Sleep Duration, Restfulness, and Screens in the Sleep Environment

Jennifer Falbe, ScD, MPH[a], Kirsten K. Davison, PhD[b,c], Rebecca L. Franckle, MPH[b,c], Claudia Ganter, MPH[b,d], Steven L. Gortmaker, PhD[c,e], Lauren Smith, MD, MPH[f], Thomas Land, PhD[g], Elsie M. Taveras, MD, MPH[b,h]

abstract

BACKGROUND AND OBJECTIVE: Associations of inadequate sleep with numerous health outcomes among youth necessitate identifying its modifiable determinants. Television (TV) has been associated with sleep curtailment, but little is known about small screens (eg, smartphones), which can be used in bed and emit notifications. Therefore, we examined associations of different screens in sleep environments with sleep duration and perceived insufficient rest or sleep.

METHODS: Participants included 2048 fourth- and seventh-graders participating in the Massachusetts Childhood Obesity Research Demonstration Study in 2012 to 2013. Using linear and log binomial regression, we examined cross-sectional associations of small screens and TVs in sleep environments and screen time with weekday sleep duration and perceived insufficient rest or sleep in the past week.

RESULTS: Children who slept near a small screen (compared with never) reported 20.6 fewer minutes of sleep (95% confidence interval [CI], −29.7 to −11.4) and had a higher prevalence of perceived insufficient rest or sleep (prevalence ratio, 1.39; 95% CI, 1.21 to 1.60). Children who slept in a room with a TV (compared with no TV) reported 18.0 fewer minutes of sleep (95% CI, −27.9 to −8.1). TV or DVD viewing and video or computer game playing were associated with both sleep outcomes ($P < .01$). Some associations were stronger among Hispanic, non-Hispanic black, and older children ($P < .05$ for heterogeneity).

CONCLUSIONS: Sleeping near a small screen, sleeping with a TV in the room, and more screen time were associated with shorter sleep durations. Presence of a small screen, but not a TV, in the sleep environment and screen time were associated with perceived insufficient rest or sleep. These findings caution against unrestricted screen access in children's bedrooms.

[a]*Division of Community Health and Human Development, School of Public Health, University of California Berkeley, Berkeley, California; Departments of* [b]*Nutrition and* [c]*Social and Behavioral Sciences, and* [e]*Prevention Research Center, Harvard School of Public Health, Boston, Massachusetts;* [d]*Technische Universität Berlin, Berlin, Germany;* [f]*National Institute for Children's Health Quality, Boston, Massachusetts;* [g]*Bureau of Community Health and Prevention, Massachusetts Department of Public Health, Boston, Massachusetts; and* [h]*Division of General Academic Pediatrics, Department of Pediatrics, Massachusetts General Hospital for Children, Boston, Massachusetts*

Dr Falbe designed, conceptualized, and carried out the analysis, interpreted the data, and drafted and revised the manuscript; Dr Davison, Ms Franckle, and Drs Gortmaker, Smith, and Land contributed to the analysis and interpretation and reviewed and revised the manuscript; Ms Gehre contributed to acquisition of data and reviewed and revised the manuscript; Dr Taveras contributed to the design, concept, analysis, and interpretation and reviewed and revised the manuscript; and all authors approved the final manuscript as submitted.

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WHAT'S KNOWN ON THIS SUBJECT: Inadequate sleep has been identified as a risk factor for obesity and other outcomes. Screen time and the presence of a television in the bedroom have been associated with inadequate sleep, but little is known about small screens (eg, smartphones).

WHAT THIS STUDY ADDS: Among 2048 fourth- and seventh-graders, children who slept near a small screen reported shorter sleep durations and perceived insufficient rest or sleep. Presence of a television in the bedroom and more screen time were also associated with poorer sleep.

Accumulating evidence indicates that inadequate sleep is a novel risk factor for obesity in childhood and later in life.[1–7] However, consequences of inadequate sleep extend well beyond obesity. Improving sleep duration and quality may improve somatic and psychosocial health, school performance, and risk-taking behaviors among youth[8] and reduce hypertension, coronary heart disease, and stroke in adulthood.[9,10] Sleep may also play a critical role in immunity.[11] Therefore, the steady decline in child sleep duration throughout the past century is troubling.[12]

Effective sleep promotion necessitates identifying its modifiable determinants in children's environments and routines. Sleep curtailment has widely been attributed to modern lifestyle, especially technology. Fueled by the proliferation of new devices and the affordability of older technologies such as televisions (TVs), youth are now consuming media for the amount of time that most adults spend at work.[13]

Presence of a TV in a child's bedroom and TV viewing have been linked to shorter sleep duration, later bedtimes, and other dimensions of sleep.[14] TV viewing is a risk factor for weight gain,[15,16] decreased academic achievement, and behavioral problems.[15] Although there is ample evidence that food marketing mediates the TV–obesity relationship,[17–20] sleep may also mediate this relationship and others. Possible mechanisms include direct displacement of screen time for sleep, increased cognitive and emotional arousal, and delays in circadian rhythm from screen light.[14] Compared with TV, which involves passive observation, interactive media such as video games and smartphones may be more disruptive of sleep.[21] Smartphones and other Internet-enabled small devices are particularly concerning, because they are portals to almost all content (eg, games, music, videos, Web sites, texts, and e-mail). Because these devices are held near the face, they may delay melatonin release more strongly than TV light, which decays with distance.[22]

Despite the dramatic increase in the use of small screens, few studies have examined children's use of small screens in relation to sleep duration,[23–25] and these studies have taken place outside the United States among predominantly white or Asian youth. However, the presence of a small screen in a child's bedroom may affect sleep beyond use, because unlike TVs, small screens can emit audible notifications (eg, text messages) when not in use. These alerts may not only delay sleep but also interrupt it, thereby reducing overall sleep quality. We are aware of only 1 study assessing small screens in children's sleep environments and sleep duration.[23]

Therefore, we sought to examine associations of small screens and TVs in children's sleep environments and reported screen time with children's sleep duration, perceived insufficient rest or sleep, and usual bedtimes and waketimes. We examined these relationships among racially and ethnically diverse fourth- and seventh-graders attending public schools in 2 Massachusetts cities.

METHODS

Participants and Setting

Data were collected in October through December 2012 as part of the baseline assessment of fourth- and seventh-grade public school students participating in the Massachusetts Childhood Obesity Research Demonstration Study (MA-CORD).[26,27] MA-CORD is a multisector intervention to address childhood obesity in 2 Massachusetts communities. MA-CORD communities are predominantly non-Hispanic white (68%) with large Hispanic populations (17% and 22%).[28] Per capita incomes in MA-CORD communities were substantially lower (~$22 900 and $21 300) than in the state overall (~$35 500) in 2012.[28]

Across 29 schools, 2456 students were invited to participate in the MA-CORD survey administered by school nurses during annual BMI screenings mandated in Massachusetts public schools. All data collection procedures were approved by the internal review board at the Massachusetts Department of Public Health.

Measures

Primary outcomes were usual weekday sleep duration and perceived insufficient rest or sleep in the past week. Secondary outcomes were usual weekday bedtimes and waketimes in the past week. We estimated sleep duration by subtracting self-reported waketime from bedtime, assessed by asking, "On a usual weekday this past week, when did you go to bed at night?" and "On a usual weekday this past week, when did you wake up the next morning?" Child-reported sleep durations from similar surveys have been moderately to strongly correlated with duration from actigraphy and sleep diaries.[29] We assessed perceived insufficient rest or sleep in the past week by using an item modified from the Behavioral Risk Factor Surveillance System Questionnaire[30]: "On how many days in the past week have you felt like you needed more sleep?" Response options ranged from 0 to 7 days. Because of its strongly bimodal distribution, perceived insufficient rest or sleep was modeled dichotomously, as feeling like more sleep was needed most days (ie, >3 days) or ≤ 3 days. In a study examining perceived insufficient rest or sleep and chronic disease risk among adults, a similar cutoff was clinically meaningful.[31]

Primary exposures were screens in children's sleep environments,

including small screens (eg, smartphones) and TVs, assessed with the following item: "Some kids use devices to play games or send text messages or chats to their friends like cell phones, smartphones, and the iPod Touch. How often do you sleep with one of these devices near where you sleep, such as in your bed or next to your bed?" Response options ranged from 0 to 7 days and were dichotomized as ever and never in the main analysis because of the strongly bimodal distribution. However, we also examined exposure as a continuous variable. We determined presence of a TV in the sleep environment by asking, "Is there a television in the room where you sleep?" We assessed additional exposures (TV or DVD viewing and video or computer games in the past week) by asking how much time students spent with each on a usual weekday and weekend in the past week. Moderate validity has been reported for similar surveys of child-reported screen time.[32,33]

Covariates included self-reported gender, grade, race or ethnicity, and physical activity. Students described their race or ethnicity by selecting ≥1 options (white, black or African American, Hispanic or Latino, Asian, Native Hawaiian or other Pacific Islander, American Indian or Alaska Native, or other). Race or ethnicity was categorized into Hispanic, non-Hispanic white, non-Hispanic black, non-Hispanic other (because of small numbers), and non-Hispanic multiracial. We assessed physical activity by asking on which days in the last week students took part in physical activity that made their heart beat fast or made them breathe hard for ≥30 minutes. Days were summed and modeled continuously. Physical activity was included as a covariate to reduce confounding by common determinants of screen time and physical activity (eg, socioeconomic status [SES], parenting).

Analytic Sample

Eligible participants (2061 of 2456) had complete data on sleep, screens in their environment, and covariates. Of the 2061 eligible participants, 13 were excluded because of implausible sleep durations (ie, <3 hours or >16 hours).[34] Therefore, our primary analytic sample consisted of 2048 children. Our sample for examining TV or DVD viewing and video or computer game playing consisted of 1908 youth with complete and plausible screen times (71 youth with TV or DVD or gaming time >3 SDs from the mean were excluded).

Statistical Analyses

Using multivariate linear regression, we examined associations of screens in children's sleep environments and screen time with sleep duration, bedtime, and waketime. Multivariate log binomial regression[35] was used to examine associations between screens in children's sleep environments and perceived insufficient rest or sleep. We used generalized estimating equations for estimation, specifying an exchangeable covariance structure to account for clustering by school.[36,37]

For each outcome, we ran partially (model 1) and fully adjusted (model 2) models. Model 1 adjusted for gender, grade, race or ethnicity, and city. Model 2 additionally adjusted for physical activity, and when exposures were screens in the sleep environment, model 2 simultaneously examined presence of small screens and a TV in the same model; when exposures were screen time, model 2 simultaneously included hours per day of TV or DVDs and video or computer games. We examined heterogeneity by grade, gender, physical activity, and race or ethnicity and tested for interaction between presence of a small screen and a TV by including cross-products of these terms in model 2.

Additionally, small screens can affect perceived insufficient rest or sleep beyond curtailing sleep (eg, by interrupting sleep or shortening rapid eye movement sleep). Consequently, to examine associations between media and aspects of sleep beyond duration, model 3, a model with perceived insufficient rest or sleep as the outcome, additionally adjusted for sleep duration. We conducted analyses by using SAS (version 9.3; SAS Institute, Inc, Cary, NC).

RESULTS

Mean age ± SD of the sample (Table 1) was 10.6 ± 1.5 years. Hispanic (40%), non-Hispanic white (38%), and non-Hispanic black (10%) were the predominant racial and ethnic groups. The majority reported sleeping near small screens (54%) and in a room with a TV (75%). A higher proportion of seventh-graders (65%) reported sleeping near a small screen than fourth-graders (46%). Seventh-graders also reported shorter sleep durations (8.8 hours) than fourth-graders (9.8 hours) but were less likely to have perceived insufficient rest or sleep.

Associations between screens in sleep environments and sleep duration are presented in Table 2. Described here are results from fully adjusted models (model 2). Children who slept near a small screen reported 20.6 fewer minutes of sleep per weekday in the past week (95% confidence interval [CI], −29.7 to −11.4) than those who never slept near a small screen, independent of having a TV in the room. When modeled as a continuous variable, each additional day of sleeping near a small screen was associated with 3.7 fewer minutes of sleep per weekday (95% CI, −5.4 to −2.0). Children who slept in a room with a TV reported 18.0 fewer minutes of weekday sleep (95% CI, −27.9 to −8.1) than those without a TV in their room, independent of small screens. For non-Hispanic black youth, sleeping near a small screen was associated with an additional 30.8 fewer minutes of weekday sleep (95% CI, −52.8 to

TABLE 1 Sample Characteristics of 2048 Children Attending Public School in 2 Massachusetts Cities

	Grade 4 (n = 1194)	Grade 7 (n = 854)
Child characteristics, mean ± SD or %		
Female	51.4	51.4
Age, y	9.4 ± 0.6	12.3 ± 0.6
Race or ethnicity		
Hispanic	38.8	42.6
White, non-Hispanic	38.0	39.0
Black, non-Hispanic	10.8	8.5
Other, non-Hispanic[a]	5.4	3.2
Multiracial, non-Hispanic[b]	7.0	6.8
Overweight (BMI ≥85th to <95th percentile[c])	18.6	19.6
Obese (BMI ≥95th percentile[c])	27.2	30.1
Days in past week participated in ≥30 min of physical activity	3.3 ± 2.2	2.8 ± 2.2
Screens in child sleep environment, %		
Ever sleeps near a small screen[d]	45.9	64.5
TV in room in which child sleeps	74.1	75.6
Screen time[e]		
TV or DVDs (h/d)	2.4 ± 1.9	2.9 ± 2.1
Video or computer games (h/d)	1.8 ± 1.8	2.0 ± 2.0
Outcomes, mean ± SD or %		
Usual sleep duration per 24 h on a weekday in the past week, h	9.8 ± 1.4	8.8 ± 1.5
Perceived insufficient rest or sleep >3 d in past week	32.8	22.6
Usual bedtime in the past week, hh:mm PM	9:15 ± 2:34	10:12 ± 3:09

[a] Includes American Indian or Alaska Natives, Asian, and Hawaiian or Pacific Islander.
[b] Includes youth who indicated >1 race but did not identify as Hispanic or Latino.
[c] Heights and weights were measured by school nurses using the protocol in the Massachusetts Department of Public Health's BMI Screening Guidelines for Schools. Percentile was calculated by using the 2000 CDC growth charts.
[d] Devices used to play games or send text messages or chats such as cell phones, smartphones, and the iPod Touch.
[e] Sample consisted of 1139 fourth-graders and 769 seventh-graders.

−8.9) compared with non-Hispanic white youth (Fig 1). Results did not vary by grade, gender, or physical activity ($P < .05$ for heterogeneity).

Associations between screens in sleep environments and sleep duration resulted from delayed bedtime. Sleeping near a small screen and sleeping with a TV in the room were associated with 37.0-minute (95% CI, 20.1 to 53.9) and 31.1-minute (95% CI, 19.1 to 43.1) later bedtimes, respectively. Both associations were stronger for non-Hispanic black and Hispanic children compared with non-Hispanic white children (Fig 1) and for seventh-graders compared with fourth-graders (Fig 2). Neither screen was associated with waketime.

Table 3 shows results for perceived insufficient rest or sleep. Sleeping near a small screen, but not a TV, was associated with 1.39 (95% CI, 1.21 to 1.60) times the prevalence of perceived insufficient rest or sleep. This did not vary significantly by grade, gender, physical activity, or race. Each additional day of sleeping near a small screen (modeled continuously) was associated with 1.07 (95% CI, 1.05 to 1.09) times the prevalence of perceived insufficient rest or sleep. For all outcomes, we did not detect interaction between small screens and presence of a TV.

Among the 1908 children with screen time data, time watching TV or DVDs and playing video/computer games was significantly associated with shorter weekday sleep durations (Table 2). Associations did not vary by grade, gender, activity, or race ($P > .05$ for heterogeneity) and were accounted for by later bedtimes. Each hour per day of TV or DVD viewing was associated with a 3.7-minute (95% CI, 0.7 to 6.7) later bedtime. Each hour per day of gaming was associated with a 9.8-minute later bedtime (95% CI, 5.1 to 14.5). Screen time was not associated with waketime.

Each hour spent watching TV or DVDs and playing video or computer games was associated with a higher prevalence of perceived insufficient rest or sleep (Table 3). The relationship between TV or DVD viewing and perceived insufficient rest or sleep was stronger for seventh- than fourth-graders (Fig 2), and the association between video or computer games and insufficient rest or sleep was attenuated (prevalence ratio [PR] for the cross-product of video or computer games and days of physical activity, 0.93; 95% CI, 0.88 to 0.98]). Associations did not vary by gender or race or ethnicity ($P > .05$ for heterogeneity).

In model 3, which additionally adjusted for sleep duration, a likely mediator, associations of small screens, TV or DVD viewing, and video and computer game playing with perceived insufficient rest or sleep were significant with some mild attenuation (PR, 1.33; 95% CI, 1.16 to 1.53 for small screens; PR 1.04; 95% CI, 1.01 to 1.07 for TV or DVD viewing; and PR 1.05; 95% CI, 1.01 to 1.08 for games).

DISCUSSION

Among 2048 fourth- and seventh-grade public school students in Massachusetts, children who slept near a small screen (compared with never) and children with a TV in their sleep environment (compared with those without) had shorter weekday sleep durations. Relationships between screens in the sleep environment and sleep curtailment were accounted for by later bedtimes, consistent with students having fixed weekday waketimes for school. Presence of a small screen but not a TV in the sleep environment was significantly related to perceived

TABLE 2 Associations of Screens in Children's Sleep Environment and Screen Time With Typical Weekday Daily Sleep Duration in the Past Week

	Weekday Sleep Duration, min	
	Model 1 (partially adjusted)[a]	Model 2 (fully adjusted)[b]
	β (95% CI)	β (95% CI)
Presence of screen in sleep environment (n = 2048)		
Small screen[c]	−22.6*** (−31.3 to −13.8)	−20.6*** (−29.7 to −11.4)
TV[d]	−21.3*** (−30.5 to −12.1)	−18.0*** (−27.9 to −8.1)
Screen time, h/d (n = 1908)		
TV or DVDs	−4.8*** (−6.4 to −3.2)	−3.6*** (−5.3 to −1.9)
Video or computer games	−6.0*** (−8.1 to −3.9)	−5.1*** (−7.4 to −2.7)

[a] Results from multivariate linear regression models using generalized estimating equations for estimation, adjusted for grade, gender, race or ethnicity (Hispanic, non-Hispanic white, non-Hispanic black, non-Hispanic other, non-Hispanic multiracial), and city.

[b] Additionally adjusted for days in past week participated in ≥30 min of physical activity, simultaneously included indicators for presence of a small screen and TV in the child's sleep environment for models examining screens in the sleep environment, and simultaneously included hours per day of TV or DVD viewing and video or computer game playing in models examining screen time.

[c] The reference group reported never sleeping near a small screen in the past week.

[d] The reference group reported there was not a TV in the room in which they sleep.

***$P < .001$.

insufficient rest or rest or sleep in the past week. TV or DVD viewing and video or computer game playing were associated with shorter weekday sleep duration and perceived insufficient rest or sleep. Children with more screen time also had later bedtimes.

The large size of our sample enabled us to detect stronger associations between screens and sleep among some groups. Small screens were associated with shorter sleep duration among non-Hispanic black compared with non-Hispanic white children. Having a small screen or TV in the sleep environment was associated with later bedtimes among non-Hispanic black and Hispanic compared with non-Hispanic white children. Associations between presence of a TV and later bedtime and between TV or DVD viewing and perceived insufficient rest or sleep were stronger for seventh-graders than fourth-graders. Lastly, physical activity attenuated the association between video or computer games and perceived insufficient rest or sleep. Although most studies of stressors related to race or ethnicity and sleep have been conducted among adults, it is possible that similar stressors increase youth's vulnerability to effects of screens on sleep. Shorter sleep durations have been documented among racial or ethnic minorities,[38–40] and discrimination may partially mediate these differences.[40] Other psychosocial stressors associated with sleep problems (eg, SES, relationship stress, neighborhood disorder, abuse, and stressful life events)[40] may have also been more common among minorities in our sample. Stronger associations observed for older youth may have been accounted for by differences in content or timing. For example, seventh-graders may watch more violent or stress-inducing programs and at later times than fourth-graders, increasing impacts of screens on sleep. Lastly, physical activity has been associated with better sleep quality,[41,42]

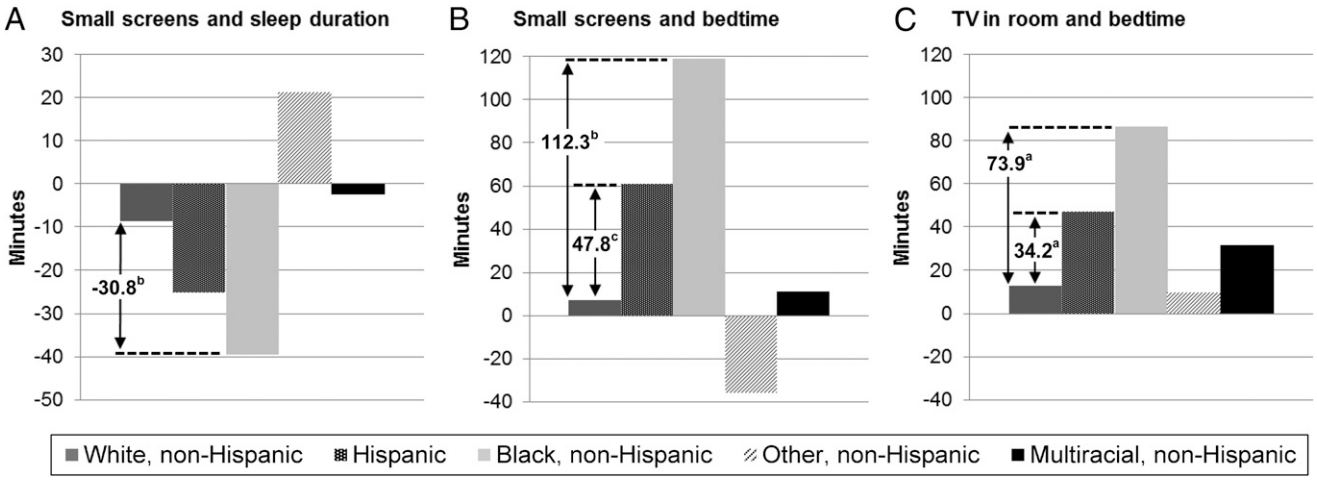

FIGURE 1

Differences by race or ethnicity in the associations between screens in the sleep environment and weekday sleep duration and bedtime estimated from fully adjusted models (model 2). A, Minutes of sleep duration associated with sleeping near a small screen. B, Bedtime (minutes) associated with sleeping near a small screen. C, Bedtime (minutes) associated with sleeping in a room with a TV. P values for differences in associations compared with non-Hispanic white youth: [a]$P < .05$, [b]$P < .01$, [c]$P < .001$.

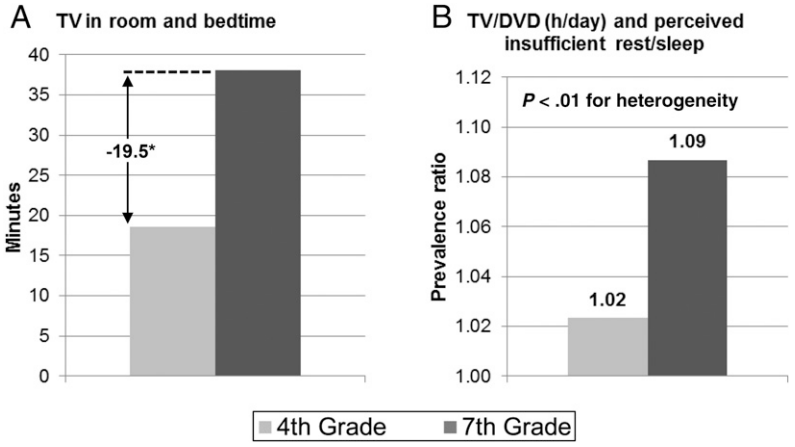

FIGURE 2

Differences by grade in the associations between (A) sleeping in a room with a TV and later bedtime (minutes) and (B) TV or DVD viewing (h/d) and perceived insufficient rest or sleep from fully adjusted models (model 2). *$P < .05$.

a characteristic that may partially compensate for sleep-disruptive activities such as video or computer game playing. These results suggest that effects of screens on sleep may not be experienced uniformly.

This study makes a novel contribution by examining how sleeping near a small screen is associated with sleep, independent of the known association with TV in the bedroom, among a diverse sample of children in the United States. One other study has examined presence of cellular phones and other handheld communication devices in a child's bedroom in relation to sleep duration among a predominantly Caucasian sample of fifth-graders in Canada.[23] The authors reported that presence of cell phones or similar devices was associated with 6 fewer minutes per day of sleep. We observed a stronger magnitude of association, perhaps because of our use of child report rather than their use of parent report, our examination of weekday duration, or differences in populations. We also observed a higher prevalence of sleeping near a small screen (54%) than was found in the Canadian sample (17%).

Additionally, we found that children who slept near a small screen had a higher prevalence of perceived insufficient rest or sleep, even after adjustment for sleep duration, a likely mediator. Perceived insufficient rest or sleep may reflect not only duration but also other sleep parameters, including poor quality, awakenings, or parasomnias. Exposure to stimulating content on small screens around bedtime and receiving calls or audible alerts while sleeping may alter these parameters. The 2011 Sleep in America Poll revealed that 18% of adolescents were awakened at least a few times a night by phones.[21] Also, a longitudinal study of children in Belgium found that using mobile phones after lights out was associated with feeling very tired 1 year later.[43]

Our finding that a TV in the sleep environment was associated with shorter sleep duration is concordant with other studies.[44–48] Also consistent with the extant literature[14] is our finding that watching TV or DVDs and playing video or computer games were associated with shorter sleep duration and perceived insufficient rest or sleep. However, unlike small screens, TV presence was not significantly related to perceived insufficient rest or sleep, perhaps because TV sets do not interrupt sleep when turned off. Also, compared with TV or DVD viewing, which was significantly associated with perceived insufficient rest or sleep, for TV presence it is possible that not all TV sets in this sample were functional or used; TV presence may not guarantee high screen time, especially if parents impose screen limits, or TV viewing may occur in other locations.

For all media, additional mechanisms that may underlie the screen–sleep relationship include direct displacement of sleep or of behaviors that may promote sleep with screen

TABLE 3 Associations of Screens in Children's Sleep Environment and Screen Time With Perceived Insufficient Rest or Sleep

	Perceived Insufficient Rest or Sleep	
	Model 1 (partially adjusted)[a]	Model 2 (fully adjusted)[b]
	PR (95% CI)	PR (95% CI)
Presence of screen in sleep environment (n = 2048)		
Small screen[c]	1.38*** (1.19 to 1.61)	1.39*** (1.21 to 1.60)
TV[d]	1.13 (0.99 to 1.29)	1.07 (0.91 to 1.26)
Screen time, h/d (n = 1908)		
TV or DVDs	1.06*** (1.03 to 1.09)	1.05*** (1.02 to 1.08)
Video or computer games	1.07*** (1.03 to 1.11)	1.05** (1.01 to 1.09)

[a] Results from multivariate log binomial regression models using generalized estimating equations for estimation, adjusted for grade, gender, race or ethnicity (Hispanic, non-Hispanic white, non-Hispanic black, non-Hispanic other, non-Hispanic multiracial), and city.

[b] Additionally adjusted for days in past week participated in ≥30 min of physical activity, simultaneously included indicators for presence of a small screen and TV in the child's sleep environment for models examining screens in the sleep environment, and simultaneously included hours per day of TV or DVD viewing and video or computer game playing in models examining screen time.

[c] The reference group reported never sleeping near a small screen in the past week.

[d] The reference group reported there was not a TV in the room in which they sleep.

**$P < .01$, ***$P < .001$.

time; consumption of heavily advertised beverages containing caffeine; evening exposure to bright, short-wavelength light interfering with circadian rhythm[40,41]; or increased cognitive, physiologic, and emotional arousal[14] after playing a video game,[49] watching an exciting movie or show, or sending chats or texts.

The primary limitation of this study is its cross-sectional design, limiting our ability to make causal inferences. Although longitudinal evidence indicates that screens affect subsequent sleep, the relationship may be bidirectional. Another limitation is that measures were self-reported, introducing random error and possible social desirability bias. Additionally, we did not measure weekend sleep duration or media content, nor did we assess and therefore adjust for potentially important confounders, such as SES, parenting style (eg, permissive parenting), or the overscheduling of youth. This study also has several strengths. It included a large, racially and ethnically diverse sample, investigated differences by grade, gender, and race or ethnicity, and helped to address the dearth of studies assessing small screens and sleep.

CONCLUSIONS

Among a diverse sample of Massachusetts fourth- and seventh-grade public school students, the presence of small screens and TVs in sleep environments and the use of TV or DVDs and video or computer games were associated with shorter weekday sleep duration. Children who slept near a small screen and those with more screen time were more likely to have perceived insufficient rest or sleep in the past week. Although longitudinal and experimental studies are needed to confirm these associations, our findings caution against children's unfettered access to screen-based media in their rooms. Future studies should incorporate detailed assessments of screen content to identify the types most strongly related to poor sleep. Longitudinal studies should also continue to examine the mediating contribution of sleep to screen time's impact on obesity and other outcomes.

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Address correspondence to Jennifer Falbe, ScD, MPH, 50 University Hall #7360, Berkeley, CA 94720-7360. E-mail: jfalbe@berkeley.edu

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REFERENCES

1. Knutson KL. Does inadequate sleep play a role in vulnerability to obesity? *Am J Hum Biol*. 2012;24(3):361–371
2. Reilly JJ, Armstrong J, Dorosty AR, et al; Avon Longitudinal Study of Parents and Children Study Team. Early life risk factors for obesity in childhood: cohort study. *BMJ*. 2005;330(7504):1357
3. Snell EK, Adam EK, Duncan GJ. Sleep and the body mass index and overweight status of children and adolescents. *Child Dev*. 2007;78(1):309–323
4. Taveras EM, Rifas-Shiman SL, Oken E, Gunderson EP, Gillman MW. Short sleep duration in infancy and risk of childhood overweight. *Arch Pediatr Adolesc Med*. 2008;162(4):305–311
5. Bell JF, Zimmerman FJ. Shortened nighttime sleep duration in early life and subsequent childhood obesity. *Arch Pediatr Adolesc Med*. 2010;164(9):840–845
6. Seegers V, Petit D, Falissard B, et al. Short sleep duration and body mass index: a prospective longitudinal study in preadolescence. *Am J Epidemiol*. 2011;173(6):621–629
7. Patel SR, Hu FB. Short sleep duration and weight gain: a systematic review. *Obesity (Silver Spring)*. 2008;16(3):643–653
8. Shochat T, Cohen-Zion M, Tzischinsky O. Functional consequences of inadequate sleep in adolescents: a systematic review. *Sleep Med Rev*. 2014;18(1):75–87
9. Guo X, Zheng L, Wang J, et al. Epidemiological evidence for the link between sleep duration and high blood pressure: a systematic review and meta-analysis. *Sleep Med*. 2013;14(4):324–332
10. Cappuccio FP, Cooper D, D'Elia L, Strazzullo P, Miller MA. Sleep duration predicts cardiovascular outcomes: a systematic review and meta-analysis of prospective studies. *Eur Heart J*. 2011;32(12):1484–1492
11. Bryant PA, Curtis N. Sleep and infection: no snooze, you lose? *Pediatr Infect Dis J*. 2013;32(10):1135–1137
12. Matricciani L, Olds T, Petkov J. In search of lost sleep: secular trends in the sleep time of school-aged children and

adolescents. *Sleep Med Rev*. 2012;16(3):203–211

13. Rideout VJ, Foehr UG, Roberts DF. *Generation M2: Media in the Lives of 8- to 18-Year-Olds*. Menlo Park, CA: Kaiser Family Foundation; 2010:8010
14. Cain N, Gradisar M. Electronic media use and sleep in school-aged children and adolescents: a review. *Sleep Med*. 2010;11(8):735–742
15. Tremblay MS, LeBlanc AG, Kho ME, et al. Systematic review of sedentary behaviour and health indicators in school-aged children and youth. *Int J Behav Nutr Phys Act*. 2011;8:98
16. Falbe J, Rosner B, Willett WC, Sonneville KR, Hu FB, Field AE. Adiposity and different types of screen time. *Pediatrics*. 2013;132(6). Available at: www.pediatrics.org/cgi/content/full/132/6/e1497
17. Harris JL, Bargh JA, Brownell KD. Priming effects of television food advertising on eating behavior. *Health Psychol*. 2009;28(4):404–413
18. Halford JC, Boyland EJ, Hughes G, Oliveira LP, Dovey TM. Beyond-brand effect of television (TV) food advertisements/commercials on caloric intake and food choice of 5–7-year-old children. *Appetite*. 2007;49(1):263–267
19. Borzekowski DL, Robinson TN. The 30-second effect: an experiment revealing the impact of television commercials on food preferences of preschoolers. *J Am Diet Assoc*. 2001;101(1):42–46
20. Falbe J, Willett WC, Rosner B, Gortmaker SL, Sonneville KR, Field AE. Longitudinal relations of television, electronic games, and digital versatile discs with changes in diet in adolescents. *Am J Clin Nutr*. 2014;100(4):1173–1181
21. Gradisar M, Wolfson AR, Harvey AG, Hale L, Rosenberg R, Czeisler CA. The sleep and technology use of Americans: findings from the National Sleep Foundation's 2011 Sleep in America poll. *J Clin Sleep Med*. 2013;9(12):1291–1299
22. Calamaro CJ, Mason TB, Ratcliffe SJ. Adolescents living the 24/7 lifestyle: effects of caffeine and technology on sleep duration and daytime functioning. *Pediatrics*. 2009;123(6). Available at: www.pediatrics.org/cgi/content/full/123/6/e1005
23. Chahal H, Fung C, Kuhle S, Veugelers PJ. Availability and night-time use of electronic entertainment and communication devices are associated with short sleep duration and obesity among Canadian children. *Pediatr Obes*. 2013;8(1):42–51
24. Arora T, Hussain S, Hubert Lam KB, Lily Yao G, Neil Thomas G, Taheri S. Exploring the complex pathways among specific types of technology, self-reported sleep duration and body mass index in UK adolescents. *Int J Obes (Lond)*. 2013;37(9):1254–1260
25. Yen CF, Ko CH, Yen JY, Cheng CP. The multidimensional correlates associated with short nocturnal sleep duration and subjective insomnia among Taiwanese adolescents. *Sleep*. 2008;31(11):1515–1525
26. Taveras EM, Blaine R, Davison KK, et al. Design of the Massachusetts Childhood Obesity Research Demonstration (MA-CORD) Study [published online ahead of print December 3, 2014]. *Child Obes*. PMID:25469676
27. Davison KK, Falbe J, Taveras EM, et al. Evaluation overview for the Massachusetts Childhood Obesity Research Demonstration (MA-CORD) Study. *Child Obes*. 2015, In press)
28. US Census Bureau. State and County QuickFacts. 2012; http://quickfacts.census.gov/qfd/states/25000.html. Accessed February 1, 2014
29. Matricciani L. Subjective reports of children's sleep duration: does the question matter? A literature review. *Sleep Med*. 2013;14(4):303–311
30. Centers for Disease Control and Prevention (CDC). Behavioral Risk Factor Surveillance System Questionnaire. Atlanta, GA: US Department of Health and Human Services, Centers for Disease Control and Prevention; 2008. Available at: www.cdc.gov/brfss/annual_data/pdf-ques/2008brfss.pdf
31. Shankar A, Syamala S, Kalidindi S. Insufficient rest or sleep and its relation to cardiovascular disease, diabetes and obesity in a national, multiethnic sample. *PLoS ONE*. 2010;5(11):e14189
32. Gortmaker SL, Peterson K, Wiecha J, et al. Reducing obesity via a school-based interdisciplinary intervention among youth: Planet Health. *Arch Pediatr Adolesc Med*. 1999;153(4):409–418
33. Schmitz KH, Harnack L, Fulton JE, et al. Reliability and validity of a brief questionnaire to assess television viewing and computer use by middle school children. *J Sch Health*. 2004;74(9):370–377
34. Kim S, DeRoo LA, Sandler DP. Eating patterns and nutritional characteristics associated with sleep duration. *Public Health Nutr*. 2011;14(5):889–895
35. Spiegelman D, Hertzmark E. Easy SAS calculations for risk or prevalence ratios and differences. *Am J Epidemiol*. 2005;162(3):199–200
36. Hanley JA, Negassa A, Edwardes MD, Forrester JE. Statistical analysis of correlated data using generalized estimating equations: an orientation. *Am J Epidemiol*. 2003;157(4):364–375
37. Liang K-Y, Zeger SL. Longitudinal data analysis using generalized linear models. *Biometrika*. 1986;73(1):13–22
38. Matthews KA, Hall M, Dahl RE. Sleep in healthy black and white adolescents. *Pediatrics*. 2014;133(5). Available at: www.pediatrics.org/cgi/content/full/133/5/e1189
39. Maslowsky J, Ozer EJ. Developmental trends in sleep duration in adolescence and young adulthood: evidence from a national United States sample. *J Adolesc Health*. 2014;54(6):691–697
40. Slopen N, Williams DR. Discrimination, other psychosocial stressors, and self-reported sleep duration and difficulties. *Sleep*. 2014;37(1):147–156
41. Lang C, Brand S, Feldmeth AK, Holsboer-Trachsler E, Pühse U, Gerber M. Increased self-reported and objectively assessed physical activity predict sleep quality among adolescents. *Physiol Behav*. 2013;120:46–53
42. Yang PY, Ho KH, Chen HC, Chien MY. Exercise training improves sleep quality in middle-aged and older adults with sleep problems: a systematic review. *J Physiother*. 2012;58(3):157–163
43. Van den Bulck J. Adolescent use of mobile phones for calling and for sending text messages after lights out: results from a prospective cohort study with a one-year follow-up. *Sleep*. 2007;30(9):1220–1223

44. Garmy P, Nyberg P, Jakobsson U. Sleep and television and computer habits of Swedish school-age children. *J Sch Nurs*. 2012;28(6):469–476

45. Li S, Jin X, Wu S, Jiang F, Yan C, Shen X. The impact of media use on sleep patterns and sleep disorders among school-aged children in China. *Sleep*. 2007;30(3):361–367

46. Mindell JA, Meltzer LJ, Carskadon MA, Chervin RD. Developmental aspects of sleep hygiene: findings from the 2004 National Sleep Foundation Sleep in America Poll. *Sleep Med*. 2009;10(7):771–779

47. Owens J, Maxim R, McGuinn M, Nobile C, Msall M, Alario A. Television-viewing habits and sleep disturbance in school children. *Pediatrics*. 1999;104(3). Available at: www.pediatrics.org/cgi/content/full/104/3/e27

48. Shochat T, Flint-Bretler O, Tzischinsky O. Sleep patterns, electronic media exposure and daytime sleep-related behaviours among Israeli adolescents. *Acta Paediatr*. 2010; 99(9):1396–1400

49. Higuchi S, Motohashi Y, Liu Y, Maeda A. Effects of playing a computer game using a bright display on presleep physiological variables, sleep latency, slow wave sleep and REM sleep. *J Sleep Res*. 2005;14(3): 267–273

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