


RESEARCH ARTICLE

Association between quality of sleep and screen time during the COVID-19 outbreak among adolescents in the United Arab Emirates

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Summary

The COVID-19 pandemic had a major impact on people of all ages. Adolescents' exposure to online learning is linked to excessive screen time on digital devices, which leads to poor sleep quality. This study aimed to investigate the association between screen time on different electronic devices and sleep quality among adolescents in the United Arab Emirates. This study was based on a self-reported questionnaire, which was administered online to school-aged adolescents (aged 12–19 years). The multicomponent questionnaire collected information on sociodemographic characteristics, sleep quality using the Pittsburgh Sleep Quality Index (PSQI), and screen time (minutes) on TV, TV-connected devices, laptops, smartphones, and tablets on weekdays, weeknight, and weekends using the Screen Time Questionnaire (STQ). Univariate and multivariate analyses were used to identify factors correlated with poor sleep quality. A total of 1720 adolescents were recruited from private and public schools (mean age 14.6 ± 1.97 years). The mean PSQI score was 8.09 ± 3.37 , and 74.3% of participants reported poor sleep (cutoff score >5). Mean scores were highest for the sleep latency (1.85 ± 0.97) and sleep disturbance (1.56 ± 0.62) domains. The highest STQ score was observed for smartphones, with a median screen time of 420 min on weekdays and 300 min on weekends. Screen time related to smartphones on weekends ($p = 0.003$) and increased screen time in bed

($p < 0.001$) were significantly associated with poor sleep. Our results confirmed the correlation between sleep and screen time in adolescents. The results may inform educational policies that target screen time and sleep among adolescents during and after the COVID-19 pandemic.

KEYWORDS

adolescents, COVID-19, digital screens, screen time, sleep quality, smartphone

1 | BACKGROUND

The sudden outbreak of the coronavirus (COVID-19) pandemic created unprecedented disruptions to economies, societies, and healthcare systems (Algahtani et al., 2021; Chen et al., 2021; Khodami et al., 2021). The pandemic also imposed a significant public health burden and negatively impacted people's quality of life, especially given the uncertainty about disease progression, economic shutdowns, and governmental application of measures such as social distancing and lockdowns/home confinement (Algahtani et al., 2021; Chen et al., 2021; Khodami et al., 2021).

The adolescent population was particularly challenged by COVID-19, and many adolescents reported that the quality of their sleep was disturbed (Liu et al., 2021; Zhou et al., 2020). Factors associated with the pandemic, such as home confinement, school shutdowns, transitioning to remote learning, decreased levels of physical activity, increased levels of stress, and loneliness contributed to poor sleep quality among adolescents. In addition, the lack of face-to-face social interactions with peers that previously occurred at school resulted in increased screen time, social media use (especially nighttime mobile phone use) to stay connected with peers. This resulted in late bedtimes, sleep deferral, and mental agitation (Nagare et al., 2019).

Excessive exposure to short-wavelength light associated with the screens of electronic devices (televisions, computers, cell phones, and tablets) is linked to risks for adverse effects, including acute melatonin suppression, delayed sleep, and circadian disruption (Nagare et al., 2019). Even with applications such as Night Shift provided by Apple Inc. or adjusting the screen to "dark mode" may not be sufficient to prevent melatonin suppression and delayed sleep among adolescents (Nagata et al., 2022). A recent systematic review confirmed that the prevalence of sleep problems in children and adolescents during the COVID-19 pandemic had reached an alarming level, with almost half of adolescents not having 8–10 h of sleep per night as recommended for adolescents aged 13–18 years in the National Sleep Foundation guidelines (Sharma et al., 2021).

Sufficient sleep is essential during adolescence (age 13–18 years), as it facilitates a smooth transition to adulthood and helps to ensure their physical and emotional health (Center of Disease Control and Prevention (CDC), 2020). Sleep is a core behaviour of adolescents that consumes up to one-third (or more) of each day and has a vital role in adolescent brain development (CDC, 2020). Sufficient sleep is associated with enhanced attention, cognitive functioning, concentration, expansive thinking, creativity, better school performance, and physical

and mental well-being in adolescents (de Zambotti et al., 2018). Adolescents with sleep difficulties are at risk for reduced learning ability, memory impairment, hyperactivity, decreased attention, lower grades, increased risk for depression, insulin resistance, and diabetes (Shochat et al., 2014; Yan et al., 2019).

Excessive screen time has been identified as the main factor contributing to poor sleep quality in adolescents during the COVID-19 pandemic (Burkart et al., 2022; Stern et al., 2020; Xiang et al., 2020). An experimental study from China ($N = 2427$ children and adolescents) reported that the weekly total screen time associated with using smartphones, TV, laptops, and iPads increased considerably during the pandemic in total (+1730 min [~ 30 h/week] on average) (Xiang et al., 2020). Another study involving US children ($N = 231$) aged 7–12 years reported that the average screen time measured over 6 weeks (2–3 random days/week) during spring and summer over 3 years increased by 97 min during the pandemic compared with pre-pandemic data (Burkart et al., 2022).

Adolescents in the United Arab Emirates (UAE) shared the same burdens associated with COVID-19 with other adolescents worldwide. Since the start of the pandemic, schools were shut down because of the strict measures to prevent the transmission of the virus, and most moved to remote education (Ministry of Education, MOE, 2020). Many parents chose e-learning for their children rather than in-person learning because of concerns about possible infection through school interactions. However, no UAE studies have addressed the impact of COVID-19 on adolescents' sleep or investigated how the increased screen time associated with the shift to online/blended educational models impacted or altered their sleep patterns. As the pandemic progresses, it is necessary to gain a better understanding of sleep and screen time attributed to the increased use of technological devices and the rapid development of screen-based technology. The media landscape has also shifted dramatically, necessitating an examination of device use and its relationship with sleep quality among adolescents. Therefore, this study used a cross-sectional sample of adolescents from UAE schools to investigate the status of sleep quality and screen time and to clarify the relationship between the two factors. In addition, this study attempted to investigate risk factors for poor sleep quality. The results may assist teachers, parents, clinicians, and the Ministry of Education (MOE) in determining and implementing effective policies and interventions for adolescents to use screen-based technology more effectively, while maintaining educational benefits and without impacting their sleep pattern.

2 | MATERIAL AND METHODS

2.1 | Study design

This study used a cross-sectional survey-based design and recruited adolescents from private and public secondary schools across the UAE.

2.2 | Study population and sampling

The target population was adolescents from private and public schools living in the UAE. The World Health Organization (WHO) defines adolescence as the period in human growth and development that occurs after childhood and before adulthood, or age 10–19 years (WHO, 2022). Therefore, we included male and female students aged 10–19 years (grades 7–12) of all nationalities that were attending public and private secondary schools across the UAE at the time of the study. To be eligible for participation, and as per the approved ethical protocol of this study, adolescents were required to declare they had gained approval from their parents/guardians before completing the online survey.

2.3 | Recruitment and sampling

Cluster sampling is recommended when it is difficult to compile a sampling frame that includes all elements of the study population (Levy & Lemeshow, 2013). One-stage cluster sampling of private and public schools was used to obtain a representative sample of the adolescent population in UAE schools. Formation of the cluster in our study using school type was appropriate because we aimed to recruit both Emirati (mostly enrolled in public schools) and expatriate (mainly enrolled in private schools) students, so the sample was representative of the UAE adolescent population.

This study followed the MOE protocol for conducting a research study in schools. First, we obtained ethical approval from the Ministry of Health and Prevention (MOHAP) Research Ethics Committee and the Principal Investigator's Institution. This approval was presented to the MOE Research Unit, which endorsed the ethical approval and then reviewed the protocol and research instruments to ensure the rigor and appropriateness for participants. MOE educational experts also pilot tested the study to ensure a smooth data collection process.

Following MOE approval, the research team was given a list of all public and private secondary schools in the UAE, from which 15 private and 15 governmental/public schools were randomly chosen. Arrangements were made with school principals and the MOE to send an invitation to participate in this study with a survey link (via Lime Survey) to students at the selected schools through the schools' portals. The link included a cover sheet that described this study and sought their consent to participate. Students were informed that participation was entirely voluntary, with no obligation to participate or

penalties (e.g., grades) for non-participation. Data were gathered over a 3-month period, from February to May 2021.

2.4 | Sample size

Sleep quality was chosen as the primary study variable. To calculate the sample size for proportional data, we used a standard sample size calculation method (Naing et al., 2006). Recent epidemiological studies on sleep in the adolescent population during the COVID-19 pandemic found that ~55% of adolescents reported poor sleep quality (Sharma et al., 2021; Zhou et al., 2020). As adolescents in the UAE faced similar challenges related to COVID-19 and its impact on sleep as other adolescents globally, and because no such studies have been conducted in our population, we used the same prevalence rate for poor sleep quality (55%) in our sample size calculation. Based on a 5% margin of error, a 95% confidence interval (CI), and a significance level of 0.05 (two-tailed), an estimated a sample size of 1900 students was required. We included an additional 100 participants ($N = 2000$ in total) to allow for non-responses and control for the design effect associated with cluster sampling, where less precise information is anticipated because people in a cluster tend to be more alike (Naing et al., 2006). The larger sample size also increased precision during multiple comparisons in the statistical analyses and aided in controlling for possible confounding variables (Naing et al., 2006).

2.5 | Data collection instruments

All instruments used in this study were well established and validated in prior research. The entire questionnaire was reviewed by a panel comprising educational experts from the MOE and the principal investigator's institution. Before data collection, pilot testing of the questionnaire and tools was performed with a group of adolescents ($N = 25$) to ensure feasibility, understanding of questions by participants and to identify any ambiguous items in the questionnaire (Polit & Beck, 2017). The research team reviewed the survey items with teachers in the selected schools/classes before launching the survey. This was essential to ensure consistency and understanding of the English version of the tool. We used the English versions of the tools because English is the standardised language of instruction in UAE schools. The survey questionnaire comprised three sections.

2.5.1 | Demographics and general information sheet

Participants' basic demographic information was collected, including age (years), gender, nationality (Emirati or non-Emirati), residency, school type (private or public), grade, medical condition, having a maid in the house (yes or no), exercising regularly (at least 3 days a week) (yes or no), weight change, and self-reported height (cm) and weight (kg). Information was also collected on parents, including their level of

education, marital status, average monthly income, and employment status.

2.5.2 | Pittsburgh sleep quality index (PSQI)

The PSQI was used to assess the quality of sleep of participating adolescents over the past month. This instrument has been used to diagnose sleep disorders in different populations (Buysse et al., 1989; Carpenter & Andrykowski, 1998). It is a self-reported tool comprising 19 items that measure seven sleep components: subjective sleep quality, latency, duration, efficiency, disturbances, use of sleep medication, and daytime dysfunction. Responses to each item range from 0 (not at all) to 3 (all the time), with higher scores indicating poorer sleep/worse sleep or sleep problems/difficulty. The global PSQI score ranges from 0–21 (Buysse et al., 1989; Buysse et al., 1991). A global score >5 indicates poor or impaired sleep quality, and the higher the score the worse the quality of sleep. The original PSQI was found to have sufficient psychometric properties with a high internal consistency reliability index (Cronbach's alpha) of 0.85 (Backhaus et al., 2002). The PSQI has been used to estimate sleep in young adult populations and reported to have adequate psychometric properties with the internal consistency reliability (Cronbach's alpha) for the questionnaire reported as 0.736 (Manzar et al., 2015). A Cronbach's alpha of more than 0.70 is considered an acceptable index of reliability (Nunnally & Bernstein, 1994). In the present study we also ran preliminary reliability testing by measuring the internal consistency reliability (Cronbach's alpha) for the total PSQI scale and all subscales.

2.5.3 | Screen time: Screen time questionnaire (STQ)

The STQ was used to quantify the use of commonly used screen devices among adolescents on a weekly basis within the past month. "Screen use" was defined as the number of hours of interaction with screens for different digital devices in a given time (Dunstan et al., 2010). The STQ is a self-reported 18-item tool that measures the screen use interaction (in minutes) during activity and as background, with five different categories of screen devices (TV, TV-connected devices, laptops/computers, smartphones, and tablets) (Vizcaino et al., 2019). Considering the variation in using technological devices throughout the day/night, weekdays/weekends, the questionnaire asked about screen use on an average weekday, an average weeknight, and an average weekend day (Friday and Saturday in our population), separately (Sigmundová et al., 2016).

We measured screen time as a primary activity as we were interested in exploring the extent of use in online learning during the COVID-19 pandemic lockdown period. The "primary activity" was defined as "the main activity you are engaged in rather than using a television or other screen in the background while performing another

activity, such as cooking or exercising" (Vizcaino et al., 2019). For example: "How many minutes do you spend on different screen devices as a primary activity during an average weekday?" In our survey, we used 15 items to measure the use of the five-screen types as primary activities: TV, TV-connected devices, laptops/computers, smartphones, and tablets (Vizcaino et al., 2019). Measuring screen time during background use was excluded to minimise the number of items, confusion and to obtain a better response as questions were repeated. However, to gain a more accurate picture of the participants' screen time, we added two additional items that measured the screen time needed to complete schoolwork and while in bed (ready to sleep).

The STQ has been used in previous research and demonstrated moderate to excellent test-retest relative reliability. The intra-class correlation coefficient ranged from 0.50 to 0.90 across the different periods studied (Vizcaino et al., 2019). Values of 0.40–0.59 are considered fair reliability, 0.60–0.74 good reliability, and >0.75 excellent reliability (Cicchetti, 1994). Previous authors indicated that the STQ is a useful tool that can be used to appropriately classify individuals into different screen time categories across multiple devices (heavy vs. light users) (Vizcaino et al., 2019). Because the STQ items are stand-alone variables and are not required to conform to a specific scale, measuring the internal consistency reliability for the STQ was not applicable.

2.6 | Ethics statement

All procedures performed in this study were in accordance with the ethical standards followed by the MOE Research Unit and MOHAP Research Ethics Committee (REC). Participation was completely voluntary, and the participants were given the choice to refuse participation without consequences. Students had to declare that their parents approved their participation before proceeding to the online survey. Proceeding to the survey items was considered participants' provision of consent to participate. This method of informed consent was approved by the MOE and MOHAP/REC. The study was approved by the MOHAP/REC and accepted and endorsed by the MOE (approval reference #: MOHAP/DXB-REC/MMM/No.20/2021).

2.7 | Data analysis

The results were described as counts and percent for categorical variables, and mean and standard deviation (SD) for normally distributed continuous variables or median and interquartile range (IQR) for skewed variables. Simple and multiple linear regression analyses were used to identify significant factors for the PSQI score. All analyses were performed using R version 4.1.1 and RStudio version 1.4.1717 for Windows. Values of $p < 0.05$ were considered statistically significant (two-sided).

TABLE 1 Participants' characteristics (N = 1720)

Variable	Category	n	%	Mean	SD
Age (years)				14.60	1.97
Gender	Male	685	39.8		
	Female	1035	60.2		
Nationality	Emirati	373	21.7		
	Non-Emirati	1347	78.3		
Residence	Sharjah	820	47.7		
	Ajman	320	18.6		
	Dubai	280	16.3		
	Abu Dhabi/Al Ain	132	7.6		
	Um-Al-Quwain	60	3.5		
	Ras Al-Khaimah	60	3.5		
	Al-Fujairah	48	2.8		
School type	Public	842	49.0		
	Private	878	51.0		
Grade	Grade 7	314	18.3		
	Grade 8	419	24.4		
	Grade 9	300	17.4		
	Grade 10	230	13.4		
	Grade 11	185	10.8		
	Grade 12	272	15.8		
Study mode	At school	209	12.2		
	Online	1330	77.3		
	Blended	181	10.5		
Medical condition	Yes	197	11.5		
	No	1523	88.5		
Father's education	Illiterate	29	1.7		
	High school	397	23.1		
	Bachelor's	688	40.0		
	Master's	459	26.7		
	PhD	147	8.5		
Mother's education	Illiterate	44	2.6		
	High school	495	28.8		
	Bachelor's	820	47.7		
	Master's	279	16.2		
	PhD	82	4.8		
Mother working	Yes	514	29.9		
	No	1206	70.1		
Maid	Yes	678	39.4		
	No	1042	60.6		
Monthly income	Above average	329	19.1		
	Average	1282	74.5		
	Below average	109	6.3		
Exercising	Yes	783	45.5		
	No	937	54.5		
Weight change	No	488	28.4		
	Gained weight	805	46.8		
	Lost weight	427	24.8		

(Continues)

TABLE 1 (Continued)

Variable	Category	n	%	Mean	SD
Height (cm)				162.62	8.33
Weight (kg)				60.25	15.67

SD, standard deviation.

TABLE 2 Pittsburgh sleep quality index component and global scores (N = 1720)

Score (0–3)	^a Score (0)		Score (1)		Score (2)		Score (3)		Mean	SD
	n	%	n	%	n	%	n	%		
Component 1: Subjective sleep quality	75	4.4	819	47.6	667	38.8	159	9.2	1.53	0.72
Component 2: Sleep latency	178	10.3	419	24.4	608	35.3	515	29.9	1.85	0.97
Component 3: Sleep duration	1156	67.2	257	14.9	189	11.0	118	6.9	0.58	0.94
Component 4: Habitual sleep efficiency	1196	69.5	183	10.6	150	8.7	191	11.1	0.61	1.04
Component 5: Sleep disturbance	32	1.9	785	45.6	818	47.6	85	4.9	1.56	0.62
Component 6: Sleep medication	1320	76.7	153	8.9	87	5.1	160	9.3	0.47	0.95
Component 7: Daytime dysfunction	326	19.0	516	30.0	567	33.0	311	18.1	1.50	1.00
Global score ^b (0–21)									8.09	3.37

SD, standard deviation.

^aA higher score indicates worse sleep problems.

^bMedian = 7; Interquartile range = 5; Minimum = 2; Maximum = 20.

3 | RESULTS

3.1 | Results of the pilot phase

The results of the pilot phase (N = 25) indicated that the survey tools were feasible and acceptable and the items were well received by participants. No unclear or ambiguous items were identified by the pilot study participants. From the pilot phase, 20 (80%) participants reported poor overall poor sleep quality (cutoff score > 5). The highest STQ score was observed for smartphones, with a mean screen time of 400 min on weekdays and 280 min on weekends. The PSQI demonstrated acceptable reliability in the pilot sample with a Cronbach alpha for the total scale of 0.75. The alpha values (α) for the subscales ranged from 0.72 to 0.75, with the highest for component 6 (use of sleep medicine) ($\alpha = 0.75$) and lowest for component 2 (sleep latency) ($\alpha = 0.72$).

3.2 | Participants' characteristics

Of the 2000 adolescents from private and public schools invited to participate in this study, complete responses were received from 1720 students (86.0% response rate). We could not include 280 students because of no consent or missing major data.

Participants' characteristics are presented in Table 1. The majority of participants were female (60.2%) and non-Emirati (78.3%). The mean age was 14.6 ± 1.97 years. More than two-thirds of participants

reported choosing to study online (77.3%) and the remainder either chose blended learning (10.5%) or face-to-face schooling (12.2%). The largest group of participants were from grade 9 (24.4%) followed by grade 7 (18.3%) and grade 8 (17.4%). Almost half (n = 805, 46.8%) reported gaining weight since the start of the pandemic and 54.5% reported they did not exercise regularly during the pandemic. Evaluation of parents' education showed that 40% of fathers and 47.7% of mothers had a bachelor's degree and 70.1% of mothers were not working. Almost two-thirds of participants (74.5%) reported an average family income and 60.6% did not have a maid in the house.

3.3 | Participants' sleep status/quality

Details of the PSQI components and global scores are presented in Table 2. The highest mean score was for sleep latency (1.85 out of a total score of 3), with 35.3% (n = 608) of participants scoring 2 (31–60 min to fall asleep) and 29.9% (n = 515) scoring 3 (>60 min to fall asleep) indicating a longer duration to fall asleep. The second highest mean score was for sleep disturbance/broken sleep (mean score 1.56), with 47.6% (n = 818) of participants scoring 2 and 4.9% (n = 85) scoring 3 (indicating worse sleep disturbance).

Similar mean scores were observed for subjective sleep quality and daytime dysfunction, with mean scores of 1.53 and 1.50, respectively. The mean scores were lower (<1) for sleep duration, habitual sleep efficiency, and sleep medication. The mean global PSQI score was 8.09 ± 3.37 indicating poor sleep quality (cutoff score > 5). The

TABLE 3 Screen time (minutes) on different devices as a primary activity during an average weekday, weeknight, and weekend day (screen time questionnaire) ($N = 1720$)

	Type of screen	Median	IQR ^a
Weekday	TV	60	90
	TV-connected devices	60	60
	Laptop/computer	300	300
	Smartphone	420	194
	Tablet	60	0
Weeknight	TV	15	50
	TV-connected devices	60	60
	Laptop/computer	300	180
	Smartphone	300	240
	Tablet	60	30
Weekend day	TV	15	50
	TV-connected devices	200	180
	Laptop/computer	120	300
	Smart phone	300	300
	Tablet	60	60
	Screen time for completing schoolwork	240	270
	Screen time while in bed	120	120

IQR, interquartile range.

^aSkewed to the right.

majority ($n = 1278$, 74.3%) of participants had a global PSQI score > 5 , indicating poor overall sleep quality.

3.4 | Screen time

Descriptive statistics for screen time (in minutes) are presented in Table 3. During weekdays, the highest median screen time was for using smartphones (420 min or 7 h) followed by laptops/computers (300 min or 5 h). During weeknights, laptops and smartphones had the highest median screen time (300 min each - 5 h), and smartphone screen time was the highest during weekends (300 min or 5 h) followed by TV-connected devices. The median screen time to complete schoolwork was 240 min (4 h) and the median screen time while in bed was 120 min (2 h).

3.5 | Factors associated with global PSQI score

The results of the univariate and multivariate analyses are presented in Table 4. In the simple linear regression analysis, 12 variables were significantly associated with a high global PSQI score (poor sleep quality): being female, older age groups, being in public schools, higher grades, not having medical conditions, not exercising, screen time with TV, screen time with laptops/computers on weekdays, screen time with laptops/computers and smartphones on weeknights, screen time with a smartphone on weekends, and screen time in bed. Variables

significantly associated with PSQI score were then entered into a multiple linear regression model. This showed that only eight variables were independently associated with a high global PSQI score after controlling for potential confounding variables: being female ($p < 0.001$), non-Emirati (expatriate) nationality ($p = 0.015$), higher school grades ($p < 0.019$), not having a medical condition ($p < 0.001$), older age ($p = 0.012$), less screen time on TV during weekdays ($p = 0.049$), more screen time with smartphones during weekends ($p = 0.003$), and more screen time in bed ($p < 0.001$).

4 | DISCUSSION

This study provided insights into and increased understanding of sleep patterns and screen time among adolescents, which can be used to guide education policies around remote learning and home schooling. The findings can also be used to re-evaluate the role of parents and educators in promoting sleep and the effective use of digital devices in the vulnerable adolescent population, not only during the pandemic but also afterward. Hybrid learning will continue to be the new normal following the COVID-19, with a continuous reliance on digital devices.

Our findings showed that nearly two-thirds of the participants reported poor sleep quality, with sleep latency and sleep disturbance being the most problematic sleep components. These results were comparable with existing research that reported a poor sleep quality pattern during the COVID-19 pandemic (Becker et al., 2021; Burkart et al., 2022; Stern et al., 2020; Xiang et al., 2020). A recent large-scale survey-based study of UK school children and adolescents ($N = 18,642$) reported that 46.4% of secondary school adolescents over age 10 years experienced poor sleep quality, with almost half reporting their sleep had deteriorated during the pandemic (Illingworth et al., 2022). Compared with before the pandemic, older adolescents reported significant delays in bedtime (sleep latency), longer sleep duration, and significant difficulty falling asleep ($p < 0.001$) during the pandemic (Illingworth et al., 2022). Another cross-sectional study that included 305 Brazilian adolescents with chronic health conditions (mean age 14 years) and 82 healthy adolescents (mean age 15 years) used the PSQI to estimate sleep quality; both groups reported poor sleep (PSQI score > 5 in 38% and 48%, respectively) (Helito et al., 2021). Similar to our findings, the highest mean scores were for sleep latency and sleep disturbance in both groups of adolescents (Helito et al., 2021).

Two similar studies from China using PSQI reported similar findings regarding sleep quality. One study found that 18.6% of high school students aged >16 years ($N = 569$) during the COVID-19 pandemic had poor sleep quality (PSQI > 5) with a mean score of 3.39 ± 2.64 (Zhai et al., 2021). Consistent with our findings, sleep latency and sleep disturbance had the highest PSQI domain scores at 0.83 and 0.64, respectively (Zhai et al., 2021). In addition, another longitudinal study from China that analyzed the impact of COVID-19 on adolescents' sleep (mean age 13.56 ± 1.46 years) during the three waves of the pandemic found a steady increase in the percentage of

TABLE 4 Single and multiple linear regression analyses of factors associated with sleep quality (N = 1720)

Factors	Simple linear regression			Multiple linear regression		
	Crude <i>b</i>	(95% CI)	<i>p</i> -value	Adj. <i>b</i>	(95% CI)	<i>p</i> -value
Gender ^a (Female)	1.233	(0.912, 1.554)	<0.001	0.905	(0.583, 1.227)	<0.001
Nationality ^b (Non-local)	0.345	(-0.042, 0.732)	0.080	0.467	(0.092, 0.842)	0.015
Residence ^d (Dubai)	-0.204	(-0.565, 0.157)	0.268			
(Other)	0.396	(-0.128, 0.92)	0.139			
School type ^e (Private)	-0.426	(-0.745, -0.108)	0.009			
Grade ^f (8)	0.511	(0.020, 1.002)	0.041	0.675	(0.167, 1.182)	0.009
(9)	0.930	(0.399, 1.461)	0.001	0.887	(0.243, 1.531)	0.007
(10)	0.599	(0.029, 1.17)	0.040	0.941	(0.153, 1.729)	0.019
(11)	0.800	(0.191, 1.41)	0.010	1.265	(0.303, 2.227)	0.010
(12)	1.353	(0.808, 1.897)	<0.001	2.168	(1.073, 3.263)	<0.001
Study type ^g (Online)	0.265	(-0.228, 0.758)	0.291			
(Blended)	0.124	(-0.548, 0.797)	0.717			
Back to school ^h (No)	0.280	(-0.068, 0.627)	0.114			
Medical condition ^h (No)	-0.915	(-1.414, -0.415)	<0.001	-0.995	(-1.474, -0.517)	<0.001
Father's Edu. ^j (High school)	-0.289	(-1.561, 0.983)	0.656			
(Bachelor's)	0.102	(-1.152, 1.356)	0.873			
(Master's)	-0.182	(-1.448, 1.085)	0.779			
(PhD)	0.352	(-0.992, 1.696)	0.608			
Mother's Edu. ^j (High school)	0.538	(-0.502, 1.579)	0.310			
(Bachelor's)	0.698	(-0.325, 1.722)	0.181			
(Master's)	0.845	(-0.228, 1.918)	0.122			
(PhD)	1.249	(0.013, 2.486)	0.048			
Mother working ^h (No)	-0.172	(-0.52, 0.177)	0.334			
Maid ^h (No)	-0.250	(-0.576, 0.077)	0.134			
Monthly income ^k (Average)	0.379	(-0.03, 0.788)	0.069			
(Below average)	0.427	(-0.304, 1.158)	0.252			
Exercising ^h (No)	0.650	(0.331, 0.969)	<0.001			
Weight change ^m (Gain)	-0.044	(-0.424, 0.335)	0.819			
(Loss)	0.312	(-0.126, 0.75)	0.163			
Age, years	0.115	(0.034, 0.196)	0.006	-0.234	(-0.416, -0.053)	0.012
Height, cm	-0.005	(-0.024, 0.015)	0.644			
Weight, kg	-0.001	(-0.011, 0.009)	0.847			
Siblings, <i>n</i>	0.036	(-0.045, 0.118)	0.383			
Mother's work (h)	0.134	(-0.057, 0.325)	0.169			
TV (wd)	-0.002	(-0.005, 0.000)	0.020	-0.002	(-0.004, 0.000)	0.049
TV-connected devices (wd)	-0.001	(-0.002, 0.001)	0.279			
Laptop/computer (wd)	0.001	(0.000, 0.002)	0.024			
Smart phone (wd)	0.001	(0.000, 0.002)	0.091			
Tablet (wd)	0.001	(-0.001, 0.003)	0.222			
TV (wn)	-0.001	(-0.003, 0.001)	0.203			
TV-connected devices (wn)	0.000	(-0.002, 0.001)	0.604			
Laptop/computer (wn)	0.001	(0.000, 0.003)	0.033			
Smart phone (wn)	0.003	(0.002, 0.004)	<0.001			
Tablet (wn)	0.002	(0.000, 0.003)	0.098			
TV (we)	-0.001	(-0.003, 0.000)	0.145			

TABLE 4 (Continued)

Factors	Simple linear regression			Multiple linear regression		
	Crude <i>b</i>	(95% CI)	<i>p</i> -value	Adj. <i>b</i>	(95% CI)	<i>p</i> -value
TV-connected devices (we)	-0.001	(-0.002, 0.001)	0.269			
Laptop/computer(we)	0.001	(0.000, 0.002)	0.222			
Smart phone (we)	0.003	(0.002, 0.004)	<0.001	0.001	(0.001, 0.002)	0.003
Tablet (we)	0.001	(-0.001, 0.002)	0.497			
Screen time for schoolwork	0.000	(-0.001, 0.001)	0.608			
Screen time while in bed	0.005	(0.004, 0.006)	<0.001	0.004	(0.003, 0.006)	<0.001

Reference level: ^amale; ^blocal; ^c(10-15); ^dSharjah; ^epublic; ^f(7); ^gat school; ^hyes; ⁱilliterate; ^kabove average; ^mno change. Crude *b*, crude regression coefficient; Adj. *b*, adjusted regression coefficient; wd, weekday; wn, weeknight; we, weekend (all screen times are in minutes); CI, confidence interval.

poor sleep (21% in wave 1, 21.9% in wave 2, and 26% in wave 3) (Wang et al., 2021). Such findings may further emphasize that adolescents globally suffered from poor sleep during the lockdown period associated with the COVID-19 pandemic. Previous studies emphasized the importance of having awareness campaigns involving parents, adolescents, social media, and schools to address sleep quality improvement in adolescents. Education about the importance of sleep hygiene practices is critical to mitigate the impact of poor sleep quality on students' health and well-being.

Conversely, there have been indications of improved sleep quality, with some studies finding adolescents having had a longer sleep duration during COVID-19, which had a beneficial effect on overall sleep quality (Socarras et al., 2021). In a qualitative study from Canada involving adolescents from multi-ethnic backgrounds ($N = 45$), the participants reported improved overall sleep quality, less daytime sleepiness, and longer sleep duration, but a shift in bedtime with a delay of about 2 h (went to bed and woke up later) (Gruber et al., 2020). Similar studies suggested that delaying high school start times, especially for older adolescents, could be an effective way to extend sleep duration, improve sleep quality, reduce daytime sleepiness, and lower adolescents' stress (Bowers & Moyer, 2017; Wahlstrom & Owens, 2017).

As noted in our study, the shift in sleep cycle (delayed sleep/wake behaviours) in adolescents during lockdown periods is associated with difficulties initiating and maintaining sleep (Helito et al., 2021; Illingworth et al., 2022; Wang et al., 2021; Zhai et al., 2021). There remains a gap in understanding sleep quality as most studies were either cross-sectional or retrospective. A large-scale study is needed to clarify if this shift in the sleep cycle leads to better or poorer sleep among adolescents. Comparative studies where sleep can be assessed before the pandemic, during different waves of the pandemic, and after the pandemic will yield better understanding of the patterns of sleep changes among adolescents.

As expected, the participants in our study reported increased screen time, which was consistent with several previous reports that established a link between increased screen time and lockdowns, possibly attributable to the transition to online education. A large cross-sectional study of multiethnic adolescents in the USA ($N = 5412$, aged 12-13 years) found that the mean total daily screen use was 7.70 h/

day (490 min), mostly spent watching or streaming videos, movies, or television shows (2.42 ± 2.45 h/day), multiple-player gaming (1.44 ± 2.21 h/day), and single-player gaming (1.17 ± 1.82 h/day) (Nagata et al., 2022). Another study involving 184 Italian children and adolescents aged 6-18 years (mean age 14.84 ± 2.73 years) found screen use related to smartphones during the second wave of the COVID-19 pandemic (Serra et al., 2021). Compared with the pre-pandemic period, 66.3% of participants spent more than 4 h/day during the COVID-19 pandemic using smartphones, and 103 (56%) children and adolescents used smartphones after midnight in bed at least three times per week. That study reported 58 (31.5%) participants were at high risk for addiction, and addiction to smartphones was documented in 48 (26.1%) participants (Serra et al., 2021).

In our study, the screen time associated with using smartphones (mean 420 min or 7 h) compared with other technological devices was expected. Smartphone accessibility, lack of physical relationships, strict social distancing measures, partial closure of educational institutions, and suspension of the majority of public-related activities may explain this excessive use of smartphones (Serra et al., 2021). The majority of adolescents turned to smartphones for entertainment (telephone calls, videos, online chats, and social networks) to remain connected to their peers, indicating that smartphones provided social benefits, psychological connections, and social support for adolescents during the COVID-19 pandemic (Serra et al., 2021; Singh & Balhara, 2021). However, smartphone screen time for recreational purposes had unfavourable outcomes and meant that adolescents spent their time unproductively, were less concentrated, and had a more superficial approach to learning (Lissak, 2018). Furthermore, smartphone overuse may also lead to adverse clinical outcomes, such as pain in the neck, shoulders, wrists, and fingers, which may indicate musculoskeletal disorders (Lissak, 2018). A large-scale study from Korea (54,243 adolescents, mean age 15.14 years) found that use of a smartphone for ≥ 4 h per day on weekdays was associated with stress perception, depressive symptoms, and suicide-related indicators (Woo et al., 2021). It has been suggested that social media use of >3 h is harmful to adolescents, meaning that effort must be made to minimise smartphone use in this age group (Woo et al., 2021). A recent cross-sectional study from Canada (grades 7-12, $N = 10,076$) revealed that social media use of more than 2 h per day was negatively associated

with school connectedness and academic performance (Sampasa-Kanyinga et al., 2019).

With the accelerated development of technology and digital media applications, further research is needed to determine the types of social media platforms preferred and used most by adolescents (e.g., Instagram, Twitter, Snapchat, YouTube, TikTok, or social networks) (Shimoga et al., 2019). Further research should also focus on the types of activities students engage in when interacting with digital screens during different times of the day to strike a balance between learning/educational activities versus leisure/social activities (Shimoga et al., 2019). Even after the COVID-19 pandemic, such research could help educational leaders and technologists to design applications and personalised programmes for this age group that meet their educational needs, while avoiding the hazardous usage of digital screens.

In our study, screen time associated with smartphone use and using digital devices at bedtime (ready to sleep) was independently associated with poor sleep quality. These findings were expected and consistent with previous research during the COVID-19 pandemic (Singh & Balhara, 2021; Wahlstrom & Owens, 2017). The use of screens of smartphones or any other digital devices at bedtime may simply displace sleep time, leading to adolescents delaying sleep and waking up late, which may negatively affect their daily functioning and quality of life (Dana et al., 2022). The American Psychological Association (2019) recommended avoiding digital screen use for at least 1 h before the usual bedtime of children and adolescents.

Given the available evidence about the correlation between excessive smartphone screen time and using screens at bedtime and poor sleep quality, the WHO (2020) called for urgent interventions to ensure safe and healthy use of digital devices during COVID-19 (WHO, 2020). A collaborative model that involves educational experts, families, and schools must be integrated to encourage adolescents to maintain a daily routine as similar to their pre-COVID routine as possible, especially with regard to sleep habits such as fixed sleep timing, limited use of digital devices at bedtime, and engagement in conversations about sleep hygiene practices (WHO, 2020). Parents should also establish rules to limit screen time and find time to interact with adolescents to minimise inappropriate and excessive interactions with digital media devices that can have a detrimental effect on adolescents' health and well-being (Bozzola et al., 2019). Watching TV with family members is recommended during lockdowns, as our study revealed that watching TV resulted in better sleep quality compared with other devices. It is possible that TV viewing is a social activity that promotes mental relaxation in adolescents, resulting in better sleep at night and less use of digital devices at bedtime.

Interestingly, we found that female and older adolescent groups were independently associated with poorer sleep. These results were also consistent with prior research. A large-scale survey of children and adolescents aged 8–19 years ($N = 18,642$, 60% female) from 230 schools in southern England found that females and older adolescents were more likely to report deterioration in sleep during the lockdown (Illingworth et al., 2022). In addition, similar findings were reported for China, where older adolescents, females attending senior

high school were associated with poor sleep quality (Zhai et al., 2021). Therefore, more attention must be directed to these adolescents with the cooperation of peers, parents, and schools to raise awareness and orientation on sleep hygiene practices. A follow-up with older and female adolescents at college level is recommended to clarify how sleep and screen time may change when transitioning to college life.

Of note, we found that adolescents who were healthy had poorer sleep quality than those with a chronic condition. These results were consistent with previous research (Zhou et al., 2020). Unlike adolescents with health conditions, healthy adolescents had increased mobile phone use, played more online games, and engaged in online shopping, leading to decreased sleep quality and prolonged sleep latency (Helito et al., 2021). This result supported the finding that excessive screen time in adolescents can negatively alter sleep (Illingworth et al., 2022; Sigmundová et al., 2016). It is therefore important that healthy adolescents are carefully monitored by parents for screen use similar to those with health conditions to limit the impact of excessive screen on their sleep patterns.

In our study, expatriate participants had poorer sleep than Emirati participants. This may be attributed to the fact that expatriate students faced stressors with lockdowns that impacted their sleep quality. In addition to the job losses that occurred in many families, expatriate families had lower socioeconomic status, meaning they may lack adequate physical space, devices, and expensive Internet connections to facilitate online learning; this may impact their anxiety and disturb their quality of sleep, academic performance, and daily functioning (Wang et al., 2021). Therefore, policymakers should secure support and resources for expatriate parents and their children to meet their needs during the pandemic period to mitigate the negative impacts on sleep and well-being. Mental health and psychosocial support activities and therapeutic interventions by parents and schools enable adolescents to cope with COVID-19 burdens and to stay resilient without impacting their sleep and general well-being. More research is needed to integrate psychological constructs as potential predictors of sleep quality.

It is critical to mention that reliance on the self-reported assessment of screen limited our ability to estimate precisely how much screen time was spent with a particular device, particularly as smartphones provide easy access to browsing at any time during the day and at almost any location, and how this may relate to sleep. The use of more objective measures will better capture screen time in the adolescent population (Vizcaino et al., 2019). Furthermore, lockdown requirements meant that we could not have direct access to schools and adolescents to integrate objective measures of sleep. Use of more validated method for objectively measuring sleep parameters (e.g., actigraphy) is recommended in further studies to obtain more accurate data on sleep quality (Smith et al., 2018).

Moreover, it was not possible to derive a causal relationship from the cross-sectional analysis used in the present study, as sleep quality and screen time were assessed at a single time point (temporal relationship). It is also possible that there were unmeasured individual

variables (possible confounding variables) that impacted sleep outcomes in our study besides screen time. Longitudinal studies are needed to establish the true cause and effect relationship between screen time and sleep quality. The lack of comparative data with which to compare the present study was a further limitation because of the reliance on subjective reporting at a single time point. Comparative studies may yield better understanding of the nature of the relationship between screen time and sleep quality in adolescents.

In conclusion we found that poor sleep represents a problem in UAE adolescents, with sleep latency and sleep disturbance being mostly impacted. Guidelines and resources for parents and teachers for safe digital education (cyber-secure) while achieving academic benefits must be available without negatively impacting their sleep. Because there are a variety of personal characteristics and variables that can impact sleep in addition to screen time, it is vital that sleep interventions be individualised. A collaborative, person-centred intervention involving adolescents, their families, schools and educational leaders is suggested to help adolescents use digital devices safely while minimising the negative effect on adolescents' sleep and overall health.

AUTHOR CONTRIBUTIONS

WBI: conceived the study, contributed to data collection analysis, interpreting data and drafting the manuscript. HR contributed to data collection, analysis and interpreting data and drafting the manuscript. RS conceived the study, contributed to data collection, analysis and interpreting data. HH contributed to data collection, analysis and data interpreting. RF contributed to data collection, analysis and interpreting data. MA contributed to data collection, analysis, writing the manuscript. FN contributed to data collection, analysis and interpreting data. AI contributed to data collection, analysis and interpreting data. LN contributed to data collection, analysis and writing report. YNG contributed to data collection, analysis and interpreting data. MA conceived the study, contributed to data collection, analysis and interpreting data. All authors contributed to final design of the study, drafted the manuscript and provided relevant contribution to its intellectual content.

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CONFLICT OF INTEREST

All the authors have no financial relationships relevant to this article to disclose. All authors have no conflicts of interest to disclose.

DATA AVAILABILITY STATEMENT

The data that support the findings of this study are available upon request from the corresponding author. The data cannot be publicly available due to privacy and ethical considerations.

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