

RESEARCH ARTICLE



Factors associated with insomnia symptoms: A cross-sectional study during a Covid-19 fully restrictive lockdown

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Summary

Insomnia is the most frequent sleep disorder and a public health concern that increased during the Covid 19 pandemic. Fully restrictive lockdowns during Covid are interesting periods to examine the impact of environmental and behavioural changes on the emergence of insomnia symptoms. In this cross-sectional study we aimed to (1) determine the main factors associated with insomnia symptoms during a Covid-19 fully restrictive lockdown examining the associated daily life alterations and (2) create a predictive model of insomnia symptoms. We used the data drawn from the “Covid-RythmE” study that reached volunteers from the general French population through an online survey during the last 2 weeks of the 2 month full lockdown. Associations with insomnia symptoms were tested and significant associations were entered in a Backward Stepwise Logistic Regression (BSLR) to assess the best combination to classify individuals with or without insomnia symptoms. From the 1624 participants, 50.64% suffered from mild to severe insomnia symptoms as assessed by the ISI. The best combination for explaining insomnia symptoms with 74.26% of accuracy included: age (OR = 1.15), females (OR = 1.26), smaller home sizes (OR = 0.77), environmental noises (OR = 1.59), anxiety symptoms (OR = 1.24), depressive symptoms (OR = 1.15), regularity of sleep-wake schedules (OR = 1.25), exposure to screen during the morning (OR = 1.13), and LED light during the evening (OR = 1.17). Thus, lifestyle schedule and exposure to natural synchronizers such as light, are primordial in considering in insomnia physiopathology, prevention and treatment, as well as the associated mental health status.

KEYWORDS

chronotype, covid-19, insomnia, sleep disorders, sleep habits, sleep-wake cycles

1 | INTRODUCTION

Insomnia is the most frequent sleep disorder affecting 11.3% of the over 18 year old population in Europe (Dopheide, 2020). In addition to being common, insomnia is a major public health concern because of its association with an increased risk of cardiovascular diseases (Laugsand et al., 2011), cognitive impairment (Yaffe

et al., 2014), psychiatric disorders (Geoffroy, Tebeka, et al., 2020; Hertenstein et al., 2019), and suicide (Geoffroy, Oquendo, et al., 2020). Moreover, insomnia disorder is associated with a huge cost to society regarding direct medical costs and indirect economic costs such as increased work stoppages (Léger & Bayon, 2010), poorer workplace performance (Kyle et al., 2017), increased health care utilisation (Olfson et al., 2018), and increased

accident risks (Taddei-Allen, 2020). In the USA, these direct and indirect costs exceed \$100 billion USD per year (Wickwire et al., 2016).

The physiopathology of insomnia and its neurobiology is thought to involve a homeostatic process (sleep drive or duration of wakefulness) and the circadian timing system, the latter being controlled by daylight exposure and several social and environmental timekeepers (Riemann et al., 2015). This neurobiology is also very sensitive to stress and has bidirectional links with psychiatric disorders such as anxiety and depression (Hertenstein et al., 2019; Palagini et al., 2019; Riemann et al., 2015b; Zhang et al., 2020). The hyperarousal, possibly caused by stress, appears to be one of the main actors leading to insomnia (Riemann et al., 2010).

Several reports emphasise that the Covid-19 pandemic led to a major increase in sleep and psychiatric disorders. According to Nochaiwong and colleagues' meta-analysis of the mental health issues among the general population, 50.0% of the individuals suffered from psychological distress, 28.0% from depression; 26.9% from anxiety, and 27.6% had insomnia or poor sleep quality (Nochaiwong et al., 2021). More specifically, insomnia symptoms/disorder prevalence reached 23.87% in the meta-analysis of Cénat and his collaborators (Cénat et al., 2021). Nevertheless, these studies used different methods and designs, from different countries with different care systems and Covid-19 contexts. Most of the countries had to set up measures to stem the Covid-19 spread such as wearing masks, hand washing, avoiding social contacts, teleworking implementation, school closures, curfew, and limitation of time spent outdoors. The most restrictive lockdowns were probably interesting periods to better understand the factors associated with insomnia symptoms because of the associated environmental and behavioural changes, such as modifying daily routines with atypical work schedules and less time spent outdoors (Bertrand et al., 2021). Some studies reported interesting positive correlations between insomnia symptoms and factors such as occupation, and symptoms of anxiety or depression (Zhang et al., 2020). However, none of them have explored the associations with specific modifications of the daily routine induced by a strict lockdown which can be seen as an almost free running state on a massive scale.

We conducted the "Covid-RythmE" survey studying sleep and circadian rhythms in individuals from the general population during the French Covid-19 full lockdown (Bertrand et al., 2021) and we observed previously that individuals had significantly less physical activity, less natural light exposure, less sleep schedule regularity, with longer exposure to screens (Bertrand et al., 2021). We also reported that half of the studied population (51.0%) had a mild to severe insomnia as assessed by the Insomnia Severity Index (ISI) (Bertrand et al., 2021). Following this first study and results, in this new work we aimed to examine the relationships between the reported alterations and behavioural changes with the development of insomnia symptoms.

In this context, we used the data from the "Covid-RythmE" survey of this particularly fully restrictive lockdown to (1) determine the associated factors with insomnia symptoms, examining the daily

life modifications, and (2) create a predictive model of insomnia symptoms.

2 | MATERIALS AND METHODS

2.1 | Study description

The "Covid-RythmE" study reached volunteers from the general population, without exclusion criteria, the survey was published online (emails, newsletter from French sleep and psychiatric societies, Facebook, and Twitter) during the last week of the lockdown, starting on May 6, 2020 (Bertrand et al., 2021). This French-language survey was conducted on the Assistance Publique-Hôpitaux de Paris (AP-HP) Lime Survey platform with anonymised data storage on the AP-HP intranet, in partnership with AP-HP-Enquêtes (<https://questionnaire.aphp.fr/>). The survey was carried out by the SOPSY section (sleep and biological rhythms in psychiatry) of the French Association of Biological Psychiatry and Neuropsychopharmacology (AFPBN) and the French Society for Sleep Research and Medicine (SFRMS). Data storage was carried out on an AP-HP computer at the Bichat hospital. This study was ethically approved (N°CER-2020-40) by the Comité d'Evaluation de l'Ethique des projets de Recherche Biomédicale (CEERB) Paris Nord (Institutional Review Board – IRB 00006477 – of HUPNVS, Paris 7 University, AP-HP). More details about the "Covid-RythmE" study have been published previously (Bertrand et al., 2021).

2.2 | Clinical characteristics

The RythmE study collected data about sociodemographic characteristics, being active or inactive (retired, student, unemployed), sleep schedule regularity, bedtime and wake-up shifts, physical activity, morning and evening light exposure (natural, LED, screen), meal regularity, weight gain or loss, social contact time. Subjects were asked to rate/rank these variables for before and during the full lockdown. We calculated the difference between "before" and "during" the lockdown creating new continuous variables for the scores and new ordinal variables for the ranks.

Insomnia disorder is defined by difficulties in initiating sleep, or difficulties in maintaining sleep, or early morning awakenings, or non-restful sleep and is associated with daytime consequences such as fatigue, attention deficits, and mood instability; at least 3 nights per week for at least 3 months (Diagnostic and statistical manual of mental disorders, 2013, p. 5) (International Classification of Sleep Disorders – Third Edition (ICSD-3) (Online) – American Academy of Sleep Medicine, n.d.).

Standardised questionnaires were also used: the Hospital Anxiety and Depression Scale (HADS) (Snaith, 2003) and the Insomnia Severity Index (ISI) (Bastien et al., 2001). The HAD-A anxiety and HAD-D depression scales are considered significant when the total score is equal to 11/21. Concerning the ISI, it is the most validated and used scale to assess insomnia, a total score of <7 is not in favour of insomnia, a score between 8 and 14 indicates mild insomnia, a score between 15 and

TABLE 1 Baseline characteristics between individuals with or without insomnia symptoms

	No insomnia N = 803 (49.46%)	Insomnia N = 821 (50.64%)	U/Chi2	p
Age			21.16	<0.0005
<18	14 (0.86%)	3 (0.18%)		
18–25	96 (5.91%)	106 (6.53%)		
26–45	369 (22.72%)	418 (25.74%)		
46–65	245 (15.09%)	251 (15.46%)		
>65	79 (4.86%)	43 (2.65%)		
Gender			20.48	<0.0005
Female	556 (34.24%)	649 (39.96%)		
Male	247 (15.21%)	172 (10.59%)		
Main occupation			2.70	0.10
Active	594 (36.58%)	636 (39.16%)		
Inactive	209 (12.87%)	185 (11.39%)		
Monthly income			21.69	<0.0005
>2000	476 (29.31%)	392 (24.14%)		
≤2000	327 (20.13%)	429 (26.42%)		
Health professional			6.91	0.009
No	507 (31.22%)	569 (35.04%)		
Yes	296 (18.17%)	252 (15.52%)		
Absence of psychiatric disorder			54.90	<0.0005
No	73 (4.50%)	185 (11.39%)		
Yes	730 (44.95%)	636 (39.16%)		
Addictive disorder			7.35	0.007
No	797 (49.08%)	801 (49.32%)		
Yes	6 (0.37%)	20 (1.23%)		
Diabetes			0.33	0.56
No	793 (48.83%)	808 (49.75%)		
Yes	10 (0.62%)	13 (0.80%)		
High blood pressure			0.83	0.36
No	744 (45.81%)	770 (47.41%)		
Yes	59 (3.63%)	51 (3.14%)		
Obesity			5.86	0.015
No	780 (48.03%)	778 (47.91%)		
Yes	23 (1.42%)	43 (2.65%)		
Cancer			0.23	0.63
No	791 (48.71%)	811 (49.94%)		
Yes	12 (0.74%)	10 (0.62%)		
Sleep apnea syndrome			0.05	0.82
No	782 (48.15%)	798 (49.14%)		
Yes	21 (1.29%)	23 (1.42%)		
Respiratory disease			3.49	0.062
No	780 (48.03%)	783 (48.21%)		
Yes	23 (1.42%)	38 (2.34%)		

Note: Bold indicates $p < 0.05$.

21 suggests moderate insomnia, and a total score between 22 and 28 is in favour of severe insomnia (Bastien et al., 2001). We used the validated ISI threshold of 8 to define two groups: people with insomnia ($ISI \geq 8$) and people without insomnia ($ISI < 8$).

2.3 | Statistical analysis

The statistical analysis was conducted with three steps. First, we checked the normality of the distributions of variables and used

the Kolmogorov–Smirnov test and QQ plot graphics. Second, non-parametric tests were used for variables showing non-normal distributions (Wilcoxon–Mann–Whitney test, “U test”). When normal distribution was confirmed, a parametric test was used (t-test), with the chi-squared tests used to compare categorical variables. Univariate two-sided analyses were performed on the total sample of 1624 participants. Each categorical variable is described with a number and percentage, whilst each continuous variable is described with a mean and standard deviation (SD). Third, any variables that were significantly different ($p < 0.05$) between groups were then entered into a Backward Stepwise Logistic Regression (BSLR) to assess the combination of these selected variables that best classify individuals as insomniac or non-insomniac. The proportion of cases correctly classified is reported along with the odds ratios (OR) and 95% confidence intervals (95% CI) for each variable included in the final optimal model. All analysis were performed using the JAMovi software (Version 0.9.5.12) and SPSS 26.0.

3 | RESULTS

3.1 | Sociodemographic characteristics between insomniacs and non-insomniacs

General details on the sociodemographic characteristics of the population are available in the study of Bertrand and Al (Bertrand

et al., 2021). From the 1624 participants, 821 (50.64%) suffered from mild to severe insomnia (30.54% mild, 16.93% moderate, 3.08% severe). Older age was associated positively with the disorder ($p < 0.0005$). In addition, 39.9% were women, which was associated with insomnia symptoms ($p < 0.0005$). Earning $>2000\text{€}$ per month income was negatively associated with insomnia symptoms ($p < 0.0005$). Being a health professional was negatively associated with insomnia symptoms ($p = 0.009$). The insomnia group was not associated with being active or inactive ($p = 0.101$) (Table 1).

3.2 | Clinical characteristics between individuals with and without insomnia

Two hundred fifty-eight persons (15.89%) suffered from psychiatric disorders and among them 185 (71.71%) suffered from insomnia symptoms ($p < 0.0005$). 26 (1.60%) persons suffered from addictive disorders and of them 20 (76.92%) suffered from insomnia symptoms ($p = 0.007$). Individuals with insomnia were significantly more anxious ($p < 0.0005$) and more depressed ($p < 0.0005$) than individuals without insomnia symptoms (Table 3). 66 (4.06%) individuals were obese and of them 43 (65.15%) suffered from insomnia symptoms ($p = 0.015$). Neither sleep apnea ($p = 0.817$), other respiratory diseases ($p = 0.062$), cancer ($p = 0.630$), high blood pressure ($p = 0.363$), nor diabetes ($p = 0.564$) were associated with insomnia symptoms (Table 1).

TABLE 2 Sleep environment characteristics between insomniac and non-insomniac people

	No insomnia <i>N</i> = 803 (49.46%)	Insomnia <i>N</i> = 821 (50.64%)	U/Chi2	<i>p</i>
Change of residence during confinement			0.40	0.53
No	711 (43.78%)	735 (45.26%)		
Yes	92 (5.67%)	86 (5.30%)		
Housing size m ²			22.87	<0.0005
>100	361 (22.22%)	274 (16.87%)		
≤100	442 (27.22%)	547 (33.68%)		
Number of people in the household			11.58	0.072
1	139 (8.56%)	156 (9.61%)		
2	289 (17.80%)	252 (15.51%)		
3	146 (8.99%)	138 (8.50%)		
4	157 (9.67%)	184 (11.33%)		
5	44 (2.71%)	65 (4.00%)		
Between 6 and 10	23 (1.42%)	25 (1.54%)		
>10	4 (0.25%)	1 (0.06%)		
Outdoor			4.94	0.026
Yes	139 (8.56%)	178 (10.96%)		
No	664 (40.89%)	643 (39.59%)		
Sleep in a noisy environment			15.86	<0.0005
No	770 (47.4%)	747 (46.0%)		
Yes	33 (2.03%)	74 (4.56%)		
Room temperature between 16 and 20°C			1.45	0.23
No	100 (6.15%)	119 (7.32%)		
Yes	703 (43.29%)	702 (43.23%)		

Note: Bold indicates $p < 0.05$.

3.3 | Sleeping habits between individuals with and without insomnia symptoms

Concerning the sleep environment, a change of residence during the lockdown was not associated with insomnia symptoms ($p = 0.527$) nor was the number of people in the household ($p = 0.072$), but the housing size and having an outdoor space (area, garden, etc.) were negatively associated with insomnia symptoms (respectively $p < 0.0005$; $p = 0.026$). Sleeping in a noisy environment was positively associated with insomnia symptoms ($p < 0.0005$) but not with a room temperature between 16 and 20°C ($p = 0.229$) (Table 2).

3.4 | Modifications of routines and light characteristics between individuals with and without insomnia symptoms

A lower social contact time per week during the full lockdown was not associated with insomnia symptoms ($p = 0.190$). The differences between before and during the full lockdown in regularity of sleep schedules, physical activity, natural light exposure the morning and the evening, screen exposure during the morning and the evening, LED light exposure in the morning and the evening were significant between insomniac and non-insomniac people. Compared with non-insomniacs, insomniacs had less regular sleep schedules ($p < 0.0005$),

less physical activity ($p = 0.19$), less exposure to natural light in the morning ($p < 0.0005$), and in the evening ($p < 0.0005$), and to have been more exposed to screens ($p < 0.0005$) and to LED light both in the morning ($p = 0.003$) and the evening ($p < 0.0005$). A shift in bedtime was also significantly different between insomniac and non-insomniac ($p < 0.0005$) but not a shift in wake-up ($p = 0.078$). Insomniacs had shifted their bedtimes more than non-insomniacs. Concerning the meal regularity, the impact of full lockdown was significantly different between insomniacs who seemed less regular than non-insomniacs ($p < 0.0005$), but it did not translate into weight gain or loss between the two groups ($p = 0.38$) (Table 3).

3.5 | Multivariate analysis to identify independent factors predicting the insomnia group

The insomniac group was coded as 1 and non-insomniac group was coded as 0. When the statistically significant variables were entered into the BSLR, a combination of nine variables was retained: older age (OR = 1.148; 95% C.I.: 0.993–1.327); female (OR = 1.257, 95% C.I.: 0.960–1.645); housing size ($>100 \text{ m}^2$) (OR = 0.768; 95% C.I.: 0.604–0.976); sleeping in a noisy environment (OR = 1.59, 95% C.I.: 0.963–2.618); less regularity of sleep schedules (OR = 1.247; 95% C.I.: 1.182–1.316); longer screen exposure in the morning (OR = 1.129, 95% C.I.: 1.003–1.271); longer LED light exposure in the evening

TABLE 3 Daily life changes during confinement and its impact on mental health between insomniac and non-insomniac people

	No insomnia N = 803 (49.46%)	Insomnia N = 821 (50.64%)	U/Chi2	p
Social contact time per week during confinement			7.43	0.19
No contact	31 (1.91%)	33 (2.03%)		
<1 h	112 (6.90%)	154 (9.48%)		
Between 1 and 5 h	467 (28.76%)	451 (27.77%)		
Between 6 and 10 h	128 (7.88%)	124 (7.64%)		
Between 10 and 20 h	41 (2.52%)	40 (2.46%)		
>20 h	24 (1.48%)	19 (1.17%)		
Difference in regularity of sleep schedules	−0.27 (±1.90)	−1.82 (±2.68)	205908.00	<0.0005
Bedtime shift	0.72 (±1.15)	1.16 (±1.29)	262419.00	<0.0005
Wake-up shift	0.85 (±1.09)	0.90 (±1.361)	313677.00	0.078
Difference in physical activity	−0.23 (±1.04)	−0.33 (±1.11)	308576.00	0.019
Difference in natural light exposure the morning	0.09 (±1.18)	−0.21 (±1.31)	288087.50	<0.0005
Difference in natural light exposure the evening	0.20 (±1.20)	−0.15 (±1.29)	280115.50	<0.0005
Difference in screen exposure the morning	0.48 (0.92)	0.76 (±1.10)	279855.50	<0.0005
Difference in screen exposure the evening	0.38 (0.69)	0.57 (±0.77)	282760.50	<0.0005
Difference in LED light exposure the morning	−0.24 (±1.00)	−0.06 (±1.10)	307021.50	0.003
Difference in LED light exposure the evening	−0.08 (±0.77)	0.13 (±0.84)	291784.50	<0.0005
Impact of lockdown on meal regularity	0.05 (±0.69)	−0.13 (±0.81)	285766.50	<0.0005
Weight gain or loss during lockdown	0.27 (±2.03)	0.31 (±2.71)	321504.50	0.38
HAD-Anxiety	6.02 (±3.08)	9.49 (±3.84)	157572.00	<0.0005
HAD-Depression	3.49 (±2.68)	6.29 (±3.89)	182907.50	<0.0005

Note: Bold indicates $p < 0.05$.

Variable	p	B	Odds ratio	95 C.I.	
				Lower	Upper
(a) Variables included in the final BSLR model					
Older age	0.06	0.14	1.15	0.99	1.33
Female	0.10	0.23	1.26	0.96	1.65
Housing size m ² (>100 m ²)	0.03	−0.264	0.77	0.60	0.98
Sleeping in a noisy environment	0.07	−0.46	1.60	0.96	2.62
Less regularity of sleep schedules	0.00	−0.22	1.25	1.18	1.32
Longer screen exposure in the morning	0.04	0.12	1.13	1.00	1.27
Longer strong light exposure in the evening	0.04	0.16	1.17	1.00	1.37
HAD-anxiety scores	0.00	0.22	1.24	1.19	1.29
HAD-depression scores	0.00	0.14	1.15	1.10	1.20
	Predicted				
Observed	No insomnia		Insomnia	% Correctly classified	
(b) Classification table and summary statistics					
No insomnia	614		187	76.77%	
Insomnia	230		589	71.92%	

Note: % of all participants correctly classified 74.26% – Chi-square = 533.534, df = 9; *p* < 0.005.

(OR = 1.172; 95% C.I.: 1.003–1.369); elevated HAD-anxiety scores (OR = 1.240, 95% C.I.: 1.192–1.289); and elevated HAD-depression scores (OR = 1.152, 95% C.I.: 1.104–1.202) correctly classified 76.77% of individuals who did not suffer from insomnia symptoms, 71.91% of individuals who suffered from insomnia symptoms which leads to a good classification for 74.26% of the study participants (Table 4).

4 | DISCUSSION

In France, the Covid-19 fully restrictive lockdown in March 2020 had an important impact on sleep. In our study, we found that 50.64% of our sample suffered from mild to severe insomnia. As the lockdown was quite strict in France, almost simulating an experiment of a free running state at the population scale, it gave us insights into factors associated with insomnia symptoms. We found an increase in insomnia symptoms, especially among certain social categories: women, the elderly, and individuals with lower incomes. This study also highlights the importance of routines and light use/habits regarding insomnia manifestations. Indeed, individuals who changed their habits compared with before lockdown with a less regular schedule, delayed bed-times, less meal regularity, practised less physical activity, and had shorter exposure to natural light and more exposure to screen or LED light were more likely to have insomnia symptoms. The best combination for predicting the groups with significant insomnia symptoms with 74.3% of accuracy was: age (the elderly were more affected), sex (women), the size of the house (smaller home size), environmental noises, anxiety symptoms, depressive symptoms, regularity of sleep schedules, and longer exposure to screen during the morning and to LED light during the evening.

TABLE 4 Backward stepwise logistic regression (BSLR) showing (a) the best combination of variables for correctly classifying study participants as insomniac or non-insomniac and (b) the overall classification rate by group

This study emphasises that the Covid-19 pandemic and the associated lockdown had a major impact on our way of living. All the population, except for workers who could not work at a distance, had to stay at home and thus had to create new routines. Studies showed that this led to an increase in psychiatric disorders (Cénat et al., 2021). When we combined the explicative variables, we showed that people between 18–45 years old and women were more at risk of suffering from insomnia. This is in line with previous studies, such as the study of Shu Wang and colleagues (Wang et al., 2020) during the very restrictive lockdown in Shandong province, China, which found that being aged between 35–49 years was a risk for insomnia (OR = 1.198; 95% CI: 1.079–1.329). It also confirms the international meta-analysis of X. Li and colleagues (X. Li et al., 2020) done before the Covid-19 period that found an increased risk for the 18–39 years population. Interestingly, this is discrepant with the usual association between poor sleep and ageing (Ohayon, 2002). One hypothesis could be that this class of age greatly modified its daily routine during the lockdown by contrast to retired people who usually have fewer time constraints. Concerning gender, in our sample, women were more at risk of suffering from insomnia, in agreement with the epidemiology of insomnia (Kocevska et al., 2021) and confirming the meta-analysis of Alimoradi and colleagues (Alimoradi et al., 2021) who studied sleep disorders according to gender during the Covid-19 pandemic. The reasons for such differences are not clear, they might result in structural differences in the brain across sexes (Xin et al., 2019), in hormone production, sex differences in the mechanism initiating sleep (Mong & Cusmano, 2016), but also in stress perception and psychological distress which seems to be higher in women (Wang et al., 2017). The study of Salfi and colleagues (Salfi et al., 2020) found that women were more at risk of suffering from insomnia, anxiety, and depression at the beginning of the lockdown, which can be considered as an acute stress, but also showed a better long-term resilience since at

the end of it the men emerged as the most vulnerable category during the extension of the restraining measures (Salfi et al., 2020).

It is also interesting to note that the sleep environment is crucial in terms of noise impact, since this factor was retained in our final model, but not the traditional temperature factor, which was not even significantly associated with insomnia symptoms in the univariate analyses. One explanation could be that the fully restrictive lockdown in France occurred in an extraordinary mild month of May. According to Météo France (the national weather agency), in May the mean temperature was 16.5, 1.5°C above normal and spring 2020 was the second hottest spring since 1900 (bilan_definitif_printemps_2020.pdf, n.d.). This can be coherent with previous studies highlighting the fact that bed temperature correlates with insomnia symptoms according to extreme exterior environment temperature (Min et al., 2021).

Home size is also an important factor in the prediction of insomnia symptoms since having a house of >100 m² decreased the risk of insomnia symptoms (OR = 0.768; C.I. 95% [0.604–0.976]), independently of the number of persons in the house (Chi-square = 11.582; $p = 0.072$). Interestingly lower incomes and not having an outdoor area were associated with insomnia symptoms, similar to previous studies (Wang et al., 2020), but these factors eventually were not retained in the final model. Having an outdoor area, a big house, and a high income are likely correlated. More than the income, these associations might be explained by the fact that having more space and an outdoor area ease the natural light exposure, a major synchronizer of sleep–wake cycles, by inducing, among others, melatonin secretion (Zisapel, 2018).

Indeed, one hypothesis on insomnia physiopathology, are disturbances in the internal clock system which is regulated by environmental time cues (such as light, meal, etc.) (Daan et al., 1984). Thus, in all insomnia therapies, adapted wake and sleep behaviours including lifestyle advice are provided (Geoffroy, Bédard, et al., 2020), however scientific literature and data on these disturbances as causal factors in insomnia are scarce. The fully restrictive Covid lockdown is an interesting period to better study these relationships and effects. The fully restrictive lockdown considerably modified our daily routines and exposure to time cues (Bertrand et al., 2021). Previous study such as that by Salfi and colleagues (Salfi et al., 2021) showed that individuals who increased their electronic device usage during lockdown had more insomnia symptoms.

Our results emphasise an important role of environmental time cue disturbances in a setting of insomnia symptoms. Having more irregular sleep schedules and meal times, being less exposed to natural light and more to screens during the morning and the evening, as well as being more exposed to LED light in the evening, were all associated with the emergence of insomnia symptoms during the full lockdown in our study. Although in the final model, only the irregularity of sleep schedules, the longer exposure to screen in the morning and the evening exposure to LED light remained as explaining insomnia symptoms, this highlights the importance of the internal clock in the physiopathology of insomnia and that preventive measures should not only be taken around sleep (traditionally stopping screen exposure

2 h before going to bed etc.) but during the 24 h of the circadian cycle.

The decrease in physical activity was also associated with the emergence of insomnia symptoms in the univariate analyses, even if it was not retained in our final model, which is in line with the results of Mandelkorn and colleagues (Mandelkorn et al., 2021). Of note, the scientific literature reported discordant findings (Atoui et al., 2021; Memon et al., 2021) and points to the necessity for further studies on physical activity and sleep in adults, with a closer look at associated factors such as different activity thresholds according to the population (active, inactive, athlete, young people...), objective sleep–activity measures.

A bedtime shift was associated with insomnia symptoms in the univariate analyses but not in the final model, the wake-up shift was not associated with insomnia symptoms at all. These observations could be coherent with the study of Blume and colleagues which highlighted that the restrictions due to lockdown, and especially working from home, reduced the mismatch between external (social) and internal (biological) sleep–wake timing, reducing social jetlag and social sleep restrictions, and thus had a positive impact with an increase in sleep duration (Blume et al., 2020).

Of note, psychiatric disorders also impact sleep quality, having a psychiatric or an addictive disorder was associated positively with insomnia symptoms. Interestingly, only the elevated scores for the HAD, as much for anxiety as depression, were retained in the final model and not answering positively to the question “do you suffer from a depressive or anxiety disorder”. We can assume that these persons aware of their disorder were under treatment by specialists and thus were less symptomatic than the others. These results are in line with previous findings highlighting bidirectional links between sleep quality, depression, and anxiety (L. Li et al., 2016; Billiard & Dauvilliers, 2011).

Some limitations have to be taken into account in our study. First, the participation via an online questionnaire could have induced a selection bias. Nevertheless, the prevalence observed in our study, about 50% of altered sleep in individuals from the general population is absolutely in line with observations from other international studies: 50.21% for the USA, 44.18% for Turkey, 58.59% for Spain, as shown in the meta-analysis of A. Jahrami and colleagues (Jahrami et al., 2022) and thus seems to us reliable. Secondly, sleep schedules were declarative, we did not use an objective tool to assess the daily activities and schedules such as actimetry measures, although it would have been very difficult in practice for a such number of participants and in the Covid-19 period. A recall bias also cannot be ruled out because of the retrospective collection of data on the pre-lockdown period. Nevertheless, we decided to perform our analyses on an inclusive definition of insomnia (mild–moderate–severe symptoms) in order to investigate the development of an early manifestation of insomnia. A high prevalence of anxiety and depressive symptoms could also have blinded the importance of the chronobiological factors in the emergence of insomnia symptoms. Also, the data were collected during the last 2 weeks of lockdown, e.g. at the very end, which could have given people more time to adapt themselves to their new

schedules. On the contrary, conducting the survey during the very end of the lockdown much improved the reliability and comparability between patients because they were all assessed in the same short time period, compared with the previous 2 months of lockdown.

5 | CONCLUSION

Insomnia is a public health issue, especially during this Covid pandemic, which allowed us to better examine its relationships with lifestyle habits, daily routines, and environmental changes. Lifestyle schedule, daily routines, and exposure to synchronizers such as natural and artificial lights are primordial in the development of insomnia symptoms. These factors are to be considered in the comprehension, prevention, and treatment of insomnia as well as the associated mental health status.

AUTHORS CONTRIBUTION

N. Christodoulou and P. Geoffroy contributed to the design and the implementation of the research, to the analysis of the results, and to the writing of the manuscript. L. Bertrand contributed to the design and the implementation of the research and the writing of the manuscript. L. Palagini, J. Frija-Masson, M-P d'Ortho, M. Lejoyeux, D. Riemann, and J. Maruani contributed to the writing of the manuscript.

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CONFLICT OF INTEREST

The authors have no conflicts of interest to declare in relation to this study.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available on request from the corresponding author. The data are not publicly available due to privacy or ethical restrictions.

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