



# 'Ice' flavoured e-cigarette use among young adults

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## ABSTRACT

**Background** 'Ice' e-cigarette flavours—marketed as a combination of fruity/sweet and cooling flavours (eg, 'blueberry ice' or 'melon ice')—recently entered the US market. The prevalence and correlates of ice flavoured e-cigarette use in young adults are unknown.

**Methods** This cross-sectional study of a Los Angeles, California, USA, cohort analysed data from the past 30-day e-cigarette (current) users (n=344; M (SD)=21.2 (0.4) years old) who completed web-based surveys from May–August 2020. The exposure variable was self-reported e-cigarette flavour used most often in the past month (menthol/mint, fruit/sweet or ice). Outcomes included self-reported combustible tobacco use, vaping dependence symptoms, frequency of use and device type used.

**Results** Among current e-cigarette users, 48.8% reported using ice flavours most often, 33.7% predominately used fruit/sweet and 17.4% used menthol/mint. Using primarily ice-flavour was associated with reporting more past-30-day vaping days (vs menthol/mint: b=4.4, 95% CI (1 to 7.7); vs fruit/sweet: b=3.6, 95% CI (0.8 to 6.4)) and more episodes per vaping day versus fruit/sweet users (b=2.4, 95% CI (0.5 to 4.3)). Ice-flavour users were less likely than menthol/mint users to use JUUL/cartridge-based rechargeable (OR=0.1, 95% CI (0.03 to 0.45)) and more likely than sweet/fruit users to use disposable non-cartridge (OR=3.9, 95% CI (2.1 to 7.4)) devices than refillable/rechargeable tank/pen or other devices. Ice users had greater odds of past 30-day combustible tobacco use versus menthol/mint users (OR=2.7, 95% CI (1.3 to 5.7)) and vaping dependence symptoms than versus sweet/fruit users (OR=2.6, 95% CI (1.5 to 4.4)).

**Conclusion** Young adult use of ice flavoured e-cigarettes may be common and positively associated with combustible tobacco use, nicotine vaping frequency and dependence and use of disposable e-cigarette devices. Further study of the prevalence, determinants and health effects of ice flavoured e-cigarette use is warranted.

E-cigarette use (vaping) is common and associated with adverse health effects in US young adults.<sup>1 2</sup> Availability of appealing flavours has been cited by young adults as one of the top reasons they use e-cigarettes.<sup>3</sup> Studying the prevalence and correlates of specific e-cigarette flavours used among young adults is important for informing policy affecting young adult health.

Until recently, most prominent non-tobacco e-cigarette flavours fell into two mutually-exclusive classes—those with either sweet (eg, fruit, dessert) or cooling (eg, menthol, mint) attributes.<sup>4</sup> In the context of recent regulations on flavoured e-cigarette products that exempted menthol products<sup>5</sup> and rapidly evolving e-cigarette markets, 'ice' e-cigarette flavours

recently entered the marketplace in conjunction with a surge of disposable e-cigarette sales.<sup>6</sup> 'Ice'-flavoured e-cigarettes are marketed as possessing both sweet and cooling properties in fruit/dessert-cooling combinations (eg, 'blueberry ice' or 'melon ice'). They may not fit into existing flavouring categorisations, which may complicate regulatory action. The prevalence and tobacco-related correlates of ice flavoured e-cigarette use among young adults are unknown.

This cross-sectional self-report study compared young adults that predominately used e-cigarettes in ice flavours to those that predominately used either menthol/mint or fruit/sweet flavours. Flavour preference groups were compared on tobacco product use characteristics of importance to public health and regulatory policy (eg, combustible tobacco use and vaping dependence, frequency of use, device type used).

## METHODS

### Participants and measures

Data were drawn from the Happiness & Health Study—a prospective cohort study of health behaviour which originally recruited ninth grade students in Los Angeles, California, USA, schools in 2013 (n=3396).<sup>7</sup> Students provided informed consent, and this study included participants who completed the most recent web-based survey (18 May–3 August 2020) as young adults (N=2179).

Of 407 past 30-day e-cigarette users, 383 responded to the question 'How would you best describe the types of flavours you use most often?' with eight forced-choice responses. Due to small cells, we excluded participants reporting 'flavourless' (n=13), 'tobacco flavoured' (n=5), 'non-sweet (eg, alcohol, spice)' (n=1) and 'mix of flavours' (n=20). In the remaining analytical sample (n=344), the exposure variable contained three mutually-exclusive groups: (1) a combination of 'menthol/mint'; (2) 'fruit/sweet'; and (3) 'ice-fruit combinations'. Online supplemental appendix figure 1 depicts participant accrual and inclusion in the analytical sample.

The following tobacco product use characteristics were outcome variables: (1) past 30-day combustible tobacco use; (2) past 30-day vaping device type used most often (response categories in [table 1](#)); (3) vaping dependence measured by the modified Hooked on Nicotine Checklist ( $\geq 1$  vs 0 symptoms)<sup>8 9</sup>; (4) quit attempts defined as 'stopped vaping for  $\geq 1$  days' in the past 6 months (yes/no); (5) vaping during versus after high school; (6) past 30-day number of days vaped (continuous, range: 1–30)<sup>10</sup>; (7) past 30-day number of nicotine vaping episodes per vaping day (continuous, range: 1–20)<sup>10</sup>; and (8) past 30-day number of puffs per nicotine vaping episode (continuous, range: 1–20).<sup>10</sup>

Covariates included age, gender, race/ethnicity, post-high school, living with parents, personal



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**Table 1** Association of ice-flavoured e-cigarette use and with tobacco product use characteristics

Outcomes	No. (%) or mean (SD)			Associations from regression models*			
	Menthol/mint†	Fruit/sweet†	Ice†	Ice vs menthol/mint		Ice vs fruit/sweet	
	(n=60)	(n=116)	(n=168)	OR or b (95% CI)	P value	OR or b (95% CI)	P value
<b>Categorical variables‡</b>							
Past 30-day combustible tobacco use (yes vs no)§	13 (21.7)	38 (32.8)	53 (31.5)	<b>2.7 (1.3 to 5.7)</b>	0.01	1.2 (0.7 to 2.1)	0.59
Device used most often							
Rechargeable/refillable tanks/pens or others¶	15 (29.4)	60 (59.4)	45 (31.3)	Reference		Reference	
JUUL or similar rechargeable with cartridges	12 (23.5)	6 (5.9)	5 (3.5)	<b>0.1 (0.03 to 0.45)</b>	0.002	1.5 (0.4 to 5.6)	0.57
Disposable without separate cartridges/pods	24 (47.1)	35 (34.7)	94 (65.3)	1.3 (0.6 to 2.8)	0.54	<b>3.9 (2.1 to 7.4)</b>	<0.001
Vaping dependence symptoms (yes vs no)**	40 (66.7)	49 (43)	112 (67.1)	1 (0.5 to 1.9)	0.93	<b>2.6 (1.5 to 4.4)</b>	<0.001
Past 6-month quit vaping attempt (yes vs no)††	23 (39)	43 (37.7)	85 (51.5)	1.7 (0.9 to 3.3)	0.10	1.4 (0.8 to 2.4)	0.19
Started vaping during vs after high school‡‡	40 (72.7)	71 (65.1)	122 (73.9)	1.1 (0.5 to 2.3)	0.77	<b>1.9 (1.02 to 3.37)</b>	0.04
<b>Continuous variables (past 30 days)§§</b>							
No. days vaped¶¶	12.2 (11.2)	12.1 (11.8)	17 (11.5)	<b>4.4 (1 to 7.7)</b>	0.01	<b>3.6 (0.8 to 6.4)</b>	0.01
No. vaping episodes/day***	9 (7.5)	7.6 (8.1)	10.8 (7.9)	1.5 (−0.8 to 3.8)	0.19	<b>2.4 (0.5 to 4.3)</b>	0.01
No. puffs/episode†††	4.1 (5.2)	3.2 (4.1)	3.6 (3.4)	−0.4 (−1.6 to 0.8)	0.49	0.3 (−0.7 to 1.3)	0.55

Unless otherwise noted, n=344. Significant associations are depicted in bold.  
 Bold values indicate p<0.05.  
 \*Multivariable model including e-cigarette flavour most often used variable and all covariates listed in online supplemental appendix table 1 as simultaneous regressors.  
 †The menthol/mint group collapsed 'menthol' (n=23) or 'mint' (n=37) responses; fruit/sweet (eg, fruit, candy, dessert, butters); and ice-fruit combinations (blueberry ice, melon ice, banana ice, ice pineapple).  
 ‡No. (column %) and ORs from logistic regression models shown.  
 §Any use of cigarettes, big cigars, little cigars or cigarillos or hookah waterpipe, use >1 vs. 0 products.  
 ¶'Mod or mech-mod rechargeable', 'Box mod', 'Other tank style device', 'Any other electronic nicotine device' (available n=296).  
 \*\*Hooked on nicotine checklist for e-cigarettes 1≥ vs 0 symptoms (n=341).  
 ††During the past 6 months, have you stopped vaping for ≥1 day because you were trying to quit? (n=338).  
 ‡‡Vaping onset during versus after high schools based on responses to ever e-cigarette use questions in survey waves administered when cohort was in high school (n=329).  
 §§Mean (SD) and b's from linear regression models shown.  
 ¶¶Number of past 30-day vaping days. Responses ('0', '1–2' (recoded=1.5), '3–5' (recoded=4), '6–9' (recoded=7.5), '10–19' (recoded=14.5), '20–29' (recoded=24.5) or '30' (recoded=30) times (range: 0–30)).  
 \*\*\*In the past 30 days, on the days you vaped nicotine, how many times did you usually pick up your e-cigarette device to vape? Responses ('0', '1', '2', '3–5' (recoded=4), '6–9' (recoded=7.5), '10–14' (recoded=12), '15–20' (recoded=17.5) or '≥20' (recoded=20) times (range: 0–20)) (n=341).  
 †††In the past 30 days, each time you picked up your e-cigarette to vape, how many puffs did you usually take before putting it away? ('0', '1', '2', '3–5' (recoded=4), '6–9' (recoded=7.5), '10–14' (recoded=12), '15–20' (recoded=17.5) or '≥20' (recoded=20) times; range: (0–20)) (n=343).  
 b, unstandardised regression weight; CI, Confidence Interval; OR, Odds Ratio.

financial situation and sexual minority status. See online supplemental appendix table 1. Participants were also asked which flavour they used when they first tried vaping nicotine.

## Statistical analyses

Associations of e-cigarette flavour used most often with tobacco product use characteristics were estimated in logistic (dichotomous outcomes) or linear (continuous outcomes) multivariable regression models including all covariates, yielding ORs or regression weights (b's) with 95% CIs, respectively. Planned pairwise tests compared ice to the two other flavour categories. Complete exposure and outcome variable data were required to be included in analyses. Missing covariate data were infrequent (n range: 0–15) and managed with multiple imputation using 20 multiply-imputed data sets.<sup>11</sup> Statistical significance was p<0.05 (two-tailed).

## RESULTS

The analytical sample (n=344; age, M (SD)=21.2 (0.4) years; 54.1% women) was sociodemographically diverse (race/ethnicity: Hispanic=40.5%, Asian=19.3%, non-Hispanic white=19.6%, non-Hispanic black=3.6%, other=17%; and 24.9% sexual minority). Sociodemographic covariates did not significantly differ by e-cigarette flavour used except for gender and race/ethnicity (see online supplemental appendix table 1).

Overall, 168 (48.8%) reported most often using ice flavours, 60 (17.4%) menthol/mint and 116 (33.7%) fruit/sweet. In comparison to menthol/mint flavoured e-cigarette users, ice flavour users were more likely to report past-30-day combustible

tobacco use (31.5% vs 21.7%, adjusted OR=2.7, 95% CI (1.3 to 5.7)). Ice flavour users were less likely than menthol/mint flavour users to report using JUUL/similar cartridge rechargeable versus refillable/rechargeable tank/pen or other e-cigarette (3.5% vs 23.5%, adjusted OR=0.1, 95% CI (0.03 to 0.45)) devices and more likely than fruit/sweet flavour users to use disposable non-cartridge versus refillable/rechargeable or other (65.3% vs 34.7%, adjusted OR=3.9, 95% CI (2.1 to 7.4)) devices. Ice versus fruit/sweet flavour users were more likely to report vaping dependence symptoms (67.1% vs 43%, adjusted OR=2.6, 95% CI (1.5 to 4.4)), starting vaping during high school (73.9% vs 65.1%, Adjusted-OR = 1.9, 95% CI (1.02–3.37)) and more vaping episodes per day (Mean[SD]=10.8(7.9) vs. 7.6(8.1), Adjusted-b=2.4, 95% CI (0.5 to 4.3)). Ice flavour users also reported more past-30-day vaping days (mean (SD)=17 (11.5)) than fruit/sweet (mean (SD)=12.1 (11.8), adjusted b=3.6, 95% CI (0.8 to 6.4)) or menthol/mint (mean (SD)=12.2 (11.2), adjusted b=4.4, 95% CI (1 to 7.7)) flavour users. Other comparisons were non-significant (table 1).

Among the 168 current ice flavour users, 43 (25.6%) used menthol/mint-flavoured e-cigarettes initially, 56 (33.3%) and 69 (41.1%) began with fruit/sweet and ice flavours, respectively. Of those that vaped ice flavours during initial use, 84.1% currently used ice flavours most often (online supplemental appendix table 2).

## DISCUSSION

In this young adult cohort from Los Angeles, California, USA, in 2020, ice was the most common e-cigarette flavour used. Recent

nationally representative studies find that most US young adults use either fruit or mint/menthol-flavoured e-cigarettes.<sup>12</sup> The supplemental analysis also suggested that most ice flavour users migrated from initially vaping other flavours.

Young adults who predominately used ice flavoured e-cigarettes in this study exhibited a profile of increased combustible tobacco product use and more frequent, heavy and dependent vaping in comparison to one or both other groups that used non-ice flavours. While causality cannot be inferred from this cross-sectional study, it is possible that exposure to e-cigarettes in ice flavours may somehow increase nicotine vaping frequency and dependence. Previous clinical laboratory studies show that fruit and menthol flavours each independently increase the appeal of e-cigarettes and suppress the aversive qualities of nicotine in young adults by creating perceptions of sweetness and coolness, respectively.<sup>4 13 14</sup> Flavours that increase the palatability of high-concentration e-cigarettes could play a role in combustible tobacco product use, given evidence that vaping higher nicotine concentration is associated with subsequent increased combustible tobacco use in young people.<sup>10</sup> If flavours with both sweet and cooling sensory attributes additively increase the appeal of nicotine vaping, it is plausible that fruit-cooling combinations in ice flavours (vs fruit-only or mint/menthol-only flavours) could incrementally increase risk for frequent vaping, nicotine dependence and poly-tobacco product use. Alternatively, more frequent and chronic vapers or smokers could be drawn to ice flavours. In this study, ice flavour users were more likely to have started vaping in high school than fruit/sweet flavour users and therefore had longer vaping histories, which could allow more time to migrate toward ice flavours.

In comparison with fruit/sweet flavour users, ice flavour users were more likely to report using disposable versus refillable devices. Disposable e-cigarettes are among the fastest-growing segments of the e-cigarette market, exemplified by the Puff Bar brand,<sup>6</sup> raising questions as to the role of ice flavours in the appeal of disposable products. JUUL, the most widely-sold US e-cigarette brand in 2019,<sup>15</sup> stopped selling non-tobacco flavours except menthol in late 2019. The USA issued guidance to clear cartridge-based e-cigarettes non-tobacco flavours other than menthol in February 2020.<sup>5</sup> In the context of such changes, the current finding that menthol/mint users were more likely to use JUUL or other cartridge-based devices than ice flavour users may reflect a concentration of sales of menthol and limited availability of ice flavour in these products. By contrast, some disposable e-cigarette makers might still have been marketing ice flavours in 2020 while awaiting enforcement of US FDA issued warning letters to stop selling flavoured disposable e-cigarettes by July 2020.<sup>16</sup> Puff Bar markets its product as containing 'tobacco-free nicotine', raising uncertainty as to whether they are subject to these and other US tobacco product regulations.<sup>17</sup> Future studies should assess how the evolving regulatory context may impact use of ice-flavoured e-cigarettes.

This study has limitations. First, all measures were self-reported and subject to recall error. As ice flavours are new in the market, optimal methods and response option labels for identifying self-reported ice flavour use worth additional research. Second, past-month number of vaping days measure did not distinguish between participants using nicotine-containing and nicotine-free e-cigarettes. Third, some cell sizes were small, which may have produced insufficient statistical power and precluded inclusion of participants that predominantly used other flavours (eg, tobacco, flavourless, non-sweet). Finally, nicotine concentration was not assessed in this study, which merits future research.

## CONCLUSION

Young adult use of ice flavoured e-cigarettes may be common and positively associated with combustible tobacco use, nicotine vaping frequency and dependence and use of disposable e-cigarette devices. Because ice flavours represent a hybrid that may contain both cooling and fruity flavouring constituents, it is unclear how these flavours fit into current and future regulatory policies that place differential restrictions across different flavour categories. Further studies of the specific cooling agents and chemical constituents in ice flavoured products and health effects of ice flavoured e-cigarette use are warranted.

## What this paper adds

- ⇒ Previous research found that young adult e-cigarette users commonly use either fruit/sweet or menthol/mint flavours.
- ⇒ 'Ice' e-cigarette flavours—marketed as a combination of fruity/sweet and cooling flavours (eg, 'blueberry ice' or 'melon ice')—recently entered the US market, but the prevalence and tobacco-related correlates of ice flavoured e-cigarette use in young adults are unknown.
- ⇒ This study provides the first evidence that young adult use of ice flavoured e-cigarettes may be common and positively associated with combustible tobacco use, nicotine vaping frequency and dependence, and use of disposable e-cigarette devices.

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## REFERENCES

- 1 U.S. Department of Health and Human Services. *E-Cigarette use among youth and young adults: a report of the surgeon General*. Atlanta: US Department of Health and Human Services, Centers for Disease Control and Prevention, National Center for Chronic Disease Prevention and Health Promotion, Office on Smoking and Health, 2016.
- 2 Dai H, Leventhal AM. Prevalence of e-cigarette use among adults in the United States, 2014-2018. *JAMA* 2019. doi:10.1001/jama.2019.15331. [Epub ahead of print: 16 Sep 2019].
- 3 Rostron BL, Cheng Y-C, Gardner LD, et al. Prevalence and reasons for use of flavored Cigars and ends among US youth and adults: estimates from wave 4 of the path study, 2016-2017. *Am J Health Behav* 2020;44:76-81.
- 4 Goldenson NI, Leventhal AM, Simpson KA, et al. A review of the use and appeal of flavored electronic cigarettes. *Curr Addict Rep* 2019;6:98-113.
- 5 The Food and Drug Administration. The food and drug administration. FDA finalizes enforcement policy on unauthorized flavored cartridge-based e-cigarettes that appeal to children, including fruit and mint, 2020. Available: <https://www.fda.gov/news-events/press-announcements/fda-finalizes-enforcement-policy-unauthorized-flavored-cartridge-based-e-cigarettes-appeal-children>
- 6 Ali FRM, Diaz MC, Vallone D, et al. E-cigarette unit sales, by product and flavor type - United States, 2014-2020. *MMWR Morb Mortal Wkly Rep* 2020;69:1313-8.

- 7 Leventhal AM, Strong DR, Kirkpatrick MG, *et al.* Association of electronic cigarette use with initiation of Combustible tobacco product smoking in early adolescence. *JAMA* 2015;314:700–7.
- 8 Vogel EA, Cho J, McConnell RS, *et al.* Prevalence of electronic cigarette dependence among youth and its association with future use. *JAMA Netw Open* 2020;3:e1921513.
- 9 DiFranza JR, Savageau JA, Fletcher K, *et al.* Measuring the loss of autonomy over nicotine use in adolescents: the DANDY (development and assessment of nicotine dependence in youths) study. *Arch Pediatr Adolesc Med* 2002;156:397–403.
- 10 Goldenson NI, Leventhal AM, Stone MD, *et al.* Associations of electronic cigarette nicotine concentration with subsequent cigarette smoking and Vaping levels in adolescents. *JAMA Pediatr* 2017;171:1192–9.
- 11 Rubin DB. *Multiple imputation for nonresponse in surveys*. John Wiley & Sons, 2004.
- 12 Leventhal AM, Dai H. Prevalence of flavored e-cigarette use among subpopulations of adults in the United States. *J Natl Cancer Inst* 2021;113:418–24.
- 13 Krishnan-Sarin S, Green BG, Kong G, *et al.* Studying the interactive effects of menthol and nicotine among youth: an examination using e-cigarettes. *Drug Alcohol Depend* 2017;180:193–9.
- 14 Leventhal A, Cho J, Barrington-Trimis J, *et al.* Sensory attributes of e-cigarette flavours and nicotine as mediators of interproduct differences in appeal among young adults. *Tob Control* 2020;29:679–86.
- 15 Truth Initiative. E-Cigarettes: facts, STATs and regulations, 2020. Available: <https://truthinitiative.org/research-resources/emerging-tobacco-products/e-cigarettes-facts-stats-and-regulations>
- 16 The Food and Drug Administration. FDA Notifies companies, including puff bar, to remove flavored disposable e-cigarettes and Youth-Appealing E-Liquids from market for not having required authorization, 2020. Available: <https://www.fda.gov/news-events/press-announcements/fda-notifies-companies-including-puff-bar-remove-flavored-disposable-e-cigarettes-and-youth>
- 17 Maloney J. Puff bar defies FDA crackdown on fruity E-cigarettes by ditching the tobacco. *wall Street Journal*, 2021. Available: <https://www.wsj.com/articles/puff-bar-defies-fda-crackdown-on-fruity-e-cigarettes-by-ditching-the-tobacco-11614681003>