

SLEEPING WHEN THE WORLD LOCKS DOWN: PREDICTORS OF SLEEP HEALTH DURING THE COVID-19 PANDEMIC ACROSS 59 COUNTRIES

Dilara Yuksel^{1*}, Grace B. McKee^{2,3}, Paul B. Perrin^{4,5}, Elisabet Alzueta^{1,6}, Sendy Caffarra^{7,8,9}, Daniela Ramos-Usuga^{10,11}, Juan Carlos Arango-Lasprilla^{11,12,13} & Fiona C. Baker^{1,14}

¹Center for Health Sciences, SRI International, Menlo Park, CA, USA

²Advanced Fellowship Program in Mental Illness Research and Treatment, Mid-Atlantic Mental Illness Research Education and Clinical Center (MIRECC), Central Virginia VA Health Care System, Richmond, VA, USA

³Department of Psychology, Virginia Commonwealth University, Richmond, VA, USA

⁴Department of Psychology, Virginia Commonwealth University, Richmond, VA, USA

⁵Central Virginia VA Health Care System, Richmond, VA, USA

⁶Biological and Health Psychology Department, Autonomous University of Madrid, Madrid, Spain

⁷Stanford University School of Medicine, Division of Developmental-Behavioral Pediatrics, Stanford, CA, USA

⁸Stanford University Graduate School of Education, Stanford, CA, USA

⁹Basque Center on Cognition, Brain and Language, Donostia-San Sebastián, Spain

¹⁰Biomedical Research Doctorate Program, University of the Basque Country, Leioa, Spain

¹¹Biocruces Bizkaia Health Research Institute, Barakaldo, Spain

¹²IKERBASQUE. Basque Foundation for Science, Bilbao, Spain

¹³Department of Cell Biology and Histology, University of the Basque Country, Leioa, Spain

¹⁴School of Physiology, University of the Witwatersrand, Johannesburg, South Africa

Corresponding Author:

Dilara Yuksel, PhD

Center for Health Sciences

SRI International

333, Ravenswood Ave

Menlo Park, CA, 94025

Email: dilara.yuksel@sri.com

Authors' Note:

The authors report no conflict of interests related to the submission of this manuscript.

ABSTRACT

Objectives. COVID-19 escalated into a global pandemic affecting countries around the world. As communities shut down to reduce disease spread, all aspects of life have been altered, including sleep. This study investigated changes in sleep patterns and predictors of sleep health in a global sample of adults and examined relationships between sleep health and psychological distress.

Design. Cross-sectional.

Settings. Online survey distributed between April 19 and May 3, 2020.

Participants. 6,882 participants (18-94 years) across 59 countries.

Measurements. Sleep health (RU-SATED), demographics, pandemic-related factors, and mood.

Results. More than half the sample shifted their sleep toward later bed- and wake-times, and more than a third reported increased sleep disturbances during the pandemic. Older age, being partnered, and living in a higher-income country were associated with better sleep health, while a stricter level of quarantine, and pandemic-related factors (being laid off from job, financial strain, or difficulties transitioning to working from home) were predictors of poorer sleep health. Domestic conflict was the strongest predictor of poorer sleep health. Poorer sleep health was strongly associated with greater depression and anxiety symptoms. Participants from Latin America reported the lowest sleep health scores.

Conclusions. COVID-19-associated factors have impacted sleep health on a global level. Sleep health is strongly linked with mental health and could play a protective role against developing mental distress during pandemic-related isolation. Sleep health should be incorporated into public health messages aimed at helping people cope with the effects of the pandemic to maintain optimal mental and physical health.

Keywords: COVID-19; sleep health; mood; sleep disturbances; social isolation

1. INTRODUCTION

The outbreak of COVID-19 in December 2019 rapidly escalated into a global pandemic affecting countries around the world, which imposed social isolation measures to stop the spread of the disease. The mass (home) confinement in addition to the uncertainty of the pandemic led to drastic changes in people's lives, affecting social interaction, work, school, physical activity, and sleep (1). Thus, the COVID-19 pandemic has imposed extreme psychological stress on many individuals, the extent of which we are only just beginning to understand.

Having healthy sleep is key to overall health. Poor sleep is associated with adverse health outcomes including cardiovascular disease (2), cancer (3), hypertension (4), obesity & diabetes (5), and all-cause mortality (6), as well as psychological disorders such as depression (7). Therefore, maintaining sleep health may be critical to preserving good overall physical and mental health during the COVID-19 pandemic. Initial regional studies conducted during the COVID-19 pandemic have suggested increases in sleep disturbances (8-13) and shifts in sleep patterns (14, 15) in frontline healthcare workers and the general community. Also, depression and anxiety levels have been shown to be elevated and potentially associated with poorer sleep quality (8-11).

Studies that have examined predictors of sleep quality amidst social isolation measures have shown that older age was associated with less difficulties falling asleep during the pandemic, and strict home confinement without working and female sex were associated with increased sleep difficulties in a Portuguese sample of respiratory patients (half of them had a confirmed diagnosis of sleep disordered breathing) (10). Also, spending more time outside has been associated with better sleep in the general UK population, though being infected with COVID-19 contributed to worse sleep quality (16). An investigation focusing on healthcare workers in Bahrain found that female sex and being a non-physician health-allied member were predictors of poorer sleep quality and moderate-severe stress levels (17). Finally, Wang and

colleagues (9) reported that medical occupation, parental burden, death of a loved one, anxiety, and depression were predictors of poorer sleep quality among Chinese healthcare workers.

Findings on predictors of sleep behavior and quality during the pandemic are inconsistent and probably influenced by different sample populations studied (e.g., healthcare workers, respiratory patients, the general population of a single country), measurement instruments used (with some studies using only a single item for sleep quality), different assessment times across the stages of the pandemic, and small sample sizes. There is a lack of studies investigating sleep in the general population or global samples, and there is a need for more research to determine the effects of the COVID-19 pandemic on sleep and how those effects are associated with demographic and social isolation specific factors. The current study focuses on sleep health, defined as “a multidimensional pattern of sleep-wakefulness, adapted to individual, social, and environmental demands, that promotes physical and mental well-being” (18). The construct of sleep health includes different factors relating sleep to other health outcomes such as sleep regularity, efficiency, adequate sleep duration, satisfaction, sleepiness/alertness, and timing (18). Sleep health is being prioritized in the public health domain (19), is associated with physical and mental health outcomes (20, 21), performs better than sleep duration in categorizing self-rated health status (20), and has the advantage over singular sleep measures of addressing the multidimensionality of sleep. Therefore, the purpose of the current study was to investigate predictors of sleep health and its relationship with psychological distress during the COVID-19 pandemic in the general population of 59 countries.

2. Methods

2.1 Participants

Of the initial sample of 9,083 people who started the survey, 26 did not consent to participate, 7 provided a nonsensical name for their city, and 2,175 did not finish the survey and were therefore excluded. The final sample consisted of 6,882 participants from 59 countries

(58.5% upper-middle income countries, according to the World Bank country classification (<https://datahelpdesk.worldbank.org>) from five continents, who ranged in age from 18 to 94 years old and mostly identified as women (78.8%). The majority reported being employed (included students) (80.1%) and being in a romantic relationship (51.1%). Sociodemographic characteristics are presented in Table 1.

2.2. Measures

The online survey consisted of questions covering five domains: (a) demographics: age (years), gender (man/women or other), country, employment status (categorized as active/not active), relationship status (categorized as partnered/not partnered), and presence of dependents under the age of 18 years in the home; (b) COVID-19-related quarantine or restriction level; (c) COVID-19 exposure; (d) COVID-19-related change in life; (e) COVID-19-related sleep changes; (f) sleep health, and (g) psychological distress.

In order to determine what kind of quarantine or social isolation measures participants were following at the time of data collection, they were asked to select one of four levels of restriction followed in the past week (Level 0 - no specific restrictions; Level 1 – mild restrictions (e.g., not gathering with 10 or more people, not traveling outside city or state); Level 2 – moderate restrictions (e.g., not leaving home except for working, care of another family member, exercise); Level 3 – severe restrictions (e.g., not leaving home at all, or only leaving to buy food or medicine).

The Epidemic-Pandemic Impacts Inventory (EPII; (22) was used to determine participant exposure to COVID-19 and to assess how the pandemic impacted different life domains. This inventory originally consisted of 92 statements, 21 of which were used in the survey: “Infection history” - 8; “Work and Employment” - 7; “Economic” - 2; “Home life” - 2; and “Social activities” - 2. Participants were asked to answer Yes/No about the impact on these specific domains.

To assess changes in sleep behavior (sleep timing, duration, trouble falling asleep, and waking up during the night) during the pandemic, participants were asked to report how each

aspect of sleep had changed during the past week compared to before the pandemic using a 5-point scale: much less than usual; less than usual; the same as usual; more than usual; or much more than usual. Participants were also asked to report how much sleep they got in a 24-hour period.

Sleep health and psychological distress were assessed through standardized and validated self-report scales. Sleep health was assessed by the Regulatory Satisfaction Alertness Timing Efficiency Duration (RU-SATED) scale (18). This measure consists of 6 items corresponding to key dimensions of sleep consistently associated with health outcomes: regularity (getting in and out of bed at similar times each day), satisfaction (feeling satisfied with one's sleep), alertness (ability to stay awake during the day without dozing), timing (sleeping between 2:00a.m. and 4:00a.m.), efficiency (being awake for less than 30min each night after trying to fall asleep), and duration (obtaining between 6 and 8h of sleep per night). Participants were asked to rate the frequency with which they experienced these behaviors on a 3-point Likert scale (0 – Rarely /Never; 1 – Sometimes; 2 – Usually/Always). A total score is obtained by summing all items (range: 0-12), with higher scores indicating better sleep health (18, 23). The scale has been shown to be psychometrically valid (24). Psychological distress was measured using two scales. DASS-21 (25) was used to assess stress and depression over the past week, and the GAD-7 (26) for assessing anxiety over the past two weeks. Each DASS-21 scale consists of 7 items of symptoms rated on a 4-point Likert scale. A total score provides a severity index of stress and depression symptoms. The GAD-7 is a 7-item scale scored on a 4-point Likert scale, and higher total scores reflect higher anxiety. Participants' home countries were classified by income (low, lower-middle, upper-middle, and high) and by geographical region (East Asia and Pacific, Europe and Central Asia, Latin America and the Caribbean, North America, Sub-Saharan Africa, and South Asia; The World Bank, 2017).

2.3 Procedure

The survey was created in English by a group of psychologists and health scientists and later translated into Spanish, Italian, German, Turkish, and French. Adapted and validated versions in each language were used for standardized questionnaires, and bilingual native speakers translated and reviewed all items without formal translations to generate a final version. Using a snowball sampling method, the online survey was distributed through social media (WhatsApp, Twitter, and Instagram) and professional emailing lists. In addition, Facebook ads were used to promote participation among the general population and to expand the sample across different countries and age ranges. Data collection took place between April 19 and- May 3, 2020.

Before starting the 15-minute survey, participants were provided with a university ethics-committee approved informed consent specifying that participation was completely voluntary and anonymous, and that they would not receive any financial compensation.

2. 4 Data Analysis

All analyses were conducted using IBM SPSS 26. A bivariate correlation matrix showing the associations among sleep health and demographic characteristics is shown in Table 2. In order to investigate demographic characteristics, COVID-19-related changes in life, and effects of the pandemic as predictors of sleep health, a hierarchical stepwise multiple linear regression was computed with sleep health as the outcome variable. In this regression, demographic characteristics (man vs. woman or non-binary/trans, age, country income classification, partnered vs. not partnered, active vs. not active work status, and dependent <18 years in the home vs. not) were included as Step 1 variables. Step 2 included variables reflecting participants' personal exposure to COVID-19. Step 3 included level of quarantine, while Step 4 included effects of the pandemic on participants' lives.

Second, sleep health scores were compared by global region using an analysis of covariance (ANCOVA). Demographics included in Step 1 of the previous regression were included as covariates. Participants from South Asia were excluded from the ANCOVA because

the small group size precluded meaningful comparisons ($n = 4$). Finally, a partial correlation matrix was constructed to evaluate the associations among sleep health, depression, anxiety, and stress scores, controlling for demographics. Because of the large number of predictors included in the analyses, significance level was set at $p < .01$.

3. Results

3.1 Changes in sleep behavior during the COVID-19 pandemic

On average, participants reported sleeping 7.1 ($SD = 1.5$) hours in a 24-hour period. Compared to pre-pandemic routines, 58.4% of the participants reported going to bed later/much later than usual and 50.5% reported that that they woke up later/much later than usual. 30.7% of the participants reported sleeping less/much less than usual, whereas 25.5% reported sleeping more/much more than usual. 39.3% had trouble falling asleep more/much more than usual, and 35.6% woke up during the night more/much more than usual, compared to pre-pandemic (Figure 1). Participants reported an average score of 8.06 ($SD = 2.54$) on the RU-SATED measure of sleep health. Distribution of sleep health scores was somewhat positively skewed, with fewer participants reporting extremely low levels of sleep health (Figure 2). Although no clinical cutoff scores are currently available for the RU-SATED scale, 2,746 participants (39.9%) scored below the median of 8.0, which was used as an indicator of poor sleep health in previous studies of sleep health using the 5-item SATED scale (20, 23).

3.2 Associations between sleep health and demographics during the COVID-19 pandemic

In the correlation matrix (Table 2), older age, higher country income classification, and being partnered were all associated with better sleep health. Sleep health was not associated with gender, employment, or having a dependent child under 18 years of age in the home.

3.3. Predictors of sleep health during the COVID-19 pandemic

In the hierarchical linear regression predicting sleep health, Step 1 was statistically significant, $F(6, 6875) = 65.92$, $R^2 = .054$, $p < .001$. Consistent with the correlation matrix, sleep

health was significantly and uniquely predicted by older age, higher country income classification, and being partnered. However, inconsistent with the bivariate correlations, sleep health was positively associated with being employed. With the addition of COVID-19 exposure predictors in Step 2, the overall model was still statistically significant, $F(14, 6867) = 30.38$, $R^2 = .058$, $p < .001$. Within this model, currently having symptoms of the disease but not having been tested was significantly associated with poorer sleep health. Stricter quarantine level (Step 3) significantly predicted lower sleep health, $p < .001$, and the overall model was significant, $F(15, 6866) = 29.32$, $R^2 = .060$, $p < .001$. After the Step 4 addition of effects of the pandemic on one's life, the overall model was still significant, $F(28, 6853) = 32.04$, $R^2 = .116$, $p < .001$ (Table 3), and explained 11.6% of the variance of sleep health. Within this step, significant predictors of poorer sleep health included getting laid off from one's job or closing one's business, having a hard time transitioning to working from home, being unable to get enough food or healthy food, being unable to pay important bills, and experiencing an increase in verbal arguments or conflict with other adults in the home. Two variables that significantly predicted sleep health in previous steps, being employed and currently having symptoms of the disease but having not been tested, were no longer significant after the addition of Step 4 predictors. Notably, having increased verbal conflicts with other adults in the home emerged as the strongest predictor of sleep health out of all predictor variables in the model at Step 4.

3.4 Differences in sleep health across global regions during the COVID-19 pandemic

In the ANCOVA predicting sleep health, there was a statistically significant effect of global region, $F(4, 6867) = 5.31$, $p < .001$, partial- $\eta^2 = .003$ (Figure 3). Bonferroni-corrected post hoc pairwise comparisons showed that participants from Latin America and the Caribbean ($M = 7.79$, $SD = 2.47$) reported significantly poorer sleep health than participants from Europe and Central Asia ($M = 8.32$, $SD = 2.56$; $p < .001$) and North America ($M = 8.64$, $SD = 2.60$; $p < .001$). No other significant differences emerged, although participants from Latin America and the Caribbean tended to exhibit poorer sleep health than participants from East Asia and the

Pacific ($M = 8.72$, $SD = 2.67$; $p = .029$) and Sub-Saharan Africa ($M = 8.64$, $SD = 2.50$, $p = .025$), and participants from Europe and Central Asia tended to experience poorer sleep health than participants from North America ($p = .019$).

3.5 Associations between sleep health and psychological distress during the COVID-19 pandemic

All associations among sleep health, depression, anxiety, and stress were highly significant (Figure 4, $p < .01$). Sleep health demonstrated moderate negative associations with depression, anxiety, and stress scores, after controlling for demographic variables (gender, age, country income classification, marital status, work status, and having dependents in the home).

4. DISCUSSION

This study investigated predictors of sleep health during the COVID-19 pandemic in the general adult population of 59 countries. A number of significant predictors were identified with demographic characteristics such as older age, having a partner, and living in a higher-income country being associated with better sleep health, and a stricter level of quarantine being associated with a poorer sleep health. In addition, the strongest predictors for poorer sleep health emerged from COVID-19-related life changes including being laid off from job, having difficulty transitioning to working from home, or being unable to pay important bills, and most significantly, increases in verbal arguments or conflicts at home. A large proportion of participants reported changed sleep patterns toward later bed- and wake-times, and greater sleep disturbances as compared to pre-pandemic routines. Participants from Latin America and the Caribbean exhibited the lowest sleep health scores. Poorer sleep health was correlated with higher depression, anxiety, and stress, reflecting the close relationship between sleep and mood.

4.1 Changes in sleep patterns during the COVID-19 pandemic

Healthy sleep is associated with enhanced mood (27), improved immune functioning (28), and better physical health (20, 23). For these reasons, healthy sleep is likely vital during the COVID-19 pandemic. Early regional studies during the pandemic have indicated that sleep disturbances (8-11, 17) and changes in sleep patterns (14, 15) are common. The current findings extend those of these regional studies to show substantial changes in sleep behavior in a global general population sample.

Almost 60% of participants reported going to bed (much) later, and ~50% stated that they woke up (much later), compared to pre-pandemic routines. With this delay in timing on both sides of the sleep period, changes in sleep duration varied, with some (~26%) reporting sleeping more than usual, possibly due to having less constraints on their sleep, whereas others (~43%) reported no change, and the remaining (~31%) reported sleeping less than usual. More than a third of the sample claimed to have more trouble falling asleep or waking up more often during the night than pre-pandemic, indicating profound changes in sleep routines and increased sleep disturbances. Results are in line with those of others (14), who reported later bed- and wake-times, more time in bed, and paradoxically lower sleep quality during the initial period of lockdown in young Italian adults. These shifts in sleep schedules may lead to negative consequences such as reduced daylight exposure or physical activity (29), further affecting mood and health.

4.2 Predictors of sleep health during the COVID-19 pandemic

Several demographic factors were associated with better sleep health, including older age, being partnered, and living in a country with a higher income classification. Older age has previously been associated with a better sleep quality and less lockdown-related sleep changes during the COVID-19 pandemic (10, 16), suggesting age as a protective factor for maintaining sleep health during quarantine and restriction measures. Being partnered and living in a higher income classification country – factors that are characterized by providing a certain degree of security and life stability – also predicted better sleep health. However, the strictness in the level

of quarantine – which differed across the global sample from strict home confinement to lighter restrictions – was associated with a poorer sleep health. Even though this finding has not been previously reported, Pinto and colleagues (10) found that strict home confinement without working was associated with increased sleep difficulties in respiratory patients during the lockdown measures in Portugal. Stricter quarantine levels potentially decrease time spent outside, physical activity, and sunlight exposure, which is vital for maintaining healthy circadian rhythms, sleep, and mood (30). Even though some studies indicated female sex as a predictor of sleep disturbances during the COVID-19 pandemic (17, 31), the current study found that gender was not a predictor of sleep health. Similarly, in a sample of adults studied in the United States in non-pandemic times, while women reported more insomnia symptoms and lower sleep self-efficacy than men, sleep health did not differ according to gender (24).

Most predictors of poorer sleep health emerged from the individual COVID-19-related life changes such as being laid off from work or closing one's business, having difficulty transitioning to working from home, being unable to pay important bills, or the inability to get enough or healthy food. Not surprisingly, financial and socio-economic burdens are a major stress factor linked to sleep disturbances (32), and can exacerbate an already stressful experience of the COVID-19 pandemic. Increases in verbal arguments or conflict with other adults in the home emerged as the strongest predictor of a poorer sleep health during the pandemic. Current research urgently warns of a dramatic increase in domestic conflicts around the globe during the pandemic, primarily caused by stresses such as isolation and economic vulnerability (33). Associations between family strain and sleep disturbances have been reported outside of the pandemic which may reflect a bidirectional relationship, such that stressful relationships with others at home could interfere with sleep and inadequate or poor quality sleep could contribute to stressful relationships (34).

Interestingly, in contrast to other studies (16), none of the predictors reflecting COVID-19 exposure reached significance. Quarantine and isolation characteristics (resulting in feelings of

anxiety, worry, and distress) could have surpassed the influence of the presence of the virus in the immediate vicinity on sleep health. It could be that not the objective exposure to COVID-19, but rather the subjective experience of the virus influences sleep health.

4.3 Global differences in changes of sleep health during the pandemic

Participants from Latin America and the Caribbean area reported the lowest total scores in sleep health relative to European and Central Asian as well as North American participants, although pandemic-related quarantine and isolation measures were ongoing in all regions at the time of data collection. However, at the time of data collection, the number of cases in Latin America and the Caribbean area were lower compared to other global regions. To our knowledge, no studies have yet compared sleep health on a global level during the pandemic, but previous research suggests a high prevalence of sleep difficulties (35) and sleep-related symptoms, e.g., excessive daytime sleepiness or insomnia (36), in the Latin American population. Possibly, sleep health was already lower in this population, although further reasons beyond what was measured in the current study that contributed to this finding need to be determined.

4.4. Sleep health and mood during the pandemic

Previous studies reported associations between lower mood, higher anxiety- or stress levels, and worsened sleep quality or sleep behavior during the COVID-19 pandemic in different countries and populations (12, 13, 16, 37-39). The current results are in line with previous research, suggesting higher levels of anxiety, depression, and stress being associated with poorer sleep health. These results emphasize the importance of maintaining a good sleep health during the pandemic, since poorer sleep health may trigger or exacerbate mental health disorders.

4.5 Future research & limitations

The current study was cross-sectional, and causality and generalizability of the findings should be considered with caution. The final regression model explained roughly 11% of the

variance, and there is more research needed to identify other key factors related to sleep health during the COVID-19 pandemic. Also, the current data represent a partial snapshot of the pandemic since data were collected during a single time point when the included countries were in the mid-phase of the social isolation measures. Although the COVID-19 pandemic is undoubtedly still affecting billions of people, the full extent of its consequences is still unclear, and more research is needed to understand the long-term impacts on health, including sleep.

Conclusion

Physiological and psychological consequences of the COVID-19 pandemic are far-reaching and wide-ranging, not only affecting people directly involved such as frontline-healthcare workers or patients, but also the general population. Maintaining a healthy sleep has become challenging during the pandemic. Our investigation is one of the first showing the impact of the COVID-19 pandemic on sleep health in a large global sample. Developing sleep disturbances during the COVID-19 pandemic may put individuals at a higher risk for long-term adverse health effects (1). It is likely that risk factors of a poorer sleep health, primarily caused by profound disruption of daily life (i.e. working from home, school closures or social isolation), will persist in the pandemic for many people, and sleep disturbances will likely accelerate anxiety, depression, and suicidal behavior (40). Notably, considering that acute insomnia can turn into chronic insomnia, the high rate of insomnia developed as a consequence of the COVID-19 pandemic is a call for public health interventions (1). Sleep is a modifiable behavior, and sleep health can be strengthened by implementing habits including increased time spent outside while social distancing (to increase sunlight exposure and physical activity), as well as keeping regular sleep routines (i.e., maintaining similar bed- and wake-times on all days of the week while avoiding under- or over-sleeping). At the public health level, sleep health should be supported by increasing public awareness via campaigns or telepsychology, and ensuring education programs so that chronic sleep problems caused or aggravated by the COVID-19 pandemic can be detected early to avoid chronicity. The social responsibility for publicly

educating the communities about the importance of sleep as well as strategies for maintaining healthy sleep during the COVID-19 pandemic should be extended to the sleep research and clinical community, which should be visible and supported by the media (1). Attention should be directed to prevent, monitor, and treat sleep problems on a global level to strengthen sleep and overall health during the COVID-19 pandemic.

ACKNOWLEDGEMENTS

We thank everyone involved in this project for their efforts in translating and distributing the survey including Harun Yuksel, Ali Yilmaz, Arda Yilmaz, Martin Hansch, Severine Lannoy, Anne-Pascale Le Berre, and Cristian Logatt. We also thank all research participants for their time and effort in filling out the questionnaires.

Support:

Ramos-Usuga was supported by a predoctoral fellowship from the Basque Government (PRE_2019_1_0164).

McKee was supported by the Department of Veterans Affairs Office of Academic Affiliations Advanced Fellowship Program in Mental Illness Research and Treatment, the Medical Research Service of the Veterans Affairs Central Virginia Health Care System, and the Department of Veterans Affairs Mid-Atlantic Mental Illness Research, Education, and Clinical Center (MIRECC).

Copyright statement:

Since Dr. McKee is an employee of the U.S. Government and contributed to the manuscript “Sleeping when the world locks down: Predictors of sleep health during the COVID-19 pandemic across 59 countries” as part of her official duties, the work is not subject to US copyright.

Disclaimer: The contents of this manuscript do not represent the views of the U.S. Department of Veterans Affairs or the United States Government.

REFERENCES

- [1] Morin CM, Carrier J. The acute effects of the COVID-19 pandemic on insomnia and psychological symptoms. *Sleep Med* 2020.
- [2] Brindle RC, Yu L, Buysse DJ, et al. Empirical derivation of cutoff values for the sleep health metric and its relationship to cardiometabolic morbidity: results from the Midlife in the United States (MIDUS) study. *Sleep* 2019;42.
- [3] von Ruesten A, Weikert C, Fietze I, et al. Association of sleep duration with chronic diseases in the European Prospective Investigation into Cancer and Nutrition (EPIC)-Potsdam study. *PLoS One* 2012;7:e30972.
- [4] Gangwisch JE, Heymsfield SB, Boden-Albala B, et al. Short sleep duration as a risk factor for hypertension: analyses of the first National Health and Nutrition Examination Survey. *Hypertension* 2006;47:833-839.
- [5] Grandner MA, Patel NP, Perlis ML, et al. Obesity, diabetes, and exercise associated with sleep-related complaints in the American population. *Z Gesundh Wiss* 2011;19:463-474.
- [6] Cappuccio FP, D'Elia L, Strazzullo P, et al. Sleep duration and all-cause mortality: a systematic review and meta-analysis of prospective studies. *Sleep* 2010;33:585-592.
- [7] Zhai L, Zhang H, Zhang D. Sleep Duration and Depression among Adults: A Meta-Analysis of Prospective Studies. *Depress Anxiety* 2015;32:664-670.
- [8] Li DJ, Ko NY, Chen YL, et al. COVID-19-Related Factors Associated with Sleep Disturbance and Suicidal Thoughts among the Taiwanese Public: A Facebook Survey. *Int J Environ Res Public Health* 2020;17.
- [9] Wang W, Song W, Xia Z, et al. Sleep Disturbance and Psychological Profiles of Medical Staff and Non-Medical Staff During the Early Outbreak of COVID-19 in Hubei Province, China. *Front Psychiatry* 2020;11:733.
- [10] Pinto J, van Zeller M, Amorim P, et al. Sleep quality in times of Covid-19 pandemic. *Sleep Med* 2020;74:81-85.
- [11] Rajkumar RP. COVID-19 and mental health: A review of the existing literature. *Asian J Psychiatr* 2020;52:102066.
- [12] Huang Y, Zhao N. Generalized anxiety disorder, depressive symptoms and sleep quality during COVID-19 outbreak in China: a web-based cross-sectional survey. *Psychiatry Res* 2020;288:112954.
- [13] Casagrande M, Favieri F, Tambelli R, et al. The enemy who sealed the world: effects quarantine due to the COVID-19 on sleep quality, anxiety, and psychological distress in the Italian population. *Sleep Med* 2020;75:12-20.
- [14] Cellini N, Canale N, Mioni G, et al. Changes in sleep pattern, sense of time and digital media use during COVID-19 lockdown in Italy. *J Sleep Res* 2020:e13074.
- [15] Krishnan V, Gupta R, Grover S, et al. Changes in sleep pattern and sleep quality during COVID-19 lockdown. *Indian Journal of Psychiatry* 2020;62.
- [16] Carrigan N, Wearn AR, Meky S, et al. Sleep quality, mental health and circadian rhythms during COVID lockdown: Results from the SleepQuest Study. *medRxiv* 2020:2020.2007.2008.20148171.
- [17] Jahrami H, BaHammam AS, AlGahtani H, et al. The examination of sleep quality for frontline healthcare workers during the outbreak of COVID-19. *Sleep Breath* 2020.
- [18] Buysse DJ. Sleep health: can we define it? Does it matter? *Sleep* 2014;37:9-17.
- [19] Chaput JP, Shiau J. Routinely assessing patients' sleep health is time well spent. *Prev Med Rep* 2019;14:100851.
- [20] Dalmaes M, Benitez ID, Mas A, et al. Assessing sleep health in a European population: Results of the Catalan Health Survey 2015. *PLoS One* 2018;13:e0194495.

- [21] Furihata R, Hall MH, Stone KL, et al. An Aggregate Measure of Sleep Health Is Associated With Prevalent and Incident Clinically Significant Depression Symptoms Among Community-Dwelling Older Women. *Sleep* 2017;40.
- [22] Grasso DJ, Briggs-Gowan MJ, Ford JD, et al. The Epidemic – Pandemic Impacts Inventory (EPII): University of Connecticut School of Medicine, 2020.
- [23] Dalmases M, Benitez I, Sapina-Beltran E, et al. Impact of sleep health on self-perceived health status. *Sci Rep* 2019;9:7284.
- [24] Ravyts SG, Dzierzewski JM, Perez E, et al. Sleep Health as Measured by RU SATED: A Psychometric Evaluation. *Behav Sleep Med* 2019;1-9.
- [25] Osman A, Wong JL, Bagge CL, et al. The Depression Anxiety Stress Scales-21 (DASS-21): further examination of dimensions, scale reliability, and correlates. *J Clin Psychol* 2012;68:1322-1338.
- [26] Spitzer RL, Kroenke K, Williams JB, et al. A brief measure for assessing generalized anxiety disorder: the GAD-7. *Arch Intern Med* 2006;166:1092-1097.
- [27] Triantafillou S, Saeb S, Lattie EG, et al. Relationship Between Sleep Quality and Mood: Ecological Momentary Assessment Study. *JMIR Ment Health* 2019;6:e12613.
- [28] Besedovsky L, Lange T, Haack M. The Sleep-Immune Crosstalk in Health and Disease. *Physiol Rev* 2019;99:1325-1380.
- [29] Altena E, Baglioni C, Espie CA, et al. Dealing with sleep problems during home confinement due to the COVID-19 outbreak: Practical recommendations from a task force of the European CBT-I Academy. *J Sleep Res* 2020:e13052.
- [30] Blume C, Garbazza C, Spitschan M. Effects of light on human circadian rhythms, sleep and mood. *Somnologie (Berl)* 2019;23:147-156.
- [31] Gualano MR, Lo Moro G, Voglino G, et al. Effects of Covid-19 Lockdown on Mental Health and Sleep Disturbances in Italy. *Int J Environ Res Public Health* 2020;17.
- [32] Hall M, Buysse DJ, Nofzinger EA, et al. Financial strain is a significant correlate of sleep continuity disturbances in late-life. *Biol Psychol* 2008;77:217-222.
- [33] Campbell AM. An increasing risk of family violence during the Covid-19 pandemic: Strengthening community collaborations to save lives. *Forensic Science International: Reports* 2020;2.
- [34] Ailshire JA, Burgard SA. Family relationships and troubled sleep among U.S. adults: examining the influences of contact frequency and relationship quality. *J Health Soc Behav* 2012;53:248-262.
- [35] Blanco M, Kriber N, Cardinali DP. [A survey of sleeping difficulties in an urban Latin American population]. *Rev Neurol* 2004;39:115-119.
- [36] Bouscoulet LT, Vazquez-Garcia JC, Muino A, et al. Prevalence of sleep related symptoms in four Latin American cities. *J Clin Sleep Med* 2008;4:579-585.
- [37] Sun L, Sun Z, Wu L, et al. Prevalence and Risk Factors of Acute Posttraumatic Stress Symptoms during the COVID-19 Outbreak in Wuhan, China. *medRxiv* 2020:2020.2003.2006.20032425.
- [38] Xiao H, Zhang Y, Kong D, et al. Social Capital and Sleep Quality in Individuals Who Self-Isolated for 14 Days During the Coronavirus Disease 2019 (COVID-19) Outbreak in January 2020 in China. *Med Sci Monit* 2020;26:e923921.
- [39] Xiao H, Zhang Y, Kong D, et al. The Effects of Social Support on Sleep Quality of Medical Staff Treating Patients with Coronavirus Disease 2019 (COVID-19) in January and February 2020 in China. *Med Sci Monit* 2020;26:e923549.
- [40] Sher L. COVID-19, anxiety, sleep disturbances and suicide. *Sleep Med* 2020;70:124.