration, we proposed focussing exclusively on participants without any disability, long-term condition or impairment (assessed on self-reported). Participants endorsing these latter options included  $N = 7,228$  (37.4%). As these participants comprised a large proportion of our sample, we decided not to exclude them from the results presented in the main body of the paper. Nonetheless, we have conducted sensitivity analyses whereby these participants were excluded (similarities and differences in results are noted below).

## 3 | RESULTS

### 3.1 | Sleep quality

Overall, more participants reported that they had very good or fairly good sleep quality ( $n = 3,361$  [17.3%] and  $n = 9,587$  [49.3%], respectively) than fairly bad or very bad ( $n = 5,345$  [27.5%] and  $n = 1,161$  [6.0%], respectively) in the total sample. When sleep quality was analysed by week (Table 1) the summed percentages of those reporting fairly bad or very bad sleep ranged from 25.8% (week 10 [March 23 to 31]) to 36.2% (week 7 [2–3 to 8–3]). The ANOVA showed that differences among weeks were significant ( $F [9, 19444] = 3.286$ ,  $p < 0.001$ ,  $\eta^2 = 0.002$ ). Post hoc comparisons revealed that the significant differences were between week 1 (January 20 to 26) and week 8 (March 9 to 15,  $p = 0.002$ ) and between week 2 (January 27 to February 2) and week 8 (March 9 to 15,  $p = 0.015$ ), suggesting that sleep quality was better during later study weeks. The regression analysis using day of completion as a continuous variable and age, sex and ethnicity as covariates showed that day of completion was a significant predictor of poor sleep quality ( $\beta = -0.035$ ;  $p < 0.001$ ) where sleep quality increased over the time (Table S1). This association remained significant in the sensitivity analysis removing participants who reported any health condition in the regression analysis ( $\beta = -0.028$ ;  $p = 0.002$ ) but not in the ANOVA ( $F [9, 12107] = 1.248$ ,  $p = 0.253$ ,  $\eta^2 = 0.001$ ).

### 3.2 | Sleep duration

Overall, 1.4% ( $n = 281$ ) slept >9 hr a night, 9.0% ( $n = 1,759$ ) slept between 8 and 9 hr a night, 29.6% ( $n = 5,752$ ) slept between 7 and 8 hr a night, 33.8% ( $n = 6,566$ ) slept between 6 and 7 hr a night, 20.3% ( $n = 3,950$ ) slept between 5 and 6 hr a night, and 5.9% ( $n = 1,142$ ) slept <5 hr. Results presented by week (Table 2) reveal that participants who slept  $\leq 7$  hr a night ranged from a sum of 57.1% (week 5 [February 17 to 23]) to 64.6% (week 9 [March 16 to 22]). The ANOVA showed that these differences were significant ( $F [9, 19449] = 2.959$ ,  $p = 0.001$ ,  $\eta^2 = 0.001$ ). Post hoc comparisons revealed that the significant differences were between week 1 (January 20 to 26) and week 5 (February 17 to 23,  $p = 0.003$ ), between week 5 (February 17

TABLE 1 Sleep quality before and during early stages of COVID-19

	Very good, % (n)	Fairly good, % (n)	Fairly bad, % (n)	Very bad, % (n)	Number of participants/week
Week 1 (January 20 to 26)	16.7 (1,494)	48.6 (4,345)	28.5 (2,544)	6.2 (533)	8,916
Week 2 (January 27 to February 2)	16.5 (580)	49.8 (1,751)	27.0 (948)	6.7 (235)	3,514
Week 3 (February 3 to 9)	16.5 (156)	49.2 (465)	29.0 (274)	5.3 (50)	945
Week 4 (February 10 to 16)	17.5 (137)	49.4 (386)	27.6 (216)	5.5 (43)	782
Week 5 (February 17 to 23)	17.7 (265)	51.7 (772)	25.7 (384)	4.9 (73)	1,494
Week 6 (February 24 to March 1)	19.3 (213)	48.5 (535)	26.8 (296)	5.4 (60)	1,104
Week 7 (March 2 to 8)	18.3 (73)	45.5 (181)	30.2 (120)	6.0 (24)	398
Week 8 (March 9 to 15)	19.2 (272)	51.5 (729)	24.2 (343)	5.0 (71)	1,415
Week 9 (March 16 to 22)	19.5 (131)	47.5 (319)	27.4 (184)	5.7 (38)	672
Week 10 (March 23 to 31)	20.6 (40)	53.6 (104)	18.6 (36)	7.2 (14)	194
Total (January 20 to March 31)	17.3 (3,361)	49.3 (9,587)	27.5 (5,345)	6.0 (1,161)	

Percentage (n) of those providing each response during each week of the study. Please note that the first cases of COVID-19 were confirmed in the UK during week 2 (January 31, 2020) and the number of cases increased each week throughout the course of the study. The Prime Minister made an announcement about lockdown in the UK on March 23, 2020, which was enforced on March 26 (i.e. week 10). Please note that participants completing this measure focus on the previous 4 weeks. Significant differences between Week 1 and Week 8 ( $p = 0.002$ ). Significant differences between Week 2 and Week 8 ( $p = 0.015$ ).

to 23) and week 9 (March 16 to 22,  $p = 0.001$ ), and between week 2 (January 27 to February 2) and week 5 (February 17 to 23,  $p = 0.024$ ), showing a longer sleep duration for week 5 as compared to weeks 9 and 1. The regression analysis using day of completion as a continuous variable and age, sex and ethnicity as covariates showed that day of completion was not a significant predictor of short sleep duration ( $\beta = -0.013$ ;  $p = 0.066$ ) (Table S2). This association was also not significant in the sensitivity analysis (excluding those endorsing health conditions) for the regression analysis ( $\beta = -0.008$ ;  $p = 0.405$ ) or for the ANOVA ( $F [9, 12105] = 1.047$ ,  $p = 0.399$ ,  $\eta^2 = 0.001$ ).

### 3.3 | Sleep latency

A large proportion of the sample had a sleep onset latency of <15 min (44.5%,  $n = 8,655$ ). This ranged from 42.4% (week 3 [February 3 to 9]) to 49.7% (week 10 [March 23 to 31]) when analysed at a week level (Table 3). The ANOVA of one factor showed statistical differences ( $F [9, 19426] = 4.822$ ,  $p < 0.001$ ,  $\eta^2 = 0.002$ ). Post hoc tests showed that there were statistical differences between week 1 (January 20 to 26) and week 5 (February 17 to 23, ( $p < 0.001$ ) and between week 1 and week 8 (March 9 to 15,  $p = 0.005$ ); sleep latency was shorter during weeks 5 and 8. The regression analysis using day of completion as a continuous variable and age, sex and ethnicity as covariates showed that day of completion was a significant predictor of sleep latency ( $\beta = -0.036$ ;  $p < 0.001$ ) where sleep latency was shorter during later study weeks (Table S3). This association remained significant in the sensitivity analysis (excluding those endorsing health conditions) for the ANOVA ( $F [9, 12098] = 2.325$ ,  $p = 0.013$ ,  $\eta^2 = 0.002$ ) and the regression analysis ( $\beta = -0.029$ ;  $p = 0.001$ ).

### 3.4 | Time awake

Overall, 16.1% ( $n = 3,121$ ) of the sample spent >60 min awake during the night. Results by week (Table 4) ranged from 15.1% (week 8 [March 9 to 15]) to 19.6% (week 7 [March 2 to 8]). These differences were non-significant ( $F [9, 19413] = 0.903$ ,  $p = 0.536$ ,  $\eta^2 < 0.001$ ). The regression analysis using day of completion as a continuous variable and age, sex and ethnicity as covariates showed that day of completion was not a significant predictor of time awake ( $\beta = -0.010$ ;  $p = 0.178$ ) (Table S4). The same pattern of results was found in the sensitivity analysis removing participants who reported any health condition for the ANOVA ( $F [9, 12091] = 0.600$ ,  $p = 0.798$ ,  $\eta^2 < 0.001$ ) and the regression analysis ( $\beta = -0.010$ ;  $p = 0.260$ ).

### 3.5 | Awakenings

Most of the sample had >1 awakening during the night (0 awakenings = 5.6%; 1 awakening = 33.7%; 2 awakenings = 33.3%; 3 awakenings = 18.0%, and 4 or more awakenings = 9.5%). The percentage of participants that had more than one awakening during the night ranged from 56.9% (week 10 [March 23 to 31]) to 62.6% (week 1 [January 20 to 26]) (Table 5). The ANOVA showed that these differences were statistically significant ( $F [9, 19425] = 4.060$ ,  $p < 0.001$ ,  $\eta^2 = 0.002$ ). Post hoc tests showed that these differences were between week 1 (January 20 to 26) and week 5 (February 17 to 23,  $p = 0.003$ ) and between week 1 (January 20 to 26) and week 8 (March 9 to 15,  $p = 0.001$ ), showing fewer awakenings in the later study weeks. The regression analysis using day of completion as a continuous variable and age, sex and ethnicity as covariates showed

TABLE 2 Sleep duration before and during early stages of COVID-19

	>9 hr, % (n)	8–9 hr, % (n)	7–8 hr, % (n)	6–7 hr, % (n)	5–6 hr, % (n)	<5 hr, % (n)	Number of participants/week
Week 1 (January 20 to 26)	1.6 (139)	9.4 (837)	28.8 (2,572)	33.1 (2,956)	20.9 (1,863)	6.3 (567)	8,934
Week 2 (January 27 to February 2)	1.4 (48)	8.9 (311)	29.6 (1,039)	34.0 (1,193)	20.2 (710)	6.0 (212)	3,513
Week 3 (February 3 to 9)	1.2 (11)	7.8 (74)	30.2 (285)	34.5 (326)	21.2 (200)	5.2 (49)	945
Week 4 (February 10 to 16)	1.5 (12)	9.2 (72)	28.8 (225)	34.5 (270)	19.3 (151)	6.6 (52)	782
Week 5 (February 17 to 23)	1.5 (23)	9.3 (139)	32.1 (479)	35.6 (532)	17.8 (266)	3.7 (55)	1,494
Week 6 (February 24 to March 1)	1.3 (14)	8.5 (94)	31.5 (347)	33.9 (374)	19.5 (215)	5.3 (59)	1,103
Week 7 (March 2 to 8)	1.3 (5)	7.3 (29)	30.7 (122)	33.9 (135)	20.9 (83)	6.0 (24)	398
Week 8 (March 9 to 15)	1.1 (16)	9.8 (138)	31.2 (442)	32.9 (466)	20.1 (285)	4.8 (68)	1,415
Week 9 (March 16 to 22)	1.2 (8)	7.0 (47)	27.2 (183)	36.0 (242)	21.8 (147)	6.8 (46)	673
Week 10 (March 23 to 31)	2.6 (5)	9.3 (18)	30.1 (58)	37.3 (72)	15.5 (30)	5.2 (10)	193
Total (20-1 to March 31)	1.4 (281)	9.0 (1,759)	29.6 (5,752)	33.8 (6,566)	20.3 (3,950)	5.9 (1,142)	

Percentage (n) of those providing each response during each week of the study. Please note that the first cases of COVID-19 were confirmed in the UK during week 2 (January 31, 2020) and the number of cases increased each week throughout the course of the study. The Prime Minister made an announcement about lockdown in the UK on March 23, 2020, which was enforced on March 26 (i.e. week 10). Please note that participants completing this measure focus on the previous 4 weeks. Significant differences between Week 1 and Week 5 ( $p = 0.003$ ). Significant differences between Week 2 and Week 5 ( $p = 0.001$ ). Significant differences between Week 5 and Week 9 ( $p = 0.024$ ).

that day of completion was a significant predictor of awakenings ( $\beta = -0.043$ ;  $p < 0.001$ ) with fewer awakenings at later points in the study (Table S5). These results remained significant in the sensitivity analysis removing participants who reported any health condition for the ANOVA ( $F [9, 12098] = 2.874$ ,  $p = 0.002$ ,  $\eta^2 = 0.002$ ) and the regression analysis ( $\beta = -0.038$ ;  $p < 0.001$ ).

### 3.6 | Chronotype

Finally, most of the sample selected their chronotype as definitely a morning type or rather more a morning type than an evening type (25.2%;  $n = 4,874$ ; 30.3%;  $n = 5,874$  respectively; Table 6). The one-factor ANOVA showed statistical differences in the proportion of participants who were definitely a morning/rather a morning types by week ( $F [9, 19346] = 3.859$ ,  $p < 0.001$ ,  $\eta^2 = 0.002$ ). Post hoc tests showed that these differences were among week 1 (January 20 to 26) and week 9 (March 16 to 22,  $p = 0.001$ ) and week 2 (January 27 to February 2) and week 9 (March 16 to 22,  $p < 0.001$ ), showing a greater proportion of participants selecting a later chronotype in week 9 compared to weeks 1 and 2. The regression analysis using day of completion as a continuous variable and age, sex and ethnicity as covariates showed that day of completion was a significant

predictor of chronotype ( $\beta = 0.037$ ;  $p < 0.001$ ) with a greater proportion of participants selecting a later chronotype during the later weeks of the study (Table S6). These results remained significant in the sensitivity analyses removing participants who reported any health condition for the ANOVA ( $F [9, 12048] = 2.759$ ,  $p = 0.003$ ,  $\eta^2 = 0.002$ ) and the regression analysis ( $\beta = 0.033$ ;  $p < 0.001$ ).

### 3.7 | Composite score of poor sleep quality

The mean (SD) value for the composite score of poor sleep quality was 10.6 (3.9); scores ranged from 10.1 (week 10) to 10.7 (weeks 1, 3 and 7). Therefore, the biggest difference was of 0.6 points. In Figure 1 the mean values across weeks are shown. The one-way ANOVA showed that these differences were significant ( $F [9, 19407] = 4.267$ ,  $p < 0.001$ ,  $\eta^2 = 0.002$ ). Post hoc tests showed that these differences were between week 1 (January 20 to 26) and week 5 (February 17 to 23;  $p < 0.001$ ); between week 1 (January 20 to 26) and week 8 (March 9 to 15,  $p = 0.001$ ); and between week 2 [January 27 to February 2) and week 5 (February 17 to 23,  $p = 0.024$ ), showing that sleep quality was better in weeks 5 and 8. The regression analysis using day of completion as a continuous variable and age, sex and ethnicity as covariates showed that day of

TABLE 3 Sleep latency before and during early stages of COVID-19

	0–15 min, % (n)	16–30 min, % (n)	31–45 min, % (n)	46–60 min, % (n)	≥61 min, % (n)	Number of participants/week
Week 1 (January 20 to 26)	42.7 (3,816)	30.4 (2,718)	12.9 (1,155)	7.2 (646)	6.7 (594)	8,929
Week 2 (January 27 to February 2)	44.9 (1,574)	31.0 (1,086)	12.3 (431)	5.6 (196)	6.3 (221)	3,508
Week 3 (February 3 to 9)	42.4 (400)	31.8 (300)	13.0 (123)	6.4 (60)	6.5 (61)	944
Week 4 (February 10 to 16)	46.6 (364)	30.6 (239)	9.6 (75)	6.3 (49)	6.9 (54)	781
Week 5 (February 17 to 23)	49.0 (731)	28.5 (425)	12.5 (186)	5.5 (82)	4.6 (69)	1,493
Week 6 (February 24 to March 1)	45.9 (506)	30.8 (340)	11.7 (129)	7.0 (77)	4.6 (51)	1,103
Week 7 (March 2 to 8)	48.2 (192)	27.9 (111)	11.3 (45)	6.0 (24)	6.5 (26)	398
Week 8 (March 9 to 15)	46.5 (658)	30.4 (430)	12.7 (180)	5.2 (73)	5.2 (74)	1,415
Week 9 (March 16 to 22)	47.3 (318)	27.1 (182)	12.5 (84)	6.5 (44)	6.5 (44)	672
Week 10 (March 23 to 31)	49.7 (96)	27.5 (53)	13.0 (25)	4.7 (9)	5.2 (10)	193
Total (January 20 to March 31)	44.5 (8,655)	30.3 (5,884)	12.5 (2,433)	6.5 (1,260)	6.2 (1,204)	

Percentage (n) of those providing each response during each week of the study. Please note that the first cases of COVID-19 were confirmed in the UK during week 2 (January 31, 2020) and the number of cases increased each week throughout the course of the study. The Prime Minister made an announcement about lockdown in the UK on March 23, 2020, which was enforced on March 26 (i.e. week 10). Please note that participants completing this measure focus on the previous 4 weeks. Significant differences between Week 1 and Week 5 ( $p < 0.001$ ). Significant differences between Week 1 and Week 8 ( $p = 0.005$ ).

completion was a significant predictor (of small magnitude) of the composite score of poor sleep quality ( $\beta = -0.039$ ;  $p < 0.001$ ) showing that sleep quality was better during later study weeks (Table S7). These results remained significant in the sensitivity analysis removing participants who stated any health condition for the ANOVA ( $F [9, 12088] = 2.085$ ,  $p = 0.017$ ,  $\eta^2 = 0.002$ ) and the regression analysis ( $\beta = -0.032$ ;  $p < 0.001$ ).

## 4 | DISCUSSION

Data on different sleep variables were collected from a large sample of adults either before or during the initial period after the arrival of COVID-19 in the UK. First, we expected sleep quality to decrease over time. We did not find large changes over the weeks, but instead a decrease in sleep quality over time, our analyses suggested a slight *increase* in sleep quality as the study progressed. This was contrary to our initial hypothesis. Second, we expected sleep quantity to remain stable or increase over time. Consistent with our initial expectations, we found only small changes over time (many of which were non-significant). Third, we expected diurnal preference not to show substantial changes across the study. Here, we found partial support for our hypothesis: while we found a significant increase in

eveningness over time, the magnitude of this effect was small, consistent with our expectations. We also confirmed the known links between age and sex for most of our sleep variables. Specifically, we found that increased age and female gender were associated with poorer sleep quality. This is consistent with previous literature (Madrid-Valero, Martínez-Selva, Ribeiro do Couto, Sánchez-Romera, & Ordoñana, 2017).

The comparison with other studies is difficult as most scientific papers on this topic do not report data before the outbreak of the COVID-19 pandemic, whereas our present study does. Furthermore, different studies span different countries and different periods along the COVID-19 timeline. Nonetheless, there are some previous studies that are particularly relevant to the work reported here. For example, respondents in one study spent 20 min more in bed during a COVID-19 lockdown without loss of sleep efficiency as compared to the period before the lockdown (Ong et al., 2020). Similarly, other studies using self-reported measures have found that people tend to spend more time in bed during the lockdown but do not report better sleep quality (Blume et al., 2020; Wright et al., 2020). Using retrospective data, another report found that sleep difficulties increased from 36% before the outbreak to 50.5% during the outbreak (Robillard et al., 2021). A further study reported that higher rates of trouble sleeping were found during the pandemic as compared to a



TABLE 4 Time awake each night before and during early stages of COVID-19

	0–15 min, % (n)	16–30 min, % (n)	31–45 min, % (n)	46–60 min, % (n)	≥61 min, % (n)	Number of participants/week
Week 1 (January 20 to 26)	35.6 (3,176)	20.8 (1,860)	14.1 (1,262)	13.3 (1,189)	16.1 (1,438)	8,925
Week 2 (January 27 to February 2)	35.9 (1,257)	19.8 (695)	13.6 (476)	14.0 (492)	16.7 (585)	3,505
Week 3 (February 3 to 9)	33.9 (320)	20.3 (192)	14.8 (140)	15.1 (143)	15.8 (149)	944
Week 4 (February 10 to 16)	34.8 (272)	20.8 (163)	17.0 (133)	12.0 (94)	15.3 (120)	782
Week 5 (February 17 to 23)	35.5 (529)	21.9 (326)	14.9 (222)	13.4 (200)	14.2 (212)	1,489
Week 6 (February 24 to March 1)	36.5 (403)	19.0 (210)	14.8 (163)	13.0 (143)	16.7 (184)	1,103
Week 7 (March 2 to 8)	35.4 (141)	18.1 (72)	12.1 (48)	14.8 (59)	19.6 (78)	398
Week 8 (March 9 to 15)	37.2 (525)	20.2 (285)	14.9 (211)	12.7 (179)	15.1 (213)	1,413
Week 9 (March 16 to 22)	36.2 (243)	21.2 (142)	13.9 (93)	12.2 (82)	16.5 (111)	671
Week 10 (March 23 to 31)	39.4 (76)	19.7 (38)	11.9 (23)	13.0 (25)	16.1 (31)	193
Total (January 20 to March 31)	35.7 (6,942)	20.5 (3,983)	14.3 (2,771)	13.4 (2,606)	16.1 (3,121)	

Percentage (n) of those providing each response during each week of the study. Please note that the first cases of COVID-19 were confirmed in the UK during week 2 (January 31, 2020) and the number of cases increased each week throughout the course of the study. The Prime Minister made an announcement about lockdown in the UK on rd March 23, 2020, which was enforced on March 26 (i.e. week 10). Please note that participants completing this measure focus on the previous 4 weeks.

previous general population survey conducted before the lockdown (Beck et al., 2021). Other studies using data collected during the pandemic report high rates of poor sleep quality (Wang et al., 2020; Zhou et al., 2020).

Studies focussing on participants from the UK are particularly relevant to the work presented here. One study of UK students found that overall sleep quality was not affected during the lockdown (Evans, Alkan, Bhangoo, Tenenbaum, & Ng-Knight, 2021). This study also found a shift towards eveningness, which chimes well with our present results. Another study of UK participants suggested that poor sleep may be a mechanism by which COVID-19 could impact mental health (L. Wright, Steptoe, & Fancourt, 2021). Furthermore, a significant association between sleep and physical activity and the risk or severity of COVID-19 infection was reported in participants from the UK (Rowlands et al., 2021).

Our present results focussed on data collected during the earliest stages of the COVID-19 outbreak up until and including the first week of lockdown and revealed that sleep did not appear to change substantially during this period of data collection. Changes were small and most of the individual indices (e.g. sleep quality, sleep duration, sleep latency), as well as the composite score of sleep quality were better over time. These results were somewhat surprising given the possibility of stress and anxiety and sleepless nights during this period of global uncertainty.

While the sleep of some population groups (e.g. health workers or those with sudden economic problems) could have been particularly negatively impacted during the early stages of COVID-19, other groups (e.g. workers who retained their salary but did not have to commute every day or found a reduction in their working hours) could have seen their sleep quality improve. Additionally, it is possible that negative consequences of COVID-19 on sleep had not yet begun, and measures of social restriction (e.g. more time at home) gave people a greater opportunity to sleep according to their needs. Furthermore, there is a tendency towards a phase delay when work/social requirements are not present, which could help to explain the shift in eveningness overtime reported in the present study. It is also possible that some of the changes in sleep we noticed over the duration of our study could be explained by seasonal changes (as our data were collected from January 20 to March 31). However, previous findings on this topic have been inconsistent and not always in line with our own results. For example, in a study comparing populations from Ghana and Norway it was found that lack of daylight was associated with phase-delayed rise- and bedtimes, increased problems falling asleep, daytime fatigue and depressive mood, but sleep quality and sleep duration appeared to be unaffected (Friborg, Bjorvatn, Amponsah, & Pallesen, 2012). Other studies have also found that sleep duration and sleep quality decrease from winter to summer (Mattingly et al., 2021; Suzuki et al., 2019), which is not in line with

TABLE 5 Awakenings before and during early stages of COVID-19

	0, % (n)	1, % (n)	2, % (n)	3, % (n)	≥4, % (n)	Number of participants/week
Week 1 (January 20 to 26)	5.2 (468)	32.1 (2,869)	33.9 (3,028)	18.8 (1,681)	9.9 (883)	8,929
Week 2 (January 27 to February 2)	6.0 (211)	33.9 (1,188)	32.5 (1,139)	17.5 (614)	10.1 (355)	3,507
Week 3 (February 3 to 9)	5.3 (50)	36.3 (342)	31.3 (295)	17.6 (166)	9.5 (90)	943
Week 4 (February 10 to 16)	5.4 (42)	33.9 (265)	32.1 (251)	18.8 (147)	9.8 (77)	782
Week 5 (February 17 to 23)	6.1 (91)	35.5 (530)	34.6 (516)	15.8 (236)	8.0 (120)	1,493
Week 6 (February 24 to March 1)	5.6 (62)	33.4 (368)	34.4 (379)	18.2 (201)	8.4 (93)	1,103
Week 7 (March 2 to 8)	5.0 (20)	36.9 (147)	30.7 (122)	18.3 (73)	9.0 (36)	398
Week 8 (March 9 to 15)	6.4 (91)	36.6 (518)	33.0 (467)	15.3 (216)	8.7 (123)	1,415
Week 9 (March 16 to 22)	5.7 (38)	36.9 (248)	30.4 (204)	19.9 (134)	7.1 (48)	672
Week 10 (March 23 to 31)	7.8 (15)	35.2 (68)	32.6 (63)	17.6 (34)	6.7 (13)	193
Total (January 20 to March 31)	5.6 (1,088)	33.7 (6,543)	33.3 (6,464)	18.0 (3,502)	9.5 (1,838)	

Percentage (n) of those providing each response during each week of the study. Please note that the first cases of COVID-19 were confirmed in the UK during week 2 (January 31, 2020) and the number of cases increased each week throughout the course of the study. The Prime Minister made an announcement about lockdown in the UK on rd March 23, 2020, which was enforced on March 26 (i.e. week 10). Please note that participants completing this measure focus on the previous 4 weeks. Significant differences between Week 1 and Week 5 ( $p = 0.003$ ). Significant differences between Week 1 and Week 8 ( $p = 0.001$ ).

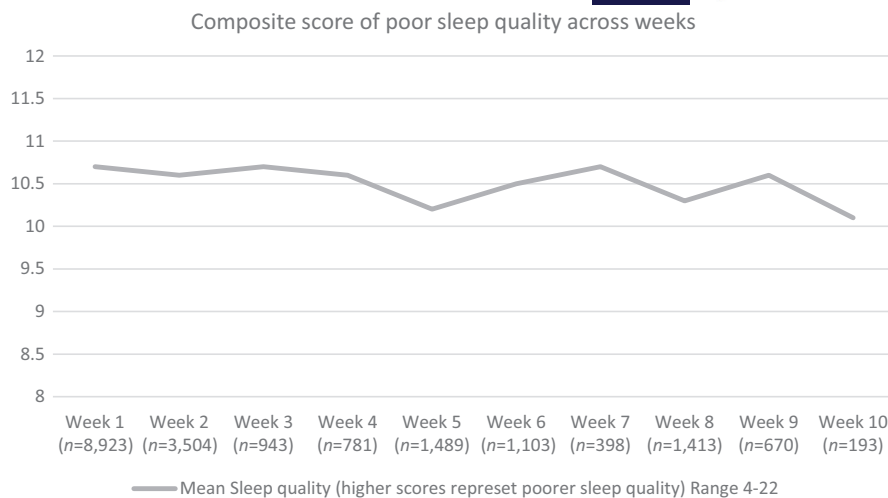
TABLE 6 Chronotype before and during early stages of COVID-19

	Definitively morning, % (n)	Rather morning, % (n)	Rather evening, % (n)	Definitively evening, % (n)	Number of participants/week
Week 1 (January 20 to 26)	25.5 (2,263)	30.7 (2,729)	27.6 (2,456)	16.2 (1,439)	8,887
Week 2 (January 27 to February 2)	27.5 (963)	29.4 (1,028)	27.0 (943)	16.1 (565)	3,499
Week 3 (February 3 to 9)	24.3 (229)	30.7 (289)	25.6 (241)	19.4 (183)	942
Week 4 (February 10 to 16)	23.8 (186)	30.0 (234)	26.9 (210)	19.2 (150)	780
Week 5 (February 17 to 23)	24.1 (359)	30.9 (459)	28.0 (416)	17.0 (253)	1,487
Week 6 (February 24 to March 1)	24.1 (265)	31.2 (343)	26.6 (292)	18.0 (198)	1,098
Week 7 (March 2 to 8)	25.8 (102)	26.3 (104)	25.3 (100)	22.7 (90)	396
Week 8 (March 9 to 15)	23.2 (326)	31.5 (442)	26.5 (372)	18.9 (265)	1,405
Week 9 (March 16 to 22)	19.9 (133)	28.7 (192)	30.8 (206)	20.6 (138)	669
Week 10 (March 23 to 31)	24.9 (48)	28.0 (54)	32.2 (64)	14.0 (27)	193
Total (January 20 to March 31)	25.2 (4,874)	30.3 (5,874)	27.4 (5,300)	17.1 (3,308)	

Percentage (n) of those providing each response during each week of the study. Please note that the first cases of COVID-19 were confirmed in the UK during week 2 (January 31, 2020) and the number of cases increased each week throughout the course of the study. The Prime Minister made an announcement about lockdown in the UK on March 23, 2020, which was enforced on March 26 (i.e. week 10). Significant differences between Week 1 and Week 9 ( $p = 0.001$ ). Significant differences between Week 2 and Week 9 ( $p < 0.001$ ).



**FIGURE 1** Overall sleep quality across weeks



our own results. However, consistent with our results, a further study found that bedtimes and wake times tend to be slightly later as outdoor temperature increases (Mattingly et al., 2021).

The present study has several strengths such as the use of a very large and diverse sample of UK residents with an ample range of ages and characteristics. Another key strength of the present study is that the data collection spanned periods before and during the COVID-19 pandemic. However, the present study must be interpreted in light of some limitations. Firstly, the present study was not designed for this purpose and data collection had begun when the outbreak started. Participants were likely to have been aware of this and may have responded to our survey as if COVID-19 was not happening (indeed, some of our participants noted that this was their approach to responding and in these instances their data were excluded from this study).

Our data collection spanned from January to the end of March, which did not allow us to investigate the impact of lockdown during the later stages of the pandemic. Indeed, only at the very end of our data collection did reports of sleep include consideration of experiences during the lockdown. In relation to this point, it is also noteworthy that for certain variables (sleep quality, sleep duration, sleep latency, and time awake), the reporting period was the 1 month prior to taking the survey, which needs to be considered when interpreting the results. This also means that for certain variables, even those reporting at the very end of the study might have been referring to a time period which spanned both before and during lockdown. Third, our measures are self-reported, and results may therefore differ from results obtained should data have been collected using objective measures including polysomnography and actigraphy. Furthermore, it is possible that the negative consequences associated with COVID-19 had not yet started to impact sleep and sleep patterns as our data collection ended at the beginning of the lockdown. Fourth, data were collected online, which could have biased our results (e.g. people with no internet access could not take part). However, the funding available and the large number of participants would have made it infeasible to carry out a more in-depth assessment of the variables (such as using polysomnography to assess

sleep for example). Finally, data were not collected longitudinally within-person and causal relationship cannot be determined.

In summary, the present study examined a wide variety of sleep variables in a non-clinical representative large sample from the UK. We did not find that sleep was strongly impacted by the COVID-19 situation in the earliest stages of the pandemic in the UK, although we did see a small increase in sleep quality and eveningness preference over the weeks of data collection. Hypotheses about the differences among studies are speculative and further research is needed to confirm the impact of COVID-19 on sleep both concurrently and over time, and in different sub-groups of the population.

It is reassuring that sleep did not appear to be severely negatively impacted during the early stages of the COVID-19 outbreak in our present participants. Nonetheless, further research is needed to understand how best to provide support to those most in need of a good night's sleep during this unprecedented time.

#### CONFLICT OF INTEREST

AMG is an advisor for a project originally partially sponsored by Johnson's Baby. She has written two books (Nodding Off, Bloomsbury Sigma, 2018; The Sleepy Pebble, Flying Eye Books, 2019) and is working on a further project with Lawrence King Publishing. She is a regular contributor to BBC Focus magazine and has contributed to numerous other outlets (such as *The Conversation* and *The Guardian*). She has been interviewed by magazines and commercial websites. She has provided a paid talk for business and is occasionally sent trial products from commercial companies (e.g. blue light blocking glasses). She has received grant funding for her research from several bodies. Over the past 3 years, DJB has served as a paid consultant to National Cancer Institute, Pear Therapeutics, Sleep Number, Weight Watchers International, and Idorsia. DJB is an author of the Pittsburgh Sleep Quality Index, Pittsburgh Sleep Quality Index Addendum for PTSD (PSQI-A), Brief Pittsburgh Sleep Quality Index (B-PSQI), Daytime Insomnia Symptoms Scale, Pittsburgh Sleep Diary, Insomnia Symptom Questionnaire, and RU\_SATED (copyrights held by University of Pittsburgh). These instruments have been licensed to commercial entities for fees. He is also

co-author of the Consensus Sleep Diary (copyright held by Ryerson University), which is licensed to commercial entities for a fee. He has received grant support from the National Institutes of Health (NIH), Patient-Centered Outcomes Research Institute (PCORI), Agency for Healthcare Research and Quality (AHRQ), and the Veteran's Administration (VA). Over the past 3 years MJB has served as a paid consultant to EVE Sleep and provided talks for business from a range of sectors. He has contributed to several media outlets worldwide, including work on The Touch Test (a science and broadcast collaboration with BBC Radio 4 funded via the Wellcome Collection). He has also received grant funding from several bodies.

## AUTHOR CONTRIBUTIONS

MJB and AMG conceptualised the original idea and constructed the methodology. JJMV and AV performed statistical analyses. JJMV and AG wrote the original manuscript in consultation with all the co-authors. All authors have read and agreed to the final version of the manuscript.

## DATA AVAILABILITY STATEMENT

Data available with restrictions

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## SUPPORTING INFORMATION

Additional Supporting Information may be found online in the Supporting Information section.