

Patterns of Youth Cigarette Experimentation and Onset of Habitual Smoking

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Abstract

Introduction: While research suggests that youth e-cigarette experimentation is associated with later combustible cigarette experimentation, it is unclear how this relates to habitual smoking.

This study assesses how minors' patterns of combustible- and e-cigarette experimentation relate to habitual smoking at ages 18-21.

Methods: Between November 2016 and May 2017, a cross-sectional, online survey of current and retrospective cigarette use was fielded among 18-21 year-olds who had tried combustible- or e-cigarettes (N=1424). Logistic regressions tested how pre-age-18 experimentation patterns related to two indicators of current habitual smoking: daily smoking and current established smoking (past-30-day use among those who had smoked at least 100 cigarettes).

Results: Respondents who first tried combustible- or e-cigarettes as minors (N=1096) were more likely to be current established users (64%) than those who first experimented at ages 18-21 (41%). Pre-age-18 experimentation patterns beginning with combustible cigarettes were the most predictive of later smoking. Relative to those who first experimented after age-17 (n=328), trying only combustible cigarettes as a minor yielded a 175% increase in one's odds of being an established smoker (OR=2.75, CI[1.99,3.79]) and a 161% increase for daily smoking (OR=2.61, CI[1.75,3.90]). Trying combustibles and then e-cigarettes yielded sizable increases in both habitual smoking measures, while trying e-cigarettes before combustibles yielded smaller effects. Trying only e-cigarettes pre-age-18 yielded a 78% decrease in both outcomes, relative to those who did not try either product as minors.

Conclusions: Minors who tried combustible cigarettes were more likely to be habitual smokers at ages 18-21 than those who tried e-cigarettes alone.

The popularity of electronic cigarette raises concerns about their impact on youth smoking (i.e., combustible cigarette use). Observational studies show that minors who try electronic cigarettes (e-cigarettes) are more likely to go on to try combustible cigarettes, with the odds of having ever smoked combustible cigarettes estimated at 3.62 for those who had versus had not tried electronic cigarettes at baseline.¹⁻²⁰ However, these studies have not addressed whether trying e-cigarettes results in habitual smoking; analyses typically consider “ever” or recent use (i.e., past 30-day) as outcomes, which may conflate experimentation with regular use. As the mortality effects of smoking seem negligible for those who quit prior to age 25,^{21,22} experimentation alone would not be expected to increase smoking-related mortality.

This study assesses how patterns of experimentation among minors — both products and order of use — relate to habitual smoking in later adolescence (ages 18-21). This age-group marks a critical period for study, as the transition from experimentation and initiation to either cessation or tobacco habituation often occurs during emerging adulthood.¹⁶ Two indicators are used to capture habitual use: daily smoking and current established smoking (past 30-day use among those with a lifetime consumption of at least 100 cigarettes). Indeed, most combustible cigarette ever-triers do not proceed to lasting habitual smoking: of 25 year-olds who ever tried a combustible cigarette, 36% percent had smoked 100 combustible cigarettes in their life, with 66% of this subgroup reporting current smoking.²³ Understanding how minors’ experimentation patterns relate to their likelihood of habitual smoking would enable better allocation of resources to reduce habitual smoking as well as associated morbidity and mortality.

Investigating how minors' combustible and electronic cigarette experimentation patterns relate to later habitual smoking requires longitudinal or retrospective data on smoking and vaping (i.e., e-cigarette use) specifying both the age at and order of experimentation (i.e., e-cigarettes tried before or after combustible cigarettes). Such data were not available with the requisite detail for a nationally representative sample. (Existing surveys like the Population Assessment of Tobacco and Health lack tiebreakers to clarify which product was tried first when respondents tried both at the same age.) Thus, new data were collected on current and retrospective smoking and vaping from a national sample of 18 to 22 year-old "ever-tryers", i.e., individuals who had tried at least one puff of a combustible cigarette, e-cigarette, or both. Focusing on 18 to 21 year-olds (N=1424) allows the sample to capture most smoking experimentation and onset of habitual smoking. Specifically, most ever-smokers try their first combustible cigarette prior to age-18, and the median "regular smoker" initiated regular use at age 17 or 18, depending on the dataset.²⁴ Thus, this age-range offers a reasonable subgroup in which to examine habitual use.²⁴ Because some respondents over age-21 may not have had access to e-cigarettes as adolescents, 21 is the maximum age for this analysis; e-cigarettes only became broadly available in the U.S. around 2012, despite entering the market five years earlier.²⁵ Thus, the 18 to 21 age-group allows examination of the transition from experimentation to onset of habitual smoking.

This paper's research question is how different patterns of minors' cigarette experimentation relate to habitual smoking and vaping at ages 18 to 21. Hypotheses are that: (1) among those who tried both products prior to age-18, order of experimentation matters, with a greater impact on smoking when combustible cigarettes are tried before e-cigarettes; and (2) pre-age-18 e-cigarette experimentation absent combustible cigarette experimentation will not be associated with a

higher likelihood of habitual smoking in late-adolescence. By analyzing how minors' experimentation patterns relate to habitual use in late-adolescence, this study will identify the strongest behavioral predictors of habitual smoking, so that prevention funding and resources can be directed accordingly.

METHODS

Sample

An online survey of 18 to 22 year-old U.S. residents was administered by Qualtrics from November 2016 through May 2017, using their standing survey panel. Inclusion criteria limited the sample to ever-triers. The survey obtained data on respondent demographics plus past and current use of both combustible and electronic cigarettes. To enhance generalizability, sampling quotas were defined to match the 2015 National Health Interview Survey's weighted distribution of respondents who reported ever-use of either product, by year-of-age, sex, education, and census region.

Qualtrics was contracted to provide data on 2003 respondents. To anticipate potential data quality issues, they oversampled and provided full data on 2710 respondents who met the inclusion criteria. Quality checks excluded 52 of these respondents: 4 were dropped for straight-lining (clicking the same answer for all multiple-choice questions in order to speed through a survey); 1 failed a minimum time threshold designed to prevent speeding through the survey; and, an additional 47 gave mutually exclusive age responses (e.g., reporting an age at first cigarette use that was greater than their current age; reporting first e-cigarette use prior to the product's entry onto the U.S. market; reporting an age and year of birth that did not match). As

sampling quotas were defined based on reported age, the last of these exclusions was critical to ensuring that the quotas were filled correctly. A further 27 observations were dropped due to concerns about duplicate responses in observations with matching IP addresses, sex, birth month, and birth year. Thus, 2,631 unique observations passed the aforementioned data quality checks. To ensure the most recent data, the contracted sample of N=2003 18 to 22 year-olds was populated with the latest survey-date observations until each quota was filled. Given the omission of 22 year-olds in this study's analysis, the analytic sample contained 1,424 ever-tryers aged 18 to 21. Analyses were conducted in 2018.

Measures

Dependent Variables

Dependent variables were binary indicators for current habitual use (i.e., at the survey date): daily smoking, daily vaping, current established smoking, and current established vaping. Current established use was defined as having reported both past 30-day use of the relevant product, and a lifetime consumption exceeding 100 cigarettes for combustible cigarettes and 100 uses for e-cigarettes. The "100 cigarettes" requirement served to distinguish established smoking from mere "recent use" (i.e., "past 30-day use," which could reflect experimentation).²⁶ Similarly, "100 uses" provided a parallel means to capture established vaping. Dual users were included in indicators for both smoking and vaping.

Current established use and daily use were not nested indicators. For example, the reference group for daily smokers included current established smokers who did not smoke daily; while that for current established smokers included (a very small number of) daily smokers who had not smoked 100 cigarettes.

Henceforth, “current established use” is referred to as “established use,” for brevity.

Experimentation Patterns

For both combustible and electronic cigarettes, respondents who reported having tried that product were asked their age at first use. Those who listed the same age for both products were asked which came first. These data were used to classify pre-age-18 experimentation patterns into tried: 1) e-cigarettes only, 2) combustible cigarettes only, 3) combustible cigarettes then e-cigarettes, 4) e-cigarettes then combustible cigarettes, 5) both on the same day, and 6) neither before age-18.

Control Variables

To adjust for differences in product use by key demographic characteristics, controls included year-of-age fixed effects as well as binary indicators for: sex, Hispanic ethnicity, and race (Black, Asian, American Indian/Alaska Native, and Native Hawaiian/Pacific Islander, with White as the reference group and respondents able to report multiple races). Whether at least one parent completed a year or more of college was included as a proxy for childhood socioeconomic status. As parental tobacco use can affect youth use, regressions controlled for binary indicators of whether any parent used (1) combustible cigarettes or (2) e-cigarettes when the respondent was 16.

Statistical Analysis

First, summary statistics described respondents’ demographics plus smoking and vaping as minors and at the survey date. Second, established-use frequencies were calculated, partitioned by respondents’ pre-age-18 experimentation patterns. Finally, logistic regressions examined how

experimentation patterns related to indicators of habitual smoking and vaping. Unadjusted results were considered alongside those adjusting for controls.

All analyses used Stata version 14, StataCorp LP, College Station, TX. Yale University's IRB approved this study (HIC Protocol #1307012384).

RESULTS

Table 1 presents sample demographics, current smoking and vaping, and cigarette-experimentation patterns prior to age-18. The sample was 59.9% male and 81.5% white. Seventy-seven percent of respondents experimented with either combustible or electronic cigarettes as a minor. Of these, about 83% started with combustible cigarettes. The average age at first combustible cigarette use (15) was lower than that for e-cigarettes (17). At age 16, 51% of respondents had at least one parent who smoked while only 8.5% had a parent who vaped.

Considering current use, the largest subgroup consisted of those who used neither product habitually (41%), followed by habitual smokers who were not habitual vapers (34%), then dual users (16%), and finally habitual vapers who were not habitual smokers (9%).

Table 2 describes the general relationship between pre-age-18 experimentation (in columns) and established use at the survey date (in rows). Respondents who experimented with either combustible or electronic cigarettes as minors were more likely to be established users than those who first used at age-18 or later (64.1% versus 40.9%, respectively). Still, early experimentation did not necessarily lead to habitual use: 35.9% of those who tried a combustible or electronic

cigarette prior to age-18 were not current established users as of their survey date. Thus, understanding which pre-age-18 experimentation patterns most strongly predict later habitual use is critical.

Table 3 summarizes different types of current established use by respondents' pre-age-18 experimentation patterns. Those who tried combustibles first as minors accounted for 64.0% of the full sample, 79.5% of exclusive smokers, 76.1% of dual users, and over half of exclusive vapers. In contrast, respondents who tried e-cigarettes first comprised 12.5% of the sample, 3.8% of exclusive smokers, 10.8% of dual users, and 26.8% of exclusive vapers. Two-sample tests of proportions verify that those who tried combustible cigarettes first were significantly more likely to be exclusive smokers ($p\text{-value}=0.00$) than those who experimented with e-cigarettes first, though the same was not true for dual users ($p\text{-value}=0.11$).

Logistic regressions examined which experimentation patterns were most likely to result in habitual smoking (i.e., smoker or dual user) and vaping (i.e., vaper or dual user) at the respondent's survey date. Dual use was not examined as a separate outcome due to the small sample size and reduced statistical power when treating these as three mutually exclusive outcomes. Two indicators of habitual use were considered: established use and daily use.

Table 4 presents regressions with and without adjustment for respondent demographics as well as parental combustible and electronic cigarette use when the respondent was age 16. Findings were similar between unadjusted and adjusted regressions, so only the latter are discussed here.

Note that the reference group for experimentation patterns was ever-tryers who did not try either product until age-18 or later.

Compared to those who did not try either product until age-18 or later, having tried only combustible cigarettes as a minor was associated with a 175% increase in the odds of being an established smoker ($OR_{Adjusted}=2.75$, $CI[1.99,3.79]$) and a 161% increase in the odds of being a daily smoker ($OR_{Adjusted}=2.61$, $CI[1.75,3.90]$). Having tried only e-cigarettes prior to age-18 was associated with a 78% *decrease* in one's odds of habitual smoking at ages 18-21 using either smoking measure ($OR_{Adjusted, Established Smoking}=0.22$, $CI[0.10,0.50]$; $OR_{Adjusted, Daily Smoking}=0.22$, $CI[0.06,0.77]$).

Considering those who tried both products before age-18, order of experimentation mattered. Experimenting with combustible cigarettes first and then e-cigarettes was associated with a statistically significant 312% increase in the odds of established smoking ($OR_{Adjusted}=4.12$, $CI[2.89,5.87]$) and a 214% increase in the odds of daily smoking ($OR_{Adjusted}=3.14$, $CI[2.05,4.81]$). In contrast, trying e-cigarettes and then combustible cigarettes yielded an 89% increase for established smoking ($OR_{Adjusted}=1.89$, $CI[1.09,3.27]$) and a statistically insignificant decrease for daily smoking. Odds ratios for “combustible then electronic cigarettes” and its inverse were statistically different ($p\text{-value} < 0.01$; see Table 4 Wald tests for $\beta_{CC \text{ then } EC} = \beta_{EC \text{ then } CC}$).

Considering e-cigarette use, analyses found that experimentation with only 1 product prior to age-18 yielded statistically insignificant coefficients for both measures of habitual vaping.

However, having tried both combustible and electronic cigarettes was associated with increased odds of established vaping, with a greater impact from trying e-cigarettes first ($OR_{Adjusted}=4.36$, $CI[2.47,7.69]$) versus combustibles first ($OR_{Adjusted}=2.60$, $CI[1.74,3.87]$). For daily vaping, trying e-cigarettes before combustible cigarettes yielded a statistically significant increase ($OR_{Adjusted}=2.35$, $CI[1.03,5.36]$), while trying combustibles first did not ($OR_{Adjusted}=1.64$, $CI[0.90,2.98]$).

For both smoking and vaping, parental use of a given product when the respondent was age-16 was associated with a more than 80% increase in the odds that the respondent would be an established user of that same product in late-adolescence. For daily use, parental smoking yielded a 146% increase in the odds of daily smoking ($OR=2.46$, $CI[1.84,3.29]$), while parental vaping did not yield a statistically significant impact on daily vaping. In all cases, odds ratios for the cross-product effects were statistically insignificant.

DISCUSSION

Using newly collected data, this study presents important evidence on the relationship between minors' combustible and electronic cigarette experimentation patterns and subsequent habitual smoking and vaping. Analyses yield three key findings. 1) Thirty-six percent of those who experimented with either product as minors reported no current established smoking or vaping. 2) Consistent with the initial hypotheses, experimentation patterns that began with combustible cigarettes were the most predictive of later habitual smoking. 3) Among ever-triers, experimentation with e-cigarettes alone prior to age-18 was associated with a *reduced* likelihood of habitual smoking in late-adolescence, relative to individuals who do not experiment with

either product until age-18 or later. As over 50 percent of habitual smoking in the U.S. begins by age-18,¹⁷ these findings suggest that efforts to prevent lasting smoking habits should focus on those who experiment with combustible cigarettes as minors, more than on minors who try only e-cigarettes.

These findings have implications for smoking prevention efforts. Specifically, habitual smoking is the main cause of tobacco-related morbidity and mortality. The fact that youth combustible cigarette use is a stronger predictor of habitual smoking than youth vaping alone suggests that new efforts to reduce e-cigarette use should not take resources away from effective smoking prevention programs.

An additional result deserves further discussion. Analyses showed a strong association between parental use of a given product when a respondent was 16 and that respondent's established use of the same product in late-adolescence. However, parental vaping when a respondent was 16 had a small and statistically insignificant association with respondent smoking at the survey date. The same was true for parental smoking and respondent vaping. This result suggests that interventions that encourage parents who are resistant to quitting smoking to switch to e-cigarettes should be tested for their effects on youth smoking, particularly as smoking appears to pose larger health risks than vaping.^{2,27-29}

Limitations

Building on the existing literature on youth tobacco experimentation, this study considers how different experimentation patterns among minors relate to onset of habitual use. This is possible

only with collection of new data on age and order of first use of combustible and electronic cigarettes. Nonetheless, these data have limitations. First, sample selection bias is a concern with online surveys e.g., online samples often have greater computer literacy, though this may be less of an issue for 18 to 21 year-olds. Similarly, recall bias could be a problem: if those who try a tobacco product only once are less likely to recall doing so, the sample may be somewhat more susceptible to habitual use than the general ever-trier population.³⁰ Reassuringly, evidence suggests high accuracy in recalled smoking status data even 20 years later, regardless of current smoking status; and, this survey's respondents typically report on behaviors occurring within the prior 10 years.³¹ Other data limitations include lack of data on additional indicators of susceptibility to tobacco use, as well as use of non-cigarette tobacco products and zero-nicotine e-cigarettes, a common behavior among youths who vape.^{32,33} If those who only experimented with e-cigarettes were more likely to use zero-nicotine e-cigarettes, this might help explain the negative relationship between e-cigarette-only experimentation and later habitual smoking.

Cohort effects limit the results' generalizability to today's youth. Specifically, respondents lacked access to e-cigarettes at very young ages and would not have had access to the more modern (and higher nicotine delivery) products (e.g., JUUL). Thus, as e-cigarette products evolve and younger cohorts age into adolescence, these results and their policy implications should be revisited. Also, as the data do not cover behavior after age 21, conclusions here rely on the fact that most habitual smoking begins prior to this age.²⁴ Due to this censoring, results may not reflect longer run habit formation, with potential for bias due to the relatively earlier age of first combustible-cigarette-use relative to first-e-cigarette use in this sample (leaving less time for habit formation in the latter case). Since relatively few respondents reported both having used

only e-cigarettes prior to age-18 and exclusive smoking at their survey date, future work should assess the stability of these results related to this subgroup, and account for behaviors in later young adulthood.

Finally, these analyses identify associations, not causal effects. Importantly, this does not preclude their use to identify minors at highest risk for future habitual smoking.

CONCLUSIONS

Results indicate that not all youth cigarette experimentation is equal in terms of later habit formation. Specifically, minors who tried combustible cigarettes first (or only) showed substantially greater likelihoods of habitual smoking by ages 18 to 21 relative to both those whose first use of either product occurred after age-18 and those who tried e-cigarettes before combustible cigarettes. In contrast, those who tried only e-cigarettes as minors had a lower probability of developing habitual smoking by ages 18 to 21, with no significant impact on habitual vaping. Thus, the group at highest risk for habitual smoking was minors who tried combustible cigarettes, much more so than minors who used e-cigarettes alone. Since minors' combustible cigarette use remains the strongest predictor of later habitual smoking, prevention efforts should take care not to divert funds away from effective anti-smoking efforts, even as they aim to address newer tobacco products.

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