Age of initiation of smokeless tobacco use among young adults: Findings from the population assessment of tobacco and health (PATH) study, 2013–2017

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ABSTRACT

INTRODUCTION Smokeless tobacco (SLT) use, across all age groups, is most prevalent among young adults in the US. A study estimating the age of initiation of SLT use among young adults is needed amid the changing landscape of tobacco products.
METHODS Secondary analyses of PATH young adults across waves 1–4 were conducted. A total of 10595 young adults who were never SLT users at their first wave of adult participation in PATH (waves 1–3) were included in the analysis. Age of initiation outcomes of ever, past 30-day, and fairly regular SLT use, were assessed prospectively in waves 2–4. Interval censoring Cox regression models were used to assess differences in the age of initiation of each outcome by sex and race/ethnicity, adjusting for other tobacco product use.
RESULTS By the age of 27 years, 4.9%, 3.0%, and 1.9% of young adults reported initiating ever, past 30-day, and fairly regular SLT use, respectively. After controlling for demographic factors and other tobacco use, males initiated each of the SLT outcomes at earlier ages than females; non-Hispanic Blacks initiated each of the SLT use at later ages than non-Hispanic Whites; and Hispanic and non-Hispanic others initiated ever use at later ages than non-Hispanic Whites.
CONCLUSIONS These data suggest that three young adult groups are more likely to initiate use of SLT at earlier ages: males, non-Hispanic Whites, and poly-tobacco users. Knowing the age of SLT initiation outcomes among young adults will educate the public domain, inform SLT use prevention campaigns, and provide a baseline to measure the success of the Tobacco 21 legislation from December 2019.

INTRODUCTION

The use of smokeless tobacco (SLT), a type of tobacco product that is not smoked or burned but is instead placed in the mouth and chewed, can lead to negative health outcomes[1]. A longitudinal analysis of 349282 US residents (median age: 26.3 years) from 1985–2011 who never used cigarettes, cigars, and pipes, found that current SLT users had a higher mortality risk from coronary heart disease (HR=1.24; 95% CI: 1.05–1.46) compared to never tobacco users[2]. In

an analysis of 11 US case-control studies between 1981–2006 including 6772 cases and 8375 controls (aged 17–94 years), never cigarette users had higher odds of developing oral cavity cancers if they ever used snuff compared to those who had never used snuff (OR=3.01; 95% CI: 1.63–5.55)[3]. Similar results were found among these never cigarette users if they had ever used chewing tobacco compared to those who had never used chewing tobacco (OR=1.81; 95% CI: 1.04–3.17)[3]. Negative health consequences caused by SLT use is a public concern as a nationally representative cross-sectional study of US adults, aged ≥18 years (n=139451) collected from 2012–2015, estimated that the US spends $3.4 billion annually in healthcare utilizations attributable to adult SLT use[4]. In addition, the US has seen a sharp increase between 2013 and 2019 in the total amount of sales of SLT products, increasing from $3.26 billion in 2013 to $4.53 billion in 2019[5].

It is especially important to monitor SLT use among young adults as prior studies suggest that young adults are more vulnerable to SLT use compared to older adults[6-9]. A nationally representative longitudinal study from 2013–2014 reported the prevalence of ever SLT use to be 16.9% among young adults aged 18–24 years versus 16.4% among adults aged ≥25 years. In the same study, the prevalence of past 30-day SLT use was 5.2% among young adults aged 18–24 years and 3.1% among adults aged ≥25 years[10], ranking SLT 5th in the prevalence of ever tobacco use and 2nd in the prevalence of daily tobacco use. Similarly, in 2014, a different cross-sectional report of US adults showed that 5.6% of young adults aged 18–25 years used SLT in the past 30-days versus 3.0% among older adults aged ≥26 years and 2.0% among adolescents (12–17 years)[8]. The 2017 National Adult Tobacco Survey (NATS) with 26742 non-institutionalized US adults reported that 2.9% of adults aged 18–24 years use SLT 'every day' or 'some days' compared to 2.5% aged 25–44 years, 2.0% aged 45–64 years, and -0.9% aged ≥65[6] years. A study of working US adults from 2012–2014 estimated that the highest prevalence of current (defined as every day, some days, or rarely) SLT use among young adults aged 18–24 years at 5.4% compared to 4.0% aged 25–44 years, 2.4% aged 45–64 years and 1.4% aged >65 years[7]. However, in the 2019 NATS study, the prevalence of 'every

day' or 'some days' SLT use was 2.2% among young adults aged 18–24 years compared to 3.2% aged 25–44 years, 2.5% aged 45–64 years, and 1.2% among adults aged ≥65 years[11]. One potential explanation for the shift in the prevalence of SLT use from young adults aged 18–24 years to adults aged 25–44 years could be the increase in e-cigarette use by young adults aged 18–24 years.

Taken together, these findings show that young adults in particular are still vulnerable to SLT use. The emerging adulthood hypothesis posits that there are developmentally distinctive features that characterize the transition into adulthood during the ages of 18–25 years, which can explain the higher rates of tobacco use in this age group compared to other ages[12]. For example, emerging adults are typically moving out of their family homes for the first time, which leads to newfound freedoms and opportunities[12]. In addition, young adulthood is characterized by identity explorations in which young people seriously question what they want out of life, love, and work[12]. Identity explorations can result in many young adults wanting to have a wide range of experiences before they settle into adult life, which can lead to experimentation with different tobacco products, including SLT[12]. In addition, much of the historical tobacco research identified adolescence as a developmental period particularly susceptible to tobacco product initiation, however, more recent studies have found that many people are initiating tobacco use in young adulthood[13,14].

Since young adulthood is a developmental period that is distinct from youth and older adulthood, we examined young adult never SLT users (aged 18–24 years at their first wave of PATH adult participation) as a subpopulation. A gap in the literature exists regarding the age of initiation of SLT use among young adults. Secondary analysis of the Population Assessment of Tobacco and Health (PATH) study data will allow us to fill this gap in the US. The PATH study is a nationally representative longitudinal study of tobacco use and its effects on health in the US among youth and adults aged ≥12 years in all 50 US states, collected annually since 2013[15,16]. In this study, we prospectively estimated the age of initiation of ever, past 30-day and fairly regular SLT use among young adults aged 18–24 years between 2013 and 2017. We also evaluated differences by sex

and by race/ethnicity on the age of initiation of SLT use among PATH young adults.

METHODS

Study design and participants

Secondary analysis of the PATH young adult (aged 18–24 years) restricted data were conducted[15,16]. Four waves of PATH data were available to researchers at the time of analysis: wave 1 (2013–2014), wave 2 (2014–2015), wave 3 (2015–2016), and wave 4 (2016–2017). In this study, young adults who had never used SLT at their first wave of adult PATH participation in waves 1–3 (2013–2016) were included in the analysis. At wave 1, there were 7432 young adults who were never users of SLT. Participants in the PATH youth survey at wave 1 but 'aged-up' (i.e. turned 18 years) were invited to participate in the PATH adult survey in waves 2 and 3. At waves 2 and 3, 1644 and 1519 of these 'aged-up' young adults were never SLT users, respectively, resulting in a total of 10595 young adults that were included in the analysis sample. The age of initiation outcomes were followed-up in waves 2–4 (2014–2017). Informed written consent was obtained from all participants by the original PATH investigators. IRB approval for this study was obtained from the Committee for the Protection of Human Subjects at the University of Texas Health Science Center at Houston with number HSC-SPH-17-0368.

Ever use, past 30-day and fairly-regular use outcomes

In waves 1–4, PATH asked the participants: 'Have you ever used any of the following smokeless tobacco products, even one or two times? Choose all that apply'[16]. Response options included: 'snus pouches'; 'loose snus, moist snuff, dip, spit, or chewing tobacco'; 'I have never used a smokeless tobacco product'; 'don't know' or 'refused'. Only those who answered 'I have never used a smokeless tobacco product' at their first wave of adult participation (waves 1–3) were classified as never users and included in the analysis to have their age of initiation outcomes followed-up in waves 2–4. Participants who reported use of 'snus pouches' or 'loose snus, moist snuff, dip, spit, or chewing tobacco' were classified as having initiated ever SLT use in waves 2–4. In waves 2–4, PATH asked participants: 'In the past 30 days, have you used smokeless tobacco, even one or two

times?'[16]. Response options included: 'yes', 'no', 'don't know' or 'refused'. Participants who responded 'yes' were classified as having initiated past 30-day SLT use. Fairly regular use of SLT was measured with the question: 'Have you ever used smokeless tobacco fairly regularly?'[16]. Response options included 'yes', 'no', 'don't know' or 'refused'. Participants who responded 'yes' were classified as having initiated fairly regular SLT use in waves 2–4. The 'don't know' and 'refused' responses from ever, past 30-day, and fairly regular SLT were excluded from analyses.

Previous ever use of other tobacco products before SLT initiation

PATH measured ever use of other tobacco products using similar individual questions for ever use of cigarettes, e-cigarettes, traditional cigars, filtered cigars, cigarillos, and hookah. We examined previous ever use of these tobacco products at the wave prior to initiation of ever, past 30-day, and fairly regular SLT use to ensure that the use of these tobacco products preceded SLT use outcomes. Six variables were created for each outcome for previous ever use of: 1) cigarettes, 2) e-cigarettes, 3) traditional cigars, 4) filtered cigars, 5) cigarillos, and 6) hookah.

Sex and race/ethnicity

Sex was classified as male or female. PATH provides derived variables of race and ethnicity. Race was provided as White race alone, Black race alone, Asian race alone, and Other race (including multi-racial), whereas ethnicity was categorized as either Hispanic or non-Hispanic. In our analyses, to be comparable to those in prior Surgeon General's reports[17], we classified race/ethnicity into four categories: non-Hispanic White, Hispanic, non-Hispanic Black, and non-Hispanic Other (Asian, multi-race, and other races).

Interval–censored outcome: Age of initiation of SLT use

The exact date of initiation of each SLT outcome (ever, past 30-day, and fairly regular use) was not feasible to ask participants. In addition, participant date of birth was also not included in the restricted-use dataset. Therefore, we used two variables as a proxy to calculate the age of initiation of SLT: the age of participants at their first wave of PATH adult

participation and the number of weeks between survey waves. For each participant, a lower age bound and an upper age bound were estimated. For all participants, the lower bound was the age at the first wave of participation plus the number of weeks between the first wave of participation and the last wave when the participant reported non-use of each SLT use outcome. For those who became users during the study period, the upper bound was the age at the first wave of participation plus the number of weeks between the first wave of participation and the wave the participant reported initiation of each SLT use outcome. For those who remained non-users, the upper age bound was censored. This yields an interval-censored age of initiation between which the initiation occurred.

Statistical analysis

Because PATH is a nationally representative study with a complex sampling design, all analyses incorporated sampling weights and 100 balance repeated replicate weights with a Fay's adjustment factor of 0.3[16]. Cross-sectional weights at each participants' first wave of adult PATH participation (waves 1–3) were used, meaning that our sample represents young adults aged 18–24 years in 2013–2016. For continuous variables, weighted means and standard errors are reported. For categorical variables, weighted frequencies, percentages, and standard errors are reported. Weighted interval-censoring survival analyses were used to estimate the hazard function and 95% CIs for each age of initiation of SLT outcome as cumulative percentages[18]. Depending on the number of waves each person participated, contributions of follow-up time across waves varied. However, in a survival analysis, each participant contributes to the analysis for the amount of time they are in the study. To detect differences in the age of initiation of each SLT outcome by sex and by race/ethnicity, weighted interval-censoring Cox proportional hazards regression models with a piecewise constant baseline hazard function were implemented[19]. We adjusted the analyses to account for the simultaneous effect of previous ever use of six other tobacco products: 1) cigarettes, 2) e-cigarettes, 3) traditional cigars, 4) filtered cigars, 5) cigarillos, and 6) hookah, on the age of initiation of SLT use. The hazard ratios (HRs) and their 95% confidence intervals (CIs) are reported for both univariate and multivariable

analyses. When statistically significant differences in the age of initiation of SLT outcomes were identified by sex or by race/ethnicity, the age of initiation of SLT use was also estimated using weighted interval-censoring survival analyses stratified by that variable[18]. All statistical analyses were completed in SAS version 9.4 using the Inter-university Consortium for Political and Social Research server hosted by the University of Michigan[15,16].

RESULTS

A total of 10595 young adults who never used SLT at their first wave of adult PATH participation were included in this study, representing a national population of over 33 million (Table 1). These young adults were 55% female, 22.3% Hispanic, 51.2% non-Hispanic White, 15% non-Hispanic Black, and 11.5% non-Hispanic Other. Of all the included participants, 79.1% entered at wave 1 and the mean age of participants at their first wave of adult participation was 20.4 years. Prior to using SLT, 48.8% reported cigarette use, 42.9% reported e-cigarette use, and the proportions for the other four tobacco products are reported in Table 1.

By the age of 21 years, 2.1% of all young adults were estimated to initiate ever SLT use, 1.3% were estimated to initiate past 30-day SLT use, and 0.6% were estimated to initiate fairly regular SLT use. By the age of 27 years, the latest age for which we had follow-up, 4.9%, 3.0%, and 1.9% were estimated to initiate ever, past 30-day, and fairly regular SLT use, respectively (Table 2). We note that between the ages of 21 and 26 years, the percentage of initiation more than doubled for all three SLT outcomes.

Table 3 shows the crude and adjusted hazard ratios for each SLT initiation outcome. After adjusting for race/ethnicity and the previous ever use of other tobacco products, young adult males were at increased risk to initiate each SLT outcome at earlier ages than females. Specifically, males were 377% more likely (AHR=4.77; 95% CI: 3.42–6.65) to initiate ever use, 483% more likely (AHR=5.83; 95% CI: 3.76–9.04) to initiate past 30-day use, and 881% more likely (AHR=9.81; 95% CI: 4.10–23.45) to initiate fairly regular use of SLT at younger ages than females. In addition, after adjusting for sex and previous ever use of other tobacco products, there were differences by race/ethnicity in the age

of initiation of all three SLT outcomes. Specifically, Hispanic young adults were 33% less likely (AHR=0.67; 95% CI: 0.49–0.90), non-Hispanic Black young adults were 65% less likely (AHR=0.35; 95% CI: 0.22–0.54), and non-Hispanic other young adults were 43% less likely (AHR=0.57; 95% CI: 0.33–0.97) to initiate ever use of SLT at earlier ages than non-Hispanic White young adults. Additionally, non-Hispanic Black young adults were also 56% less likely (AHR=0.44; 95% CI: 0.25–0.77) to initiate

Table 1. Demographic characteristics of PATH a US young adult (aged 18–24 years) never smokeless tobacco users at their first wave of adult participation

		Total: n=10595; N=33073893[b]	
		n (N)	*Weighted % (SE)[c]*
First wave of adult participation	Wave 1 (2013–2014)	7432 (26164602)	79.1 (0.18)
	Wave 2 (2014–2015)	1644 (3635269)	11.0 (0.15)
	Wave 3 (2015–2016)	1519 (3274023)	9.9 (0.17)
Age at first wave of adult participation (years)	Weighted mean (SE)[c]	20.4 (0.03)	
Sex	Female	5910 (18166512)	55.0 (0.25)
	Male	4682 (14899936)	45.0 (0.25)
	Missing	3 (7446)	
Race/ethnicity	Non-Hispanic White	4924 (16926152)	51.2 (0.76)
	Hispanic	2851 (7375578)	22.3 (0.55)
	Non-Hispanic Black	1786 (4963871)	15.0 (0.42)
	Non-Hispanic Other[d]	1034 (3808292)	11.5 (0.64)
Previous ever use of other tobacco products before SLT initiation (waves 1–3)			
Cigarettes	Yes	5907 (16131042)	48.8 (0.87)
	No	4683 (16933537)	51.2 (0.87)
	Missing	5 (9315)	
E-cigarettes	Yes	5402 (14200691)	42.9 (0.89)
	No	5176 (18823701)	56.9 (0.89)
	Missing	17 (49501)	
Cigarillos	Yes	4435 (11667800)	33.3 (0.82)
	No	6036 (21038555)	63.6 (0.82)
	Missing	124 (367539)	
Traditional cigars	Yes	2505 (6956796)	21.0 (0.68)
	No	8032 (25913368)	78.4 (0.69)
	Missing	58 (203729)	
Filtered cigars	Yes	1979 (4997828)	15.1 (0.52)
	No	8487 (27701229)	83.8 (0.54)
	Missing	129 (374836)	
Hookah	Yes	5370 (14600452)	44.1 (1.08)
	No	5215 (18446587)	55.8 (1.08)
	Missing	10 (26854)	

a PATH: Population Assessment of Tobacco and Health study. PATH restricted file received disclosure to publish: 20 January 2022. US Department of Health and Human Services. National Institutes of Health. National Institute on Drug Abuse, and US Department of Health and Human Services. Food and Drug Administration. Center for Tobacco Products. Population Assessment of Tobacco and Health (PATH) Study [US] Restricted-Use Files. ICPSR36231-v13.Ann Arbor, MI: Inter-university Consortium for Political and Social Research [distributor], 5 November 2019. https://doi.org/10.3886/ICPSR36231.v23. b n: sample size; N: estimated population. c SE: standard error. dNon-Hispanic Other includes Asian, multi-race, etc.

past 30-day use and 59% less likely (AHR=0.41; 95% CI: 0.19–0.87) to initiate fairly regular use of SLT at younger ages than non-Hispanic White young adults.

After adjusting for sex, race/ethnicity, and previous ever use of five other tobacco products, young adults who used e-cigarettes before initiating SLT were 51% more likely (AHR=1.51; 95% CI: 1.04–2.19) to initiate ever SLT use at earlier ages than those who did not. Similarly, after controlling for sex, race/ethnicity, and previous ever use of five other tobacco products, young adults who used cigarillos before initiating SLT were 81% more likely (AHR=1.81; 95% CI: 1.23–2.65) to initiate ever and past 30-day SLT use at earlier ages compared to those who did not.

Table 4 reports the hazard function and 95% CIs for the age of initiation of the three SLT outcomes stratified by sex. By the age of 21 years, 4.0% of males and 0.7% of females were estimated to initiate ever SLT use, 2.6% of males and 0.3% of females were estimated to initiate past 30-day SLT use, and 1.3% of

Table 2. Estimated hazard functions a (95% confidence intervals[b]) of the age of initiation of smokeless tobacco use outcomes for PATH young adults

Age of initiation (years)	Ever	Past 30-Day	Fairly regular
18	0.0	0.0	0.0
19	0.7 (0.0–1.5)	0.6 (0.5–0.8)	0.1 (0.04–0.2)
20	1.6 (1.3–1.9)	1.0 (0.7–1.2)	0.4 (0.2–0.6)
21	2.1 (1.7–2.6)	1.3 (0.9–1.7)	0.6 (0.4–0.8)
22	2.4 (2.0–2.9)	1.3 (1.0–1.6)	0.7 (0.4–0.9)
23	2.4 (2.0–2.9)	1.5 (1.2–1.8)	0.7 (0.4–0.9)
24	3.3 (2.6–4.0)	2.3 (1.5–3.0)	1.1 (0.7–1.5)
25	3.6 (3.1–4.1)	2.3 (1.9–2.7)	1.1 (0.6–1.7)
26	4.4 (3.8–5.1)	2.9 (2.3–3.5)	1.4 (0.9–1.9)
27	4.9 (4.1–5.7)	3.0 (2.4–3.7)	1.9 (1.0–2.8)

a Hazards are reported as cumulative percentages (i.e. cumulative incidence). b Turnbull 95% confidence interval.

Table 3. Crude and adjusted hazard ratios (95% confidence intervals[a]) for smokeless tobacco use initiation outcomes (2013–2017) in PATH young adults

Crude hazard ratios	Ever	Past 30-day	Fairly regular
Sex			
Female	1	1	1
Male	5.12 (1.05–25.0)	6.19 (4.02–9.53)	10.33 (4.43–24.12)
Race/ethnicity			
Non–Hispanic White	1	1	1
Hispanic	0.76 (0.57–1.03)	0.88 (0.57–1.33)	0.76 (0.38–1.49)
Non–Hispanic Black	0.42 (0.27–0.65)	0.52 (0.30–0.90)	0.45 (0.21–0.96)
Non–Hispanic Other[b]	0.57 (0.33–0.97)	0.71 (0.38–1.31)	0.78 (0.32–1.91)
Previous ever use of other tobacco products[c]			
Cigarettes	1.99 (1.44–2.75)	1.57 (1.05–2.33)	2.53 (1.48–4.33)
E-cigarettes	2.25 (1.65–3.05)	1.93 (1.30–2.87)	2.09 (1.28–3.42)
Cigarillos	2.68 (2.03–3.54)	2.29 (1.62–3.23)	2.31 (1.53–3.49)
Traditional cigars	2.35 (1.79–3.07)	1.99 (1.44–2.77)	2.46 (1.62–3.74)
Filtered cigars	2.27 (1.71–3.03)	2.07 (1.43–2.99)	2.29 (1.37–3.85)
Hookah	1.54 (1.20–1.99)	1.31 (0.96–1.79)	1.28 (0.82–2.00)
Adjusted hazard ratios			
Sex			
Female	1	1	1
Male	4.77 (3.42–6.65)	5.83 (3.76–9.04)	9.81 (4.10–23.45)
Race/ethnicity			
Non–Hispanic White	1	1	1

Table 3. Continued

Adjusted hazard ratios	Ever	Past 30-day	Fairly regular
Hispanic	**0.67 (0.49–0.90)**	0.77 (0.50–1.18)	0.64 (0.33–1.23)
Non-Hispanic Black	**0.35 (0.22–0.54)**	**0.44 (0.25–0.77)**	**0.41 (0.19–0.87)**
Non-Hispanic Other[b]	**0.57 (0.33–0.97)**	0.68 (0.37–1.26)	0.75 (0.29–1.91)
Previous ever use of other tobacco products[c]			
Cigarettes	1.11 (0.75–1.66)	0.90 (0.52–1.56)	2.02 (0.87–4.69)
E-cigarettes	**1.51 (1.04–2.19)**	1.48 (0.90–2.44)	1.34 (0.73–2.46)
Cigarillos	**1.81 (1.23–2.65)**	**1.87 (1.21–2.88)**	1.22 (0.69–2.18)
Traditional cigars	0.98 (0.68–1.42)	0.87 (0.58–1.30)	1.10 (0.59–2.04)
Filtered cigars	1.28 (0.92–1.77)	1.32 (0.90–1.92)	1.32 (0.75–2.33)
Hookah	0.89 (0.67–1.17)	0.82 (0.58–1.17)	0.66 (0.39–1.12)

a Turnbull 95% confidence interval. b Non-Hispanic Other includes Asian, multi-race, etc. c The reference category for each of the tobacco products previously used before SLT initiation is 'no'.

males and 0.08% of females were estimated to initiate fairly regular use of SLT. By the age of 27 years, the latest age for which we had follow-up, 9.0% of males and 1.7% of females were estimated to initiate ever use, 5.6% of males and 1.1% of females were estimated to initiate past 30-day use, and 4.0% of males and 0.4% of females were estimated to initiate fairly regular use of SLT. Again, between the ages of 21 and 26 years, the percentage of all SLT initiation outcomes more than doubled for males and females.

Table 5 shows the age of initiation of SLT outcomes stratified by race/ethnicity. By the age of 21 years, 2.7% of non-Hispanic white young adults were estimated to initiate ever use of SLT whereas 1.8% of Hispanic, 1.0% of non-Hispanic Black, and 1.8% of non-Hispanic Other young adults were estimated to initiate ever use of SLT. In addition, by the age of 21 years, 1.5% of non-Hispanic White, 1.3% of Hispanic, 0.8% of non-Hispanic Black, and 1.2% of non-Hispanic Other young adults were estimated to initiate past 30-day use. Finally, 0.5% of non-Hispanic White, 0.3% of Hispanic, 0.3% of non-Hispanic Black, 0.6% of non-Hispanic Other young adults were estimated to initiate fairly regular SLT use by the age of 21 years. Between ages of 21 and 26 years, the percentage of all three SLT outcomes doubled for non-Hispanic White, Hispanic, and non-Hispanic Black young adults.

Table 4. Estimated hazard functions[a] (95% confidence intervals[b]) in PATH young adults of the age of initiation of smokeless tobacco use outcomes by sex

Age of Initiation (years)	Ever		Past 30-day		Fairly regular	
18	0.0	0.0	0.0	0.0	0.0	0.0
19	1.5 (0.1–2.9)	0.2 (0.1–0.3)	1.2 (0.9–1.5)	0.1 (0.04–0.2)	1.2 (0.9–1.5)	0.1 (0.04–0.2)
20	2.8 (2.2–3.4)	0.6 (0.4–0.8)	1.7 (1.3–2.2)	0.3 (0.1–0.5)	1.7 (1.3–2.2)	0.3 (0.1–0.5)
21	4.0 (3.2–4.8)	0.7 (0.4–0.9)	2.6 (2.0–3.2)	0.3 (0.2–0.5)	2.6 (2.0–3.2)	0.3 (0.2–0.5)
22	4.4 (3.5–5.2)	0.9 (0.6–1.2)	2.6 (2.0–3.2)	0.3 (0.2–0.5)	2.6 (2.0–3.2)	0.3 (0.2–0.5)
23	4.4 (3.6–5.2)	0.9 (0.6–1.2)	2.8 (2.2–3.4)	0.4 (0.2–0.6)	2.8 (2.2–3.4)	0.4 (0.2–0.6)
24	5.9 (4.4–7.4)	1.3 (0.9–1.7)	4.2 (2.7–5.6)	0.8 (0.5–1.1)	4.2 (2.7–5.6)	0.8 (0.5–1.1)
25	6.9 (5.2–8.7)	1.4 (1.1–1.8)	4.9 (3.1–6.7)	0.8 (0.5–1.1)	4.9 (3.1–6.7)	0.8 (0.5–1.1)
26	8.1 (6.6–9.5)	1.5 (1.1–2.0)	5.5 (4.3–6.7)	0.9 (0.5–1.3)	5.5 (4.3–6.7)	0.9 (0.5–1.3)
27	9.0 (6.8–11.2)	1.7 (1.2–2.3)	5.6 (4.4–6.9)	1.1 (0.5–1.7)	5.6 (4.4–6.9)	1.1 (0.5–1.7)

a Hazards are reported as cumulative percentages (i.e. cumulative incidence). b Turnbull 95% confidence interval.

Table 5. Estimated hazard functions[a] (95% confidence intervals[b]) in PATH young adults of the age of initiation of smokeless tobacco use outcomes by race/ethnicity

Age of Initiation (years)	Non-Hispanic White	Hispanic	Non-Hispanic Black	Non-Hispanic Other
Ever smokeless tobacco use				
18	0.0	0.0	0.0	0.0
19	1.1 (0.1–2.2)	0.8 (0.4–1.2)	0.5 (0.1–0.8)	0.4 (0.02–0.8)
20	1.9 (1.4–2.4)	1.6 (1.1–2.1)	0.9 (0.4–1.4)	0.9 (0.2–1.7)
21	2.7 (2.2–3.3)	1.8 (1.1–2.6)	1.0 (0.4–1.6)	1.8 (0.5–3.1)
22	3.1 (2.4–3.7)	1.8 (1.3–2.4)	1.1 (0.6–1.6)	1.9 (0.7–3.2)
23	3.1 (2.4–3.7)	2.8 (2.1–3.5)	1.1 (0.6–1.6)	1.9 (0.7–3.2)
24	4.0 (3.1–4.9)	2.8 (2.1–3.5)	1.5 (0.8–2.2)	2.9 (1.1–4.7)
25	5.5 (3.3–7.7)	4.1 (2.9–5.3)	2.0 (1.1–3.0)	3.5 (1.7–5.4)
26	5.5 (4.4–6.7)	4.1 (2.9–5.3)	2.6 (1.5–3.6)	3.5 (1.7–5.4)
27	6.0 (4.8–7.2)	4.8 (3.3–6.4)	2.6 (1.5–3.6)	3.5 (1.7–5.4)
Past 30-day smokeless tobacco use				
18	0.0	0.0	0.0	0.0
19	0.8 (0.6–1.1)	0.5 (0.2–0.8)	0.4 (0.1–0.7)	0.2 (0.0–0.4)
20	1.1 (0.8–1.5)	1.1 (0.02–2.1)	0.8 (0.3–1.3)	0.3 (0.01–0.5)
21	1.5 (1.1–1.9)	1.3 (0.7–1.9)	0.8 (0.3–1.4)	1.2 (0.2–2.1)
22	1.5 (1.1–1.9)	1.3 (0.7–1.9)	0.9 (0.4–1.4)	1.3 (0.3–2.2)
23	1.8 (1.3–2.2)	1.6 (1.0–2.3)	0.9 (0.4–1.4)	1.3 (0.3–2.3)
24	2.6 (1.7–3.6)	1.6 (1.0–2.3)	1.2 (0.5–1.8)	2.1 (0.6–3.7)
25	3.5 (1.8–5.2)	2.7 (1.5–3.9)	1.6 (0.8–2.4)	2.8 (1.2–4.4)
26	3.5 (2.5–4.5)	2.7 (1.5–3.9)	1.8 (0.9–2.8)	2.8 (1.2–4.4)
27	3.5 (2.5–4.5)	3.4 (1.9–5.0)	1.8 (0.9–2.8)	2.8 (1.2–4.4)
Fairly regular smokeless tobacco use				
18	0.0	0.0	0.0	0.0
19	0.3 (0.2–0.5)	0.2 (0.0–0.4)	0.1 (0.0–0.3)	0.3 (0.0–0.6)
20	0.5 (0.2–0.8)	0.3 (0.0–0.7)	0.3 (0.04–0.6)	0.6 (0.0–1.2)
21	0.5 (0.2–0.7)	0.3 (0.0–0.6)	0.3 (0.03–0.7)	0.6 (0.0–1.2)
22	0.8 (0.4–1.2)	0.6 (0.2–1.0)	0.3 (0.03–0.7)	0.6 (0.0–1.2)
23	0.8 (0.4–1.2)	0.6 (0.2–1.0)	0.7 (0.2–1.1)	0.6 (0.0–1.3)
24	1.4 (0.7–2.0)	0.6 (0.2–1.0)	0.7 (0.2–1.1)	0.9 (0.1–1.7)
25	1.4 (0.8–1.9)	0.9 (0.4–1.4)	0.7 (0.2–1.1)	1.6 (0.5–2.8)
26	1.9 (1.1–2.7)	2.0 (0.5–3.5)	0.7 (0.2–1.1)	1.6 (0.5–2.8)
27	1.9 (1.1–2.7)	3.0 (0.0–6.8)	0.7 (0.2–1.1)	1.6 (0.5–2.8)

a Hazards are reported as cumulative percentages (i.e. cumulative incidence). b Turnbull 95% confidence interval.

DISCUSSION

We filled the gap in the literature by prospectively estimating the age of initiation of SLT outcomes among young adults who had never used SLT. A previous report that surveyed non-institutionalized US civilians in 2014, estimated that 1.6% of young adults (aged 18–25 years) initiated SLT in the previous year[8]. The NATS from 2012–2013 reported

a prevalence of 4.4% (95% CI: 3.7–5.1) among adults aged 18–24 years who reported using SLT at least 'some days'[6]. Syamlal et al.[7] reported the prevalence of current (every day, some days, or rarely) SLT use as 5.4% (95% CI: 4.5–6.2) among working young adults from 2012–2014[7], while Lipari and Van Horn[8] reported that in 2014, 5.6% of young adults aged 18–25 years used SLT in the past 30-days. A different analysis of the PATH study using data from 2013–2016 found that 5.3% young adults aged 18–24 years used SLT in the past 30-days[20]. The previous studies reported higher prevalence or incidence than our cumulative incidence because we start with never users of SLT to estimate the age of initiation prospectively. Importantly, estimating the age of initiation is more efficient than just reporting incidence of SLT. Our results indicate that SLT initiation occurs in young adults with the highest increase in initiation of ever SLT use between 19 to 20 years old (0.9%), which represents 297668 young adults. This is in line with the emerging adulthood hypothesis, as these are emerging adults who have moved away from their family for the first time and are faced with unprecedented freedom[12]. Past 30-day SLT initiation occurs in young adults with the highest increase between the ages of 22 and 23 years (0.8%), which represents 264591 young adults. Fairly regular SLT initiation occurs in young adults with the highest increase between the ages of 26 and 27 years (0.5%), which represents 165369 young adults. These specific ages of initiation of SLT outcomes overall can inform education and prevention communication campaigns for the public (i.e. parents, professors, physicians), before young adults initiate SLT use or become more frequent users of SLT.

In addition to the overall age of initiation in young adults, our study highlights three young adult demographic groups who are at higher risk for earlier ages of SLT initiation: males, non-Hispanic Whites, and poly-tobacco users. Our results showing that young adult males initiated all SLT outcomes earlier than females are similar to previous studies that reported higher SLT use prevalence and/or incidence among males compared to females[7,8,21-23]. Differences between race/ethnicity groups emerged in our analyses as well. Non-Hispanic White young adults were more likely than any other race/ethnicity to initiate ever SLT use at earlier ages.

This is similar to previous studies, which repeatedly identify non-Hispanic White race/ethnicity as a risk factor for higher prevalence of SLT use in the US in comparison to young adults of other race/ethnicities[7,21-23]. Interestingly, our findings highlight that only the non-Hispanic Black young adults had a decreased risk of an earlier age of initiation of past 30-day and fairly regular SLT use compared to non-Hispanic White young adults. To our knowledge, this is the first study demonstrating that non-Hispanic Black young adults are less likely to initiate past 30-day and fairly regular SLT use at earlier ages than non-Hispanic White young adults.

Along with demographic differences, we also concluded that ever use of e-cigarettes and cigarillos prior to initiation of SLT was associated with earlier ages of initiation of SLT outcomes. Similarly, one study of PATH adults (aged ≥18 years) from 2013–2014 (wave 1) found that 74.9% (95% CI: 66.4–83.5) of 'current established' SLT users were also current users of at least 1 other tobacco product, including cigarettes, e-cigarettes, cigars, hookah, or pipes[23]. In contrast to our findings, a study evaluating adult males in the US from 1992–2011 found that former cigarette smokers were twice as likely to be SLT users (OR=2.0; 95% CI: 1.8–2.2) compared to never smokers[22]. Future research is needed to determine why previous use of e-cigarettes and cigarillos were associated with the age of initiation of SLT outcomes while all other tobacco products were not.

Considering the multiple demographic differences in age of initiation of SLT use suggested by our analyses, interventions to delay the onset and progression of SLT use should be implemented earlier in the life course of males, non-Hispanic Whites, and those who have experience with other types of tobacco product use. One possible venue for targeted anti-SLT campaigns is the workplace. Male-saturated industries such as mining and construction have been associated with high SLT use[7,21]. Therefore, communication campaigns that highlight the harms of SLT[1-3] use might plausibly reach more high-risk young adults if provided at these workplaces, emphasizing the need to implement those communication campaigns for males at earlier ages.

An effort has already been made to prevent

tobacco use in young adults at the national level, in the form of the Tobacco 21 Act. The Act was signed into law in 2019, prohibiting the sale of tobacco products to individuals under the age of 21 years[24]. This relatively new legislation has provided the opportunity for a natural experiment regarding the effect of legal age limits on the age of initiation of SLT use. If the law is effective, we expect to see an increase in age of SLT initiation and a decrease in the overall prevalence among young adults aged 18–20 years, after 2019. To the authors' knowledge, ours is the most recent study reporting the age of initiation of SLT use in young adults aged 18–24 years preceding 2019. For future studies, our results provide a useful baseline measure to evaluate any changes in age of initiation, given this new law.

Strengths and limitations
A strength of the current study is the longitudinal availability of waves in PATH. While some studies rely on participant recall of the age of initiation, which could have occurred five, ten, or more years before a survey, our approach implements interval-censored survival analysis which does not rely on the recalled age of initiation for each outcome. One limitation is that our analysis did not incorporate wave 5 data because wave 5 data were not available at the time our analyses were conducted.

CONCLUSIONS
We used nationally-representative data to estimate the age of initiation of important SLT use behaviors among young adults in the US. These findings can help inform anti-tobacco campaigns, as well as educate the public about the age of initiation of SLT use in the US.

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