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Association of Noncigarette Tobacco Product Use With Future Cigarette Smoking Among Youth in the Population Assessment of Tobacco and Health (PATH) Study, 2013-2015

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IMPORTANCE Approximately 90% of adult smokers first tried a cigarette by 18 years of age, and even infrequent smoking in adolescence is associated with established adult smoking. Noncigarette tobacco use is increasing and could stimulate subsequent conventional cigarette smoking in youths.

OBJECTIVE To estimate the longitudinal association between noncigarette tobacco use and subsequent cigarette smoking initiation among US youth.

DESIGN, SETTING, AND PARTICIPANTS In this prospective cohort study of the Population Assessment of Tobacco and Health (PATH) waves 1 (September 12, 2013, to December 14, 2014) and 2 (October 23, 2014, to October 30, 2015), a nationally representative sample of youths who never smoked a conventional cigarette at baseline and completed wave 2 follow-up (N = 10 384) was studied. PATH retention at follow-up was 87.9%.

EXPOSURES Ever use and past 30-day use of electronic cigarettes (e-cigarettes), hookah, noncigarette combustible tobacco, or smokeless tobacco at baseline.

MAIN OUTCOMES AND MEASURES Ever use and past 30-day use of cigarettes at follow-up.

RESULTS The present analysis was based on the 10 384 PATH youth respondents who reported never having smoked a cigarette in wave 1 and whose cigarette ever or past 30-day use was reported in wave 2 (mean [SD] age, 14.3 [1.7] years; age range, 12-17 years; 5087 [49.1%] female; 4829 [52.5%] white). At 1-year follow-up, 469 (4.6%) of all baseline never-smoking youths had tried a cigarette and 219 (2.1%) had smoked a cigarette within the past 30 days. Cigarette ever use at follow-up was higher among youths who had ever used e-cigarettes (78 [19.1%]), hookah (60 [18.3%]), noncigarette combustible tobacco (45 [19.2%]), or smokeless tobacco (29 [18.8%]) at baseline. After adjusting for sociodemographic, environmental, and behavioral smoking risk factors and for baseline ever use of other tobacco products, the odds of past 30-day cigarette use at follow-up were approximately twice as high among baseline ever users of e-cigarettes (odds ratio [OR], 1.87; 95% CI, 1.15-3.05), hookah (OR, 1.92; 95% CI, 1.17-3.17), noncigarette combustible tobacco (OR, 1.78; 95% CI, 1.00-3.19), and smokeless tobacco (OR, 2.07; 95% CI, 1.10-3.87). Youths who had tried more than 1 type of tobacco product at baseline had 3.81 (95% CI, 2.22-6.54) greater adjusted odds of past 30-day cigarette smoking at follow-up than did baseline never tobacco users.

CONCLUSIONS AND RELEVANCE Any use of e-cigarettes, hookah, noncigarette combustible tobacco, or smokeless tobacco was independently associated with cigarette smoking 1 year later. Use of more than 1 product increased the odds of progressing to cigarette use.

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Approximately 90% of adult smokers used their first cigarette by 18 years of age,[1] and smoking as few as 1 cigarette per month in adolescence is associated with future daily smoking and smoking in adulthood.[2,3] In 2016, a total of 3.9 million middle and high school students were currently using at least 1 tobacco product, and 1.8 million reported using 2 or more products.[4] With increasing popularity among youths of noncigarette tobacco products, including electronic cigarettes (e-cigarettes) and hookah (tobacco waterpipe),[4] it is important to know whether use of these alternative products diverts youths from smoking conventional cigarettes or encourages smoking initiation. In addition to their direct health effects, how these products affect youth cigarette smoking is a major consideration in determining their net influence on public health.[5]

To our knowledge, no prospective study has simultaneously estimated the associations of e-cigarette, cigar, hookah, and smokeless tobacco product use with subsequent cigarette smoking initiation. A meta-analysis[6] of 9 longitudinal studies found that e-cigarette use by never-smoking adolescents was associated with approximately 4 times greater odds of future cigarette smoking. Two of the studies[7,8] controlled for baseline use of other noncigarette tobacco products, and 1 study[8] reported the association (baseline use of a tobacco product other than e-cigarettes was not associated with future cigarette smoking after adjusting for e-cigarette use). Other longitudinal studies found that smokeless tobacco use[9-11] and hookah use[11,12] were associated with cigarette initiation in youths. This is the first longitudinal study, to our knowledge, that simultaneously assessed e-cigarettes, hookah, noncigarette combustible tobacco, and smokeless tobacco as determinants of future cigarette smoking, including whether poly-use of noncigarette products has a greater association with future smoking compared with use of 1 product alone.

Key Points

Question Does noncigarette tobacco use among never-smoking youth determine subsequent cigarette smoking initiation?

Findings In this cohort study of the Population Assessment of Tobacco and Health, ever and past 30-day use of electronic cigarettes, hookah (tobacco waterpipe), noncigarette combustible tobacco, or smokeless tobacco was associated with cigarette initiation within 1 year.

Meaning Youths who use any tobacco product may be at greater risk of initiating cigarette smoking.

Methods

The Population Assessment of Tobacco and Health (PATH) study protocol received approval from the Westat Institutional Review Board and a National Institutes of Health certificate of confidentiality. Parental consent was requested on behalf of participating youths. Youths who completed the questionnaire were given $25. The University of California San Francisco Institutional Review Board exempted the present analysis from review. All data were deidentified.

Survey Population

The PATH study includes a nationally representative longitudinal cohort of 13 651 US youth ages 12 to 17 years at baseline with follow-up 1 year later.[13] We used PATH data to test the hypothesis that among youth who had never tried a cigarette at baseline, ever and past 30-day use of e-cigarettes, hookah, noncigarette combustible tobacco, or smokeless tobacco is associated with initiation of cigarette smoking (ever and past 30 days) within 1 year.

PATH questionnaires were administered through in-person computer-assisted interviews at home. Questionnaires included detailed self-assessments of behaviors related to 8 types of combustible and noncombustible tobacco and nicotine products: bidis, cigarettes, cigars (traditional, filtered, and cigarillos), e-cigarettes, hookah, kreteks, pipes, and smokeless tobacco (chewing tobacco, dissolvable tobacco, moist snuff, and snus).

The PATH study featured a 4-stage, stratified probability sample design. Adults (age ≥18 years, up to 2 per household) were oversampled for tobacco users, African American individuals, and young adults (age 18-24 years). The PATH youth sample consists of individuals whose parents were sampled for the PATH adult survey. Up to 2 youths were selected per household; sample and replicate weights were generated so that the sampled population reflected the noninstitutionalized youth population at baseline.

The wave 1 youth survey was administered from September 12, 2013, to December 14, 2014, and wave 2 from October 23, 2014, to October 30, 2015. Of 13 651 wave 1 youth participants, 11 996 completed wave 2 (unweighted retention, 87.9%), including 1915 individuals who reached 18 years of age before follow-up and were administered the wave 2 adult survey. The weighted wave 1 response rate for the youth survey was 78.4% among households screened for participation.[13]

Study Measures

We measured the outcome new cigarette initiation between waves 1 and 2 in 2 ways: (1) whether the respondent ever smoked a cigarette, even 1 or 2 puffs (ever use, yes/no), and (2) whether the respondent smoked a cigarette at least 1 day in the past 30 days (past 30-day use, yes/no). Because of low baseline prevalence of ever use for pipes, bidis, kreteks, snus, and dissolvable tobacco (all <1%), we created 4 categories of products: e-cigarettes, hookah, noncigarette combustible tobacco (bidis, cigarillos, filtered cigars, kreteks, pipes, and traditional cigars), and smokeless tobacco.

We defined wave 1 use of noncigarette tobacco products in 3 ways. First, we defined ever use as having used a product, even once or twice, regardless of use of any other tobacco product. Second, we divided ever use into former use and past 30-day use. Former use indicated having ever used a product but not having used in the prior 30 days. Third, we defined ever only use as having tried only a single product and no other tobacco product. Under this definition, respondents who had ever used 2 or more products comprised a separate category of poly-ever users.

The statistical analyses included baseline variables that were presumed to be causal influences of youth cigarette smoking that

would be associated with but not caused by wave 1 use of noncigarette tobacco products.[14] We did not include mediators, such as perceived cigarette harm, cigarette social acceptability, and nicotine dependence. To account for variation in smoking across sociodemographic groups, we adjusted for sex, age, race/ethnicity (black or African American, Latino, or other), parental educational level (bachelor's degree or higher), and urban residence. The models included other established determinants of cigarette use: the extent to which the respondent was sensation seeking[15] (a score from 3 to 15 that aggregated three 5-point Likert-type measures of affinity for frightening things, new and exciting experiences, and exciting and unpredictable friends), had ever used alcohol, lived with a tobacco user, frequency of noticing health warning labels on cigarette packages (5-point scale from never to very often), and receptivity to tobacco advertising (measured by recalling the brand of their favorite tobacco advertisement).[16] We included whether the wave 1 questionnaire was administered during the summer to capture potential seasonal variation in tobacco use.

Statistical Analysis

We fitted weighted logistic regression models to obtain unadjusted and adjusted relative odds of wave 2 cigarette smoking initiation across groups of wave 1 noncigarette tobacco use. Each unadjusted model included all noncigarette tobacco products as risk indicators of future cigarette use. Adjusted models added baseline variables described above. All models used wave 2 sample weights that account for nonresponse (could not contact or refusal) so that the weighted sample reflected the US civilian household population at the time of wave 1.[17] We used multiple imputation by chained equations (30 imputations) to account for missing data in independent variables (0.9% of data). We calculated weighted, unadjusted prevalences of wave 1 tobacco use after imputation. Analyses were completed using Stata statistical software (version 14.2, StataCorp) and the svy and mi command suites.

We conducted 6 sensitivity analyses. First, we reestimated all model specifications using listwise deletion rather than multiple imputation. Then we repeated that analysis using PATH replicate weights in addition to sample weights. We reestimated the listwise deletion models adding wave 1 cigarette susceptibility[18] and marijuana ever use as model covariates. We estimated unadjusted and adjusted regressions for each noncigarette tobacco product determinant without controlling for other tobacco use. Finally, we estimated polytomous models with a categorical dependent variable of cigarette never, former, or past 30-day use.

Results

Study Population

The present analysis was based on the 10 384 PATH youth respondents who reported never having smoked a cigarette in wave 1 and whose cigarette ever or past 30-day use was reported in wave 2 (mean [SD] age, 14.3 [1.7] years; age range, 12-17 years; 5087 [49.1%] female; 4829 [52.5%] white). At baseline, 851 (9.1%) of never-smoking youths had tried at least 1 noncigarette tobacco product and 242 (2.2%) had used at least 1 noncigarette tobacco product in the past 30 days (**Table 1**). The most commonly tried product was e-cigarettes. Ever use of 2 or more noncigarette tobacco products was reported by 200 (2.1%) of youths, of whom 170 (73.9%) had tried e-cigarettes and 150 (64.8%) had tried hookah.

Table 1. Characteristics of the Study Participants

Characteristic	No./Total No. (%)[a]
Wave 2	
Cigarette use initiation	
Cigarette ever use	469/10 384 (4.6)
Cigarette use in the past 30 d	219/10 380 (2.1)
Wave 1	
Ever use	
E-cigarettes	425/10 348 (4.2)
Hookah	339/10 365 (3.3)
Other combustibles	226/10 044 (2.3)
Smokeless	155/10 256 (1.6)
Past 30-d use	
E-cigarettes	87/10 329 (0.9)
Hookah	63/10 362 (0.6)
Other combustibles	59/10 031 (0.6)
Smokeless	NR[b]
Ever only use	
E-cigarettes only	255/9909 (2.6)
Hookah only	189/9909 (1.9)
Other combustibles only	114/9909 (1.1)
Smokeless only	93/9909 (1.0)
Polyuse (≥2 product types)	200/9909 (2.1)
Covariates[c]	
Female	5271/10 358 (49.1)
Age group, y	
12	1983/10 383 (18.9)
13	1979/10 383 (18.3)
14	1861/10 383 (17.6)
15	1704/10 383 (16.5)
16	1555/10 383 (15.2)
17	1301/10 383 (13.5)
Race/ethnicity	
White	4829/10 384 (52.5)
African American	1422/10 384 (13.9)
Latino	3009/10 384 (22.3)
Other	1124/10 384 (11.3)
Parent's educational level (bachelor's degree or higher)	4187/10 318 (44.8)
Urban residence	8359/10 384 (80.7)
Has ever used alcohol	3217/10 336 (32.2)
Lives with tobacco user	3212/10 292 (30.2)
Tobacco advertising receptivity	728/10 177 (7.2)
Questionnaire completed in the summer months	2701/10 384 (25.9)

Abbreviation: NR, not reported.

[a] Counts were calculated before multiple imputation, and percentages were weighted using wave 2 weights before multiple imputation.

[b] Results suppressed because of limited sample size.

[c] Additional covariates: sensation seeking, a score from 3 to 15 that aggregated three 5-point Likert-type measures of affinity for frightening things, new and exciting experiences, and exciting and unpredictable friends (n = 10 187; mean [SD], 7.6 [2.8]); noticed cigarette health warning, a score on a 5-point scale, with 1 indicating never and 5 indicating very often (n = 10 108; mean [SD], 2.0 [1.3]).

Table 2. Associations of Noncigarette Tobacco Ever Use With Subsequent Cigarette Use

Wave 1 Use	No. of Observations Before Multiple Imputation	Wave 2 Cigarette Ever Use (n = 10 384)[a]			Wave 2 Cigarette Past 30-d Use (n = 10 380)[b]		
		Weighted, Unadjusted Cigarette Ever Use, %	OR (95% CI)		Weighted, Unadjusted Cigarette Past 30-d Use, %	OR (95% CI)	
			Model 1[c]	Model 2[d]		Model 3[c]	Model 4[d]
E-cigarettes							
Never	9923	3.9	1 [Reference]	1 [Reference]	1.8	1 [Reference]	1 [Reference]
Ever	425	19.1	3.50 (2.48-4.94)	2.53 (1.80-3.56)	8.2	2.39 (1.42-4.00)	1.87 (1.15-3.05)
Hookah							
Never	10 026	4.1	1 [Reference]	1 [Reference]	1.9	1 [Reference]	1 [Reference]
Ever	339	18.3	2.67 (1.81-3.93)	1.79 (1.23-2.62)	9.4	2.85 (1.69-4.79)	1.92 (1.17-3.17)
Noncigarette combustibles							
Never	9818	4.2	1 [Reference]	1 [Reference]	1.9	1 [Reference]	1 [Reference]
Ever	226	19.2	2.23 (1.42-3.49)	1.64 (1.06-2.54)	10.8	2.47 (1.36-4.47)	1.78 (1.00-3.19)
Smokeless							
Never	10 101	4.4	1 [Reference]	1 [Reference]	1.9	1 [Reference]	1 [Reference]
Ever	155	18.8	2.64 (1.60-4.35)	1.66 (1.00-2.76)	12.5	3.78 (2.07-6.89)	2.07 (1.10-3.87)

Abbreviation: OR, odds ratio.

[a] For cigarette use ever, the *F* statistic was 56.1 in model 1 and 24.6 in model 2, and the largest fraction of missing information was 0.011 in model 1 and 0.0186 in model 2.

[b] For past 30-day cigarette use, the *F* statistic was 36.8 in model 1 and 19.7 in model 2, and the largest fraction of missing information was 0.028 in model 1 and 0.032 in model 2.

[c] Model includes all ever tobacco use categories.

[d] Model includes all ever tobacco use categories and the following wave 1 covariates: female, age, race/ethnicity, parental educational level, urban residence, sensation seeking, alcohol ever use, living with tobacco user, notice of cigarette warning labels, tobacco advertising receptivity, and summer season. Coefficient values for adjustment variables are given in eTable 8 in the Supplement.

Cigarette Use Initiation

Of wave 1 never-smoking youths, 469 (4.6%) tried a cigarette for the first time between waves 1 and 2 and 219 (2.1%) had smoked a cigarette within the past 30 days at wave 2 (Table 1). Among youths who had never smoked a cigarette at baseline, adjusted odds of any cigarette use initiation were approximately double for ever users of e-cigarettes (odds ratio [OR], 2.53; 95% CI, 1.80-3.56), hookah (OR, 1.79; 95% CI, 1.23-2.62), noncigarette combustible tobacco (OR, 1.64; 95% CI, 1.06-2.54), and smokeless tobacco (OR, 1.66; 95% CI, 1.00-2.76) compared with never users (**Table 2**). Odds of past 30-day cigarette use at follow-up were also approximately double for ever users of e-cigarettes (OR, 1.87; 95% CI, 1.15-3.05), hookah (OR, 1.92; 95% CI, 1.17-3.17), noncigarette combustible tobacco (OR, 1.78; 95% CI, 1.00-3.19), and smokeless tobacco (OR, 2.07; 95% CI, 1.10-3.87) compared with never users.

Both former and past 30-day use of each baseline tobacco product was associated with cigarette initiation and past 30-day cigarette smoking in wave 2. In adjusted models, past 30-day use of e-cigarettes (OR, 2.65; 95% CI, 1.38-5.10; $P = .004$), hookah (OR, 2.58; 95% CI, 1.20-5.55; $P = .02$), and noncigarette combustibles (OR, 3.05; 95% CI, 1.37-6.77; $P = .006$) were significantly associated with subsequently trying cigarettes. Former use of e-cigarettes (OR, 2.58; 95% CI, 1.77-3.76; $P<.001$), hookah (OR, 1.54; 95% CI, 1.02-2.34; $P = .04$), and smokeless tobacco (OR, 2.26; 95% CI, 1.34-3.81; $P = .002$) were also independently associated with smoking initiation (**Table 3**). These ORs were similar for former and past 30-day use and similar to the ORs for ever use (Table 2). Baseline past 30-day use of noncigarette combustible tobacco was associated with 3 times greater odds of past 30-day cigarette use at follow-up compared with baseline combustible tobacco never use (Table 3). Former e-cigarette users had 1.84 times the odds of reporting wave 2 past 30-day cigarette use than e-cigarette never users.

Baseline ever exclusive use (ever only use) of noncigarette tobacco products was also positively associated with future cigarette smoking (**Table 4**). Youths who had used only e-cigarettes, used only hookah, or used only noncigarette combustibles had 2 to 3 times greater odds than tobacco never users of reporting cigarette ever use or past 30-day use 1 year later (Table 4). Baseline use of only smokeless tobacco was also positively associated with future smoking but was not statistically significant in the adjusted model (OR, 1.53; 95% CI, 0.56-4.19; $P = .41$). Ever use of 2 or more types of products (polyuse) was associated with nearly 4 times greater adjusted odds of ever using a cigarette (OR, 3.95; 95% CI, 2.65-5.90; $P < .001$) and past 30-day cigarette use (OR, 3.81; 95% CI, 2.22-6.54; $P < .001$).

There was little collinearity among baseline tobacco use variables (all variance inflation factors <1.4). Sensitivity analyses yielded similar findings to the main analyses (eTables 1-7 in the Supplement). Associations decreased in magnitude with adjustment for marijuana use (eTable 4 in the Supplement). The ORs not adjusted for other noncigarette tobacco products were consistently larger than the ORs with simultaneous control for other products (eTable 5 and eTable 6 in the Supplement).

Discussion

We report 3 central findings. First, youths who initiated tobacco use with noncigarette products were more likely to have smoked cigarettes 1 year later than were youths who had never used tobacco. Second, the ORs were of similar magnitude across products and between ever use (Table 2) and former and current use

Table 3. Associations of Noncigarette Tobacco Current and Former Use With Subsequent Cigarette Use[a]

Wave 1 Use	No. of Observations Before Multiple Imputation	Wave 2 Cigarette Ever Use (n = 10 384)[b]			Wave 2 Cigarette Past 30-d Use (n = 10 380)[c]		
		Weighted, Unadjusted Cigarette Ever Use, %	OR (95% CI)		Weighted, Unadjusted Cigarette Past 30-d Use, %	OR (95% CI)	
			Model 1[d]	Model 2[e]		Model 3[d]	Model 4[e]
E-cigarettes							
Never	9923	3.9	1 [Reference]	1 [Reference]	1.8	1 [Reference]	1 [Reference]
Former	319	18.6	3.66 (2.52-5.32)	2.58 (1.77-3.76)	7.5	2.42 (1.40-4.19)	1.84 (1.07-3.15)
Past 30 d	87	23.8	3.61 (1.82-7.16)	2.65 (1.38-5.10)	11.6	2.48 (0.91-6.78)	2.08 (0.81-5.40)
Hookah							
Never	10 026	4.1	1 [Reference]	1 [Reference]	1.9	1 [Reference]	1 [Reference]
Former	273	16.4	2.32 (1.52-3.53)	1.54 (1.02-2.34)	8	2.39 (1.41-4.05)	1.57 (0.92-2.68)
Past 30 d	63	26.4	3.78 (1.69-8.44)	2.58 (1.20-5.55)	15	3.86 (1.24-12.0)	2.69 (0.91-7.98)
Noncigarette combustibles							
Never	9818	4.2	1 [Reference]	1 [Reference]	1.9	1 [Reference]	1 [Reference]
Former	154	15.4	1.65 (0.95-2.84)	1.22 (0.73-2.04)	7.8	1.68 (0.84-3.36)	1.23 (0.62-2.40)
Past 30 d	59	30.6	3.98 (1.91-8.32)	3.05 (1.37-6.77)	19.7	4.99 (1.92-13.0)	3.55 (1.27-9.93)
Smokeless							
Never	10 101	NR[f]	1 [Reference]	1 [Reference]	NR[f]	1 [Reference]	1 [Reference]
Former	114	NR[f]	3.19 (1.95-5.22)	2.26 (1.34-3.81)	NR[f]	4.48 (2.53-7.92)	2.83 (1.49-5.38)
Past 30 d	56	NR[f]	1.42 (0.25-8.00)	0.62 (0.14-2.77)	NR[f]	2.60 (0.33-20.3)	0.93 (0.18-5.38)

Abbreviations: CI, confidence interval; NR, not reported; OR, odds ratio.

[a] Former use indicates having ever used the product but not within the past 30 days.

[b] For cigarette use ever, the *F* statistic was 30.4 in model 1 and 20.9 in model 2, and the largest fraction of missing information was 0.009 in model 1 and 0.021 in model 2.

[c] For past 30-day cigarette use, the *F* statistic was 17.8 in model 1 and 16.4 in model 2, and the largest fraction of missing information was 0.018 in model 1 and 0.033 in model 2.

[d] Model includes all former and past 30-day tobacco use categories.

[e] Model includes all former and past 30-day tobacco use categories and the following wave 1 covariates: female, age, race/ethnicity, parental educational level, urban residence, sensation seeking, alcohol ever use, living with tobacco user, notice of cigarette warning labels, tobacco advertising receptivity, and summer season. Coefficient values for adjustment variables are shown in eTable 9 in the Supplement.

[f] Results suppressed because of limited sample size.

(Table 3), suggesting that any use of noncigarette tobacco, whether former or current, is similarly associated with future smoking. Ever users of multiple tobacco products were more likely to initiate smoking than were ever users of a single product, and product-specific associations with future smoking were essentially independent, suggesting that the risk of progressing to conventional cigarette smoking is increased with use of multiple forms of noncigarette tobacco.

Cigarette ever use is a meaningful outcome given that nicotine dependence can manifest in adolescents soon after their first puff, but other smoking milestones, such as daily smoking, can take years to develop.[19] Past 30-day use is the standard surveillance measure for current smoking among youths and is associated with smoking in adulthood.[2,3]

Recent scholarship has focused on the potential of e-cigarettes to engage youths in tobacco use.[6,20-22] Our findings confirm that use of the full range of tobacco products, including cigars, hookah, and smokeless tobacco, is associated with future cigarette smoking. E-cigarette use, combustible tobacco use, and noncombustible tobacco use have positively determined cigarette smoking intentions.[23] Our findings confirm that use of these products is also independently associated with greater odds of future cigarette smoking.

The OR point estimates in models that simultaneously accounted for use of all noncigarette tobacco products are generally smaller than previously reported associations. For example, we estimated that ever use of e-cigarettes was associated with 2.53 times greater odds of subsequent cigarette use (Table 2), which is lower than the summary OR of 3.62 (95% CI, 2.24-5.41) reported in a meta-analysis[6] of 7 longitudinal studies, although the 95% CIs overlap. We estimated an OR of 1.79 for the association between hookah ever use and subsequent cigarette ever use, whereas Soneji and colleagues[11] estimated an OR of 2.56 (95% CI, 1.46-4.47). These differences likely occurred because in our sample, 40% of youths who used e-cigarettes and 44% of youths who used hookah were poly-tobacco users. Not accounting for poly-tobacco use will overestimate the magnitude of the effects of e-cigarettes or hookah alone. A sensitivity analysis without other tobacco use variables yielded similar adjusted odds of subsequent cigarette smoking as reported in other studies (ORs of 3.24 [95% CI, 2.35-4.48] for e-cigarettes and 2.59 [95% CI, 1.82-3.68] for hookah).

Adolescent use of noncigarette tobacco increased between 2011 and 2015, particularly use of e-cigarettes and hookah.[24] In the past decade, the rate of decrease in youth smoking has slowed.[24] Poly-tobacco users comprise nearly half of all youth tobacco users[4]; in our study, having tried more than 1 noncigarette tobacco product had a greater association with future smoking than did ever use of a single tobacco product. In light of these observed associations between noncigarette tobacco use and future smoking, novel tobacco products have the potential to undermine public health gains in combatting the smoking epidemic.

Multiple factors could explain our findings. Nontobacco cigarette products might induce nicotine dependence, symptoms of

Table 4. Associations of Noncigarette Tobacco Single-Product Ever Use and Polyuse With Subsequent Cigarette Use

Wave 1 Use	No. of Observations Before Multiple Imputation	Wave 2 Cigarette Ever Use (n = 10 384)[a]			Wave 2 Cigarette Past 30-d Use (n = 10 380)[b]		
		Weighted, Unadjusted Cigarette Ever Use, %	OR (95% CI)		Weighted, Unadjusted Cigarette Past 30-d Use, %	OR (95% CI)	
			Model 1[c]	Model 2[d]		Model 3[c]	Model 4[d]
Never use	9058	3.5	1 [Reference]	1 [Reference]	1.6	1 [Reference]	1 [Reference]
E-cigarettes only	255	15.3	4.98 (3.39-7.31)	2.99 (1.98-4.53)	5.4	3.59 (1.96-6.60)	2.12 (1.11-4.03)
Hookah only	189	13.6	4.35 (2.79-6.76)	2.35 (1.46-3.77)	6.3	4.17 (2.24-7.78)	2.15 (1.11-4.16)
Combustibles only	114	11.4	3.57 (1.96-6.48)	2.14 (1.14-4.04)	7.9	5.34 (2.65-10.8)	3.08 (1.43-6.66)
Smokeless only	93	12	3.77 (1.97-7.24)	1.88 (0.91-3.86)	6.4	4.28 (1.72-10.6)	1.53 (0.56-4.19)
Polyuse	200	23.7	8.57 (6.00-12.20)	3.95 (2.65-5.90)	12.4	8.86 (5.54-14.20)	3.81 (2.22-6.54)

Abbreviation: OR, odds ratio.

[a] For cigarette use ever, the *F* statistic was 46.0 in model 1 and 24.0 in model 2, and the largest fraction of missing information was <0.001 in model 1 and 0.019 in model 2.

[b] For past 30-day cigarette use, the *F* statistic was 24.4 in model 1 and 18.38 in model 2, and the largest fraction of missing information was <0.001 in model 1 and 0.030 in model 2.

[c] Model includes all ever-only and poly-tobacco use categories.

[d] Model includes all ever-only and poly-tobacco use categories and the following wave 1 covariates: female, age, race/ethnicity, parental educational level, urban residence, sensation seeking, alcohol ever use, living with tobacco user, notice of cigarette warning labels, tobacco advertising receptivity, and summer season. Coefficient values for adjustment variables are shown in eTable 10 in the Supplement.

which have been reported by youths who use tobacco, including cigars and smokeless tobacco, as few as 1 to 5 days per month.[25] Youths who use noncigarette tobacco products find conventional cigarettes to be more convenient and effective in satisfying nicotine cravings.[12,26,27] Use of noncigarette tobacco could change how youths perceive cigarettes. Of all tobacco products, adolescents generally perceive cigarettes to convey the most health risks.[28,29] In a Monitoring the Future follow-up sample, among youth never-smokers who reported that cigarettes pose great risk, baseline e-cigarette users were approximately 4 times more likely than e-cigarette nonusers to later change their cigarette harm perception away from great risk.[30] A structural modeling analysis found other social mediators between youth e-cigarette use and subsequent smoking: perceived benefits of smoking, social affiliation with smokers, and favorable opinions of cigarette smoking peers.[22] Alternatively, our findings might reflect a general propensity toward tobacco use or risk taking: youths who try noncigarette tobacco may be likely to smoke cigarettes regardless of other product use. However, when we accounted for confounders, including risk-taking affinity (sensation seeking), meaningful and statistically significant associations between other tobacco use and cigarette smoking persisted. Other studies[11,31] have also found consistent associations after adjusting for confounders.

A proposed catalyst model comprehensively summarizes possible causal pathways from initial use of e-cigarettes to tobacco smoking among youths.[32] This model includes e-cigarette characteristics initially favored by youths (eg, flavors, social acceptability, and lower perceived harm) before transition to smoking through nicotine dependence, sensorimotor stimulation, increasing accessibility, and other pathways.[32] Similarly comprehensive models are lacking for other noncigarette tobacco products, but factors such as flavors and nicotine experiences may apply analogously.

Future work could directly compare these proposed mechanisms by observing patterns of use, addiction, risk perception, and subsequent smoking longitudinally. Regardless of the explanation for the observed associations, this study found that any noncigarette tobacco use is significantly associated with risk of future cigarette use. Given the heterogeneity of polyuse patterns among adolescents, future work should explore distinct patterns of polyuse and their implications for future cigarette use.

Limitations

Lack of statistical significance in adjusted models of baseline past 30-day tobacco use to determine wave 2 past 30-day cigarette use may reflect power limitations. Despite the large sample size of PATH overall, the number of past 30-day users of some products limited statistical power. By analyzing ever use, past 30-day use, and ever only use, this analysis demonstrated that measurement choice in defining risk variables is not a major determinant of study findings.

The PATH study has strong external validity, featuring a large, nationally representative sample with excellent retention. The longitudinal design and multiple imputation for missing covariate data further strengthen the internal validity of this analysis. Despite these advantages, residual confounding is possible, as is true in any observational study, despite statistical adjustment for known youth smoking risk factors and for baseline use of the other tobacco products. In-home, computer-assisted interviews used in PATH may have resulted in different prevalence estimates compared with in-school surveys, with an unknown effect on associations between noncigarette tobacco use and cigarette use initiation.

Conclusions

Although e-cigarettes are the most common form of noncigarette tobacco used by youths (exceeding cigarette use), any use of all forms of noncigarette tobacco was independently associated with greater risk of future cigarette smoking; risk was greatest with use of multiple products, a use pattern that is increasing among youths. Strategies to prevent cigarette use initiation in youths, such as pack size requirements and flavor restrictions, should be extended to other tobacco products. Even for youths who had not used tobacco recently, having ever tried a noncigarette product at any point was associated with smoking initiation within

a year. This study's findings provide evidence that despite their differences, disparate alternative-cigarette products contribute to a similar process that leads to cigarette use initiation. In policy terms, the findings provide a rationale to treat alternative cigarette products as a group and potentially extend policies that work for one product to the others (such as a ban on flavoring). Even if youths do not progress to smoking cigarettes, any tobacco use is harmful. The estimated health risks of noncigarette tobacco products should include the additional health consequences of future cigarette use.

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