Is Cannabis Use Associated With Increased Risk of Cigarette Smoking Initiation, Persistence, and Relapse?
Longitudinal Data From a Representative Sample of US Adults

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ABSTRACT

Objective: The current study prospectively investigated the relationship between cannabis use and cigarette smoking initiation, persistence, and relapse during a 3-year period among adults in the United States.

Methods: Analyses included respondents who completed Waves 1 (2001–2002) and 2 (2004–2005) of the National Epidemiologic Survey on Alcohol and Related Conditions and responded to questions about cannabis use and smoking status (n = 34,639). Multivariable logistic regression models were used to calculate the odds of cigarette use at Wave 2 among Wave 1 daily smokers, nondaily smokers, former smokers, and nonsmokers by Wave 1 cannabis use.

Results: In unadjusted analyses, Wave 1 cannabis use was associated with increased odds of Wave 2 daily and nondaily smoking for Wave 1 nonsmokers (daily OR = 2.90; 95% CI, 2.10–4.00; nondaily OR = 4.45; 95% CI, 3.97–5.00) and Wave 2 relapse to daily and nondaily smoking for Wave 1 former smokers (daily OR = 4.18, 95% CI, 3.01–5.81; nondaily OR = 5.24; 95% CI, 3.74–7.34). Wave 1 cannabis use was associated with decreased odds of Wave 2 smoking cessation for Wave 1 daily cigarette smokers (OR = 0.57; 95% CI, 0.51–0.64). The associations remained significant for daily smoking initiation (OR = 1.43; 95% CI, 1.06–1.93), daily smoking relapse (OR = 1.47; 95% CI, 1.00–2.16), and smoking cessation (OR = 0.77; 95% CI, 0.69–0.87) after adjusting for demographics and psychiatric disorders. Associations remained significant for nondaily smoking initiation (OR = 1.85; 95% CI, 1.59–2.16) and nondaily smoking relapse (OR = 1.63; 95% CI, 1.05–2.54) after adjusting for these covariates as well as for alcohol and substance use disorders.

Conclusions: Cannabis use was associated with increased initiation of, persistence of, and relapse to cigarette smoking. Additional attention to cannabis use in tobacco control efforts and in clinical settings aimed at reducing cigarette smoking and smoking-related negative consequences may be warranted.

J Clin Psychiatry 2018;79(2):17m11522

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Smoking is a leading cause of preventable disease and death in the United States and around the globe,[1,2] and the risk of mortality from smoking-related illnesses has increased over time.[2,3] While smoking cessation reduces or eliminates the negative consequences of smoking, most smokers are unable to quit or maintain abstinence over the long term.[2,4] It is therefore important to understand factors associated with smoking, especially potential barriers to successful abstinence.

Cannabis is the most frequently used illicit drug in the United States, and tobacco and cannabis are often used together—in the sense that the same person uses both substances and that they can be coadministered (ie, in "blunts"). The use of cannabis by cigarette smokers has increased dramatically over the past 2 decades[5,6] to the point where smokers are more than 10 times as likely as nonsmokers to use cannabis daily.[55] Persons who use cannabis are more likely to report current smoking,[7] and cigarette smokers who use cannabis, compared to smokers who do not use cannabis, report a greater number of cigarettes smoked per day[8,9] and more symptoms of nicotine dependence.[8,10,11] The use of cannabis and cigarettes together is associated with a range of negative physical, psychological, and social variables and less success with cannabis abstinence (see Subramaniam et al[12] and Peters et al[13] for reviews).

Moving beyond the well-documented link between cannabis use and cigarette smoking, less is known about the relationship between cannabis use and transitions in cigarette smoking status over time (eg, smoking initiation, cessation, and relapse). Data from one cross-sectional sample[14] of US adolescents found that lifetime cannabis use was associated with decreased likelihood of a successful quit attempt. In community samples in the United States and Australia, cannabis use in the past 6 months by adolescents was associated with increased smoking initiation as young adults,[15] whereas past-month cannabis use among adults was associated with a greater likelihood of continued tobacco use 13 years later.[16]

Clinical Points

- Cigarette smoking is a leading cause of mortality and morbidity in the United States, and cannabis is the most frequently used federally illicit drug in the United States. Little is known about the relationship between cannabis use and transitions in smoking such as smoking initiation, smoking cessation, and smoking relapse over time.

- Past-year cannabis use was associated with increased odds of smoking initiation and relapse and decreased odds of quitting smoking and reducing cigarette use from daily to nondaily smoking during a 3-year period relative to those who did not use cannabis.

- Future research should examine mechanisms underlying the relationship between cannabis use and smoking initiation, persistence, and relapse as well as whether treatments targeting both cannabis and smoking behavior can improve cigarette smoking quit rates.

Few studies have investigated the association between cannabis use and smoking transitions using prospective, longitudinal data that are applicable to the general population. Among 5,590 men from Switzerland, lifetime cannabis use among nonsmokers was associated with the onset of daily smoking 18 months later,[17] whereas among US adults, past-year cannabis use was associated with prevalence and incidence of nicotine dependence 3 years later.[18] Although these studies provide initial evidence for an association between cannabis use and smoking onset and nicotine dependence, little is known about the association between cannabis use and smoking cessation or relapse over time in the general adult population.

Developing a better understanding of the relationship between cannabis use and cigarette use transitions seems quite critical and timely as cigarette smoking remains the leading preventable cause of mortality and morbidity in the United States and there has been increased use of cannabis in general[19,20] and among smokers.[5,6] The primary aim of the current study was to examine the relationship between cannabis use and transitions in cigarette smoking during a 3-year period. Specifically, the study examined the following questions: (1) Is cannabis use by nonsmokers associated with increased odds of daily and nondaily cigarette smoking onset 3 years later? (2) Is cannabis use by former smokers associated with increased odds of relapse to cigarette smoking 3 years later? (3) Is cannabis use by daily and nondaily smokers associated with decreased odds of quitting or decreasing cigarette smoking 3 years later? (4) Do these relationships persist after adjusting for demographics, psychiatric disorders, alcohol/substance use disorders, and nicotine dependence?

METHODS

Data Source and Study Population

The study used 2 waves of data from the National Epidemiologic Survey on Alcohol and Related Conditions (NESARC; Wave 1, 2001–2002, n = 43,093; Wave 2, 2004–2005, n = 34,69; 80.4% of the original Wave 1 sample), which surveyed a population-representative sample of civilian, non-institutionalized, adults in the United States. The study used a 2-wave multistage stratified design in which primary sampling units, housing units, and group-quarter units were stratified to oversample non-Hispanic black, Hispanic, and young (aged 18–24 years) adults. Study design and administration details are described elsewhere.[21,22] NESARC data sets were obtained from the National Institute on Alcohol Abuse and Alcoholism (NIAAA, http://www.niaaa.nih.gov), and researchers can currently request specific analyses of the data sets through the NIAAA. All analyses were completed in Stata[23] using weighted analysis to account for residual differences between the sample and the population profile according to the 2000 US Population Census and to account for nonresponse and sample attrition.

Measures

Smoking status. Cigarette smoking status at Wave 1 and Wave 2 was classified using Centers for Disease Control and Prevention definitions.[24] At Wave 1, respondents were classified into 1 of 4 mutually exclusive smoking status groups. Wave 1 nonsmokers were defined as respondents who reported smoking < 100 lifetime cigarettes. Wave 1 former smokers were defined as respondents who reported having smoked ≥ 100 lifetime cigarettes and no smoking at the time of the Wave 1 assessment. Wave 1 daily and nondaily smokers were defined as respondents who reported smoking ≥ 100 lifetime cigarettes and reported smoking some (nondaily smoking) or all (daily smoking) days at the time of the Wave 1 assessment. At Wave 2, respondents were classified as being nonsmokers (ie, < 100 lifetime cigarettes and no past-year smoking at Wave 2), former smokers (ie, ≥ 100 lifetime cigarettes and no past-year smoking at Wave 2), daily smokers (ie, ≥ 100 lifetime cigarettes and smoking 7 days per week at Wave 2), or nondaily smokers (ie, ≥ 100 lifetime cigarettes and smoking < 7 days per week at Wave 2).

Cannabis use. Cannabis use was defined as any past year use of cannabis at Wave 1.

Sociodemographic, psychiatric disorder, and substance use disorder covariates. Sociodemographics included sex (male, female), age (a continuous variable), level of education (a continuous variable), race/ethnicity groups (Asian/Pacific Islander, non-Hispanic black, Hispanic, Native American/Alaskan, and non-Hispanic white), marital status (married/living with someone as married, widowed, divorced/separated, single), and income (a continuous variable).

Psychiatric and alcohol/substance use diagnoses were determined using the AUDADIS-IV (Alcohol Use Disorder and Associated Disabilities Interview Schedule—*Diagnostic and Statistical Manual of Mental Disorders*, Fourth Edition [*DSM-IV*] Version), a fully structured diagnostic interview instrument[25] with good to excellent reliability and validity.[26,27] A summary dichotomous variable was created to assess for the presence of lifetime psychiatric disorders (yes/no) as measured at Wave 1 including major depressive disorder,

Table 1. Demographic Characteristics Associated With Cigarette Use at Wave 1 Among Adults 18 Years and Older in the United States

Characteristic	Total n	Total %	Wave 1 Nonsmokers[a] n	Wave 1 Nonsmokers[a] %	Wave 1 Former Smokers[b] n	Wave 1 Former Smokers[b] %	Wave 1 Nondaily Smokers[c] n	Wave 1 Nondaily Smokers[c] %	Wave 1 Daily Smokers[d] n	Wave 1 Daily Smokers[d] %	P Value
Total	34,639		20,077	56.2	6,232	18.3	1,419	4.1	6,911	21.5	<.0001
Sex											<.0001
Men	14,554	47.2	7,385	42.1	3,015	51.5	763	58.0	3,391	54.5	
Women	20,085	52.8	12,692	57.9	3,217	48.5	656	42.0	3,520	45.5	
Age, y											<.0001
18–29	4,911	15.7	3,294	18.2	174	3.1	335	27.4	1,108	17.6	
30–44	10,602	30.0	6,909	33.3	953	15.9	557	38.2	2,183	31.7	
45–64	11,951	36.3	6,119	32.6	2,643	44.7	414	27.7	2,775	40.5	
65+	7,175	18.0	3,755	15.9	2,462	36.3	113	6.7	845	10.3	
Race/ethnicity											<.0001
Non-Hispanic white	20,155	72.7	10,488	67.5	4,342	82.5	817	72.3	4,508	78.2	
Non-Hispanic black	6,583	10.8	4,186	12.5	924	7.0	209	8.1	1,264	9.7	
Non-Hispanic Native American/Alaska Native	578	2.2	262	1.8	96	1.8	32	2.9	188	3.4	
Non-Hispanic Asian/ Pacific Islander	968	3.9	722	5.3	103	2.1	29	3.3	114	2.0	
Hispanic	6,355	10.4	4,419	12.9	767	6.5	332	13.4	837	6.7	
Marital status											<.0001
Currently married	18,860	64.3	11,092	64.5	3,753	72.2	703	58.3	3,312	58.1	
Previously married	9,146	18.8	4,688	16.0	1,968	21.7	339	17.3	2,151	23.7	
Never married	6,633	17.0	4,297	19.5	511	6.1	377	24.3	1,448	18.3	
Total annual family income											<.0001
$0–$19,999	15,180	41.8	8,823	41.6	2,529	38.4	539	37.5	3,289	45.9	
$20,000–$34,999	8,085	23.0	4,491	22.0	1,495	23.4	346	24.0	1,753	25.1	
$35,000–$69,999	8,177	24.6	4,758	24.7	1,567	26.4	371	26.1	1,481	22.5	
$70,000+	3,197	10.6	2,005	11.7	641	11.8	163	12.3	388	6.4	
Education											<.0001
Less than high school	5,510	13.5	2,970	11.4	998	14.4	177	10.5	1,365	18.7	
High school degree	16,848	49.1	9,145	45.4	3,039	49.0	704	50.4	3,960	58.6	
More than high school	12,281	37.4	7,962	43.2	2,195	36.6	538	39.1	1,586	22.8	
Lifetime psychiatric disorder[e]	9,714	27.8	4,844	23.4	1,722	27.9	494	34.3	2,654	38.1	<.0001
Lifetime substance use disorder[f]	612	2.0	156	0.9	48	0.9	71	5.0	337	5.1	<.0001
Nicotine dependence	5,695	18.1	…	…	1,106	18.7	415	30.7	4,003	59.4	<.0001
Wave 1 past-year cannabis use	491	1.6	167	0.9	49	0.9	46	3.8	229	3.5	<.0001

[a]Report of fewer than 100 lifetime cigarettes at the time of the Wave 1 assessment.
[b]Report of 100 or more lifetime cigarettes and no smoking at the time of the Wave 1 assessment.
[c]Report of 100 or more lifetime cigarettes and smoking cigarettes fewer than 7 days per week at the time of the Wave 1 assessment.
[d]Report of 100 or more lifetime cigarettes and smoking cigarettes 7 days per week at the time of the Wave 1 assessment.
[e]Met criteria at Wave 1 for a lifetime diagnosis of major depressive disorder, bipolar disorder, dysthymia, hypomania, panic disorder with or without agoraphobia, agoraphobia, social and specific phobia, generalized anxiety disorder, posttraumatic stress disorder, attention deficit-hyperactivity disorder, antisocial personality disorder, borderline personality disorder, or schizotypal or narcissistic personality disorder.
[f]Met criteria at Wave 1 for a lifetime diagnosis of nicotine dependence or abuse/dependence of alcohol, sedatives, tranquilizers, opioids, heroin, amphetamines, cocaine, hallucinogens, inhalants/solvents, or other drugs.
Symbol: … = not applicable.

bipolar disorder, dysthymia, hypomania, panic disorder with or without agoraphobia, agoraphobia, social and specific phobia, generalized anxiety disorder, posttraumatic stress disorder, attention-deficit/hyperactivity disorder, antisocial personality disorder, borderline personality disorder, and schizotypal or narcissistic personality disorder. Also, a dichotomous variable (yes/no) was created to adjust for nicotine dependence, alcohol use disorders, and substance use disorders (ie, sedatives, tranquilizers, opioids, heroin, amphetamines, cocaine, hallucinogens, inhalants/solvents, and other drugs).

Statistical Analysis

Analytic sample. Our full analytic sample included respondents who completed both waves of data collection, responded to questions about cannabis use at Wave 1, and

responded to questions about smoking status at both Wave 1 and Wave 2 (n = 34,621; 80.3% of the original Wave 1 sample). From this full analytic sample, 4 separate analytic subsamples were created based on Wave 1 smoking status as defined in the Smoking Status section: Wave 1 nonsmokers, Wave 1 former smokers, Wave 1 nondaily smokers, and Wave 1 daily smokers.

Sample frequencies. The frequency of smoking status at Wave 2 was compared among those with and without Wave 1 cannabis use. Standard errors were computed using Taylor series linearization, and frequency differences were tested using Rao-Scott χ^2 tests to account for complex survey design. Due to the small number of participants who reported a Wave 1 cannabis use disorder (3.5% for participants who were Wave 1 current daily smokers, 3.8% for Wave 1 current nondaily smokers, 0.9% for Wave 1

former smokers, and 0.9% for Wave 1 nonsmokers), analyses of changes in smoking status by cannabis use disorder were not conducted.

Regression modeling. A series of logistic regression models were run to model the odds of Wave 1 past-year cannabis use and Wave 2 smoking status for the 4 Wave 1 smoking status groups: Wave 1 nonsmokers, Wave 1 former smokers, Wave 1 daily smokers, and Wave 1 nondaily smokers. For each of the 4 smoking groups, a crude model was run first to determine the unadjusted odds ratio (OR) of a smoking status by cannabis use status (labeled as OR1 in Table 2). Then, 3 additional models were run to control for potential confounders and covariates measured at Wave 1. The first adjusted model (OR2) controlled for sociodemographic covariates. The second model (OR3) adjusted for OR2 covariates plus lifetime history of psychiatric disorders. The third model (OR4) adjusted for OR3 covariates plus alcohol use disorders and other substance use disorders. The final model (OR5) adjusted for OR4 covariates plus lifetime nicotine dependence.

RESULTS

Sample Characteristics

Table 1 includes demographic data for the full analytic sample and by Wave 1 smoking status. Wave 1 past-year cannabis use and changes in smoking status from Wave 1 to Wave 2 are shown in Table 2.

Wave 2 smoking onset among Wave 1 nonsmokers. Among non–cigarette smokers at Wave 1, cannabis use was associated with increased odds of daily and nondaily cigarette initiation at Wave 2 (Table 2). Wave 1 nonsmokers who reported Wave 1 past-year cannabis use, compared to those who did not report Wave 1 past-year cannabis use, were nearly four and a half times more likely to report nondaily smoking at Wave 2. The increased odds of nondaily smoking onset remained significant after controlling for Wave 1 demographics, psychiatric disorders, alcohol/substance use disorders, and nicotine dependence. In the fully controlled model, Wave 1 nonsmokers with past-year cannabis use were nearly 2 times more likely to report nondaily smoking at Wave 2 than Wave 1 past-year cannabis nonusers.

Wave 1 nonsmokers who reported Wave 1 past-year cannabis use, compared to those who did not report Wave 1 past-year cannabis use, were nearly 3 times more likely to report daily smoking at Wave 2. The increased odds of daily smoking onset remained significant after controlling for Wave 1 demographics and psychiatric disorders but did not remain significant after additional controls for alcohol/substance use disorders and nicotine dependence.

Wave 2 smoking relapse among Wave 1 former smokers. Among Wave 1 former smokers, those with Wave 1 past-year cannabis use, compared to Wave 1 former smokers who did not report Wave 1 past-year

Table 2. Wave 1 Past-Year Cannabis Use and Odds of Cigarette Smoking at Wave 2 Among Wave 1 Non–Cigarette Smokers and Wave 1 Former, Daily, and Nondaily Cigarette Smokers[a]

Wave 1 Past-Year Cannabis Use	Wave 2 Nondaily Smoking		Wave 2 Daily Smoking	
	OR	95% CI	OR	95% CI
Wave 1 Non–Cigarette Smokers[b]				
OR1				
No past-year use	1.0	…	1.0	…
Past-year use	**4.45**	**3.97–5.00**	**2.90**	**2.10–4.00**
OR2				
No past-year use	1.0	…	1.0	…
Past-year use	**2.04**	**1.79–2.32**	**1.38**	**1.02–1.86**
OR3				
No past-year use	1.0	…	1.0	…
Past-year use	**2.03**	**1.76–2.34**	**1.43**	**1.06–1.93**
OR4				
No past-year use	1.0	…	1.0	…
Past-year use	**1.85**	**1.59–2.16**	0.99	0.60–1.63
OR5				
No past-year use	1.0	…	1.0	…
Past-year use	**1.86**	**1.59–2.16**	1.00	0.61–1.65
Wave 1 Former Cigarette Smokers[c]				
OR1				
No past-year use	1.0	…	1.0	…
Past-year use	**5.24**	**3.74–7.34**	**4.18**	**3.01–5.81**
OR2				
No past-year use	1.0	…	1.0	…
Past-year use	**1.84**	**1.33–2.55**	**1.54**	**1.03–2.29**
OR3				
No past-year use	1.0	…	1.0	…
Past-year use	**1.89**	**1.34–2.65**	**1.47**	**1.00–2.16**
OR4				
No past-year use	1.0	…	1.0	…
Past-year use	**1.63**	**1.05–2.54**	1.04	0.65–1.66
OR5				
No past-year use	1.0	…	1.0	…
Past-year use	**1.64**	**1.06–2.53**	1.06	0.67–1.68
Wave 1 Daily Smokers[d]				
	Wave 2 Nondaily Smoking		Wave 2 Nonsmoking	
	OR	95% CI	OR	95% CI
OR1				
No past-year use	1.0	…	1.0	…
Past-year use	**1.32**	**1.09–1.59**	**0.57**	**0.51–0.64**
OR2				
No past-year use	1.0	…	1.0	…
Past-year use	0.97	0.81–1.17	**0.70**	**0.63–0.79**
OR3				
No past-year use	1.0	…	1.0	…
Past-year use	1.07	0.89–1.28	**0.77**	**0.69–0.87**
OR4				
No past-year use	1.0	…	1.0	…
Past-year use	0.95	0.74–1.22	0.94	0.84–1.06
OR5				
No past-year use	1.0	…	1.0	…
Past-year use	0.97	0.75–1.24	0.97	0.86–1.09
Wave 1 Nondaily Smokers[e]				
	Wave 2 Daily Smoking		Wave 2 Nonsmoking	
	OR	95% CI	OR	95% CI
OR1				
No past-year use	1.0	…	1.0	…
Past-year use	0.79	0.61–1.03	0.88	0.70–1.10
OR2				
No past-year use	1.0	…	1.0	…
Past-year use	**0.75**	**0.56–0.99**	1.03	0.81–1.31
OR3				
No past-year use	1.0	…	1.0	…
Past-year use	0.76	0.57–1.02	1.06	0.82–1.36
OR4				
No past-year use	1.0	…	1.0	…
Past-year use	1.02	0.68–1.53	1.33	0.96–1.84
OR5				
No past-year use	1.0	…	1.0	…
Past-year use	1.04	0.68–1.59	1.38	0.99–1.93

[a]Boldface indicates a statistically significant difference. "Past-year use" represents reference values. [b]Compared with no cigarette smoking at Wave 2. [c]Compared with former cigarette smoking at Wave 2. [d]Compared with daily cigarette smoking at Wave 2. [e]Compared with nondaily cigarette smoking at Wave 2.
Abbreviations: OR1 = unadjusted estimates, OR2 = adjusted for demographic covariates, OR3 = adjusted for OR2 covariates + Wave 1 psychiatric disorders, OR4 = adjusted for OR3 covariates + Wave 1 alcohol and other drug use disorders, OR5 = adjusted for OR4 covariates + Wave 1 nicotine dependence.

cannabis use, were more than 5 times more likely to report relapse to nondaily smoking than Wave 1 former smokers who did not report past-year cannabis use (Table 2). The odds of Wave 2 nondaily smoking remained significant after controlling for Wave 1 demographics, psychiatric disorders, alcohol/substance use disorders, and nicotine dependence. In the fully controlled model, Wave 1 former smokers who reported Wave 1 past-year cannabis use were 1.64 times more likely to report relapse to nondaily smoking by Wave 2 than those who did not use cannabis in the past year at Wave 1.

Among Wave 1 former smokers, those with Wave 1 past-year cannabis use, compared to no past-year cannabis use, were > 4 times more likely to report relapse to daily smoking at Wave 2 than Wave 1 former smokers who did not report past-year cannabis use. The odds of daily smoking at Wave 2 among Wave 1 former smokers remained significant after controlling for demographics and psychiatric disorders, but not after controlling for alcohol/substance use disorders and/or nicotine dependence.

Wave 2 smoking behavior among Wave 1 daily and nondaily smokers. Wave 1 daily smokers who reported Wave 1 past-year cannabis use, compared to those who did not report Wave 1 past-year cannabis use, were less likely to report quitting smoking at Wave 2 (Table 2). This finding remained significant after controlling for demographics and psychiatric disorders but not after controlling for alcohol and other substance use disorders. Wave 1 daily smokers who reported past-year cannabis use were more likely to report decreasing cigarette frequency to nondaily use at Wave 2 compared to those without past-year cannabis use, although this finding was no longer significant after controlling for demographics and other covariates. Among Wave 1 nondaily smokers, there was no significant relationship between cannabis use and the odds of decreasing to Wave 2 nonsmoking in unadjusted analyses. After adjusting for demographics, cannabis use among Wave 1 nondaily smokers was associated with a significantly decreased likelihood of increasing to daily smoking by Wave 2, though this relationship was no longer significant after adjusting for psychiatric disorders, substance use disorders, or nicotine dependence (Table 2).

DISCUSSION

To our knowledge, the current study is the first to examine the association between past-year cannabis use and a range of smoking transitions during a 3-year period among US adults. Cannabis use, compared to nonuse, was associated with increased odds of smoking onset and relapse and decreased odds of quitting smoking and reducing cigarette use from daily to nondaily smoking.

Previous work had shown that cannabis use disorders were associated with an increased likelihood of smoking initiation,[28] current smoking,[7,29] smoking maintenance,[30] and smoking relapse.[30] Our study extends this work to suggest that cannabis use, even in the absence of a cannabis use disorder, is also associated with increased odds of smoking onset, relapse, and persistence. As cannabis use is much more

common than cannabis use disorder, the potential impact of cannabis use on cigarette use in the general community may be greater than estimates based on studies of cannabis use disorder alone.

Several relationships between cannabis use and smoking transitions remained significant after controlling for demographics and psychiatric disorders, but were no longer significant after controlling for alcohol/substance use disorders. The use of alcohol and illicit substances is associated with a greater prevalence of smoking and lower quitting.[31] The use of these other drugs—or, alternatively, the use of more than 1 drug (eg, cannabis plus alcohol)—may account for a large enough amount of variance in smoking transitions that the remaining variance due to the use of cannabis alone is too small to remain significant. While this study examines cannabis and smoking, it is important to recognize that use of other substances by cannabis users may also have negative impacts on smoking behavior. Future studies should more closely examine the role of the use of other substances in the impact of cannabis use on smoking behaviors.

Recent data from representative samples of the US population found that the prevalence of past-year cannabis use has increased significantly over the past decade,[19,20] and the rate of cannabis use initiation is also increasing, with nearly 7,000 new users per day in 2014.[19] Simultaneously, the percentage of persons who perceive risks related to cannabis use has decreased and the percentage of people who believe there are no risks related to using cannabis has increased.[19,32] It is conceivable that changes in the laws around cannabis use and views of cannabis as accessible and without major harms may result in increased cannabis use, which may then have a negative impact on the smoking transitions seen in this study.

A number of mechanisms have been proposed to explain the high rates of co-use of nicotine and cannabis[33,34] that may be applicable to the association of cannabis use and changes in smoking behaviors. There are overlaps in the neurobiological systems involved with nicotine and cannabis (see Subramaniam et al[12] and Rabin and George[34]). Consequently, a number of cannabis users report using tobacco to extend and enhance the effects of cannabis,[35] and persons receiving nicotine through a transdermal patch reported increased effects from cannabis such as higher heart rate and self-rating of being "stimulated" and "high"[36] (although see also Haney et al[37]). Further, the use of nicotine or cannabis may alleviate negative effects of the other substance such as withdrawal symptoms[38] or cognition.[39,40] Both cannabis and nicotine are typically used by the same route of administration (ie, inhalation) and are often used simultaneously through blunts, which increases the amount of tetrahydrocannabinol inhaled.[41] Simultaneous users of cannabis and nicotine who try to stop using nicotine may experience cue-induced cravings for nicotine when using cannabis. There are very likely multiple other psychosocial, individual, environmental, and genetics factors that influence the co-use of nicotine and cannabis. Future research that can

examine how these potential mechanisms relate specifically to initiation, relapse, and cessation of cigarette use among those using cannabis is needed along with investigations of potential moderators of these relationships (eg, demographics, alcohol and other drug use).

Several clinical trials[42–46] that examined the association between cannabis use and smoking outcomes for persons receiving smoking cessation treatment found mixed results. Our study used epidemiologic data, and therefore our results are generalizable to smokers in the population, very few of whom use the types of intensive smoking treatments examined in clinical trials. It may be fruitful for smoking cessation studies to assess cannabis use and examine outcomes by cannabis use status. It may also be useful for smoking cessation treatment and outreach programs, including quitlines, to consider monitoring cannabis use as well as integrating topics related to cannabis use (eg, reasons for use, methods to decrease or stop use). Treatments targeting both smoking and cannabis use appear to be feasible and to be successful—at least in the short term—in reducing nicotine use.[47–49]

One limitation is that there was no biological confirmation of smoking or cannabis use. Both smoking and cannabis use may be underreported,[50,51] and persons underreporting cannabis use are more likely to also underreport tobacco use compared to persons who accurately report cannabis use.[52] Second, due to the small samples sizes, we were not able to examine daily cannabis use or cannabis use disorder. Third, no information was available about the context of smoking transitions (eg, reasons for relapse) or utilization of smoking treatments. Fourth, longitudinal studies with a greater number of years of data would allow the examination of cannabis use in relation to changes in smoking behaviors over a longer period of time. Fifth, results would need to be replicated in persons living outside of the United States or persons under the age of 18 years, who make up a large number of smoking initiators.[53,54]

In sum, our results suggest that, during a 3-year period, cannabis use is associated with increased risk of cigarette smoking onset, decreased likelihood of smoking cessation, and increased risk of relapse among former smokers. Additional attention to cannabis use in tobacco control efforts and clinical settings aimed at reducing the prevalence of cigarette smoking and long-term smoking-related negative consequences may be warranted.

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