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Reducing late evening bedtime electronic device intentions and use among young adults

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ABSTRACT

Objectives: We examined (Study #1) the association of attitudes, subjective norms (SN), and perceived behavioral control (PBC) with intentions to reduce late evening electronic device (e-device) use and (Study #2) the impact of a brief theory-driven message on reducing the use.
Methods: Young adults aged 18-30 years participated in Internet surveys to assess sleep quality, attitudes, SN, PBC, and intentions to reduce and patterns of late evening e-device use. In Study #1, participants (n = 160) were randomized to receive a Theory of Planned Behavior (TPB)–driven message based on information from the National Sleep Foundation and were assessed for intentions to decrease late evening e-device use immediately afterward. In Study #2, participants (n = 148) were given the same message but were assessed for behaviors 24 hours–1 week afterward.
Results: In Study #1, regressions indicated that less supportive attitudes and higher PBC were associated with higher intention to reduce e-device use at baseline ($P < .01$); intentions and PBC were associated with current use ($P < .01$). Participants receiving the message were more likely to reduce late evening e-device use intentions (adjusted odds ratio: 2.30, 95% confidence interval: 1.06-4.99). In Study #2, those receiving the intervention with attitudes consistent with limiting use were more likely to reduce use 24 hours–1 week after the intervention (adjusted odds ratio: 3.13, 95% confidence interval: 1.10-8.91).
Conclusion: Attitudes and PBC were associated with intention to reduce late evening e-device use, and our brief TPB-driven message benefited young adults with attitudes inconsistent with use. TPB-based interventions can decrease late evening e-device use and promote better quantity and quality of sleep.

Introduction

The National Sleep Foundation (NSF) advocates that sleep is considered a “vital sign,” mainly as more than half of adults in the United States are not getting adequate restorative sleep.[1] The Centers for Disease Control and Prevention indicate that sleep disorders have constituted a public health epidemic in the United States (US), leading to a wide range of health problems (eg, heart diseases[2]) as well as threats to public safety (eg, motor vehicle accidents[3]). Young adults (those who are 18-29 years old) are notorious for sleep deprivation (eg, Bixler[4] and Gradisar et al[5]). Results of the 2011 NSF Sleep in America Poll indicated that young adults were more likely to report sleep problems at least a few nights a week as compared to those 30 years or older, and the 2018 NSF Sleep in America Poll indicated that individuals 18-29 were most likely to take their amount of sleep into account when planning for the next day.[5,6] Although sleep problems contribute to the development of various health problems and influence decision making and planning, many sleep problems are preventable.[7] Sleep hygiene education has demonstrated a great potential to address the growing public health concern of sleep complaints.[8,9]

During sleep hygiene education, individuals are advised to reduce or avoid behaviors that decrease the quality and quantity of sleep (eg, maintaining a sleep schedule, reducing distractions in the sleep environment).[10] One critical area for sleep education is the need to

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decrease or eliminate electronic device (e-device) use in the evening, especially when it is before sleep. The rise in the use of e-devices such as cellular telephones, tablets, and laptops in late evening has paralleled the increasing prevalence of sleep problems among young adults in the US,[5,11] and a mounting body of evidence links late evening e-device use to poor sleep among young adults (eg, Exelmans and Van den Bulck,[12] Orzech et al,[13] and Fossum et al[14]). For example, a recent study examining e-device use near bedtime among young adults found that a longer duration of e-device use was associated with reduced total sleep and a later bedtime.[13] Furthermore, using cellular telephones (ie, smartphones) and computers before sleep was found to be positively associated with sleep disorders such as insomnia.[14–16] Several mechanisms have been proposed to elucidate how using e-devices at night impairs sleep. The NSF highlights the role of blue light from e-devices in suppressing the release of a sleep-inducing hormone in the human body, creating difficulties in falling asleep. Such an effect could lead to significant sleep deficiency over time.[17]

Considering the high prevalence of late evening e-device use and the associated poor sleep outcomes among young adults, it is crucial to understand the factors that are responsible for late evening e-device use and to promote proper sleep hygiene, accordingly. Behavioral theory–based research is one way to organize the varied and often complex factors associated with sleep hygiene behaviors, like late evening e-device use. Numerous sources advocate for theory-based research to understand, predict, and modify health behavior to improve health outcomes.[18] Furthermore, theory-based interventions have been found more effective in changing health behaviors as compared to those that are not grounded in theories (eg, Noar et al[19]).

The Theory of Planned Behavior (TPB) is one of the most widely applied models of health behaviors (eg, Knowlden et al[20] and Kor and Mullan[21]). It posits that the proximal determinant of behavior is intention (eg, intention to avoid late evening e-device use) which, in turn, is determined by (1) attitude (eg, favorable or unfavorable evaluations of using e-devices in the evening), (2) subjective norm (SN) (ie, perception of a significant other's beliefs about using e-devices in the evening), and (3) perceived behavioral control (PBC) (ie, perceived ease or difficulty of using e-devices in the evening).[22] PBC also modifies the intention-behavior relationship: intention is more likely to lead to actual behavior when PBC is high.[22] A prior study using the TPB in the context of sleep in college students found that attitudes, SN, and PBC were all predictors of intentions to obtain adequate sleep, whereas intentions and PBC were predictors of sleep behavior.[20] Thus, attitudes, SN, and PBC are important factors in sleep intentions and behavior and may help elucidate the factors associated with the burgeoning utilization of e-devices in late evening and predictors of change.

Recent health behavior interventions based on the TPB have demonstrated a medium-sized effect on changing multiple health behaviors among young adults.[23] Health messaging research has widely accomplished improvements in health behavior and health outcomes, and messaging about sleep is no exception.[24,25] Using TPB-guided messaging can be a powerful and novel tool to guide uptake of positive health behaviors and can be used to discourage late evening e-device use to promote better quality and quantity of sleep. Especially as the research on late evening e-device use is new and findings of the detrimental impact on sleep are relatively recent, those whose attitudes, social norms, and behavioral control levels are currently consistent with late evening e-device use may be the most primed to change in response to messages. Thus, we conducted 2 studies based on the TPB framework to (1) examine the associations of attitudes, SN, and PBC with late evening e-device use and the intention to reduce usage; (2) assess if change in intentions to use e-devices in late evening occurred in response to a pilot interventional message guided by the TPB; and (3) assess if reduced use of e-devices in late evening occurred in response to the interventional message in a short follow-up period.

Study #1

Methods

Participants

We conducted an online randomized study of young adults between 18 and 30 years of age who could read and write in English. We posted flyers and advertisements on campus (eg, student recreation center) and social network websites (eg, Facebook, Twitter, Campus listservs) to recruit potential participants.

Procedures

The Institutional Ethical Review Board of West Virginia University approved all study instruments and procedures at each phase of the study. We received a waiver of written consent from participants due to the minimal risk involved in the study. All participants gave informed consent by accepting the terms of participation before navigating to the questionnaires.

We designed our baseline and postintervention surveys based upon the conceptual framework of TPB.[26,27] Participants' attitudes, SN, PBC, and intention to use e-device in late evening were assessed. The study instruments were piloted through in-person cognitive interviews among a purposive sample of young adults ($n = 10$), representing a diversity of ages, races, and socioeconomic statuses. With an online pilot survey ($n = 52$), we assessed the reliability of the scales used in the surveys and the feasibility of the intervention. The final instrument (Supplemental material) was adjusted based on feedback received from the cognitive interviews and pilot survey. An online survey-distributing program, Qualtrics (2016 Qualtrics LLC, Provo, UT), facilitated the collection of data. At the end of the baseline survey, participants were randomized to receive a brief intervention using a randomizer generated by Qualtrics. A postintervention item asked about participants' intentions for reducing late evening e-device use in the future immediately afterward. Time to complete the study was approximately 10 minutes.

Measures

Demographic information asked at baseline included age, sex, race/ethnicity, education level, employment status, annual household income, and living situation. In this study, we assessed late evening e-device use within 2 hours before trying to sleep, assuming this period is approximately bedtime. We chose 2 hours as the time window based on a previous study that examined digital media use before bedtime among university students.[13] Furthermore, research indicated that melatonin, the hormone that induces sleep, starts rising about 2 hours before an individual's regular bedtime.[28] The NSF has highlighted the role of blue light from e-devices in suppressing the release of melatonin in the human body, creating difficulties in falling asleep.[17]

Sleep behavior and well-being constructs. Sleep quality was assessed with total sleep time in hours and perceived sleep quality measured by an item inquiring about the overall sleep quality ("Very bad" to "Very good") from the Pittsburgh Sleep Quality Index.[29] For analytic purposes, we further identified participants who did not sleep for appropriate hours based on the latest NSF recommended sleep time for the respective age group (ie, 6-11 hours for 18-25 years old; 6-10 for 25-30 years old[30]). *Late evening e-device use* was assessed regarding the frequency (number of nights), intensity (average duration), and the type of e-device used near bedtime in the past 2 weeks. The e-devices included television, computers (desktop and laptop), cellular telephones (eg, smartphones and any cellphone), tablets (eg, iPads and e-readers), and gaming devices (eg, Xbox, PlayStation, Nintendo).[5] *Perceived sleep disturbers* were measured with a list of factors, including bedtime e-device use, mental conditions, pressure from study/work, unpleasant environment, and daytime napping, which were commonly referenced by individuals who complained about poor sleep.[31] Participants were directed to select all the factors that applied to them. *Mental health status* of participants was evaluated with an item from the Patient-Reported Outcomes Measurement Information System on general mental health (ie, "In general, how would you rate your mental health, including your mood and your ability to think?"[32]). All sleep behavior and well-being items were asked at baseline.

TPB constructs. Attitude, SN, and PBC regarding late evening e-device use were measured at baseline. *Attitude* toward late evening e-device use was measured by the mean score of 3 items on a 5-point Likert scale. The response scale ranged from "strongly disagree (1)" to "strongly agree (5)," with a higher score indicating a stronger favorable attitude toward late evening e-device use (Table 1). *SN* for late evening e-device use was assessed by a single item with the response scale ranged from "strongly disagree (1)" to "strongly agree (5)" on the statement that "Most of the people who are important to me use an electronic device at bedtime." *PBC* of late evening e-device use was measured as the mean of 4 items from a 5-point Likert scale anchored by "strongly disagree (1)" to "strongly agree (5)," with a higher score indicating better PBC (Table 1). *Intention* to reduce late evening e-device use was assessed at baseline and postintervention with the item "I intend to reduce my electronic device use at bedtime in the future" using a 5-point scale anchored by "strongly disagree (1)" to "strongly agree (5)."

Intervention

A brief intervention in the form of a persuasive message guided by the TPB was given electronically to participants who were randomized to the intervention group at the end of the baseline survey. Participants in the intervention group were informed of the recent scientific findings of the negative impact of late evening e-device use on sleep and the suggestion from the NSF that they can control their late evening e-device use to improve sleep.[17] The message targeted attitude (eg, "…using electronic devices at bedtime can disrupt sleep…"), SN (eg, "…95% people use some type of electronic device at bedtime…"), and PBC (eg, "…You can control your electronic device use at bedtime to improve your sleep."). Participants in the control group received no message and were directed to the second intention question (consistent with the postintervention assessment for those in the intervention group). After all postintervention assessments, all participants were given a hyperlink to a relevant Web page of the NSF about sleep and e-device use if they desired further information.

Statistical analysis

Separate principle components analyses were conducted to examine the factor structure of the attitude and PBC scales. Both scales achieved acceptable reliability (Table 1). We used means with standard errors (SEs) to report the descriptive statistics for continuous variables and frequencies with percentages for categorical variables. We examined the associations between TPB constructs (PBC and intention to reduce use) and late evening e-device use at baseline with Spearman correlations and multinomial logistic regressions. Associations between TPB constructs and baseline intention to reduce late evening e-device use were assessed with Pearson correlations and generalized linear model regressions. χ^2 tests and 2-tailed Student t test for independent samples were used to compare participants who received the intervention vs those who did not. We calculated the difference between postintervention and baseline intention scores and created a binary variable for those who increased in intentions (difference >0) vs those whose intention did not change or decreased. Logistic regression analyses were used to assess the impact of the intervention on increasing intentions to reduce late evening e-device use.

Results

Description of participants

We obtained 390 responses from the online survey, of which 178 responses were excluded from the analyses due to refusal (n = 4), early dropout (n = 44), ineligible age (n = 49), duplicate reports (n = 11), and incomplete responses (n = 70). After feasibility testing (n = 52), a total of 160 participants completed all parts of the study. As shown in Table 2, participants in the feasibility testing consisted of a significantly lower percentage of whites, whereas participants randomized for the intervention had significantly lower percentages of students, individuals with high education (>bachelor's degree), and those living alone. However, the 2 groups were similar regarding late evening e-device use, sleep quality, and TPB constructs.

Of the 160 participants included in the randomization, the mean age was 24.9 (SE = 3.0). Most of them were females (80.0%), were white (97.5%), had at least a bachelor's degree (71.9%), and had an annual household income higher than $35,000 (81.2%). More than half of participants (55.6%) reported fair or worse sleep, and 15% did not sleep for appropriate hours. All participants reported using some e-devices near bedtime in the past 2 weeks, of whom the majority (72.3%) were frequent users (>10 nights). Over half (59.7%) spent more than 30 minutes on an e-device at bedtime daily. Telephones (66.3%) were the most commonly used e-device, followed

Table 1
Scale development (N = 212): attitude and PBC regarding late evening electronic device use

Scale items	Mean (SD)	Factor loading	Cronbach α
Attitude			
Using an electronic device at bedtime is enjoyable.	3.80 (0.82)	0.74	.66
Using an electronic device at bedtime is bad for my health.	2.48 (0.84)	0.74	
Bedtime is a good time for me to use an electronic device	3.05 (1.00)	0.82	
Mean score	**3.11 (0.68)**		
PBC			
I can avoid using any electronic device at bedtime.	3.48 (1.07)	0.80	.76
If I really wanted to, I could stop using any electronic device at bedtime.	3.90 (0.93)	0.88	
I can control how long I use any electronic device at bedtime.	4.00 (0.77)	0.72	
I am confident that I can fall asleep without using any electronic device.	3.89 (1.02)	0.64	
Mean score	3.82 (0.72)		

Table 2
Characteristics of participants in the feasibility testing and randomized study in Study #1

Variables	Feasibility group (n = 52) Mean (SD)	Randomized group (n = 160) Mean (SD)
Age, y	24.9 (3.0)	25.0 (3.0)
Female %	69.2	80.0
Race***		
White	37 (71.2)	156 (97.5)
Other	15 (28.8)	4 (2.5)
Education**		
<Bachelor	17 (32.7)	45 (28.1)
Bachelor	11 (21.2)	71 (44.4)
>Bachelor	24 (46.2)	44 (27.5)
Household income		
≤$35,000	14 (26.9)	30 (18.8)
$35,001-$50,000	8 (15.4)	33 (20.6)
>$50,000	30 (57.7)	97 (60.6)
Living status*		
Alone	13 (25.0)	19 (11.9)
With child(ren)	3 (5.8)	19 (11.9)
Without child(ren)	36 (69.2)	122 (76.3)
Student %***	80.8	40.6
Employed %	91.9	95.5
Mental health		
Poor/fair	6 (17.1)	14 (8.8)
Good	13 (37.1)	48 (30.0)
Very good/excellent	16 (45.7)	98 (61.3)
Sleep quality		
Bad/very bad	6 (11.8)	25 (15.6)
Fair	16 (31.4)	64 (40.0)
Good/excellent	29 (56.9)	71 (44.4)
Appropriate sleep %	80.8	85.0
Frequency		
1-3 evenings	5 (9.6)	10 (6.3)
4-9 evenings	7 (13.5)	34 (21.4)
≥10 evenings	40 (76.9)	115 (72.3)
Duration		
<15 min	9 (17.3)	32 (20.1)
15-30 min	13 (25.0)	32 (20.1)
30 min–1 h	16 (30.8)	56 (35.2)
1-2 h	14 (26.9)	39 (24.5)
Attitude	3.04 (0.83)	3.13 (0.63)
PBC	3.70 (0.75)	3.85 (0.72)
SN	3.63 (1.07)	3.79 (0.89)
Preintervention intention	3.25 (1.33)	3.01 (1.11)

* $P < .05$.
** $P < .01$.
*** $P < .001$.

by tablets (64.4%) and television (43.1%). Compared to the nearly three-quarters of frequent late evening e-device users, only about one-third (35.6%) of participants perceived late evening e-device use as a major contributor to their impaired sleep (Table 2). For those who did not perceive late evening e-device use as impairing sleep, pressure from work/study (49.4%) and mental health conditions (35.0%) were the most common sleep disturbers.

Associations with intention to reduce late evening e-device use

Before the intervention, about 42% of the respondents intended to reduce late evening e-device use in the future. In the Pearson correlation analyses, less supportive attitude ($\rho = -0.32$, $P < .001$) and higher PBC ($\rho = 0.27$, $P = .006$) were significantly associated with higher intentions to reduce e-device use in the future at baseline. Such associations remained significant in the adjusted analyses where demographics, use pattern, sleep quality, mental health, and perceived sleep disturbers were controlled (Table 3). Furthermore, participants who perceived late evening e-device use as disturbing sleep showed significantly higher intentions to reduce use as compared to their counterparts ($\beta = 0.54$, $P = .007$).

Table 3
Parameter estimates of selected variables from a generalized linear model on baseline intention to reduce late evening e-device use

Variables	β	SE	P value
Relevant participants characteristics			
Perceived sleep disturber			
Late evening e-device use vs. other factors	0.54	0.20	.007**
Constructs from the Planned Behavior Theory			
Attitude	−0.50	0.15	.002**
PBC	0.41	0.13	.003**
SN	−0.14	0.11	.200

** $P < .01$.

Associations with late evening e-device use

Results from Spearman correlation and adjusted regression analysis indicated that, at baseline, lower PBC was associated with longer time and more nights of late evening e-device use, whereas less intention to reduce use was associated with longer time but not the number of evenings of use. As Table 4 shows, factors associated with a *longer time* of e-device use included being female and having poorer mental health, lower PBC, and less intention. On the other hand, lower household income (<$35,000/y) and lower PBC were associated with *more evenings* of use.

Impact of the intervention in increasing intention

Eighty-four participants received the intervention, whereas 76 did not (control). Participants who received the intervention were similar to those in the control group in characteristics and TPB constructs, except that the intervention group had a higher proportion of participants with annual household income higher than $50,000 (69.0% vs 51.3%, $P = .017$). After the intervention, about 13.7% and 17.1% of the participants in the intervention and control group had decreased intention to reduce e-device use, respectively. Meanwhile, a significantly higher proportion of the participants in the intervention group increased in intention as compared to those in the control group (36.9% vs 21.0%, $P < .05$). The results of the multivariate logistic regression indicated that the participants in the intervention group were 130% (adjusted odds ratio [AOR] = 2.30, 95% confidence interval [CI]: 1.06-4.99) more likely to increase the intention to reduce late evening e-device use in the future as compared to those in the control group. Baseline participant characteristics (ie, demographics, sleep quality, mental health, TPB constructs) were not associated with the increase in intentions.

Study #2

Methods

Participants

We conducted an online randomized study of young adults between 18 and 30 years of age who could read and write in English. We sent recruiting advertisements to university students by a university e-mail list and posted flyers on campus to recruit participants.

Procedures

The Institutional Ethical Review Board of West Virginia University approved all study instruments and procedures at each phase of the study. All participants gave informed consent by accepting the terms of participation before navigating to the questionnaires. We used the same baseline survey developed in Study #1. Participants were randomized to receive the same intervention in Study #1 at the end of the baseline survey and were asked to provide e-mail

Table 4
Odds ratio (OR) with 95% CIs of selected variables from multinomial logistic regressions on baseline late evening electronic device use

	Duration of use			No. of nights with use		
	0-15 min	0.5-1 h	1-2 h	1-4 nights	5-9 nights	≥10 nights
Variable	Reference	OR (95% CI)	OR (95% CI)	Reference	OR (95% CI)	OR (95% CI)
Participant characteristics						
Sex (reference: male)						
Female	1.00	3.60 (1.07-12.11)	2.24 (0.60-8.39)*	1.00	3.60 (0.48-27.00)	3.11 (0.49-19.62)
Annual household income (reference: >$50,000)						
≤$35,000	1.00	0.62 (0.16-2.39)	0.62 (0.14-2.67)	1.00	0.11 (0.01-0.94)*	0.09 (0.01-0.64)*
$35,000-$50,000	1.00	0.72 (0.23-2.27)	0.61 (0.15-2.42)	1.00	1.35 (0.11-17.36)	1.38 (0.12-16.45)
Mental health (reference: Good/very good)						
Fair/bad/very bad	1.00	2.11 (0.76-5.85)	6.11 (1.95-19.14) **	1.00	1.39 (0.27-7.06)	1.51 (0.32-7.02)
Constructs of the TPB						
Intention	1.00	0.98 (0.62-1.55)	0.58 (0.35-0.95) *	1.00	1.13 (0.51-2.51)	0.84 (0.39-1.78)
PBC	1.00	0.40 (0.18-0.89)	0.40 (0.18-0.89) *	1.00	0.23 (0.05-1.15)	0.15 (0.03-0.71) *

* $P < .05$.
** $P < .01$.

addresses for the follow-up survey. Participants who did not receive the intervention were also asked for e-mail addresses. To assess the expectancy effect of the brief intervention, we examined the intention to reduce use, along with actual behavioral change 24 hours to 1 week after the intervention with a follow-up survey. The follow-up survey was developed based on the postintervention part of Study #1 instrument with 2 additional items that assessed behavior change and information seeking after the baseline survey. Participants received a request to complete follow-up surveys by e-mail.

Measures

We measured demographic characteristics, sleep behavior, and well-being constructs as well as the TPB constructs as described in Study #1. In addition, we examined behavior change 24 hours to 1 week after the intervention with the item "I reduced my electronic device use at bedtime after the initial survey." The response categories included a 5-point scale anchored by "strongly disagree (1)" to "strongly agree (5)" and a separate response indicating never used any e-device at bedtime. We also assessed participants' information seeking behavior by asking whether they searched for any information about using e-devices at bedtime after the baseline survey.

Intervention

The same intervention message from Study #1 was given electronically to participants who were randomized to the intervention group at the end of the baseline survey. Participants in the control group received nothing and were directed to the question inquiring e-mail addresses for the follow-up survey. Consistent with Study #1, after all postintervention assessments, all participants were given a hyperlink to a relevant Web page of the NSF about sleep and e-device use if they desired further information.

Statistical analysis

χ^2 tests and 2-tailed Student t test for independent samples were used to compare participants who completed follow-up surveys vs those who did not, as well as participants in Study #2 vs those in Study #1. Logistic regression analyses were used to assess the impact of the intervention, changes in intentions, attitude and e-device use at baseline, as well as the lag time between baseline and follow-up assessments on behavioral change.

Results

Description of participants

We obtained 279 responses from the baseline survey, of which 131 responses were excluded from analyses due to loss to follow-up. A total of 148 participants completed baseline and follow-up surveys. Participants who completed Study #2 and those who were lost to follow-up were similar in most baseline demographic characteristics, late evening e-device use, sleep quality, and TPB constructs, except for that completers consisted of higher percentages of participants with fair/poor mental health status (35.6% vs 26.2%, $P = .011$) and those living alone (20.3% vs 11.5%, $P = .038$). The average lag time between baseline and follow-up surveys was 2.4 days (SE = 1.7 days). Most participants (74.5%) responded to the follow-up survey within 48 hours. About 8.1% did it between 48 and 72 hours; 6.7% and 10.7% did it between 3 and 6 days and after 1 week, respectively. There was no differential dropout by randomization. Participants in Study #2 were significantly younger (21.6 vs 25.0, $P < .001$) and had lower percentages of participants with at least a bachelor's degree (37.6% vs 71.9%, $P < .001$), who were WV residents (65.8% vs 80.6%, $P = .003$), who were nonstudents (20.8% vs 59.4%, $P < .001$), and who were employed (49.0% vs 95.5%, $P < .01$) as compared to those in Study #1. However, the 2 study samples were similar in late evening e-device use, sleep quality, and TPB constructs (Table 5).

Impact of the intervention in reducing late evening e-device use

Sixty-eight received the intervention, whereas 81 did not (control). Participants in the intervention group and those in the control group were similar in demographic characteristics, mental health status, attitude, norm, and PBC, except that the intervention group comprised of a higher percentage of students (86.8% vs 72.8%, $P = .044$). Furthermore, participants in the control group had significantly lower scores for baseline intention to reduce late evening e-device use (2.78 vs 3.21, $P = .035$). There was no difference in the average lag time between baseline and follow-up surveys between the 2 groups (2.6 days vs 2.4 days, $P = .478$). After the intervention, although approximately one-third of participants in the intervention and control group reported reduced late evening e-devices use, results from the multivariate logistic regression indicated that

Table 5
Characteristics of participants in Study #1 and Study #2

Variables	Study #1 (N = 160) Mean (SD)	Study #2 (N = 148) Mean (SD)
Age***	25.0 (3.0)	21.6 (3.7)
Female %	80.0	73.2
Race		
White	156 (97.5)	145 (97.3)
Other	4 (2.5)	4 (2.7)
Education***		
<Bachelor	45 (28.1)	93 (62.4)
Bachelor	71 (44.4)	50 (33.6)
>Bachelor	44 (27.5)	6 (4.0)
Household income		
≤$35,000	30 (18.8)	38 (26.6)
$35,001-$50,000	33 (20.6)	22 (15.4)
>$50,000	97 (60.6)	83 (58.0)
Living status		
Alone	19 (11.9)	30 (20.3)
With child(ren)	19 (11.9)	13 (8.8)
Without child(ren)	122 (76.3)	105 (70.9)
Student % ***	40.6	79.2
Employed % ***	95.5	49.0
Mental health		
Poor/fair	6 (17.1)	14 (8.8)
Good	13 (37.1)	48 (30.0)
Very good/excellent	16 (45.7)	98 (61.3)
Sleep quality		
Bad/very bad	25 (15.6)	24 (16.1)
Fair	64 (40.0)	72 (48.3)
Good/excellent	71 (44.4)	53 (35.6)
Appropriate Sleep %	85.0	86.6
Frequency		
1-3 evenings	10 (6.3)	14 (8.4)
4-9 evenings	34 (21.4)	29 (19.5)
≥10 evenings	115 (72.3)	106 (71.1)
Duration		
<15 min	32 (20.1)	25 (16.8)
15-30 min	32 (20.1)	32 (21.5)
30 min–1 h	56 (35.2)	46 (30.9)
1-2 h	39 (24.5)	46 (30.9)
Attitude	3.13 (0.63)	3.01 (0.75)
PBC	3.85 (0.72)	3.80 (0.75)
SN	3.79 (0.89)	3.89 (0.92)
Preintervention intention	3.01 (1.11)	2.97 (1.24)

*** P < .001.

participants in the intervention group with low attitudes (ie, baseline attitude score ≤3, attitude consistent with reducing late evening e-device use) at baseline (ie, mean score ≤3) were 2 times (AOR = 3.13, 95% CI: 1.10-8.91, $P < .001$) more likely to reduce late evening e-device use as compared to participants in the control group and those with high baseline attitude (ie, mean score >3) in the intervention group. Other factors associated with reduced behavior included higher baseline intention, increased intention, and less than 4 days of use at baseline (Table 6).

Table 6
Parameter estimates of selected variables from a logistic regression on reduced late evening e-device use at follow-up

Variables	AOR	95% CI	P value
Attitude × intervention			
Intervention with low attitude vs others	3.13	(1.10-8.91)	.033 *
Lag time between baseline and follow-up (days)	0.98	(0.91-1.07)	.702
Days of use at baseline			
0-3 d vs 10 d or more	5.02	(1.05-24.02)	.043 *
Relevant participants characteristics			
Age	0.92	(0.79-1.07)	.262
Student (yes vs no)	0.74	(0.24-2.23)	.590
Employed (yes vs no)	1.56	(0.61-4.00)	.359
Education (≥Bachelor vs <Bachelor)	0.69	(0.24-2.01)	.500
Constructs from the Planned Behavior Theory			
Baseline intention (high vs low)	8.25	(2.62-25.92)	<.001 ***
Changes in intention (follow-up–baseline)	2.81	(1.68-4.70)	<.001 ***

* $P < .05$.
*** $P < .001$.

Discussion

The findings of the present study offer valuable insights into an increasingly prevalent "risky" behavior among young adults—late evening e-device use—that is closely tied with the rise in sleep problems. Notably, nearly three-fourths of our study population was using e-devices in late evening heavily, whereas only about a third thought that such behavior was impairing their sleep. Thus, young adults may not be aware of the potential detrimental impact of using e-devices in late evening. In addition, we sought to better understand the role of key behavioral constructs in late evening e-device intentions and use. Our study adds support to the utility of the TPB in sleep research to late evening e-device use intentions and behavior among young adults. We also found that messaging based on constructs from the TPB can increase intentions to change late evening e-device use behavior.

To begin, we examined the TPB constructs in association with intentions to change late evening e-device use at baseline. Participants who perceived more harm associated with late evening e-device use (ie, having a less favorable attitude) and those who reported more control (PBC) over their behaviors were more likely to intend to reduce late evening e-device use. In addition to attitude and PBC, participants who viewed using e-devices in late evening as impairing their sleep were more likely to intend to reduce late evening e-device use. Knowledge and attitudes have long been key factors in health behavior (eg, drinking[33]), and to some extent, simply providing more information to young adults about the potential harms of late evening e-device use may be beneficial. As a corollary to younger children, the 2016 American Academy of Pediatrics guidelines and informational campaign to reduce screen time in children have been gaining traction, which could be an indicator of the success of a potential informational campaign about late evening e-device use.[34]

In addition, being female and having poorer mental health, PBC, and intention to reduce late evening e-device use were associated with late evening e-device use at baseline. Our finding of sex difference in late evening e-device use echoed previous reports highlighting females' greater likelihood to be involved in activities associated with e-devices (eg, messaging, talking, social networking).[35] Our finding that poorer mental health was associated with late evening e-device use may reflect a possible vicious circle between mental health problems and late evening e-device use: anxious/depressed individuals were more likely to use e-device close to sleep, and late evening e-device use may increase anxiety and depression.[36] Rather than focusing on completely removing this connection in late evening, intervention efforts may want to encourage young adults, especially females and those with mental health problems, to be more thoughtful about controlling their amount and timing of exposure.

Participants who perceived themselves as having poorer behavioral control and those who had less intention to reduce late evening e-device use were more likely to be heavy users of e-devices near bedtime (ie, used for 10 evenings or more and/or used for >1 hour each evening). It is unclear why individuals feel that they cannot control their late evening e-device use, particularly as controlling e-device use may be as simple as turning off the e-device near bedtime. However, these feelings of lack of control may be more reflective of the increasing adoption of social media among young adults.[37] For example, young adults are extremely likely to keep their mobile devices near their beds and use these devices while in bed.[38] Given the negative effect of using e-devices near bedtime on sleep and mental health, keeping e-devices away from the bed is a simple action to promote sleep health and overall well-being of young adults.

Along with examining factors associated with late evening e-device intentions and behaviors, a pilot TPB-guided message intervention based on recent scientific findings, as well as recommendations from the NSF, was used. The intervention message, which informed participants of the potential negative effect of late evening e-device use on sleep and promoted controlling the use of e-device near bedtime, had a positive impact. Other factors asked at baseline, including mental health status, sleep quality, demographic characteristics, the perception of late evening e-device use, attitudes, social norms, and PBC, did not contribute to the observed change in intentions. We speculate that our intervention resulted in changes in attitudes, social norms, and PBC among participants, although our study was not designed to explore this. Thus, it seems that everyone benefitted from our brief messaging intervention in forming an intention, not merely those who may have had lower levels of knowledge or incompatible attitudes, social norms, and behavioral control at the beginning. However, our results also indicated that the brief messaging intervention might be more beneficial in reducing behavior in the short term among young adults who already had an attitude compatible with reducing late evening e-device use than others. High baseline intention and increased intention also contributed to behavioral change independently.

Limitations should be considered when interpreting the results. First, our study used a convenience sample, recruited primarily through a college student population, which may limit the generalizability of our study. Although results from regression analyses indicated that the education level and student status were not associated with changes in intentions and behavior, we noticed that our study sample was composed primarily of young adults with at least a bachelor's degree. It is possible that young adults with higher education were more receptive to TPB-based intervention or interventions in the form of persuasive messages. Future studies focusing on young adults with less education are needed to confirm our findings. Furthermore, our study sample was majorly female or white. A previous study reported that differences in attitude and PBC might explain the sex difference in health behaviors.[39] Similarly, a stronger PBC-intention relationship has been reported among white students as compared to black students.[40] There might be sex and/or ethnic differences in changing intention to reduce late evening e-device use with TPB-based interventions. Future studies can explore more on how each construct of TPB contributes to the intention and behavioral change in sex and/or ethnic subgroups.

Second, our study had a high percentage of “heavy users” of e-devices; this can also be seen as a strength of our study, as this population may have been most in need of intervention. Of note, our estimates of heavy users may be inflated. We asked participants about their e-device use within 2 hours of going to bed. However, bedtimes vary. Individuals may not think of bedtime as being 2 hours before going to bed. Yet, sleep-inducing hormones anticipate bedtime based on previous history and not based on whether or not an individual is preparing for sleep.[28] This need of a 2-hour time frame is particularly challenging for a college population who may stay up late to meet deadlines. Thus, estimates of “late evening e-device use” may or may not synchronize with “bedtime e-device use” or sleep-inducing hormone release. Future sleep hygiene interventions may target both “late evening e-device use” and “2 hours before bedtime use” to improve sleep outcomes.

Third, we did not examine the changes in attitude, PBC, and SN after the intervention. The contribution of each construct to the change of intention needs further exploration because we did not anticipate the overall high need and the overall impact of the intervention in our study sample. Fourth, participants who completed Study #2 consisted of slightly higher percentages of young adults with fair/poor mental health or those living alone than participants lost to follow-up. Thus, results from Study #2 may be affected by fair/poor mental health and the lifestyle of young adults who live alone. It is possible that young adults used e-devices near bedtime to ease mental health problems or aloneness. Future studies may explore the reasons behind late evening e-device use and design interventions accordingly. Lastly, there was a short follow-up (24 hours–1 week) period between pre- and postintervention assessments of intentions and behavioral change. Thus, future studies using prospective longitudinal designs are needed to assess the longer-term impact of the intervention on intentions and behavior. We believe that changing intention is an essential element in behavioral change, as rising intentions can create a commitment to the intended behavior.[41]

Conclusions

In summary, our study indicated that young adults are high users of e-devices but appear to be unaware of the potential negative impact of late evening e-device use on sleep. Guided by the TPB, we found that attitudes and PBC played critical roles in late evening e-device intentions and behavior and can serve as change objectives to reduce e-device use in late evening or near bedtime. Our brief, theory-based messaging intervention increased intentions to curtail late evening e-device use, especially the use near bedtime, and reduced such behavior among young adults with compatible attitudes. Such simple messaging could be used to increase awareness of the detrimental impact of late evening e-device use and as a simple way to reduce the behavior.

Disclosure statement

The authors have no conflicts of interest.

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Appendix A. Supplementary data

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