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Adolescents' awareness of the nicotine strength and e-cigarette status of JUUL e-cigarettes

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ABSTRACT

Background: JUUL e-cigarettes are popular among youth. However, it is unknown whether adolescents understand that 5% JUUL pods contain a high nicotine concentration or consider JUULs to be e-cigarettes.
Method: 3170 students from 4 Connecticut high schools completed a school-based survey (May–October 2018). Students reported on lifetime and past-month JUUL use and perceived JUUL nicotine strength (low/medium/high/don't know) when no information about nicotine concentration was provided and, subsequently, when informed JUULs contain 5% nicotine. Students reported whether they believe JUULs are e-cigarettes (no/yes/don't know).
Results: Students were never JUUL users (56.6%), ever users (13.2%), and past-month users (30.2%). When no information was provided, students reported that JUULs contain low (10.5%), medium (26.9%), or high nicotine levels (31.1%); 31.4% did not know. When informed JUULs contain 5% nicotine, students were more likely to believe JUUL's nicotine strength was low (29.5%) or medium (29.3%) than high (21.3%) and less likely to report not knowing (19.9%). 39% of students believed JUULs are not e-cigarettes or did not know.
Discussion: Most students were unaware of JUUL's high nicotine concentration, with more believing that JUULs contain low or medium nicotine concentrations when informed JUULs contain 5% nicotine. Thus, youth may misinterpret the nicotine concentration printed on JUUL pod packaging, raising concerns about inadvertent exposure to high nicotine levels and dependence risk. Further, 39% of adolescents believed JUULs are not e-cigarettes or were unsure. Regulatory efforts are needed to establish understandable nicotine concentration labels, require products to be labeled accordingly, and clarify what products constitute e-cigarettes.

1. Introduction

JUUL e-cigarettes resemble USB flash drives and use disposable pods containing nicotine salt and flavors (e.g., tobacco, mango). JUUL is the most popular American e-cigarette brand (Carver, 2018), and, at the time the study was conducted, its pods uniformly contained among the highest nicotine concentrations commercially available (5% or 59 mg/ml; JUUL Labs Inc, 2019). JUUL Labs Inc. (2019) claims that JUULs are a "satisfying alternative to cigarettes" for adult smokers. However, JUULs are popular among youth (Huang et al., 2019; Kavuluru et al., 2019; Willett et al., 2019), with a recent study showing that JUULs were the most popular vaping device used by high school students (Krishnan-Sarin et al., 2019). JUULs' popularity combined with their high nicotine content raises concerns about exposing youth to the deleterious effects of nicotine on the developing brain and addiction risk (Morean et al., 2018; U.S. Department of Health and Human Services [USDHHS], 2012).

Importantly, youth often are unaware of the nicotine content of e-liquids (Morean et al., 2016), and most youth are unaware that JUULs always contain nicotine (Willett et al., 2019). Beginning in August 2018, the US Food and Drug Administration (FDA) mandated that all e-liquid packaging display a warning ("This product contains nicotine. Nicotine is an addictive chemical."), which may improve youths' knowledge of whether a product contains any nicotine. However, this warning does not address nicotine strength. Although no reporting standard exists, e-liquid nicotine concentrations typically are presented

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as milligrams/milliliter or as percent nicotine. At the time of the study, all JUUL pod packages were labeled as "5% strength." While "5% strength" refers to the fact that pods contain 5% nicotine, the word "nicotine" was absent from the label (although it has since been added). It is important to understand how youth interpret this information, as the labeling of JUUL nicotine pods could lead to misunderstanding. For example, 5% sounds like a small amount, so youth may incorrectly believe that JUUL pods contain a low nicotine concentration.

Further, youth commonly use the term "JUULing" to refer to JUUL use instead of terms more commonly used to refer to e-cigarette use like "vaping," raising questions about whether youth view JUULs as e-cigarettes (Huang et al., 2019; Kavuluru et al., 2019). Understanding whether youth consider JUULs to be e-cigarettes is critical to informing youth-focused regulatory and prevention efforts (FDA, 2018a, 2018b). If youth do not think JUULs are e-cigarettes, this may represent an additional pathway through which youth inadvertently expose themselves to vaping-related harms and suggests that products should be labeled clearly as e-cigarettes.

We addressed these aforementioned issues by examining adolescents' perceptions of JUUL pods' nicotine strength when no information about nicotine concentration explicitly was provided versus when adolescents were informed JUUL pods contain 5% nicotine. We included the no information condition to assess adolescents' baseline knowledge of JUULs' nicotine strength. We showed adolescents a picture of JUUL pod packaging and highlighted that "JUULs contain 5% nicotine" to understand how adolescents perceive the nicotine concentration label. Finally, we evaluated whether adolescents view JUULs as e-cigarettes.

2. Methods

2.1. Participants

All students from 4 Connecticut high schools who were in attendance on the dates of survey administration (May-October 2018) were invited to participate (N = 3730). 85.0% of students (N = 3170) completed the anonymous, computerized survey (52.4% female, 60.4% White; 15.87[SD = 1.29] years old).

2.2. Procedures

The Institutional Review Board of Yale University, the school boards, and the participating schools approved the study. Passive parental permission was obtained prior to survey administration. Three parents refused their child's participation. All participants were informed that participation was voluntary. Completing the survey indicated participants' consent/assent.

2.3. Measures

Participants reported on lifetime and past-30-day JUUL use (Table 1). Participants also reported on perceived nicotine strength of JUUL pods (low, medium, high, I don't know), first when no information about nicotine concentration was provided, and, subsequently, when informed that JUULs contain "5% nicotine." The nicotine strength questions were presented separately, and participants could not use the "back/forward" buttons to view or change previous responses. Finally, participants reported whether they believe JUULs are e-cigarettes (no, yes, I don't know).

2.4. Data analyses

We categorized students as never JUUL users, ever JUUL users (tried a JUUL but no past-month use), and past-30-day (past-month) JUUL users. We then ran descriptive statistics within the total sample and by JUUL use status. To evaluate whether there were significant differences in perceived nicotine strength when no information was provided versus when 5% nicotine was specified, we ran a multinomial Generalized Estimating Equation (GEE) model to assess the effects of the within-subjects factor "information" (no information vs. 5% content) and the between-subjects factor "JUUL use status" (never, ever, past-month) on perceived nicotine strength (low, medium, high, don't know). Tests of the interaction of information by JUUL use status and of the main effects were performed. Significant results were followed by tests of effect slices (i.e., assessments of the effect of information for each type of JUUL user) and pairwise comparisons. School (4 levels) was entered as a fixed effect in the model to control for potential differences by school. Significance was set at 0.05. Odds ratios and 95% confidence intervals were calculated to evaluate the magnitude of effects. Finally, we ran a chi-square evaluating whether JUUL use status influenced beliefs that JUULs are e-cigarettes.

3. Results

The sample comprised 56.6% never JUUL users, 13.2% ever users, and 30.2% past-month users (Table 1). When no information about nicotine strength was provided, 37.4% of all students thought JUULs contain a low or medium nicotine strength and 31.4% were unsure. After informing students that JUULs contain 5% nicotine, 58.8% of all students thought JUULs contain a low or medium nicotine strength and 19.9% were unsure. The GEE model produced a statistically significant interaction between information and JUUL use status (χ^2 (6) = 101.73, $p < .001$) and significant main effects for information (χ^2 (3) = 499.19, $p < .001$) and JUUL use (χ^2 (6) = 164.80, $p < .001$). The significant interaction was explained by a larger difference between the no information and information conditions in predicting perceived nicotine strength among never users than ever users (χ^2 (3) = 29.52, $p < .001$) and past month users (χ^2(3) = 98.52, $p < .001$; Fig. 1). However, there were no significant differences in the impact of information on perceived nicotine strength between ever and past month users (χ^2(3) = 4.59, $p = 0.20$). Never users were more likely to rate nicotine strength as low (OR = 7.50, 95% CI: [6.21, 9.06]) or medium (2.06, 95% CI: [1.76, 2.42]) rather than high when informed that JUULs contain 5% nicotine. Ever and past month users also were more likely to rate nicotine strength as lower after being informed that JUULs contain 5% nicotine, but the effects were smaller than for never users (low versus high nicotine: ever users OR = 2.97, 95% CI: [2.25,3.92], past-month users OR = 2.22, 95% CI: [1.87, 2.62]; medium versus high nicotine: ever users OR = 1.53, 95% CI: [1.17, 2.01], past-month users OR = 1.19, 95% CI: [1.03, 1.36]). Past month users also were less likely to respond "don't know" compared to rating the nicotine strength as high when they were informed that JUULs contain 5% nicotine (OR = 0.76, 95% CI: [0.63, 0.91]). Taken together, the findings suggest that most students, including JUUL users, were unaware of JUULs' high nicotine concentration, with even more students indicating that JUULs contain low or medium nicotine (versus high) when they were informed that JUULs contain 5% nicotine.

In total, 61.1% of adolescents believed that JUULs are e-cigarettes; 15.3% believed that JUULs are not e-cigarettes, and 23.7% did not know whether JUULs are e-cigarettes. Believing JUULs are e-cigarettes differed by JUUL use status (χ^2[4] = 94.73, $p < .001$). Ever users (66.3%) and past-month users (68.9%) were more likely to think that JUULs are e-cigarettes than never users (55.7%). In addition, ever users (17.4%) and past-month users (14.4%) were less likely to report not knowing if JUULs are e-cigarettes compared to never users (30.0%).

4. Discussion

At the time of the study, JUUL pods contained a uniformly high nicotine concentration (5%). However, when adolescents' baseline knowledge of JUULs nicotine strength was assessed, 37.4% of all adolescents thought JUULs were low or medium nicotine strength

Table 1
Descriptive statistics for central study variables within the total sample and by JUUL use status.

Study Variables	Study Questions and Responses by Study Sample			
	Total Sample (N = 3170)	Never JUUL Users (n = 1795, 6.6%)	Ever JUUL Users (n = 419; 3/2%)	Past-Month JUUL Users (n = 956; 30.2%)
Birth Sex	*At birth, what was your sex?*			
Female (%)	52.4	52.1	51.8	53.1
Age	*How old are you?*			
Mean years (std. dev.)	15.87 (1.29)	15.69 (1.28)	15.95 (1.25)	16.17 (1.26)
Race	*How would you describe your race?*			
White (%)	60.4	55.7	62.5	68.1
Ever JUUL Use	*Have you ever tried a JUUL?*			
Yes (%)	43.4	0.0	100.0	100.0
Past 30 Day JUUL Use	*Approximately how many days out of the past 30 days did you use a JUUL?*			
Frequency in # Days	–	0.0	0.0	13.59 (11.68)
Any Past 30 Day Use (%)	30.2	0.0	0.0	100.0
JUUL Nicotine Strength (No Info)	*Which of the following do you think best describes the amount of nicotine in a JUUL?*			
Low (%)	10.5	7.3	15.6	14.4
Medium (%)	26.9	23.6	27.4	33.0
High (%)	31.1	29.4	28.8	35.4
I don't know (%)	31.4	39.7	28.1	17.2
JUUL Nicotine Strength (5% Specified)	*The nicotine content of a JUUL is 5%. Which of the following do you think best describes the amount of nicotine in a JUUL?*			
Low (%)	29.5	30.3	32.9	26.5
Medium (%)	29.3	27.4	29.8	32.7
High (%)	21.3	16.8	20.9	29.9
I don't know (%)	19.9	25.6	16.3	10.8
JUUL as a Type of E-cigarette	*Do you consider a JUUL to be a type of e-cigarette?*			
No (%)	15.3	14.3	16.2	16.6
Yes (%)	61.1	55.7	66.3	68.9
I don't know (%)	23.7	30.0	17.4	14.4

(including 59.2% of past-month users) and 31.4% did not know. When adolescents were told "JUULs contain 5% nicotine," all adolescents were more likely to think that JUULs contain low or medium nicotine (compared to high) than when they were given no information about nicotine content. Differences based on JUUL use status suggested that the findings were most pronounced among never JUUL users, which may be expected given their lack of familiarity with the product. However, believing JUULs contain a low level of nicotine may be a risk factor for experimentation/initiation among never users. With regard to JUUL users, the impact of being informed that "JUULs contain 5% nicotine" was not negligible; ever and past-month users were more than twice as likely to believe JUULs contain low nicotine after reading that JUULs contain 5% nicotine. These findings may be due to the fact that 5% sounds like a small amount, although this was not tested in the study. Further research is needed to determine whether labeling nicotine concentrations in milligrams/milliliter, using combustible cigarettes as a reference point (e.g., 1 pod = 20 cigarettes), or developing a novel method of labeling nicotine concentrations increases youths' ability to understand nicotine strength. Irrespective of why youth misunderstand JUULs' nicotine strength, the findings are concerning for

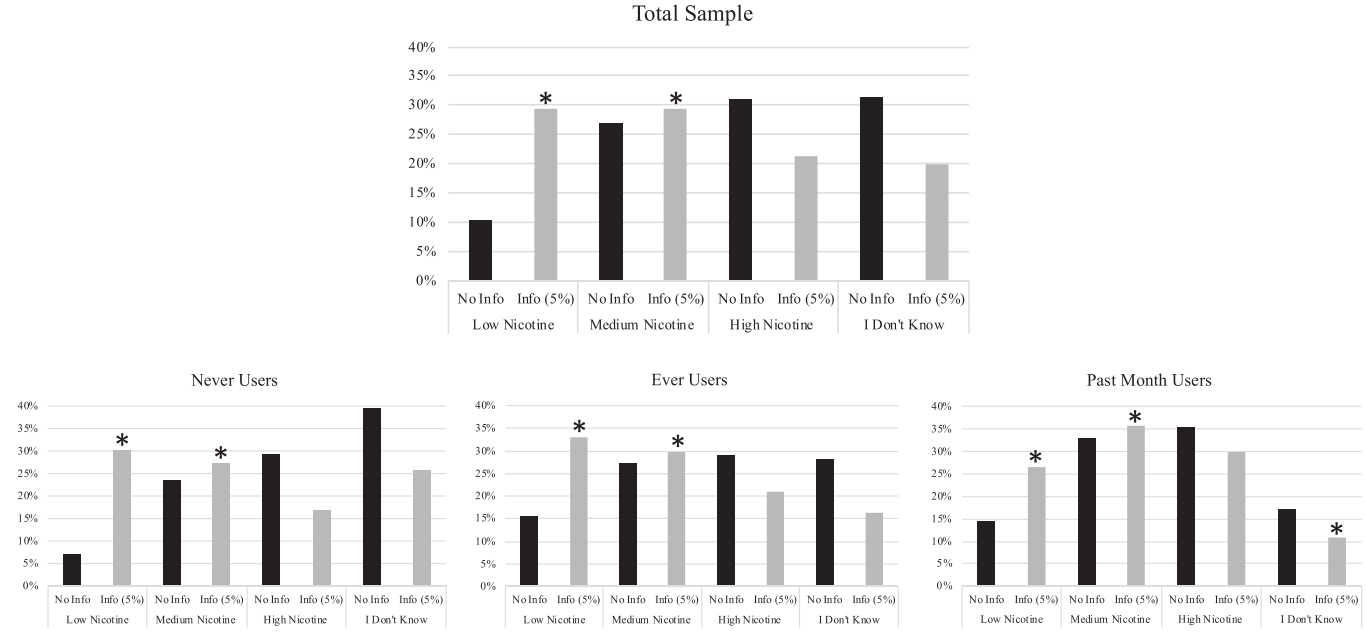

Fig. 1. Perceived nicotine strength varies based on information about nicotine content provided (no information vs. informed JUULs contain 5% nicotine) and JUUL use status.
Note. * denotes responses that differ significantly from a response of "high nicotine" after adolescents were informed that JUULs contain 5% nicotine.

several reasons. First, adolescent JUUL users could be inadvertently exposing themselves to high nicotine levels, which is associated with deleterious effects on the developing brain including impaired cognitive development, executive functioning, and impulse control (USDHHS, 2012). Second, adolescents are more susceptible to developing nicotine dependence than adults (USDHHS, 2012), and recent evidence demonstrates that adolescents can experience nicotine dependence via using e-cigarettes (Morean et al., 2018). Thus, adolescents using high nicotine content products like JUUL may be especially vulnerable to addiction.

Furthermore, 39% of all adolescents did not consider JUULs to be e-cigarettes or were unsure, and a sizeable percentage (31%) of JUUL users did not recognize they are using an e-cigarette. It is possible that adolescents simply do not understand what constitutes a product being considered an e-cigarette, and, as a result, also may be unaware that they are using a tobacco product; this idea needs to be explored in future studies. Alternatively, adolescents may consider JUULs to be separate devices entirely, consistent with using the term "JUULing." Given that many adolescents did not realize that JUULs are e-cigarettes, our findings indicate that it is critical to ensure that questions assessing "e-cigarette" use are easily understood by participants (Alexander et al., 2016), and we suggest including popular brand examples in definitions. Alternatively, assessing the use of specific e-cigarette devices including JUUL may yield more accurate use rates, consistent with prior studies (Morean et al., 2019).

The study findings should be interpreted in light of several limitations. First, we informed students that JUULs contain 5% nicotine, which is not exactly what was printed on JUUL packaging at the time of the study (i.e., JUUL packages used the terminology "5% strength"). It is possible that youth may have been even more confused about what "5% strength" means. Second, we focused on 5% nicotine JUUL pods, but did not assess adolescents' ability to understand the nicotine strength of alternative brand pods that are compatible with JUUL yet are available in variable nicotine concentrations (e.g., Ziip Pods, 2019) or newer 3% nicotine JUUL pods. While additional research is needed, the central finding that youth did not understand what 5% nicotine means likely extends to other concentrations labeled as percent nicotine. Third, the response options for the nicotine strength questions (i.e., low, medium, high) were somewhat vague, did not undergo cognitive testing, and no comparison point was provided (e.g., tobacco cigarettes). While future research is needed to quantify what constitutes low, medium, and high nicotine concentrations, at the time of the study, JUULs' nicotine concentration was among the highest commercially available, clearly situating JUUL in the "high nicotine" category. Finally, data were obtained from four Connecticut high schools, and replication is needed in nationally representative samples.

In sum, the current study is the first to provide direct evidence that 1) most adolescents are unaware that JUUL pods contain a high nicotine concentration (when they are given no information about JUUL's nicotine strength), 2) most adolescents do not understand that the nicotine concentration printed on JUUL pod packaging corresponds to a high nicotine level, and 3) nearly 40% of adolescents do not think JUULs are e-cigarettes or do not know. As previously noted, a standardized nicotine warning now is required on all e-liquid packaging. Although this warning informs users that a product contains nicotine, it does not speak to the strength of the product. Our results suggest that labeling nicotine concentrations using percent nicotine may be misleading, especially among youth. Regulatory efforts are needed to develop labels that convey nicotine concentrations in a meaningful way to all consumers and to ensure that products are labeled accordingly. Further, considering the known neurotoxic effects of nicotine on the developing brain, regulators should consider including content on labels that educates youth about the negative consequences of nicotine exposure. In addition, given that nearly 40% of students did not think JUULs are e-cigarettes or were unsure, efforts are needed to determine the best ways to clarify for youth what products constitute e-cigarettes and that e-cigarettes are tobacco products. Health risk communication and prevention efforts targeting youth e-cigarette use should include specific language about JUUL and other pod-based systems, including nicotine levels, to ensure that youth understand that the risks associated with e-cigarette use extend to these products. Alternatively, given the ever evolving landscape of nicotine-delivering products, efforts may be more effective if they simply educate youth about the dangers of inhaling nicotine in any form.

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Contributors

Drs. Morean, Bold, Kong, Camenga, Simon, Jackson, Cavallo, and Krishnan-Sarin collaborated on the development of the original study and conceptualized the current research question. Drs. Morean and Gueorguieva completed the statistical analyses. Dr. Morean drafted the original version of the manuscript and all other authors provided substantive feedback on further drafts. All authors approved the submitted manuscript.

Declaration of Competing Interest

No conflicts declared. Although unrelated to the current study, MM consults for Gofire, Inc with a restricted stock agreement.

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