Screen exposure and sleep

How the COVID-19 pandemic influenced children and adolescents - A questionnaire-based study

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Screen exposure and sleep: How the COVID-19 pandemic influenced children and adolescents – A questionnaire-based study

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ABSTRACT

Background: COVID-19 pandemic has drastically increased the exposure to electronic devices in children, influencing their lifestyle and their sleep. This study was conducted to explore the relationship between the augmented screen exposure and sleep habits in children during and after the pandemic.
Methods: Using the "Google Forms" tool, we created an online questionnaire addressed to parents of children and adolescents aged 2–18 years. We explored the use of screens before and during/after the lockdown and assessed the presence of sleep disturbances through the Sleep Disturbance Scale for Children (SDSC), referring to the period before and during/after COVID-19 pandemic.
Results: We collected 1084 valid questionnaires (median age 8.5 ± 4.1 years). We observed a significant increase in screens exposure for school (72%) and for leisure (49.7%) during the pandemic. We reported an increased sleep disturbances prevalence from 22.1% before the pandemic to 33.9% during the outbreak ($p < 0.001$). Even before the pandemic, the highest risks for sleep disorders were related to daily screen time for school reasons (OR 1.65, $p < 0.001$) and total screen time after 6 p.m. (OR 1.59, $p < 0.001$). The augmented exposure to screens for any reasons during the pandemic was significantly related to an increase of sleep disorders, especially regarding the increased exposure after 6 p.m. (OR 1.67, $p < 0.001$).
Conclusions: The augmented use of electronic devices was recognized to be a significant predisposing factor in increasing the rate of sleep disorders during and after the pandemic, thus sleep hygiene recommendations should be highlighted to improve sleep habits.

1. Introduction

The World Health Organization has deemed the coronavirus disease 2019 (COVID-19) outbreak a global pandemic. On January 30th, 2020, the Italian National Institute of Health (ISS) confirmed the first two cases of COVID-19 infection in Italy. The infection rapidly spread, thus leading the government to order the closure of schools and universities in the whole country on March 4th, 2020, with a general lockdown starting a few days later and continuing until May 3rd. People were thus forced into home confinement and restrictions continued up to June 15th, 2020, when a partial reopening of the major activities has been established. From November 3rd, 2020, given the new rise in infections, the Italian regions were divided by colors according to the transmissibility index RT, so each region should have followed precise restrictions and closures in relation to the number of its residents infected with COVID-19; for all the regions, curfew at night was established. In January 2021, vaccinations against COVID-19 were finally available, ensuring a huge decrease in deaths by COVID-19 and reducing the measures of containment imposed by the pandemic. From then, vaccinations or recovery from COVID-19 certificate, the so called "Green Pass", is mandatory to have access to the main indoor activities although some restrictions still persisted. Although these measures and efforts have been considered necessary to limit contagion and pressure on the Italian healthcare system, there

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were several concerns due to the possible negative effects of such severe and prolonged restrictions on mental health [1,2]. Indeed, the lifestyle of children and adolescents was deeply affected by the lockdown, with a marked reduction of peer interaction, reduced (or lack of) physical activity and even of exposure to daylight. Furthermore, the lockdown also determined an increase of desk-bound activities, increased food consumption with consequent weight gains [3]. Being confined at home, children, adolescents, and even toddlers also began to be much more exposed to electronic devices and screen light, both for leisure and for school activities, since distance learning replaced the in-person lessons. Blue light, such as those from electronic devices, has many physiologic effects, in particular it influences the circadian rhythm, since blue wave-lenghts suppress sleep-associated delta brainwaves and boost the alpha ones, related to alertness [3–5]. Home confinement and reduced sociality inevitably led to increased stress levels and to the emergence of neuropsychiatric conditions [6,7]. All these factors, as well as possible changes in family financial conditions, health concerns and uncertainty about the future, also contributed to alter the sleep/wake pattern and circadian rhythmicity during the outbreak and for the whole period of pandemic [8,9].

Sleep is crucial for child and adolescent health and wellbeing and the potential for sleep problems to emerge or worsen during home confinement is high [8,10].

There is now a big amount of medical literature on the impact of COVID-19 lockdown on sleep of adults and children. A study on 1310 Italian adults demonstrated an increased usage of digital media near bedtime, with an associated change of sleep schedule and a reduction of sleep quality [11]. An Italian multicenter study on a wide sample of pediatric subjects (4314) revealed a significant delay in bedtime and risetime both in younger children and adolescents thus reflecting the modification of lifestyles [8]. But above all this study documented a significant increase in sleep disturbances, including difficulties in falling asleep in all age ranges, anxiety at bedtime, daytime sleepiness and number of night awakenings especially in children up to 12 year of age. This study also confirmed the expected increase of screen exposure during the pandemic, which was also confirmed by other literature data [6,12]. Other studies pointed out that, above all in the first period of lockdown, the total amount of sleep in children and adolescents appeared to increase, probably due to the more relaxed time schedules of distance learning [13–16]. However, these studies did not specifically investigate how the increased use of electronic devices was related to the modification of sleep patterns.

Therefore, the aim of this study was to investigate how screen exposure during COVID-19 pandemic modified in children and adolescents (also describing it according to the different age groups), and to correlate these modifications with sleep characteristics, investigated through standardized questionnaires.

2. Materials and methods

2.1. Subjects' recruitment

We identified potential subjects for our study spreading the link for questionnaires through schools, sport academies, and social media. We included all individuals aged 2–18 years, whose parents agreed to complete the questionnaires. Data have been collected between April and June 2021.

2.2. Questionnaire structure and procedures

To investigate the presence of sleep disorders in children and adolescents before and during the lockdown, we created an online questionnaire using the "Google Forms" tool provided by Google. We asked parents to fill out the questionnaire by following a link spread through social media or instant messaging applications. The study was approved by the Ethical Committee of Tor Vergata University Hospital.

The questionnaire was structured as follows:

1. A first part with general questions on demographic characteristics (age, gender, school attended ….);
2. Questions about the presence of organic or neurodevelopmental comorbidities, chronic drug use, or rehabilitation therapies;
3. Questions related to the use of electronic devices (and so screen exposure) before and during the lockdown, including questions specifying the reason for screen exposure (school or leisure) and the time of exposure (before or after 6 p.m.);
4. A last section containing the whole standardized questionnaire Sleep Disturbance Scale for Children (SDSC) referring to the period before Sars-COV2 pandemic and during and after lockdown. So, families were asked to complete a first questionnaire referring to the period before pandemic and before the first lockdown, and a second referring to the actual period.

2.2.1. Sleep evaluation

2.2.1.1. SDSC. The SDSC is one of the most used assessment tools for pediatric sleep. It is a parent-report sleep screening survey developed by Bruni et al. [17], whose application has been extended even in preschoolers [18].

The questionnaire consists of 26 items grouped in 6 subscales relating to the major presenting clinical sleep complaints in pediatric age: difficulty in initiating and maintaining sleep factor (DIMS), sleep breathing disorders (SBD), disorders of arousals/nightmares (DA), sleep/wake transition disorders (SWTD), disorders of excessive somnolence (DOES), and sleep hyperhydrosis (SHY). Each item is rated on a five-point scale, and items questioning about desirable and pathological sleep behaviors are reversed in scoring so that a higher score is indicative of more disrupted sleep.

We divided our population into two groups, patients *with sleep disorders* and *without sleep disorders*, according to the results of the SDSC. We considered as having a sleep disturbance those patients with SDSC total score over the cut-off score of 39 indicated by the authors. Indeed, this was found to be the cut-off score with the best diagnostic confidence with a sensitivity of 0.89 and a specificity of 0.74 [17]. For the subscales we considered T-scores (normal if ≤ 70) as reported on the original paper, therefore pathologic scores were ≥ 17 for DIMS, ≥ 7 for SBD, ≥ 6 for DA, ≥ 14 for SWTD, ≥ 13 for DOES and ≥ 7 for SHY.

2.3. Statistical analysis

Changes between baseline and follow-up in terms of total scores of sleep questionnaires were evaluated with the Wilcoxon matched-pair signed-rank test. Differences between groups were analyzed, as appropriate, by means of the Mann-Whitney *U* test, Pearson's Chi-squared test, or Fishers Exact tests (for small groups). Effect sizes were estimated by means of the Cohen's d. Univariate binary logistic regression models have been developed, considering Sleep disorders/No Sleep Disorders as outcome variable and screen exposure or neuropsychiatric diagnosis as possible predictive variables, to estimate the Odds Ratios. Multivariate binary logistic regression models have been then developed to estimate the odds of Sleep Disorders (dependent variable), in relation and after adjusting for possible predictive variables, such as age, sex, and neuropsychiatric disorders of the child. An alpha level of 0.05 was used for all statistical analyses. When performing multiple comparisons (up to 16), we adjusted the p-value using the Bonferroni correction. To keep the family-wise error rate at <0.05, the alpha level was thus set at 0.003 for each comparison. We decided to use the more stringent Bonferroni correction given the high number of statistical comparisons included in the study to guard against Type I errors. Results, if not otherwise specified, are given as means ± SDs. All analyses were performed using R Language and Environment for Statistical Computing programme (http://www.R-project.org; accessed September 2021).

3. Results

3.1. Demographics and main clinical features

We collected 1209 questionnaires; out of these, 125 have been withdrawn due to incomplete/unreliable answers, duplicate forms, or age outside the range. Therefore, the final dataset comprised 1084 questionnaires.

Mean age at questionnaires' completion was 8.5 ± 4.1 years (range: 2–18 years; median 8 years). Overall, 569 (52.5%) were males and 515 (47.5%) females. Table 1 summarizes the main characteristics of the included individuals.

In all, 126 individuals (10.7%) reported a neuropsychiatric diagnosis. Epilepsy was present in five subjects (0.4%) and headache in six (0.5%). Other non-neurologic diseases have been reported in 70 children (5.9%), including allergies in 26 subjects (2.2%). A pharmacological treatment was ongoing in 56 subjects (4.8%) (details in Table 1). A rehabilitation therapy was ongoing in 106 subjects (9.0%), with 72 (6.1%) performing speech therapy, 29 (2.4%) physical therapy and/or psychomotricity, 28 (2.4%) psychological therapy, while 31 (2.6%) children have benefited from telerehabilitation during the COVID-19 outbreak.

Table 1
Characteristics of the sample.

Gender	M 569 (52.5%); F 515 (47.5%)
School	
Not in school	19 (1.7%)
Nursery[a]	68 (6.3%)
Kindergarten[a]	255 (23.5%)
Primary school[a]	430 (39.7%)
Secondary school[a]	172 (15.9%)
High school[a]	140 (12.9%)
Neuropsychiatric disorders	
Overall	115 (10.6%)
Academic difficulties	47 (4.3%)
Learning Disability	12 (1.1%)
Autism Spectrum Disorder	4 (0.3%)
Attention Deficit Hyperactivity Disorder	22 (2%)
Oppositional Defiant Disorder	0 (0%)
Language Disorder	23 (2.1%)
Anxiety Disorder	16 (1.5%)
Mood Disorder	8 (0.7%)
Tic Disorder	2 (0.2%)
Dyspraxia	3 (0.3%)
Gifted	1 (<0.1%)
Epilepsy	5 (0.5%)
Cerebral Palsy	5 (0.5%)
Headache	5 (0.5%)
Allergies	24 (2.2%)
Drug therapy	
Overall	51 (4.7%)
Antiseizure medications	10 (0.9%)
Antihistamines	13 (1.2%)
Antipsychotics or antidepressants	5 (0.4%)
Benzodiazepines	2 (0.2%)
Melatonin	6 (0.5%)

[a] Italian School System Organization: Nursery: 0–3 years old children; Kindergarten 3–6 years old; primary school: 6–10 years; secondary school: 11–13 years old; high school 14–18 years old.

3.2. Distance online learning and screen exposure

A total of 148 children (13.6%) were attending school through distance online learning at the time of our interview, with 113 (10.4%) individuals using this modality only for a part, and 35 (3.2%) for the whole weekly school time. Overall, 155 children (almost exclusively in the age range of nursery and kindergarten) reported a total absence of use of distance online learning during the whole COVID-19 outbreak, which began in March 2020. The mean total daily time spent using devices for school reasons was 0.94 ± 1.04 h before the outbreak, increasing to 3.51 ± 2.53 h during pandemic. There was an increase also in screen exposure for leisure: 1.74 ± 1.58 h and 3.00 ± 2.30 h, respectively, before and during the outbreak.

Fig. 1 reports the total daily screen exposure, both before and during the outbreak. Supplementary Figs. S1 and S2 report the detail for screen exposure due to school or leisure.

Considering the total estimated screen device use throughout the day, whatever the aim of the screen exposure, an increase was observed in 745 children (68.7%).

In particular, 780 children (72%) have been reported to be exposed to devices for school reasons for a larger number of hours. Considering leisure time, 539 children (49.7%) used their devices more.

We also evaluated the different exposure to screens according to the age range. Not surprisingly, older children presented a stronger increase of devices utilization, with 15.6% of children in the primary school, 39.5% in the secondary school, and 62.1% in the high school reaching more than 10 h of exposure throughout the day. However, also younger infants presented an increased use. In particular, children under 3 years of age before the outbreak presented an exposure between 1 and 3 h in 100% of cases, while after the outbreak 22.1% of them were exposed for at least 3 h/day. In the kindergarten, 11% of preschoolers were exposed for at least 3 h before pandemic, increasing to 44.7% after outbreak. Fig. 2 shows the details of the time of exposure according to age groups.

Considering only the evening hours (after 6 p.m.) the increase in the exposure time to devices was observed in 325 children (30%). Considering only the use for school purposes an increase was observed in 260 children (24%), while a non-scholastic use increase was observed in 267 children (24.6%).

Fig. 3 shows the increase of exposure to screens during night.

3.3. Sleep disturbance scale for children

A positive SDSC score, suggesting a sleep disorder, was observed in 240 children (22.1%) before COVID outbreak. Prevalence increased to 367 subjects (33.9%) during the outbreak. When looking for status modifications (sleep disorder no/yes) before and after the outbreak, it emerged that 130 (12.0%) children shifted from no sleep-disorder to sleep disorder (McNemar's chi-squared = 119.37; $p < 0.001$). Looking at the different subscales, there was a new positive score in DIMS in 171 children (15.8%), in SBD in 11 (1.0%), in DA in 31 (2.9%), in SWTD in 85 (7.8%), in DOES in 64 (5.9%), and in SHY in 18 (1.7%). Also the mean total SDSC scores, as well as the subitems scores, changed during the outbreak. Results are reported in Table 2.

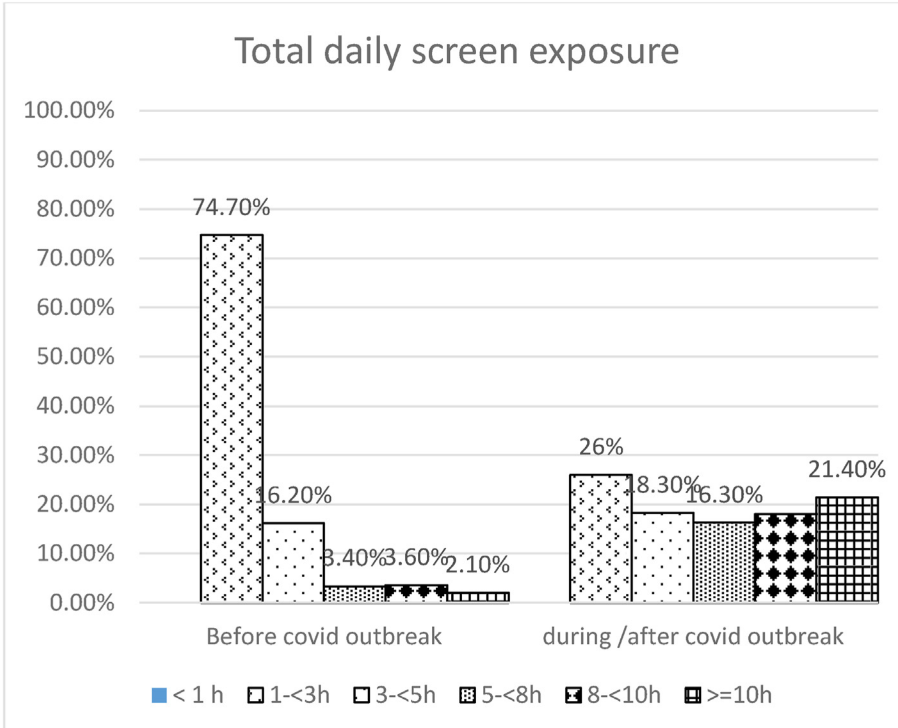

Fig. 1. Chart showing the distribution of total daily screen exposure before and during/after the outbreak. There has been a reduction of children exposed up to 3 h with an important increase for all the ranges of superior exposure.

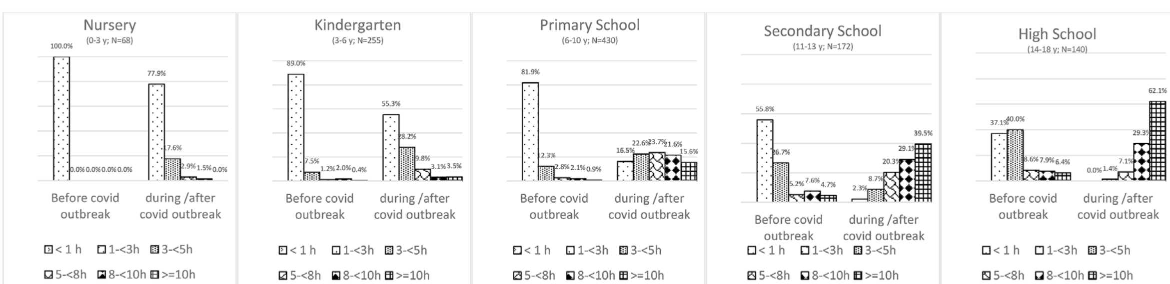

Fig. 2. Increase of exposure to screen devices according to age groups (school attended). The charts show an increase in all the age groups.

3.4. *Analysis of possible factors influencing sleep*

3.4.1. *Before the outbreak*

In univariate logistic regression analyses (Table 3) all the variables of screen exposure (total screen time, daily screen time for school and leisure, total screen time after 6 p.m., and screen time after 6 p.m. both for school and leisure) appeared to increase the odds of a positive total SDSC score. The highest risks were related to daily screen time for school reasons and total screen time after 6 p.m. Furthermore, the presence of a neuropsychiatric disorder was associated as well with an increased risk of a positive SDSC total score. Age, school attended, and gender were not significantly associated to the presence of sleep disorders.

Adding age, gender, and neuropsychiatric conditions as covariates in multivariate binary logistic regression models, increased odds were confirmed for all the analyzed variables (Table 4, for full results Supplementary Table 1).

3.4.2. *During/after the outbreak*

In univariate logistic regression analyses the total screen time, daily screen time for school reasons and for leisure, total screen time after 6 p.m., screen time after 6 p.m. for school reasons and for leisure, appeared to increase the risk of a positive total SDSC score. Furthermore, also a neuropsychiatric diagnosis appeared to increase the risk. School attended, gender, and age did not appear to significantly increase the risk of sleep disorders.

Furthermore, taking into consideration the increase in screen exposure, we found that the increased exposure to screens for both school and leisure (in particular: difference in daily screen exposure for school; difference in daily exposure for leisure; difference in night exposure; difference in night exposure for school; difference in night exposure for leisure; difference in total screen exposure) increased the odds of a positive SDSC score during/after the outbreak.

Finally, we performed univariate and multivariate (Table 5) logistic regression analyses (adding age, gender, and neuropsychiatric conditions as covariates) to look for possible variables associated with the presence of a sleep disorder during/after COVID19 outbreak. In the multivariate analysis age, gender and neuropsychiatric conditions have been added as covariates. Multivariate logistic regression analysis has been performed only in case of statistical significance of the univariate analysis. Full results of the multivariate analysis are available in Supplementary Table 2.

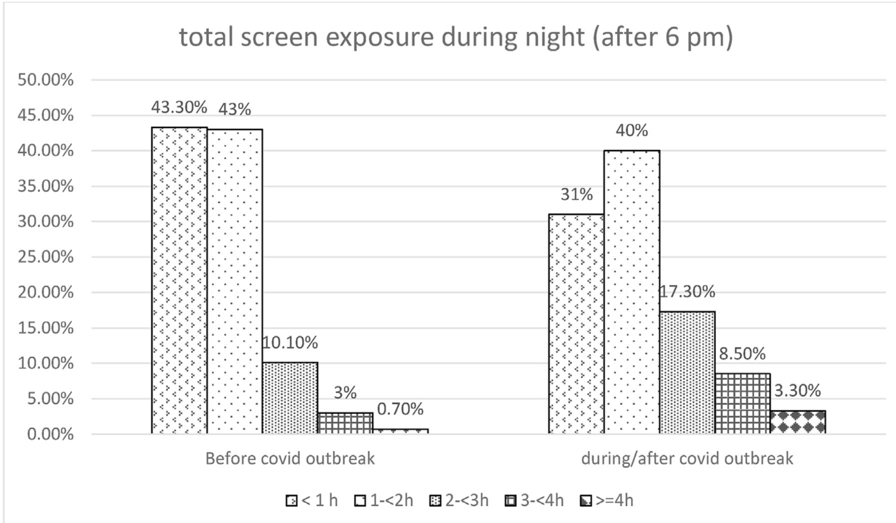

Fig. 3. Chart showing a reduction of children using devices for less than 2 h in the evening time (after 6 p.m.) with a concomitant increase of those exposed for longer time.

Table 2
Comparison of SDSC total and subscales scores (mean ± SD) before and during the Covid outbreak.

	Before covid outbreak	during covid outbreak	T	p-value	Cohen's d
SDSC total	43.8 ± 10.5	47.5 ± 12.9	T = 208,220	< 0.001	0.3
DIMS	13.2 ± 4.2	15.1 ± 5.3	T = 165,644	< 0.001	0.4
SBD	4.1 ± 1.7	4.2 ± 1.8	T = 3289	< 0.001	0.06
DA	3.6 ± 1.2	3.8 ± 1.4	T = 8502	< 0.001	0.1
SWTD	11.0 ± 3.7	11.8 ± 4.1	T = 59,415	< 0.001	0.2
DOES	8.2 ± 2.9	8.9 ± 3.6	T = 49,895	< 0.001	0.2
SHY	3.5 ± 2.2	3.7 ± 2.2	T = 3368	< 0.001	0.09

T = Wilcoxon matched-paired signed-rank test.
Abbreviations. DIMS: difficulties in initiating and maintaining sleep; SBD: sleep related breathing disorders; DA: disorders of arousals; SWTD: sleep-wake transition disorders; DOES: disorders of excessive somnolence; SHY: sleep hyperhydrosis.

Table 3
Before the outbreak - univariate logistic regression. Binary dependent variable: Sleep Disorder/No Sleep Disorder.

	OR (95%CI)	p-value
Total screen time	1.38 (1.19–1.59)	<0.001
Daily screen time for school reasons	1.49 (1.2–1.85)	<0.001
Daily screen time for leisure	1.37 (1.17–1.61)	<0.001
Total screen time after 6 p.m.	1.47 (1.24–1.73)	<0.001
Screen time after 6 p.m. for school reasons	1.32 (1.06–1.66)	0.01
Screen time after 6 p.m. for leisure	1.29 (1.1–1.52)	0.002
Neuropsychiatric condition	2.05 (1.36–3.10)	<0.001
Age	0.99 (0.97–1.03)	0.973
School Attended	1.00 (0.90–1.12)	0.945
Gender	0.81 (0.6–1.08)	0.142

Table 4
Before the outbreaks - adjusted odds ratios and p-values for the multivariate binary logistic regression analysis adjusted for age, gender and presence of neuropsychiatric conditions. Dependent variable: Sleep Disorder/No Sleep Disorder.

	Adjusted OR (95%CI)[a]	p-value
Total screen time	1.47 (1.25–1.72)	<0.001
Daily screen time for school reasons	1.65 (1.3–2.1)	<0.001
Daily screen time for leisure	1.42 (1.19–1.69)	<0.001
Total screen time after 6 p.m.	1.59 (1.32–1.92)	<0.001
Screen time after 6 p.m. for school reasons	1.38 (1.09–1.75)	0.008
Screen time after 6 p.m. for leisure	1.31 (1.1–1.55)	0.002

Full results are available in Supplementary Material. Dependent variable: Sleep Disorder/No Sleep Disorder.
[a] Each adjusted OR refers to the independent variable named in each row.

4. Discussion

In our study we observed that after COVID-19 pandemic the rate of sleep disturbances in childhood appeared to be increased, with a positive total SDSC score observed in 33.9% of children during pandemic versus 22.1% before outbreak. Difficulties in initiating and maintaining sleep appeared as the most important problems, since a new positive score in this area was observed in 15.8% of cases. Furthermore, both the total SDSC total score and all the subscales scores significantly increased during pandemic, with the major effect being given by SDSC total score and, once again, the DIMS subscale, with a significant effect size.

All these data are in good agreement with previous reports showing a significant later bedtime and risetime [19–21], as well as an increased sleep onset latency [8]. Although many reports suggest an increased total sleep time in the 24-h period, results are contradictory [13–16,22]. Furthermore, although different studies reported an increased sleep time with less daily somnolence, this was mainly due to the different school start times during and after pandemic [23], that have actually been restored to previous ones. Although the pandemic in itself is a major cause of the major sleep disturbances, it is interesting to analyze the precise relationship of screen exposure with sleep quality as investigated through SDSC.

Our sample confirmed a previous report of an alarming increase in screen exposure on behalf of children and adolescents during the COVID-19 pandemic [20,21,24–26], with a total of 72% of children using screens more than before the outbreak for school reasons, and 49.7% for leisure. Our data also underlined that the increased

Table 5
Univariate and multivariate logistic regression analysis, dependent variable: sleep disorder/no sleep disorder after pandemic.

	Univariate		Multivariate	
	OR (95%CI)	p-value	Adjusted OR (95%CI)	p-value
Difference in the daily exposure for school reasons	1.38 (1.17–1.62)	<0.001	1.35 (1.09–1.66)	0.005
Difference in the daily exposure for leisure	1.66 (1.35–2.03)	<0.001	1.58 (1.29–1.95)	<0.001
Difference in the night exposure	1.74 (1.4–2.16)	<0.001	1.67 (1.33–2.08)	<0.001
Difference in the night exposure for school reasons	1.47 (1.23–1.75)	<0.001	1.38 (1.14–1.68)	<0.001
Difference in the night exposure for leisure	1.33 (1.06–1.67)	0.015	1.3 (1.03–1.62)	0.02
Overall difference in exposure	1.44 (1.25–1.65)	<0.001	1.44 (1.22–1.7)	<0.001
Age	1.07 (1.02–1.11)	0.003		
School	1.12 (0.99–1.27)	0.079		
Neuropsychiatric Conditions	1.89 (1.14–3.13)	0.014		
Gender	1.12 (0.78–1.62)	0.54		
Daily exposure for school reasons before outbreak	0.88 (0.63–1.22)	0.439		
Daily exposure for leisure before outbreak	0.9 (0.71–1.13)	0.348		
Night exposure before outbreak	0.9 (0.71–1.14)	0.394		
Night exposure for school reasons before outbreak	0.93 (0.66–1.31)	0.665		
Night exposure for leisure before outbreak	0.94 (0.75–1.17)	0.589		
Overall exposure before outbreak	0.86 (0.68–1.09)	0.22		
Daily exposure for school reasons during outbreak	1.27 (1.09–1.48)	0.002	1.22 (0.98–1.52)	0.08
Daily exposure for leisure during outbreak	1.28 (1.09–1.5)	0.002	1.19 (1–1.42)	0.05
Night exposure during outbreak	1.27 (1.08–1.5)	0.004	1.19 (0.99–1.43)	0.06
Night exposure for school reasons during outbreak	1.29 (1.1–1.51)	0.001	1.2 (1.01–1.43)	0.03
Night exposure for leisure during outbreak	1.13 (0.94–1.35)	0.183	1.05 (0.88–1.27)	0.58
Overall exposure during outbreak	1.27 (1.12–1.44)	<0.001	1.26 (1.06–1.49)	0.008

*Each adjusted OR refers to the independent variable named in each row.

use involved all the different age groups, with about 22% of children up to 3 years and almost 45% of those aged 3–6 years spending more than 3 h/day in front of a screen. This study has been conducted after the most significant periods of lockdown and distance learning, suggesting that the lockdown paved the way to a more diffuse and extended exposure to screens. Due to the significant role played by the evening use of electronic devices in influencing night-time sleep, we specifically evaluated the exposure to screens during the evening, observing also in this case a significant increase, both for didactic and leisure reasons.

We analyzed the predisposing factors for a sleep disorder before and during the outbreak, and we observed that age, school attended and gender did not appear to be associated to the presence of sleep disorders. On the other hand this association was found, both before and during pandemic, for neuropsychiatric disorders. This result was expected, since children with neuropsychiatric disorders are known to be much more prone to sleep disorders; furthermore, the sudden lifestyle changes determined by the COVID-19 outbreak have drastically destabilize their sleep schedule due to their important distress susceptibility [27,28]. Besides neuropsychiatric conditions, we obviously decided to focus on the risk factors associated with the use of electronic devices, and we observed that at the baseline the presence of sleep disorders was associated with most of the variables of screen exposure (total screen time, daily screen time for school and leisure, total screen time after 6 p.m. and screen time after 6 p.m. both for leisure). Interestingly, the highest risk was related to daily screen time for school reasons and total screen time after 6 p.m., confirming previous reports underlining that screen time exposure especially after 6 p.m. could be associated with bedtime delay and difficulties in maintaining sleep, as the use of blue light-emitting devices in this time range may represent a disturbance in the timing of sleep cycles due to the interference with endogenous melatonin secretion [4]. However, there are many other factors to be considered, since using electronic devices determines a clear cognitive, emotional and physiological arousal interfering with a good sleep hygiene [5]. Furthermore, recent data underlined that in this view the most important role is played by the so called “displacement” effect [29], meaning that the negative role exerted by using technology in the night-time could be due to the fact that subjects (mainly adolescents) continue using devices past their usual sleep time, thus delaying their sleep onset.

We also performed a more indepth analysis, specifically looking at those children in which there was a variation of time spent in front of electronic devices. We observed that the increased exposure to screens for leisure was significantly associated with the presence of a sleep disorder during/after the COVID-19 pandemic. Once again, the highest risk appeared to be associated with the increased exposure after 6 p.m., thus reinforcing the concept that the use of electronic devices in the late afternoon and in the evening is a crucial risk factors for an alteration of sleep quality and/or quantity.

Our study has different limitations. First, we collected our data from parental answers to an online questionnaire, so we evaluated a subjective perception of their children sleep difficulties, and also comorbidities were exclusively self-reported. We are also aware that self-reported questionnaire are particularly prone to possible intra-observer variability, particularly in relation to small score changes; therefore a thorough within-subject analysis at this stage was not performed. Secondly, we collected our data from April to June 2021, therefore we conducted a partially retrospective analysis on COVID-19 outbreak, resulting in a possible bias linked to incorrect parental observations referred to the past year. Our questionnaire did not investigate the socioeconomical conditions of families, and we are aware that this can strongly influence children's habits and lifestyle, even including devices use and sleep. Also the uneven distribution of participants' age should be considered as a limitation, since most of data came from children up to the primary school, and it is possible that this influenced our results. Furthermore, children are naturally and continuously evolving, and so their sleep do, therefore we can not exclude that some changes in sleep patterns observed in our study were linked to the growing age of children and not specifically to pandemic and its consequences. In addition, the time spent in front of screens was a merely subjective measure, and although we investigate the main reason for use (leisure or school) we had no information on the real purpose of the use, including type of videos, games, active or passive use. Finally, parents of children with sleep disorders might have been more predisposed to participate to this study, with a risk of selection bias.

5. Conclusion

In conclusion, our study suggested that COVID-19 pandemic contributed to modify the lifestyle of a wide sample of children and adolescents, who began to be much more exposed to electronic devices, not only for leisure but also for didactic reasons. This new attitude persisted even after the end of the real lockdown. The time spent in front of screens appeared as a significant risk factor for sleep disorders already before the outbreak, and the increased use was recognized to play a significant role in increasing the rate of sleep disorders during pandemic.

These results underline the importance of sleep hygiene recommendations, that should always be considered as a first-line treatment to promote adequate sleep behaviors in childhood and adolescence as poor sleep quality affects the psychosocial health, the learning efficiency and the academic achievement of adolescents and children. The use of screens above all in the evening hours should be considered in discussing the bed routines, in order to understand if a better usage schedule could help in obtaining a higher quality sleep.

CRediT authorship contribution statement

Romina Moavero: Conceptualization, Writing – original draft, Investigation, Formal analysis. **Valentina Di Micco:** Writing – original draft. **Giusy Forte:** Investigation. **Alessandra Voci:** Investigation. **Luigi Mazzone:** Supervision. **Massimiliano Valeriani:** Supervision. **Leonardo Emberti Gialloreti:** Supervision, Formal analysis, Writing – review & editing. **Oliviero Bruni:** Conceptualization, Supervision, Writing – review & editing.

Declaration of competing interest

None.

Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.sleep.2023.04.009.

References

[1] Wang C, et al. Immediate psychological responses and associated factors during the initial stage of the 2019 coronavirus disease (COVID-19) epidemic among the general population in China. Int J Environ Res Publ Health 2020;17(5).
[2] Organization, W.H. Mental health and psychosocial considerations during the COVID-19 outbreak, 18 March 2020 [cited 2021; Available from: https://apps.who.int/iris/handle/10665/331490. License: CC BY-NC-SA 3.0 IGO; 2020.
[3] Cao W, et al. The psychological impact of the COVID-19 epidemic on college students in China. Psychiatr Res 2020;287:112934.
[4] Tahkamo L, Partonen T, Pesonen AK. Systematic review of light exposure impact on human circadian rhythm. Chronobiol Int 2019;36(2):151–70.
[5] Bruni O, et al. Technology use and sleep quality in preadolescence and adolescence. J Clin Sleep Med 2015;11(12):1433–41.
[6] Cellini N, et al. Sleep and psychological difficulties in Italian school-age children during COVID-19 lockdown. J Pediatr Psychol 2021;46(2):153–67.
[7] Operto FF, et al. Impact of COVID-19 pandemic on children and adolescents with neuropsychiatric disorders: emotional/behavioral symptoms and parental stress. Int J Environ Res Publ Health 2022;19(7).
[8] Bruni O, et al. Changes in sleep patterns and disturbances in children and adolescents in Italy during the Covid-19 outbreak. Sleep Med 2021;91:166–74.
[9] Becker SP, Gregory AM. Editorial Perspective: perils and promise for child and adolescent sleep and associated psychopathology during the COVID-19 pandemic. JCPP (J Child Psychol Psychiatry) 2020;61(7):757–9.
[10] Wang G, et al. Mitigate the effects of home confinement on children during the COVID-19 outbreak. Lancet 2020;395(10228):945–7.
[11] Cellini N, et al. Changes in sleep pattern, sense of time and digital media use during COVID-19 lockdown in Italy. J Sleep Res 2020;29(4):e13074.
[12] Guo YF, et al. Physical activity, screen exposure and sleep among students during the pandemic of COVID-19. Sci Rep 2021;11(1):8529.
[13] Moore SA, et al. Few Canadian children and youth were meeting the 24-hour movement behaviour guidelines 6-months into the COVID-19 pandemic: follow-up from a national study. Appl Physiol Nutr Metabol 2021;46(10):1225–40.
[14] Lopez-Bueno R, et al. Health-related behaviors among school-aged children and adolescents during the Spanish covid-19 confinement. Front Pediatr 2020;8:573.
[15] Kahn M, et al. COVID-19 babies: auto-videosomnography and parent reports of infant sleep, screen time, and parent well-being in 2019 vs 2020. Sleep Med 2021;85:259–67.
[16] Kahn M, Gradisar M. Sleeping through COVID-19: a longitudinal comparison of 2019 and 2020 infant auto-videosomnography metrics. JCPP (J Child Psychol Psychiatry) 2022;63(6):693–700.
[17] Bruni O, et al. The Sleep Disturbance Scale for Children (SDSC). Construction and validation of an instrument to evaluate sleep disturbances in childhood and adolescence. J Sleep Res 1996;5(4):251–61.
[18] Romeo DM, et al. Application of the sleep disturbance scale for children (SDSC) in preschool age. Eur J Paediatr Neurol 2013;17(4):374–82.
[19] Pietrobelli A, et al. Effects of COVID-19 lockdown on lifestyle behaviors in children with obesity living in verona, Italy: a longitudinal study. Obesity 2020;28(8):1382–5.
[20] Moore SA, et al. Impact of the COVID-19 virus outbreak on movement and play behaviours of Canadian children and youth: a national survey. Int J Behav Nutr Phys Activ 2020;17(1):85.
[21] Liu Z, et al. Sleep of preschoolers during the coronavirus disease 2019 (COVID-19) outbreak. J Sleep Res 2021;30(1):e13142.
[22] Zreik G, et al. Maternal perceptions of sleep problems among children and mothers during the coronavirus disease 2019 (COVID-19) pandemic in Israel. J Sleep Res 2021;30(1):e13201.
[23] Team AR, et al. Stay-at-home circumstances do not produce sleep disorders: an international survey during the COVID-19 pandemic. J Psychosom Res 2020;139:110282.
[24] Bruni O, et al. The impact of lockdown on sleep patterns of children and adolescents with ADHD. J Clin Sleep Med 2021;17(9):1759–65.
[25] Guan H, et al. Promoting healthy movement behaviours among children during the COVID-19 pandemic. Lancet Child Adolesc Health 2020;4(6):416–8.
[26] Xiang M, Zhang Z, Kuwahara K. Impact of COVID-19 pandemic on children and adolescents' lifestyle behavior larger than expected. Prog Cardiovasc Dis 2020;63(4):531–2.
[27] Angriman M, et al. Sleep in children with neurodevelopmental disabilities. Neuropediatrics 2015;46(3):199–210.
[28] Belli A, et al. Children with neurodevelopmental disorders: how do they sleep? Curr Opin Psychiatr 2022;35(5):345–51.
[29] Gradisar M, et al. Sleep's role in the development and resolution of adolescent depression. Nat Rev Psychol 2022;1(9):512–23.