



## Differences in intention to use flavored oral nicotine products among young adult e-cigarette users and non-users

Adam M. Leventhal<sup>a,b,c,d,\*</sup>, Junhan Cho<sup>a,b,d</sup>, Erin A. Vogel<sup>a,b,d</sup>, Alayna P. Tackett<sup>a,b,c,d</sup>, Alyssa F. Harlow<sup>a,b,d</sup>, Melissa Wong<sup>a,b</sup>, Dae-Hee Han<sup>a,b,c,d</sup>, Chanita Hughes Halbert<sup>b,c</sup>, Jennifer Unger<sup>a,b,c,d</sup>, Caryn Lerman<sup>a,c</sup>, Jessica L. Barrington-Trimis<sup>a,b,c,d</sup>

<sup>a</sup> USC Institute for Addiction Science, University of Southern California, Los Angeles, CA, USA

<sup>b</sup> Department of Population and Public Health Sciences, University of Southern California, Keck School of Medicine, Los Angeles, CA, USA

<sup>c</sup> USC Norris Comprehensive Cancer Center, University of Southern California, Keck School of Medicine, Los Angeles, CA, USA

<sup>d</sup> USC Tobacco Center of Regulatory Science, University of Southern California, Los Angeles, CA, USA

### ABSTRACT

New oral nicotine products (ONPs; nicotine pouches, gums, lozenges, and gummies), which are regulated as nonmedicinal tobacco products in the U.S., have flavors and other characteristics that previously attracted young adults to e-cigarettes. Whether young adults' interest in ONPs differs by e-cigarette use status and quit-vaping motivation is unknown but important for understanding the possible health impact of ONPs. It is particularly important to study if nonmedicinal ONPs attract e-cigarette users interested in quitting vaping, given that nicotine replacement (NRT) therapy uptake in young adults is low. In this study, ONP non-users (ages: 20–24) from California viewed digital images of 5 flavored ONPs (4 nonmedicinal and one NRT gum product) and reported intention to use each ONP (0–100 score). Main and interactive effects of Group (past-6-month e-cigarette non-users [ $n = 1,1388$ ], e-cigarette users unmotivated to quit vaping [ $n = 168$ ], and e-cigarette users motivated to quit vaping [ $n = 99$ ]) and ONP type (nonmedicinal gum, nonmedicinal lozenge, gummy, pouch, and NRT gum) on use intention were tested. For each nonmedicinal ONP, use intention was higher in both e-cigarette user groups than non-users ( $d_s = 0.47$ – $0.59$ ;  $P_s < 0.001$ ), but did not differ between e-cigarette users with and without quit-vaping motivation ( $P_s \geq 0.31$ ). A Group  $\times$  ONP type interaction was found, whereby higher use intention for e-cigarette users with vs without quit motivation was present for only gum NRT (Cohens  $d = 0.17$ ;  $P = .01$ ). Among young adults, e-cigarette users might be more inclined than e-cigarette non-users to try nonmedicinal ONPs regardless of quit-vaping motivation.

### 1. Introduction

Young adulthood is a developmental period marked by risk of nicotine and tobacco product use initiation (Pérez et al., 2021), with e-cigarettes being the most commonly used product among United States (U.S.) young adults in 2020 (Schulenberg et al., 2020). An emerging sector of flavored commercial oral nicotine products (ONPs; nicotine pouches, nonmedicinal gums, nonmedicinal lozenges, and gummies) has several characteristics that are similar to e-cigarettes that could make these ONPs attractive to young adults. Like e-cigarettes, commercial ONPs use social media advertisements, contain no tobacco leaves, are available in fruit and mint flavors, and have aesthetically modern packaging that could appeal to young people (see Fig. 1) (Czaplicki et al., 2021; Lucy Goods, 2022a; Robichaud et al., 2020). In the U.S. (U. S. Food and Drug Administration, 2016) and several other countries (Salokannel and Ollila, 2021), these commercial ONPs are marketed and regulated as nonmedicinal tobacco products unlike nicotine

replacement therapy (NRT) ONPs, such as nicotine gums and lozenges used for tobacco use cessation, which are regulated as medicines. Several nonmedicinal ONP manufacturers have submitted tobacco product marketing applications for ONPs that are under regulatory review (Lucy Goods, 2021; Reynolds American Inc, 2020). Data are lacking to inform regulatory decisions on nonmedicinal ONP marketing applications because of limited evidence on whether key populations, such as young adults, are likely to use them, and which subgroups of young adults are most inclined to initiate ONP use.

The health implications of ONP use may vary across different young adult subpopulations distinguished by their tobacco product use status. Of the various tobacco products used by young adults, nonmedicinal ONPs may appeal especially to young adults who use e-cigarettes because of their similarities. Both nonmedicinal ONPs and e-cigarettes are non-combusted nicotine products, come in various flavors, and have modern packaging. While the risks of ONP use are unclear, prior research indicates that oral nicotine pouches may possess some

\* Corresponding author at: University of Southern California, 2001 N Soto St., Los Angeles, CA 90033, USA.

E-mail address: [adam.leventhal@usc.edu](mailto:adam.leventhal@usc.edu) (A.M. Leventhal).

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| Product type                  | Brand/Flavor Variant  |  |
|-------------------------------|---|--|
| Medicinal nicotine gum        | Variant A (mint)  | Variant B (fruit)  |
|                               |    |    |
| Nonmedicinal nicotine gum     | Variant A (mint)  | Variant B (fruit)  |
|                               |    |    |
| Nonmedicinal nicotine lozenge | Variant A (mint)  | Variant B (fruit)  |
|                               |   |   |
| Tobacco free nicotine pouch   | Variant A (mint)  | Variant B (fruit)  |
|                               |  |  |
| Nicotine gummy                | Variant A (fruit #1)  | Variant B (fruit #2)   |
|                               |  |  |

Fig. 1. Images of Oral Nicotine Products Displayed in Use Intention Rating Assessment.

addiction potential (Rensch et al., 2021; Lunell et al., 2020). Additionally, preliminary evidence indicates that some pouch users anecdotally report experiencing oral symptoms, such as gum bleeding (Shao et al., 2022). Hence, ONP uptake among nicotine/tobacco non-users might pose health hazards. ONP adoption amongst e-cigarette users may have various health implications, some of which may depend on whether users who uptake ONPs intend to quit vaping. Young adult e-cigarette users who initiate ONP use and then quit vaping and switch to using only ONPs could benefit by avoiding untoward pulmonary exposures present with e-cigarettes (Azzopardi et al., 2021). Although there is no evidence yet of whether nonmedicinal ONPs promote, has no effect, or hinders vaping cessation efforts. However, if ONP use is adopted by e-cigarette users with no motivation to quit, ONP use could lead to dual use patterns with important implications. Dual use of nonmedicinal ONPs and e-cigarettes with no intention to quit vaping could increase cumulative nicotine exposure by enabling use in situations where vaping is not possible, which could accelerate acquisition of nicotine dependence. It is also possible that dual use could cause some vapers with no intention to quit to substitute some of their vaping episodes with ONP use, which could reduce pulmonary exposure. Given the diversity of outcomes that could follow ONP adoption, investigating interest in using nonmedicinal ONPs with among young adult e-cigarette users with varying interest in quitting vaping would be informative.

It is also important to understand whether the association of motivation to quit vaping with intention to use ONPs varies across NRT and nonmedicinal ONPs. Some nonmedicinal ONP manufacturers encourage consumers to use their products instead of vaping (Lucy Goods, 2022b). In the cigarette literature, NRT utilization is less common among younger vs older adult cigarette smokers (Babb et al., 2017), because young tobacco product users might find NRT unappealing. If research were to demonstrate that young adult quit-vaping motivation was associated with interest in using nonmedicinal ONPs, not but not NRT ONPs, this evidence would indicate that novel nonmedicinal ONPs could encourage young adult e-cigarette users to switch to oral nicotine who otherwise might not use oral NRTs. If research does not find this pattern, new nonmedicinal ONPs could divert young adult e-cigarette users who are motivated to quit vaping away from U.S. Food and Drug Administration (FDA)-approved medicinal nicotine and toward nonmedicinal ONPs instead.

For novel products with minimal public awareness, the U.S. FDA provides guidance for tobacco product perception or intention studies in which participants report their intention to use products after viewing product packaging (Food and Drug Administration, 2020). We applied this paradigm in a sample of young adult non-users of ONPs participating in a prospective cohort study. This cross-sectional study examined intention to use several types of commercially marketed nonmedicinal novel ONPs in comparison to therapeutic nicotine gum, the top-selling NRT formulation in the U.S. (Fortune Business Insights, 2021). The primary aim was to examine whether young adults' ONP use intention differed by e-cigarette use/quit-motivation group (i.e., e-cigarette non-users, e-cigarette users without motivation to quit vaping, and e-cigarette users motivated to quit vaping), and for which particular ONP types (i.e., NRT gum, nonmedicinal gum, nonmedicinal lozenges, gummies, and pouches). As a supplementary aim, we examined whether e-cigarette use/quit motivation group differences in ONP use intentions varied across different brands of ONPs with either fruit and mint flavors, which would inform the generalizability of the findings across products and whether regulations should target specific flavors of ONPs.

## 2. Methods

### 2.1. Study sample and procedures

Data are from an ongoing cohort study of health behaviors among high school students who were recruited from 10 Southern California area high schools in 2013 and were followed throughout high school and into young adulthood (Leventhal et al., 2015). All students enrolled in

the partnering schools were eligible to participate in the cohort study, which involved surveys of health behaviors 1–2 times per year. Data for the current study represent a cross-sectional analysis of a recent data collection wave, which occurred from November 2021 to December 8, 2021, and included all individuals who reported no past 6-month use of nonmedicinal ONPs. Participants were sent a digital invitation with a link to complete a web survey including self-report measures of demographics, nicotine/tobacco product use, and intentions to use ONPs. Participants provided informed consent and the study was approved by the University of Southern California institutional review board.

### 2.2. Measures

#### 2.2.1. Intention to Use ONPs

Participants were asked: “Below are various types of nicotine products you can eat, suck on, or chew. We’re curious about whether you would try using any of them if you were offered them by a friend or someone you trust.” Next, images of five types of widely-marketed ONPs drawn from manufacturer and distributor websites were displayed in the following order: nonmedicinal nicotine gum, nicotine gummies, nonmedicinal nicotine lozenge, nicotine pouch, and NRT gum. Underneath each respective product’s image, “Would you use this product?” was displayed alongside a visual analogue rating scale (continuous: 0 “definitely not” to 100 “definitely yes”). To determine the generalizability of the results across different brands and flavors, participants were randomly assigned to view either stimulus variant A (brands in mint flavors) or B (brands in fruit flavors) for each product type (see Fig. 1). Because gummies are not available in mint, participants were randomly assigned to view either “Cherry Bomb” or “BlueRaz” flavor gummies of the same brand.

#### 2.2.2. E-cigarette use and motivation to Quit Vaping

Participants were categorized into three groups (e-cigarette non-users, e-cigarette users motivated to quit, e-cigarette users not motivated to quit) based on responses to two dichotomous items: 1) past 6-month use of e-cigarettes to vape nicotine (yes/no) and 2) for those who used e-cigarettes in past 6 months: “seriously considering reducing or quitting vaping nicotine within the next 6 months” (yes/no). We also collected information on whether participants who used e-cigarettes vaped on a weekly or more basis in the past 30 days (yes vs no) for descriptive purposes and to explore the generalization of study results across different levels of vaping frequency.

#### 2.2.3. Sociodemographic characteristics and Past 6-month Tobacco Product Use

Sociodemographic and tobacco product use variables were incorporated to describe the sample and to use as covariates in analyses to ensure that any differences between e-cigarette use group/quit-vaping motivation status were not confounded by external socio-environmental factors that may confer a common liability for e-cigarette use and interest in trying ONPs. Participants completed questionnaire items assessing current age, race/ethnicity, gender identity, sexual identity, education, employment, personal financial status (see response categories in Table 1). Past 6-month use of combustible cigarettes, little cigars or cigarillos, and hookah/waterpipe were combined into an “any combustible tobacco product use” variable (yes/no). Items assessing past 6-month use of tobacco-free nicotine pouches (yes/no) and non-medical flavored oral nicotine products (i.e., nicotine gums, lozenges, mints/tablets, and/or gummies; yes/no) were administered to identify existing users of nonmedicinal ONPs to exclude from analyses.

### 2.3. Data analysis

Initial analyses described the study sample and compared participant characteristics across the three e-cigarette use/quit motivation status groups. The primary analysis used random effect-repeated measures linear regression, accounting for within-person clustering and adjusting

**Table 1**  
Participant characteristics, by e-cigarette use and quit vaping motivation status.<sup>a</sup>

| Variables  | Past 6-month e-cigarette use and quit vaping motivation status |                                   |                                       | Group difference, P-value <sup>e</sup> |
|--|--|-----------------------------------|---------------------------------------|--|
|  | No e-cigarette use (N = 1118)                                  | Use with quit motivation (N = 99) | Use without quit motivation (n = 168) |  |
| Age, year, M (SD)  | 22.58 (0.39) <sup>1</sup>                                      | 22.55 (0.38) <sup>1</sup>         | 22.61 (0.40) <sup>1</sup>             | 0.49                                   |
| Race/ethnicity, N (%)                                    |  |                                   |                                       | 0.11                                   |
| Hispanic   | 528 (48.1) <sup>1</sup>  | 40 (42.1) <sup>1</sup>            | 69 (41.6) <sup>1</sup>                |  |
| Asian  | 235 (21.4) <sup>1,2</sup>                                      | 15 (15.8) <sup>2</sup>            | 44 (26.5) <sup>1</sup>                |  |
| Black  | 47 (4.3) <sup>1</sup>  | 7 (7.4) <sup>1</sup>              | 7 (4.2) <sup>1</sup>                  |  |
| White  | 171 (15.6) <sup>1</sup>  | 17 (17.9) <sup>1</sup>            | 21 (12.7) <sup>1</sup>                |  |
| Another <sup>b</sup>                                     | 117 (10.7) <sup>1</sup>  | 16 (16.8) <sup>1</sup>            | 25 (15.1) <sup>1</sup>                |  |
| Gender identity, N (%)                                   |  |                                   |                                       | 0.40                                   |
| Cisgender male   | 341 (32.5) <sup>2</sup>  | 39 (43.8) <sup>1</sup>            | 68 (43.3) <sup>1</sup>                |  |
| Cisgender female   | 681 (64.9) <sup>1</sup>  | 49 (55.1) <sup>1,2</sup>          | 86 (54.8) <sup>2</sup>                |  |
| Transgender male   | 3 (0.3) <sup>1</sup>   | 0 (0.0) <sup>1</sup>              | 0 (0.0) <sup>1</sup>                  |  |
| Transgender female                                       | 1 (0.1) <sup>1</sup>   | 0 (0.0) <sup>1</sup>              | 0 (0.0) <sup>1</sup>                  |  |
| Gender variant/Non-binary                                | 9 (0.9) <sup>1</sup>   | 0 (0.0) <sup>1</sup>              | 1 (0.6) <sup>1</sup>                  |  |
| Another/prefer not to disclose                           | 3 (0.3) <sup>1</sup>   | 0 (0.0) <sup>1</sup>              | 0 (0.0) <sup>1</sup>                  |  |
| Sexual identity, N (%)                                   |  |                                   |                                       | 0.29                                   |
| Asexual  | 33(3.2) <sup>1</sup>   | 1 (1.1) <sup>1</sup>              | 6 (3.8) <sup>1</sup>                  |  |
| Bisexual   | 77 (7.4) <sup>2</sup>  | 14 (15.9) <sup>1</sup>            | 16 (10.3) <sup>1,2</sup>              |  |
| Gay  | 25 (2.4) <sup>1</sup>  | 4 (4.5) <sup>1</sup>              | 2 (1.3) <sup>1</sup>                  |  |
| Straight   | 841 (80.7) <sup>1</sup>  | 65 (73.9) <sup>2</sup>            | 124 (79.5) <sup>1,2</sup>             |  |
| Lesbian  | 7 (0.7) <sup>1</sup>   | 0 (0.0) <sup>1</sup>              | 0 (0.0) <sup>1</sup>                  |  |
| Pansexual  | 17 (1.6) <sup>1</sup>  | 0 (0.0) <sup>1</sup>              | 3 (1.9) <sup>1</sup>                  |  |
| Queer  | 7 (0.7) <sup>1</sup>   | 0 (0.0) <sup>1</sup>              | 1 (0.6) <sup>1</sup>                  |  |
| Another/prefer not to disclose                           | 35 (3.3) <sup>1</sup>  | 4 (4.5) <sup>1</sup>              | 4 (2.5) <sup>1</sup>                  |  |
| Enrolled in a degree program, N (%)                      | 458 (45.3) <sup>1</sup>  | 30 (32.6) <sup>1</sup>            | 68 (43.6) <sup>1</sup>                | 0.09                                   |
| Full-time job (vs Other <sup>c</sup> ), N (%)            | 368 (36.4) <sup>1</sup>  | 43 (46.7) <sup>1</sup>            | 67 (42.9) <sup>1</sup>                | 0.20                                   |
| Personal financial status, N (%)                         |  |                                   |                                       | 0.60                                   |
| Live comfortably   | 398 (39.4) <sup>1</sup>  | 28 (30.4) <sup>1</sup>            | 62 (39.7) <sup>1</sup>                |  |
| Meet needs with a little left                            | 342 (33.9) <sup>1</sup>  | 35 (38.0) <sup>1</sup>            | 53 (34.0) <sup>1</sup>                |  |
| Just meet basic expenses                                 | 207 (20.5) <sup>1</sup>  | 25 (27.2) <sup>1</sup>            | 32 (20.5) <sup>1</sup>                |  |
| Don't meet basic expenses                                | 63 (6.2) <sup>1</sup>  | 4 (4.3) <sup>1</sup>              | 9 (5.8) <sup>1</sup>                  |  |
| Past 6-month combustible tobacco use, <sup>d</sup> N (%) | 53 (4.7) <sup>2</sup>  | 42 (42.4) <sup>1</sup>            | 61 (36.3) <sup>1</sup>                | <.001 <sup>f</sup>                     |
| Vaped at least weekly past 30 days, N (%)                | N/A <sup>g</sup>   | 57 (57.6)                         | 110 (65.5)                            | <.001 <sup>f</sup>                     |

<sup>a</sup> Analytic sample N = 1385. Available data Ns for all study variables ranged from 1258 to 1385.

<sup>b</sup> American Indian/Alaska Native, Native Hawaiian/Pacific Islander, or other responses constituted an "Another" category.

<sup>c</sup> "Other" category included "Working part-time", "Not working for pay", and "Prefer not to disclose".

<sup>d</sup> Any use of combustible cigarettes, hookah, or cigars/cigarillos.

<sup>e</sup> Calculated using the  $\chi^2$  test for categorical variables and one-way Analysis of Variance (ANOVA) for continuous variables. Groups not sharing superscript numerals are significantly different in post-hoc pairwise contrasts for  $\chi^2$  tests and ANOVA Least Significant Difference. P-values of post-hoc pairwise contrast were statistically significant after Benjamini-Hochberg corrections for multiple testing.

<sup>f</sup> P-values were statistically significant after Benjamini-Hochberg corrections for multiple testing to control false discovery rate at 0.05 (based on a 2-tailed corrected P-value).

<sup>g</sup> N/A = Not applicable.

for demographics and combustible tobacco use. Models tested the simultaneous main effects of Group (e-cigarette non-user, user motivated to quit vaping, user not motivated to quit) and ONP type (non-medicinal gum, nonmedicinal lozenge, gummy, pouch, and NRT gum) on use intention scores, followed by pairwise contrasts. The Group  $\times$  ONP type interaction term was then added to determine whether differences in ONP use intention by e-cigarette use/quit-vaping motivation to quit varied by ONP type. Interactions were followed by stratified simple effect analyses comparing ONP use intention levels by e-cigarette use/quit-vaping motivation status separately for each ONP type. Supplementary analyses examined whether the interaction effects varied across brand/flavor variants with Group  $\times$  ONP type  $\times$  Brand/flavor three-way tests, excluding data on use intention for gummies that were only available in fruit flavors. To determine the generalizability of any differences across e-cigarette use/quit-vaping motivation status groups in intention to use certain ONPs vs others based on recency of vaping and combustible tobacco use, we also tested Group  $\times$  ONP type  $\times$  Past-month vaping frequency-three-way tests in the subset of past 6-month e-cigarette users. We also examined if poly-use of combustible tobacco among the subsample of e-cigarette users differentiated ONP preferences by testing past-6-month combustible tobacco use  $\times$  ONP type interactions. Results reported are unstandardized regression coefficients (bs) indicating the adjusted difference in intention ratings across

categories and are accompanied by unadjusted Cohen's d effect size estimates of the differences in standard deviation units. Because e-cigarette use/quit-vaping motivation status was associated with combustible tobacco use (see Table 1), the two-way interaction model was additionally adjusted for the combustible tobacco use  $\times$  ONP type term. The analytic sample included participants with complete e-cigarette use/quit-vaping motivation and outcome data. Missing covariate data were managed with full information maximum likelihood estimation. Analyses were conducted in Mplus version 8 (Muthén and Muthén, 1998–2017.) with significance set to 0.05 (two-tailed). Benjamini-Hochberg multiple testing corrections were applied to control the false discovery rate at 0.05 (Benjamini and Hochberg, 1995).

### 3. Results

#### 3.1. Study sample

Among the 3396 original cohort enrollees in 2013, 1517 completed surveys for the most recent data collection featured in this study. After excluding past 6-month users of any nonmedicinal ONP (n = 31) and those with incomplete past 6-month e-cigarette use/quit-vaping motivation or ONP use intention outcome data (n = 101), the study's analytic sample was 1385.

The sample was demographically heterogeneous and none of the demographic variables significantly differed by e-cigarette use/quit-vaping motivation status ( $P_s \geq 0.09$ ) (Table 1). Past 6-month combustible tobacco use was more common among past 6-month e-cigarette users with (42.4 %) or without (36.3 %) quit motivation compared to e-cigarette non-users (4.7 %;  $P < .001$ ).

3.2. Differences in ONP use intentions, by E-cigarette use/quit-vaping motivation group and ONP type

3.2.1. Main effects

There were significant Group main effects (Table 2). Averaged across the five ONP types, use intentions were higher in users unmotivated to quit vs non-users (Cohen's  $d = 0.55$ ,  $p = .001$ ) and users motivated to quit vs non-users ( $d = 0.55$ ,  $p < .001$ ), but did not differ between the two e-cigarette user groups ( $d = 0.01$ ,  $p = .83$ ). There were also significant ONP type main effects (Table 2). In the overall sample collapsed across groups, use intentions were slightly higher for nonmedicinal gum than NRT gum ( $d = 0.12$ ,  $p < .001$ ) but did not significantly differ between NRT gum and the other nonmedicinal ONPs ( $p$ -values  $> 0.05$ ).

3.2.2. Group  $\times$  ONP type interaction

The main effects were qualified by a significant Group  $\times$  ONP type interaction. Stratified analyses depicted in Fig. 2 indicate that the interaction was driven by higher use intentions for e-cigarette users with vs without quit motivation that were present only with the NRT gum ( $d$

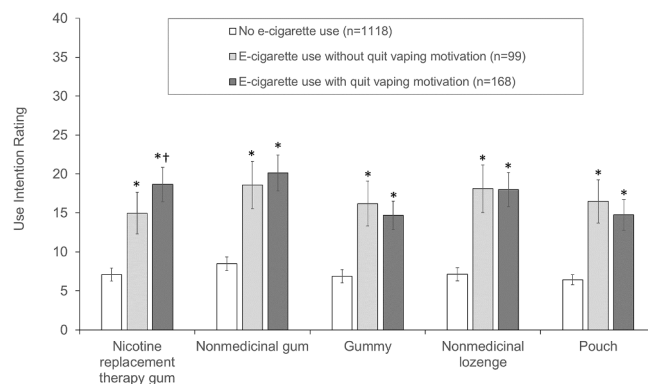


Fig. 2. Mean (SE) intention to use oral nicotine products, by e-cigarette use and quit vaping motivation status<sup>a,b</sup>. <sup>a</sup>Outcome was responses to “Would you use this product?” (0 “definitely not” to 100 “definitely yes”). <sup>b</sup>Statistical significance of pairwise contrast was estimated using Benjamini-Hochberg corrections for multiple testing (based on a 2-tailed corrected P-value at 0.05). \*Significantly different from no e-cigarette use group for respective product type ( $p < .001$ ). †Significantly different from e-cigarette use without quit vaping motivation for respective product type ( $p = .01$ ).

$= 0.17$ ;  $p = .01$ ). For each nonmedicinal ONP, both e-cigarette user groups reported higher use intentions than non-users of e-cigarettes (Nonmedicinal gum,  $d_s = 0.55$ – $0.59$ , nonmedicinal lozenge,  $d_s =$

Table 2

Main and interactive effects of e-cigarette use/quit motivation group and oral nicotine product type on oral nicotine use intention.<sup>a</sup>

|   | Outcome: Intention to use oral nicotine products <sup>b</sup> |                                  |                     |
|---|---|----------------------------------|---------------------|
|   | Mean Score (95 %CI) <sup>c</sup>                              | Adjusted b (95 %CI) <sup>d</sup> | P-value             |
| <b>Main effects model<sup>e</sup></b>                 |   |                                  |                     |
| Past 6-month e-cigarette use and quit motivation      |   |                                  |                     |
| No e-cigarette use                                    | 7.09<br>(6.71, 7.48) <sup>2</sup>                             | Reference                        | –                   |
| E-cigarette use without quit vaping motivation        | 18.06<br>(15.81, 20.30) <sup>1</sup>                          | 8.60<br>(3.46, 13.74)            | 0.001 <sup>h</sup>  |
| E-cigarette use with quit vaping motivation           | 18.27<br>(16.52, 20.02) <sup>1</sup>                          | 8.97<br>(5.37, 12.57)            | <0.001 <sup>h</sup> |
| Oral nicotine product type                            |   |                                  |                     |
| Nicotine replacement therapy gum                      | 9.20<br>(8.26, 10.15) <sup>2</sup>                            | Reference                        | –                   |
| Nonmedicinal gum                                      | 10.58<br>(9.54, 11.61) <sup>1</sup>                           | 1.55<br>(0.80, 2.30)             | <0.001 <sup>h</sup> |
| Gummy   | 8.38<br>(7.52, 9.24) <sup>2</sup>                             | –0.56<br>(–1.23, 0.12)           | 0.10                |
| Nonmedicinal lozenge                                  | 9.24<br>(8.29, 10.19) <sup>2</sup>                            | 0.16<br>(–0.53, 0.85)            | 0.65                |
| Pouch   | 8.60<br>(7.70, 9.49)  | –0.59<br>(–1.23, 0.50)           | 0.07                |
| <b>Interaction effect model<sup>f</sup></b>           |   |                                  |                     |
| E-cigarette use/quit motivation $\times$ product type | –   | –                                | 0.03 <sup>g,h</sup> |

<sup>a</sup> Analytic sample N = 1385.

<sup>b</sup> “Would you use this product?” (possible range from: 0 “definitely not” to 100 “definitely yes”).

<sup>c</sup> Means with different superscripts are significantly different in pairwise comparisons of one-way Analysis of Variance Least Significant Difference tests. P-values of post-hoc pairwise contrast were statistically significant after Benjamini-Hochberg corrections for multiple testing.

<sup>d</sup> Parameter estimate from linear random effect-repeated measures regression models accounting for within-person clustering and adjusting for all sociodemographic and combustible tobacco use variables in Table 1. Past 6-month combustible tobacco use was associated with ONP use intention (adjusted b[95 %CI] = 5.36[1.29, 9.43],  $p = .01$ ).

<sup>e</sup> Including past 6-month e-cigarette use and quit motivation, oral nicotine product type, all sociodemographic variables, and combustible tobacco use as simultaneous regressors.

<sup>f</sup> Additionally adjusted for the oral product type  $\times$  past 6-month combustible product use status interaction term, which was not significant ( $P = .38$ ).

<sup>g</sup> Result from omnibus test of overall interaction effect.

<sup>h</sup> P-values were statistically significant after Benjamini-Hochberg corrections for multiple testing to control false discovery rate at 0.05 (based on a 2-tailed corrected P-value).

0.57–0.58, pouch ds = 0.51–0.58, gummy ds = 0.47–0.56; all p-values < 0.001); however, the two e-cigarette user groups did not significantly differ from one another in intention to use each of the nonmedicinal ONPs (p-values  $\geq$  0.31).

### 3.3. Sensitivity analyses

There was no evidence that differences in e-cigarette use/quit-vaping motivation status by ONP type interaction varied depending on whether the stimulus included brand variants with mint or fruit flavors (3-way interaction  $p = .23$ ) or whether e-cigarette users vaped at least weekly in the past 30 days (3-way interaction  $p = .67$ ). There was also no evidence that preferences for certain ONP types differed in the subsample of e-cigarette users ( $n = 267$ ) based on whether they did vs did not also use combustible tobacco in the past 6 month (product type  $\times$  ONP interaction,  $p = .38$ ).

## 4. Discussion

This study provides new evidence that young adult e-cigarette users may have comparatively higher intention to use all types of ONPs than e-cigarette non-users. Notably, higher use intention for e-cigarette users vs non-users was found for nicotine gummies, nonmedicinal nicotine gums, and nonmedicinal lozenges as well as NRT. These findings do not indicate that the packaging of novel ONPs might disproportionately attract young adults who do not already use e-cigarettes, and rather are preferred more by young adults that vape (Ambrose et al., 2015).

The current results indicate that intention to use NRT gum might modestly differ between e-cigarette users with versus without quit-vaping motivation, while intention to use nonmedicinal ONPs may not differ across these two groups. This pattern of results does not indicate that nonmedicinal ONPs divert young vapers motivated to quit away from NRT products. Lack of a significant difference in nonmedicinal ONP use intentions between e-cigarette users with and without quit-vaping motivation suggests that novel nonmedicinal ONPs may have broader appeal to the overall young vaper population. Nonmedicinal ONPs can be used discreetly and are advertised by manufacturers as products that can be used at the workplace without others being aware (Lucy Nicotine, 2020). Young adult e-cigarette users who enjoy vaping and wish to continue using e-cigarettes might be more inclined to try novel ONPs because these products have similarities to e-cigarettes that they already prefer, including flavors. A sensitivity analysis indicated that the differential association of e-cigarette use/quit-vaping motivation status with intention to use NRT gum vs non-medicinal ONPs may generalize across varying ONP brands in both fruit and mint flavors. Because this study tested only two variants for each ONP, future research of young adult ONP use intentions across a wider diversity of brands and flavors is warranted.

Although e-cigarette users' ONP use intention scores were 2–3 times higher than those of non-users in this study, absolute mean use intention levels were low. Caution should be exercised in interpreting these absolute values, which may underestimate use uptake in the natural ecology. Digital tobacco product perception and intention studies cannot simulate certain real-world conditions (Lempert et al., 2020). Young adults' first trial of a new nicotine/tobacco product typically occurs after having an opportunity to physically handle the product, inspect the packaging and labeling, observe other individuals using the product, speak with others about the product, and see the product's advertisements. Hence, this study's results are best suited for making comparative inferences about differences in use intention across populations or products. Additionally, existing users of ONPs were excluded from analyses by design. Hence, absolute use intention scores reported here might underestimate ONP use in the overall population.

Previous studies found that use or intention to purchase nicotine pouches may be more common in younger adults than older adults and higher among poly-tobacco users than single-product or non-users

(Plurphanswat et al., 2020; Brose et al., 2021; Havermans et al., 2021). Prevalence estimates of ever-nicotine pouch use were <1 % in Dutch adolescents in 2020 (Havermans et al., 2021) and 4 % in a sample of UK adults who have smoked or vaped in 2019 (Brose et al., 2021). Ever use of any nonmedicinal ONP was estimated at 3.4 % in a sample of Southern California adolescents in 2021 (Harlow et al., 2022). Analyses of nicotine pouch manufacturer-collected data found that approximately half of nicotine pouch consumers stated that they used pouches to reduce or quit tobacco use (Plurphanswat et al., 2020). Observational surveillance of self-reported ONP use will be needed to accurately estimate the absolute prevalence of ONP adoption and its association with e-cigarette use status and quit vaping motivation in the young adult population. Additionally, surveillance of product packaging/branding to understand how the marketplace is shifting and the potential influence that different language or claims on packaging might have on interest to use ONPs. Language around 'quit smoking' on NRT gum packaging may attract more users interested in quitting. It will be important to study the effects of including unauthorized language implying cessation assistance on the packaging of nonmedicinal ONPs.

This study had limitations. First, a single picture of each ONP's packaging was displayed with cursory use intention assessment in this remote digital survey to reduce participant burden. The real-world applicability of this method is not entirely clear; however, prior research using similar methods has found some concordance between results from tobacco perception and intention studies and observational assessment of product adoption (McCaffrey et al., 2021). Second, the pictures were selected from authentic marketing images of the products on vendor websites resulting in variability in elements across the products (e.g., some show packaging only vs others show products and packaging), which could have affected use intentions. Third, there may be differences between e-cigarette users and non-users that were not accounted for in this study, leading to residual confounding. However, there were few differences identified between the groups in 7 demographic variables and we statistically adjusted for combustible tobacco product use. Fourth, use of smokeless tobacco or nicotine replacement therapy use was not assessed and therefore could not be addressed in data analyses or sample exclusions. Fifth, the various ONP products were reported in fixed order; leaving the possibility that order effects might influence study results. Order effects, such as sensitization or habituation, would generate successive increases or decreases in ratings with each sequential response and could confound the main effects of ONP type. This study's results did not follow this pattern; overall mean scores decreased from first to second rating, increased by rating three, decreased by rating four, and then increased again by the final rating. Thus, order effects did not appear to substantially influence study results. Regardless, order effects would not presumably impact e-cigarette users vs non-users differently and are unlikely to influence associations of user group with ONP use intention. Finally, the study design was focused on comparing e-cigarette use status and therefore treated combustible tobacco use as a confounder. Incidentally combustible tobacco use had a main effect association with greater intention to try ONPs regardless of the ONP type (see Table 2 note), although the association was weaker than the corresponding association of e-cigarette use with ONP use intention. Future research using different study designs will be needed to address the important question of whether combustible tobacco users are interested in trying nonmedicinal ONPs.

## 5. Conclusions

In this study of ONP use intention among young adults, intention to try novel nonmedicinal nicotine gums, lozenges, and gummies was higher in e-cigarette users than non-users, regardless of users' motivation to quit vaping. These findings can inform decisions on nonmedicinal ONP marketing applications from various manufacturers submitted to the U.S. FDA (Lucy Goods, 2021; Reynolds American Inc, 2020) and regulatory agencies in other countries (Salokannel and Ollila, 2021).

The findings also aid in interpreting the FDA's decision to authorize marketing of mint-flavored nicotine gum and lozenges as commercial tobacco products (FDA, 2021). The current study's results do not indicate that authorizing sales of flavored nonmedicinal ONPs would put products on the market that disproportionately attract young adult e-cigarette non-users, nor do the study results indicate that nonmedicinal ONPs could substantially divert young adults motivated to quit vaping away from using NRTs. The results do, however, raise the possibility that authorizing nonmedicinal ONPs could attract some young adult e-cigarette users without intention to quit vaping into ONP-e-cigarette poly-nicotine use patterns. Regulatory decisions on nonmedicinal ONPs should consider the current evidence alongside future research addressing ONP use surveillance in youth and older adult nicotine/tobacco users, addiction potential, toxicity, and effects on use of other nicotine/tobacco products.

#### CRedit authorship contribution statement

**Adam M. Leventhal:** Conceptualization, Funding acquisition, Investigation, Methodology, Project administration, Supervision, Writing – original draft, Writing – review & editing. **Junhan Cho:** Writing – original draft, Formal analysis, Data curation, Writing – review & editing. **Erin A. Vogel:** Writing – original draft, Writing – review & editing. **Alayna P. Tackett:** Writing – review & editing. **Alyssa F. Harlow:** Writing – review & editing. **Melissa Wong:** Data curation, Project administration, Writing – review & editing. **Dae-Hee Han:** Writing – review & editing. **Chanita Hughes Halbert:** Writing – review & editing. **Jennifer Unger:** Writing – review & editing. **Caryn Lerman:** Writing – review & editing. **Jessica L. Barrington-Trimis:** Funding acquisition, Writing – review & editing.

#### Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

#### Data availability

Data will be made available on request.

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