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The impact of screen use on sleep health across the lifespan: A National Sleep Foundation consensus statement

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ABSTRACT

Objective: To achieve consensus on whether screen-based digital media (1) in general, (2) via prebedtime content, and (3) via prebedtime light impairs sleep health in (a) childhood, (b) adolescence, and (c) adulthood. Furthermore, to address whether employing behavioral strategies and interventions may reduce the potential negative effects of screens on sleep health.

Methods: The National Sleep Foundation convened a 16-person multidisciplinary expert panel ("Panel"). Panelists met virtually 5 times throughout 2023, during which they followed a modified Delphi RAND/UCLA Appropriateness Method to reach consensus.

Results: The Panel conducted a literature review starting with 2209 articles, narrowed down to 522 relevant empirical articles and 52 relevant review articles. The search was refined to include 35 experimental/intervention studies that examined whether there was a causal link between screen-based digital media and sleep. In addition, panelists reviewed 5 recent relevant systematic review articles. After reviewing the summarized current literature, panelists voted on 10 candidate statements about whether screen use impairs sleep health. The Panel met virtually to discuss the results of the first round of votes, which was then followed by a second round of voting, ultimately achieving consensus on 5 out of the 10 statements.

Conclusions: The Panel achieved consensus that (1) in general, screen use impairs sleep health among children and adolescents, (2) the content of screen use before sleep impairs sleep health of children and adolescents, and (3) behavioral strategies and interventions may attenuate the negative effects of screen use on sleep health.

Monique K. LeBourgeois was a participating panelist before she passed away in November 2023.

Lauren E. Hartstein, Gina Marie Mathew, David A. Reichenberger, and Isaac Rodriguez shared first authorship.

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Introduction

The advent of the modern smartphone in 2007 sparked a revolution in screen-based digital media. Smartphones and other portable light-emitting devices quickly became ubiquitous, and digital media evolved in tandem to drive engagement and hold attention. Screen-based digital media has become an ever-present feature of daily life. Tweens, teens, and adults respectively report using screen-based media for an average of 5.5, 8.5, and 7 hours per day,[1-3] with much of this time occurring in the evening hours preceding and possibly interfering with sleep.[1,3]

Screen-based digital media lengthens the time that individuals spend illuminated by the glow of a screen and remain alert due to engaging, entertaining, or upsetting content, potentially displacing, delaying, or disrupting time spent sleeping. That is, the content of screen-based digital media may evoke psychological consequences (e.g., fear, anxiety, excitement) that drive cognitive arousal, all of which may interact with the light emitted by these devices to delay or disrupt subsequent sleep. Greater use of screen-based digital media, particularly around bedtime,[4] is consistently associated with negative sleep health (i.e., quantity, quality, and daytime functioning[5]) outcomes across the lifespan (although most of the observational studies focus on children and adolescents), often coinciding with later bedtimes and shorter sleep durations.[6–12] However, whether screen-based digital media *causes* worse sleep health is unclear, and the heterogeneity among experimental studies further complicates the synthesis of published literature.

Insufficient sleep duration is both widespread and associated with a higher risk of adverse health outcomes, including obesity, cardiovascular disease, and depression,[13,14] thus presenting a public health challenge.[15] Indeed, between 2016 and 2018, more than one-third of U.S. children and adolescents slept less than the recommended amount for their age group.[16,17] Additionally, between 2010 and 2018, the percentage of working American adults reporting short sleep duration (< 7 hours) increased from 30.9% to 35.6%.[18] Given the public health impact of insufficient sleep, the potential role of screen-based digital media in contributing to poor sleep health requires further understanding and public-facing recommendations.

Despite the consistent empirical literature demonstrating cross-sectional associations between screen-based digital media use and poor sleep health, experimental data demonstrating a causal relationship remain limited and inconsistent. Furthermore, most studies have relied upon self-reported data for both digital media exposure and sleep outcomes and focused on between-person rather than within-person effects, with study designs that fail to elucidate the underlying mechanisms.[19] Proposed mechanisms include screen time displacing sleep, psychological stimulation from screen-based content interfering with sleep, the alerting effects of screen-emitted light on the circadian system, and sleep disruptions from devices themselves (e.g., notifications).[19] While several dozen studies have experimentally explored some of these mechanisms, little has been done to synthesize these results to provide a coherent public health message. Thus, there is a need for consensus-based statements on the effects of screen use on sleep health across the lifespan. This motivated the National Sleep Foundation to convene a consensus panel of experts to conduct a review of the published experimental/intervention literature and develop consensus statements on if, how, when, and for whom screen-based digital media impairs sleep health through the application of a modified Delphi RAND/UCLA Appropriateness Method.[20]

Methods

Participants and development of the research question

The National Sleep Foundation formed a panel of 16 sleep and circadian experts with scientific and/or clinical backgrounds to conduct a systematic review and evaluation of the evidence for a causal impact of screen use on sleep health in children, adolescents, and adults. The panelists were selected based on recommendations from members of the Population Health and Methodology Committee of National Sleep Foundation, which is the committee that proposed the consensus panel. This committee nominated Dr Hale, a member of the committee, to serve on the panel based on her prior work and a highly cited systematic literature review on this topic. The panelists' expertise included sleep and circadian science, psychology, epidemiology, medicine, and public health. To determine appropriate research questions to guide the literature search, panel members suggested various aspects of screen use to consider, including content, duration of use, screen-emitted light exposure, effects of daytime vs. prebedtime use, using screens in the bedroom, and behavioral strategies to reduce screen time, including the effectiveness of light-altering software applications, blue-light blocking glasses, and setting screen time limits. Age-related differences in these recommendations were also considered. Ultimately, the research question, "What is the association between screen use and sleep?" guided the systematic literature review.

Procedures

Five-panel members (LEH, GMM, DAR, IR, and LH) and a Stony Brook University health sciences librarian (JAK) identified published peer-reviewed original research and literature reviews using databases including the National Library of Medicine's PubMed, Elsevier's EMBASE, and Clarivate's Web of Science. The search was limited to articles published in English after 2007, as this is when the first iPhone became commercially available. Keywords, MeSH (Medical Subject Headings) terms, and tiab (title/abstract) terms were generated to identify relevant articles that covered the concepts "screen use" and "sleep." Appendix A shows the full set of search terms and results for each database. After deduplication, the Panel identified 2209 articles using the search terms. Each individual abstract was reviewed and the total was narrowed down to 522 relevant articles that met the following four criteria: (1) original peer-reviewed empirical research, (2) a nonpatient population as the sole group of study or as a comparison group matched to patients, (3) not a meta-analysis or review, and (4) examined association(s) between screen use and sleep health in humans.

To better understand the characteristics of these studies, the 522 relevant articles were then reviewed to identify only articles that included at least one of the following metrics important to screen use and sleep health: (1) objective measure(s) of sleep (n = 58), (2) validated sleep scale(s) (n = 248), (3) objective measure(s) of screen use (n = 30), (4) validated screen use scale(s) (n = 97), (5) repeated measures design (n = 70), (6) experimental or intervention design (n = 42), and (7) specificity/granularity of the type(s) and/or timing of screen use (n = 355).

The Panel discussed these metrics after reviewing the relevant systematic reviews[6,7,10-12] and determined that the largest knowledge gap was whether there is a *causal* association between screen use and sleep health. The original search strategy identified published experimental or intervention studies (n = 34), and panelists identified additional articles (n = 8). Of the 42 published experimental or intervention research studies identified above, some were excluded as unrelated to the overarching research question, leading to our final summary of empirical studies (n = 35).

Review articles

From the initial search and review of 2209 abstracts, the panelists identified 52 review articles related to the topic of screen use and sleep. These review articles were examined for relevance, including recency, age group of focus, and whether they were

systematic vs. narrative reviews. Five articles were identified as fitting criteria for recent systematic review articles examining the association between screen use and sleep health.[6,7,10-12] Of note, there was only one systematic review of experimental or intervention studies.[10]

Panel deliberations and consensus voting

A modified Delphi RAND/UCLA Appropriateness Method[20] was applied to develop the following 10 candidate consensus statements for voting purposes: (1) In general, screen use impairs sleep health, (2) The content of presleep screen use impairs sleep health, (3) Light from presleep screen use impairs sleep health, and (4) Behavioral strategies and interventions can reduce the potentially negative effects of screen use on sleep health. All consensus statements except for #4 were voted separately for each age group, including children (defined as ages 5 through 12 years), adolescents (defined as ages 13 through 19 years), and adults (defined as age 20 years or older). The panelists developed ten statements that were sufficiently covered by extant literature and would be relevant to the public. The statements were not exhaustive. Future consensus panels may consider a different set of statements.

The Panel held five virtual meetings, occurring every other month throughout 2023, to define the goals of the consensus panel, review the RAND/UCLA Appropriateness Method process, discuss literature review strategies and inclusion criteria, share interim literature review findings, develop candidate consensus statements for the voting process, summarize findings of the experimental and intervention literature, and discuss voting procedures and results.[20] As part of the process, after the literature review was conducted and summary spreadsheets were shared with all panelists, there were two rounds of voting in which each panelist provided an agreement score (1-9) on each of the 10 statements (see Appendix B for sample voting ballot) based on published evidence in combination with their professional and/or clinical experience related to the topic. Votes were cast asynchronously by individual panelists and submitted via email to a Panel member (JMD). Between the two rounds of voting, the Panel convened and discussed the results of each of the votes based on the evidence and summaries of the literature. Consensus was considered to be achieved if at least 80% of votes were cast within the same category, either agree, disagree, or uncertain.

Results

Description of the literature

The Panel ultimately reviewed evidence from 35 experimental/intervention studies that examined the effects of screen use on sleep health (19 experimental; 16 intervention) and 5 recent systematic reviews.[6,7,10-12] Panelists were provided a summary spreadsheet as well as a shared folder with the full set of articles in advance of both rounds of voting. Among these studies, nearly half (n = 16; 46%) used objective measures, such as third-party phone applications that passively assessed screen use or screenshots of the phone's native screen use application. The other half (n = 17; 49%) used self-reported measures; one (3%) used both objective and self-reported measures; and one study did not specify. Most studies used self-reported measures of sleep (n = 30; 86%). Others used objective methods to assess sleep, including polysomnography (n = 13; 37%) and actigraphy (n = 4; 11%), or a combination of objective and self-reported sleep measures. Dimensions of sleep included, but were not limited to, sleep onset latency, total sleep time, wake after sleep onset, sleep staging, sleep arousals, sleep efficiency, subjective sleep quality, insomnia symptoms, and sleepiness.

Interventions employed educational content, behavioral modifications, and/or physical methods to mitigate the potential alerting effects of screen-emitted light, such as blue light-blocking glasses or software that altered the screen light color temperature (i.e., reducing the typical cool-temperature, short-wavelength blue light emitted from screens).

The majority of the experimental/intervention studies focused on adolescents (n = 24; 69%), followed by adults (n = 16; 46%) and children (n = 8; 23%), with some studies focusing on more than one age group. Most of the studies on adults (n = 14) examined young adults (< 30 years). Some studies (n = 4; 11%) administered an intervention to guardians and observed effects on their children. The evidence from experimental/intervention studies is summarized in Table 1.

Four out of the five systematic reviews described research regarding the association between screen use and sleep health in both children and adolescents, whereas the fifth focused only on adolescents. Three reviews covered cross-sectional research[7,11,12]; and one article examined effects of screen-use interventions.[10] One systematic review and meta-analysis by Pagano et al[6] examined the longitudinal associations between screen use and sleep health in adolescents as reported within 23 high-quality studies. The analysis indicated that screen use (both through social media and nonsocial media), prolonged screen use, and dysfunctional screen use (including aspects such as cognitively arousing material and addictive behaviors) predicted poorer sleep health (shorter sleep duration, later sleep timing, poorer sleep quality, and insomnia symptoms) at a later time point (ranging from the daily level to 4 years later) in adolescents aged 10-19 years old.

The current evidence suggested that overall screen use and the content of presleep screen use impaired the sleep health of children, but there was minimal published evidence that the light of presleep screen use affected children's sleep health. Few studies of adolescents and adults separately examined the effects of content and light from screens, and therefore, evidence among these age groups was less clear. Among the studies that reported light-related effects,[21-24] effects were typically small or the consequence of laboratory design that did not represent how people typically use screen-based digital media.[25] Evidence for the effectiveness of behavioral strategies and interventions to mitigate the effects of screen use on sleep health was also mixed, with many studies that produced null results. However, strategies that targeted evening interactive screen use were generally successful.

Consensus panel voting

Figs. 1 and 2 depicts the Panel's median agreement ratings (from 1-9) for each statement regarding the effects of screen use on sleep health and whether the statement reached consensus.

Statement 1: In general, screen use impairs sleep health
Part a: Children (5-12 years). The Panel reached consensus and **agreed** that, in general, screen use impairs sleep health for children.

Part b: Adolescents (13-19 years). The Panel reached consensus and **agreed** that, in general, screen use impairs sleep health for adolescents.

Part c: Adults (20+ years). The Panel **did not reach consensus** on whether, in general, screen use impairs sleep health for adults.

Statement 2: The content of presleep screen use impairs sleep health
Part a: Children (5-12 years). The Panel reached consensus and **agreed** that the content of presleep screen use impairs sleep health for children.

Part b: Adolescents (13-19 years). The Panel reached consensus and **agreed** that the content of presleep screen use impairs sleep health for adolescents.

Table 1
Summary of evidence from experimental/intervention studies informing the expert panel

Reference	Primary study design	Sample	Gender distribution (%F)	Age in years: mean ± SD (range)	Exposure (s)	Outcome (s)	Major findings
Dworak et al 2007[31]	Experimental repeated measures	11 male older children and adolescents	0%	13.5 ± 1.0 (12-14)	Playing video game vs. watching movie for 1 h each evening between 18:00-19:00 (2-3 h before BT)	Sleep architecture, continuity, efficiency, WASO, SOL (PSG)	Decreased sleep efficiency after TV vs., baseline; SOL and N2 sleep increased and SWS decreased after video games compared to baseline
Ivarsson et al 2009[46]	Experimental repeated measures	22 male older child and adolescent students	0%	13.3 ± 0.7 (12-15)	Playing violent video game, nonviolent video game, or nothing between 20:00 and 22:00. 1 weekday evening each condition	Self-reported sleep onset, quality, disturbance	BT significantly later after both violent game and nonviolent game, vs. nonvideo game night; After nonviolent game, WT significantly earlier and it was significantly easier to fall asleep (self-report)
Weaver et al 2010[47]	Experimental repeated measures	13 evening-type male adolescents	0%	16.6 ± 1.1 (14-18)	Playing violent video game (*Call of Duty 4*) vs. watching animal documentary (*March of the Penguins*) for 50 min. Each condition tested in evening presleep, 1 week apart.	SOL, sleep architecture (PSG); self-reported sleepiness (ESS)	Video gaming slightly increased SOL and decreased sleepiness, compared to documentary
Garrison et al 2012[48]	Intervention between persons	565 preschool children who consumed at least some media each week	45%	50.9 ± 7.7 mo for intervention; 51.6 ± 7.7 mo for control	12-mo intervention (home visit, mailings, monthly phone calls encouraging parents to replace violent or age-inappropriate media content with quality educational and prosocial content) vs. active control group (nutrition intervention)	Parent-reported sleep problems (CSHQ)	Intervention group had lower odds of any sleep problem at follow-up compared to baseline
Ivarsson et al 2013[49]	Experimental mixed design	30 adolescent males	0%	Range 13-16 ± 0.9	Half of boys habitually played violent computer/video games ≥ 3 h/d (“high-exposed”); other half habitually played ≤1 h or less daily (“low-exposed”). All boys played violent vs. nonviolent video games on 2 weekday nights between 20:00 and 22:00	Self-reported sleep onset, offset, disturbance, quality	High-exposed gamers reported shorter SOL, felt significantly more alert at WT, had significantly higher awakening index vs. low-exposed gamers. Low-exposed gamers reported lower sleep quality after violent video games than high-exposed gamers
King et al 2013[32]	Experimental repeated measures	17 evening-type adolescent males	0%	16 ± 1 (15-17)	Playing violent video game for 150 min vs. 50 min directly before BT for 1 night	TST, SOL, sleep efficiency, architecture (PSG); self-reported sleepiness, SOL, sleep quality, TST, restedness	Night after prolonged video-gaming vs. regular video gaming, TST and efficiency (PSG) decreased and self-reported SOL increased
Heath et al 2014[50]	Experimental repeated measures	16 good-sleeping adolescents	56%	17.4 ± 1.9 (14-19)	Watching videos and playing games for 1 h before BT on bright tablet screen (80 lux) vs. filtered short-wavelength screen (f.lux, 50 lux) vs. dim screen (1 lux) for 1 night each in 3-night protocol	SOL, sREMs, architecture (PSG); self-reported sleepiness	No effects of screen use on subjective sleepiness, SOL, SREMs, SWS, REM, or morning alertness
Chang et al 2015[21]	Experimental repeated measures	12 young adults	50%	24.9 ± 2.9 (range not stated)	Read electronic book at maximum brightness vs. print book for 4 h before BT in 14-d protocol	SOL (PSG); self-reported and EEG-derived sleepiness	Pre-bed reading of light-emitting electronic book decreased subjective sleepiness, decreased EEG delta/theta activity, suppressed melatonin, lengthened SOL, impaired morning alertness vs. control
Harris et al 2015[51]	Intervention between persons	48 high school adolescents	39%	16.7 ± 0.9 (range not stated)	Discontinuing electronic media from 22:00 to wake every night vs. use-as-usual group for 4 wk	Self-reported sleep timing, quality, TST, efficiency, SOL, WASO, daytime functioning	No effects of intervention on any sleep measure

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Table 1 (*continued*)

Reference	Primary study design	Sample	Gender distribution (%F)	Age in years: mean ± SD (range)	Exposure (s)	Outcome (s)	Major findings
Van Der Lely et al 2015[34]	Experimental repeated measures	13 male high school adolescents	0%	16.2 ± 0.7 (15-17)	Wearing blue blockers vs. clear lenses in the evening hours. 2-wk cross-over protocol	Self-reported sleepiness	Participants felt sleepier at end of evening with blue blockers
Grønli et al 2016[22]	Experimental repeated measures	16 young adults	75%	25.1 ± 2.9 (22-33)	Reading stories on iPad vs. printed book for 30 min before sleep. 3-night protocol (1 adaptation night, 2 test nights)	TST, SOL, WASO, arousal index (PSG); self-reported sleepiness	Lower sleepiness and reduced SWS after reading from iPad
Green et al 2017[36]	Experimental repeated measures	19 good-sleeping young adults	58%	24.3 ± 2.8 (20-29)	Screen light at high intensity/short wavelength vs. low intensity/short wavelength vs. high intensity/long wavelength vs. low intensity/long wavelength from 21:00-23:00 for 1 night each in 4 nonconsecutive testing nights across 2 wk.	Sleep continuity and architecture; self-reported sleepiness (ESS)	Short-wavelength light shortened TST, increased WASO, and decreased sleep efficiency vs. long-wavelength light. Short-wavelength light and high-intensity light decreased SWS. greater morning sleepiness after short-wavelength vs. long-wavelength light
Romanzini et al 2017[52]	Intervention between persons	125 high school adolescents	68%	17.1 ± 1.5 (range?)	Group A: no sleep problems, attended no lectures (passive control); group B: sleep problems, attended lecture on sleep hygiene (intervention); group C: sleep problems, attended lecture on bullying (active control); group D: sleep problems and attended no lectures (passive control)	Self-reported sleepiness (ESS) and quality (PSQI)	A lecture on sleep hygiene showed positive effects on sleep quality
Bartel et al 2018[29]	Intervention pre-post	63 adolescents	83%	16.3 ± 0.9 (14-18)	Discontinuing phone use 1 h before BT vs. 1-wk baseline for school week only, 5 nights (Sunday-Thursday night)	Self-reported SOL, sleep timing and duration	During 1-wk phone restriction before BT, participants put phones away earlier, turned lights off earlier, and slept longer, vs. baseline week
Bickham et al 2018[27]	Intervention between persons	529 child and adolescent students	50%	12 (6-8 graders)	Take the Challenge (TtC): 6-wk middle-school-based media education/reduction program to prevent sleep deprivation, dysfunctional behavior, and poor academic performance using content about media effects and media reduction integrated into regular classroom activities. 1 school received TtC intervention; 1 comparison school did not.	Self-reported sleep duration	Students at intervention school viewed less television and had longer sleep duration than comparison group
Chinoy et al 2018[38]	Experimental repeated measures	9 young adults	33%	25.7 ± 3.0	2 sets of 5 consecutive evening readings on LE-tablet vs. printed media. Sessions began at 18:00; 15-min break from 20:45 to 21:00. At 21:05, participant took computerized test. After test, could keep reading or go to sleep.	TST, SOL, sleep onset, WASO (PSG); sleepiness (KDT)	Following LE-tablet nights, self-selected BTs and sleep onset were later, N3 was greater, and WASO and subjective sleepiness were reduced
Green et al 2018[24]	Experimental repeated measures	19 good-sleeping adults	58%	28.1 ± 7.2 (20-45)	One night of "acute" screen use vs. 4 nights of "chronic" screen use from 21:00-23:00 vs. night 1 baseline	Sleep continuity and architecture (PSG); self-reported sleepiness (ESS)	Both acute and chronic use reduced SWS, suppressed melatonin, and increased self-reported daytime sleepiness vs. baseline

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Table 1 (*continued*)

Reference	Primary study design	Sample	Gender distribution (%F)	Age in years: mean ± SD (range)	Exposure (s)	Outcome (s)	Major findings
Jones et al 2018[39]	Experimental repeated measures	8 athletic older adolescents	100%	18 ± 1	Performed puzzles vs. read magazines on tablet vs. paper for 2 h before BT	TST, sleep efficiency, SOL, WASO, sleep architecture (PSG); self-reported sleep quality (PSQI), insomnia symptoms (ISI), sleepiness (ESS), SOL, and restfulness	Self-reported sleepiness increased following tablet-based puzzles, tablet-based reading, and paper-based reading, but not paper-based puzzles. REM latency and percentage of time in REM increased after paper-based puzzles vs. tablet-based puzzles. Participants in tablet-based reading condition had greater REM sleep percentage. Participants in tablet-based puzzles felt less rested vs. tablet-based reading and paper-based puzzles. Participants rated sleep quality higher in paper-based conditions vs. tablet-based
Krossbakken et al 2018[53]	Intervention between persons	1657 guardians and their 1635 children	62% guardians 46% children	10.1 (8-12)	Parent intervention: brief parental guide on regulating video game behavior in children vs. control. Intervention group received a guide in the mail; both groups received questionnaire 4 mo later. All participants told that the study aimed to "map out how parents regulate gaming in children."	Self-reported sleep behavior problems	No significant differences in sleep observed between conditions
Bowler et al 2019[35]	Experimental repeated measures	30 undergraduate older adolescents and young adults	70%	(18-23)	Viewing real Facebook account on tablet with normal settings vs. mock Facebook account with normal settings vs. real account with amber screen filter vs. mock Facebook account with filter	Self-reported quality (PSQI)	Higher quality sleep was reported only when nonpersonal Facebook account was viewed in blue-filtered light
Das-Friebel et al 2019[54]	Intervention between persons	352 adolescent and young adult students	46%	15.1 ± 1.7 (12-21)	School classes assigned to intervention (psychoeducation regarding sleep hygiene and sleep's associations with daily functioning) vs. control (presentation on human dreams and parasomnias and sleep of animals)	Self-reported sleep duration, daytime sleepiness and fatigue, and sleep disturbance (ISI)	Intervention significantly reduced electronic media use in bed before sleep between baseline and follow-up vs. controls. No intervention effects on any sleep measure
Hartmann et al 2019[55]	Experimental repeated measures	18 male adolescents with habitual video gaming and experience playing violent video games	0%	16.8, SD not stated (16-18)	Playing violent video game vs. playing nonviolent board game for 5 h before 1 night of sleep each	SOL, efficiency, WASO, sleep architecture and arousals (PSG)	Night after violent video gaming vs. board gaming: sleep efficiency, time in N2, and time in N1 decreased; arousals/h increased
Laborde et al 2019[56]	Intervention between persons	64 older adolescents and young adults	48%	22.1 ± 3.1 (18-29)	Slow-paced breathing experimental group vs. social media use vs. control group for 15 min before sleep for 30 d	Self-reported sleep quality (PSQI)	PSQI score lower for experimental group vs. control group at post-test; PSQI score in experimental group significantly decreased, indicating higher subjective sleep quality from pre-test to post-test; no significant difference was found for control group

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Table 1 (*continued*)

Reference	Primary study design	Sample	Gender distribution (%F)	Age in years: mean ± SD (range)	Exposure (s)	Outcome (s)	Major findings
Perrault et al 2019[30]	Intervention pre-post	569 adolescent students	53%	15.35 ± 2.1 (12-19)	Reducing use of screen devices after 21:00 during weekdays for 2 wk vs. 2-wk baseline	Actigraphic sleep onset, WT, TST, SE; self-reported BT and WT, SOL, out of bedtime, sleep quality, number of nocturnal awakenings	Reduced screen time after 21:00 had earlier sleep onset and increased total sleep duration. Decreased screen time in evenings preceding school days associated with earlier lights off time and sleep onset time, and longer sleep duration, especially in older adolescents (14-19 years old)
Rogers et al 2019[57]	Intervention pre-post	97 older adolescent and young adult college students	62%	19.8 ± 2.6	Sleep hygiene presentation vs. sleep hygiene presentation + technology-related module vs. control (no intervention)	Self-reported sleep hygiene (SHI)	Technology use before/during bed and social media use at baseline correlated with sleep hygiene after intervention; No differences in sleep between conditions
Combertaldi et al 2021[58]	Experimental repeated measures	32 young adults without an extreme chronotype	66%	22.5 ± 3.0 (range not stated)	Using social media ("media") vs. progressive muscle relaxation ("relaxed") vs. control ("neutral") for 30 min on 1 night before sleep each	TST, sleep quality, SOL, WASO, sleep depth (PSG); self-reported sleep quality and depth, SOL, WASO	Compared to "relaxed" and "neutral" conditions, participants in "media" condition had shorter TST; After progressive muscle relaxation: longer sleep duration, higher sleep efficiency, shorter SOL compared to neutral
Duraccio et al 2021[40]	Experimental between persons	167 healthy-sleeping older adolescents and young adults	71%	20.86 ± 2.1 (18-24)	Phone use with Night Shift enabled vs. disabled vs. no phone use for 60 min before bed across 7 nights	SOL, TST, sleep efficiency, WASO (actigraphy)	No effect of condition on sleep measures across sample; For participants averaging > 6.8 h of sleep, no phone condition resulted in significantly better sleep efficiency vs. other conditions
Graham et al 2021[33]	Intervention between persons	124 older adolescents and adults	76%	22.5 ± 6.8 (18-61)	Limiting use of each social media app to 10 min/d vs. control group using social media as normal for 1 wk	Self-reported sleep quality	Intervention group spent significantly less time on social media vs. control at follow-up; Significant increase in sleep quality for intervention group vs. control
Kent et al 2021[41]	Intervention pre-post	10 older adolescent and young adult undergraduates with problematic online use, contemplating screen use change, using Android smartphone	90%	18-31 (*M* ± SD not stated)	Intervention personalized to each participant to reduce screen time and increase mindfulness/positive behaviors followed by continuation of positive behaviors over 4 wk, vs. 2-wk baseline	Duration (Fitbit); self-reported duration	Most participants' problematic smartphone use decreased, but "clear association between the two could not be determined" due to small sample size; Change in objective screen use varied across participants; 8/10 participants self-reported greater sleep duration postintervention (statistical significance not reported); Most participants had large fluctuations in Fitbit sleep duration but no significant changes overall

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Table 1 (*continued*)

Reference	Primary study design	Sample	Gender distribution (%F)	Age in years: mean ± SD (range)	Exposure (s)	Outcome (s)	Major findings
Lin et al 2021[28]	Intervention between persons	128 parent-child dyads; 129 children	Parents: 49% Children: 53%	Parents: 36.8 ± 5.2 (24-56) Children: 5.6 ± 0.7 (4-6)	Parental education intervention for 50 min/wk over 8 wk to increase knowledge and self-efficacy regarding screen use vs. control group	Self-reported sleep quality, disorder, and disturbances	After intervention, sleep quality was better vs. unchanged in control group
Smidt et al 2021[59]	Experimental between persons	55 older adolescents and young adults owning an iOS smartphone and Mac/Windows laptop they used within 2 h of BT, without f.lux application installed	78%	19.5 ± 1.5 (18-24)	Using laptops, tablets, and smartphones with f.lux installed, which lowered screen color temperature to 2200 K vs. active control (f.lux installed but not activated) in evenings over 2 wk	TST, efficiency, SOL, WASO (actigraphy); self-reported disturbance global score, sleep duration, efficiency, SOL (PSQI), presleep arousal (PSAS), daytime sleepiness (PDSS)	No effects of intervention on any objective or self-reported sleep measure
Bretler et al 2022[26]	Intervention pre-post between persons	70 dyads of parents and their children	Parents: 97% Children: 50%	Parents: 41.4 ± 3.9 Children: 10.7 ± 0.9 (10-12)	Intervention (6 bi-weekly parental workshops on changes during early adolescence, importance of sleep, authoritative parenting style) vs. control (written information on sleep patterns and media exposure in adolescents)	Child's actigraphic sleep onset, duration, efficiency	Intervention reduced video games exposure and led to earlier sleep onset, increased sleep efficiency, and increased sleep duration, which was maintained at follow-up
Pedersen et al 2022[60]	Intervention between persons	89 families with parents working normal day shifts and their children	Parents: 54% Children: 55%	Parents: 41.3 ± 5.2 Children: 9.1 ± 2.6 (6-10)	Families randomly assigned to screen-based media-reduction intervention vs. usual screen-based media use (passive control)	Sleep architecture (PSG) and self-reported bedtime and waketime	No significant between-group mean differences were observed between groups for any sleep outcome
Baselgia et al 2023[37]	Experimental repeated measures	50 older adolescents and young adults with sufficient habitual sleep (6+ h)	78%	22.6 ± 2.6 (18-28)	Watching 3-4 episodes (173 ± 3 min) of suspenseful TV shows vs. neutral TV shows in evening, spaced 1 wk apart	Presleep arousal, sleep efficiency, WASO, and sleep architecture (PSG); self-reported sleep quality	Suspenseful TV shows had minimal impact on sleep. Participants fell asleep faster after suspenseful TV shows than neutral TV shows.
Mahalingham et al 2023[61]	Intervention between persons	107 older adolescent and young adult undergraduate students	53% F; 3% unspecified	21.9 ± 4.0 (17-43)	Deleting social media apps from smartphones for 1 wk vs. passive control using social media as usual	Self-reported insomnia symptoms	No significant interaction between time and social media use; No effects of discontinuing social media use on insomnia

Abbreviations: BT, bedtime; CSHQ, Children's Sleep Habits Questionnaire; EEG, electroencephalography; ESS, Epworth Sleepiness Scale; ISI, Insomnia Severity Index; KDT, Karolinska Drowsiness Test; N1, non-REM stage 1 sleep; N2, non-REM stage 2 sleep; N3, non-REM stage 3 sleep; PDSS, Pediatric Daytime Sleepiness Scale; PSAS, Presleep Arousal Scale; PSG, polysomnography; PSQI, Pittsburgh Sleep Quality Index; REM, rapid eye movement sleep; SHI, Sleep Hygiene Index; SOL, sleep onset latency; sREMs, slow rolling eye movements; SWS, slow-wave sleep; TST, total sleep time; WASO, wake after sleep onset; WT, wake time.
Note. Studies are sorted by year of publication and first author's name.

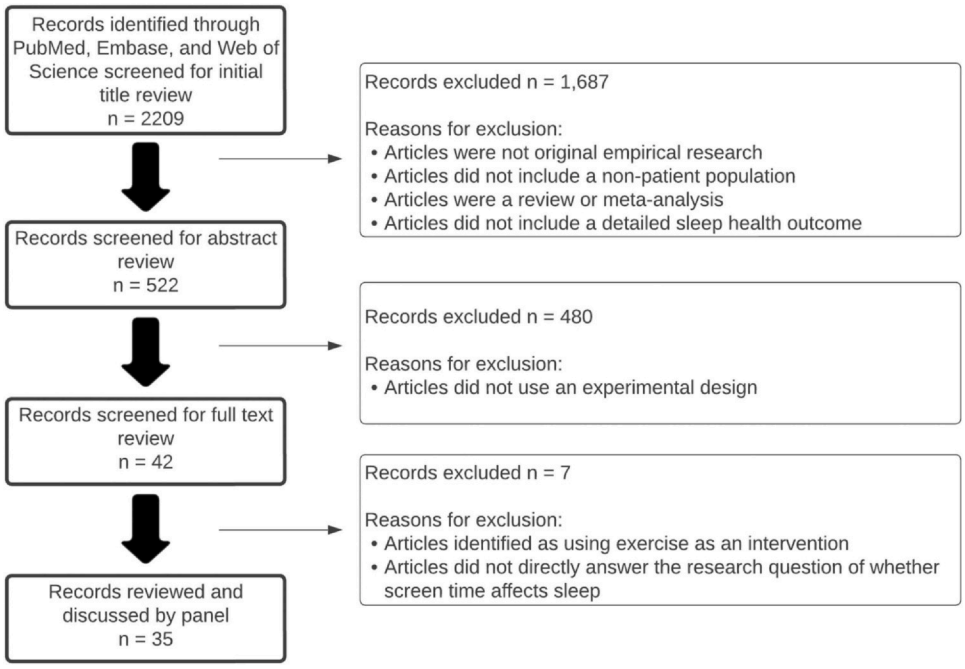

Fig. 1. Flowchart depicting down-selection of literature reviewed by the Panel

Part c: Adults (20+ years). The Panel **did not reach consensus** on whether the content of presleep screen use impairs sleep health for adults.

Statement 3: The light from presleep screen use impairs sleep health
Part a: Children (5-12 years). The Panel **did not reach consensus** on whether the light of presleep screen use impairs sleep health for children.

Part b: Adolescents (13-19 years). The Panel **did not reach consensus** on whether the light of presleep screen use impairs sleep health for adolescents.

Part c: Adults (20+ years). The Panel **did not reach consensus** on whether the light of presleep screen use impairs sleep health for adults.

Statement 4: Behavioral strategies and interventions can reduce potentially negative effects of screen use on sleep health

The Panel reached consensus and **agreed** that behavioral strategies and interventions can reduce potentially negative effects of screen use on sleep health.

Discussion

The National Sleep Foundation expert consensus panel on screen use and sleep health conducted a systematic review of the literature on screen use and sleep across the lifespan with a focus on experimental and intervention research. Based on this review, discussion amongst panel members, and voting across two waves, the Panel reached consensus on the following statements:

1) In general, screen use impairs sleep health for children and adolescents (Statements 1a and 1b).

	Statement	Median agreement rating (range)	Consensus threshold (80%)	Decision
CHILDREN	General screen[a]	7 (5–9)	Consensus (81%)	Agree
	Screen content[b]	7 (6–9)	Consensus (81%)	Agree
	Screen light[c]	7 (4–9)	No consensus (75%)	—
ADOLESCENTS	General screen[a]	8 (5–9)	Consensus (81%)	Agree
	Screen content[b]	7 (5–9)	Consensus (81%)	Agree
	Screen light[c]	6 (4–8)	No consensus (50%)	—
ADULTS	General screen[a]	7 (3–8)	No consensus (75%)	—
	Screen content[b]	7 (5–9)	No consensus (63%)	—
	Screen light[c]	6 (4–8)	No consensus (56%)	—
NOT AGE SPECIFIC	Interventions[d]	7 (5–9)	Consensus (88%)	Agree

Fig. 2. Results of panel consensus voting. *Note.* Consensus recommendations were given as disagree (1-3), uncertain (4-6), or agree (7-9). Consensus was defined as at least 80% of votes falling within any one of the 3-point ranges. [a] "In general, screen use impairs sleep health." [b]"The content of presleep screen use impairs sleep health." [c]"The light from presleep screen use impairs sleep health." [d]"Behavioral strategies and interventions can reduce potentially negative effects of screen use on sleep health."

2) The content of presleep screen use impairs sleep health for children and adolescents (Statements 2a and 2b).
3) Behavioral strategies and interventions can reduce potentially negative effects of screen use on sleep (Statement 4).

The other candidate consensus statements did not reach consensus, meaning that less than 80% of the Panel felt that there was sufficient evidence to agree with the statement; this does not, however, imply that the candidate statements are necessarily untrue as the body of evidence continues to evolve.

Interventions aimed at reducing screen use (regardless of timing) among school-aged children were commonly associated with subsequent improvements in sleep, including earlier bedtimes,[26] longer sleep duration,[26,27] and better sleep quality.[28] Interventions aimed at reducing evening screen use among adolescents were associated with earlier sleep onset and longer sleep duration,[29,30] and experimental studies wherein participants played video games subsequently increased sleep onset latency,[31] shortened sleep duration,[32] and reduced time spent in deep sleep.[31] While not all interventions reported in the literature were successful at reducing screen use and/or improving sleep, many strategies that focused on reducing screen use were associated with improvements in sleep, especially when evening screen use was reduced. More specifically, reducing time spent using digital media devices such as smartphones[29] or televisions[27] or reducing engagement with interactive screen-based content such as video games[26] or social media[27,33] encouraged earlier bedtimes, increased sleep duration, and improved sleep quality.

Panelists did not reach consensus on all statements. In particular, based on the summarized current evidence, consensus was not reached on whether the light emitted by screen-based digital media devices before sleep impairs sleep health nor for any of the substatements concerning adults. Interventions that filtered the transmission of short wavelength "blue light" consistently showed only minimal improvements in sleep health.[34,35] Although several seminal studies of adults reported light-related effects of screen use on sleep,[21,22,24,36] other published studies have reported inconsistent effects and insufficient evidence among adults.[37-41] Adults may be more resilient to the effects of screen use on sleep health due to matured physiology (e.g., smaller pupils, opaque crystalline lenses)[42,43] or the moderating effects of daytime light exposure on evening responses to light.[25,44] Alternatively, there may be insufficient published research to reach consensus at this time. Indeed, much of the observational literature on screen-based digital media and sleep focuses on studies of children and adolescents, including all five of the relevant review articles.

The consensus panel process revealed gaps in the literature and future research needs. In particular, we found gaps concerning objective measurement, causality, and effective interventions. We recommend that future research improve both the objectivity and granularity of data collection regarding screen use and sleep health measures. Screen use data can include more detailed and qualitative information on the content and interactivity of use. For example, some screen-based technology or apps may be used for either therapeutic or sleep-promoting content, which may confer benefits and/or harms. Sleep data can include additional measures such as wake-after sleep onset, sleep efficiency, and sleep regularity, in addition to longer prospective assessment of sleep over multiple days or weeks. Furthermore, additional research may include experimental research designs and develop, test, and implement effective policies, programs, and interventions. Given the lack of consensus for any effect of screen use on sleep health in adults, there lies an opportunity for future research to further evaluate the extent of impact of screen use on adult sleep health.

To summarize, based on the current evidence and expert opinion, the Panel reached consensus on three key themes: (1) In general, screen use among children and adolescents impairs sleep health, (2) The content of screen use before sleep impairs the subsequent sleep health of children and adolescents, and (3) Behavioral strategies and interventions may attenuate the negative effects of screen use on sleep health. As screen-based digital media devices continue to grow in ubiquity as sources of entertainment, information, and communication, beginning in childhood, it becomes imperative to understand the proposed mechanisms and range of effects screen-based digital media devices can have across age groups. While this may seem daunting given the pervasive exposure to these technologies, new insights can help to inform effective educational campaigns and targeted interventions to promote appropriate and healthy screen use and improve sleep health, especially for younger populations.[45] This raises the opportunity to further investigate appropriate and healthy screen use in this population alongside our growing understanding of social drivers and sleep especially in adolescents. The expert panel did not address questions surrounding the duration or timing of screen-based digital media device use and subsequent sleep health. Importantly, the links between screen-based digital media device use and sleep health are likely related to how and when these devices are used—attempts to answer these important considerations should be the focus of future multidisciplinary work. Appropriate use of screen-based digital media devices should be incorporated in healthy lifestyle habits. While complete discontinuation of screen-based digital media devices is unrealistic and fraught with a host of consequences, sensible reduction in overall screen use coupled with avoidance of highly stimulating and interactive content during the presleep wind-down window is a logical starting point. Efforts to identify shared interest and opportunities for public health advocates, families, and industry to act on insights and evidence that help balance goals for screen-based digital media and sleep health is needed. The National Sleep Foundation will use these consensus statements to help guide public-facing recommendations regarding the use of screen-based digital media and sleep health.

Disclosures

All panelists received a small honorarium from the National Sleep Foundation for participation in this consensus panel. In addition, LH receives honoraria for various speaking engagements and is a paid consultant for the Alliance for Sleep by Idorsia. LH ended her term as Editor-in-Chief of Sleep Health in 2020. JMD served on an advisory panel for Eisai Pharmaceuticals, received an honorarium for a presentation given for the Nevada Psychological Association, and is employed by National Sleep Foundation. DAC serves as ad advisor to KIWI Co. NBA has received research funding from Google Health, has acted as a consultant to Snap Inc, and holds an equity interest in and receives salary from Ksana Health Inc.

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Author contributions

The National Sleep Foundation conceived the topic and convened the panel. All authors contributed to the parameters of the literature search and agreed on the questions to be addressed. LEH, GMM, DAR, and IR wrote the original draft. All authors read, edited, and approved the final manuscript. LH chaired the panel and supervised the project as a whole.

Declaration of conflicts of interest

The authors have declared no conflicts of interest.

Appendix A. Supporting information

Supplementary data associated with this article can be found in the online version at doi:10.1016/j.sleh.2024.05.001.

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