



## Research article

# The effects of COVID-19 on sleep and general health of Czech patients with epilepsy<sup>☆</sup>

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## A B S T R A C T

**Objectives:** To assess the impact of COVID-19 illness and pandemic era on sleep, general health, health care, and social status in patients with epilepsy in the Czech Republic.

**Methods:** Our designed and approved questionnaire consisted of 23 questions. We focused on (1) patients' demographic and epidemiological data regarding COVID-19, (2) subjective assessment of sleep; (3) epilepsy, and (4) perception of general health during the first year of the COVID-19 pandemic in the Czech Republic from March 2020 to May 2021. We administered the questionnaires during outpatient visits or by phone calls in three major university Czech epilepsy centers (Ostrava, Brno, Pilsen).

**Results:** We enrolled 227 (100%) patients. The mean age ( $\pm$ SD) was  $41.2 \pm 14.82$  years (min 18, max 86 years), and 138 (61%) were women. COVID-19 was confirmed using the PCR test method in 57 (25.1%) patients. In the pre-pandemic era, 62 (27.3%) patients reported sleep disturbances. Insomnia in 46 (74.2%) and excessive daytime sleepiness in 6 (9.7%) were the most mentioned sleep abnormalities. Nocturnal seizures predispose to sleep impairment ( $p = 0.014$ ) and vivid dreams and nightmares ( $p = 0.033$ ). COVID-19 infection significantly increased the risk of vivid dreams and nightmares in patients with diurnal seizures ( $p = 0.006$ ). Sleep quality impairment and seizure frequency worsening [ $(p < 0.001)$  and ( $p = 0.001$ ), respectively] were the most significant risk factors to perform general health deterioration regardless of having COVID-19 ( $p = 0.559$ ). The most affected age group was 51+ years ( $p = 0.033$ ). The three centers provided adequate outpatient care during the first year of the pandemic. The employment and social status of the patients remained unchanged ( $p = 0.074$ ).

**Conclusions:** COVID-19 infection significantly increased the occurrence of vivid dreams and nightmares in patients with diurnal seizures. Sleep quality deterioration and seizure frequency worsening significantly negatively impacted general health performance.

## 1. Introduction

The first cases of pneumonia caused by the new type of coronavirus SARS-CoV-2 (named COVID-19) emerged in China from early October to mid-November 2019 and, by January 2020, progressed into a global pandemic [1]. The Czech Republic was one of the most

**Abbreviations:** COVID-19, coronavirus disease- 19; PwE, patients with active epilepsy; ASM, anti- seizure medication.

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affected European countries in 2020 and 2021, with a high risk of disease severity and its fatal consequences. Czech governmental updated statistical data present 3,93 mil confirmed cases of 10 mil population and 40 309 people have died. The increased numbers from 123 thousand up to 158 thousand from SEP 2020 till MAR 2021 with a six percent increased death rate in biannual comparison led to efforts to minimize the chances of infection transmission and resulted in many non-standard government procedures and subsequent lockdowns in society [2].

Epilepsy can be related to the wake-sleep cycle. Based on this pattern, epilepsy is defined as diurnal, nocturnal, or diffuse [3]. Different factors besides epilepsy, epilepsy care, and treatment may be affected by COVID-19 illness, and the COVID-19 era thus needs to consider essential consequences [4]. Lower quality of life, higher prevalence of depression, healthcare availability issues, and perceived fears during pandemic all suggest COVID-19 negatively impacts lives of patients with epilepsy [5]. Sleep dysfunction such as insomnia, disrupted sleep continuity, changes in the sleep-wake cycle, feelings of non-restorative sleep, and decreased sleep quality arise due to stresses related to fear or the psychosocial impact on daily living. We focus on the loss of employment, financial concerns, social isolation resulting from lockdowns and quarantine, or the medical and psychological sequelae of contracting COVID-19. However, the long-term implications remain and need to be determined, and the global health crisis is ongoing [6].

Our work retrospectively assessed the impact of COVID-19 illness and the pandemic era with restrictive government measures on Czech patients with active epilepsy (PwE). It provided healthcare during the first year of the pandemic. The study aimed to determine the subjective perception of the effects of COVID-19 infection and the COVID-19 era on sleep and general health, regardless of the type and etiology of epilepsy, but the seizure diurnal and nocturnal occurrence and change in epilepsy course.

## 2. Materials and methods

### 2.1. Design and procedure

We conducted a multicenter questionnaire study from May to July 2021 at three Czech University Hospital Epilepsy Centers (University Center Ostrava, Brno Epilepsy Center, and University Center Pilsen), providing tertiary public care in adult PwE. We interviewed the registered patients during restricted outpatients' visits or by phone based on a long-term random planned schedule. COVID-19 illness we considered positive in patients with clinical symptoms or if traced by government tracing strategy and was confirmed by certified PCR test method only. We have built the 23 items questionnaire to modify the regular outpatient care and personal visits protocol, focusing on subjective patients' perceptions of COVID-19 illness and the COVID-19 era. The number of simplified questions should not extend to 15 min to be answered on average to prevent patients' impatience to participate in this combined in-person/phone-call study.

We enrolled patients meeting baseline criteria: (1) age  $\geq 18$  years, (2) ability and consent to complete a questionnaire, and (3) regular registered visits (personal or phone contact) in the outpatient department. The local ethical committees approved the informed consent and questionnaire, and the questionnaire consisted of 23 questions divided into several groups.

- (1) patients' demographic and epidemiological data regarding COVID-19
- (2) subjective assessment of sleep; e.g., quality and disorders in the pre-pandemic era and during the pandemic epoch, its length, maintenance, and dreams
- (3) epilepsy (change of seizure frequency and severity, and availability of healthcare and anti-seizure medication [ASM]) resupply
- (4) perception of general health, patient's employment, and social status

All addressed patients were registered for at least one year in our regular care before the pandemic. We excluded (1) patients with uncountable seizures, (2) patients who underwent epilepsy surgery before one year and during the designated period of our study, (3) patients with progressive brain lesions, (4) patients with uncontrolled behavioral or psychiatric comorbidity, and (5) patients with caregivers.

The patients evaluated the sleep characteristics and quality regarding subjective experience. We were interested in the average length of sleep, the number of arousals, or other newly occurring sleep-related abnormalities. We stressed the question about vivid dreams and nightmares due to clinical and literature experience in PwE. The question concerning subjective sleep quality is a part of a routine medical history and bodily status evaluation in our outpatient epilepsy centers. We regularly ask patients to record essential changes for further assessment in their diaries. The COVID-19 pandemic brought restrictions on scheduled care during government lockdowns; thus, we did not perform polysomnography to obtain objective data.

The severity of the seizures patient evaluated in a parameter of the length of the seizure, increased occurrence of focal seizures evolving into bilateral tonic-clonic seizures in patients with focal epilepsy, prolonged confusion after the attack, or seizure-related bodily injury requiring examination by the specialist. The information about ASM prescriptions per patient is available in the electronic patient's institution information database.

The fourth main topic of the questionnaire was self-evaluation of the general health, social, and employment status. We measured general health perception on a 10-degree scale before and during the pandemic.

The complete English version of the questionnaire we attached in the Supplementary Material.

### 2.2. Statistical analysis

We selected the statistical tests concerning their validity: continuous and ordinal variables we presented as the mean  $\pm$  standard

deviation (SD), categorical variables as the number of cases and percentages, the distribution of COVID-19 among centers using the Pearson chi-squared test, differences between means of COVID-19 positive and negative groups using the Student t-test. We used Fisher's exact test to determine the significant associations between two categorical variables and the Mann-Whitney test to compare non-normally distributed continuous or ordinal variables in COVID-19 positive and negative groups. We used binary logistic regression to assess risk factors and data we calculated as crude odds ratio and fully adjusted odds ratio with 95% confidence intervals (95% CI). We divided the enrolled patients into four age groups to evaluate age as a potentially significant risk factor. We used Stata v. 17 software and presented the results at a 5% significance level.

### 3. Results

#### 3.1. Demographic data and primary COVID-19 effects on sleep, epilepsy, and general health

We addressed 274 adults PwE in three University Hospital Epilepsy Centers and enrolled 227 (83%) patients fulfilling baseline criteria. There were no significant differences in regional COVID-19 illness affection in PwE ( $p = 0.617$ ). Six (2.6%) patients with confirmed COVID-19 infection required hospitalization, and nobody died. We summarized subjective changes in seizure frequency and severity and the number of administered ASM per patient. In our study, 60 (26.4%) patients performed nocturnal episodes only, and we confirmed PCR COVID-19 positivity in 20 (33.3%) cases. The essential characteristics of our cohort we presented in [Table 1](#).

**Table 1**  
Demographic data and essential characteristics of the cohort.

n = 227		
Men (number, %)	89	39.2
Woman (number, %)	138	60.8
<b>AGE</b>		
Age years (mean; SD; min-max)	41.3	14.8; (18–86)
Age group 18–30 years (number, %)	62	27.3
Age group 31–40 years (number, %)	63	27.8
Age group 41–50 years (number, %)	50	22
Age group 51+ years (number, %)	52	23
<b>COVID-19 POSITIVITY (number, %)</b>		
Ostrava	28 of 120	23.3
Brno	7 of 21	33.3
Pilsen	22 of 86	25.6
<b>SLEEP</b>		
Sleep quality during last year- worsening (number, %)	23	10.1
Sleep quality during last year -improvement (number, %)	8	3.5
Vivid dreams and nightmares positive (number, %)	31	13.7
Vivid dreams and nightmares negative (number, %)	113	49.8
<b>EPILEPSY (number, %)</b>		
No seizure	126	55.5
Less than one seizure per month	50	22
Diurnal seizures	167	73.6
Nocturnal seizures	60	26.4
Seizure frequency- worsening	26	11.5
Seizure frequency- improvement	48	21.2
Seizure severity- worsening	17	7.5
Seizure severity- improvement	46	20.3
<b>ANTISEIZURE MEDICATION [(ASM) number, %]</b>		
Monotherapy	111	48.9
Dual ASM therapy	76	33.5
Three ASMs	35	15.4
Four ASMs	2	0.9
Without ASM	2	0.9
<b>COVID-19 PANDEMIC (number, %)</b>		
Effect of pandemic COVID-19 on epilepsy-worsening	28	12.3
Effect of pandemic COVID-19 on epilepsy-improvement	4	1.8
Effect of pandemic COVID-19 on general health worsening	61	26.9
Effect of pandemic COVID-19 on general health-improvement	18	7.9
Effect of pandemic COVID-19 on health care- worsening	23	10.1
Effect of pandemic COVID-19 on health care-improvement	14	6.2

**Table 2**

\* Fully adjusted models for gender, age, COVID-19, and nocturnal seizures to Vivid dreams and nightmares, Sleep Quality worsening, Seizure frequency and severity worsening; 1+ reference category.

Model*	Vivid dreams and nightmares			Sleep Quality worsening			Seizure frequency worsening			Seizure severity worsening		
	ORmodel	95% CI	p-value	ORmodel	95% CI	p-value	ORmodel	95% CI	p-value	ORmodel	95% CI	p-value
Gender	<b>0.95</b>	(0.39–2.28)	0.903	<b>1.43</b>	(0.56–3.65)	0.45	<b>0.6</b>	(0.25–1.45)	0.25	<b>1.14</b>	(0.38–3.4)	0.82
Age group 18–30 years	1+											
Age group 31–40 years	<b>0.98</b>	(0.59–5.62)	0.3	<b>0.82</b>	(0.23–2.93)	0.76	<b>1.46</b>	(0.45–4.71)	0.53	<b>1.8</b>	(0.37–8.76)	0.47
Age group 41–50 years	<b>1.16</b>	(0.35–3.78)	0.81	<b>1.9</b>	(0.6–6.06)	0.28	<b>2.7</b>	(0.89–8.32)	0.08	<b>5.7</b>	(1.38–23.57)	<b>0.016</b>
Age group 51+ years	<b>1.48</b>	(0.46–4.71)	0.51	<b>0.82</b>	(0.21–3.16)	0.78	<b>0.4</b>	(0.08–2.12)	0.29	<b>0.5</b>	(0.05–5.06)	0.56
COVID-19 positivity	<b>2.74</b>	(1.12–6.67)	<b>0.027</b>	<b>2.23</b>	(0.89–5.63)	0.09	<b>1.13</b>	(0.44–2.95)	0.8	<b>1.24</b>	(0.39–3.92)	0.72
Nocturnal seizures	<b>2.31</b>	(0.98–5.44)	0.056	<b>0.85</b>	(0.31–2.38)	0.76	<b>4.6</b>	(1.86–11.31)	<b>0.001</b>	<b>3.7</b>	(1.04–9.01)	<b>0.042</b>

### 3.2. Sleep

In the pre-pandemic era, 62 (27.3%) PwE reported sleep disturbances. Insomnia in 46 (74.2%) and excessive daytime sleepiness in 6 (9.7%) cases were this group's most mentioned sleep abnormalities. During the pandemic, the mean sleep time of PwE was  $7.54 \pm 1.44$  h (minimum four and maximum 16 h) with a mean of 1.3. ( $\pm 1.63$ ) of arousals (minimum 0 and maximum 12) during sleep maintenance. The total number of 31 (13.7%) patients presented changes in sleep quality. Thirteen (56.5%) out of 23 worsened patients reported sleep impairment for the first time in their life. Twenty-four (40%) of 60 patients with nocturnal seizures had a significantly higher incidence of subjective severe sleep impairment ( $p = 0.014$ ). The most frequent complaint was about insomnia and dreams. Thirty-one (13.7%) patients experienced vivid dreams and nightmares, 113 (49.8%) did not, and 83 (36.6%) reported the uncertainty ("not known"). Multivariable analyses showed a higher risk of vivid dreams and nightmares in patients with nocturnal seizures regardless of age, gender, and COVID-19 infection. However, COVID-19 illness had a significant impact on vivid dreams and nightmares performance [( $p = 0.027$ ) Table 2] predominantly in patients with diurnal seizures [( $p = 0.006$ ) Table 3].

Except for non-pharmacological measures, sedative medication use referred 25 (11%) patients.

Eighty-one (35.7%) patients were snorers.

### 3.3. Epilepsy and healthcare during the pandemic

PwE with nocturnal seizures are in significant risk for worsening seizure frequency ( $p = 0.001$ ) and severity ( $p = 0.042$ ). The 41-50-year-old patients are at significant risk of worsening seizure severity compared to the reference group [( $p = 0.016$ ). Table 2]. One-hundred ninety (83.7%) patients did not perceive a change in health service availability. We canceled the scheduled visit at least once in 75 (30%) patients and substituted them with phone calls or personal visits on another day. We did not provide any alternative contact only in five cases (2.2%). We prescribed ASMs via email and phone short message service (SMS); thus, the resupply remained continual; only one (0.4%) patient found this issue problematic. During the COVID-19 pandemic, there was no significant difference in provided healthcare among three specialized epilepsy centers in the Czech Republic ( $p = 0.626$ ).

### 3.4. Perception of general health, employment, and social status

Sixty-one (26.9%) patients significantly worsened in the perception of their general health status on 10° graphical scales in comparison to 18 (7.9%) cases which improved ( $p < 0.001$ ) regardless of COVID-19 infection. [Two-sample Wilcoxon rank-sum test (Mann-Whitney); ( $p = 0.345$ )]. Besides no significant effect of COVID-19 infection, multivariable analysis proved sleep quality and seizure frequency worsening the most significant risk factors to perform general health impairment ( $p < 0.001$ ) and ( $p = 0.001$ ), respectively. From the perspective of age, the group of 51+ years was a significant risk factor compared to other age sub-groups ( $p = 0.033$ ). Table 4. The COVID-19 pandemic did not affect employment in 193 (85%) PwE. Fourteen previously unemployed patients found a new position. Out of 20 patients, who had COVID-19 and lost their job, seven (3.1%) remained unemployed, while 13 (5.7%) succeeded in finding a new position. There were no statistical differences in COVID-19 positive and COVID-19 negative patients concerning the loss or retrieval of employment ( $p = 0.275$ ) and ( $p = 0.074$ ), respectively. Eighty-four (37%) patients received social and financial support.

## 4. Discussion

In our study, one-third of our responders reported a sleep disorder, most often insomnia, in the pre-pandemic period, and insomnia was the most common sleep disorder during the pandemic, either worsened or newly diagnosed. Most patients in our study reported at least one awakening during sleep. Patients with nocturnal seizures performed vivid dreams and nightmares regardless of COVID-19 infection or the pandemic. Surprisingly, we described a significantly higher incidence of vivid dreams and nightmares in a group of patients with confirmed COVID-19 disease and diurnal seizures. We can speculate about either epileptic syndrome change, from diurnal to diffuse, with seizure performance also during sleep [7], or symptoms of dreams and nightmares recently accompanied patients with diurnal epilepsy. One-third of the patients in our study are snorers, but they did not point out the sign as sleep disruptive.

COVID-19 is well-known as a new infectious disease. Still, Hani et al. and Tal et al. pointed out the effect on somatic, e.g., cardiorespiratory system [8,9], and Winkler et al. described mental disorders sequelae [10]. Gobbi et al. focused on the deterioration of the course of pre-existing illnesses [11]. Sleep deterioration during the COVID-19 pandemic affects approximately 40% of the subjects

**Table 3**

Sleep-wake cycle and seizure occurrence, vivid dreams and nightmares concerning COVID-19; Pearson chi-squared test. (VD + vivid dreams and nightmares positivity; VD-vivid dreams and nightmares negativity).

N = 144 (100%) Number (%)	COVID-19 positive N = 36 (25.0)		COVID-19 negative N = 108 (75.0)		P value
	VD +	VD-	VD+	VD-	
Nocturnal seizures N = 51 (35.4)	6 (4.2)	11 (7.6)	10 (6.9)	24 (16.7)	0.67
Diurnal seizures N = 93 (64.6)	7 (4.9)	12 (8.3)	8 (5.6)	66 (45.8)	<b>0.006</b>

**Table 4**

Crude Odds Ratio and \* fully adjusted model for General health worsening and gender, age, COVID-19, sleep quality deterioration, vivid dreams and nightmares, and epilepsy worsening.

General Health Worsening	Crude OR	95% CI	OR model*	95% CI	p-value
Gender	<b>0.82</b>	(0.45–1.5)	1.60	(0.59–4.36)	0.354
Age group 18–30 years	1+				
Age group 31–40 years	<b>0.98</b>	(0.43–2.23)	1.46	(0.38–5.56)	0.578
Age group 41–50 years	<b>1.10</b>	(0.47–2.6)	1.41	(0.34–5.91)	0.635
Age group 51+ years	<b>1.66</b>	(0.73–3.75)	<b>3.78</b>	<b>(1.11–12.89)</b>	<b>0.033</b>
COVID-19 positivity	<b>1.70</b>	(0.89–3.25)	0.70	(0.21–2.32)	0.559
Sleep quality worsening	<b>5.20</b>	(2.12–12.76)	<b>10.79</b>	<b>(2.92–39.91)</b>	< <b>0.001</b>
Vivid dreams and nightmares	<b>3.57</b>	(1.56–8.18)	1.62	(0.5–5.2)	0.417
Seizure frequency worsening	<b>10.28</b>	(4.05–26.07)	<b>16.94</b>	<b>(3.23–88.69)</b>	<b>0.001</b>
Seizure severity worsening	<b>16.18</b>	(4.46–58.71)	8.43	(0.76–93.54)	0.082

from the general and health care populations; thus, it seems to be one of the most powerful adverse effects of the COVID-19 era on a human organism. Patients with COVID-19 illness also appeared to have higher prevalence rates of sleep problems [12]. COVID-19 accompanies psychological and sleep disorders outbursts, including parasomnias [13,14]. Regardless of de-novo insomnia occurrence during the pandemic, one-fourth of the patients with pre-existing insomnia rated their sleep improved during this epoch. Kocovska et al. explained this improvement by the social factors, i.e., home office [15]. Musse et al. pointed out the negative impact of COVID-19 on dreams in patients with psychiatric disorders. They conclude that the increase in the frequency of vivid dreams and nightmares and their association with previous conditions affect public mental health issues [16]. Fränkl et al. provided an international cross-sectional web survey in 14 countries about the impact of the COVID-19 pandemic on dreams. There were 19,355 participants, and parasomnias like nightmares and REM behavior disorders occurred as significant sleep disorders, besides sleep maintenance and post-traumatic stress disorder symptoms. The pandemic was negatively associated with depression and anxiety [17]. We are aware of a possible risk factor for abnormal nocturnal breathing. Snoring is a phenomenon that often accompanies sleep. It is either independent sound or belongs to risk factors for sleep apnea [18]. After canceling the lockdowns, as the sleep laboratories were closed during the pandemic, we plan to screen all snoring patients for sleep apnea.

The link between the pandemic, COVID-19, and sleep disorders in PwE is complicated.

Epilepsy is well-known for its negative impact on sleep quality [19], especially concerning nocturnal seizures [20]. According to the previous description of the general population, we were concerned about sleep and social conditions and consequences in our questionnaire in PwE. We focused in our questionnaire on the subjective link between the pandemic and COVID-19 positivity and seizure frequency or severity during the period of one of the most severely affected European countries. In our cohort, COVID-19 had a mild course in most patients. Most cases underwent home treatment, and no one who required hospitalization died because of severe COVID-19. We did not prove any significant changes in seizure frequency or severity related to the course of COVID-19 illness. PwE with nocturnal seizures reported significantly seizure frequency and severity worsening. Age between 41 and 50 years was the risk factor for seizure severity worsening.

Cabezudo-García et al. pointed out that epilepsy is a condition that seems to predispose COVID-19-positive patients to a more severe course of infection, and even a higher lethality was described in patients with epilepsy when compared to the general population [21]. On the contrary, Granata et al. did not confirm this link between epilepsy and COVID-19 [22].

Some recent publications suggest the worsening of the course of epilepsy during the pandemic. Literary data describe an increased seizure frequency in 8–35% of patients with epilepsy regardless of COVID-19. Alkhotani et al. include one of the factors, the impact of stress [23], and Casassa et al. described the importance of anxiety about medication access and the cost of life-saving medications during the pandemic [24]. Assenza et al. concluded the negative impact of the pandemic on patients with epilepsy in difficulties in follow-up, and they described seizures number increase, particularly in those chronically taking more ASMs and with poor sleep quality [25]. Sanchez-Larsen et al. were concerned about the negative influence of the pandemic era on a cohort of 100 PwE in worsening up to 50% of seizure frequency in 27% of cases. Only one worsened patient with clinical cluster seizures was PCR confirmed for SARS-CoV-2 [26]. We explain the variability between studies by differences in patients' population (age, comorbidities), pandemic period, or government restrictions.

Our patients reported a significant difference in their general health condition. Sleep quality impairment, vivid dreams and nightmares, and worsening seizure frequency and severity were the most critical risk factors for deteriorating general health. We only obtained statistically significant results in declining sleep quality and seizure frequency. The riskiest age group were patients over the 51 years.

Other multiple reasons might cause worsening in the general population. Stress, anxiety, and depression seem to be the most frequent risk factors described in the literature [27].

Most of our patients did not recognize a change in their access to healthcare; thus, our results supported the critical role of phone calls and electronic medication resupply during pandemic lockdowns. Employment is essential to daily life, and most Czech adults have a job before retirement. The governmental social programs support people with severe disabilities. PwE may face many complex and interacting problems in finding and maintaining employment. It seems that the COVID-19 pandemic did not negatively influence the employment status of our patients. Surprisingly, some of our patients successfully found new positions during this period.

The crucial factors negatively impacting employment are stigma, seizure severity, and psychosocial variables such as low self-

esteem, passive coping style, or low self-efficacy [28]. PwE are often limited in their work by several other factors, including seizures, adverse effects of ASM, and physical or cognitive impairment. Moreover, they are often stigmatized by a surrounding “healthy” society [29]. PwE are permanently at risk of losing their employment [30].

## 5. Limitations of the study

Our study brought insight into epilepsy, sleep and COVID-19 in a relatively limited number of patients from three epileptic centers in the Czech Republic. It was a questionnaire study consisting of 23 questions, and the patient should not respond for longer than 15 min. We decided on this number as a compromise. On one side, we wanted to obtain as much information as possible. On the other side, we did not like to initiate a long time-consuming survey. We believed many respondents would refuse or provide incorrect information because of decreased concentration and fatigue. We offered a cross-sectional study concerning about 12 months previous period, and some questions could give merely estimated answers. The questionnaire was not originally designed for a study assessing sleep characteristics; thus, the information collected about the main topics could be incomplete. Nevertheless, the association between COVID-19 and vivid dreams and nightmares in patients with diurnal epilepsy is extremely interesting. We want to investigate these subjects further to reveal the basis of this phenomenon.

## 6. Conclusions

To conclude, insomnia is the most common sleep disorder in patients with epilepsy. Vivid dreams and nightmares significantly appeared in COVID-19-positive patients with active epilepsy with diurnal seizures. Patients with active epilepsy and COVID-19 did not significantly experience the epilepsy worsening. Epilepsy did not predispose to a severe course of the COVID-19 infection. We observed a significant deterioration in general health in patients with active epilepsy during the COVID-19 pandemic, regardless of COVID-19 disease. Besides sleep impairment, more frequent seizures, and age over 51, other multifactorial reasons are future research issues.

The COVID-19 pandemic had no significant impact on access to health care provided by epilepsy centers in the Czech Republic. The pandemic did not negatively influence the social status concerning employment in Czech patients with active epilepsy.

## Author contribution statement

Jana Slonkova, Milos Chudy, Irena Dolezalova: Conceived and designed the experiments; Performed the experiments; Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data; Wrote the paper.

Ariunjargal Togtokhjargal, Hana Tomaskova, Hana Vacovska, Gisela Rytirova: Conceived and designed the experiments; Performed the experiments; Analyzed and interpreted the data; Contributed reagents, materials, analysis tools or data.

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## Data availability statement

Original source documentation is stored in Archive of University Hospital Ostrava and in Electronic Database Server. Full version of the Questionnaire is attached as Supplemental material.

## Declaration of interest's statement

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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## Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.heliyon.2023.e13413>.

## References

- [1] WHO, Press conference. Press conf, 2020. <https://www.who.int/director-general/speeches/deta>. <https://www.who.int/director-general/speeches/detail/who-director-general-s-opening-remarks-at-the-media-briefing-on-covid-19-11-march-2020>.
- [2] The Ministry of Health, *Czech Republic* [online]. Prague [cit. 2022-08-10]. Available at: <https://onemocneni-aktualne.mzcr.cz/covid-19>.
- [3] M.K. Smyk, G. van Luijtelaar, Circadian rhythms and epilepsy: a suitable case for absence epilepsy, *Front. Neurol.* 245 (2020) 11, <https://doi.org/10.3389/fneur.2020.00245>.
- [4] N. Kuroda, Epilepsy and COVID-19: updated evidence and narrative review, *Epilepsy Behav.* 116 (2021), <https://doi.org/10.1016/j.yebeh.2021.107785>.
- [5] S. Strizović, N. Vojvodić, M. Kovačević, A. Pejović, Z. Bukumirić, D. Sokić, et al., Influence of COVID-19 pandemic on quality of life in patients with epilepsy – follow-up study, *Epilepsy Behav.* 121 (2021), <https://doi.org/10.1016/j.yebeh.2021.108026>.
- [6] S. Bhat, S. Chokroverty, Sleep disorders and COVID-19, *Sleep Med.* 91 (2022), <https://doi.org/10.1016/j.sleep.2021.07.021>.
- [7] R.F. Liebman, A.J. Rodriguez, A patient with epilepsy and new onset of nocturnal symptoms, *Rev. Neurol. Dis.* (2009) 6.
- [8] C. Hani, N.H. Trieu, I. Saab, S. Dangeard, S. Bennani, G. Chassagnon, et al., COVID-19 pneumonia: a review of typical CT findings and differential diagnosis, *Diagn Interv Imaging* 101 (2020), <https://doi.org/10.1016/j.diii.2020.03.014>.
- [9] W. Tan, J. Aboulhosn, The cardiovascular burden of coronavirus disease 2019 (COVID-19) with a focus on congenital heart disease, *Int. J. Cardiol.* 309 (2020), <https://doi.org/10.1016/j.ijcard.2020.03.063>.
- [10] P. Winkler, T. Formanek, K. Mlada, A. Kagstrom, Z. Mohrova, P. Mohr, et al., Increase in prevalence of current mental disorders in the context of COVID-19: analysis of repeated nationwide cross-sectional surveys, *Epidemiol. Psychiatr. Sci.* (2020), <https://doi.org/10.1017/S2045796020000888>.
- [11] S. Gobbi, M.B. Plomecka, Z. Ashraf, P. Radziński, R. Neckels, S. Lazzeri, et al., Worsening of preexisting psychiatric conditions during the COVID-19 pandemic, *Front. Psychiatr.* 11 (2020), <https://doi.org/10.3389/fpsy.2020.581426>.
- [12] H. Jahrami, A.S. BaHammam, N.L. Bragazzi, Z. Saif, M. Faris, M.V. Vitiello, Sleep problems during the COVID-19 pandemic by population: a systematic review and meta-analysis, *J. Clin. Sleep Med.* 17 (2021), <https://doi.org/10.5664/JCSM.8930>.
- [13] K.E.R. Kennedy, C.H. Bastien, P.M. Ruby, W.D.S. Killgore, C.C.A. Wills, M.A. Grandner, Nightmare content during the COVID-19 pandemic: influence of COVID-related stress and sleep disruption in the United States, *J. Sleep Res.* (2021), <https://doi.org/10.1111/jsr.13439>.
- [14] S. Scarpelli, V. Alfonsi, A. Mangiaruga, A. Musetti, M.C. Quattropani, V. Lenzo, et al., Pandemic nightmares: effects on dream activity of the COVID-19 lockdown in Italy, *J. Sleep Res.* 30 (2021), <https://doi.org/10.1111/jsr.13300>.
- [15] D. Kocovska, T.F. Blanken, E.J.W. Van Someren, L. Rösler, Sleep quality during the COVID-19 pandemic: not one size fits all, *Sleep Med.* 76 (2020), <https://doi.org/10.1016/j.sleep.2020.09.029>.
- [16] F.C.C. Musse, S. Castro L de, K.M.M. Sousa, T.F. Mestre, C.D.M. Teixeira, S.M. Pelloso, et al., Mental violence: the COVID-19 nightmare, *Front. Psychiatr.* 11 (2020), <https://doi.org/10.3389/fpsy.2020.579289>.
- [17] E. Fränkl, S. Scarpelli, M.R. Nadorff, B. Bjorvatn, C.J. Bolstad, N.Y. Chan, et al., How our dreams changed during the COVID-19 pandemic: effects and correlates of dream recall frequency - a multinational study on 19,355 adults, *Nat. Sci. Sleep* 13 (2021), <https://doi.org/10.2147/NSS.S324142>.
- [18] M. Sowho, F. Sgambati, M. Guzman, H. Schneider, A. Schwartz, Snoring: a source of noise pollution and sleep apnea predictor, *Sleep* 43 (2020), <https://doi.org/10.1093/sleep/zsz305>.
- [19] T. Gutter, P.M.C. Callenbach, O.F. Brouwer, A.W. de Weerd, Prevalence of sleep disturbances in people with epilepsy and the impact on quality of life: a survey in secondary care, *Seizure* (69) (2019) 298–303, <https://doi.org/10.1016/J.SEIZURE.2019.04.019>.
- [20] K. Klobučniková, Z. Čarnická, H. Wagnerová, P. Šiarnik, Is nocturnal epilepsy cause of disturbed quality of sleep and elevated daytime sleepiness? *Neuroendocrinol. Lett.* (2014) 35.
- [21] P. Cabezedo-García, N.L. Ciano-Petersen, N. Mena-Vázquez, G. Pons-Pons, M.V. Castro-Sánchez, P.J. Serrano-Castro, Incidence and case fatality rate of COVID-19 in patients with active epilepsy, *Neurology* 95 (2020), <https://doi.org/10.1212/WNL.0000000000010033>.
- [22] T. Granata, F. Bisulli, A. Arzimanoglou, R. Rocamora, Did the COVID-19 pandemic silence the needs of people with epilepsy? *Epileptic Disord.* 22 (2020) <https://doi.org/10.1684/epd.2020.1175>.
- [23] A. Alkhotani, M.I. Siddiqui, F. Almutashri, R. Baothman, The effect of COVID-19 pandemic on seizure control and self-reported stress on patient with epilepsy, *Epilepsy Behav.* 112 (2020), <https://doi.org/10.1016/j.yebeh.2020.107323>.
- [24] C. Casassa, R. Moss, D.M. Goldenholz, Epilepsy during the COVID-19 pandemic lockdown: a US population survey, *Epileptic Disord.* 23 (2021), <https://doi.org/10.1684/epd.2021.1259>.
- [25] G. Assenza, J. Lanzone, F. Brigo, A. Coppola, G. Di Gennaro, V. Di Lazzaro, et al., Epilepsy care in the time of COVID-19 pandemic in Italy: risk factors for seizure worsening, *Front. Neurol.* 11 (2020), <https://doi.org/10.3389/fneur.2020.00737>.
- [26] A. Sanchez-Larsen, E. Gonzalez-Villar, I. Díaz-Maroto, A. Layos-Romero, Alcahut-Rodriguez C. Martínez-Martín Á, et al., Influence of the COVID-19 outbreak in people with epilepsy: analysis of a Spanish population (EPICOVID registry), *Epilepsy Behav.* 112 (2020), <https://doi.org/10.1016/j.yebeh.2020.107396>.
- [27] N. Salari, A. Hosseini-Far, R. Jalali, A. Vaisi-Raygani, S. Rasoulopoor, M. Mohammadi, et al., Prevalence of stress, anxiety, depression among the general population during the COVID-19 pandemic: a systematic review and meta-analysis, *Glob. Health* 16 (2020), <https://doi.org/10.1186/s12992-020-00589-w>.
- [28] V.M.J. Smeets, B.A.G. van Lierop, J.P.G. Vanhoutvin, A.P. Aldenkamp, F.J.N. Nijhuis, Epilepsy and employment: literature review, *Epilepsy Behav.* 10 (2007), <https://doi.org/10.1016/j.yebeh.2007.02.006>.
- [29] H.M. De Boer, Epilepsy stigma: moving from a global problem to global solutions, *Seizure* 19 (2010), <https://doi.org/10.1016/j.seizure.2010.10.017>.
- [30] A. Subotic, D.F. Pricop, C.B. Josephson, S.B. Patten, E.E. Smith, P. Roach, Examining the impacts of the COVID-19 pandemic on the well-being and virtual care of patients with epilepsy, *Epilepsy Behav.* 113 (2020), <https://doi.org/10.1016/j.yebeh.2020.107599>.