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

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Objective: To achieve consensus on whether screen-based digital media (1) in general, (2) via prebedtime content, and (3) via prebedtime light impair 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.

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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 functioning5–7) outcomes across the lifespan (although most of the observational studies focus on children and adolescents), often coinciding with later bedtimes and shorter sleep durations.8–12 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.6,16,17 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 standards 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.

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. Of note, there was only one systematic review of experimental or intervention studies.  

Panel deliberations and consensus voting  

A modified Delphi RAND/UCLA Appropriateness Method 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. 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.

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. 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 and one article examined effects of screen-use interventions. One systematic review and meta-analysis by Pagano et al 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, effects were typically small or the consequence of laboratory design that did not represent how people typically use screen-based digital media. 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>
<thead>
<tr>
<th>Reference</th>
<th>Primary study design</th>
<th>Sample</th>
<th>Gender distribution</th>
<th>Age in years: mean ± SD (range)</th>
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<tbody>
<tr>
<td>Dworak et al 2007</td>
<td>Experimental repeated measures</td>
<td>11 male older children and adolescents</td>
<td>0%</td>
<td>13.3 ± 1.0 (12-14)</td>
<td>Playing video game vs. watching movie for 1 h each evening between 18:00-19:00 (2-3 h before BT)</td>
<td>Sleep architecture, continuity, efficiency, WASO, SOL (PSG)</td>
<td>Decreased sleep efficiency after TV vs. baseline; SOL and N2 sleep increased and SWS decreased after video games compared to baseline.</td>
</tr>
<tr>
<td>Ivarsson et al 2009</td>
<td>Experimental repeated measures</td>
<td>22 male older child and adolescent students</td>
<td>0%</td>
<td>13.3 ± 0.7 (12-15)</td>
<td>Playing violent video game, nonviolent video game, or nothing between 20:00 and 22:00, 1 weekday each condition</td>
<td>Self-reported sleep onset, quality, disturbance</td>
<td>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). Video gaming slightly increased SOL and decreased sleepiness, compared to documentary.</td>
</tr>
<tr>
<td>Weaver et al 2010</td>
<td>Experimental repeated measures</td>
<td>13 evening-type male adolescents</td>
<td>0%</td>
<td>16.6 ± 1.1 (14-18)</td>
<td>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.</td>
<td>SOL, sleep architecture (PSG); self-reported sleepiness (ESS)</td>
<td></td>
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<tr>
<td>Garrison et al 2012</td>
<td>Intervention between persons</td>
<td>565 preschool children who consumed at least some media each week</td>
<td>45%</td>
<td>50.9 ± 7.7 mo for intervention; 51.6 ± 7.7 mo for control</td>
<td>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)</td>
<td>Parent-reported sleep problems (CSHQ)</td>
<td>Intervention group had lower odds of any sleep problem at follow-up compared to baseline.</td>
</tr>
<tr>
<td>Ivarsson et al 2013</td>
<td>Experimental mixed design</td>
<td>30 adolescent males</td>
<td>0%</td>
<td>Range 13-16 ± 0.9</td>
<td>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</td>
<td>Self-reported sleep onset, offset, disturbance, quality</td>
<td>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.</td>
</tr>
<tr>
<td>King et al 2013</td>
<td>Experimental repeated measures</td>
<td>17 evening-type adolescent males</td>
<td>0%</td>
<td>16 ± 1 (15-17)</td>
<td>Playing violent video game for 150 min vs. 50 min directly before BT for 1 night</td>
<td>TST, SOL sleep efficiency, architecture (PSG); self-reported sleepiness, SOL sleep quality, TST, restlessness</td>
<td>Night after prolonged videogaming vs. regular video gaming, TST and efficiency (PSG) decreased and self-reported SOL increased No effects of screen use on subjective sleepiness, SOL, SREMs, SWS, REM, or morning alertness.</td>
</tr>
<tr>
<td>Heath et al 2014</td>
<td>Experimental repeated measures</td>
<td>16 good-sleeping adolescents</td>
<td>56%</td>
<td>17.4 ± 1.9 (14-19)</td>
<td>Watching videos and playing games for 1 h before BT on bright tablet screen (80 lux) vs. filtered short-wavelength screen (Lux. 50 lux) vs. dim screen (1 lux) for 1 night each in 3-night protocol</td>
<td>SOL, sREMs, architecture (PSG); self-reported sleepiness</td>
<td>No effects of screen use on subjective sleepiness, SOL, SREMs, SWS, REM, or morning alertness.</td>
</tr>
<tr>
<td>Chang et al 2015</td>
<td>Experimental repeated measures</td>
<td>12 young adults</td>
<td>50%</td>
<td>24.9 ± 2.9 (range not stated)</td>
<td>Read electronic book at maximum brightness vs. print book for 4 h before BT in 14-d protocol</td>
<td>SOL (PSG); self-reported and EEG-derived sleepiness</td>
<td>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.</td>
</tr>
<tr>
<td>Harris et al 2015</td>
<td>Intervention between persons</td>
<td>48 high school adolescents</td>
<td>39%</td>
<td>16.7 ± 0.9 (range not stated)</td>
<td>Discontinuing electronic media from 22:00 to wake every night vs. use-as-usual group for 4 wk</td>
<td>Self-reported sleep timing, quality, TST, efficiency, SOL, WASO, daytime functioning</td>
<td>No effects of intervention on any sleep measure.</td>
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</table>

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Table 1 (continued)

<table>
<thead>
<tr>
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<tr>
<td>Van Der Lely et al 2015</td>
<td>Experimental repeated measures</td>
<td>13 male high school adolescents</td>
<td>0%</td>
<td>16.2 ± 0.7 (15-17)</td>
<td>Wearing blue blockers vs. clear lenses in the evening hours. 2-wk cross-over protocol</td>
<td>Self-reported sleepiness</td>
<td>Participants felt sleepier at end of evening with blue blockers</td>
</tr>
<tr>
<td>Grønli et al 2016</td>
<td>Experimental repeated measures</td>
<td>16 young adults</td>
<td>75%</td>
<td>25.1 ± 2.9 (22-33)</td>
<td>Reading stories on iPad vs. printed book for 30 min before sleep. 3-night protocol (1 adaptation night, 2 test nights)</td>
<td>TST, SOL, WASO, arousal index (PSG); self-reported sleepiness</td>
<td>Lower sleepiness and reduced SWS after reading from iPad</td>
</tr>
<tr>
<td>Green et al 2017</td>
<td>Experimental repeated measures</td>
<td>19 good-sleeping young adults</td>
<td>58%</td>
<td>24.3 ± 2.8 (20-29)</td>
<td>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.</td>
<td>Sleep continuity and architecture; self-reported sleepiness (ESS)</td>
<td>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 light vs. long-wavelength light. A lecture on sleep hygiene showed positive effects on sleep quality</td>
</tr>
<tr>
<td>Romanzini et al 2017</td>
<td>Intervention between persons</td>
<td>125 high school adolescents</td>
<td>68%</td>
<td>17.1 ± 1.5 (range?)</td>
<td>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)</td>
<td>Self-reported sleepiness (ESS) and quality (PSQI)</td>
<td></td>
</tr>
<tr>
<td>Bartel et al 2018</td>
<td>Intervention pre-post</td>
<td>63 adolescents</td>
<td>83%</td>
<td>16.3 ± 0.9 (14-18)</td>
<td>Discontinuing phone use 1 h before BT vs. 1-wk baseline for week only, 5 nights (Sunday-Thursday night)</td>
<td>Self-reported SOL, sleep timing and duration</td>
<td>During 1-wk phone restriction before BT, participants put phones away earlier, turned lights off earlier, and slept longer, vs. baseline week Students at intervention school viewed less television and had longer sleep duration than comparison group</td>
</tr>
<tr>
<td>Bickham et al 2018</td>
<td>Intervention between persons</td>
<td>529 child and adolescent students</td>
<td>50%</td>
<td>12 (6-8 graders)</td>
<td>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.</td>
<td>Self-reported sleep duration</td>
<td></td>
</tr>
<tr>
<td>Chinoy et al 2018</td>
<td>Experimental repeated measures</td>
<td>9 young adults</td>
<td>33%</td>
<td>25.7 ± 3.0</td>
<td>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.</td>
<td>TST, SOL, sleep onset, WASO (PSG); sleepiness (KDT)</td>
<td>Following LE-tablet nights, self-selected BTs and sleep onset were later, N3 was greater, and WASO and subjective sleepiness were reduced</td>
</tr>
<tr>
<td>Green et al 2018</td>
<td>Experimental repeated measures</td>
<td>19 good-sleeping adults</td>
<td>58%</td>
<td>28.1 ± 7.2 (20-45)</td>
<td>One night of “acute” screen use vs. 4 nights of “chronic” screen use from 21:00-23:00 vs. night 1 baseline</td>
<td>Sleep continuity and architecture (PSG); self-reported sleepiness (ESS)</td>
<td>Both acute and chronic use reduced SWS, suppressed melatonin, and increased self-reported daytime sleepiness vs. baseline</td>
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<tr>
<td>Jones et al 2018</td>
<td>Experimental repeated measures</td>
<td>8 athletic older adolescents</td>
<td>100%</td>
<td>18 ± 1</td>
<td>Performed puzzles vs. read magazines on tablet vs. paper for 2 h before BT</td>
<td>TST, sleep efficiency, SOL, WASO, sleep architecture (PSG); self-reported sleep quality (PSQI), insomnia symptoms (I1), sleepiness (I3), SOL, and restfulness</td>
<td>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.</td>
</tr>
<tr>
<td>Krossbakken et al 2018</td>
<td>Intervention between persons</td>
<td>1657 guardians and their 1635 children</td>
<td>62% guardians 46% children</td>
<td>10.1 (8-12)</td>
<td>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 &quot;map out how parents regulate gaming in children.&quot;</td>
<td>Self-reported sleep behavior problems</td>
<td>No significant differences in sleep observed between conditions</td>
</tr>
<tr>
<td>Bowler et al 2019</td>
<td>Experimental repeated measures</td>
<td>30 undergraduate older adolescents and young adults</td>
<td>70%</td>
<td>(18-23)</td>
<td>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</td>
<td>Self-reported quality (PSQI)</td>
<td>Higher quality sleep was reported only when nonpersonal Facebook account was viewed in blue-filtered light</td>
</tr>
<tr>
<td>Das-Friebel et al 2019</td>
<td>Intervention between persons</td>
<td>352 adolescent and young adult students</td>
<td>46%</td>
<td>15.1 ± 1.7 (12-21)</td>
<td>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)</td>
<td>Self-reported sleep duration, daytime sleepiness and fatigue, and sleep disturbance (I1)</td>
<td>Intervention significantly reduced electronic media use in bed before sleep between baseline and follow-up vs. controls. No intervention effects on any sleep measure</td>
</tr>
<tr>
<td>Hartmann et al 2019</td>
<td>Experimental repeated measures</td>
<td>18 male adolescents with habitual video gaming and experience playing violent video games</td>
<td>0%</td>
<td>16.8, SD not stated (16-18)</td>
<td>Playing violent video game vs. playing nonviolent board game for 5 h before 1 night of sleep each</td>
<td>SOL, efficiency, WASO, sleep architecture and arousals (PSG)</td>
<td>Night after violent video gaming vs. board gaming: sleep efficiency, time in N2, and time in N1 decreased; arousals/h increased 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</td>
</tr>
<tr>
<td>Laborde et al 2019</td>
<td>Intervention between persons</td>
<td>64 older adolescents and young adults</td>
<td>48%</td>
<td>22.1 ± 3.1 (18-29)</td>
<td>Slow-paced breathing experimental group vs. social media use vs. control group for 15 min before sleep for 30 d</td>
<td>Self-reported sleep quality (PSQI)</td>
<td>(continued on next page)</td>
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<tr>
<td>Perrault et al 2019</td>
<td>Intervention pre-post</td>
<td>569 adolescent students</td>
<td>53%</td>
<td>15.35 ± 2.1 (12-19)</td>
<td>Reducing use of screen devices after 21:00 during weekdays for 2 wk vs. 2-wk baseline</td>
<td>Actigraphic sleep onset, WT, TST, SE; self-reported BT and WT, SOL, out of bedtime, sleep quality, number of nocturnal awakenings</td>
<td>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)</td>
</tr>
<tr>
<td>Rogers et al 2019</td>
<td>Intervention pre-post</td>
<td>97 older adolescent and young adult college students</td>
<td>62%</td>
<td>19.8 ± 2.6</td>
<td>Sleep hygiene presentation vs. sleep hygiene presentation + technology-related module vs. control (no intervention)</td>
<td>Self-reported sleep hygiene (SHH)</td>
<td>Technology use before/during bed and social media use at baseline correlated with sleep hygiene after intervention; No differences in sleep between conditions Compared to &quot;relaxed&quot; and &quot;neutral&quot; conditions, participants in &quot;media&quot; condition had shorter TST; After progressive muscle relaxation: longer sleep duration, higher sleep efficiency, shorter SOL compared to neutral</td>
</tr>
<tr>
<td>Combertaldi et al 2021</td>
<td>Experimental repeated measures</td>
<td>32 young adults without an extreme chronotype</td>
<td>66%</td>
<td>22.5 ± 3.0 (range not stated)</td>
<td>Using social media (&quot;media&quot;) vs. progressive muscle relaxation (&quot;relaxed&quot;) vs. control (&quot;neutral&quot;) for 30 min on 1 night before sleep each</td>
<td>TST, sleep quality, SOL, WASO, sleep depth (PSG); self-reported sleep quality and depth, SOL, WASO</td>
<td>Compared to &quot;relaxed&quot; and &quot;neutral&quot; conditions, participants in &quot;media&quot; condition had shorter TST; After progressive muscle relaxation: longer sleep duration, higher sleep efficiency, shorter SOL compared to neutral</td>
</tr>
<tr>
<td>Duraccio et al 2021</td>
<td>Experimental between persons</td>
<td>167 healthy-sleeping older adolescents and young adults</td>
<td>71%</td>
<td>20.86 ± 2.1 (18-24)</td>
<td>Phone use with Night Shift enabled vs. disabled vs. no phone use for 60 min before bed across 7 nights</td>
<td>SOL, TST, sleep efficiency, WASO (actigraphy)</td>
<td>No effect of condition on sleep measures across sample; For participants averaging &gt; 6.8 h of sleep, no phone condition resulted in significantly better sleep efficiency vs. other conditions</td>
</tr>
<tr>
<td>Graham et al 2021</td>
<td>Intervention between persons</td>
<td>124 older adolescents and adults</td>
<td>76%</td>
<td>22.5 ± 6.8 (18-61)</td>
<td>Limiting use of each social media app to 10 min/d vs. control group using social media as normal for 1 wk</td>
<td>Self-reported sleep quality</td>
<td>Intervention group spent significantly less time on social media vs. control at follow-up; Significant increase in sleep quality for intervention group vs. control</td>
</tr>
<tr>
<td>Kent et al 2021</td>
<td>Intervention pre-post</td>
<td>10 older adolescent and young adult undergraduates with problematic online use, contemplating screen use change, using Android smartphone</td>
<td>90%</td>
<td>18-31 (M ± SD not stated)</td>
<td>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</td>
<td>Duration (Fitbit); self-reported duration</td>
<td>Most participants’ problematic smartphone use decreased, but &quot;clear association between the two could not be determined&quot; due to small sample size; Change in objective screen use varied across participants; 8/10 participants self-reported greater sleep duration post-intervention (statistical significance not reported); Most participants had large fluctuations in Fitbit sleep duration but no significant changes overall</td>
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</table>

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

**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.
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).
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, longer sleep duration, and better sleep quality. Interventions aimed at reducing evening screen use among adolescents were associated with earlier sleep onset and longer sleep duration, and experimental studies wherein participants played video games subsequently increased sleep onset latency, shortened sleep duration, and reduced time spent in deep sleep. 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 or televisions or reducing engagement with interactive screen-based content such as video games or social media 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 or for any of the sub-statements concerning adults. Interventions that filtered the transmission of short wavelength “blue light” consistently showed only minimal improvements in sleep. Although several seminal studies of adults reported light-related effects of screen use on sleep, other published studies have reported inconsistent effects and insufficient evidence among adults. 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) or the moderating effects of daytime light exposure on evening responses to light. 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. 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—efforts 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 an 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.

Funding
LEH receives research support from NICHD (F32 HD103390). GMM and DAR are supported by the NICHD (R01 HD073352). DAR is also supported by the NIA and Social Science Research Institute (U2C AG060408) and a grant to the Pennsylvania State University from Kunsan, Inc. AMC is partially supported by R01 HD073352, R01 NS113889, and a grant to the Pennsylvania State University from Kunsan, Inc. JPC is supported by the Canadian Institutes of Health Research and the CHEO Research Institute. JMZ is partially supported by NICHD (R01 HD102344), LH is partially supported by grants from NICHD (R01 HD073352 and R21 HD097491) and the Della Pietra Family Foundation.
Appendix A. Supporting information

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

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