

The Longitudinal Association Between Sleep and Adolescent uptake of ENDS

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Background

Curbing the uptake of electronic nicotine delivery systems (ENDS) among adolescents is an important public health initiative because of the wide range of health and behavioral problems associated with ENDS use.^{1,2} One such problem is trouble with sleeping. Research has found that the stimulatory effects of nicotine from ENDS use disrupt sleep,³⁻⁶ however the directionality of this relationship has not been thoroughly explored, and sleep problems may increase the likelihood an individual initiates ENDS use.³

Previous longitudinal research has found that sleep problems in early childhood predicted cigarette uptake later in adolescence.⁷ Because ENDS are similar to cigarettes, we wanted to explore if the association existed between sleep and ENDS use. In a prior cross-sectional study, we found that sleep deprivation was associated with susceptibility to initiate ENDS.⁸ In this study, we longitudinally assessed whether adolescent self-reported sleep problems related to actual initiation of ENDS use after one year. Because of our previous findings and previous findings regarding sleep trouble and cigarettes, we hypothesized that adolescents who reported sleep troubles would have significantly higher risk of actual ENDS use one year later.

Methods

We used data from Waves 4.5 and 5 (2017-2018 to 2018-2019) of the Population Assessment of Tobacco and Health (PATH) study to conduct this analysis. We received exemption from

ethical compliance from KDH Research & Communication's internal IRB, FWA00011177, IRB 00005850. We used the PATH weighting for national representativeness.

Data collection

The design of the PATH study oversamples tobacco users and is susceptible to attrition due to its longitudinal nature.⁹ We used the svyset procedure with wave 5's special collection all-waves cohort 4 weights to adjust for oversampling and nonresponse from wave 4.5 to wave 5. Our estimates were computed with balanced repeated replication (BRR) using a Fay's adjustment value of 0.3 based on the PATH study user guide.¹⁰

Study population

The PATH youth datasets include noninstitutionalized, nonincarcerated, 12- to 17-year-old United States (US) citizens. We excluded youth who had previously used tobacco, alcohol, or illicit substances. The sample used in analysis included 6,466 youth, representative of 13,295,663 youth living across the US.

Analyses

We used STATA 16.1 for all statistical analyses. We conducted four Poisson regression models¹¹ exploring whether reported sleep problems during Wave 4.5 related to ENDS initiation by Wave 5. In each model, we added covariates relevant to sleep and ENDS initiation.

Model 1, was a crude, unadjusted model. Model 2, controlled for age, race/ethnicity, sex, parental

education, household income, physical activity, and body mass index (BMI). Model 3, additionally controlled for exposure to social media ENDS advertising, whether tobacco products could be found in the home, previous year depression, anxiety, school performance, sensation seeking scores, perceptions of ENDS harmfulness, and the respondent's proximity to friends who use ENDS. Finally, in Model 4, we further controlled for the Pierce susceptibility scale,¹² adapted to predict susceptibility to ENDS initiation.¹³⁻¹⁵

Independent variable

Past year sleep troubles: Respondents were asked, "When was the last time that you had significant problems with sleep trouble, such as bad dreams, sleeping restlessly, or falling asleep during the day?" Answer choices included, "Past month," "Two to twelve months ago," "Over a year ago," and "Never." We created a dummy variable where 1 represented a respondent who answered either "Past month" or "Two to twelve months ago", and 0 represented a respondent who answered either "Over a year ago" or "Never." This variable was pulled from Wave 4.5 since we were exploring the potential to predict later ENDS initiation at Wave 5.

Dependent variable

Never-to-ever ENDS use: Respondents were asked, "In the past 12 months, have you used an electronic nicotine product, even one or two times?" with answer choices of "Yes" or "No". We created a dummy variable where 1 represented a respondent who answered "No" at wave 4.5 but "Yes" at wave 5, and 0 represented a respondent who answered "no" at both wave 4.5 and wave 5.

Findings

The majority of youth respondents were Non-Hispanic White (45.78%) while age groups were approximately equal with 50.04% being between the ages of 12 to 14. There were slightly more males (51.77%). Less than half (42.30%) reported experiencing sleep troubles in the past year at wave 4.5, and about 7% initiated ENDS use by wave 5.

In Model 1, adolescents who reported past year sleep troubles at wave 4.5 were associated with significantly higher risk of initiating ENDS use by wave 5 compared to adolescents who reported no past year sleep troubles at wave 4.5 (Past year sleep trouble: RR = 1.75 95% CI = [1.4–2.2]). Model 2 maintained this significant relationship while controlling for socio-demographics and health related variables (Past year sleep trouble: RR = 1.75 95% CI = [1.4–2.2]). In Model 3, the significant association was upheld

while adding covariates for previous year anxiety, previous year depression, exposure to ENDS advertising on social media, whether tobacco products could be found in the home, proximity to friends who use ENDS, school performance, sensation seeking score, and perceived harmfulness of ENDS (Past year sleep trouble: RR = 1.57 95% CI = [1.2–2.0]). The association persisted even in Model 4, when further controlling for susceptibility to initiate ENDS at wave 4.5 (Past year sleep trouble: RR = 1.48 95% CI = [1.1–1.9]).

Discussion

Adolescents face many barriers to achieving healthy sleep including stress from school and social encounters,^{16,17} and detrimentally stimulating environments and behaviors.^{18,19} Furthermore, sleep quality may be affected differently among adolescents by age and sex because of biological transitions occurring during puberty.^{20,21}

Adjustments to earlier school schedules may coincide with such transitions and further obstruct healthy levels of sleep. Research has found that delaying a high school's start time was associated with benefits in mood, alertness, and overall health among students. Future research should explore whether initiation of ENDS differs between schools with different starting times.²²

Classes on sleep hygiene have been developed for adolescents and have shown promise in outcomes besides better sleep such as reduced internalizing behaviors and increased performance at school.²³ Sleep targeted interventions may serve as a protective factor, preventing initiation of ENDS use. Future research should explore whether sleep hygiene classes may affect adolescent susceptibility to initiating ENDS.

We encountered several limitations in this study including the potential of response bias in the PATH study, memory of sleep problems may be inaccurate and concerns about confidentiality may sway adolescent answers about ENDS use. We were limited in the self-reported variable we used to represent sleep problems as it did not have information on the frequency or duration of the sleep issues reported. We excluded adolescents who had previously used alcohol and/or illicit substances, it is possible that sleep problems relate to higher risk of these substances as well.

We used a nationally representative sample of US adolescents aged 12 to 17 to assess the association between self-reported sleep troubles and initiation of ENDS use one year later. Even while controlling for a

substantial list of relevant covariates, we found that adolescents who reported experiencing past year sleep troubles during 2017-2018 had increased risk of initiating ENDS use by 2018-2019 compared to adolescents who reported no sleep troubles.

These findings are essential to parents, researchers, and other professionals directly engaged in ENDS prevention efforts. It is important for research to learn how to better identify the individuals who are most at risk of ENDS initiation and the measures needed for tailoring an environment that is conducive to the healthiest adolescent outcomes. Our findings show that ensuring an optimal amount and quality of sleep may be an effective measure.

References

- ¹ Jones, K., & Salzman, G. A. (2020). The vaping epidemic in adolescents. *Missouri medicine*, 117(1), 56.
- ² Tobore, T. O. (2019). On the potential harmful effects of E-Cigarettes (EC) on the developing brain: The relationship between vaping-induced oxidative stress and adolescent/young adults social maladjustment. *Journal of adolescence*, 76, 202-209.
- ³ Wiener, R. C., Waters, C., Bhandari, R., Trickett Shockey, A. K., & Alshaarawy, O. (2020). The association of sleep duration and the use of electronic cigarettes, NHANES, 2015-2016. *Sleep disorders*, 2020, 1-12.
- ⁴ Mathews, H. L., & Stitzel, J. A. (2019). The effects of oral nicotine administration and abstinence on sleep in male C57BL/6J mice. *Psychopharmacology*, 236, 1335-1347.
- ⁵ Cohrs, S., Rodenbeck, A., Riemann, D., Szagun, B., Jaehne, A., Brinkmeyer, J., ... & Winterer, G. (2014). Impaired sleep quality and sleep duration in smokers—results from the German Multicenter Study on Nicotine Dependence. *Addiction biology*, 19(3), 486-496.
- ⁶ Zhang, L., Samet, J., Caffo, B., & Punjabi, N. M. (2006). Cigarette smoking and nocturnal sleep architecture. *American journal of epidemiology*, 164(6), 529-537.
- ⁷ Wong, M. M., Brower, K. J., Nigg, J. T., & Zucker, R. A. (2010). Childhood sleep problems, response inhibition, and alcohol and drug outcomes in adolescence and young adulthood. *Alcoholism: Clinical and Experimental Research*, 34(6), 1033-1044.
- ⁸ Holtz, K. D., Simkus, A. A., Twombly, E. C., Fleming, M. L., & Wanty, N. I. (2022). Sleep deprivation and adolescent susceptibility to vaping in the United States. *Preventive Medicine Reports*, 26, 101756.
- ⁹ Hyland, A., Ambrose, B. K., Conway, K. P., Borek, N., Lambert, E., Carusi, C., ... & Compton, W. M. (2017). Design and methods of the Population Assessment of Tobacco and Health (PATH) Study. *Tobacco control*, 26(4), 371-378.
- ¹⁰ Zou, G. (2004). A modified poisson regression approach to prospective studies with binary data. *American journal of epidemiology*, 159(7), 702-706.
- ¹¹ USDHHS, 2021a. United States Department of Health and Human Services. National Institutes of Health. National Institute on Drug Abuse, and United States Department of Health and Human Services. Food and Drug Administration. Center for Tobacco Products (2021a). Population Assessment of Tobacco and Health (PATH) Study [United States] Public-Use Files. Inter-university Consortium for Political and Social Research [distributor], 2021-12-1610.3886/ICPSR36498.v16.
- ¹² Zou, G. (2004). A modified poisson regression approach to prospective studies with binary data. *American journal of epidemiology*, 159(7), 702-706.
- ¹³ Pierce, J. P., Choi, W. S., Gilpin, E. A., Farkas, A. J., & Merritt, R. K. (1996). Validation of susceptibility as a predictor of which adolescents take up smoking in the United States. *Health psychology*, 15(5), 355.
- ¹⁴ Strong, D. R., Hartman, S. J., Nodora, J., Messer, K., James, L., White, M., ... & Pierce, J. (2015). Predictive validity of the expanded susceptibility to smoke index. *Nicotine & Tobacco Research*, 17(7), 862-869.
- ¹⁵ Bold, K. W., Kong, G., Cavallo, D. A., Camenga, D. R., & Krishnan-Sarin, S. (2017). E-cigarette susceptibility as a predictor of youth initiation of e-cigarettes. *Nicotine and Tobacco Research*, 20(1), 140-144.
- ¹⁶ Cheng, H. G., Lizhnyak, P. N., Knight, N. A., Vansickel, A. R., & Largo, E. G. (2021). Youth susceptibility to tobacco use: is it general or specific?. *BMC Public Health*, 21(1), 1-8.
- ¹⁷ Hiller, R. M., Lovato, N., Gradisar, M., Oliver, M., & Slater, A. (2014). Trying to fall asleep while catastrophising: what sleep-disordered adolescents think and feel. *Sleep Medicine*, 15(1), 96-103.
- ¹⁸ Gruber, R., Somerville, G., Paquin, S., & Boursier, J. (2017). Determinants of sleep behavior in adolescents: A pilot study. *Sleep health*, 3(3), 157-162.
- ¹⁹ Bartel, K. A., Gradisar, M., & Williamson, P. (2015). Protective and risk factors for adolescent sleep: a meta-analytic review. *Sleep medicine reviews*, 21, 72-85.

- ¹⁹ King, D. L., Gradisar, M., Drummond, A., Lovato, N., Wessel, J., Micic, G., ... & Delfabbro, P. (2013). The impact of prolonged violent video-gaming on adolescent sleep: an experimental study. *Journal of sleep research*, 22(2), 137-143.
- ²⁰ Knutson, K. L. (2005). The association between pubertal status and sleep duration and quality among a nationally representative sample of US adolescents. *American Journal of Human Biology: The Official Journal of the Human Biology Association*, 17(4), 418-424.
- ²¹ Pesonen, A. K., Martikainen, S., Heinonen, K., Wehkalampi, K., Lahti, J., Kajantie, E., & Räikkönen, K. (2014). Continuity and change in poor sleep from childhood to early adolescence. *Sleep*, 37(2), 289-297.
- ²² Owens, J. A., Belon, K., & Moss, P. (2010). Impact of delaying school start time on adolescent sleep, mood, and behavior. *Archives of pediatrics & adolescent medicine*, 164(7), 608-614.
- ²³ Wolfson, A. R., Harkins, E., Johnson, M., & Marco, C. (2015). Effects of the Young Adolescent Sleep Smart Program on sleep hygiene practices, sleep health efficacy, and behavioral well-being. *Sleep health*, 1(3), 197-204.

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