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RESEARCH ARTICLE

Students' Cigarette Smoking and the Perceived Nicotine Content of Their E-cigarettes

Jamie Tam, MPH, Kenneth E. Warner, PhD

Introduction: There is concern that youth e-cigarette use may serve as a gateway to cigarette smoking, and that nicotine exposure may harm brain development. It is therefore important to know how much nonsmoking youth perceive being exposed to nicotine through e-cigarettes.

Methods: Data on smoking and vaping from the 2016 Monitoring the Future survey of eighth, tenth, and 12th grade students were analyzed in 2017. The weighted percentage distributions of self-reported e-cigarette mist last inhaled were calculated according to ever-smoking status and past 30-day smoking frequency. Chi-square tests of the association between smoking status and use of e-cigarettes perceived to contain nicotine, marijuana or hash oil, or just flavoring were performed. Never smokers and regular smokers were compared regarding the type of e-cigarette mist they believe they last used.

Results: A significant relationship exists between smoking behavior and reportedly vaping nicotine ($p<0.01$) or just flavors ($p<0.01$). With increasing smoking intensity, an increasing proportion of students report they are vaping nicotine; a decreasing proportion report just flavors. Among 12th graders, prevalence of vaping nicotine is lowest among never smokers and non-current smokers (14.3% and 18.1%) and highest among current and frequent smokers (61.3% and 60.9%, $p<0.01$). Substantially larger proportions of never smokers and 30-day nonsmokers report vaping just flavors (76.0% and 69.6%) compared with regular or frequent smokers (31.0% and 29.3%, $p<0.01$).

Conclusions: Most nonsmoking students perceive limited nicotine exposure from vaping. Future research should evaluate the accuracy of self-reported e-cigarette nicotine content and monitor students who are consciously using nicotine-based e-cigarettes.

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INTRODUCTION

Numerous governmental and nongovernmental public health organizations have expressed concern that widespread use of electronic- or e-cigarettes by youth[1] may lead to nicotine addiction and the "renormalization" of cigarette smoking.[2] They worry as well that exposure to nicotine through vaping may damage young people's developing brains.[3]

Several prospective studies have found that adolescent never smokers who use e-cigarettes are statistically more likely to smoke at least one cigarette by follow up (6–18 months later) compared with never smokers who did not vape.[4–6] However, problems with the quality of measures used for smoking, substance use, and other confounders make it difficult to assess whether there is a causal relationship between vaping and subsequent smoking, and have been described in detail elsewhere.[7] Whether e-cigarettes lead to smoking uptake depends in part on the extent to which young nonsmokers are vaping nicotine and whether they are knowingly doing so.

In 2015, Monitoring the Future (MTF), an annual national survey of middle and high school students' drug use,[8,9] first asked respondents what they believed was in

From the Department of Health Management and Policy, School of Public Health, University of Michigan, Ann Arbor, Michigan

Address correspondence to: Kenneth E. Warner, PhD, Department of Health Management and Policy, School of Public Health, University of Michigan, 1415 Washington Heights, Ann Arbor MI 48109. E-mail: kwarner@umich.edu.

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the mist they inhaled from their electronic vaporizers, with e-cigarettes and e-pens given as examples. Nearly two thirds responded "just flavoring." "Nicotine" was a distant second, the answer of only one fifth of students.[10] The finding suggests that large proportions of youth who vape are not exposing themselves to nicotine through e-cigarettes, or at least do not think that they are. The "just flavoring" response consistently dominated across gender, race and ethnicity, and parental education. The single major differentiation among students was related to the frequency of e-cigarette use: The only group of students who responded "nicotine" about as often as "just flavoring" (47.5% and 44.6%, respectively) were high school seniors who vaped six or more times in the past 30 days.

Concern about vaping among young people derives primarily from its potential effects on nonsmokers. Whereas current smokers are already exposed to significant amounts of nicotine, especially those who smoke frequently, nonsmoking youth are much less exposed to nicotine, and thus to its adverse effects on the brain and its potential for addiction. The question arises, therefore, as to how much nonsmokers are exposed to nicotine through their use of e-cigarettes. To address this question, this study examines perceived use of nicotine-containing e-cigarettes by students' smoking status.

METHODS

Study Sample

Data on smoking and e-cigarette use from the 2016 MTF survey were analyzed in 2017.[8,9] That year, 45,473 students in 372 public and private schools participated in the survey, with response rates of 90%, 88%, and 80% for eighth, tenth, and 12th graders, respectively. A random sample of one third of the students from each grade, totaling 13,926 students, were queried about their knowledge of and experience with vaping. The subject of vaping was initiated with the following background information: "Electronic vaporizers make a mist that is inhaled and have the feel of cigarette smoking. Examples include e-cigarettes and e-pens." The students were then asked, *Have you ever used an electronic vaporizer such as an e-cigarette?* Those who responded affirmatively were then asked, *The LAST TIME you used an electronic vaporizer such as an e-cigarette, what was in the mist you inhaled?* The options were the following, with each respondent permitted to select only one: *nicotine*, *marijuana or hash oil*, *just flavoring*, *other*, and *don't know*.

Students were queried about their ever-smoking status, with the response options being *never*, *once or twice*, *occasionally but not regularly*, *regularly in the past*, and *regularly now*. They were also asked about the frequency of their smoking in the past 30 days, with answers being *not at all*, *<1 cigarette/day*, *1–5 cigarettes/day*, *about ½ pack/day*, *about 1 pack/day*, *about 1½ packs/day*, and *≥2 packs/day*.

For more information on MTF's coverage and sampling procedures, see Johnston et al.[8,9] and Miech and colleagues.[10] The MTF data set is publicly available and de-identified.

Measures

Among those who had ever vaped, weighted percentages of students' reported e-cigarette contents were measured by smoking status. This was done for both measures of smoking behavior: ever-smoking status and past 30-day smoking frequency. The responses of 12th graders are reported separately, whereas eighth and tenth graders are combined. Eighth and tenth graders were combined due to the small numbers of respondents in each grade in the higher-intensity smoking categories, and because qualitatively similar results were found with respect to nicotine and just flavoring when analyzed separately. All students reporting smoking half a pack or more/day were combined into this single category due to the very small number of students in each of the individual categories with more than one to five cigarettes/day.

Statistical Analysis

Chi-square tests of independence of smoking status and use of e-cigarettes reported to contain nicotine (2 X 4 and 2 X 5 contingency tables) were conducted using the Rao–Scott second-order correction for survey design effects, which yields an F statistic.[11,12] This was similarly done for e-cigarettes reported to contain just flavoring and marijuana mist, with Bonferroni adjustment[13] of p-values to account for multiple comparisons (m=3). Denominators in these analyses were respondents who reported that they had ever vaped. Second, separate tests of equal proportions were performed comparing never smokers and regular smokers with respect to the type of e-cigarette mist last used (results included as parenthetical notes in the main text). This was likewise done comparing individuals who reported smoking no cigarettes with those who smoked half a pack or more of cigarettes per day in the past month. Taken together, these two tests assess whether there is an association between smoking frequency X type of e-cigarette vaped, and whether the two most opposite smoking groups are equally likely to vape nicotine or just flavoring. All analyses were conducted in R, version 3.1.3, using the survey package,[14,15] which makes necessary adjustments for subpopulation or domain estimates.

RESULTS

In 2016, a total of 33.4% of 12th grade students reported ever vaping (95% CI=31.7%, 35.2%), and 12.3% reported vaping in the past 30 days (95% CI=11.5%, 13.1%). There were 71.9% of seniors that were never smokers (95% CI=71.0%, 72.9%), 28.1% had ever smoked (95% CI=27.1%, 29.0%), and among ever smokers, 62.8% did not smoke in the past 30 days (95% CI=60.8%, 64.7%). A total of 10.4% of seniors report smoking within the past 30 days (95% CI=9.8%, 11.0%). Tables 1 and 2 present 12th grade students' responses to the question, *The LAST TIME you used an electronic vaporizer such as an e-cigarette, what was in the mist you inhaled?* Table 1