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Original article

E-cigarette Use, Cigarette Smoking, Dual Use, and Problem Behaviors Among U.S. Adolescents: Results From a National Survey

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 A B S T R A C T

Purpose: There is a need to obtain greater clarity regarding adolescents' e-cigarette use and the associations of use with a wider range of risk behaviors. This study examines the associations among past-month e-cigarette use only, traditional cigarette smoking only, dual use (i.e., concurrent e-cigarette use and cigarette smoking), school-related (i.e., truancy and poor academic performance) risk behaviors, and substance-related (i.e., alcohol use, binge drinking, marijuana use, illicit drug use, and nonmedical prescription drug use) risk behaviors.

Methods: Data were collected via self-administered questionnaires from a nationally representative sample of 8,696 high school seniors.

Results: An estimated 9.9% of U.S. high school seniors reported past-month e-cigarette use only, 6.0% reported past-month cigarette smoking only, and 7.3% reported past-month dual use. School- and substance-related risk behaviors had strong associations with past-month e-cigarette use. Adolescents who only used e-cigarettes had significantly greater odds of all school- and substance-related risk behaviors relative to nonusers. Dual users had significantly greater odds of frequent/daily e-cigarette use as well as all school- and substance-related risk behaviors relative to those who only used e-cigarettes. Finally, adolescents who engaged in frequent/daily e-cigarette use had significantly greater odds of binge drinking, marijuana use, other illicit drug use and nonmedical prescription drug use, relative to experimental e-cigarette users.

Conclusions: E-cigarette use is common among U.S. adolescents, and there are robust associations between e-cigarette use and school- and substance-related risk behaviors. There is evidence that e-cigarette use clusters with risk behaviors and appears to represent a problem behavior, especially dual use of e-cigarettes and traditional cigarettes.

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 IMPLICATIONS AND
 CONTRIBUTION

The academic- and substance-related risk behaviors associated with e-cigarette use were examined among high school seniors. E-cigarette use was common and significantly associated with all risk behaviors. Dual users had the greatest risk for engaging in risk behaviors followed by single users of cigarettes, single users of e-cigarettes, and nonusers.

Conflicts of Interest: The authors have no conflicts of interest to disclose.

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Past-month e-cigarette use is now more prevalent among U.S. adolescents than any other nicotine or tobacco product, including traditional cigarette smoking [1–3]. Based on the National Youth Tobacco Survey, past-month e-cigarette use among U.S. high school students increased from 1.5% to 16.0% between 2011 and 2015, whereas past-month traditional cigarette smoking decreased from 15.8% to 9.3% over this same period [3]. Adolescents' e-cigarette use is more prevalent than any other nicotine or tobacco product in part due to e-cigarettes having the lowest perceived risk for regular use relative to any other substance [2].

Initial findings indicate that while e-cigarette use is associated with higher odds of cigarette smoking and lower intentions to quit smoking, more than a quarter million adolescent e-cigarette users have no history of cigarette smoking or other tobacco use [4–10]. Based on the recent increases in e-cigarette use among U.S. adolescents, there are growing concerns that early exposure to these products could lead to increased risk of cigarette smoking and use of other tobacco products [8–10].

More than one in every six U.S. high school seniors reports past-month e-cigarette use [2]. This raises new public health concerns about the health implications of this behavior, which include acute toxicity, asthma, nicotine dependence/tobacco use disorder, adverse brain development, adverse fetal development, lung cancer, injuries related to e-cigarette battery explosions, and accidental overdose [11,12]. While prior empirical and theoretical work has posited that cigarette smoking is associated with risk behaviors during adolescence such as binge drinking, marijuana use, illicit drug use, poor school work, and truancy [13–16], much less is known about the relationships between e-cigarette use and risk behaviors. There is preliminary evidence demonstrating an increased risk for individual substance use behaviors among e-cigarette users such as cigarette smoking and marijuana use, especially among older adolescents [8,16–19]. However, few studies have differentiated between dual users and e-cigarette-only users, and no studies have examined a wider range of risk behaviors. Thus, it is imperative to obtain greater clarity regarding adolescents' e-cigarette use and its relationships with a wider range of school- and substance-related risk behaviors, when adjusting for other relevant covariates based on prior research (including sex, age, race/ethnicity, parental education, college plans, urbancity, and geographical region [1–10,12,16–20]).

Given existing studies on e-cigarette use among adolescents, the current research tests the following hypotheses: (1) recent e-cigarette-only users are more likely than nonusers to engage in school- and substance-related risk behaviors; (2) dual users are more likely than nonusers and e-cigarette-only users to engage in school- and substance-related risk behaviors; and (3) frequent/daily e-cigarette users are more likely than nonusers and less frequent e-cigarette users to engage in school- and substance-related risk behaviors. Accordingly, the hypotheses to be tested in this study will help in understanding whether e-cigarette use clusters with other risk behaviors or reduces the likelihood of risk behaviors.

Methods

Study design

The Monitoring the Future (MTF) study annually surveys a cross-sectional, nationally representative sample of high school

seniors in more than 120 U.S. public and private schools, using self-administered paper-and-pencil questionnaires in classrooms. The samples analyzed in this study consisted of high school seniors from the 2014 cohort, and the MTF study used a multistage sampling procedure. The response rate in the MTF study for high school seniors was 82% in 2014.

Because so many questions are included in the MTF study, much of the questionnaire content is divided into six different questionnaire forms which are randomly distributed to students. This approach results in six identical subsamples. The measures most relevant for this study were asked on forms 1, 2, 5, and 6, so this study focuses on the cross-sectional subsamples receiving these four forms. Additional details about the MTF design and methods are available elsewhere [2,20,21]. Approval was granted for this study by the University of Michigan Institutional Review Board.

The sample for this study included 8,696 individuals who completed questionnaires during the spring of their senior year. The sample represented a population that was 52% female, 54% white, 12% African-American, 16% Hispanic, and 18% other/not disclosed (see Table 1). The modal age of the individuals in the sample was 18 years, and the majority of the population represented was from urban areas, had parents with some college education, and had plans to attend college.

Measures

The MTF study assesses a wide range of variables relevant to e-cigarette use. For the present study, we selected validated measures for analyses, including demographic characteristics and standard measures of school- and substance-related risk behaviors based on previous work using MTF data [2,18,20–23]. Demographic and background characteristics included sex, age (less than 18 years or 18 years and older), race/ethnicity (black, white, Hispanic, and other), parental education (some college vs. high school or less), college plans (any plans to attend college vs. no plans to attend college), metropolitan statistical area (large, other, and nonmetropolitan statistical area), and U.S. Census geographical region (Northeast, Midwest, South, and West).

Past-month e-cigarette use was assessed with the following item: "During the last 30 days, on how many occasions (if any) have you used electronic cigarettes (e-cigarettes)?" The response options ranged from (1) none to (6) 20–30 days and were dichotomized (yes/no) based on previous work [2,18,20].

Past-month traditional cigarette smoking was assessed with the following item: "How frequently have you smoked cigarettes during the past 30 days?" The response options ranged from (1) none to (7) two packs or more per day and were dichotomized based on previous work [2,18,20–23].

Substance-related risk behaviors

Binge drinking was measured with a single item focused on the frequency of having five or more drinks in a row during the past 2 weeks. The response scale ranged from (1) none to (6) 10 or more times. Marijuana and other illicit drug use—including cocaine, ecstasy, lysergic acid diethylamide (LSD), psychedelics other than LSD, heroin—were measured by asking respondents on how many occasions (if any) they used [specified drug] in the past 30 days. The response scale for these items ranged from (1) no occasions to (7) 40 or more occasions. Nonmedical use of prescription drugs was assessed by asking respondents on how

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