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RESEARCH REPORT

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Young adult responses to taxes on cigarettes and electronic nicotine delivery systems

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Abstract

Background and Aims: Although over half of United States states have passed taxes on electronic nicotine delivery systems (ENDS), recent evidence links ENDS tax rates to increases in smoking, suggesting potentially substantive health costs. Overall health implications will depend on how these taxes affect transitions from experimentation to regular smoking and vaping. Current analyses have not assessed ENDS tax rates' effects in young adulthood (ages 18–25). This study measures the relationship between ENDS and cigarette tax rates and ENDS use and smoking in young adulthood, a key period for initiation of regular tobacco use.

Design: Observational study of data from the Current Population Survey's 2010–2019 Tobacco Use Supplements.

Setting: The United States.

Participants/Cases: A total of 38 906 18 to 25 year-olds

Measurements: Multivariable linear regressions estimated two-way fixed effects analyses to assess ENDS and cigarette tax rates' relationships to recent and daily smoking and vaping, adjusting for an array of potential sociodemographic and policy confounders along with state and year fixed effects.

Findings: A $1 increase in ENDS taxes yielded significant reductions in young adults' daily vaping ($\widehat{\beta}$ = −0.025; 95% CI, −0.037, −0.014) alongside increases in recent smoking ($\widehat{\beta}$ = 0.037; 95% CI, 0.013, 0.061), primarily reflecting greater dual use ($\widehat{\beta}$ =2.078; 95% CI, 0.890, 4.852; P = 0.09). A $1 cigarette tax increase yielded 2.1 and 2.5 percentage point increases in recent and daily vaping, with 95% CIs of (0.004, 0.038) and (0.018, 0.032) respectively.

Conclusions: In the United States, higher ENDS tax rates are associated with decreased ENDS use but increased cigarette smoking among 18- to 25-year-olds, with associations reversed for cigarette taxes.

KEYWORDS
Cigarettes, electronic nicotine delivery systems, smoking, taxes, tobacco control, vaping

Author order is alphabetical: both authors contributed equally to the study design and analysis, as well as drafting and revision of the manuscript. Both authors approved the final manuscript as submitted and agree to be accountable for all aspects of the work.

INTRODUCTION

The past decade's surge in use of electronic nicotine delivery systems (ENDS) has prompted tension between perceptions that ENDS may fuel new nicotine dependence versus facilitate harm reduction. Corresponding research tends to consider youths or adults, obscuring liminal age-groups. In particular, 18- to 25-year-olds are often analyzed as adults and sometimes considered as youths, but are more precisely categorized as young adults or "emerging adults," a period of ongoing brain development and high rates of risky behaviors [1]. Although first tobacco use often occurs before age 18, transitions to regular use are more common in young adulthood: among 22- to 23-year-olds in the United States (US) who smoked daily in 2018, 56% reported transitioning to daily smoking at or after age 18 [2]. To the extent that young adulthood marks a transitional period when youth may either solidify or abandon a smoking habit, policies that reduce 18 to 25 year-olds' initiation of habitual smoking may have added value for health over the life course. Therefore, our objective is to estimate how cigarette and ENDS tax rates relate to young adults' use of both products.

Although a large evidence base suggests substantive effects of conventional cigarette tax rates on adult smoking [3], evidence for young adults is more limited and mixed. One study of youth interviewed first as high school seniors and again around age 26 found no effect of state-level cigarette taxes on smoking participation, but some evidence of increased cessation among baseline light smokers facing higher taxes [4]. In contrast, an interrupted time series study found that the 2009 federal cigarette tax increase (from $0.39 to $1.01 per pack) reduced the odds of smoking initiation among 18- to 25-year-olds, but had no effect on smoking cessation [5].

With the first US ENDS tax implemented in 2010, the literature on these taxes' effects is smaller than that for cigarette taxes, and primarily estimates associations between binary indicators for ENDS tax adoption and product use. Consequent findings are inconsistent. Estimating the association between ENDS use and ENDS tax adoption (i.e. not accounting for variation in tax sizes), three studies found evidence for a negative relationship [6–8], whereas two suggested a positive relationship [9, 10]. Considering cigarette use, a synthetic control analysis found evidence that ENDS tax adoption increased smoking [11], whereas two other studies yielded imprecisely estimated relationships [7, 9]. As each of the analyses using ENDS tax adoption implicitly treated all ENDS taxes equally, their contradictions might be resolved by accounting for variation and changes in the size of ENDS taxes, alongside adoption *per se*.

To this end, we consider a standardized ENDS tax rate; that is, converting per unit, per mL, and percent-of-cost ENDS taxes into a single tax measure in per fluid mL units using a recently published standardized ENDS tax methodology and database [12]. Thus, our analyses capture responses to tax sizes and changes as well as initial adoption. Broad differences in ENDS tax rates, which range from $0.05 to $2.52 per fluid mL, suggest that such variation likely impacts consumer responses to these policies. Evidence that ENDS taxes are almost fully passed-through to consumers in the form of higher prices supports the use of tax variation to test for economic substitution/complementarity [13].

Matching standardized ENDS tax rates to adult respondents from two nationally-representative surveys, the study most closely related to ours linked higher ENDS taxes to reduced vaping and increased smoking [14]. In particular, it found that, among 18- to 40-year-old adults, a $1 increase in ENDS taxes was associated with a 0.6 percentage point (ppt) reduction in daily ENDS use alongside 1.2 ppt increases in daily cigarette use, whereas a $1 increase in cigarette taxes yielded 0.7 ppt reductions in daily cigarette use but 0.5 ppt increases in daily ENDS use [14]. Findings from several working papers assessing the effect of ENDS tax rates—on teenagers [15], pregnant women [16], and using sales data [13]—concur in suggesting that ENDS and cigarettes are economic substitutes; that is, two products for which raising the price of one increases demand for the other. This finding is consistent with results from analyses of other policies' variation, such as enactment of minimum legal sales age laws for ENDS [17–20].

Still, none of these papers estimated the effect of ENDS tax rates on young adults alone. Because this age-group marks a critical period for transitions to regular tobacco and nicotine use, understanding their smoking- and vaping-responses to ENDS taxes is crucial for informing policy decisions to promote population health.

The project aims are to estimate ENDS and cigarette tax rates' relationships to ENDS and cigarette use among 18- to 25-year-olds.

METHODS

Data

To address this gap in the evidence, we matched state policy and economic information to nationally representative data from nine waves of the Current Population Survey's Tobacco Use Supplement (CPS-TUS), collected between 2010 and 2019 (response rate ≈58%) [21]. Our inclusion criteria limited consideration to 18- to 25-year-olds, the ages when most US smokers report first transitioning to daily use [2].

Measures

Outcomes were binary indicators for recent and daily cigarette and ENDS use, based on survey questions asking whether respondents "now use" each product "every day, some days, or not at all." ENDS data were only available post-2013. Therefore, the analytic sample covers 2014 to 2019 for ENDS outcomes, but 2010 to 2019 for cigarette outcomes to ensure greater statistical power while focusing on the same decade.

Exposures were continuous measures of cigarette taxes (dollars/pack) and ENDS taxes in standardized dollar/mL units—standardized across both percent-of-cost and per-unit ENDS taxes in accordance with a recently published methodology and database [12].

Covariates included state and month-year fixed effects to adjust for time-invariant state characteristics and common time trends respectively, indicators for respondent demographics that are correlated with cigarette or ENDS use and may differ between states (i.e. sex, year of age, race/ethnicity, any college education, and employment status), and relevant state characteristics and policies by interview quarter: unemployment and poverty rates, smoke- and vape-free indoor air law indexes, percent of population covered by tobacco-21 laws, indicators for whether the respondent could legally be sold cigarettes in their state, and significant Medicaid expansions, as well as policies likely to affect consumption of potential substitutes or complements for tobacco and nicotine products (i.e. beer taxes, indicators for medical and recreational marijuana legalization) (see Supporting information for further details).

Statistical Analysis

Using the CPS-TUS sample weights, χ^2, and Wald tests compared sample-weighted means in states with versus without ENDS taxes. Multivariable linear regressions used respondent-level data to estimate each outcome's relationship to cigarette and ENDS taxes, controlling for the aforementioned covariates and clustering standard errors by state (the level of policy exposure) [22]. Sometimes called a "dose-response difference-in-differences analysis," these regressions compared outcomes in areas with different levels of ENDS and cigarette taxes, before versus after the taxes were adopted/changed. Such analyses may yield causal estimates if adopting versus non-adopting areas' outcomes were trending in parallel before the tax was implemented. We test this by repeating the main analyses with leads on each tax as covariates, to assess whether outcome trends shifted in advance of tax changes.

Although linear models were preferred here because of concerns about attenuation bias in non-linear models with large numbers of fixed effects [23], sensitivity checks repeated the main analyses as logistic regressions. Additionally, sex-stratified regressions were run to clarify whether a single sex drove the full sample responses. Finally, we estimated these relationships as a discrete choice analysis: multinomial logistic regressions tested how cigarette and ENDS taxes related to exclusive smoking, exclusive vaping, and dual use—all based on self-reported recent use variables, with "no recent use" as the reference group—adjusting for the same covariates as above. Critically, this analysis has a caveat: with only two waves of data capturing cigarette and ENDS use as well as dual use's relatively low prevalence, these results may be under-powered.

The Georgia State University Institutional Review Board (IRB) deemed this study exempt from human subjects review (Protocol H18423). The research question and analysis plan considered here were not pre-registered on a publicly available forum. However, applying difference-in-differences methods to address this research question was a component of grant proposals submitted and funded before the full data's availability.

RESULTS

Comparing means in states with versus without ENDS taxes, Table 1 finds statistically significant differences in all but two covariates—percent female and recreational marijuana legalization—supporting their inclusion as controls. Both recent and daily smoking are more common in states without ENDS taxes (15.6% vs 12.8% and 11.2% vs 8.8%, respectively; $P < 0.001$ for both), reinforcing the need for state fixed effects in multivariable analyses (to absorb average differences in the outcome variable between states).

Figure 1 presents each regression's tax coefficients and 95% CIs, adjusting for the aforementioned covariates. ENDS taxes yielded statistically significant reductions in daily ENDS use and increases in recent cigarette use, alongside marginally non-significant reductions in recent ENDS use ($P = 0.07$) and increases in daily cigarette use ($P = 0.054$). Cigarette tax estimates were flipped, yielding significant reductions in recent and daily cigarette use, versus increases in recent and daily ENDS use. In particular, a $1 increase in ENDS taxes was associated with a 2.5 ppt reduction in daily ENDS use (95% CI, −3.68,−1.38), and 3.7 ppt increase in recent smoking (95% CI, 1.30, 6.12). Symmetrical effects were seen with cigarette taxes, with a $1 increase yielding a 2.5 ppt reduction in recent smoking (95% CI, −4.73, −0.21) alongside a 2.5 ppt increase in daily ENDS use (95% CI, 1.77, 3.24).

Implications were similar when assessed via logistic regression (See Supporting information Table S2) and when stratified by sex (see Figs. 2 and 3), particularly for ENDS taxes' relationship to daily ENDS use and, among males, recent smoking.

Adding controls for next-year's cigarette and ENDS taxes to the main specification yielded statistically insignificant coefficients on taxation-leads in all cases except next-year's cigarette tax in the recent-ENDS-use analysis ($\widehat{\beta} = 0.029$, 95% CI, 0.015, 0.044) (see Supporting information Table S3). Therefore, respondent behavior did not appear to respond to ENDS taxes before they were in effect.

Taking a discrete choice approach, Fig. 4 presents relative risk ratios (RRRs) from a multinomial logistic regression assessing the tax variables' associations with exclusive smoking, exclusive vaping, and dual use (reference group: "no use"). This analysis used only the last two waves of data, as it required information on cigarette and ENDS use. Both taxes yielded statistically insignificant RRRs for exclusive smoking. Their RRRs for exclusive vaping and dual use; however, had similar implications to earlier analyses: higher ENDS taxes were associated with reductions in exclusive vaping (RRR = 0.161, 95% CI, 0.067, 0.384; $P < 0.001$) and increases in dual use (RRR = 2.078, 95% CI, 0.890, 4.852; $P = 0.09$), whereas higher cigarette taxes yielded increases in exclusive vaping (RRR = 4.041, 95% CI, 2.211, 7.385; $P < 0.001$) and decreases in dual use (RRR = 0.484, 95% CI, 0.225, 1.040; $P = 0.06$). Although both taxes' associations with dual use were marginally nonsignificant (i.e. $P < 0.1$), the sample's lower prevalence of dual use (2%) suggests that more limited statistical power may have been a factor here.

TABLE 1 Summary statistics by ENDS taxation in respondent's state of residence

	ENDS tax	*No ENDS tax*	*χ^2 test P-values*
Recent ENDS use	3.7%	4.0%	0.500
Daily ENDS use	1.3%	1.3%	0.825
Recent smoking	12.8%	15.6%	<0.001
Daily smoking	8.8%	11.2%	<0.001
Female	50.3%	50.7%	0.550
Race/ethnicity			<0.001
Non-Hispanic White	50.9%	58.8%	
Non-Hispanic Black	13.8%	14.5%	
Non-Hispanic Asian	8.0%	5.4%	
Non-Hispanic, other race	2.0%	2.2%	
Hispanic	25.3%	19.1%	
Any college	57.1%	53.1%	<0.001
Employment status			0.001
Employed	60.4%	62.8%	
Unemployed	11.0%	10.1%	
Not in labor force	28.7%	27.0%	
State characteristics			
Standardized ENDS tax rate	$0.15/mL	–	<0.001
Cigarette tax	$2.54/pack	$2.74/pack	<0.001
Index of indoor vaping restrictions	0.174	0.074	<0.001
Index of indoor smoking restrictions	0.888	0.728	<0.001
Individual cannot be legally sold cigarettes per state law	2.2%	0.5%	<0.001
Percent of population with tobacco-21	5.3%	3.7%	<0.001
Poverty rate	13.9%	14.5%	<0.001
Unemployment rate	7.6%	6.8%	<0.001
Significant Medicaid expansions	45.1%	31.4%	<0.001
Beer tax (per gallon)	$0.32	$0.23	<0.001
Medical marijuana legalization	60.4%	29.2%	<0.001
Recreational marijuana legalization	4.3%	4.1%	0.307
n	11 141	27 765	38 906

Notes: Sample-weighted means are calculated for 18- to 25-year-old respondents in states that did versus did not have an ENDS tax at any point during the study period (expressed as percentages for binary variables and rates or means for continuous variables). Illinois and Maryland, which have sizable county- and/or city-level taxes, are also classified as having an ENDS tax. χ^2 tests (for categorical variables) and Wald tests (for continuous variables) confirm whether variable values are statistically different between states with versus without ENDS taxes. Data are complete for all variables except vaping (n = 199 missing recent and daily ENDS use, out of 22 478 post-2013 respondents ages 18–25 years) and smoking (n = 121 missing for recent and daily smoking). Vaping and smoking variable means are calculated across non-missing observations only. ENDS = electronic nicotine delivery system.

DISCUSSION

Among 18- to 25-year-olds, ENDS taxes were associated with increased cigarette use, whereas cigarette taxes yielded increased ENDS use, consistent with prior evidence that the two products are economic substitutes [14, 16–20, 24]. Moreover, tax coefficient estimates for this sample of young adults were roughly three times larger in magnitude than those estimated for adults ages 18 to 40 years in a similar specification, [14] underscoring the importance of assessing young adult nicotine and tobacco use separately from other age groups.

To our knowledge, this study provides the first analysis of how ENDS and cigarette tax rates relate to use of both products among 18- to 25-year-olds, a critical period for transitions to regular tobacco use. Limitations include, first, reliance on self-reported cigarette and ENDS use, which may introduce social desirability bias. Consequent under-reporting, however, would have to be correlated with tax increases, and in opposite directions for smoking versus vaping, to explain our findings. Second, because most ENDS taxes implemented during the analytic period (2010–2019) came into effect between 2015 and 2017, many young adults facing an ENDS tax in our sample were not exposed to those taxes as minors. Therefore, findings may

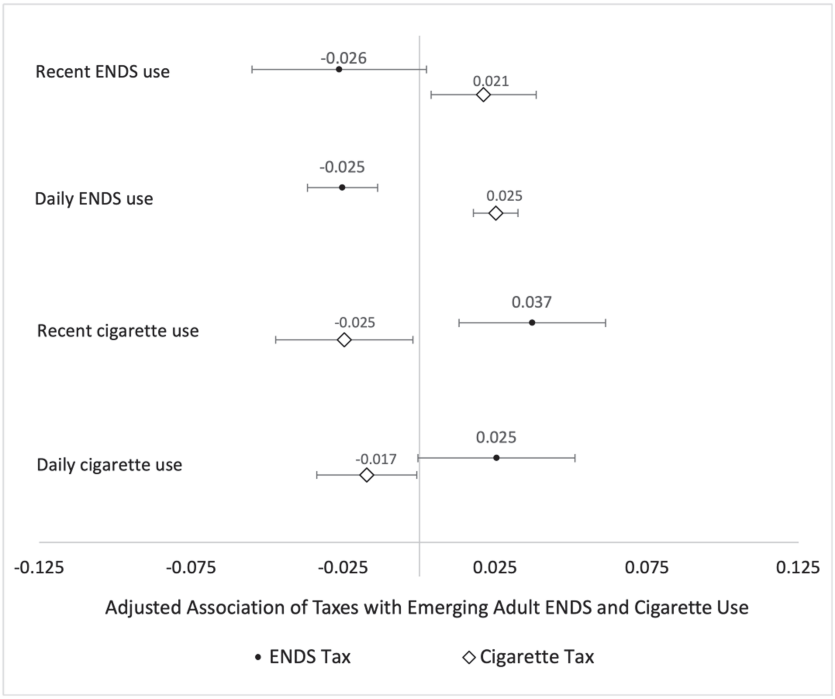

FIGURE 1 Tax associations with ENDS and cigarette use, 18- to 25-year-olds. Sample-weighted multivariable linear regressions use data on 18- to -25- year-olds from the 2010–2019 waves of the Current Population Survey's Tobacco Use Supplement to estimate ENDS and cigarette tax rates' relationships to recent ENDS use, daily ENDS use, recent cigarette use, and daily cigarette use. Covariates adjust for state and month-by-year fixed effects, individual sociodemographics—indicators for sex, year of age, race/ethnicity, any college education, and employment status—and state covariates: unemployment and poverty rates, smoke- and vape-free indoor air law indexes, percent of population covered by tobacco-21 laws, beer tax rates, and binary indicators for whether the respondent could legally be sold cigarettes, medical and recreational marijuana legalization, and significant Medicaid expansions. Standard errors are clustered by state. Coefficient estimates and 95% confidence intervals are given for each tax variable above, with the corresponding outcome noted along the plot's left-hand side. Each outcome is a separate regression. The Supporting information Table S1 gives these findings in tabular form. ENDS = electronic nicotine delivery system.

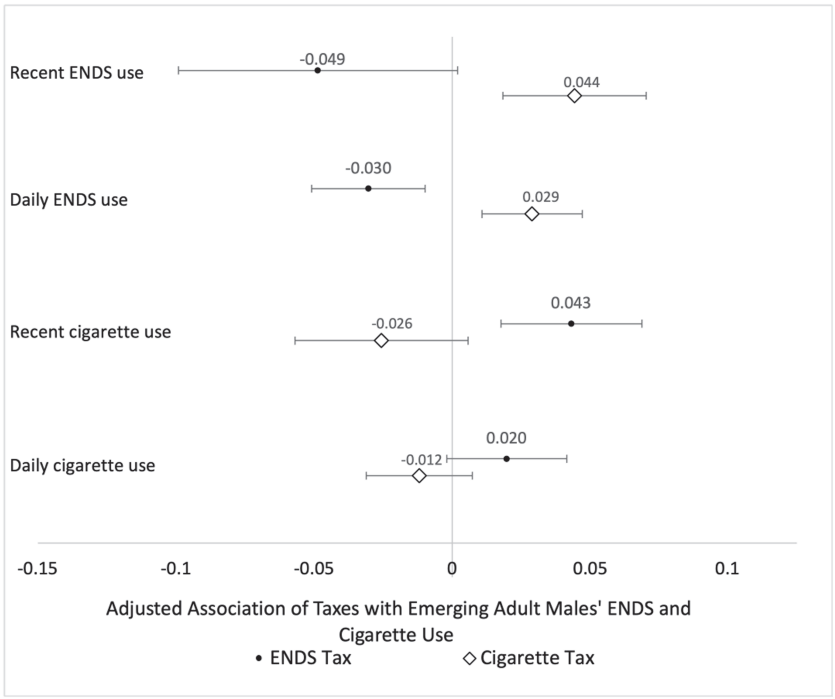

FIGURE 2 Tax associations with ENDS and cigarette use, 18- to 25-year-old males. Sample-weighted multivariable linear regressions use data on 18- to -25-year-old males from the 2010–2019 waves of the Current Population Survey's Tobacco Use Supplement to estimate ENDS and cigarette tax rates' relationships to recent ENDS use, daily ENDS use, recent cigarette use, and daily cigarette use. Covariates adjust for state and month-by-year fixed effects, individual sociodemographics—indicators for sex, year of age, race/ethnicity, any college education, and employment status—and state covariates: unemployment and poverty rates, smoke- and vape-free indoor air law indexes, percent of population covered by tobacco-21 laws, beer tax rates, and binary indicators for whether the respondent could legally be sold cigarettes, medical and recreational marijuana legalization, and significant Medicaid expansions. Standard errors are clustered by state. Coefficient estimates and 95% CIs are given for each tax variable above, with the corresponding outcome noted along the plot's left-hand side. Each outcome is a separate regression. ENDS = electronic nicotine delivery system.

be best interpreted as estimating ENDS taxes' short-run effects. A third data issue concerns the level of the analysis: without substate geocodes for all respondents, we cannot link individuals to local taxes. Instead of omitting local ENDS and cigarettes taxes—which might bias estimates away from the null by under-estimating the true tax respondents are exposed to—our data use population-weighted tax variables at the state level. Consequently, some respondents in states with local taxes are assigned to higher ENDS taxes than they actually faced (e.g. Illinois residents who do not live in Cook County) and others lower taxes than they actually faced (e.g. Cook County

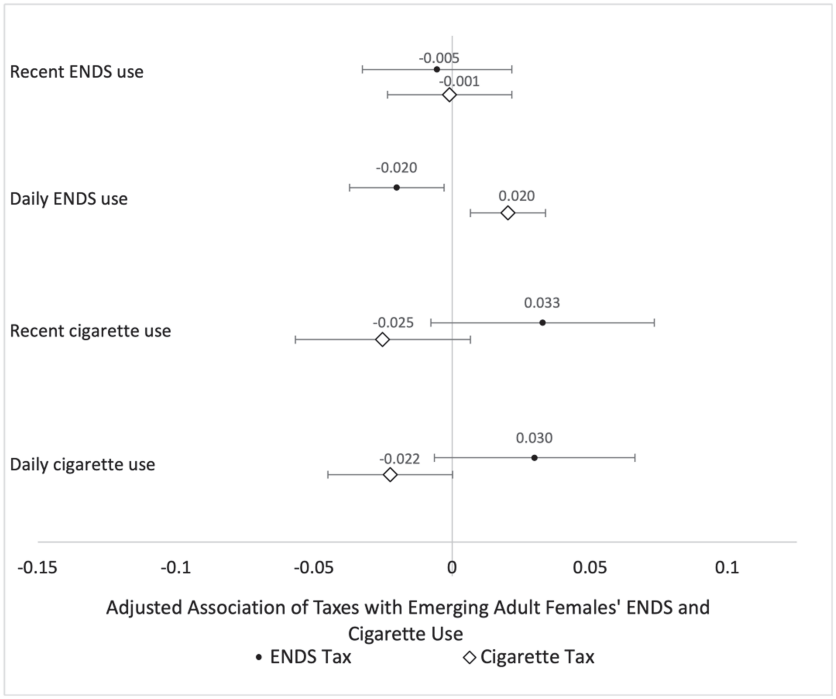

FIGURE 3 Tax associations with ENDS and cigarette use, 18- to 25-year-old females. Sample-weighted multivariable linear regressions use data on 18- to 25-year-old females from the 2010–2019 waves of the Current Population Survey's Tobacco Use Supplement to estimate ENDS and cigarette tax rates' relationships to recent ENDS use, daily ENDS use, recent cigarette use, and daily cigarette use. Covariates adjust for state and month-by-year fixed effects, individual sociodemographics—indicators for sex, year of age, race/ethnicity, any college education, and employment status—and state covariates: unemployment and poverty rates, smoke- and vape-free indoor air law indexes, percent of population covered by tobacco-21 laws, beer tax rates, and binary indicators for whether the respondent could legally be sold cigarettes, medical and recreational marijuana legalization, and significant Medicaid expansions. Standard errors are clustered by state. Coefficient estimates and 95% CIs are given for each tax variable above, with the corresponding outcome noted along the plot's left-hand side. Each outcome is a separate regression. ENDS = electronic nicotine delivery system.

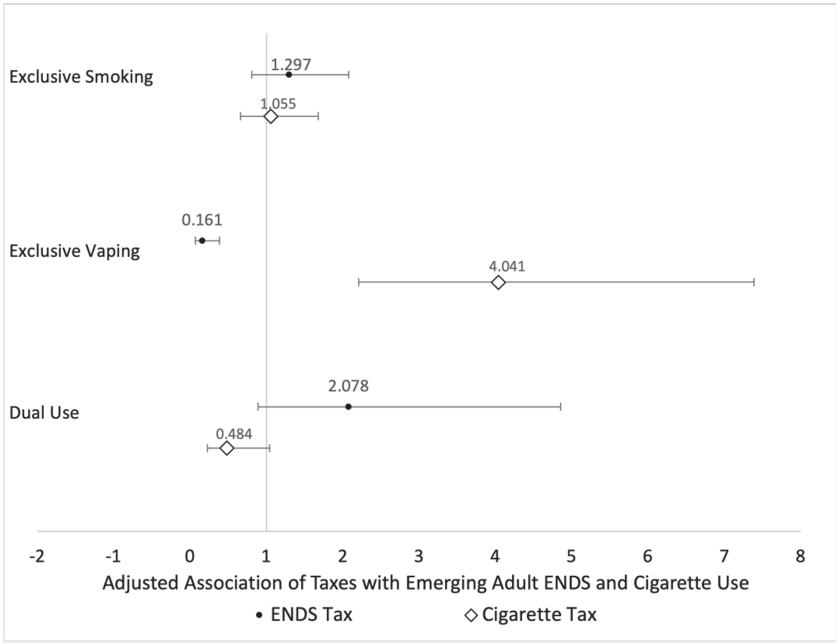

FIGURE 4 Relative risk ratios for tax associations with exclusive vaping, exclusive smoking, and dual use, 18- to 25-year-olds. A single sample-weighted multinomial logistic regression uses data on 18- to 25-year-olds from the 2014–2019 waves of the Current Population Survey's Tobacco Use Supplement to estimate ENDS and cigarette tax rates' relationships to exclusive cigarette use ("smoking"), exclusive ENDS use ("vaping"), and dual use, taking "no use" as the reference group. Covariates adjust for state and month-by-year fixed effects, individual sociodemographics—indicators for sex, year of age, race/ethnicity, any college education, and employment status—and state covariates: unemployment and poverty rates, smoke- and vape-free indoor air law indexes, percent of population covered by tobacco-21 laws, beer tax rates, and binary indicators for whether the respondent could legally be sold cigarettes, medical and recreational marijuana legalization, and significant Medicaid expansions. Standard errors are clustered by state. Each tax variable's estimated relative risk ratios are presented with their 95% CI, alongside the corresponding outcome category noted on the plot's left-hand side. The Supporting information Table S4 gives these results in tabular form.

residents), potentially reducing our estimates' precision. A fourth limitation is our inability to conduct an event study to validate the analytic approach: with the CPS-TUS fielded in only 9 months between 2010 and 2019, extended breaks between infrequent data collection periods preclude an event study. Instead, regressions assess pre-trends by testing whether leads on the tax variables predict either outcome (Supporting information Table S3), as in prior work [15]. Finally, our results may not generalize to taxes that are substantially larger than those observed in our data. Specifically, this sample's ENDS and cigarette tax exposures range from $0 to $2.52 per mL in

the former case, and $1.13 to $6.49 per pack in the latter. Consumer responses to a $1 tax increase (i.e. our regression estimates) might differ at much higher initial tax rates (e.g. ≥$10/mL).

An increase in combustible tobacco product use in response to ENDS taxes complicates tobacco policymaking, as various reviews and expert opinions have concluded that cigarettes are the more lethal product. In 2018, the National Academies of Sciences, Engineering, and Medicine concluded that vaping ENDS is "likely to be far less harmful than combustible tobacco cigarettes," [25] a conclusion endorsed more recently by 15 former presidents of the Society for Research on Nicotine and Tobacco in a 2021 summary of the evidence [26]. Still, in the interval between these publications, the percent of the general population who believed that ENDS use was more harmful than smoking increased, specifically following the 2019 outbreak of vaping-associated lung injuries [27]. Yet that concern was misplaced: the Centers for Disease Control and Prevention (CDC) subsequently identified additives in informally-sourced tetrahydrocannabinol (THC) concentrates (i.e. products not purchased from a formal retailer) as the outbreak's primary cause. [28] When Allcott and Rafkin [29] assessed 137 experts' perceptions of ENDS' harms relative to cigarettes in August 2020, their average response was that "vaping [ENDS] is 37 percent as harmful as smoking cigarettes." This estimate is consistent with a 2021 biomarker study suggesting that ENDS use is 33% as harmful as smoking [30]; a systematic review finding a 40% lower odds of respiratory outcomes among smokers who switched to ENDS [31]; randomized controlled trial findings of improvements in vascular function within a month of switching from smoking to ENDS [32]; and evidence of significant reductions in carcinogen and toxicant exposure among smokers who switched to ENDS [33]. Therefore, if choosing between a policy that produces net increases in ENDS-use versus one that generates net increases in smoking, current evidence suggests that the latter is likely to be substantively worse for public health.

CONCLUSIONS

There has been some discussion in the literature recently that cigarette taxes have "lost their bite" potentially because of the hardening of remaining smokers [34]. Focusing on young adults during a period of time when ENDS were available, we find evidence that cigarette taxes remain effective in preventing smoking in this age-group. At the same time, however, the evidence links ENDS taxes to increases in young adult smoking.

Alongside current evidence on the relative health risks of using ENDS versus smoking and prior work indicating that ENDS taxes reduce adult smoking cessation [11], our findings suggest a need for nuance in ENDS policymaking. Specifically, although higher ENDS taxes risk incentivizing young adult smoking, this can perhaps be offset with a sufficiently large cigarette tax increase. Similarly, cigarette tax increases alone may increase ENDS use in this age-group, which is not necessarily a bad outcome if that increase stems from people who would otherwise smoke. As prior work has demonstrated that life expectancies for smokers who quit before age 35 are not statistically different than those for never smokers, young adults' responses to these policies may have significant consequences for population health [35]. Still, caution is called for: to fully understand which policy combination best serves public health, future research needs to assess such taxes' effects, not only on use of mainstream ENDS products, but also on use of informally-sourced vaping concentrates, which can impose even larger health risks (i.e. from contaminants or additives in street-purchased products) [36]. Given young adulthood's significance as a time of transitions toward regular tobacco use, tailoring differential tobacco and nicotine product taxes to reduce this age-group's use of more lethal products—both combustibles and informally sourced vaping concentrates—is a critical goal for public health policy.

Recently, 15 former presidents of the Society for Research on Nicotine and Tobacco endorsed a position on ENDS and cigarette taxation: "Tax cigarettes and other combustible tobacco products heavily; impose a more modest tax on e-cigarettes. Taxes should be proportionate to risk. A much higher tax on combustibles will encourage adult smokers to quit smoking or to switch to less expensive e-cigarettes. By raising the price of e-cigarettes, a modest tax will discourage their use by price-sensitive youths." [26] Our results provide empirical support for this strategy as a means to interrupt transitions to habitual use, by disincentivizing young adult vaping without increasing smoking in this key age-group. These findings are consistent with other studies linking ENDS tax rates to increased smoking among adults [14], teenagers [15], and pregnant women [16], and cigarette sales in retail data [13]. Further research is needed to confirm whether they hold post-2019 and clarify what size tax differential would be optimal for population health.

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DECLARATION OF INTERESTS

Neither author has conflicts of interest to disclose.

AUTHOR CONTRIBUTIONS

Abigail Friedman: Conceptualization; formal analysis; funding acquisition; investigation; methodology; visualization. **Michael Pesko:** Conceptualization; formal analysis; funding acquisition; investigation; methodology; visualization.

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SUPPORTING INFORMATION

Additional supporting information can be found online in the Supporting Information section at the end of this article.

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