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# Cannabis use and progression to regular tobacco use among United States youth and young adults: evidence from the Population Assessment of Tobacco and Health (PATH) study, 2017–2021

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## ABSTRACT

**Background** Tobacco use among United States (US) youth and young adults has declined from historic levels, but cannabis use has not. The importance of cannabis use as a risk factor for tobacco initiation is not known.

**Methods** The association between past 12-month cannabis use in 2017 (study exposure; wave 4) and new-onset regular tobacco use in 2021 (study outcome; wave 6) was examined in a prospective representative US cohort aged 12–24 years who had never regularly used tobacco. Exposed respondents were propensity score matched to unexposed controls on demographics, tobacco use history, perceived harmfulness of cigarettes, mental health symptoms and other measures.

**Results** Among these US youths aged 12–17 years who used cannabis, 32.7% (95% CI: 28.9% to 36.7%) progressed to regular tobacco use in 2021, an increase of 15.6 percentage points (pp) (95% CI: 11.1 pp to 20.2 pp) compared with their matched controls. Among the young adults aged 18–24 years, 14.0% (95% CI: 11.9% to 16.5%) of cannabis users reported regular tobacco use at follow-up, an increase of 5.4 pp (95% CI: 2.6 pp to 8.2 pp) over their matched controls. The matching analysis attributed 13.0% of total new regular tobacco use in the US to cannabis (the population attributable fraction), and estimated that in the absence of cannabis, 509 800 fewer US youth and young adults would have progressed to regular tobacco use in 2021.

**Conclusion** Among US youth and young adults who had never regularly used tobacco, cannabis use in 2017 was associated with a large increase in current regular tobacco use in 2021.

## INTRODUCTION

Cigarette smoking remains a leading cause of preventable disease and death in the United States (US),<sup>1,2</sup> and has been the most popular mode of tobacco use for many decades. Historically, smoking has also been the most popular method of cannabis use.<sup>3</sup> In the 1970s, when 74% of US high school (HS) seniors had smoked a cigarette compared with 47% who had ever used cannabis,<sup>4</sup> a “gateway” hypothesis noted that adolescent cannabis users had almost all started by first smoking tobacco.<sup>5</sup>

With public health action against tobacco, cigarette smoking declined among US youth,<sup>6</sup> but, importantly, cannabis use did not decline in the

## WHAT IS ALREADY KNOWN ON THIS TOPIC

- ⇒ Smoking is a well-established risk factor for initiating cannabis use.
- ⇒ Evidence for cannabis as a risk factor for tobacco initiation is limited however.

## WHAT THIS STUDY ADDS

- ⇒ Among United States (US) youth, cannabis use is a major risk factor for progression to regular tobacco use, independent of whether or not they have yet tried tobacco.
- ⇒ Cannabis use accounted for about 13% of total new-onset regular tobacco use in the US in 2021, according to a propensity score matching analysis.

## HOW THIS STUDY MIGHT AFFECT RESEARCH, PRACTICE OR POLICY

- ⇒ Cannabis prevention should be incorporated as a synergistic strategy within tobacco control programmes.

same way. By 2005, 50% of US HS seniors had ever used tobacco, and 45% had ever used cannabis.<sup>4</sup> Around this time, a “reverse gateway” hypothesis proposed cannabis as a risk factor for future cigarette smoking.<sup>7,8</sup>

Among US youths, although cigarette smoking is now at a historically low level, electronic nicotine delivery systems (ENDS) have become the most popular tobacco product.<sup>9,10</sup> Vaped nicotine is highly addictive and may lead to long-term harm of the respiratory and cardiovascular systems.<sup>11–14</sup> Given the rise of newer tobacco products, ever-use of any tobacco product has been comparatively stable among US HS students in recent years, at 25% in 2011 and 23.4% in 2024.<sup>4</sup> Cannabis can also be vaped, and vaping is now a popular delivery method for cannabinoids.<sup>15</sup> Ever-use of cannabis also has been comparatively stable, at 47% among US HS students in 2024, higher than rates of tobacco use.<sup>4</sup>

There are common liabilities for the initiation of both tobacco and cannabis, which include the individual's level of anxiety, depression, conduct disorder and attention-deficit/hyperactivity disorder, as well as environmental factors such as



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stress, drug use modelling in the family, the social norms of friendship groups and easy access to products.<sup>16 17</sup> Twin studies have identified overlapping genetic influences in the use of cannabis and tobacco. These include genes that influence dopamine signalling and genetic factors that predispose people to impulsivity and risk taking.<sup>18 19</sup> Co-use of nicotine and cannabinoids is common,<sup>8 16 20–22</sup> given these common risk factors, their common modes of administration and their potential synergistic effects.<sup>20 23</sup>

A recent meta-analysis investigated whether each of cannabis and tobacco was a risk factor for initiation of the other.<sup>24</sup> The review identified only a few studies investigating a “reverse gateway” from cannabis to initiation of tobacco use and did not identify a statistically significant effect among US youth.<sup>25–27</sup> However, given the prevalence of cannabis use, and the potential and known long-term health effects of tobacco use, the extent to which cannabis use is a risk factor for initiation of tobacco use remains an important public health question.

Studies of tobacco use initiation in the US have historically focused on cigarette smoking uptake in adolescents, from susceptibility,<sup>28</sup> through experimentation, to established cigarette smoking.<sup>29</sup> However, adolescents now initiate use across multiple tobacco products,<sup>25 30 31</sup> including into young adulthood.<sup>32</sup> In the nationally representative Population Assessment of Tobacco and Health (PATH) cohort study, “regular tobacco use” is established across a comprehensive list of tobacco products by asking whether a respondent has ever used each product “fairly regularly”.

In this study, we investigated a representative longitudinal cohort of US youth and young adults aged 12–24 years who had never or never regularly used any tobacco product in 2017. We hypothesised there would be an association of past-year cannabis use at baseline with progression to current regular tobacco use at follow-up 4 years later, in 2021. To control for confounding, we used propensity score matching because of its relative transparency and ease of interpretation.<sup>33</sup> We matched each cannabis user to a similar non-user on demographics, history of experimentation with tobacco products, perceived harmfulness of cigarettes, mental health symptoms and other baseline measures. To quantify the effect of cannabis as a risk factor for initiation of tobacco use we compared rates of current regular tobacco use at follow-up between the users and the matched non-users. We also used this approach to compute the population proportion of new current regular tobacco use in the US that was associated with prior cannabis use, both for tobacco naive respondents and for those who had previously experimented with tobacco. Multi-variable logistic regression was used as a sensitivity analysis.

## METHODS

### Data source

The PATH cohort study comprises a representative probability sample from an address-based list of US households. PATH survey weights adjust for the sampling design, for longitudinal dropout and for non-response, and weighted estimates are representative of the civilian non-institutionalised US population.<sup>34</sup> Subjects are regularly assessed using computer-assisted self-interviews, with separate questionnaires for youth and adults.<sup>35</sup> The study sample was refreshed at wave 4 (W4; December 2016 to January 2018), which re-interviewed 11 059 youth and 27 757 adults from the initial cohort along with a newly recruited replenishment sample of 1574 youth and 6065 adults. The W4 cohort was re-interviewed in 2019 (W5) and 2021 (W6; March through September). Our study sample included all respondents

aged 12–24 years at PATH study W4 (2017, n=21 395) who had never or never regularly used any tobacco product, and who also responded to W5 (n=18 390) and W6 (n=13 851). Survey response rates were above 60% for adults and 70% for adolescents.<sup>34</sup> Missing data items were infrequent and were imputed to the lowest-risk category (online supplemental eTables 1 and 2). The Westat Institutional Review Board approved the study and all respondents provided written informed consent. We used the PATH restricted-use data files<sup>36</sup> and followed the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) reporting guidelines.<sup>37</sup>

### Tobacco use status

At W4–W6, respondents were asked if they had smoked at least 100 cigarettes in their lifetime and, after seeing product images, if they had ever used an ENDS, traditional cigar, cigarillo, filtered cigar, hookah, smokeless tobacco or snus, and, for adults, a pipe; if affirmative, they were asked if they had “ever used [the product] fairly regularly”. Those indicating that they had *never used any tobacco product* were further categorised as either committed never-users or susceptible never-users of tobacco.<sup>28 38</sup> Respondents who indicated that they had used at least one product at some point, but had *never used any tobacco product regularly*, were identified as having a history of use of (1) non-combusted tobacco only (ie, ENDS, smokeless tobacco, snus); (2) combusted tobacco only (ie, cigarettes, cigars, cigarillos, pipes, hookah); or (3) a history of ever-use of both combusted and non-combusted tobacco. The study outcome was current regular tobacco use at W6, indicating that a respondent had progressed to regular tobacco use by W5 or W6 and also reported current use of one or more tobacco products at W6.

### Past 12-month cannabis use at W4

Cannabis use was ascertained as a positive response to either “In the past 12 months, [have you] smoked part or all of a traditional cigar, cigarillo or filter cigar with marijuana?” or “In the past 12 months, [have you] used marijuana, hash, THC, grass, pot or weed?”.

### Potential confounders at W4

Potential confounders for tobacco use progression<sup>39</sup> assessed by the PATH study have been previously described.<sup>40</sup> All confounders were assessed at W4 including age (classified into youth ages 12–14, 15–17 years; and young adults ages 18–21, 22–24 years), sex (male, female), race/ethnicity (Hispanic, non-Hispanic Asian, non-Hispanic Black, non-Hispanic White, non-Hispanic Other), regions (West, Midwest, Northeast, South), living with a tobacco user (yes/no) and living in a smoke-and-vape-free home (yes/no). Additional confounders included perceived harmfulness of cigarettes<sup>41</sup> (low/moderate vs high), exposure to advertisement of cigarettes or ENDS in the past 30 days (yes/no) and internalising and externalising mental health symptoms<sup>42</sup> (low, moderate or high).

### Statistical analysis

All estimates were weighted to represent the civilian, non-institutionalised US population, using the W4 to W6 all-wave weights which adjust for the sampling design and non-response. US subpopulation totals were estimated by summing the survey weights.<sup>43</sup> Inference used replicate weights with balanced repeated replication (BRR) and Fay’s adjustment (p=0.3) (R package ‘survey’).<sup>43</sup> Estimates are presented with 95% confidence

**Table 1** Past 12-month cannabis use among United States 12–24-year-old never regular tobacco users, by baseline characteristics, 2017

Baseline characteristics		Sample size* N (weighted %†)	Past 12-month cannabis use, weighted %† (95% CI)
Overall		13 851 (100)	15.4 (14.3 to 16.5)
Age (years)	12–14	4925 (27.9)	2.6 (2.2 to 3.0)
	15–17	4335 (26.2)	14.6 (13.3 to 15.9)
	18–21	3388 (28.5)	25.3 (22.9 to 27.7)
	22–24	1203 (17.4)	20.9 (18.2 to 23.6)
Tobacco use history	Never tried tobacco	10216 (68.7)	4.5 (4.0 to 5.1)
	Tried only combusted	1083 (10.5)	29.1 (26.3 to 32.0)
	Tried only non-combusted	935 (6.6)	27.7 (24.2 to 31.2)
	Tried both combusted and non-combusted tobacco	1617 (14.2)	52.2 (49.1 to 55.3)
Sex	Female	7182 (51.7)	16.3 (15.0 to 17.5)
	Male	6669 (48.3)	14.5 (13.0 to 15.9)
Race/ethnicity	Hispanic	4236 (23.4)	15.7 (14.0 to 17.4)
	Non-Hispanic Asian	508 (6.0)	15.0 (10.8 to 19.1)
	Non-Hispanic Black	2094 (14.3)	18.0 (16.0 to 20.0)
	Non-Hispanic Other	866 (4.6)	18.1 (14.8 to 21.4)
	Non-Hispanic White	6147 (51.7)	14.3 (12.6 to 16.1)
Live with tobacco user	No	10 126 (73.1)	13.8 (12.6 to 14.9)
	Yes	3725 (26.9)	19.8 (18.1 to 21.5)
Smoke-and-vape-free home	No	3126 (23.4)	19.2 (17.5 to 20.9)
	Yes	10725 (76.6)	14.2 (13.0 to 15.5)
Perceived harmfulness of smoking cigarettes	Low/Moderate	835 (5.6)	21.5 (18.2 to 24.7)
	High	13 016 (94.4)	15.0 (13.9 to 16.2)
Internalised mental health symptoms	Low	6810 (49.6)	12.2 (11.0 to 13.4)
	Moderate	3865 (27.9)	15.5 (13.7 to 17.4)
	High	3176 (22.5)	22.3 (20.0 to 24.5)
Externalised mental health symptoms	Low	7458 (54.9)	12.9 (11.8 to 14.1)
	Moderate	5520 (39.5)	18.1 (16.2 to 19.9)
	High	873 (5.7)	20.9 (17.2 to 24.7)

Note: The range of survey weighted proportion of missingness is (0%, 3.5%). Details for missing values are in online supplemental eTable 1.

\*Data are from the Population Assessment of Tobacco and Health (PATH) study wave 4 (2017).

†Weighted United States population estimates using the wave 6 all-wave longitudinal weights for the wave 4 cohort.

CI, confidence interval.

intervals (95% CI) and statistical significance was assessed at the two-sided 5% level using R (version 4.4.3).

The propensity score model was estimated using unweighted logistic regression<sup>33</sup> on W4 data, with dependent variable past 12-month (p12m) cannabis use. We used two to one nearest neighbour matching without replacement (R package ‘MatchIt’) with a calliper of 0.10, prioritising exact matching<sup>44</sup> on age group and tobacco ever-use status. Matching quality was assessed via Love plots. The survey-weighted difference in progression rates at W6 was computed between the matched exposed and control groups, using the survey weight from the exposed respondent. The number progressing attributed to cannabis use was estimated by multiplying the risk difference from the matching analysis by the estimated size of the exposed population. As sensitivity analyses, we investigated matching with replacement and also estimated adjusted effect sizes from weighted multivariable logistic regression.

## RESULTS

### Sample characteristics

The study cohort comprised a representative US sample of 13 851 respondents aged 12–24 years who had never or never regularly used tobacco at W4 (2017) and who completed the W5 and W6 surveys. The cohort was 51.7% non-Hispanic White, 44.1% aged under 18 years and 15.4% had used cannabis in

the past year (table 1). Cannabis use increased with age (12–14 years, 2.6%; 18–21 years, 25.3%), was lowest among those who had never tried tobacco (4.5%) and was highest among those who had tried both combustible and non-combustible tobacco (52.2%).

### Population rates of progression to current regular tobacco use

Among US youth aged 12–17 years in 2017 who had never regularly used tobacco, 33.8% (95% CI: 30.1% to 37.8%) of those who used cannabis reported current regular tobacco use in 2021, compared with 8.5% (95% CI: 7.8% to 9.2%) who did not use cannabis. Considering US young adult never-regular tobacco users, these rates were 14.4% (95% CI: 12.0% to 17.1%) and 5.0% (95% CI: 4.1% to 6.1%), respectively. Table 2 presents rates of progression to regular tobacco use stratified by age, tobacco experimentation history and cannabis use status.

### Propensity score matching

The propensity score was estimated from logistic regression using baseline data (online supplemental eTable 3). The adjusted odds of p12m cannabis use were higher at older ages and among those who had experimented with tobacco, and differed by race, US region, presence of mental health symptoms and presence of

**Table 2** Current regular tobacco use in 2021, among United States youth and young adults who had never regularly used tobacco in 2017, by age group, tobacco use history and cannabis use status\*

2017 status			Cannabis use in past 12 months N (weighted %†)	2021 prevalence of current regular tobacco use, weighted %† (95% CI)
Age‡	Tobacco use history			
Youth	Never tried any tobacco	No	7654 (44.2)	6.3 (5.7 to 6.9)
		Yes	242 (1.4)	24.0 (17.7 to 31.8)
	Tried only non-combusted tobacco	No	431 (2.6)	27.5 (23.0 to 32.5)
		Yes	171 (1.0)	33.0 (25.4 to 41.6)
	Tried only combusted tobacco	No	227 (1.5)	25.4 (18.8 to 33.3)
		Yes	90 (0.5)	32.3 (22.1 to 44.6)
	Tried both combusted and non-combusted tobacco	No	204 (1.3)	26.1 (19.9 to 33.3)
		Yes	241 (1.6)	43.4 (36.3 to 50.7)
Young adults	Never tried any tobacco	No	2140 (21.4)	2.5 (1.9 to 3.4)
		Yes	180 (1.7)	2.8 (1.1 to 7.0)
	Tried only non-combusted tobacco	No	234 (2.2)	7.0 (3.8 to 12.7)
		Yes	99 (0.8)	8.6 (4.1 to 17.1)
	Tried only combusted tobacco	No	520 (6.0)	6.1 (4.1 to 9.1)
		Yes	246 (2.5)	10.0 (6.6 to 14.8)
	Tried both combusted and non-combusted tobacco	No	551 (5.5)	12.7 (9.3 to 17.0)
		Yes	621 (5.8)	20.5 (16.6,25.1)
Overall			13 851 (100)	

\*Data are from the Population Assessment of Tobacco and Health (PATH) study wave 4 (2017) and wave 6 (2021).

†Weighted United States population estimates using the wave 6 all-wave longitudinal weights for the wave 4 cohort.

‡Youth: ages 12–17 years; young adults: ages 18–24 years.

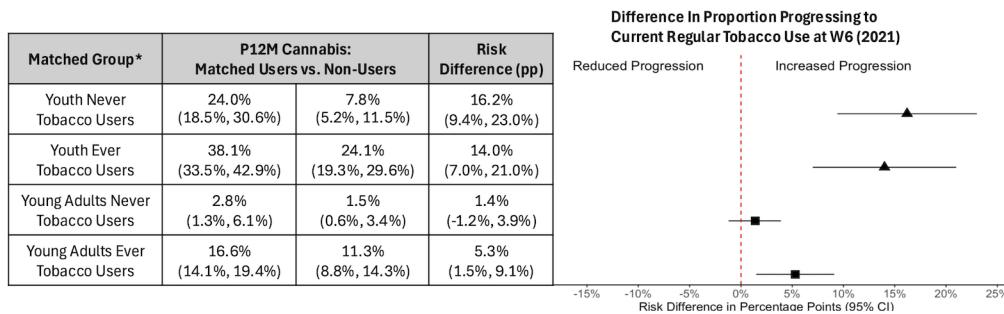
CI, confidence interval.

a tobacco user in the home. We used the estimated propensity score to match each exposed respondent (cannabis user) with up to two similar unexposed respondents, with exact matching

on age group and tobacco ever-use. Most cannabis users were successfully matched (93%). Imbalance in the baseline covariates is apparent in the Love plot before matching (figure 1);



**Figure 1** Absolute standardised mean differences (Love plot) for potential baseline confounders, comparing those who used cannabis to those who did not, among 12–24-year-old never regular tobacco users in 2017.



**Figure 2** Percent progressing to new regular tobacco use in 2021 among United States never regular tobacco users in 2017, comparing cannabis users to their matched controls; stratified by youth versus young adults and never versus ever tobacco use in 2017. \*Youth: ages 12–17 years; young adults: ages 18–24 years in 2017; never tobacco users: those with no report of ever having tried any tobacco product by wave 4 (2017) of the Population Assessment of Tobacco and Health (PATH) survey. P12M cannabis: past 12-month cannabis use, reported at wave 6 (W6) (2021) of the PATH survey. pp, percentage points.

after matching, the exposure groups were well balanced on all confounders.

### Matched analysis of progression to current regular tobacco use, by baseline cannabis use

The proportion who progressed to current regular tobacco use in 2021 was compared between those who used cannabis at baseline, and their matched controls with no cannabis use, stratified by baseline age and tobacco use history (figure 2). Among 12–17-year-old US youths who had never used tobacco, 24.0% (95% CI: 18.5% to 30.6%) of those who used cannabis at baseline reported current regular tobacco use in 2021, compared with 7.5% (95% CI: 5.2% to 10.7%) of their matched controls who did not use cannabis, an increase of 16.5 pp (95% CI: 9.9 pp to 23.2 pp;  $p < 0.001$ ). Among 12–17-year-old youths who had experimented with but never regularly used tobacco, 36.8% (95% CI: 32.1% to 41.9%) of those who used cannabis reported current regular tobacco use in 2021, compared with 22.9% (95% CI: 19.7% to 26.4%) of their matched peers who did not use cannabis, an increase of 14.0 pp (95% CI: 8.0 pp to 19.9 pp;  $p < 0.001$ ).

Among 18–24-year-old US young adults who had never used tobacco but who used cannabis, 2.8% (95% CI: 1.3% to 6.1%) reported current regular tobacco use at follow-up, compared with 1.5% (95% CI: 0.6% to 3.4%) among their matched controls, a non-significant increase of 1.4 pp (95% CI: 1.9 pp to 7.4 pp;  $p = 0.29$ ). Among 18–24-year-old US young adults who used cannabis and had experimented with but not regularly used tobacco, 16.3% (95% CI: 13.8% to 19.2%) reported current regular tobacco use at follow-up, compared with 10.8% (95% CI: 8.9% to 13.0%) among their matched controls, an increase of 5.6 pp (95% CI: 2.2 pp to 9.0 pp;  $p = 0.001$ ).

### Sensitivity analysis

Matching with replacement, which matches all cannabis users, gave risk differences within 2 percentage points of the results above (online supplemental eFigures 1 and 2). Weighted adjusted logistic regression analysis (online supplemental eTable 4) provided results with similar effect sizes and direction as the matched analysis.

### Estimated proportion of 2021 new regular tobacco use attributed to cannabis

Estimated numbers of US youth and young adults who had never used tobacco regularly in 2017 but who progressed to current regular tobacco use in 2021 are given in table 3. The number of

these who are attributed to cannabis use by the matching analysis is computed using the risk differences presented in figure 2. Among the estimated 1.96 million never regular tobacco users aged 12–17 years who used cannabis in 2017, 33.8% or 0.66 million progressed to current regular tobacco use by 2021, and the matched analysis estimates that these numbers would have been reduced by 43.6% in the absence of cannabis. Among the 4.69 million never regular tobacco user young adults who used cannabis, 0.67 million or 14.4% progressed to current regular tobacco use, and it is estimated that these numbers would have been reduced by 32.6% in the absence of cannabis. Overall, the matched analysis estimated that 0.51 million youths and young adults progressed to new-onset current regular tobacco use in 2021, in association with cannabis use, and that cannabis use accounted for 13.0% of the total progression.

### DISCUSSION

Our study population comprised a nationally representative cohort of US youth and young adults who had never regularly used tobacco in 2017. We examined the association of past 12-month cannabis use with new-onset regular tobacco use 4 years later, in 2021. After adjusting for confounding factors, we found that those who reported past-year cannabis use were significantly more likely to progress to regular tobacco use. Our results suggest that reducing cannabis use among youth and young adults, in itself an important public health goal, would also substantially reduce progression to regular tobacco use.

In this cohort, cannabis and tobacco shared many common risk factors, including prior experimentation with tobacco products, living with a smoker in the home, reported mental health symptoms and residence in the South or Midwest. To adjust for potential confounding, we matched each subject who reported cannabis use with one or two control subjects who did not use cannabis but were otherwise similar as regards these baseline characteristics. We then compared the rate of progression to current regular tobacco use between the cannabis users and their matched controls. From this matching analysis, we found that among US youth who had never regularly used tobacco, cannabis use in 2017 was associated with a 14–17 percentage point increase in current regular tobacco use in 2021. Importantly, the increase was similar among youths who had previously experimented with tobacco, and among those youths who were tobacco-naive. Among young adults, if they had never tried tobacco at baseline, cannabis use was not associated with increased progression to current regular tobacco use. However, for young adults who had already tried a tobacco product at

**Table 3** United States population estimates of numbers progressing to new-onset regular tobacco use in 2021, by age, tobacco use history and cannabis use status in 2017; and estimated proportion progressing which is attributed to cannabis use by the matched analysis

2017 tobacco use		Ages 12–17 years		Ages 18–24 years		Total
		P12M cannabis use		P12M cannabis use		
		No	Yes	No	Yes	
Never tried tobacco in 2017	US population 2017*	19 107 701	594 668	9 269 767	747 033	29 719 169
	Number (%)* who progressed to regular tobacco use in 2021	1 199 038 (6.3%)	142 866 (24.0%)	234 558 (2.5%)	20 991 (2.8%)	1 597 453 (5.4%)
	Number (%)† of new 2021 regular users attributed to cannabis		98 262 (68.8%)		NA‡	98 262 (6.2%)
Tried a tobacco product by 2017, but never used tobacco regularly	US population 2017*	2 316 217	1 369 587	5 902 979	3 948 296	13 537 079
	Number (%)* who progressed to regular tobacco use in 2021	615 966 (26.6%)	521 568 (38.1%)	526 599 (8.9%)	654 557 (16.6%)	2 318 690 (17.1%)
	Number (%)† of new 2021 regular users attributed to cannabis		191 361 (36.7%)		220 177 (33.6%)	411 538 (17.7%)
Overall	US population 2017*	21 423 918	1 964 255	15 172 746	4 695 329	43 256 248
	Number (%)* who progressed to regular tobacco use in 2021	1 815 004 (8.5%)	664 434 (33.8%)	761 157 (5.0%)	675 548 (14.4%)	3 916 143 (9.1%)
	Number (%)† of new 2021 regular users attributed to cannabis		289 623 (43.6%)		220 177 (32.6%)	509 800 (13.0%)

\*Population estimates from the Population Assessment of Tobacco and Health (PATH) survey, using the wave 6 all-wave longitudinal weights for the wave 4 cohort.

†Risk differences given in figure 2 times the estimated US population size above.

‡Not statistically significant.

P12M, past 12-month; US, United States.

baseline, cannabis was associated with a more than 5 percentage point increase in risk of current regular tobacco use at follow-up. Overall, we were able to estimate that cannabis accounted for about 13.0% of total new-onset regular tobacco use in the US, or about 509 800 new regular tobacco users in 2021.

At baseline, close to three-quarters of this cohort had never used tobacco at all, and only 15.4% had used cannabis. Thus, many of the new-onset regular tobacco users in 2021 (1.2 million; table 3) came from the largest and lowest-risk baseline group: underage youths who did not use cannabis and had never used tobacco. Among the other groups, who had experimented with tobacco but never used tobacco regularly (young adult tobacco experimenters who did and did not use cannabis; youth tobacco experimenters who did use cannabis), population sizes were smaller but the risk was higher. These higher-risk groups contributed the majority of new-onset regular tobacco users in 2021, for a total of almost 4 million new regular tobacco users. Among those who did use cannabis at baseline, a large proportion of their progression to regular smoking could be attributed to cannabis use: over 30%–40% for youth and young adults, and up to ~70% among youth with a history of tobacco experimentation (table 3). This finding suggests that it may be synergistic to target youth and young adults who have both used cannabis and experimented with tobacco products. Strategies for integrating cannabis prevention into tobacco control campaigns should be considered, including regulatory approaches, school-based interventions and targeted public health messaging campaigns.

Note that an important consideration for a cost-effective tobacco control intervention is the identification of a high-risk group, the estimated impact of reducing the risk factor within the group, and finally the relative contribution of the group to the overall population of cases.<sup>45</sup> As we demonstrate here, matching analysis can be an effective approach to estimating these quantities.

Our findings are consistent with two earlier PATH studies<sup>46 47</sup> which reported a six-fold increase in the adjusted odds of progressing to past 30-day cigarette smoking associated

with cannabis use. In our logistic regression models, where the exposure and outcome measures differed, we found a consistent but somewhat smaller adjusted odds ratio of 1.07–4.15. A recent meta-analysis,<sup>24</sup> which included these prior studies and four others, noted a moderate but statistically non-significant association of cannabis use with subsequent smoking initiation among US youths, in support of a “reverse gateway” hypothesis among teens. Our study clarifies these results, showing that cannabis use is a potent risk factor for initiating future regular tobacco use. Cannabis use is more common among young adults than youth, but the rate of progression to regular tobacco use is higher for youth, so that youth and young adults who use cannabis contributed in fairly similar numbers to new-onset regular tobacco use in 2021.

### Limitations

Limitations of the study include the use of self-reported measures of tobacco and cannabis use; however, such measures have been validated with biomarkers of nicotine and cannabis exposure.<sup>48 49</sup> Socioeconomic factors such as education and income are not as meaningful for young adults as for older adults, and parental socioeconomic measures were only available for adolescents, and so these measures are not included. Although we adjusted for a comprehensive list of baseline covariates, unmeasured confounding remains an issue, as in any observational study. In particular, peer influences, socioeconomic factors and an underlying common liability to substance use may not be fully captured by the survey measures, so that cannabis use may in part be a marker for these underlying factors rather than a cause of increased tobacco use. As in any longitudinal survey, attrition and non-response are also issues, although we used the carefully constructed survey weights which are designed to mitigate these issues. The exposure measure of “past 12 months” cannabis use is likely to attenuate effect sizes compared with a more proximal measure such as current cannabis use. Our study outcome, the report of “current regular use of any tobacco product”, lacks

a quantitative threshold of use, such as 100 cigarettes lifetime. However, “regular use” has face validity across the full array of tobacco products and represents progression among those who have never tried tobacco or never reported such regular use. Furthermore, other studies in earlier analyses using the PATH study have produced similar effect sizes, using different measures of baseline cannabis use and more usual measures of cigarette use.<sup>46 47</sup> This suggests that the large associations we observed do not depend on measurement details.

## Implications

The finding that prior cannabis use is a major risk factor for initiation of current regular tobacco use among youth, independent of whether or not they have tried tobacco, suggests that cannabis prevention should be included as a key goal in tobacco control programmes. In some instances, successful teenage tobacco control activities have been shown to have spillover effects in reducing teenage cannabis use.<sup>4</sup> However, while early cannabis use is seen as a major public health problem, none of the major health agencies<sup>2 50 51</sup> have addressed the potential of early cannabis use to increase future regular tobacco use. This study provides evidence that failure to address cannabis use among young people has the potential to undermine the progress tobacco control efforts have made in reducing tobacco initiation and progression to regular use.

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