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Original Investigation

Disposable E-Cigarette Use Prevalence, Correlates, and Associations With Previous Tobacco Product Use in Young Adults

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Abstract

Introduction: Novel, inexpensive disposable e-cigarettes widely sold in attractive flavors might be exempt from US federal regulations. To inform regulatory and public health priorities, this study examined young adult disposable e-cigarette use uptake among existing tobacco users versus non-users and possible use correlates that could be potential regulatory targets.

Aims and Methods: Prospective cohort data were analyzed in 2021. Among baseline (2018–2019) never disposable e-cigarette users (n = 1903; mean [SD]: 19.3 [0.8] years-old), we tested prospective associations of baseline tobacco product use with follow-up (2020) disposable e-cigarette use initiation, followed by stratified analyses distinguishing baseline exclusive and dual e-cigarette/combustible tobacco use. Exploratory cross-sectional associations of tobacco-related correlate with vaping frequency among current disposable users (n = 266) were tested.

Results: Follow-up ever disposable e-cigarette use initiation was higher among baseline former (22.1%) and current (50.2%) versus never (6.3%) rechargeable (non-disposable) e-cigarette users. In stratified analyses, follow-up disposable e-cigarette use initiation was 0% in baseline never-vaping exclusive current smokers, higher in baseline never-vaping former smokers versus never users of any tobacco product (18.2% vs. 5.7%; adjusted odds ratio [95% CI] = 3.9 [2.1–7.5]), and higher among baseline current dual users versus never-smoking exclusive current vapers (61.3% vs. 42.2%; adjusted odds ratio [95% CI] = 3.0 [1.5–6.0]). Among follow-up current disposable e-cigarette users (overall prevalence = 10.9%), using ice-flavored (vs. fruit/sweet-flavored) e-cigarettes (adjusted rate ratio [95% CI] = 1.5 [1.0–2.1]) and vaping dependence symptoms (adjusted rate ratio [95% CI] = 2.2 [1.5–3.2]) were cross-sectionally associated with more past-month disposable e-cigarette use days.

Conclusions: Young adult disposable e-cigarette use was of appreciable prevalence, including among tobacco product never users and former smokers. Regulation of disposable e-cigarettes, including ice-flavored products, might benefit young adult health.

Implications: Sales of disposable e-cigarette products increased significantly in the United States from 2019 to 2020. These products contain high nicotine concentrations and various flavors that may appeal to young people. This study provides the first evidence that disposable

e-cigarette use may be common among young adults, including among tobacco product never users and former smokers. Frequency of disposable e-cigarette use was positively associated with using ice-flavored e-cigarettes and vaping dependence. Regulatory policies and enforcement strategies addressing disposable e-cigarettes merit consideration in young adult health policy and prevention priorities.

Introduction

Over the past decade, electronic cigarette (e-cigarette) products have rapidly evolved over time, and use among US youth and young adults has grown.[1–3] Early model e-cigarettes were predominately disposable devices that mimicked the look and feel of combustible cigarettes but delivered modest amounts of nicotine, called cigalikes.[4] Cigalikes became displaced by various rechargeable (non-disposable) e-cigarettes over several years until a new generation of pre-charged and pre-filled disposable e-cigarette products entered the market in 2019.[5] Unlike cigalikes, modern disposable devices leveraged industry innovations developed by JUUL and other pod-style rechargeable e-cigarette makers. Modern disposables come in various flavors (eg, mint, fruit, menthol, and fruit-ice [ie, flavors with both cooling and fruity/sweet characteristics]), have a sleek design, are small enough to be used discretely, and contain high concentrations of nicotine in the salt formulation[6]—which permit delivery of substantial nicotine amounts[7] with palatable aerosol.[8] Disposable e-cigarettes are less expensive and easier to use than JUUL and other non-disposable products that require purchasing costly startup kits and constant recharging.[9] Consequently, disposable e-cigarettes products might appeal to a broad audience and expand the tobacco product user population to include young people who otherwise might be deterred from vaping non-disposable (rechargeable) e-cigarettes.

The current marketplace and regulatory context indicate that disposable e-cigarettes warrant scientific attention. US disposable e-cigarette sales rose[5] shortly after JUUL, the top-selling non-disposable e-cigarette brand,[10] removed many flavored products in late 2019[11] and became subject to a 2020 federal enforcement policy targeting flavored, closed-cartridge rechargeable e-cigarettes; the policy had exempted disposable products.[12] Additionally, products with synthetic nicotine (not derived from tobacco plants) might be exempt from FDA tobacco product regulations,[13] which is notable because Puff Bar—a widely sold modern disposable e-cigarette brand—markets their product as containing "tobacco-free nicotine."[14] Research is needed to determine whether disposable e-cigarette products pose a public health concern for priority populations, including young adults, and therefore merit consideration in regulatory policies and prevention programs.

Concerns about rising disposable e-cigarette sales are lessened if young adult use prevalence is low and concentrated among existing tobacco product users, particularly combustible tobacco smokers who might vape to aid smoking cessation. Alternatively, if disposable e-cigarette use is uptaken by appreciable numbers of young adults that had not used e-cigarettes prior to the recent emergence of disposables, these products might be a public health concern. Previous research indicates that the vast majority of US young e-cigarette users (or "vapers") first try e-cigarettes before age 18.[15] Appreciable numbers of young adults who initiate e-cigarette use with disposable devices could signal that the widespread availability of novel, inexpensive e-cigarettes could potentially expand the young adult e-cigarette user population. Such evidence could inform the need for (re)considering policies to ensure that all disposable e-cigarettes are subject to federal regulations, are addressed in local and state regulatory policies, and incorporated into young adult prevention programming. There are currently no prospective longitudinal studies of the prevalence of young uptake of modern disposable e-cigarettes.

This observational two-timepoint cohort study of young adults surveyed in 2018–2020 examined the prevalence and correlates of disposable e-cigarette use. In baseline disposable e-cigarette never users, we estimated disposable e-cigarette use initiation at follow-up prevalence and prospective longitudinal associations with prior baseline rechargeable (non-disposable) e-cigarette and combustible tobacco use. The secondary aim was to estimate associations of tobacco product use characteristics with past 30-day disposable e-cigarette use frequency. This aim used cross-sectional data at the follow-up timepoint that overlapped with peak disposable e-cigarette sales in 2020,[5] and incorporated all disposable e-cigarette users to broaden the population studied. This analysis is important because if young adult disposable e-cigarette use is ultimately deemed a concern, identifying the tobacco product use characteristics (eg, preferred e-cigarette flavor) that correlate with more frequent vaping could be promising targets in regulatory and prevention tactics aimed to reduce young adult frequent disposable e-cigarette use.

Methods

Participants and Procedures

The Happiness & Health Study[16] originally recruited ninth-grade students from 10 schools in Los Angeles, CA, USA in 2013 who completed semiannual in-school surveys through 2017. This study used two post-high school remote (online) survey waves conducted in October 2018-October 2019 (termed "baseline" here) and May 2020–October 2020 ("follow-up"). This study was approved by the University of Southern California Institutional Review Board. Informed consent was obtained from participants prior to data collection.

Measures

At each timepoint, separate ever use (yes/no) and past-30-day use frequency items were administered for "Disposable devices (eg, Puff Bar, NIC STIX, Hyppe Bar) without separate cartridges/pods," each of 6 other rechargeable device types (ie, pen, mod, box mod, JUUL, other pod-mod, other rechargeable), and each of 4 combustible tobacco products (ie, cigarette, big cigars, little cigars and cigarillos, and hookah).

Responses to the above items were coded as follows for the longitudinal analysis: (1) *Follow-up disposable e-cigarette ever use* (yes/no) was the primary outcome variable, with current disposable e-cigarette use as a supplementary outcome (>1 vs. 0 past-month use days); (2) *Baseline rechargeable e-cigarette use* was a trichotomous exposure variable (coded: never [never used any of the six rechargeable device types] vs. former [ever used ≥1 rechargeable product without any past-30-day use] vs. current [used ≥1 rechargeable

product in the past 30 days]); (3) *Baseline combustible tobacco use* was a trichotomous exposure variable (never [never used any combustible product] vs. former [ever used ≥1 combustible product without past-30-day use] vs. current [used ≥1 product in the past 30 days]).

For the cross-sectional analysis of follow-up data, a *past 30-day disposable e-cigarette use frequency* (continuous variable with range: 1–30 days) was the primary outcome. We measured the following exposure variables for the cross-sectional analysis: (1) *e-cigarette flavor used most often* measures included seven responses options recoded into four groups: "Fruit/Sweet (eg, fruit, candy, dessert, buttery)," "Menthol/Mint," "Ice-fruit combinations (eg, blueberry ice, melon ice, banana ice, ice pineapple)," or Others (ie, "Flavorless," "Tobacco," "Non-sweet,"); (2) type of e-cigarette products used in the past month (only disposable e-cigarettes vs. both disposable and rechargeable e-cigarettes); (3) *vaping dependence* was measured by the 10-item Hooked on Nicotine Checklist with items keyed for e-cigarette use/vaping, which has shown adequate internal consistency and predictive validity coded as (1≥ vs. 0 dependence symptom) per prior work[17,18]; (4) *vaping onset during versus after high school* was coded based on ever/never e-cigarette use in prior survey waves administered when the cohort was in high school; and (5) *vaping to quit smoking* was based on past-year use of e-cigarettes, JUUL, or other electronic nicotine vaping devices "to try to stop smoking," coded as (yes/no). A follow-up *combustible tobacco use status* was coded as a trichotomous exposure variable (never, former, current) for the cross-sectional analysis.

Sociodemographic Covariates

To adjust for potential confounding associations by sociodemographics, we included self-reported baseline age (years, continuous), gender (male vs. female), race/ethnicity (non-Hispanic White, non-Hispanic Black, Hispanic, Asian, and other), post-high school degree program (yes/no), living with parents (yes/no), personal financial situation (living comfortably vs. just meet or don't meet basic expenses), and sexual orientation identity (straight vs. non-straight) as covariates.

Data Analysis

Descriptive statistics of sample demographic characteristics were reported for the (non-mutually exclusive) analytic samples used to address the longitudinal study aim (baseline never disposable e-cigarette users) and secondary cross-sectional aim (all follow-up past 30-day disposable e-cigarette users). In longitudinal analyses of baseline never disposable e-cigarette users, we examined follow-up disposable e-cigarette use initiation prevalence, and logistic regression models estimated associations of baseline combustible tobacco and rechargeable e-cigarette use with ever disposable use at follow-up. To distinguish associations involving single versus dual tobacco product use and confounding effects across combustible and rechargeable e-cigarette use, we retested baseline combustible tobacco use associations in stratified subsamples of baseline rechargeable e-cigarette never, former, and current users. Results were re-examined for past-30 day use outcomes as a supplemental sensitivity analysis. In cross-sectional analyses of follow-up past 30-day disposable e-cigarette users, separate truncated negative binomial regressions tested associations of each tobacco product use variable with past 30-day disposable e-cigarette use frequency (a count of days with zero truncated). All models were tested both unadjusted and adjusted for demographic covariates. Missing covariate data were managed with multi-imputation using 20 multiply-imputed data sets.[19] Odds ratios (ORs), adjusted ORs (AORs), or rate ratios (RRs) with 95% CIs were calculated. Analyses were conducted in 2021 using SAS 9.4 (Cary, NC). p values <.05 (two-tailed) were considered significant.

Results

Analytic Samples

Depicted in Figure S1, 2548 of 3396 cohort enrollees completed the baseline (2018–2019) survey. Among baseline never disposable e-cigarette users (n = 2123), 1903 had disposable e-cigarette use outcome data, constituting the longitudinal sample. For the cross-sectional analysis, 2436 respondents completed the follow-up survey, which included some cohort enrollees unavailable to complete the baseline survey and permitted inclusion of baseline ever disposable e-cigarette users. Of these, 266 reported current (past 30-day) disposable e-cigarette use, constituting the cross-sectional analytic sample. Descriptive statistics of sample characteristics are reported in Table 1. Both the baseline never disposable e-cigarette users for longitudinal analyses (n = 1903; age, M [SD] = 19.3 [0.8] years; 61.9% of females; 47.3% of Hispanics, 19.2% of Asians, 5.0% of non-Hispanic Blacks) and follow-up current disposable e-cigarette users for cross-sectional analyses (n = 266; age, M [SD] = 21.2 [0.4] years; 54.1% of females; 33.7% of Hispanics, 21.1% of Asians, 3.1% of non-Hispanic Blacks) were sociodemographically diverse.

Longitudinal Analysis of Disposable E-Cigarette Use Uptake

Among baseline never disposable e-cigarette users, ever disposable e-cigarette use at follow-up was 14.3% overall, and varied across baseline never (9.9%), former (32.5%), and current (40.2%) combustible tobacco users and across baseline never (6.3%), former (22.1%), and current (50.2%) rechargeable e-cigarette users. With and without adjustment for demographics and combustible tobacco use, baseline former and current versus never rechargeable e-cigarette use were robustly associated with ever disposable e-cigarette use initiation by follow-up (see the top of Table 2). Associations of baseline combustible tobacco use with follow-up ever disposable e-cigarette use were robust in unadjusted models but substantially weakened after adjustment for baseline rechargeable e-cigarette use and demographics for both former versus never (OR [95% CI] = 4.4 [3.2–6.1], AOR [95% CI] = 2.3 [1.5–3.5]) and current versus never (OR [95% CI] = 6.1 [4.0–9.4], AOR [95% CI] = 1.9 [1.2–3.0]) smoking comparisons. This pattern indicates that co-use with baseline rechargeable e-cigarette use might be a confounder of the relation between combustible tobacco use and disposable e-cigarette uptake.

The lower portion of Table 2 presents the stratified analysis of disposable e-cigarette use initiation rates across baseline dual product, single product, and non-vaper/non-smoker use patterns. Stratified estimates indicated that 5.7% of baseline never users of combustible tobacco or rechargeable e-cigarettes (ie, never-vaper/never-smokers) had initiated disposable e-cigarette use by follow-up, which constituted 26.7% of disposable initiators. Follow-up disposable e-cigarette use initiation among baseline never-vaper/former smokers was 18.2%, which was significantly higher than initiation rates among baseline never-vaper/never smokers (AOR [95% CI] = 3.9 [2.1–7.5]). None of the baseline never-vaping/current smokers tried disposable e-cigarettes by follow-up, which precluded comparisons. Baseline dual users

Table 1. Characteristics of Analytic Samples

	Baseline never disposable e-cigarette users[a] (*n* = 1903)		Follow-up current disposable e-cigarette users[b] (*n* = 266)	
	n	Mean (SD) or %	*n*	Mean (SD) or %
Age, years	1897	19.3 (0.8)	266	21.2 (0.4)
Female sex	1178	61.9	144	54.1
Race/ethnicity				
Non-Hispanic White	294	15.7	55	21.1
Non-Hispanic Black	93	5.0	8	3.1
Hispanic	888	47.3	88	33.7
Asian	361	19.2	55	21.1
Other	240	12.8	55	21.1
In a degree program	1247	68.1	162	62.5
Living with parents	248	13.5	178	68.5
Financially comfortable situation[c]	846	46.4	108	41.9
Non-straight sexual orientation[d]	345	18.9	56	21.6
Follow-up				
Past 30-day disposable e-cigarette use				
1–2 days	—	—	58	21.8
3–5 days	—	—	55	20.7
6–9 days	—	—	43	16.2
10–19 days	—	—	47	17.7
20–29 days	—	—	28	10.5
30 days	—	—	35	13.2
E-cigarette flavor most used[e]	—	—		
Fruit/sweet	—	—	58	21.9
Menthol/mint	—	—	39	14.7
Ice	—	—	144	54.3
Others			24	9.1
Used both disposable and rechargeable e-cigarettes in past 30 days	—	—	170	63.9
Vaping dependence symptoms[f]	—	—	171	64.5
Vaping onset in high school[g]	—	—	188	73.4
Vaping to quit smoking[h]	—	—	21	7.9
Combustible tobacco use[i]				
Never	—	—	71	26.7
Former	—	—	113	42.5
Current	—	—	82	30.8

[a]Data from responses at baseline (2018–2019) wave. Sample includes individuals that never used disposable e-cigarettes at baseline.
[b]Data from responses at follow-up (2020) survey wave. Sample includes individuals that reported using disposable e-cigarettes ≥1 day in the past 30 days at follow-up, including both individuals who have ever and never used disposable e-cigarettes at baseline.
[c]"Meet basic expenses," or "Don't meet basic expenses" vs. "Live comfortably."
[d]Non-straight (ie, lesbian, gay, bisexual, queer, questioning, or other sexual orientation) vs. straight.
[e]Others include "Mostly Flavorless," "Mostly Tobacco flavored," "Mostly Non-sweet," and "Mix of flavors."
[f]Hooked on nicotine checklist for e-cigarettes 1≥ vs. 0 symptoms.
[g]Vaping onset during vs. after high schools based on responses to ever e-cigarette use questions in survey waves administered when the cohort was in high school.
[h]Participants reported using e-cigarette products to try to stop smoking during the past 12 months.
[i]Use of cigarettes, big cigars, little cigars or cigarillos, or hookah water pipe. Former: ever use, but not use in the past 30 days. Current: use ≥1 day in the past 30 days.

(AOR [95% CI] = 3.0 [1.5–6.0]) and current-vapers/former smokers (AOR [95% CI] = 2.2 [1.1–4.4]) had higher disposable e-cigarette use initiation rates than baseline never-smoker/current vapers. No significant differences in disposable e-cigarette initiation by baseline smoking status were found among baseline former vapers. Sociodemographic covariates and their associations with follow-up disposable e-cigarettes use in adjusted models are reported in Supplementary Table 1.

Sensitivity analyses of the supplementary follow-up past 30-day disposable e-cigarette use outcome found similar results (see Supplementary Table 2). Unadjusted associations were robust for both baseline combustible tobacco use and rechargeable e-cigarette use. In multivariable analyses, associations for baseline rechargeable e-cigarette use remained robust, whereas baseline combustible tobacco use associations were substantially reduced and became insignificant.

Cross-sectional Analysis of Current Disposable E-Cigarette Use Frequency at Follow-up

Current disposable e-cigarette use was reported by 10.9% of all follow-up survey completers (*n* = 266; see the right hand of Table 1 for descriptive statistics). Among current disposable e-cigarette users, number of past 30-day disposable e-cigarette use days was significantly higher among respondents that typically used ice (vs. fruit/sweet) flavored e-cigarettes (mean [SD] = 12.9 [10.3] vs. 8.6 [8.7], adjusted-RR [95% CI] = 1.5 [1.0–2.1]) or reported ≥1 (vs. 0) vaping dependence

Table 2. Association of Baseline Tobacco Product Use With Ever Disposable E-Cigarette Use at Follow-up

	Ever disposable e-cigarette use at follow-up				
	Prevalence, *n* (row %)	OR (95% CI)[a]	*p*	AOR (95% CI)[b]	*p*
Overall sample (*n* = 1903)	273 (14.3)				
Baseline regressors[c]					
Rechargeable e-cigarette use[d]					
Never (*n* = 1391)	87 (6.3)	Reference		Reference	
Former (*n* = 253)	56 (22.1)	**4.3 (2.9–6.2)**	<.001	**3.1 (2.1–4.8)**	<.001
Current (*n* = 259)	130 (50.2)	**15.1 (10.9–20.9)**	<.001	**11.9 (8.3–16.9)**	<.001
Combustible tobacco use[d,e]					
Never (*n* = 1562)	154 (9.9)	Reference		Reference	
Former (*n* = 234)	76 (32.5)	**4.4 (3.2–6.1)**	<.001	**2.3 (1.5–3.5)**	<.001
Current (*n* = 107)	43 (40.2)	**6.1 (4.0–9.4)**	<.001	**1.9 (1.2–3.0)**	.01
Baseline combustible tobacco use regressors, stratified by baseline rechargeable e-cigarette use					
Never rechargeable e-cigarette users (*n* = 1391)					
Never combustible tobacco use (*n* = 1289)	73 (5.7)	Reference		Reference	
Former combustible tobacco use (*n* = 77)	14 (18.2)	**3.7 (2.0–6.9)**	<.0001	**3.9 (2.1–7.5)**	<.0001
Current combustible tobacco use[f] (*n* = 25)	0 (0)	N/A	N/A	N/A	N/A
Former rechargeable e-cigarette users (*n* = 253)					
Never combustible tobacco use (*n* = 138)	24 (17.4)	Reference		Reference	
Former combustible tobacco use (*n* = 77)	27 (28.4)	**1.9 (1.0–3.6)**	.0496	1.8 (0.950–3.49)	.07
Current combustible tobacco use (*n* = 20)	5 (25.0)	1.6 (0.5–4.8)	.42	1.6 (0.5–5.2)	.47
Current rechargeable e-cigarette users (*n* = 259)					
Never combustible tobacco use (*n* = 135)	57 (42.2)	Reference		Reference	
Former combustible tobacco use (*n* = 62)	35 (56.5)	1.8 (1.0–3.3)	.07	**2.2 (1.1–4.4)**	.02
Current combustible tobacco use (*n* = 62)	38 (61.3)	**2.2 (1.2–4.0)**	.01	**3.0 (1.5–6.0)**	.003

Significant associations are depicted in bold. AOR = adjusted odds ratios, CI = confidence interval, N/A = not applicable, OR = odds ratio.

[a]Unadjusted univariable model.

[b]Multivariable models adjusted for all covariates listed in Table 1. Missing covariate data (Ns missing range: 0–81) were managed with multi-imputation using 20 multiply-imputed data sets.

[c]Combustible tobacco use and rechargeable tobacco entered as simultaneous regressors in multivariable model.

[d]Former: ever use, but not use in the past 30 days. Current: used ≥1 day in the past 30 days.

[e]Use of cigarettes, big cigars, little cigars or cigarillos, or hookah water pipe.

[f]Among baseline never rechargeable e-cigarette users, associations for baseline current tobacco use could not be calculated because no current baseline combustible tobacco/never rechargeable e-cigarette users became ever disposable users by follow-up.

symptom (mean [SD] = 14.1 [10.5] vs. 6.6 [6.9], adjusted-RR [95% CI] = 2.2 [1.5–3.2]). Other factors were not significantly associated with follow-up disposable vaping frequency (Table 3).

Discussion

This is the first longitudinal study to examine the prevalence and correlates of modern disposable e-cigarette use. At this study's follow-up survey in 2020, disposable e-cigarettes were currently used among 10.9% of all young adults and had been tried by 5.7% that had never used e-cigarettes or combustible tobacco products in 2018–2019. These results, plus national studies reporting that 5.1% of US high school students in 2020 currently used disposable e-cigarettes,[20] indicate this e-cigarette product class may substantively impact the population health of young people.

The relative odds of disposable e-cigarette use uptake in this study were substantially higher among those who had already used non-disposable (rechargeable) cigarettes at baseline compared with tobacco product naive young adults. Because young adult tobacco product never users represent a large population, small but appreciable percentages of disposable e-cigarette initiation might carry public health significance. Research conducted before novel pod-style disposable e-cigarettes were available found that costs were a commonly cited e-cigarette use deterrent among young adults.[21] Although this study did not have the price information of modern disposable products in the analysis, we conjecture that young people who might be dissuaded from using rechargeable e-cigarettes because of their costs might be inclined to try inexpensive modern disposable e-cigarettes. This speculative hypothesis merits testing, and it remains possible that never-smoking/never-vaping young adults in this study would have tried e-cigarettes even if disposable products were not available.

A sizeable proportion of former rechargeable e-cigarette users had initiated disposable e-cigarette either ever or current use by follow-up. Young adults have reported that they dislike the high costs and time spent purchasing and upgrading rechargeable devices and e-cigarette solution refills.[22] It is possible that some young adults who quit vaping due to the costs and time commitment might have resumed vaping with disposable e-cigarettes because of their attractive cost and ease to use. Another speculative hypothesis is some young adults quit vaping after regulations restricted the availability of flavored pod-style e-cigarettes in 2019–2020. These same individuals might have returned to vaping via disposable e-cigarette use because such products remain available in numerous flavors. Qualitative research found that some individuals who could no longer obtain rechargeable e-cigarettes in preferred flavors after recent regulations decided to start using disposable e-cigarettes products because they remained available in desirable flavors.[23]

Table 3. Cross-sectional Associations of Tobacco Product Use Characteristics With Past 30-Day Disposable E-Cigarette Use Frequency Among Current Disposable E-Cigarette Users

	No. days used disposable e-cigarettes in past 30 days				
	Mean (SD)	RR (95% CI)[a]	*p*	Adj-RR (95% CI)[b]	*p*
Regressors					
E-cigarette flavor most used[c]					
Fruit/sweet	8.6 (8.7)	Reference		Reference	
Menthol/mint	10.3 (10.4)	1.2 (0.8–1.9)	.36	1.1 (0.6–2.1)	.75
Ice	12.9 (10.3)	**1.6 (1.1–2.2)**	.007	**1.5 (1.0–2.1)**	.04
Others	12 (10.1)	1.5 (0.9–2.4)	.15	1.5 (0.9–2.5)	.17
Types of e-cigarette used in past month					
Only disposable	12.5 (11.5)	Reference		Reference	
Disposable and rechargeable	10.8 (9.8)	0.9 (0.6–1.1)	.25	0.9 (0.6–1.1)	.24
Vaping dependence symptoms[d]					
No	6.6 (6.9)	Reference		Reference	
Yes	14.1 (10.5)	**2.1 (1.9–2.3)**	<.0001	**2.2 (1.5–3.2)**	<.0001
Vaping onset in high school[e]					
No	11.4 (10.0)	Reference		Reference	
Yes	11.4 (10.1)	1.0 (0.7–1.4)	.99	1.0 (0.7–1.3)	.93
Vaping to quit smoking[f]					
No	11.2 (9.9)	Reference		Reference	
Yes	15.0 (11.3)	1.4 (0.8–2.2)	.19	1.5 (0.9–2.5)	.11
Combustible tobacco use[g]					
Never	11.4 (10.2)	Reference		Reference	
Former	10.5 (9.7)	0.9 (0.7–1.3)	.55	0.9 (0.7–1.3)	.75
Current	12.9 (10.4)	1.1 (0.8–1.6)	.46	1.3 (0.9–1.9)	.15

Significant associations ($p < .05$) are depicted in bold.

All observations during follow-up wave. Adj-RR = adjusted rate ratio, CI = confidence interval, RR = rate ratio.

[a]Univariate truncated negative binomial model included the exposure and each predictor variable listed in table.

[b]Separate multivariable truncated negative binomial models were performed for each predictor variable, adjusted for demographic covariates listed in Table 1. Missing covariate data (Ns missing range: 0–19) were managed with multi-imputation using 20 multiply-imputed data sets.

[c]Others include "Mostly Flavorless," "Mostly Tobacco flavored," "Mostly Non-sweet," and "Mix of flavors."

[d]Hooked on nicotine checklist for e-cigarettes 1≥ vs. 0 symptoms.

[e]Vaping onset during vs. after high schools based on responses to ever e-cigarette use questions in survey waves administered when the cohort was in high school.

[f]Participants reported using e-cigarette products to try to stop smoking during the past 12 months.

[g]Use of cigarettes, big cigars, little cigars or cigarillos, or hookah water pipe. Former: ever use, but not use in the past 30 days. Current: use ≥1 day in the past 30 days.

Switching from combustible cigarettes to e-cigarettes reduces tobacco-related health risks.[4] This study does not provide evidence that never-vaping young adult combustible tobacco users are taking advantage of the potential for reducing toxin exposure by switching to disposable e-cigarettes.[4] Indeed, none of the baseline never-vaping current smokers ultimately tried disposable e-cigarettes by follow-up. A caveat is that baseline current combustible tobacco use without use of rechargeable e-cigarettes was rare in this sample (n = 25; 1.3%), which might have limited this study's statistical power to detect associations. The low prevalence of combustible tobacco use without concurrent e-cigarette use in young people has also been reported in previous research.[24] Additionally, only a small proportion of current disposable vapers in the cross-sectional analysis indicated vaping to help quit smoking (7.9%) and this factor was not cross-sectionally associated with vaping frequency.

While no never-vaping current smokers switched starting use of disposable e-cigarettes in this study, we did find that never-vaping former (vs. never) combustible tobacco smokers were more likely to try and currently use disposable e-cigarettes at follow-up. It is plausible that some of these former smokers might have achieved long-term abstinence from combustible tobacco and then started vaping disposable products for reasons other than smoking cessation. Previous research has found that former smokers with long histories of cigarette abstinence and use of e-cigarettes are at increased risk of smoking recurrence one year later.[25] While some former smokers in this sample might have had only limited experimentation with combustible tobacco, recent research indicates that even young adult smokers of <100 cigarettes in their lifetime experience substantive smoking-related harm risk.[26,27] Future studies should assess whether these former combustible tobacco smokers later resumed smoking during the follow-up interval and subsequently uptook disposable e-cigarettes to quit smoking or if they started vaping disposable products for other reasons.

If replicated in nationally representative samples, these findings indicate that any public health benefit gained by combustible tobacco smokers switching to disposable e-cigarettes might be modest or negligible in the young adult population. Prior to the recent rise in novel disposable e-cigarettes, the prevalence of vaping in middle-aged and older adult smokers has historically been low.[2] If, however, future research finds that many older adult smokers are switching to disposable e-cigarettes, regulations that reduce the availability of disposable e-cigarettes may have a detrimental impact on public health. To discern whether policies that reduce the availability of disposable e-cigarettes would have a net improvement in overall population health, considering all ages, research on older adult use of novel disposable e-cigarettes to quit smoking and the health effects of disposable e-cigarette aerosol exposure is warranted.

Some modern disposable e-cigarette products like Puff Bar market their products as containing synthetic nicotine without residual impurities of tobacco-derived nicotine and odors.[14] Whether synthetic nicotine in disposable products truly lacks such impurities and if such impurities impact health are unknown and merits research. Regardless, such advertising messages could presumably reduce perceived harm and the appeal of disposable products by potential consumers is an important topic for future research and target for regulation. If e-cigarettes with synthetic nicotine products remain exempt from FDA regulation, US e-cigarette manufacturers would financially benefit by intentionally developing and marketing products with synthetic nicotine.[28] Although this study could not assess which certain disposable e-cigarette brands contain synthetically-derived nicotine, further efforts may be needed to address the federal regulatory gap for synthetic nicotine products in disposable e-cigarettes in the United States.

If policies and prevention aimed to reduce young adult use of novel disposable products were considered, this study's cross-sectional analysis identified two factors linked with frequent vaping. First, current disposable e-cigarette users of ice versus sweet flavors vaped more. Ice flavors (eg, "blueberry ice," "melon ice"), which are marketed as combining fruit taste with a purported cooling sensation, have previously been observed in disposable e-cigarette marketing.[9] Prior studies have shown that both sweet and menthol-cooling flavors can individually mask the harsh effects of nicotine[29] and increase the appeal of e-cigarettes in young adults,[29,30] which raises the question of whether their combination in ice flavors additively increase the risk of frequent vaping. Second, this study found that experiencing vaping dependence symptoms was correlated with more frequent disposable e-cigarette use, which concords with previous e-cigarette dependence research conducted prior to the emergence of modern disposables.[17] This finding provides preliminary evidence indicating that nicotine dependence may be a valid expression of tobacco product use disorder and a useful screening target to identify cases of high-frequency disposable e-cigarette use. Other factors (ie, vaping for the purpose of quitting smoking, vaping onset timing, combustible tobacco use, and poly-device use of rechargeable and disposable e-cigarettes) were not correlated with past 30-day disposable e-cigarette use frequency. This cross-sectional analysis can be explained by reverse causality or other non-causal explanations. Prospective studies are needed to identify risk and protective factors for disposable e-cigarette use frequency. If further prospective research finds ice flavors increase risk of e-cigarette use progression in young people, regulations that reduce the availability of disposable products in these flavors merit consideration.

This study has limitations. First, self-report data are subject to reporting error. However, the test-retest reliability of self-reported behaviors related to tobacco use is high.[31] Second, the sample was from Los Angeles, CA with unknown generalizability to other regions. Third, variability in e-cigarette device terminology could lead to respondent difficulty in distinguishing e-cigarette devices. However, misclassification was minimized because follow-up disposable e-cigarette use survey item language specifically distinguished disposable from other pod-style devices ("without cartridges/pods") and specified prominent disposable brands (eg, "Puff Bar") with pictures. Additionally, excluding baseline ever disposable e-cigarette users in longitudinal analyses ensures that disposable e-cigarette use uptake cases likely capture novel disposable products, but reduce generalizability to individuals that might have used early-model disposable cigalike e-cigarettes during early adolescence. Fourth, the follow-up survey occurred during the COVID-19 pandemic and study results should be interpreted in this context. Finally, the cell sizes were relatively small for some stratified analyses and lacked sufficient statistical power.

Conclusion

This study provides timely evidence that young adult disposable e-cigarette use in 2020 was appreciably prevalent in this regional sample, disproportionately prevalent among (but not solely limited to) ever vapers and former smokers that never vaped, and associated with using ice flavored e-cigarettes and vaping dependence. If disposable e-cigarette use uptake patterns observed in the present study generalize to nationally representative samples and to adolescent populations, (re)consideration of regulatory policies and enforcement strategies addressing disposable e-cigarettes merit attention.

Supplementary Material

A Contributorship Form detailing each author's specific involvement with this content, as well as any supplementary data, are available online at https://academic.oup.com/ntr.

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Declaration of Interests

None declared.

Data Availability

The data underlying this article will be shared at reasonable request to the corresponding author.

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