

# Longitudinal pathways of exclusive and polytobacco cigarette use among youth, young adults and adults in the USA: findings from the PATH Study Waves 1–3 (2013–2016)

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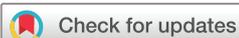
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## ABSTRACT

**Objective** Cigarettes are the most harmful and most prevalent tobacco product in the USA. This study examines cross-sectional prevalence and longitudinal pathways of cigarette use among US youth (12–17 years), young adults (18–24 years) and adults 25+ (25 years and older).

**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 adults and youth. Respondents with data at all three waves (youth, N=11 046; young adults, N=6478; adults 25+, N=17 188) were included in longitudinal analyses.

**Results** Among Wave 1 (W1) any past 30-day (P30D) cigarette users, more than 60%, persistently used cigarettes across three waves in all age groups. Exclusive cigarette use was more common among adult 25+ W1 P30D cigarette users (62.6%), while cigarette polytobacco use was more common among youth (57.1%) and young adults (65.2%). Persistent exclusive cigarette use was the most common pathway among adults 25+ and young adults; transitioning from exclusive cigarette use to cigarette polytobacco use was most common among youth W1 exclusive cigarette users. For W1 youth and young adult cigarette polytobacco users, the most common pattern of use was persistent cigarette polytobacco use.

**Conclusions** Cigarette use remains persistent across time, regardless of age, with most W1 P30D smokers continuing to smoke at all three waves. Policy efforts need to continue focusing on cigarettes, in addition to products such as electronic nicotine delivery systems that are becoming more prevalent.

## INTRODUCTION

Cigarettes are the most common tobacco product in the USA, with approximately 61 million people in 2016 having smoked cigarettes in the past year, almost 2 million of them younger than age 18.<sup>1</sup> Cigarette use is more than twice as prevalent as the use of any other tobacco product among US adults; in 2014, 18.1% currently smoked cigarettes, and 16.0% smoked cigarettes daily.<sup>2</sup> Furthermore,

cigarettes are the product most commonly used by tobacco users, including those who use one product and those who use multiple products.<sup>2–4</sup>

Tobacco products have been conceptualised as falling along a continuum of risk,<sup>5 6</sup> with cigarettes on the most harmful end of the continuum considering exposure to harmful chemicals multiplied by vast number of users.<sup>7</sup> Although cigarette smoking prevalence has decreased over the past decades,<sup>8–10</sup> the resulting public health benefit may be tempered by evolving patterns of cigarette use, including increases in non-daily cigarette smoking,<sup>10</sup> and disparities in cigarette smoking prevalence based on race/ethnicity,<sup>11 12</sup> socioeconomic status,<sup>13 14</sup> sexual orientation and/or gender identity.<sup>15 16</sup>

Polytobacco use, or use of more than one tobacco product, is increasing<sup>10</sup> and is associated with continued cigarette smoking behaviour and nicotine dependence among youth and adults.<sup>17–19</sup> Among youth and adults, approximately 40% of tobacco users use multiple tobacco products,<sup>2</sup> with cigarette polytobacco use (using cigarettes plus at least one other product) consistently included in the top combinations of products.<sup>2 4 20–22</sup> Among adult smokers, 16.3% smoked cigarettes with at least one other tobacco product,<sup>23</sup> while among young adult smokers, 22.6% were polytobacco users<sup>23</sup> and among youth cigarette smokers in grades 6–12, 46.1% smoked cigarettes and also used one or more other tobacco products.<sup>24</sup>

This study draws from the longitudinal cohort design of the Population Assessment of Tobacco and Health (PATH) Study and examines pathways of cigarette use in the USA across three waves from 2013 to 2016. We first provide overall cross-sectional weighted estimates of ever: past 12-month (P12M), past 30-day (P30D) and daily P30D use for US youth (aged 12–17), young adults (aged 18–24) and adults aged 25 and older (adults 25+) from 2013 to 2016. Using the first three waves of longitudinal within-person data from the PATH Study, Aim 2 is to examine whether the known age group differences in tobacco use discussed above are found among the pathways of persistent use, discontinued use and reuptake of cigarettes among Wave 1 (W1) P30D cigarette users. The focus is

on P30D use to provide a broad overview of the transitions in cigarette use. Aim 3 is to compare longitudinal transitions of use among W1 exclusive cigarette smokers and W1 cigarette smokers who use multiple tobacco products (cigarette polytobacco use) to understand broad transitions such as tobacco cessation, tobacco reuptake, persistent cigarette use, discontinued cigarette use and switching to another tobacco product. Monitoring these longitudinal transitions among cigarette smokers separately for exclusive and polytobacco users will advance our understanding of critical product transitions, improving comprehension of the health risks associated with cigarette smoking at the population level. The important topic of initiation of cigarette use is addressed in another paper in this supplement issue.<sup>25</sup>

## METHODS

### Study design and population

The PATH Study is an ongoing, nationally representative, longitudinal cohort study of youth (aged 12–17) and adults (aged 18 or older) in the US. Self-reported data were collected using audio computer-assisted self-interviews administered in English and Spanish. Further details regarding the PATH Study design and W1 methods are published elsewhere.<sup>26,27</sup> At W1, the weighted response rate for the household screener was 54.0%. Among screened households, the overall weighted response rate was 78.4% for youth and 74.0% for adults at W1, 87.3% for youth and 83.2% for adults at Wave 2 (W2) and 83.3% for youth and 78.4% for adults at Wave 3 (W3). Details on interview procedures, questionnaires, sampling, weighting and adjustments for non-response, and information on accessing the data are available online (<https://doi.org/10.3886/Series606>). The study was conducted by Westat and approved by the Westat Institutional Review Board. All participants aged 18 and older provided informed consent, with youth participants aged 12–17 providing assent while their parent/legal guardian provided consent.

This study reports cross-sectional estimates from 13 651 youth and 32 320 adults who participated in W1 (data collected from 12 September 2013 through 14 December 2014), 12 172 youth and 28 362 adults at W2 (data collected from 23 October 2014 through 30 October 2015) and 11 814 youth and 28 148 adults at W3 (data collected from 19 October 2015 to 23 October 2016). The differences in the number of completed interviews between W1, W2 and W3 reflect attrition due to non-response, mortality and other factors, as well as youth who enrolled in the study at W2 or W3.<sup>26</sup> We also report longitudinal estimates from W1 youth (n=11 046), W1 young adults (n=6 478) and W1 adults 25+ (n=17 188) with data collected at all three waves. See online supplementary figure 1 for a detailed description of the analytic sample for longitudinal analysis.

### Measures

#### Tobacco use

At each wave, adults and youth were asked about their tobacco use behaviours for cigarettes and electronic nicotine delivery systems, including e-cigarettes, traditional cigars, cigarillos, filtered cigars, pipe tobacco, hookah, snus pouches, other smokeless tobacco and dissolvable tobacco. Participants were asked about P30D use of 'e-cigarettes' at W1 and W2 and 'e-products' (e-cigarettes, e-cigars, e-pipes and e-hookah) at W3; all electronic products noted above are referred to as ENDS. In addition, youth were asked about their use of bidis and kreteks. However, use of bidis, kreteks and dissolvable tobacco were not included in the analyses due to small sample sizes.

### Outcome measures

Cross-sectional definitions of use included ever, P12M, P30D and daily P30D use. Longitudinal outcomes included persistent cigarette use, discontinued cigarette use and reuptake of cigarette use, as well as transitions among exclusive and polytobacco cigarette users. The definition of each outcome is included in the footnote of the table/figure in which it is presented.

### Analytic approach

To address Aim 1, weighted cross-sectional prevalence of cigarette use was estimated across ever, P12M, P30D and daily P30D use at each wave stratified by age. For Aim 2, irrespective of other tobacco product use, longitudinal W1–W2–W3 transitions in P30D cigarette use were summarised to represent pathways of persistent any P30D cigarette use (defined as continued exclusive or polytobacco cigarette use at W2 and W3), discontinued any P30D cigarette use (stopped cigarette use at W2 and W3 or just W3) and reuptake of any P30D cigarette use (used cigarettes at W1, discontinued cigarette use at W2 and used cigarettes again at W3). Finally, to address Aim 3, longitudinal W1–W2–W3 cigarette use pathways that flow through five mutually exclusive and exhaustive transition categories were examined for W1 P30D exclusive cigarette use and W1 P30D cigarette polytobacco use (see online supplementary figure 2). These pathways represent building blocks that may be aggregated to reflect higher level behavioural transitions, such as discontinued tobacco use, tobacco use reuptake, persistent use, transition to exclusive or polytobacco use, exclusive use reuptake, switching product use and inconsistent use. For each aim, weighted t-tests were conducted on differences in proportions to assess statistical significance. To correct for multiple comparisons, Bonferroni post hoc tests were used where relevant.

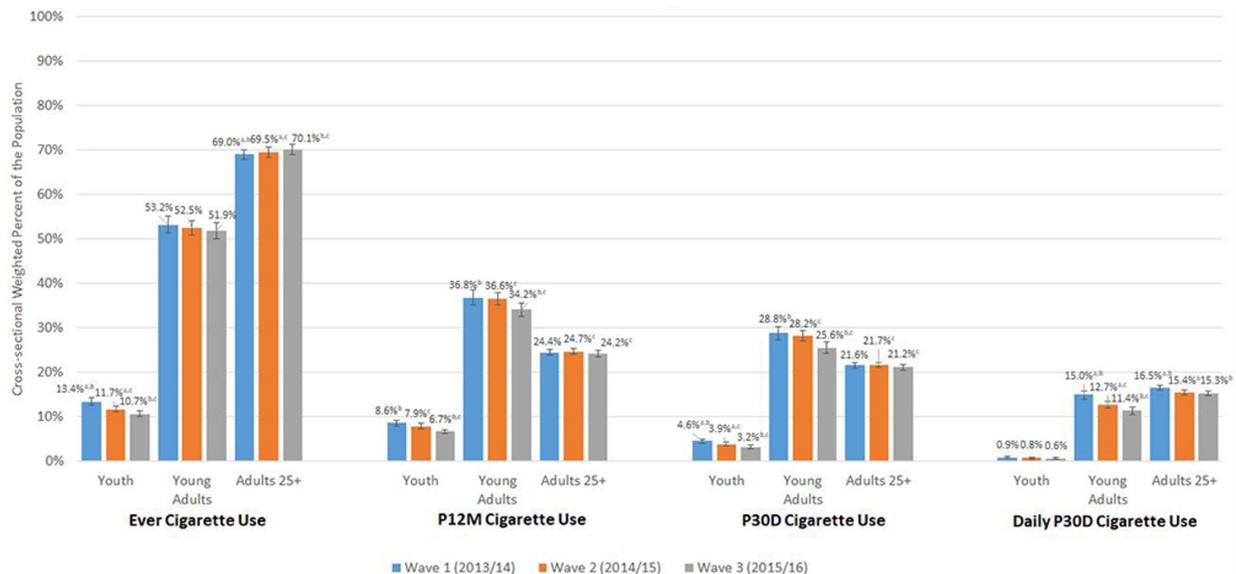
Cross-sectional estimates (Aim 1) were calculated using the PATH Study cross-sectional weights for W1 and single-wave (pseudo-cross-sectional) weights for W2 and W3. The weighting procedures adjusted for complex study design characteristics and non-response. Combined with the use of a probability sample, the weighted data allow these estimates to be representative of the non-institutionalised, civilian, resident US population aged 12 or older at the time of each wave. Longitudinal estimates (Aims 2 and 3) were calculated using the PATH Study W3 all-waves weights. These weighted estimates are representative of the resident US population aged 12 and older at the time of W3 (other than those who were incarcerated) who were in the civilian, non-institutionalised population at W1.

All analyses were conducted using SAS Survey Procedures, V.9.4 (SAS Institute). Variances were estimated using the balanced repeated replication method<sup>28</sup> with Fay's adjustment set to 0.3 to increase estimate stability.<sup>29</sup> Analyses were run on the W1–W3 Public Use Files (<https://doi.org/10.3886/ICPSR36498.v8>). Estimates with low precision (those based on fewer than 50 observations in the denominator or with a relative standard error greater than 0.30) were flagged and are not discussed in the Results. Respondents missing a response to a composite variable (eg, ever, P30D) were treated as missing; missing data were handled with listwise deletion.

## RESULTS

### Cross-sectional weighted prevalence

As shown in figure 1, for youth, there were statistically significant decreases in prevalence of ever use of cigarettes at every wave from 13.4% (95% CI 12.6 to 14.3) at W1, 11.7% (95% CI 11.0 to 12.3) at W2 to 10.7% (95% CI 10.0 to 11.4) at W3. For



**Figure 1** Cross-sectional weighted percent of ever, P12M, P30D and daily P30D cigarette use among youth, young adults and adults 25+ in W1, W2 and W3 of the Population Assessment of Tobacco and Health (PATH) Study. P12M, past12-month; P30D, past30-day; W1, Wave 1; W2, Wave 2; W3, Wave 3.

Abbreviations: P12M = past 12-month; P30D = past 30-day; W1 = Wave 1; W2 = Wave 2; W3 = Wave 3

W1/W2/W3 ever cigarette use unweighted Ns: youth (ages 12-17) = 1,838/1,428/1,220; young adults (ages 18-24) = 5,963/4,853/4,580; adults 25+ (ages 25 and older) = 19,213/16,790/16,305

W1/W2/W3 P12M cigarette use unweighted Ns: youth = 1,170/965/757; young adults = 4,392/3,564/3,202; adults 25+ = 11,538/9,927/9,267

W1/W2/W3 P30D cigarette use unweighted Ns: youth = 634/481/366; young adults = 3,593/2,799/2,456; adults 25+ = 10,624/8,880/8,275

W1/W2/W3 daily P30D cigarette use unweighted Ns: youth = 127/96/73; young adults = 1,931/1,338/1,138; adults 25+ = 8,236/6,596/6,229

X-axis shows four categories of cigarette use (ever, P12M, P30D, and daily P30D). Y-axis shows weighted percentages of W1, W2, and W3 users.

Sample analyzed includes all W1, W2, and W3 respondents at each wave. All respondents with data at one wave are included in the sample for that wave's estimate and do not need to have complete data at all three waves. The PATH Study cross-sectional (W1) or single-wave weights (W2 and W3) were used to calculate estimates at each wave. W1-W3 ever cigarette use is defined as having smoked cigarettes, even once or twice in lifetime. W1-W3 P12M cigarette use is defined as any cigarette use within the past 12 months. W1-W3 P30D cigarette use is defined as any cigarette use within the past 30 days. W1-W3 daily P30D cigarette use is defined as cigarette use every day within the past 30 days. All use definitions refer to any use that includes exclusive or polytobacco use of cigarettes.

<sup>a</sup>denotes significant difference at  $p < 0.0167$  (Bonferroni corrected for three comparisons) between W1 and W2

<sup>b</sup>denotes significant difference at  $p < 0.0167$  (Bonferroni corrected for three comparisons) between W1 and W3

<sup>c</sup>denotes significant difference at  $p < 0.0167$  (Bonferroni corrected for three comparisons) between W2 and W3

The logit-transformation method was used to calculate the 95% confidence intervals.

Analyses were run on the W1, W2, and W3 Public Use Files (<https://doi.org/10.3886/ICPSR36498.v8>).

adults 25+, there are small increases in prevalence of ever use across waves that are statistically significant: ever use increased from 69.0% (95% CI 67.9 to 70.1) at W1, to 69.5% (95% CI 68.3 to 70.7) at W2 to 70.1% (95% CI 68.9 to 71.3) at W3. For P12M cigarette use, among youth there was a decline between W1 (8.6% (95% CI 8.0 to 9.3)) and W3 (6.7% (95% CI 6.3 to 7.2)). Similarly, among young adults, there was a decline between W1 (36.8% (95% CI 35.2 to 38.5)) and W3 (34.2% (95% CI 32.7 to 35.6)). For adults 25+, there was a statistically significant decline between W2 (24.7% (95% CI 24.1 to 25.4)) and W3 (24.2% (95% CI 23.4 to 24.9)). Prevalence of P30D cigarette use decreased among youth between W1 (4.6% (95% CI 4.2 to 5.0)) and W3 (3.2% (95% CI 2.8 to 3.6)), and among young adults P30D cigarette use decreased between W2 (28.2% (95% CI 27.0 to 29.4)) and W3 (25.6% (95% CI 24.3 to 26.9)). Among adults 25+, P30D cigarette use decreased slightly between W2 and W3, from 21.7% (95% CI 21.1 to 22.3) at W2 to 21.2% (95% CI 20.5 to 21.8) at W3. Across all three waves, less than 1% of youth smoked cigarettes every day in the past 30 days. Among young adults, daily use of cigarettes in the past 30 days decreased between W1 (15.0% (95% CI 14.0 to 15.9)), W2

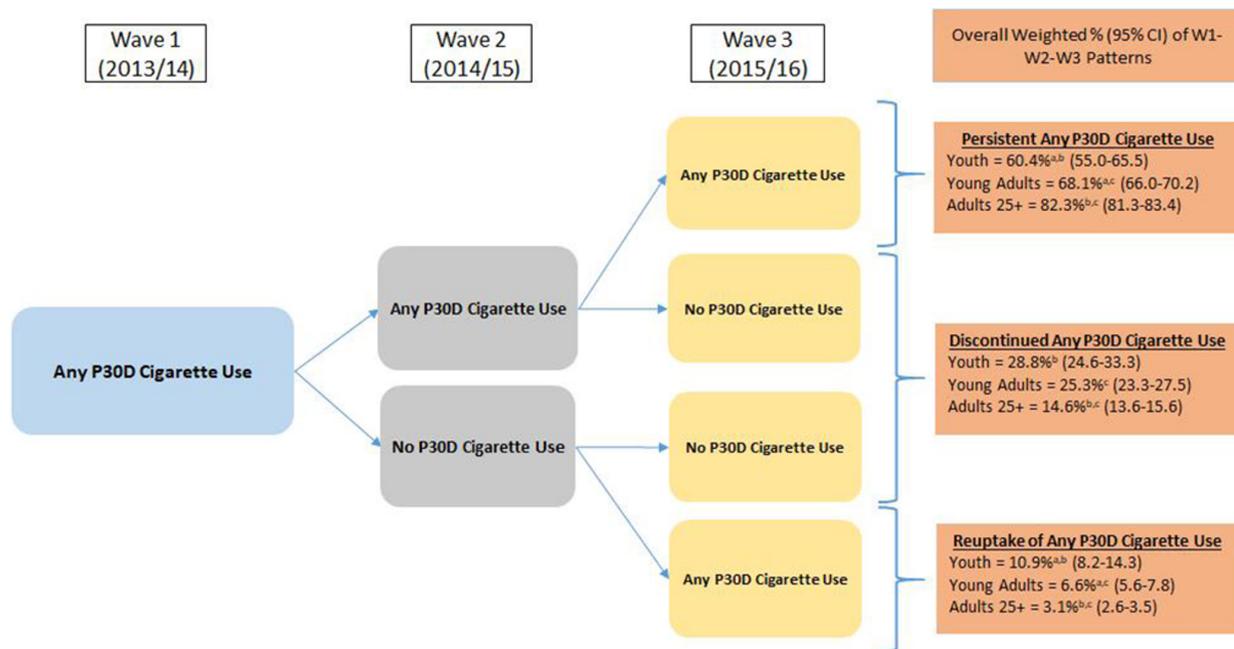
(12.7% (95% CI 11.9 to 13.5)) and W3 (11.4% (95% CI 10.5 to 12.3)). Among adults 25+, daily use declined between W1 (16.5% (95% CI 16.0 to 17.1)) and W2 (15.4% (95% CI 14.9 to 16.0)) and remained about the same at W3.

### Longitudinal weighted W1–W2–W3 pathways

To address Aim 2, [figure 2](#) illustrates the potential longitudinal pathways among those who smoked cigarettes in the P30D at W1.

#### Among P30D cigarette users at W1

Among those with data from all waves (W1, W2 and W3), 4.5% (95% CI 4.1 to 5.0) of youth, 28.3% (95% CI 26.8 to 29.7) of young adults and 21.3% (95% CI 20.7 to 22.0) of adults 25+ were P30D cigarette users at W1. Persistent P30D cigarette use, regardless of concurrent P30D use of other products, was found among 60.4% (95% CI 55.0 to 65.5) of youth, 68.1% (95% CI 66.0 to 70.2) of young adults and 82.3% (95% CI 81.3 to 83.4) of adults 25+, and the differences among all three age groups were statistically significant. Discontinued cigarette use occurred



**Figure 2** Patterns of W1–W2–W3 persistent any P30D cigarette use, discontinued any P30D cigarette use and reuptake of any P30D cigarette use among W1 any P30D cigarette users.

Abbreviations: W1 = Wave 1; W2 = Wave 2; W3 = Wave 3; P30D = past 30-day; CI = confidence interval

W1 any P30D cigarette use weighted percentages (95% CI) out of total U.S. population: youth (ages 12–17) = 4.5% (4.1–5.0); young adults (ages 18–24) = 28.3% (26.8–29.7); adults 25+ (ages 25 and older) = 21.3% (20.7–22.0)

Analysis included W1 youth, young adults, and adults 25+ P30D cigarette users with data at all three waves. Respondent age was calculated based on age at W1. W3 longitudinal (all-waves) weights were used to calculate estimates. These rates vary slightly from those reported in Figure 1 or Supplemental Table 1 because this analytic sample in Figure 2 includes only those with data at each of the three waves to examine weighted longitudinal use and non-use pathways.

Any P30D cigarette use was defined as any cigarette use within the past 30 days. Respondents could be missing data on other P30D tobacco product use and still be categorized into the following three groups:

- 1) Persistent any P30D cigarette use: Defined as exclusive or cigarette polytobacco use at W2 and W3.
- 2) Discontinued any P30D cigarette use: Defined as any noncigarette tobacco use or no tobacco use at either W2 and W3 or just W3.
- 3) Reuptake of any P30D cigarette use: Defined as discontinued any cigarette use at W2 and any cigarette use at W3.

<sup>a</sup>denotes significant difference at  $p < 0.0167$  (Bonferroni corrected for three comparisons) between youth and young adults

<sup>b</sup>denotes significant difference at  $p < 0.0167$  (Bonferroni corrected for three comparisons) between youth and adults 25+

<sup>c</sup>denotes significant difference at  $p < 0.0167$  (Bonferroni corrected for three comparisons) between young adults and adults 25+

The logit-transformation method was used to calculate the 95% CIs.

Analyses were run on the W1, W2, and W3 Public Use Files (<https://doi.org/10.3886/ICPSR36498.v8>).

among 28.8% (95% CI 24.6 to 33.3) of youth, 25.3% (95% CI 23.3 to 27.5) of young adults and 14.6% (95% CI 13.6 to 15.6) of adults 25+; the differences between youth and adults 25+, and between young adults and adults 25+ were statistically significant. Reuptake of cigarette use occurred among 10.9% (95% CI 8.2 to 14.3) of youth, 6.6% (95% CI: 5.6 to 7.8) of young adults and 3.1% (95% CI 2.6 to 3.5) of adults 25+ and the differences among all three age groups were statistically significant.

#### Among P30D exclusive cigarette users and P30D cigarette polytobacco users at W1

As shown in the notes to online supplementary figure 2, among adult 25+ W1 P30D cigarette users, the majority were exclusive cigarette users (62.6% (95% CI: 61.1 to 64.0)) compared with cigarette polytobacco users (37.4% (95% CI 36.0 to 38.9)). In contrast, among W1 P30D youth and young adult cigarette users, more were cigarette polytobacco users (57.1% (95% CI 52.1 to 61.9) of youth and 65.2% (95% CI 63.0 to 67.4) of young adults). Only 42.9% (95% CI 38.1 to 47.9) of youth and

34.8% (95% CI 32.6 to 37.0) of young adults W1 P30D smokers were exclusive cigarette users. Aim 3 examined 25 possible W1–W2–W3 pathways across five mutually exclusive use categories (online supplementary figure 2) among W1 exclusive cigarette users (online supplementary table 1a) and W1 cigarette polytobacco users (online supplementary table 1b). Described below are aggregated pathways from online supplementary table 1a,b that estimate broad behavioural transitions such as persistent use, tobacco cessation and relapse in these two W1 user groups (table 1).

*Among youth.* As shown in table 1, 14.2% (95% CI 9.6 to 20.4) of W1 exclusive cigarette users persisted as exclusive users across all three waves, compared with 42.7% (95% CI 35.5 to 50.2) of W1 cigarette polytobacco users who persisted as cigarette polytobacco users across all three waves. Complementing this finding, 38.8% (95% CI 31.8 to 46.3) of W1 exclusive cigarette users transitioned to some form of polytobacco use by W3, in contrast to 10.7% (95% CI 7.2 to 15.4) of W1 cigarette polytobacco users transitioning to exclusive cigarette use by W3.

**Table 1** Transitions in P30D product use at W2 (2014/15) and W3 (2015/16) among W1 (2013/14) P30D cigarette users

	Youth			Young Adults			Adults 25+			
	W1 Exclusive Cigarette Use			W1 Exclusive Cigarette Use			W1 Exclusive Cigarette Use			
	Weighted %	95% CI	PTU	Weighted %	95% CI	PTU	Weighted %	95% CI	PTU	
<b>Mutually Exclusive Pathways</b>										
Persistent cigarette use type at all waves										
Continuing the same W1 use type (exclusive or PTU) at each wave	14.2 <sup>a</sup>	(9.6-20.4)	42.7 <sup>a</sup>	26.2 <sup>a</sup>	(23.0-29.7)	36.5 <sup>a</sup>	54.1 <sup>a</sup>	(52.3-55.9)	34.9 <sup>a</sup>	(33.0-36.9)
Cigarette use type reuptake										
The same use type (exclusive or PTU) at W1 and W3 (but a different tobacco use at W2)	11.3	(6.5-18.7)	11.8	14.9 <sup>a</sup>	(12.1-18.2)	10.1 <sup>a</sup>	10.2	(9.2-11.3)	10.6	(9.2-12.2)
Cigarette use type transition										
Transition from W1 exclusive use to PTU by W3, or transition from W1 PTU to exclusive use by W3 (without discontinuing all tobacco use at W2)	38.8 <sup>b</sup>	(31.8-46.3)	10.7 <sup>a</sup>	26	(22.6-29.8)	24.5	18.3 <sup>a</sup>	(16.9-19.8)	37.4 <sup>a</sup>	(35.4-39.4)
Switch or discontinue cigarette use, but continue other tobacco use										
W1 exclusive user who switches to another tobacco product by W3 or W1 polytobacco user that discontinues cigarette use by W3 but uses another tobacco product (without discontinuing all tobacco use at W2)	4.7 <sup>c</sup>	(2.1-10.0)	6.9	5.0 <sup>a</sup>	(3.5-7.0)	10.5 <sup>a</sup>	1.7 <sup>a</sup>	(1.3-2.3)	7.3 <sup>a</sup>	(6.3-8.5)
Tobacco use reuptake										
W1 users who discontinue all tobacco use at W2 and use again at W3	11.5	(7.7-16.8)	8.2	7.2	(5.3-12.6)	4.9	2.8 <sup>a</sup>	(2.3-3.4)	1.9 <sup>a</sup>	(1.4-2.5)
Discontinue all tobacco use										
W1 users who discontinue all tobacco use at either W2 and W3 or just W3	19.5	(14.1-26.4)	19.8	20.7 <sup>b</sup>	(17.3-24.6)	13.4 <sup>b</sup>	12.9 <sup>a</sup>	(11.7-14.2)	7.9 <sup>a</sup>	(7.0-9.1)

Analysis included youth (ages 12-17), young adult (ages 18-24), and adult 25+ (ages 25 and older) W1 P30D cigarette users with data at all three waves. Respondent age was calculated based on age at W1. W3 longitudinal (all-waves) weights were used to calculate estimates. All tobacco use is defined as P30D use. Use type refers to exclusive use or PTU.

<sup>a</sup>denotes significant difference at  $p < 0.05$  between W1 Exclusive Cigarette Use and W1 Cigarette PTU.

The logit-transformation method was used to calculate the 95% CIs.

<sup>b</sup>Estimate should be interpreted with caution because it has low statistical precision. It is based on a denominator sample size of less than 50, or the coefficient of variation of the estimate or its complement is larger than 30%.

Analyses were run on the W1, W2, and W3 Public Use Files (<https://doi.org/10.3886/ICPSR36498.v8>).

CI, confidence interval; P30D, past 30-day; PTU, polytobacco use; W1, Wave 1; W2, Wave 2; W3, Wave 3.

*Among young adults.* As shown in [table 1](#), 26.2% (95% CI 23.0 to 29.7) of W1 exclusive cigarette users persisted as exclusive users across all three waves, compared with 36.5% (95% CI 33.9 to 39.2) of cigarette polytobacco users who persisted as cigarette polytobacco users across all three waves. In addition, there were differences in other pathways such as cigarette use type reuptake and switching or discontinuing cigarette use without quitting tobacco. For instance, 14.9% (95% CI 12.1 to 18.2) of W1 exclusive cigarette users stopped exclusive cigarette use at W2 and took it up again at W3, without quitting tobacco entirely, compared with 10.1% (95% CI 8.6 to 11.8) of W1 cigarette polytobacco users who stopped cigarette polytobacco use at W2 but took it up again at W3, without quitting tobacco entirely. Additionally, while 5.0% (95% CI 3.5 to 7.0) of W1 exclusive cigarette users discontinued cigarettes while still using tobacco, compared with 10.5% (95% CI 8.9 to 12.4) of W1 cigarette polytobacco users who discontinued cigarettes while still using tobacco. Finally, 20.7% (95% CI 17.3 to 24.6) of W1 exclusive cigarette users discontinued all tobacco use by Wave 3, compared with 13.4% (95% CI 11.6 to 15.5) of W1 cigarette polytobacco users.

*Among adults 25+.* As shown in [table 1](#), 54.1% (95% CI 52.3 to 55.9) of W1 exclusive cigarette users persisted as exclusive users across all three waves, compared with 34.9% (95% CI 33.0 to 36.9) of W1 cigarette polytobacco users who persisted as cigarette polytobacco users across all three waves. Additionally, 18.3% (95% CI 16.9 to 19.8) of W1 exclusive cigarette users transitioned from W1 exclusive use to polytobacco use by W3, compared with 37.4% (95% CI 35.4 to 39.4) of W1 cigarette polytobacco users who transitioned to exclusive use by W3. Almost 13% (12.9% (95% CI 11.7 to 14.2)) of W1

exclusive cigarette users discontinued all tobacco use by Wave 3, compared with 7.9% (95% CI 7.0 to 9.1) of W1 cigarette polytobacco users.

## DISCUSSION

Cigarettes are the most prevalent form of tobacco used in the USA<sup>2</sup> as well as the most harmful tobacco product.<sup>7</sup> This combination of higher prevalence and greater harm has significant implications for public health. In cross-sectional analyses based on data from 2013 to 2016 (W1–W3), prevalence of ever (only among youth), P12M and P30D cigarette smoking decreased among youth and young adults but remained relatively constant for adults 25+ (although statistically significant changes in adult 25+ ever, P12M and P30D use were detected, they are of small magnitude and may not be meaningful). Likely of greater import for public health, there were statistically significant decreases in daily cigarette use among both young adults and adults 25+, with the largest decreases occurring between W1 and W2.

The observed decrease in youth cigarette smoking is consistent with other national surveillance studies,<sup>8</sup> although the rates of P30D cigarette smoking in 2016 are slightly lower among youth in the PATH Study (5.5% among 15–17-year olds and 1.0% among 12–14-year olds), compared with those in the 2016 National Youth Tobacco Survey (NYTS) (8.0% in high school students and 2.2% in middle school students).<sup>8</sup> This may be due to differences in the definition of youth, with high school students aged 18 and older included in the NYTS estimate but not in the PATH Study youth estimate, as well as different skip patterns in the data collection instruments. There is also evidence that household-based assessments of tobacco use prevalence, such as the PATH Study, tend to be lower than school-based assessments (eg, NYTS).<sup>30</sup>

Across the 3 years observed in this paper, about 60% of youth W1 P30D cigarette smokers smoked cigarettes in P30D at all three waves, compared with almost 70% of young adults and 80% of adults 25+. Several other longitudinal studies have identified that cigarette smoking is persistent over even longer time periods.<sup>31–33</sup> For example, over a 15-year period of the National Longitudinal Survey of Youth 1997, almost 40% of established smokers continued to smoke cigarettes over time.<sup>17</sup> In the Coronary Artery Risk Development in Young Adults study, 52.8% of baseline current smokers continued cigarette smoking over 25 years.<sup>34</sup> Given ongoing changes in the US tobacco market, where an increasingly diverse mix of tobacco products, including ENDS, cigars and smokeless tobacco products are available, the finding that cigarette use remains persistent highlights the continued importance of monitoring all tobacco products, including cigarette.

Nevertheless, we also found that 15%–30% of W1 P30D cigarette smokers discontinued cigarette use by W3, with youth having the highest rate of discontinuing cigarettes and adults 25+ having the lowest. Looking across the papers in this supplement issue, the P30D cigarette discontinuation rate was lower than that of other tobacco products,<sup>35–37</sup> with the exception of smokeless tobacco.<sup>38</sup> In contrast to their low P30D cigarette discontinuation rate, adults 25+ had higher rates of discontinuing ENDS and hookah, compared with youth and young adults.<sup>35–38</sup>

Among W1 P30D exclusive cigarette smokers, less than 15% of youth, a quarter of young adults and more than half of adults 25+ used only cigarettes across all three waves without using another product. We also found that among W1 cigarette polytobacco users in all age groups, the most common transition among

### What this paper adds

- ▶ This study adds a three-wave examination of cigarette use rates in the United States across multiple definitions of use for youth, young adults and adults 25+. Across all three waves, young adults have the highest prevalence rates of past 12-month and past 30-day (P30D) use, compared with youth and adults 25+.
- ▶ Longitudinal pathways indicate that cigarette use is persistent over time, with more than 80% of W1 P30D adult 25+ cigarette smokers, almost 70% of W1 P30D young adult cigarette smokers and about 60% of W1 P30D youth cigarette smokers using cigarettes at all three waves. Since cigarettes have been identified as the most harmful tobacco product on the continuum of risk, the persistent use of cigarettes is a risk to public health.
- ▶ Consistent with the finding that the majority of W1 P30D cigarette smokers continued to smoke, 15%–30% of P30D smokers discontinued cigarette use between W1 and W3, with youth having the highest rate of discontinuation and adults 25+ the lowest.
- ▶ While almost 40% of youth cigarette users transitioned from exclusive cigarette use at W1 to cigarette polytobacco use by W3, only 26% of young adults and 18.3% of adults 25+ followed this pathway. Transitions from W1 cigarette polytobacco use to exclusive cigarette use at W3 occurred in only about 10% of youth, a quarter of young adults and about one-third of adults 25+. These finding suggests that youth may be more likely to be cigarette polytobacco users, compared with adults 25+.

those examined was to continue cigarette polytobacco use at W2 and W3; the second most common transition for young adults and adults 25+ was a transition back to exclusive cigarette use by W3. This is consistent with studies that have found higher levels of nicotine dependence among polytobacco users, which might lead to continued cigarette use,<sup>39</sup> and those that have found that cigarette use is persistent over time, as discussed above. The finding that both exclusive and polytobacco cigarette users tend to continue cigarette use further demonstrates the persistence of cigarette use and the pressing need to determine the most effective strategies to help users of all tobacco products, including cigarettes, quit tobacco.

Among youth, the pattern among cigarette polytobacco users was different. After persistent cigarette polytobacco use, the next most common transition among those examined was discontinued use of all tobacco, which likely reflects the more episodic, less stable pattern of youth tobacco use.<sup>40</sup> However, there are also patterns of youth reuptake of cigarette polytobacco use and transition to exclusive cigarette use, which may indicate that among those youth who continue using tobacco, cigarette use also persists.

Finally, we found that the frequency of transitioning to cigarette polytobacco use among W1 exclusive cigarette smokers differed among age groups. While almost 40% of youth transitioned from exclusive to cigarette polytobacco use by W3, only 26% of young adults and 18% of adults 25+ followed this pathway. In contrast, transitions from W1 cigarette polytobacco use to exclusive cigarette use at W3 occurred in only about one-third of adults 25+, a quarter of young adults and about 10% of youth. These findings suggest that, compared with adults, youth may be more vulnerable to polytobacco use, which may be due to the appeal of other tobacco products like flavoured products and products that are perceived as at low risk like ENDS.<sup>41</sup> In addition, it is also not clear if youth use of tobacco products is mere experimentation or if these patterns are indicative of the future long-term use. This report is a resource that provides building blocks to aggregate different pathways to explore a variety of research questions regarding cigarette use.

### Limitations

This study relies on self-reported data, which is subject to recall bias. In addition, discontinued use was defined as no P30D use, without any consideration of intent to quit or duration of cessation, which may have overestimated rates of discontinued use. This study also did not examine transitions in frequency of use, especially transitions to daily use, which may be important to understanding overall patterns of transition. Future studies are needed to examine correlates that predict patterns of transition among exclusive and polytobacco users. Within this journal supplement, Kasza *et al*<sup>42,43</sup> and Edwards *et al*<sup>44</sup> examine demographic correlates of initiation, cessation and relapse of cigarette use to further explore predictors of these behavioural outcomes.

### Summary and implications

The persistence of cigarette use among all types of cigarette users (exclusive cigarette users and cigarette polytobacco users) is of particular public health concern since cigarettes have been identified as the most harmful tobacco product. Policy efforts that focus on the continuum of risk, such as the Food and Drug Administration's comprehensive plan for tobacco and nicotine, which is aimed at reducing the harmful effects of tobacco, need to consider a continued focus on cigarettes in addition to new and emerging products such as ENDS.

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