

Correlates of tobacco product cessation among youth and adults in the USA: findings from the PATH Study Waves 1–3 (2013–2016)

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ABSTRACT

Objective To report on demographic and tobacco use correlates of cessation behaviours across tobacco products (cigarettes, electronic nicotine delivery systems (ENDS), cigars, hookah and smokeless tobacco) among the US population.

Design Data were drawn from the first three waves (2013–2016) of the Population Assessment of Tobacco and Health Study, a nationally representative, longitudinal cohort study of US youth (ages 12–17) and adults (ages 18+). Past 30-day (P30D) tobacco users at Wave 1 (W1) or Wave 2 (W2) were included (n=1374 youth; n=14 389 adults). Generalised estimating equations were used to evaluate the association between demographic and tobacco use characteristics at baseline, with cessation behaviours at follow-up (discontinuing use, attempting to quit, quitting), over two 1-year periods (W1–W2, W2–Wave 3).

Results Among adult users of each type of tobacco product, frequency of use was negatively associated with discontinuing use. Among adult cigarette smokers, non-Hispanic white smokers, those with lower educational attainment and those with lower household income were less likely to discontinue cigarette use; ENDS use was positively associated with making quit attempts but was not associated with cigarette quitting among attempters; smokeless tobacco use was positively associated with quitting among attempters; tobacco dependence was negatively associated with quitting among attempters. Among youth cigarette smokers, tobacco dependence was negatively associated with making quit attempts.

Discussion Demographic correlates of tobacco cessation behaviours underscore tobacco use disparities in the USA. Use of ENDS and use of smokeless tobacco products are positively associated with some adult cigarette cessation behaviours.

INTRODUCTION

In 2013–2016, tobacco product cessation rates among youth and adults were lowest for cigarettes,¹ followed by smokeless tobacco,² electronic nicotine delivery systems (ENDS) among youth³ and cigars among adults⁴ and were highest for hookah among youth and adults.⁵ Understanding correlates of cessation behaviours across tobacco products can help in targeted intervention efforts and can enable

researchers to better predict the potential impacts of regulatory actions and other public health efforts.

Population level tobacco cessation rates depend on the fraction of tobacco users who make a quit attempt and the fraction of those who quit when they try.⁶ For cigarette smoking, there are similarities and differences in factors associated with quit attempt and quit success rates.⁷ Two nationally representative longitudinal studies prospectively evaluated cigarette cessation behaviours among adults: the International Tobacco Control 4-Country survey^{8,9} and the Tobacco Use Supplement to the Current Population Survey (TUS-CPS)¹⁰ evaluated discontinuing cigarette smoking (ie, from use to non-use),^{8,10} attempting to quit cigarette smoking^{8,9} and quitting among attempters.^{8,9} These studies found that adults who are younger,⁸ have higher educational attainment⁹ and have lower tobacco dependence⁸ are more likely to attempt to quit cigarette smoking than their counterparts. Further, lower tobacco dependence⁸ and higher income⁹ are positively associated with quitting among attempters.

As the scope of tobacco products has expanded and concurrent use of multiple tobacco products has become common among tobacco users in the USA,^{11–15} large-scale prospective studies are beginning to evaluate how ENDS may impact cigarette cessation. Using the Population Assessment of Tobacco and Health (PATH) Study, Coleman *et al*¹⁶ found that, among adult cigarette smokers, daily ENDS use and lower tobacco dependence were positively associated with cigarette smoking ‘not at all’ 1 year later. Also using PATH Study data, Buu *et al*¹⁷ found that exclusive cigarette smokers who started using ENDS and used ENDS more frequently had lower cigarette consumption and tobacco dependence 1 year later than those who used ENDS less frequently. Benmarhnia *et al*¹⁸ found that cigarette smokers who used ENDS to quit cigarette smoking had higher rates of not smoking for at least the past 30 days at 1 year follow-up than those who did not use ENDS. Using data from the National Health Interview Survey (NHIS) and the TUS-CPS, Johnson *et al*¹⁹ found that, among cigarette smokers, ENDS use was associated with greater likelihood of making a quit attempt and with higher rates of not smoking for at least the past 90 days

at 1-year follow-up. On the other hand, a meta-analysis of 38 studies concluded that e-cigarette use was associated with 28% lower odds of quitting cigarettes, though these studies varied in design and in how e-cigarette use was defined.²⁰

Using the TUS-CPS, Messer *et al*²¹ found that cigarette smokers who also used smokeless tobacco were more likely to make a cigarette quit attempt but were less likely to quit when they tried compared with those who did not use smokeless tobacco. Nationally representative data on cessation of non-cigarette tobacco products are limited; Coleman *et al*¹⁶ found that non-daily ENDS use, non-use of combustible tobacco products and use of non-customisable ENDS devices were positively associated with using ENDS 'not at all' 1 year later.

Understanding factors associated with the transition from tobacco product use to non-use is important to efforts aimed at decreasing tobacco use prevalence in the population.²² The purpose of this study is to report on demographic and tobacco use correlates of the following cessation behaviours among the US population of youth (ages 12–17) and adult (ages 18+) tobacco users, for different types of tobacco products, using the PATH Study: (1) discontinuing tobacco product use overall, (2) attempting to quit tobacco product use and (3) quitting tobacco product use among those who attempted to quit.

METHODS

Data source and participants

The PATH Study is an ongoing, nationally representative, longitudinal cohort study of youth and adults in the USA. Data were collected from 12 September 2013 through 14 December 2014 (Wave 1 (W1)); from 23 October 2014 through 30 October 2015 (Wave 2 (W2)) and from 19 October 2015 through 23 October 2016 (Wave 3 (W3)). The study uses audio computer-assisted self-interviews (ACASI) administered in English or Spanish to collect self-reported information on tobacco-use patterns and associated health behaviours. At W1, the overall weighted response rate was 78.4% for the youth interview and 74.0% for the adult interview; at W2, it was 87.3% for the youth interview and 83.2% for the adult interview and at W3, it was 83.3% for the youth interview and 78.4% for the adult interview. Further details regarding the PATH Study design and W1 methods are published elsewhere.²³ Details on interview procedures, questionnaires, sampling, weighting, response rates and accessing the data are described in the PATH Study Restricted Use Files (RUF) User Guide, and Non-response Bias Analysis Reports for W1–W3 are available at <https://doi.org/10.3886/Series606>.²⁴ The study was conducted by Westat and approved by the Westat Institutional Review Board. All respondents ages 18 and older provided informed consent, with youth respondents ages 12 to 17 providing assent and each youth's parent/legal guardian providing consent. Data in this paper were drawn from respondents present in W1, W2 and W3 of the PATH Study, which includes 25 384 adults at W1 or W2 and 12 993 youth at W1 or W2.

This paper describes tobacco product cessation behaviours over two 1-year periods. The analytic sample was restricted to respondents who were past 30-day (P30D) users of at least one type of tobacco product at W1 or W2, which includes 14 389 adults and 1374 youth. W1 and W2 are each considered the 'baseline' wave to the subsequent wave, such that W1 is the baseline wave to W2, and W2 is the baseline wave to W3. Inclusion in the youth analyses versus the adult analyses was determined based on age at the respective baseline wave. (That is, youth who aged into the adult cohort at W2 were included in the youth

analyses between W1 and W2 (N=352 current users) and were included in the adult analyses between W2 and W3 (N=334 current users). 'Shadow youth' who aged into the youth cohort at W2 (N=14 current users) were included in the youth analyses only between W2 and W3.) See online supplemental table 1 for additional details. The weighted estimates presented in this paper represent the civilian, non-institutionalised population of the USA at the time of W3 who were age 9 or older at W1, through application of population and replicate weights that adjust for the complex study design characteristics (eg, oversampling at W1) and non-response at W1, W2 and W3.

Measures

Tobacco product use

Tobacco products were grouped into five types: cigarettes, ENDS (e-cigarettes at W1 and e-cigarettes, e-cigars, e-pipes and e-hookah at W2 and W3), cigars (traditional cigars, cigarillos and filtered cigars), hookah and smokeless tobacco (loose snus, moist snuff, dip, spit, chewing tobacco and snus pouches). For each of these five types of tobacco products, P30D use, current established use (adults only) and P30D non-light cigarette smoking (youth only) were defined, as shown in table 1. Current established use and P30D non-light cigarette smoking were additionally categorised according to frequency of use (table 1).

Cessation behaviours

The following cessation behaviours were assessed at follow-up (table 1): (1) discontinuing use (P30D use to no P30D use), (2) making a quit attempt and (3) quitting among quit attempters (current established use to no current established use among quit attempters (adults) and P30D non-light cigarette smoking to no P30D cigarette smoking among quit attempters (youth)).

Tobacco dependence

Sixteen items assessing symptoms of tobacco dependence were included in the PATH Study; responses to these items were combined and scaled to produce an overall tobacco dependence score as described and validated by Strong and colleagues.²⁵

Demographic characteristics

Demographic characteristics were assessed at baseline wave and categorised as shown in the tables. Missing data on age, sex, race and Hispanic ethnicity at W1 were imputed as described in the PATH Study RUF User Guide (Imputed sex and race/ethnicity were carried forward to also represent these characteristics at W2; however, age at W2 was used since the time between interviews may not have yielded one additional year in all instances).²⁴

Statistical analyses

For each type of tobacco product, generalised estimating equations (GEEs) were used to evaluate the association between correlates assessed at baseline and cessation behaviours assessed at follow-up, over two 1-year periods (W1–W2 and W2–W3). This statistical method allows for the inclusion of transitions from both periods in a single analysis while statistically controlling for interdependence among observations contributed by the same individuals.^{26 27} Specifically, GEE logistic regression models specified unstructured covariance and within-person correlation matrices and the binomial distribution of the dependent variable using the logit link function. Analyses were weighted using the W3 'all-wave' weights (including full-sample and 100 replicate weights) to produce nationally representative

Table 1 Definitions

Cessation behaviours	Baseline tobacco use group (W1 or W2)	Follow-up outcome (W2 or W3)
Discontinuing use (table 2 and online supplemental table 2)	<i>Adults & Youth, Past 30-day users:</i> For each of the five types of tobacco products,* used (product/any tobacco) at least once in the past 30 days	<i>Adults & Youth, Discontinuing use:</i> No past 30-day use of the given tobacco product
Making a quit attempt (table 3 and online supplemental table 3)	<i>Adults, Current established users†:</i> For cigarettes, currently smoking every day or some days and smoked at least 100 cigarettes in the lifetime; for other tobacco products, currently using the product every day or some days and ever used the product 'fairly regularly'; for each type of tobacco product, current established use was further categorised according to frequency as everyday use versus not everyday use <i>Youth, Past 30-day non-light cigarette smokers‡:</i> For cigarettes, smoked on at least 10 of the past 30 days, which was further categorised according to frequency as smoked on 20 or more days in the past 30 days versus smoked on 10–19 days in the past 30 days (other tobacco products were not assessed)	<i>Adults, Making a quit attempt:</i> Making an attempt to completely quit use of the given tobacco product/tobacco generally,§ or not using the given tobacco product (ie, currently using 'not at all' at follow-up or did not use in the past 12 months)¶ <i>Youth, Making a quit attempt:</i> Making an attempt to completely quit cigarettes or not being a past 30-day cigarette smoker
Quitting among quit attempters (table 4 and online supplemental table 4)	<i>Adults, Current established users who made a quit attempt as defined above</i> <i>Youth, Past 30-day non-light smokers who made a quit attempt as defined above</i>	<i>Adults, Quitting:</i> No everyday/someday use of the given tobacco product <i>Youth, Quitting:</i> No past 30-day use of cigarettes

*Tobacco product categories include cigarettes, ENDS (e-cigarettes at W1 and e-cigarettes, e-cigars, e-pipes and e-hookah at W2 and W3), cigars (traditional cigars, cigarillos and filtered cigars), hookah and smokeless tobacco (loose snus, moist snuff, dip, spit, chewing tobacco and snus pouches).

†The current established use definition (adults) was used in analyses because these users were asked about making a quit attempt.

‡The past 30-day non-light use definition (youth) for cigarettes was used in analyses because these cigarette smokers were asked about making a quit attempt. Users of other products were not asked about quit attempts.

§Respondents who were current established users of the given tobacco product at follow-up and were current established users of any non-ENDS product at follow-up or were current established users of the given tobacco product at follow-up and were current established users of ENDS and at least one other tobacco product at follow-up, were asked about making an attempt to quit using tobacco generally at follow-up rather than specifically about making an attempt to quit use of the given tobacco product at follow-up.

¶Asked consistently across tobacco products.

ENDS, electronic nicotine delivery systems; W1, Wave 1; W2, Wave 2; W3, Wave 3.

estimates. Variances were computed using the balanced repeated replication method²⁸ with Fay's adjustment set to 0.3 to increase estimate stability.²⁹ All analyses were conducted using SAS 9.4 software (SAS Institute, Cary, North Carolina, USA). See online supplementary material for the SAS macro code created to run weighted GEE analyses and calculate adjusted ORs (aORs) and CIs. Analyses were run on the W1–W3 RUF (<https://doi.org/10.3886/ICPSR36231.v18>).

For each type of tobacco product, cessation behaviours were evaluated with respect to the given tobacco product regardless of other products used (However, depending on whether respondents were exclusive or multiple product users, they may have been asked about their cessation behaviour regarding the specific product, or tobacco products generally (see table 1 for more details)). All analyses were conducted among adults and youth at baseline separately and were adjusted for all correlates plus wave (some significant wave effects were observed). Estimates with a relative standard error >30 or with a denominator <50 are suppressed since these estimates may provide unreliable precision and to protect respondent confidentiality.

RESULTS

Discontinuing use

Adults

Among adult P30D users of each type of tobacco product at baseline, rates of discontinuing use of each product at approximately 1-year follow-up were 13.4% (95% CI: 12.8 to 14.1) for cigarettes, 52.6% (95% CI: 50.9 to 54.4) for ENDS, 48.6% (95% CI: 47.0 to 50.2) for cigars, 63.8% (95% CI: 61.6 to 66.0) for hookah and 25.9% (95% CI: 24.2 to 27.7) for smokeless tobacco (table 2).

Cigarettes

Those ages 25–39 or 40–54 had lower odds of discontinuing cigarette use than those ages 18–24 (aOR=0.7, 95% CI: 0.6 to 0.9; aOR=0.6, 95% CI: 0.5 to 0.7, respectively); Hispanic smokers had higher odds than non-Hispanic white smokers

(aOR=1.3, 95% CI: 1.1 to 1.6), those with some college or associate degree (aOR=1.4, 95% CI: 1.1 to 1.6) or bachelor's degree or more (aOR=1.5, 95% CI: 1.2 to 1.8) had higher odds than those with less than a high-school diploma, those with income US\$25 000–US\$74 999 (aOR=1.3, 95% CI: 1.1 to 1.5) or US\$75 000+ (aOR=1.5, 95% CI: 1.3 to 1.9) had higher odds than those with income <US\$25 000, and frequent cigarette smokers had much lower odds than infrequent smokers (aOR=0.2, 95% CI: 0.2 to 0.2), of discontinuing cigarette use (table 2).

ENDS

Non-Hispanic black ENDS users had higher odds than non-Hispanic white users (aOR=1.3, 95% CI: 1.0 to 1.8), those with income US\$75 000+ had lower odds than those with income <US\$25 000 (aOR=0.8, 95% CI: 0.6 to 1.0), those who used cigarettes had higher odds than those who did not use cigarettes (aOR=1.5, 95% CI: 1.2 to 1.8), those who used hookah had lower odds than those who did not use hookah (aOR=0.8, 95% CI: 0.6 to 1.0) and those who were frequent ENDS users had much lower odds than infrequent users (aOR=0.3, 95% CI: 0.3 to 0.4), of discontinuing ENDS use (table 2).

Cigars

Those ages 40–54 or 55+ had lower odds than those ages 18–24 (aOR=0.7, 95% CI: 0.6 to 1.0; aOR=0.4, 95% CI: 0.3 to 0.6, respectively), male users had lower odds than female users (aOR=0.8, 95% CI: 0.7 to 1.0), non-Hispanic black users had lower odds than non-Hispanic white users (aOR=0.7, 95% CI: 0.5 to 0.8), with those who identified as gay or lesbian had higher odds than those who identified as straight/heterosexual (aOR=1.6, 95% CI: 1.0 to 2.6), those who used hookah had lower odds than those who did not use hookah (aOR=0.8, 95% CI: 0.6 to 0.9) and those who were frequent cigar users had much lower odds than infrequent users (aOR=0.4, 95% CI: 0.3 to 0.5), of discontinuing cigar use (table 2).

Table 2 Correlates of discontinuing P30D use among P30D users (adults 18+) at baseline

Correlates at baseline	No P30D use at follow-up														
	Cigarettes			Cigars			Hookah			Smokeless					
	%	95% CI	aOR ¹	%	95% CI	aOR ¹	%	95% CI	aOR ¹	%	95% CI	aOR ¹	%	95% CI	aOR ¹
Overall	13.4 (12.8-14.1)	N/A	N/A	48.6 (47.0-50.2)	N/A	N/A	63.8 (61.6-66.0)	N/A	N/A	25.9 (24.2-27.7)	N/A	N/A	N/A	N/A	
DEMOGRAPHIC CHARACTERISTICS															
Age group															
18-24	21.6 (20.1-23.3)	--	--	51.7 (49.6-53.9)	--	--	61.4 (59.0-63.9)	--	--	33.7 (30.4-37.2)	--	--	--	--	
25-39	13.7 (12.6-14.9)	0.7 (0.6-0.9)***	1.0 (0.8-1.2)	49.7 (46.9-52.5)	1.0 (0.8-1.1)	1.3 (0.9-2.0)	67.9 (63.0-72.4)	1.3 (0.6-1.1)	1.7 (0.6-4.4)	18.5 (14.6-23.0)	0.9 (0.6-1.3)	1.0 (0.6-1.6)			
40-54	9.6 (8.6-10.6)	0.6 (0.5-0.7)***	1.1 (0.9-1.4)	47.7 (44.4-51.0)	0.7 (0.6-1.0)*	0.4 (0.3-0.6)***	68.2 (57.2-77.5)	1.7 (0.6-1.0)*	0.4 (0.3-0.6)***	17.7 (13.2-23.2)	1.0 (0.6-1.6)				
55+	11.9 (10.4-13.5)	0.8 (0.6-1.0)	0.8 (0.6-1.1)	42.3 (37.7-46.9)	0.4 (0.3-0.6)***	0.4 (0.3-0.6)***	68.2 (57.2-77.5)	1.7 (0.6-1.0)*	0.4 (0.3-0.6)***	17.7 (13.2-23.2)	1.0 (0.6-1.6)				
Sex															
Female	12.7 (11.8-13.7)	--	--	53.1 (50.5-55.6)	--	--	64.4 (61.2-67.5)	--	--	48.6 (36.6-60.8)	--	--			
Male	14.1 (13.2-15.0)	1.0 (0.9-1.2)	1.1 (0.9-1.3)	46.8 (44.8-48.8)	0.8 (0.7-1.0)*	0.8 (0.7-1.0)*	63.4 (60.4-66.2)	1.1 (0.8-1.5)	1.1 (0.8-1.5)	24.2 (22.5-25.9)	0.7 (0.4-1.0)*				
Race/ethnicity															
Non-Hispanic White	11.8 (11.0-12.5)	--	--	52.5 (50.1-54.8)	--	--	67.6 (64.2-70.8)	--	--	23.4 (21.6-25.3)	--	--			
Non-Hispanic Black	12.7 (11.4-14.1)	1.0 (0.9-1.2)	1.3 (1.0-1.8)*	35.9 (33.0-39.0)	0.7 (0.5-0.8)***	0.7 (0.5-0.8)***	65.8 (61.6-69.7)	1.0 (0.6-1.6)	1.0 (0.6-1.6)	40.6 (30.1-52.0)	1.1 (0.6-2.0)				
Non-Hispanic Other (includes two or more races)	18.0 (15.2-21.1)	1.2 (0.9-1.7)	0.9 (0.7-1.3)	50.7 (44.5-56.9)	1.2 (0.8-1.8)	1.2 (0.8-1.8)	50.5 (41.9-59.0)	0.5 (0.3-1.0)*	0.5 (0.3-1.0)*	32.1 (23.7-41.8)	1.1 (0.7-1.9)				
Hispanic															
	20.5 (18.5-22.6)	1.3 (1.1-1.6)*	1.2 (1.0-1.6)	50.2 (46.4-54.0)	1.0 (0.8-1.3)	1.0 (0.8-1.3)	61.4 (57.6-65.0)	0.8 (0.6-1.1)	0.8 (0.6-1.1)	50.7 (41.1-60.2)	1.5 (0.9-2.7)				
Sexual orientation															
Straight/Heterosexual	13.3 (12.7-14.0)	--	--	48.6 (46.9-50.4)	--	--	63.6 (61.2-66.0)	--	--	25.0 (23.3-26.8)	--	--			
Gay or Lesbian	11.3 (8.4-15.0)	0.7 (0.5-1.1)	0.9 (0.6-1.4)	50.2 (43.0-57.5)	1.6 (1.0-2.6)*	1.6 (1.0-2.6)*	62.1 (49.7-73.1)	1.3 (0.6-2.9)	1.3 (0.6-2.9)	1.2 (0.9-1.6)					
Bisexual	14.5 (11.9-17.7)	1.1 (0.8-1.3)	0.9 (0.7-1.3)	48.1 (42.3-54.0)	1.3 (0.8-2.0)	1.3 (0.8-2.0)	65.0 (56.9-72.4)	1.1 (0.7-1.7)	1.1 (0.7-1.7)	1.2 (0.9-1.6)					
Something else	17.1 (12.0-23.9)	0.9 (0.5-1.7)	0.6 (0.3-1.1)	39.9 (30.2-50.5)	0.9 (0.4-2.0)	0.9 (0.4-2.0)	71.8 (58.9-81.8)	1.0 (0.4-2.6)	1.0 (0.4-2.6)	1.2 (0.9-1.6)					
Educational attainment															
Less than high school or some high school (no diploma) or GED	9.1 (8.0-10.2)	--	--	47.6 (44.4-50.9)	--	--	62.9 (58.1-67.5)	--	--	27.4 (24.0-31.1)	--	--			
High school graduate—diploma	12.4 (11.2-13.6)	1.2 (1.0-1.5)	1.1 (0.9-1.3)	47.4 (44.1-50.8)	1.0 (0.8-1.3)	1.0 (0.8-1.3)	64.5 (59.5-69.1)	0.9 (0.6-1.3)	0.9 (0.6-1.3)	24.4 (21.5-27.6)	1.2 (0.8-1.8)				
Some college (no degree) or associate degree	14.5 (13.3-15.8)	1.4 (1.1-1.6)***	0.9 (0.8-1.1)	46.8 (44.0-49.6)	1.0 (0.8-1.2)	1.0 (0.8-1.2)	64.3 (60.4-68.0)	0.7 (0.5-1.1)	0.7 (0.5-1.1)	26.0 (22.6-29.6)	0.9 (0.6-1.4)				
Bachelor's degree or more	22.6 (20.6-24.7)	1.5 (1.2-1.8)**	1.0 (0.8-1.4)	54.5 (50.5-58.5)	1.1 (0.8-1.6)	1.1 (0.8-1.6)	62.6 (56.4-68.3)	0.7 (0.4-1.2)	0.7 (0.4-1.2)	26.7 (21.7-32.3)	0.9 (0.6-1.5)				
Annual household income															
> \$25,000	11.0 (10.2-11.9)	--	--	45.9 (43.7-48.0)	--	--	62.0 (58.6-65.3)	--	--	33.6 (30.2-37.2)	--	--			
\$25,000-\$74,999	13.9 (12.8-15.0)	1.3 (1.1-1.5)**	1.0 (0.8-1.2)	50.4 (47.7-53.2)	1.1 (0.9-1.4)	1.1 (0.9-1.4)	66.4 (62.6-70.1)	1.2 (0.9-1.6)	1.2 (0.9-1.6)	21.8 (18.6-25.4)	0.8 (0.5-1.1)				
≥ \$75,000	20.6 (18.6-22.8)	1.5 (1.3-1.9)***	0.8 (0.6-1.0)*	51.2 (47.4-55.0)	1.2 (0.9-1.6)	1.2 (0.9-1.6)	64.0 (57.6-70.0)	1.2 (0.8-1.8)	1.2 (0.8-1.8)	23.4 (19.2-28.2)	1.1 (0.7-1.8)				

Continued

Table 2 Continued

Correlates at baseline	No P30D use at follow-up																			
	Cigarettes				Cigars				Hookah				Smokeless							
	%	95% CI	aOR ¹	95% CI	%	95% CI	aOR ¹	95% CI	%	95% CI	aOR ¹	95% CI	%	95% CI	aOR ¹	95% CI				
Not reported	13.8	(11.8-16.0)	1.2	(0.9-1.6)	54.9	(48.2-61.4)	1.1	(0.7-1.6)	52.1	(46.3-57.8)	0.8	(0.6-1.1)	63.9	(56.1-71.0)	1.0	(0.6-1.7)	24.8	(19.1-31.6)	0.9	(0.5-1.6)
TOBACCO USE CORRELATES																				
Use of cigarettes																				
No P30D use	N/A	N/A	N/A	N/A	45.2	(41.7-48.8)	--	--	49.6	(46.5-52.6)	--	--	64.3	(61.2-67.2)	--	--	16.4	(14.5-18.6)	--	--
P30D use	N/A	N/A	N/A	N/A	54.9	(53.1-56.6)	1.5	(1.2-1.8) ^{***}	48.0	(46.3-49.8)	1.1	(0.9-1.3)	63.4	(60.4-66.4)	1.1	(0.8-1.5)	38.8	(35.7-42.1)	1.9	(1.5-2.5) ^{***}
Use of ENDS																				
No P30D use	13.8	(13.0-14.6)	--	--	N/A	N/A	N/A	N/A	48.2	(46.2-50.2)	--	--	65.0	(62.4-67.6)	--	--	22.0	(20.1-24.0)	--	--
P30D use	12.8	(11.7-13.9)	1.0	(0.8-1.1)	N/A	N/A	N/A	N/A	49.6	(46.9-52.3)	1.0	(0.8-1.2)	60.3	(56.4-64.0)	0.8	(0.6-1.1)	43.7	(38.9-48.7)	1.3	(0.9-1.9)
Use of cigars																				
No P30D use	12.9	(12.2-13.6)	--	--	52.4	(50.3-54.4)	--	--	N/A	N/A	N/A	N/A	65.8	(63.0-68.5)	--	--	22.4	(20.6-24.4)	--	--
P30D use	15.6	(14.3-17.0)	1.0	(0.9-1.2)	53.5	(50.5-56.5)	0.9	(0.7-1.1)	N/A	N/A	N/A	N/A	60.8	(57.0-64.6)	0.8	(0.6-1.1)	38.2	(33.8-42.7)	0.8	(0.6-1.2)
Use of hookah																				
No P30D use	12.9	(12.3-13.6)	--	--	53.0	(51.1-54.9)	--	--	48.9	(47.1-50.7)	--	--	N/A	N/A	N/A	N/A	24.6	(22.8-26.3)	--	--
P30D use	21.3	(18.4-24.4)	1.0	(0.8-1.3)	49.5	(45.2-53.7)	0.8	(0.6-1.0) [*]	46.2	(42.8-49.7)	0.8	(0.6-0.9) [*]	N/A	N/A	N/A	N/A	46.7	(39.4-54.2)	1.2	(0.7-1.9)
Use of smokeless																				
No P30D use	13.3	(12.7-14.0)	--	--	52.5	(50.8-54.3)	--	--	48.5	(46.7-50.3)	--	--	63.6	(61.3-66.0)	--	--	N/A	N/A	N/A	N/A
P30D use	15.6	(13.2-18.4)	1.0	(0.7-1.4)	52.5	(46.7-58.2)	1.0	(0.7-1.3)	49.1	(44.8-53.5)	1.0	(0.7-1.3)	64.9	(57.1-72.1)	1.1	(0.7-1.8)	N/A	N/A	N/A	N/A
Frequency of use of the given product (in the past 30 days)																				
1-19 days	28.9	(27.4-30.5)	--	--	57.5	(55.6-59.4)	--	--	44.1	(41.8-46.5)	--	--	51.8	(48.3-55.3)	--	--	42.2	(37.6-46.8)	--	--
20-30 days	5.9	(5.5-6.3)	0.2	(0.2-0.2) ^{***}	27.0	(24.3-29.8)	0.3	(0.3-0.4) ^{***}	22.0	(18.9-25.5)	0.4	(0.3-0.5) ^{***}	44.2	(35.9-52.8)	0.7	(0.4-1.0) [*]	10.8	(9.4-12.5)	0.2	(0.2-0.3) ^{***}

The percentages and ORs in the table are based on weighted data.

Denominator N (unweighted number of observations) for aOR in 'Cigarettes'=17792

Denominator N (unweighted number of observations) for aOR in 'ENDS'=4350

Denominator N (unweighted number of observations) for aOR in 'Cigars'=3576

Denominator N (unweighted number of observations) for aOR in 'Hookah'=1262

Denominator N (unweighted number of observations) for aOR in 'Smokeless'=2132

Tobacco product types were categorised into five groups: cigarettes; ENDS (e-cigarettes at Wave 1, and e-cigarettes, e-cigars, e-pipes and e-hookah at Waves 2 and 3); cigars (traditional cigars, cigarillos, filtered cigars), hookah and smokeless tobacco (loose snus, moist snuff, dip, spit, chewing tobacco and snus pouches).

For each of the five tobacco products, and for any tobacco product, use is defined with respect to the given tobacco product/any tobacco product: P30D use is defined as using the product at least once in the past 30 days.

The outcome 'discontinuing P30D use' is defined as no P30D use at follow-up (vs P30D use at follow-up) among P30D users at baseline. Since no P30D use at baseline is defined with respect to each tobacco product, P30D use of 'other' tobacco products are considered as correlates of P30D use of the given tobacco product at follow-up.

Tobacco dependence was not assessed among all P30D users and thus is not included in these analyses.

GEE logistic regression analyses were used to assess correlates of no P30D use at follow-up among P30D users at baseline over a 1 year period of time (ie, Wave 1-Wave 2 and Wave 2-Wave 3), including up to two change data points per individual and statistically controlling for the correlation among observations from the same individuals. All correlates reflect baseline measurement for each wave pair (eg, when evaluating change between Wave 1 and Wave 2, the age correlate reflects a person's age at Wave 1, and when evaluating change between Wave 2 and Wave 3, the age correlate reflects a person's age at Wave 2).

¹Analyses adjusted for age group, sex, race/ethnicity, sexual orientation, educational attainment, annual household income, each tobacco use correlate and wave.

†Estimates with either a relative SE greater than 30 or a corresponding denominator less than 50 have been suppressed.

*p<0.05, **p<0.01, ***p<0.001.

aOR, adjusted OR; ENDS, electronic nicotine delivery system; GEE, generalised estimating equation; N/A, not applicable; P30D, past 30-day.

Hookah

Non-Hispanic other users had lower odds than non-Hispanic white users (aOR=0.5, 95% CI: 0.3 to 1.0), and those who were frequent hookah users had lower odds than infrequent users (aOR=0.7, 95% CI: 0.4 to 1.0), of discontinuing hookah use (table 2).

Smokeless tobacco

Male users had lower odds than female users (aOR=0.7, 95% CI: 0.4 to 1.0), those who smoked cigarettes had higher odds than those who did not smoke cigarettes (aOR=1.9, 95% CI: 1.5 to 2.5) and those who were frequent smokeless tobacco users had much lower odds than infrequent users (aOR=0.2, 95% CI: 0.2 to 0.3), of discontinuing smokeless tobacco use (table 2).

Youth

Among youth P30D users of each type of tobacco product at baseline, rates of discontinuing use of each product at approximately 1 year follow-up were 32.5% (95% CI: 29.0 to 36.1) for cigarettes, 55.6% (95% CI: 51.5 to 59.6) for ENDS, 54.8% (95% CI: 49.1 to 60.3) for cigars, 70.8% (95% CI: 65.4 to 75.6) for hookah and 36.3% (95% CI: 29.2 to 44.1) for smokeless tobacco (online supplementary table 2). For youth, GEE models failed to converge for discontinuing use of cigars, hookah and smokeless tobacco; thus, correlates for discontinuing use of these products are not reported, though rates of discontinuing use for these products, stratified by correlate, are shown in online supplementary table 2. Significant correlates were age, with older youth less likely than younger youth, sexual orientation, with those who did not identify as straight/heterosexual less likely than those who did identify as straight/heterosexual, and frequency of cigarette use, with those who used 20–30 days less likely than those who used 1–19 days, to discontinue cigarette use (online supplementary table 2).

Making a quit attempt

Adults

Among adult current established users of each type of tobacco product at baseline, rates of making a quit attempt at follow-up were 35.6% (95% CI: 34.6 to 36.7) for cigarettes, 45.8% (95% CI: 43.8 to 47.8) for ENDS, 56.2% (95% CI: 53.6 to 58.7) for cigars, 61.5% (95% CI: 58.6 to 64.3) for hookah and 39.2% (95% CI: 36.5 to 42.0) for smokeless tobacco (table 3).

Cigarettes

Similar to correlates of discontinuing cigarette use, young adults (18–24 years), Hispanic smokers, those with more education and those who were not daily smokers at baseline all had higher odds of making a quit attempt than their counterparts (table 3). Additionally, those who used ENDS had higher odds of making a quit attempt than those who did not use ENDS (aOR=1.2, 95% CI: 1.1 to 1.3; table 3).

ENDS

Similar to correlates of discontinuing ENDS use, non-Hispanic black users, those who used cigarettes and those who were not daily ENDS users all had higher odds of making a quit attempt than their counterparts (table 3). Additionally, those with higher tobacco dependence scores had higher odds of making a quit attempt than those with lower scores (aOR=1.1, 95% CI: 1.0 to 1.3, table 3; not assessed for discontinuing use outcome).

Cigars

Somewhat similar to correlates of discontinuing cigar use, young adults (ages 18–24 years, compared with those ages 40–54 years or 55+ years) and those who were not daily cigar users (compared with daily users) had higher odds of making a quit attempt (table 3). Additionally, Hispanic users had higher odds than non-Hispanic white users (aOR=1.6, 95% CI: 1.1 to 2.3), those with a bachelor's degree had lower odds than those with less than a high-school diploma (no diploma) or GED (aOR=0.6, 95% CI: 0.4 to 0.9), those with household income \$75 000+ had lower odds than those with household income <US\$25 000 (aOR=0.7, 95% CI: 0.5 to 1.0), those who used cigarettes had higher odds than those who did not use cigarettes (aOR=1.4, 95% CI: 1.0 to 1.9) and those with higher tobacco dependence scores had higher odds than those with lower scores (aOR=1.3, 95% CI: 1.1 to 1.5, not assessed for discontinuing use outcome) of making a quit attempt (table 3).

Hookah

Somewhat similar to correlates of discontinuing hookah use, non-Hispanic other users had lower odds than non-Hispanic white users of making a quit attempt (table 3). Additionally, those who used cigarettes had higher odds of making a quit attempt than those who did not use cigarettes (aOR=1.6, 95% CI: 1.1 to 2.4; table 3).

Smokeless tobacco

Somewhat similar to correlates of discontinuing smokeless tobacco use, those who were daily users had lower odds of making a quit attempt than those who were not daily users (table 3). Additionally, those ages 40–54 and those ages 55+ had lower odds than those ages 18–24 (aOR=0.6, 95% CI: 0.5 to 0.9; aOR=0.6, 95% CI: 0.4 to 0.9, respectively), and those with income US\$25 000–US\$74 999 had lower odds than those with income <US\$25 000 (aOR=0.8, 95% CI: 0.6 to 1.0) of making a quit attempt (table 3).

Youth

Among youth P30D non-light cigarette smokers at baseline, 57.8% (95% CI: 53.4 to 62.0) made a quit attempt at follow-up (online supplementary table 3). The only significant correlate of making a quit attempt was tobacco dependence, with those with higher tobacco dependence having lower odds of making a quit attempt than those with lower tobacco dependence.

Quitting among quit attempters

Adults

Among adult current established users of each type of tobacco product at baseline who made a quit attempt at follow-up, rates of quitting (ie, no everyday/someday use) at follow-up were 32.9% (95% CI: 31.4 to 34.3) for cigarettes (table 4), 85.4% (95% CI: 82.7 to 87.7) for ENDS, 62.5% (95% CI: 59.7 to 65.2) for cigars, 84.2% (95% CI: 81.2 to 86.9) for hookah and 51.6% (95% CI: 47.7 to 55.5) for smokeless tobacco. GEE models failed to converge for ENDS, cigars and hookah; thus, correlates of quitting for these products are not reported, although percentages for quitting for these products, stratified by correlate, are shown in table 4.

Cigarettes

Somewhat similar to correlates of discontinuing cigarette smoking/making a quit attempt, young adults, those with higher educational attainment, those with higher income and those

Table 3 Correlates of making a quit attempt among current established users (adults 18+) at baseline

Correlates at baseline	Quit attempt at follow-up																					
	Cigarettes				ENDS				Cigars				Hookah				Smokeless					
	%	95% CI	aOR ¹	95% CI	%	95% CI	aOR ¹	95% CI	%	95% CI	aOR ¹	95% CI	%	95% CI	aOR ¹	95% CI	%	95% CI	aOR ¹	95% CI		
Demographic characteristics																						
Age group																						
18-24	41.5	(39.3-43.6)	--	--	51.1	(46.9-55.3)	--	--	67.1	(62.7-71.2)	--	--	59.4	(55.8-63.0)	--	--	50.9	(45.9-55.9)	--	--		
25-39	36.8	(34.9-38.8)	0.9	(0.8-1.0)*	49.1	(45.8-52.4)	1.0	(0.8-1.3)	60.5	(56.4-64.5)	0.8	(0.6-1.0)	65.4	(59.0-71.2)	1.3	(0.9-1.8)	46.1	(41.4-50.9)	0.9	(0.7-1.2)		
40-54	32.1	(30.5-33.7)	0.8	(0.6-0.9)**	41.3	(36.7-46.0)	0.7	(0.5-1.0)	52.3	(47.0-57.5)	0.7	(0.5-0.9)*	†	†	†	†	31.0	(26.8-35.6)	0.6	(0.5-0.9)**		
55+	34.9	(32.7-37.2)	0.9	(0.7-1.0)	36.8	(31.7-42.3)	0.8	(0.5-1.1)	44.1	(39.0-49.4)	0.6	(0.4-0.9)**	†	†	†	†	28.8	(22.0-36.6)	0.6	(0.4-0.9)*		
Sex																						
Female	35.6	(34.2-37.0)	--	--	45.2	(41.6-48.9)	--	--	65.5	(61.5-69.2)	--	--	59.3	(53.8-64.6)	--	--	44.9	(35.0-55.3)	--	--		
Male	35.6	(34.2-37.0)	1.0	(0.9-1.1)	46.3	(43.6-49.1)	1.0	(0.8-1.2)	53.7	(50.8-56.7)	0.9	(0.7-1.1)	62.8	(58.9-66.6)	1.1	(0.8-1.5)	38.9	(35.9-41.9)	0.9	(0.6-1.5)		
Race/ethnicity																						
Non-Hispanic White	33.7	(32.4-35.0)	--	--	43.2	(41.0-45.4)	--	--	52.4	(48.9-55.9)	--	--	63.3	(58.9-67.6)	--	--	38.1	(35.0-41.2)	--	--		
Non-Hispanic Black	35.5	(33.4-37.7)	1.1	(1.0-1.3)	58.2	(48.3-67.5)	1.7	(1.0-2.8)*	61.6	(56.8-66.1)	1.3	(1.0-1.6)	55.4	(47.6-62.9)	0.7	(0.4-1.1)	48.6	(35.5-62.0)	1.4	(0.7-2.9)		
Non-Hispanic Other (includes two or more races)	41.5	(37.9-45.1)	1.3	(1.1-1.5)**	48.1	(41.2-55.1)	1.1	(0.8-1.6)	60.2	(49.6-69.9)	1.3	(0.8-2.0)	50.4	(40.4-60.3)	0.6	(0.4-0.9)*	46.3	(35.6-57.3)	1.0	(0.6-1.7)		
Hispanic	44.0	(41.1-46.9)	1.4	(1.2-1.6)**	54.0	(46.1-61.7)	1.4	(1.0-2.0)	66.6	(59.9-72.6)	1.6	(1.1-2.3)**	66.7	(60.0-72.9)	1.4	(0.9-2.1)	48.1	(36.6-59.9)	0.9	(0.5-1.6)		
Sexual orientation																						
Straight/Heterosexual	35.4	(34.3-36.5)	--	--	45.1	(42.9-47.3)	--	--	54.7	(52.0-57.4)	--	--	61.5	(58.3-64.5)	--	--	38.9	(36.2-41.7)	--	--		
Gay or Lesbian	36.1	(30.2-42.4)	1.0	(0.7-1.3)	49.6	(40.3-58.8)	1.1	(0.7-1.7)	69.6	(56.5-80.1)	1.3	(0.7-2.5)	61.8	(46.3-75.3)	1.0	(0.5-2.2)	†	†	†	†		
Bisexual	39.1	(35.4-42.8)	1.1	(0.9-1.4)	50.1	(41.1-59.1)	1.1	(0.8-1.6)	74.4	(65.9-81.4)	1.6	(0.9-2.7)	56.0	(45.8-65.7)	0.8	(0.5-1.3)	†	†	†	†		
Something else	35.2	(26.3-45.3)	1.0	(0.6-1.5)	†	†	†	†	†	†	†	†	†	†	†	†	†	†	†	†		
Educational attainment																						
Less than high school or some high school (no diploma) or GED	32.1	(30.6-33.7)	--	--	48.7	(43.4-54.1)	--	--	64.1	(58.9-68.9)	--	--	62.9	(54.9-70.1)	--	--	38.8	(33.8-43.9)	--	--		
High school graduate—diploma	32.4	(30.7-34.1)	1.0	(0.9-1.2)	47.6	(43.5-51.8)	1.1	(0.8-1.5)	60.3	(56.0-64.5)	0.9	(0.6-1.2)	63.1	(57.6-68.3)	1.1	(0.7-1.7)	36.5	(32.8-40.4)	1.1	(0.8-1.4)		
Some college (no degree) or associate degree	38.5	(36.9-40.0)	1.3	(1.2-1.4)**	45.1	(41.9-48.3)	1.0	(0.7-1.3)	58	(54.6-61.3)	0.9	(0.7-1.3)	61.3	(56.6-65.9)	1.2	(0.8-1.9)	41.8	(37.2-46.5)	1.2	(0.9-1.6)		
Bachelor's degree or more	42.9	(40.0-45.8)	1.3	(1.1-1.6)**	39.7	(33.8-45.9)	0.9	(0.6-1.3)	36.4	(30.2-43.1)	0.6	(0.4-0.9)*	59.1	(51.5-66.4)	1.1	(0.6-2.1)	39.7	(33.2-46.6)	1.2	(0.8-1.9)		
Annual household income																						
< \$25,000	34.5	(33.1-35.9)	--	--	50.0	(46.4-53.6)	--	--	64.1	(61.2-67.0)	--	--	62.9	(58.2-67.3)	--	--	46.3	(42.3-50.3)	--	--		
\$25,000- \$74,999	35.9	(34.2-37.6)	1.0	(0.9-1.2)	43.9	(40.1-47.9)	1.0	(0.8-1.3)	56.7	(52.4-60.9)	0.9	(0.7-1.2)	58.5	(53.5-63.3)	0.8	(0.6-1.1)	35.8	(31.3-40.6)	0.8	(0.6-1.0)*		
≥ \$75,000	39.3	(36.9-41.7)	1.1	(0.9-1.2)	38.9	(33.8-44.2)	0.9	(0.6-1.2)	37.5	(31.5-43.9)	0.7	(0.5-1.0)*	62.8	(54.2-70.7)	1.0	(0.7-1.6)	36.8	(30.8-43.2)	0.8	(0.6-1.3)		
Not reported	35.1	(31.9-38.5)	1.0	(0.9-1.2)	50.4	(41.8-59.0)	1.0	(0.7-1.6)	55.9	(46.3-65.1)	0.7	(0.4-1.0)	62.9	(52.8-72.0)	0.9	(0.5-1.5)	39.2	(30.3-49.0)	0.9	(0.6-1.5)		
Tobacco use correlates																						
Use of cigarettes																						
No P30D use	N/A	N/A	N/A	N/A	28.7	(24.9-32.9)	--	--	39.8	(35.4-44.4)	--	--	53.5	(48.2-58.8)	--	--	30.8	(26.9-35.0)	--	--		
P30D use	N/A	N/A	N/A	N/A	52.5	(50.1-54.9)	1.9	(1.5-2.4)**	64.5	(61.7-67.1)	1.4	(1.0-1.9)*	67.1	(63.1-70.8)	1.6	(1.1-2.4)*	52.1	(47.4-56.7)	1.3	(0.9-1.7)		
Use of ENDS																						
No P30D use	34.4	(33.2-35.6)	--	--	N/A	N/A	N/A	N/A	52.9	(49.9-55.9)	--	--	59.8	(56.1-63.4)	--	--	36.1	(33.0-39.4)	--	--		
P30D use	39.1	(37.2-40.9)	1.2	(1.1-1.3)**	N/A	N/A	N/A	N/A	65.9	(61.3-70.2)	1.1	(0.9-1.5)	63.8	(58.7-68.7)	1.0	(0.8-1.4)	56.3	(49.6-62.8)	1.1	(0.8-1.6)		

Continued

Table 3 Continued

Correlates at baseline	Cigarettes					ENDS					Cigars					Hookah					Smokeless				
	%	95% CI	aOR ¹	95% CI	%	95% CI	aOR ¹	95% CI	%	95% CI	aOR ¹	95% CI	%	95% CI	aOR ¹	95% CI	%	95% CI	aOR ¹	95% CI	%	95% CI	aOR ¹	95% CI	
Use of cigars																									
No P30D use	35.2	(34.1-36.4)	--	--	43.0	(40.7-45.4)	--	--	N/A	N/A	N/A	N/A	61.6	(57.8-65.3)	--	--	35.3	(32.4-38.4)	--	--	54.3	(49.6-58.9)	1.2	(0.9-1.6)	
P30D use	38.0	(36.2-39.7)	1.0	(0.9-1.1)	56.0	(52.2-59.7)	1.1	(0.9-1.4)	N/A	N/A	N/A	N/A	62.1	(57.1-66.9)	0.8	(0.6-1.1)	54.3	(49.6-58.9)	1.2	(0.9-1.6)	54.3	(49.6-58.9)	1.2	(0.9-1.6)	
Use of hookah																									
No P30D use	35.2	(34.2-36.3)	--	--	45.3	(43.2-47.4)	--	--	55.0	(52.3-57.7)	--	--	N/A	N/A	N/A	N/A	38.0	(35.2-40.9)	--	--	65.9	(56.6-74.2)	1.6	(1.0-2.6)	
P30D use	43.4	(39.7-47.3)	1.0	(0.9-1.2)	49.8	(43.3-56.2)	0.7	(0.5-1.0)*	66.1	(59.3-72.3)	1.0	(0.7-1.5)	N/A	N/A	N/A	N/A	65.9	(56.6-74.2)	1.6	(1.0-2.6)	65.9	(56.6-74.2)	1.6	(1.0-2.6)	
Use of smokeless																									
No P30D use	35.6	(34.5-36.7)	--	--	44.9	(42.8-47.1)	--	--	55.0	(52.4-57.7)	--	--	60.6	(57.4-63.7)	--	--	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
P30D use	37.0	(33.1-41.2)	0.9	(0.8-1.2)	56.3	(47.5-64.7)	1.4	(0.9-2.0)	64.8	(58.3-70.9)	1.2	(0.9-1.7)	68.8	(60.1-76.3)	1.2	(0.8-1.9)	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	
Frequency of use of the given product																									
No every day use	53.3	(51.2-55.5)	--	--	59.5	(57.0-61.9)	--	--	58.0	(55.0-60.9)	--	--	62.0	(59.0-64.9)	--	--	57.0	(53.1-60.7)	--	--	49.4	(47.8-51.0)	1.1	(1.0-1.3)	
Every day use	30.5	(29.4-31.5)	0.4	(0.4-0.5)***	27.3	(24.5-30.4)	0.3	(0.3-0.4)***	48.8	(44.4-53.3)	0.6	(0.5-0.7)***	48.8	(38.0-62.3)	0.7	(0.3-1.4)	27.9	(24.9-31.2)	0.4	(0.3-0.5)***	27.9	(24.9-31.2)	0.4	(0.3-0.5)***	
Mean tobacco dependence score ²	51.8	(51.1-52.6)	1.0	(1.0-1.1)	44.2	(42.6-45.7)	1.1	(1.0-1.3)*	38.7	(36.7-40.6)	1.3	(1.1-1.5)***	26.4	(24.0-28.8)	1.1	(0.9-1.3)	49.4	(47.8-51.0)	1.1	(1.0-1.3)	49.4	(47.8-51.0)	1.1	(1.0-1.3)	

The percentages and ORs in the table are based on weighted data.
 Denominator N (unweighted number of observations) for aOR in 'Cigarettes'=14619
 Denominator N (unweighted number of observations) for aOR in 'ENDS'=2350
 Denominator N (unweighted number of observations) for aOR in 'Cigars'=2355
 Denominator N (unweighted number of observations) for aOR in 'Hookah'=1293
 Denominator N (unweighted number of observations) for aOR in 'Smokeless'=2172
 Tobacco product types were categorised into five groups: cigarettes, ENDS (e-cigarettes at Wave 1, and e-cigarettes, e-cigars, e-pipes and e-hookah at Waves 2 and 3), cigars (traditional cigars, cigarillos, filtered cigars, loose snus, moist, dip, spit, chewing tobacco and snus pouches). For each of the five tobacco products, use is defined with respect to the given tobacco product (any tobacco product). Current established use is defined for cigarettes as currently smoking every day or some days and having smoked at least 100 cigarettes in the lifetime; current established use is defined for other tobacco products as currently using the product every day or some days and having ever used the product 'fairly regularly'; Making a quit attempt is defined as having tried to quit using tobacco products generally in the past 12 months (or having tried to quit using tobacco products generally in the past 12 months if the respondent was using more than one type of tobacco product at baseline), or indicating not currently using the given tobacco product (or tobacco products generally) at follow-up (ie, not using every day or sometimes at follow-up). The outcome 'making a quit attempt' is defined as a quit attempt at follow-up (vs no quit attempt at follow-up) among current established users at baseline. Since no P30D use at baseline is defined with respect to each tobacco product, P30D use of 'other' tobacco products at baseline are considered as correlates of 'making a quit attempt' of the given tobacco product at follow-up.
 GEE logistic regression analyses were used to assess correlates of making a quit attempt at follow-up among current established users at baseline over a 1 year period of time (ie Wave 1-Wave 2 and Wave 2-Wave 3), including up to two change data points per individual and statistically controlling for the correlation among observations from the same individuals.
 All correlates reflect baseline measurement for each wave pair (eg, when evaluating change between Wave 1 and Wave 2, the age correlate reflects a person's age at Wave 2).
 Analyses adjusted for age group, sex, race/ethnicity, sexual orientation, educational attainment, annual household income, each tobacco use correlate and wave.
¹Tobacco dependence score was defined as described and validated by Strong et al.¹⁸. Weighted means are presented with 95% CIs. To estimate ORs and 95% CIs, the tobacco dependence variable was scaled to a mean of 0 with SD of 1 for each tobacco product (therefore, ORs indicate the likelihood of the outcome per SD unit increase in the level of tobacco dependence for each tobacco product).
²Estimates with either a relative SE greater than 30 or a corresponding denominator less than 50 have been suppressed.
 *p<0.05, **p<0.01, ***p<0.001.
 aOR, aOR; ENDS, ENDS; GEE, generalised estimating equations; N/A, not applicable; P30D, past 30-day.

Table 4 Correlates of quitting among quit attempters who were current established users (adults 18+) at baseline and made a quit attempt at follow-up

Correlates at baseline	Quitting among quit attempters at follow-up																				
	Cigarettes				ENDS				Cigars				Hookah				Smokeless				
	%	95% CI	aOR ¹	95% CI	%	95% CI	aOR ¹	95% CI	%	95% CI	aOR ¹	95% CI	%	95% CI	aOR ¹	95% CI	%	95% CI	aOR ¹	95% CI	
Overall	32.9	(31.4-34.3)	N/A	N/A	85.4	(82.7-87.7)	N/A	N/A	62.5	(59.7-65.2)	N/A	N/A	84.2	(81.2-86.9)	N/A	N/A	51.6	(47.7-55.5)	N/A	N/A	
Demographic characteristics																					
Age group																					
18-24	40.5	(37.1-44.0)	--	--	83.2	(78.2-87.3)	--	--	67.5	(63.4-71.4)	--	--	82.6	(78.7-85.9)	--	--	51.9	(45.6-58.2)	--	--	
25-39	34.3	(31.6-37.2)	0.8	(0.7-1.0)*	84.1	(79.3-88.0)	.	.	64.7	(60.2-69.0)	.	.	87.6	(81.9-91.7)	.	.	53.5	(46.6-60.2)	1.1	(0.7-1.8)	
40-54	27.4	(24.7-30.2)	0.7	(0.5-0.9)**	88.5	(83.8-91.9)	.	.	63.3	(56.7-69.4)	.	.	†	†	.	.	49.6	(41.5-57.8)	1.3	(0.8-2.2)	
55+	31.6	(28.2-35.2)	0.9	(0.7-1.3)	88.9	(82.3-93.3)	.	.	49.7	(42.1-57.3)	.	.	†	†	.	.	49.3	(33.4-65.3)	1.3	(0.6-3.0)	
Sex																					
Female	30.5	(28.6-32.6)	--	--	87.2	(83.7-90.0)	--	--	65.1	(60.6-69.4)	--	--	85.2	(80.3-89.0)	--	--	57.2	(44.0-69.4)	--	--	
Male	34.8	(32.8-36.8)	1.1	(1.0-1.3)	84.0	(79.7-87.5)	.	.	61.6	(58.0-65.0)	.	.	83.7	(79.3-87.3)	.	.	51.4	(47.4-55.4)	0.8	(0.4-1.7)	
Race/ethnicity																					
Non-Hispanic White	33.1	(31.4-35.0)	--	--	86.5	(83.3-89.1)	--	--	62.7	(58.7-66.4)	--	--	88.3	(84.3-91.4)	--	--	51.2	(47.0-55.5)	--	--	
Non-Hispanic Black	25.5	(21.4-30.1)	0.7	(0.5-0.9)**	78.9	(70.4-85.4)	.	.	56.7	(50.4-62.8)	.	.	83.4	(72.8-90.4)	.	†	†	†	1.2	(0.4-3.4)	
Non-Hispanic Other (includes two or more races)	36.8	(30.4-43.6)	1.0	(0.7-1.4)	†	†	.	.	68.4	(54.8-79.4)	.	.	74.9	(60.2-85.5)	.	.	46.4	(31.4-62.0)	0.7	(0.3-1.5)	
Sexual orientation																					
Straight/heterosexual	32.9	(31.3-34.4)	--	--	85.4	(82.5-87.9)	--	--	62.1	(58.9-65.1)	--	--	83.0	(79.6-85.9)	--	--	51.0	(47.0-55.0)	--	--	
Gay or Lesbian	29.5	(21.3-39.1)	0.8	(0.5-1.4)	†	†	.	.	†	†	.	.	†	†	.	.	†	†	0.3	(0.0-4.8)	
Bisexual	34.1	(27.9-40.9)	1.1	(0.8-1.4)	†	†	.	.	62.2	(50.6-72.5)	.	.	†	†	.	.	†	†	3.0	(0.9-10.4)	
Something else	32.5	(21.4-46.0)	1.1	(0.6-2.2)	†	†	.	.	†	†	.	.	†	†	.	.	†	†	2.0	(0.0-91.4)	
Educational attainment																					
Less than high school or some high school (no diploma) or GED	24.7	(22.3-27.1)	--	--	86.9	(81.7-90.7)	--	--	65.8	(60.4-70.8)	--	--	77.2	(68.1-84.2)	--	--	54.5	(47.7-61.2)	--	--	
High school graduate—diploma	33.3	(30.2-36.6)	1.4	(1.1-1.7)**	82.7	(77.3-86.9)	.	.	65.6	(57.8-72.6)	.	.	84.6	(78.3-89.2)	.	.	51.2	(45.0-57.4)	1.0	(0.7-1.6)	
Some college (no degree) or associate degree	33.6	(31.2-36.2)	1.3	(1.1-1.6)*	85.3	(81.0-88.7)	.	.	59.0	(54.9-63.0)	.	.	84.6	(79.4-88.7)	.	.	50.1	(43.8-56.4)	0.9	(0.6-1.4)	
Bachelor's degree or more	44.4	(40.3-48.5)	1.5	(1.1-1.9)**	88.4	(81.6-92.8)	.	.	60.8	(51.1-69.7)	.	.	†	†	.	.	52.5	(40.2-64.5)	1.0	(0.4-2.5)	
Annual household income																					
< \$25,000	27.1	(25.3-29.1)	--	--	84.5	(80.8-87.6)	--	--	60.8	(56.7-64.8)	--	--	81.5	(76.9-85.4)	--	--	59.2	(53.3-64.9)	--	--	
\$25,000-\$49,999	35.7	(33.1-38.3)	1.3	(1.1-1.6)**	88.1	(84.3-91.1)	.	.	65.7	(60.9-70.2)	.	.	81.1	(74.9-86.0)	.	.	47.2	(41.2-53.3)	0.6	(0.4-1.0)*	
≥ \$75,000	44.1	(40.0-48.2)	1.5	(1.2-1.8)**	83.2	(73.7-89.7)	.	.	60.1	(51.1-68.5)	.	.	†	†	.	.	47.4	(38.0-56.9)	0.7	(0.4-1.4)	
Not reported	31.8	(26.8-37.3)	1.1	(0.8-1.6)	†	†	.	.	66.7	(56.5-75.5)	.	.	†	†	.	.	53.3	(35.7-70.0)	0.9	(0.4-2.0)	
Tobacco use correlates																					
Use of cigarettes																					
No P30D use	N/A	N/A	N/A	N/A	83.1	(77.5-87.6)	--	--	62.8	(55.7-69.3)	--	--	90.9	(86.6-93.9)	--	--	44.3	(38.1-50.6)	--	--	
P30D use	N/A	N/A	N/A	N/A	85.9	(82.8-88.5)	.	.	62.4	(59.3-65.3)	.	.	80.6	(76.5-84.1)	.	.	58.3	(53.4-62.9)	2.0	(1.3-2.9)**	

Continued

Table 4 Continued

Correlates at baseline	Quitting among quit attempters at follow-up																	
	Cigarettes			ENDS			Cigars			Hookah			Smokeless					
	%	95% CI	aOR ¹	%	95% CI	aOR ¹	%	95% CI	aOR ¹	%	95% CI	aOR ¹	%	95% CI	aOR ¹	%	95% CI	aOR ¹
Use of ENDS																		
No P30D use	33.0	(31.3-34.7)	--	N/A	N/A	N/A	61.8	(58.0-65.5)	--	--	86.2	(82.0-89.6)	--	--	51.6	(46.8-56.2)	--	--
P30D use	33.0	(30.3-35.9)	1.0	(0.8-1.2)	N/A	N/A	64.1	(59.0-68.9)	.	.	81.6	(76.8-85.6)	.	.	53.0	(45.5-60.4)	0.7	(0.5-1.2)
Use of cigars																		
No P30D use	32.6	(31.0-34.3)	--	86.3	(83.3-88.8)	--	N/A	N/A	N/A	N/A	87.1	(83.3-90.2)	--	--	50.4	(45.4-55.4)	--	--
P30D use	33.5	(30.9-36.2)	1.1	(0.9-1.3)	83.1	(78.0-87.2)	.	N/A	N/A	N/A	79.6	(73.1-84.8)	.	.	55.0	(47.9-61.9)	0.7	(0.4-1.1)
Use of hookah																		
No P30D use	32.4	(30.9-33.9)	--	85.5	(82.7-87.9)	--	62.9	(59.7-66.0)	--	--	N/A	N/A	N/A	N/A	51.5	(47.3-55.7)	--	--
P30D use	39.8	(34.2-45.7)	1.1	(0.8-1.5)	84.9	(78.1-89.8)	.	59.7	(52.9-66.1)	.	.	N/A	N/A	N/A	52.9	(40.8-64.7)	1.1	(0.6-2.2)
Use of smokeless																		
No P30D use	32.2	(30.7-33.7)	--	86.1	(83.5-88.4)	--	62.8	(59.7-65.8)	--	--	84.3	(81.1-87.1)	--	--	N/A	N/A	N/A	N/A
P30D use	41.8	(35.9-47.9)	1.5	(1.1-1.9)**	†	†	61.0	(53.7-67.7)	.	.	83.4	(72.9-90.4)	.	.	N/A	N/A	N/A	N/A
Frequency of use of the given product																		
No every day use	50.2	(47.2-53.2)	--	88.7	(85.7-91.1)	--	66.7	(63.6-69.6)	--	--	85.0	(81.9-87.6)	--	--	63.7	(57.3-69.6)	--	--
Every day use	24.0	(22.5-25.6)	0.5	(0.4-0.6)***	75.7	(69.9-80.8)	.	45.1	(38.1-52.2)	.	†	†	36.8	(30.6-43.6)	0.4	(0.2-0.6)***		
Mean tobacco dependence score ²	48.5	(47.4-49.5)	0.6	(0.6-0.7)***	48.3	(46.1-50.6)	.	44.4	(42.1-46.7)	.	.	28.6	(26.2-31.1)	.	49.6	(47.0-52.1)	0.7	(0.6-0.9)**

The percentages and ORs in the table are based on weighted data.
 Denominator N (unweighted number of observations) for aOR in 'Cigarettes'=5208
 Denominator N (unweighted number of observations) for aOR in 'ENDS'=1183
 Denominator N (unweighted number of observations) for aOR in 'Cigars'=1369
 Denominator N (unweighted number of observations) for aOR in 'Hookah'=785
 Denominator N (unweighted number of observations) for aOR in 'Smokeless'=859
 Tobacco product types were categorised into five groups: cigarettes, ENDS (e-cigarettes at Wave 1, and e-cigarettes at Wave 2 and 3), cigars (traditional cigars, cigarillos, filtered cigars), hookah and smokeless tobacco (loose snus, moist snuff, dip, spit, chewing tobacco and snus pouches).
 For each of the five tobacco products, use is defined with respect to the given tobacco product/any tobacco product: Current established user as currently smoking every day or some days and having smoked at least 100 cigarettes in the lifetime; current established use is defined for other tobacco products as currently using the product every day or some days and having ever used the product 'fairly regularly'. Making a quit attempt is defined as having tried to quit using the given tobacco product in the past 12 months (or having tried to quit using tobacco products generally in the past 12 months if the respondent was using more than one type of tobacco product at baseline), or not currently using the given tobacco product (or tobacco products generally) at follow-up (ie, not using every day or some days at follow-up). P30D use is defined as using the product at least once in the past 30 days. P30D use is defined as using the product at least once in the past 30 days.
 The outcome 'quitting' is defined as no everyday/someday use at follow-up (vs everyday/someday use at follow-up) among current established users at baseline who made a quit attempt at follow-up. Since no P30D use at baseline is defined with respect to each tobacco product, P30D use of 'other' tobacco products at baseline are considered as correlates of 'quitting' for the given tobacco product at follow-up.
 GEE logistic regression analyses were used to assess correlates of no everyday/someday use at follow-up among current established users at baseline who made a quit attempt at follow-up using two wave pairs (ie, Wave 1-Wave 2 and Wave 2-Wave 3), including up to two change data points per individual and statistically controlling for the correlation among observations from the same individuals.
 All correlates reflect baseline measurement for each wave pair (eg, when evaluating change between Wave 1 and Wave 2, the age correlate reflects a person's age at Wave 1, and when evaluating change between Wave 2 and Wave 3, the age correlate reflects a person's age at Wave 2).
 † Analyses adjusted for age group, sex, race/ethnicity, sexual orientation, educational attainment, annual household income, each tobacco use correlate and wave.
 ‡ Tobacco dependence score was defined as described and validated by Strong *et al.*²⁵ Weighted means are presented with 95% CIs. To estimate ORs and 95% CIs, the tobacco dependence variable was scaled to a mean of 0 with SD of 1 for each tobacco product (therefore, ORs indicate the likelihood of the outcome per SD unit increase in the level of tobacco dependence for each tobacco product).
 † Estimates with either a relative SE greater than 30 or a corresponding denominator less than 50 have been suppressed.
 ‡ GEE models failed to converge for ENDS, Cigars, hookah and smokeless tobacco.
 †† indicates the adjusted GEE model was not able to converge, likely due to small cell sizes.
 *p<0.05, **p<0.01, ***p<0.001.
 aOR, adjusted OR; ENDS, electronic nicotine delivery system; GEE, generalised estimating equation; N/A, not applicable; P30D, past 30-day.

who were not daily smokers all had higher odds than their counterparts of quitting when they attempted to do so (table 4). In addition, non-Hispanic black smokers had lower odds than non-Hispanic white smokers (aOR=0.7, 95% CI: 0.5 to 0.9), those who used smokeless tobacco had higher odds than those who did not use smokeless tobacco (aOR=1.5, 95% CI: 1.1 to 1.9), and those with higher tobacco dependence had lower odds than those with lower dependence (aOR=0.6, 95% CI: 0.6 to 0.7), of quitting when they attempted to do so (table 4).

Smokeless tobacco

Similar to correlates of discontinuing smokeless tobacco use/making a quit attempt, those with income US\$25 000–US\$74 999 had lower odds than those with income <US\$25 000, those who used smokeless tobacco daily had lower odds than those who used less than daily and those who smoked cigarettes had higher odds than those who did not smoke cigarettes, of quitting when they attempted to do so (table 4). In addition, those with higher tobacco dependence had lower odds than those with lower dependence (aOR=0.7, 95% CI: 0.6 to 0.9), of quitting when they attempted to do so (table 4).

YOUTH

Among youth P30D non-light cigarette smokers at baseline who made a quit attempt at follow-up, 38.9% (95% CI: 32.9 to 45.3) did not smoke in the P30D at follow-up (online supplementary table 4). GEE models failed to converge; thus, correlates for quitting among attempters are not reported, although percentages, stratified by correlate, are shown in online supplementary table 4.

DISCUSSION

PATH Study W1–W3 data show that, among the US population of adult P30D users of each type of tobacco product examined here (cigarettes, ENDS, cigars, hookah and smokeless tobacco), frequent users were less likely to discontinue use at approximately 1 year follow-up than infrequent users. Among cigarette smokers, non-Hispanic white smokers (compared with Hispanic smokers), those with lower educational attainment and those with lower household income were less likely to discontinue cigarette use, whereas among ENDS users, those with lower income were more likely to discontinue ENDS use than those with higher income, and among cigar smokers, non-Hispanic white smokers were more likely to discontinue cigar use than non-Hispanic black smokers.

For cigarette cessation behaviours, tobacco dependence was associated with a lower likelihood of cigarette quitting among those who attempted to quit, as shown before.⁸ Additionally, use of ENDS was associated with a greater likelihood of attempting to quit, which is consistent with prior research showing that some cigarette smokers use ENDS to help them quit smoking.^{19 30 31} However, we did not see an association between ENDS use and discontinuing cigarette smoking or quitting among attempters as others have found,¹⁸ though this is not surprising given that our descriptive analysis did not consider features of ENDS use that would be important when assessing ENDS use as a potential cessation aid, such as daily versus non-daily ENDS use.³²

We did, however, find that smokeless tobacco use was associated with greater cigarette quitting among attempters, which differs from the Messer *et al*²¹ finding and may reflect substitution of cigarette use with smokeless tobacco use.^{33–35} However, here we also found that cigarette smoking was associated with

greater smokeless tobacco quitting among quit attempters. Future research can investigate possible explanations for these results by considering whether use of one type of tobacco product is intended to help quit use of another type.

While demographic correlates of cessation behaviours found here generally align with the limited prior national data on cigarette cessation behaviours among adults,^{8–10} the PATH Study data additionally show that age, sex, race/ethnicity and sexual orientation are significant correlates of discontinuing tobacco use among youth. Further, these data show that youth cigarette smokers with higher tobacco dependence were less likely to attempt to quit than those with lower tobacco dependence, though this finding may reflect those with lower dependence being less established smokers/experimental smokers who are no longer smokers at follow-up rather than those with lower dependence being more likely to attempt to quit per se.

Limitations

The findings reported here cover broad cessation behaviours across a range of tobacco products, but this necessarily limits the depth of correlates that could be examined. Future studies can build on these foundational data; for example, studies can consider previous quit attempts, mental health and other substance use correlates, motivations for product use, intentions to quit product use, device features of ENDS, features of quit attempts such as use of cessation medications, and future studies can consider more stringent definitions of quitting such as abstinence for 12+ months.

Another limitation is the way in which quit attempts were queried; those who used multiple tobacco products are sometimes asked whether they tried to quit ‘tobacco’ rather than whether they tried to quit specific types of tobacco products, so in some cases, we were unable to attribute a quit attempt to a specific product. Indeed, we find that about 36% of adult cigarette smokers made a past-year quit attempt, while the NHIS data show that about 55% of adult cigarette smokers (defined the same way) made a past-year quit attempt in 2015.³⁶ As with survey designs in general, it is also possible that some participants failed to recall having made a quit attempt.³⁷

Despite these limitations, and taken together with correlates of tobacco product initiation³⁸ and tobacco product relapse behaviours,³⁹ findings underscore tobacco use disparities in the USA. For example, adults with low income are less likely to quit cigarette smoking when they try and are more likely to relapse after they quit.³⁹ We also see that a history of tobacco product use predicts transitions both toward and away from using another tobacco product, and additional waves of data will track the stability/transience of tobacco use behaviours over longer periods of time.^{1–5 40}

SUMMARY AND IMPLICATIONS

Demographic correlates of tobacco cessation behaviours underscore tobacco use disparities in the USA, such as socioeconomic disparities in cigarette use, which calls for renewed efforts to reduce tobacco use disparities. Further, findings show that the use of ENDS and use of smokeless tobacco products are positively related to some adult cigarette cessation behaviours.

Contributors KAK and KCE led the conceptual design of the work. KAK drafted the initial manuscript and all authors critically revised it. ZT conducted the statistical analyses and all authors contributed to the interpretation of results. All authors approved the work for journal publication and agree to be accountable for all aspects of the work.

What this paper adds

- ▶ Among adult cigarette smokers, those who are younger, have higher educational attainment and lower tobacco dependence are more likely to attempt to quit than their counterparts, and lower tobacco dependence is also associated with greater quitting among quit attempters.
- ▶ Nationally representative longitudinal data on correlates of cessation behaviours across other tobacco products are limited.
- ▶ This paper reports on demographic and tobacco use correlates of cessation behaviours across cigarettes, electronic nicotine delivery systems (ENDS), cigars, hookah and smokeless tobacco among the US population of adults and youth.
- ▶ Findings indicate that among adult users of each type of tobacco product, frequent users were less likely to discontinue use than infrequent users; among adult cigarette smokers, those who used ENDS were more likely to attempt to quit but were not more likely to quit when they attempted compared with those who did not use ENDS, while those who used smokeless tobacco were more likely to quit when they attempted compared with those who did not use smokeless tobacco.
- ▶ Among adult ENDS users, those with lower income were more likely to discontinue ENDS use than those with higher income; among cigar smokers, non-Hispanic white smokers were more likely to discontinue cigar use than non-Hispanic black smokers.
- ▶ Among youth cigarette smokers, those with higher tobacco dependence were less likely to attempt to quit than those with lower tobacco dependence.

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REFERENCES

- 1 Taylor KA, Sharma E, Edwards KC, et al. Longitudinal pathways of exclusive and polytobacco cigarette use among youth, young adults, and adults in the United States: findings from the PATH Study Waves 1-3 (2013-2016). *Tob Control* 2020;29:s139-46.
- 2 Sharma E, Edwards KC, Halenar MJ, et al. Longitudinal pathways of exclusive and polytobacco smokeless use among youth, young adults, and adults in the United States: findings from the PATH Study Waves 1-3 (2013-2016). *Tob Control* 2020;29:s170-7.
- 3 Stanton CA, Sharma E, Edwards KC, et al. Longitudinal pathways of exclusive and polytobacco electronic nicotine delivery systems (ENDS) use among youth, young adults, and adults in the United States: findings from the PATH Study Waves 1-3 (2013-2016). *Tob Control* 2020;29:s147-54.
- 4 Edwards KC, Sharma E, Halenar MJ, et al. Longitudinal pathways of exclusive and polytobacco cigar use among youth, young adults, and adults in the United States: findings from the PATH Study Waves 1-3 (2013-2016). *Tob Control* 2020;29:s163-9.
- 5 Sharma E, Bansal-Travers M, Edwards KC, et al. Longitudinal pathways of exclusive and polytobacco hookah use among youth, young adults, and adults in the United States: findings from the path study waves 1-3 (2013-2016). *Tob Control* 2020;29:s155-62.
- 6 Zhu S-H, Zhuang Y-L, Wong S, et al. E-Cigarette use and associated changes in population smoking cessation: evidence from US current population surveys. *BMJ* 2017;358.
- 7 Vangeli E, Stapleton J, Smit ES, et al. Predictors of attempts to stop smoking and their success in adult general population samples: a systematic review. *Addiction* 2011;106:2110-21.
- 8 Hyland A, Borland R, Li Q, et al. Individual-Level predictors of cessation behaviours among participants in the International Tobacco Control (ITC) Four Country survey international tobacco control policy evaluation project. *Tob Control* 2006;15 Suppl 3:iii83-94.
- 9 Reid JL, Hammond D, Boudreau C, et al. Socioeconomic disparities in quit intentions, quit attempts, and smoking abstinence among smokers in four Western countries: findings from the International Tobacco Control Four Country survey. *Nicotine Tob Res* 2010;12 Suppl:S20-33.
- 10 Yi Z, Mayorga ME, Hassmiller Lich K, et al. Changes in cigarette smoking initiation, cessation, and relapse among U.S. adults: a comparison of two longitudinal samples. *Tob Induc Dis* 2017;15:17.
- 11 Kasza KA, Ambrose BK, Conway KP, et al. Tobacco-Product use by adults and youths in the United States in 2013 and 2014. *N Engl J Med* 2017;376:342-53.
- 12 Lee YO, Hebert CJ, Nonnemaker JM, et al. Multiple tobacco product use among adults in the United States: cigarettes, cigars, electronic cigarettes, hookah, smokeless tobacco, and snus. *Prev Med* 2014;62:14-19.
- 13 Rath JM, Villanti AC, Abrams DB, et al. Patterns of tobacco use and dual use in US young adults: the missing link between youth prevention and adult cessation. *J Environ Public Health* 2012;2012:1-9.
- 14 Gentzke AS, Creamer M, Cullen KA, et al. *Vital Signs*: Tobacco product use among middle and high school students - United States, 2011-2018. *MMWR Morb Mortal Wkly Rep* 2019;68:157-64.
- 15 Wang TW, Asman K, Gentzke AS, et al. Tobacco product use among adults — United States, 2017. *MMWR Morb Mortal Wkly Rep* 2018;67:1225-32.
- 16 Coleman B, Rostron B, Johnson SE, et al. Transitions in electronic cigarette use among adults in the Population Assessment of Tobacco and Health (PATH) Study, Waves 1 and 2 (2013-2015). *Tob Control*.
- 17 Buu A, Hu Y-H, Piper ME, et al. The association between e-cigarette use characteristics and combustible cigarette consumption and dependence symptoms: results from a national longitudinal study. *Addict Behav* 2018;84:69-74.
- 18 Benmarhnia T, Pierce JP, Leas E, et al. Can e-cigarettes and pharmaceutical AIDS increase smoking cessation and reduce cigarette consumption? Findings from a nationally representative cohort of American smokers. *Am J Epidemiol* 2018;187:2397-404.
- 19 Johnson L, Ma Y, Fisher SL, et al. E-Cigarette usage is associated with increased past-12-month quit attempts and successful smoking cessation in two US population-based surveys. *Nicotine Tob Res* 2019;21:1331-8.
- 20 Kalkhoran S, Glantz SA. E-Cigarettes and smoking cessation in real-world and clinical settings: a systematic review and meta-analysis. *Lancet Respir Med* 2016;4:116-28.
- 21 Messer K, Vijayaraghavan M, White MM, et al. Cigarette smoking cessation attempts among current US smokers who also use smokeless tobacco. *Addict Behav* 2015;51:113-9.
- 22 Hyland A, Kasza KA, Borek N, et al. Overview of tobacco use transitions for population health. *Tob Control* 2020;29:s134-8.
- 23 Hyland A, Ambrose BK, Conway KP, et al. Design and methods of the population assessment of tobacco and health (path) study. *Tob Control* 2017;26:371-8.
- 24 Population Assessment of Tobacco and Health (PATH) study. Available: <https://doi.org/10.3886/Series606>
- 25 Strong DR, Pearson J, Ehle S, et al. Indicators of dependence for different types of tobacco product users: descriptive findings from wave 1 (2013-2014) of the population assessment of tobacco and health (path) study. *Drug Alcohol Depend* 2017;178:257-66.

- 26 Liang K-YEE, Zeger SL. Longitudinal data analysis using generalized linear models. *Biometrika* 1986;73:13–22.
- 27 Hardin JW, Hilbe JM. *Generalized estimating equations*. Boca Raton, FL: Chapman and Hall/CRC, 2003.
- 28 McCarthy PJ. Pseudoreplication: further evaluation and applications of the balanced half-sample technique; 1969.
- 29 Judkins DR. Fay's method for variance estimation. *Journal of Official Statistics* 1990;6:223.
- 30 Delnevo CD, Giovenco DP, Steinberg MB, et al. Patterns of electronic cigarette use among adults in the United States. *NICTOB* 2016;18:715–9.
- 31 Richardson A, Pearson J, Xiao H, et al. Prevalence, harm perceptions, and reasons for using noncombustible tobacco products among current and former smokers. *Am J Public Health* 2014;104:1437–44.
- 32 Hitchman SC, Brose LS, Brown J, et al. Associations between e-cigarette type, frequency of use, and quitting smoking: findings from a longitudinal online panel survey in Great Britain. *NICTOB* 2015;17:1187–94.
- 33 Ramström LM, Foulds J. Role of snus in initiation and cessation of tobacco smoking in Sweden. *Tob Control* 2006;15:210–4.
- 34 Furberg Het al. Is Swedish snus associated with smoking initiation or smoking cessation? *Tob Control* 2005;14:422–4.
- 35 Schauer GL, Pederson LL, Malarcher AM. Past year quit attempts and use of cessation resources among cigarette-only smokers and cigarette smokers who use other tobacco products. *Nicotine Tob Res* 2016;18:41–7.
- 36 Babb S, Malarcher A, Schauer G, et al. Quitting smoking among adults - United States, 2000-2015. *MMWR Morb Mortal Wkly Rep* 2017;65:1457–64.
- 37 Berg CJ, An LC, Kirch M, et al. Failure to report attempts to quit smoking. *Addict Behav* 2010;35:900–4.
- 38 Kasza KA, Edwards KC, Tang Z, et al. Correlates of tobacco product initiation among youth and adults in the United States: findings from the PATH Study Waves 1-3 (2013-2016). *Tob Control* 2020;46:s191–202.
- 39 Edwards KC, Kasza KA, Tang Z, et al. Correlates of tobacco product relapse among youth and adults in the United States: findings from the PATH Study Waves 1-3 (2013-2016). *Tob Control* 2020;29:s216–26.
- 40 Stanton CA, Sharma E, Seaman EL, et al. Initiation of any tobacco and five tobacco products across 3 years among youth, young adults, and adults in the United States: findings from the path Study waves 1-3 (2013-2016). *Tob Control* 2020;29:s178–90.