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Original Investigation

# Increasing Cannabis Use Is Associated With Poorer Cigarette Smoking Cessation Outcomes: Findings From the ITC Four Country Smoking and Vaping Surveys, 2016–2018

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## Abstract

**Introduction:** Concurrent use of tobacco and cannabis may impede successful cigarette smoking cessation. This study examined whether changes in cannabis use frequency were associated with smoking cessation.

**Aims and Methods:** Nationally representative samples of adult cigarette smokers from Canada ($n = 1455$), the United States ($n = 892$), England ($n = 1416$), and Australia ($n = 717$) were surveyed in 2016 and 2018. In each year, smokers reported how often they used cannabis in the previous 12 months. Reports were compared to determine whether cannabis use increased, remained unchanged, or decreased. Smoking cessation outcomes, measured in 2018, were (1) any attempt to quit in the previous year, (2) currently quit, and (3) currently quit for at least 6 months. Weighted multivariable logistic regression estimated the association between changes in cannabis use and cessation outcomes.

**Results:** Cigarette smokers who increased their frequency of cannabis use were significantly less likely to be currently quit than noncannabis-using smokers (adjusted odds ratio (aOR) = 0.52, 95% CI = 0.31% to 0.86%); they were also less likely to have quit for at least 6 months (aOR = 0.30; 95% CI = 0.15% to 0.62%).

**Conclusions:** Smokers who increase their frequency of cannabis use have poorer smoking cessation outcomes compared to noncannabis-using smokers. It will be important to monitor the impact of cannabis legalization on patterns of cannabis use, and whether this influences cigarette smoking cessation rates.

**Implications:** Cigarette smokers who start using cannabis may be less likely to quit cigarettes compared with smokers who do not use cannabis at all. If smokers who also use cannabis are more likely to continue smoking, it is important to monitor these trends and understand the impact, if any, on smoking cessation in jurisdictions that have legalized cannabis for nonmedical use.

## Introduction

Tobacco and cannabis are among the most commonly used psychoactive substances in the world.[1] Concurrent use (co-use) of these substances encompasses use of either substance by the same individual on separate occasions, use of both substances within the same use episode (simultaneous use), or use through the same delivery mechanism (coadministration). Co-use of tobacco and cannabis is common, with current smokers being more likely to use cannabis than nonsmokers. In 2014, 16% of current cigarette smokers in the United States and 28% of cigar smokers reported using cannabis in the previous month, compared with 4% of nontobacco users.[2] In that same year, 6% of current cigarette smokers from the Netherlands reported using cannabis in the previous month compared with 2% of never smokers.[3] Daily cannabis use is also more prevalent among current cigarette smokers. In 2014, 11% of current US cigarette smokers used cannabis daily compared with 1% of never smokers.[4] Similarly, in 2017, 14% of current cigarette smokers in Canada used cannabis daily compared with only 1% of never smokers.[5]

Several mechanisms have been proposed to explain the co-use of tobacco and cannabis. Both substances are commonly smoked, which may serve as a cue to use the other product. In addition, the endocannabinoid system may play a role in tobacco addiction while nicotine may enhance the subjective effects of cannabis.[6,7] Existing research suggests that tobacco smokers who use cannabis are less motivated to quit smoking, less likely to try to quit, less likely to successfully quit, and score higher on nicotine dependence measures than nonusing smokers.[1,2,6,8,9] Population quit ratios indicate that a smaller percentage of cannabis-using smokers quit smoking cigarettes compared with nonusing smokers (25% vs. 51%, respectively).[10] Patient-based data from Canadian cigarette smokers seeking cessation treatment indicate that smokers who used cannabis for nonmedical reasons in the previous month had significantly lower odds of being abstinent from cigarettes at 6-month follow-up compared to noncannabis-using smokers.[11] In addition, current smokers who used cannabis in the previous year had significantly lower odds of subsequently quitting cigarettes than smokers who did not use cannabis.[12,13] There is also evidence that cannabis use can be a trigger for relapse to smoking among ex-smokers. Longitudinal data from the United States indicate that former smokers who used cannabis in the previous year had significantly greater odds of relapse to cigarette smoking than former smokers who did not use cannabis.[12,13]

Unlike these studies, secondary analyses of randomized smoking cessation trials have not found differences in cessation rates between co-using and noncannabis-using smokers. Controlling for intervention status, Rabin et al. found no difference in 7-day abstinence rates between co-using and nonusing smokers following a 12-week intervention.[14] A pooled analysis of three separate trials also found no difference in 7-day abstinence by cannabis usage frequency.[15]

Differences in findings between population-based studies and randomized trials may be attributable to differences in study populations or the measures used to define smoking cessation. For example, participants in randomized controlled trials were actively seeking smoking cessation treatment while population-based studies estimated cessation outcomes among all tobacco smokers. However, the self-selection factors associated with cannabis use are likely a bigger concern in nonrandomized studies. Another issue that could explain differences between population studies and clinical trials is that the trials used 7-day abstinence to define smoking cessation, whereas population-based studies vary considerably in how smoking cessation is defined and verified, often relying on self-reported measures of point-prevalence abstinence.[14,15] It is plausible that cannabis-using tobacco smokers may have more difficulty remaining quit over longer time periods than noncannabis-using smokers, either because cannabis smoking serves as a cue to smoke tobacco, making relapse more likely, or because cannabis use may play a role in tobacco addiction.[6,7]

Existing research examining the relationship between cannabis use and cigarette smoking cessation has either relied on cross-sectional data or only considered baseline cannabis use as a predictor of subsequent cessation. However, cannabis use behaviors may change over time thereby influencing the likelihood of successful smoking cessation. Taking advantage of nationally representative samples of adult cigarette smokers from four high-income countries, this study is the first multicountry study to examine smoking cessation behaviors among cigarette smokers who also use cannabis. This study first examined factors associated with changes in cannabis use frequency between 2016 and 2018. Next, this study tested whether smokers who maintained or increased their frequency of cannabis use over time had worse smoking cessation outcomes than smokers who did not use cannabis at all in either year. As some jurisdictions have legalized the nonmedical use of cannabis, it is important to understand whether changing patterns of cannabis use among cigarette smokers are associated with their efforts to quit cigarettes.

## Materials and Methods

### Sample

Data were from waves 1 (July–November 2016) and 2 (March–June 2018) of the International Tobacco Control Four Country Smoking and Vaping Survey (ITC 4CV), a prospective cohort survey of adult smokers and vapers from Canada (CA), the United States (US), England (EN), and Australia (AU). In each country, wave 1 respondents were recruited from commercial, probability- and nonprobability-based web panels. Quota sampling within age, sex, and geographic region ensured respondents represented the adult population of smokers and vapers in each country. Recontact respondents from the original ITC Four Country Survey were also included in the wave 1 sample.[16] Cross-sectional and longitudinal sampling weights were computed using a raking algorithm to ensure respondents represented the population of adult smokers and vapers in each country at wave 1.[17] Sampling weights were rescaled to sum to the achieved sample size within each country to ensure

each country had approximately equal representation in the analysis. All ITC Four Country Survey protocols and questionnaires received ethical approval from the Office of Research Ethics, University of Waterloo, Canada (ORE#20803/30570 and ORE#21609/30878); the Research Ethics Office, King's College London, UK (RESCM-17/18–2240); Human Research Ethics, Cancer Council Victoria, Australia (HREC1603); Human Ethics, Research Management Office, University of Queensland, Australia (2016000330/HREC1603); and the Institutional Review Board Medical University of South Carolina (waived because of minimal risk). All participants consented to participate in the ITC Survey.

Of 12 294 respondents recruited in wave 1, 9568 reported smoking at least 100 cigarettes in their lifetimes, smoked at least monthly, and did not have any missing information regarding their use of cannabis in the previous 12 months. Of these, 4480 were re-surveyed in wave 2 for a follow-up rate of 53% in CA (1455/2742), 42% in the US (892/2115), 41% in EN (1416/3436), and 56% in AU (717/1275).

### Cigarette Smoking Cessation Outcome Measures

Outcome measures were three binary indicators of cigarette smoking cessation behaviors reported in wave 2: (1) any attempt to quit cigarettes in the last year, (2) currently quit smoking cigarettes, and (3) currently quit cigarettes for at least 6 months. The first measure was based on self-reported attempts to quit smoking in the previous 12 months, irrespective of the duration of those attempts (any vs. none). Of 1879 smokers who reported an attempt, 1723 (92%) reported the attempt lasted at least 24 hours. Smokers at wave 1 who quit by wave 2 were also classified as having made an attempt to quit. The second measure was point-prevalence abstinence, defined as currently quit at the time of the wave 2 survey, irrespective of duration. Of 504 smokers who had quit at wave 2, 496 (98%) were smoke-free for at least 7 days. The third measure was sustained cessation, defined as currently quit and having been quit for at least 6 months at the time of the wave 2 survey.

### Cannabis Use Behaviors

Several measures quantified cannabis use behaviors at both waves. Respondents were asked how often they used cannabis in the previous 12 months and were classified as using cannabis "not at all," "less than weekly" (either "less than once a month" or "at least once a month"), "weekly," or "daily." Based on reported past 12-month cannabis use in each survey year, respondents were classified into four categories: (1) being a "nonuser" in both years, (2) having "reduced their frequency of use or stopped using," (3) having "stable use" (ie, having maintained their level of use), and (4) having "increased their frequency of use or started using." For less than weekly users in both waves, their original responses ("less than once a month" or "at least once a month") were used to classify change in use as "reduced frequency," "no change," or "increased frequency" (eg, cannabis users who used less than once a month in wave 1 and at least once a month in wave 2 were classified as having increased their frequency of use by wave 2).

Respondents who reported using cannabis in the last 30 days were also asked their method of using cannabis. All respondents, irrespective of use in the last 30 days, were classified into five mutually exclusive categories: "smoked cannabis with tobacco," "smoked cannabis without tobacco," "used cannabis another way," "use method not reported," or "does not use cannabis." Since respondents could report multiple use methods, those who reported smoking cannabis with tobacco were classified into that category irrespective of other use methods. Respondents who reported smoking cannabis without tobacco were only classified into that category if they did not also select the "smoked cannabis with tobacco" option. Respondents who did not report smoking cannabis but reported other methods (edibles, vaping, concentrates, and another way) were classified into the "used cannabis another way" category. Respondents who reported using cannabis in the previous 12 months but not in the previous 30 days were not asked the method of use question. These respondents were classified into the "use method not reported" category. Finally, respondents who reported not using cannabis were classified into the "does not use cannabis" category.

### Covariates

Sociodemographic covariates were country, sample source (commercial firm vs. ITC owned), sex (male vs. female), age (25–39, 40–54, ≥55 vs. 18–24), ethnicity (defined as white or non-white in CA, US, and EN and as primary language spoken at home in AU, ie, English or non-English), income (not stated, low, moderate vs. high, Supplementary Table 1), and education (low, moderate vs. high, Supplementary Table 1). Behavioral covariates were smoking status (daily vs. nondaily smoker), cigarettes smoked per day (≥31, 21–30, 11–20 vs. ≤10), vaping status (daily vaper, nondaily vaper vs. does not vape, where vaping was use of e-cigarettes with or without nicotine but not vaping of cannabis), and intentions to quit smoking (plans to quit within next 6 months vs. no definite plans including "don't know"). Risky alcohol consumption, adapted from National Institute on Alcohol Abuse and Alcoholism's definition of low risk drinking,[18] was defined as "low risk" drinking (≤4 drinks per occasion for men, ≤2 drinks per occasion for women) and "high-risk" drinking (≥5 drinks per occasion for men, ≥3 drinks per occasion for women, and ≥6 drinks on a single occasion at least once a month for men and women). The comparison group was infrequent drinking or abstains from drinking, where infrequent drinking was defined as drinking only once per month or less often and never consuming more than six drinks on those occasions. The final covariates were self-reported diagnoses of anxiety, depression, and chronic pain (diagnosed with or treated for vs. not). All covariates were measured at wave 1 in 2016.

### Statistical Analysis

Descriptive statistics were used to examine differences in sociodemographic and behavioral measures by wave 1 cannabis use behaviors. Multiple multinomial logistic regression examined the relationship between predictors of cannabis use and cannabis use transitions between waves. Bivariate analysis then tested the association between cannabis use behaviors and smoking cessation outcomes. Finally, multivariable logistic regression examined the relationship between cannabis use transitions and wave 2 smoking cessation outcomes, controlling for all covariates. The analysis was conducted using SAS-callable SUDAAN version 11.0.3 to account for the stratified sampling design and longitudinal sampling weights.

## Results

### Characteristics of Smokers Who Did and Did Not Use Cannabis

In 2016, 15%–32% of current cigarette smokers in each of the four countries reported using cannabis in the previous 12 months (EN = 15%, US = 22%, AU = 23%, and CA = 32%). While only

a minority of current smokers reported daily cannabis use, daily use was most common among Canadian smokers. Daily cannabis use was reported by 4.9% of English smokers (95% CI = 3.4% to 6.8%) to 7.0% of Australian smokers (95% CI = 4.1% to 11.0%), 7.1% of US smokers (95% CI = 5.1% to 9.8%), and 10.6% of Canadian smokers (95% CI = 8.8% to 12.6%). A slightly greater percentage of male smokers reported daily cannabis use (8.8%) compared with female smokers (6.0%). Finally, 15.5% of smokers aged 18–24 reported daily use compared with 12.5% of smokers aged 25–39, 6.5% of smokers aged 40–54, and 3.8% of smokers 55 and older.

Cigarette smokers reporting cannabis use in 2016 differed from nonusing smokers (Supplementary Table 2). About two-thirds (65%) of cannabis users across all user groups were men compared with 52% of nonusers. Daily users were also younger: 41% were 25–39 years of age compared with 21% of nonusers. Daily users tended to be from low-income households compared with nonusers (42% vs. 29%, respectively) although educational attainment was similar across groups. While a smaller percentage of less than weekly users were daily cigarette smokers (77%) than either daily users (92%) or nonusers (90%), a greater percentage of daily, weekly, and less than weekly users were high-risk drinkers than nonusers (44%, 58%, and 54% vs. 31%, respectively). About 30% of daily users reported being diagnosed with or treated for anxiety or depression compared with about 15% of nonusers.

## Changes in Cannabis Use From 2016 to 2018

Most smokers who did not report using cannabis in wave 1 remained nonusers by wave 2 (Supplementary Table 2 and Supplementary Figure 1); only 8.3% of nonusing smokers in wave 1 started using cannabis by wave 2. Likewise, most smokers (70%) who reported daily cannabis use in wave 1 remained daily users by wave 2. Among smokers reporting weekly use in wave 1, 22% reported no longer using cannabis in wave 2, 19% reported less than weekly use, and 22% had increased to daily use. About 50% of less than weekly users in wave 1 remained less than weekly users by wave 2 while 34% reported no longer using cannabis by wave 2. In summary, wave 1 noncannabis users and daily cannabis users tended to remain nonusers and daily users, respectively, by wave 2; transitions to other levels of use were more common among wave 1 weekly and less than weekly users.

Supplementary Table 3 presents results from a multinomial logistic regression model examining the correlates of cannabis use transitions. In this model, smokers (a) who reduced their frequency of use or stopped using cannabis, (b) who reported stable cannabis use, or (c) who started using or increased their frequency of cannabis use were compared with smokers who did not report using cannabis in either wave. In general, sociodemographic factors (sex, age, and income), substance use behaviors (cigarettes smoked per day, vaping status, and alcohol consumption), and indicators of well-being (self-reported diagnosis of depression and chronic pain) were all associated with changes in cannabis use frequency from wave 1 to wave 2. For example, male smokers had significantly greater odds of reducing (adjusted odds ratio (aOR) = 2.30; 95% CI = 1.63% to 3.23%), maintaining (aOR = 2.21; 95% CI = 1.63% to 2.98%), or increasing their frequency of cannabis use (aOR = 1.47; 95% CI = 1.09% to 1.99%) than not using it at all in either wave compared with female smokers. This was also true of smokers aged 18–24. These younger smokers had significantly greater odds of reducing (aOR = 6.15; 95% CI = 3.37% to 11.25%), maintaining (aOR = 6.24; 95% CI = 3.73% to 10.42%), or increasing their frequency of cannabis use (aOR = 6.15; 95% CI = 3.45% to 10.97%) than not using it at all compared with smokers aged 55 and older. Similarly, smokers who were high-risk drinkers had significantly greater odds of reducing (aOR = 3.10; 95% CI = 1.83% to 5.26%), maintaining (aOR = 2.80; 95% CI = 1.76% to 4.45%), or increasing their frequency of cannabis use (aOR = 1.64; 95% CI = 1.03% to 2.60%) than not using it at all compared with smokers who infrequently consumed or abstained from alcohol in wave 1.

Indicators of well-being were also associated with changes in the frequency of cannabis use over time. Smokers who reported a diagnosis of depression had significantly greater odds of reducing (aOR = 1.69; 95% CI = 1.07% to 2.66%) or maintaining their frequency of cannabis use (aOR = 1.70; 95% CI = 1.14% to 2.53%) than not using it at all compared with smokers not reporting a diagnosis of depression. However, there was no difference in the odds of increasing cannabis use frequency for smokers reporting a diagnosis of depression compared with those who did not (aOR = 1.30; 95% CI = 0.87% to 1.95%). Finally, smokers reporting a diagnosis of chronic pain did not have significantly greater odds of reducing their frequency of cannabis use (aOR = 1.49; 95% CI = 0.87% to 2.52%) but they did have greater odds of maintaining (aOR = 1.87; 95% CI = 1.23% to 2.85%) or increasing their frequency of use (aOR = 2.34; 95% CI = 1.52% to 3.59%) than not using it all compared with smokers not reporting a diagnosis of chronic pain.

## Cannabis Use Transitions and Cigarette Smoking Cessation

Neither wave 1 cannabis use nor method of use was associated with wave 2 cigarette smoking cessation outcomes (Table 1). However, change in cannabis use frequency between waves was associated with quitting ($p < .01$) and sustained cessation ($p < .001$). For example, 18.3% of wave 1 smokers who reduced their frequency of cannabis use or who stopped using cannabis also quit smoking cigarettes by wave 2, compared with 12.4% of nonusing smokers ($p = .046$) and 7.7% of smokers who increased their frequency of cannabis use ($p = .001$). Similar effects were observed for sustained cessation: 7.7% of wave 1 users who reduced their frequency of cannabis use or who stopped using cannabis reported having quit for at least 6 months by wave 2 compared with only 2.3% of smokers who increased their frequency of cannabis use ($p = .004$).

Controlling for other factors, change in cannabis use frequency was significantly associated with having currently quit smoking at wave 2 and with sustained cessation (all $p$ values < .01) but not with past-year quit attempts ($p = .14$, Table 2 and Supplementary Table 4). Smokers who maintained their frequency of cannabis use over time had lower, but not significantly lower, odds of being quit in wave 2 (OR = 0.67; 95% CI = 0.43% to 1.04%) than noncannabis-using smokers. Likewise, smokers who increased their frequency of cannabis use had 0.52 times the odds of being quit in wave 2 than nonusing smokers (95% CI = 0.31% to 0.86%). This effect was stronger for sustained cessation: smokers who increased their frequency of cannabis use had 0.30 times the odds (95% CI = 0.15% to 0.62%) of being quit for at least 6 months in wave 2 compared with nonusing smokers. Smokers who decreased their frequency of cannabis use or who stopped using cannabis did not differ in their odds of quitting compared with nonusing smokers (Table 2).

**Table 1.** Cannabis Use, Use Methods, and Transitions From 2016 to 2018 and Cigarette Smoking Cessation Outcomes (Weighted Estimates, $n = 4480$)

| | Tried to quit cigarettes | | | | Quit smoking cigarettes | | | | Quit cigarettes for at least 6 months | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Cannabis use | (Freq.) | % | (95% CI) | *p* | (Freq.) | % | (95% CI) | *p* | (Freq.) | % | (95% CI) | *p* |
| Wave 1 cannabis use | | | | | | | | | | | | |
| Does not use cannabis | (1423/3482) | 42.0 | (39.7, 44.3) | NS | (394/3482) | 12.2 | (10.7, 13.7) | NS | (204/3482) | 6.3 | (5.2, 7.5) | NS |
| Occasionally | (238/477) | 45.7 | (39.7, 51.9) | | (56/477) | 12.5 | (9.0, 17.0) | | (26/477) | 5.5 | (3.2, 8.7) | |
| At least once/week | (79/210) | 35.5 | (27.0, 44.9) | | (17/210) | 10.5 | (5.4, 17.8) | | (7/210) | 4.0 | (1.5, 8.4) | |
| Daily | (139/311) | 42.8 | (35.7, 50.2) | | (37/311) | 11.5 | (7.6, 16.6) | | (21/311) | 6.4 | (3.5, 10.4) | |
| Wave 1 cannabis use method | | | | | | | | | | | | |
| Does not use cannabis | (1423/3482) | 42.0 | (39.7, 44.3) | NS | (394/3482) | 12.2 | (10.7, 13.7) | NS | (204/3482) | 6.3 | (5.2, 7.5) | NS |
| Used cannabis another way | (26/55) | 47.0 | (28.0, 66.7) | | (4/55) | 10.2 | (1.8, 28.9) | | (2/55) | 3.3 | (0.3, 12.8) | |
| Smoked cannabis without tobacco | (159/330) | 45.1 | (38.3, 52.1) | | (45/330) | 14.8 | (10.4, 20.2) | | (18/330) | 6.3 | (3.5, 10.2) | |
| Smoked cannabis with tobacco | (124/314) | 34.9 | (28.1, 42.3) | | (24/314) | 7.7 | (4.2, 12.7) | | (13/314) | 3.8 | (1.8, 7.1) | |
| Use method not reported | (147/299) | 47.8 | (40.0, 55.7) | | (37/299) | 13.4 | (8.6, 19.5) | | (21/299) | 6.8 | (3.6, 11.5) | |
| Wave 2 cannabis use | | | | | | | | | | | | |
| Does not use cannabis | (1398/3403) | 42.0 | (39.7, 44.3) | NS | (399/3403) | 13.1 | (11.5, 14.8) | * | (209/3403) | 6.7 | (5.7, 8.0) | NS |
| Occasionally | (234/486) | 45.9 | (39.9, 52.1) | | (51/486) | 10.3 | (7.3, 14.3) | | (22/486) | 4.8 | (2.7, 7.8) | |
| At least once/week | (85/197) | 45.0 | (35.7, 54.7) | | (18/197) | 8.2 | (4.1, 14.4) | | (12/197) | 4.8 | (2.0, 9.5) | |
| Daily | (140/332) | 38.3 | (31.6, 45.3) | | (31/332) | 8.5 | (5.4, 12.5) | | (14/332) | 3.6 | (1.8, 6.3) | |
| Wave 2 cannabis use method | | | | | | | | | | | | |
| Does not use cannabis | (1398/3403) | 42.0 | (39.7, 44.3) | NS | (399/3403) | 13.1 | (11.5, 14.8) | *** | (209/3403) | 6.7 | (5.7, 8.0) | *** |
| Used cannabis another way | (42/81) | 41.8 | (28.6, 56.0) | | (14/81) | 11.9 | (5.3, 21.9) | | (7/81) | 7.0 | (2.1, 16.1) | |
| Smoked cannabis without tobacco | (142/333) | 37.6 | (31.3, 44.3) | | (40/333) | 13.8 | (9.4, 19.2) | | (20/333) | 6.4 | (3.7, 10.3) | |
| Smoked cannabis with tobacco | (119/288) | 41.0 | (33.4, 49.1) | | (11/288) | 2.2 | (0.9, 4.7) | | (7/288) | 1.6 | (0.5, 3.8) | |
| Use method not reported | (156/313) | 51.3 | (43.6, 59.1) | | (35/313) | 11.2 | (7.1, 16.7) | | (14/313) | 4.6 | (2.1, 8.7) | |
| Cannabis use transitions | | | | | | | | | | | | |
| Nonusers both waves | (1287/3192) | 41.4 | (39.0, 43.7) | NS | (365/3192) | 12.4 | (10.9, 14.1) | ** | (195/3192) | 6.7 | (5.6, 8.0) | *** |
| Reduced frequency or stopped using | (188/353) | 49.2 | (42.1, 56.5) | | (54/353) | 18.3 | (13.3, 24.5) | | (27/353) | 7.7 | (4.7, 11.9) | |
| No change in use | (194/470) | 40.3 | (34.5, 46.4) | | (43/470) | 8.9 | (6.1, 12.5) | | (21/470) | 4.7 | (2.6, 7.7) | |
| Increased frequency or started using | (188/403) | 44.3 | (37.7, 51.1) | | (37/403) | 7.7 | (4.8, 11.6) | | (14/403) | 2.3 | (1.1, 4.3) | |

Freq. = unweighted frequency; NS = not significant.
*$p < .05$.
** $p < .01$.
***$p < .001$.

**Table 2.** Adjusted Odds Ratios From Multivariable Logistic Regression Models Estimating the Association Between Smoking Cessation Outcomes in Wave 2 as a Function of Changes in Cannabis Use Between Waves (Weighted Estimates, $n = 4261$)

| Change in cannabis use[a] | aOR | (95% CI) | $\chi^2$ | *p* |
|---|---|---|---|---|
| Model 1: tried to quit cigarettes | | | | |
| Reduced frequency or stopped using | 1.13 | (0.79, 1.60) | 5.51 | .138 |
| No change in use | 0.74 | (0.54, 1.01) | | |
| Increased frequency or started using | 0.84 | (0.60, 1.17) | | |
| Model 2: quit smoking cigarettes | | | | |
| Reduced frequency or stopped using | 1.48 | (0.96, 2.29) | 15.10 | .002 |
| No change in use | 0.67 | (0.43, 1.04) | | |
| Increased frequency or started using | 0.52 | (0.31, 0.86) | | |
| Model 3: quit cigarettes for at least 6 months | | | | |
| Reduced frequency or stopped using | 1.00 | (0.57, 1.77) | 12.46 | .006 |
| No change in use | 0.63 | (0.35, 1.14) | | |
| Increased frequency or started using | 0.30 | (0.15, 0.62) | | |

[a]Results of three separate multivariable logistic regression models examining the association between change in cannabis use frequency between waves and smoking cessation outcomes. Each model adjusted for the following covariates: sample source, country, sex, age group, ethnicity, income, education, smoking status, cigarettes smoked per day, vaping status, intentions to quit smoking, alcohol consumption, and self-reported diagnoses of anxiety, depression, and chronic pain. Full model results with adjusted odds ratios (aOR) for all covariates are presented in Supplementary Table 4.

## Discussion

Using nationally representative samples of adult cigarette smokers from Canada, the United States, England, and Australia, this study found that changes in or maintenance of cannabis use were not associated with attempts to quit cigarettes compared with nonuse of cannabis. However, smokers who maintained or increased their use of cannabis over an 18-month period had significantly lower odds of successful smoking cessation compared with noncannabis-using smokers. This was true even after controlling for sociodemographic factors, high-risk drinking behaviors, and indicators of depression and chronic pain that are associated with changes in cannabis use frequency. These findings are consistent with previous population studies of US smokers[2,10,12,19] and observational studies of smokers seeking cessation treatment.[11] They also indicate that smokers who reduce their frequency of cannabis use or stop altogether do not differ significantly from nonusers in their odds of quitting successfully.

While co-use of tobacco and cannabis may impede smokers' efforts to quit smoking, it is plausible that smokers who are motivated to quit smoking are also more motivated to quit using cannabis. Whatever the effects of decreased or complete cessation of cannabis use, continued cannabis use may act as a barrier to successful cigarette smoking cessation.[2,6,11] Whether this is because cannabis co-use reduces motivation to quit cigarettes,[1] or because it increases the risk of relapse,[12] or because it reflects a group less interested in reducing drug use,[2] is less clear. However, in this study, cannabis users were no less likely to try to quit than nonusing smokers, suggesting they may be unable to stay quit. It will be important to monitor both attempts to quit and successful cessation among smokers who also use cannabis and to monitor the impacts, if any, of cannabis legalization on smoking cessation.

It is worth noting that these relationships were observed across four high-income countries having different historical patterns in the prevalence of cannabis use. Results presented here reflect overall average effects across these countries. Country-specific odds ratios were consistent with the overall results presented in Supplementary Table 4 for all cessation outcomes. While there may be a generalized effect of continued cannabis use on cigarette smoking cessation, additional longitudinal research is needed in different countries and settings to establish whether this is the case.

This study has limitations that need to be acknowledged. First, it was not possible to determine whether changes in cannabis use preceded or followed smoking cessation. This is problematic because the endocannabinoid system may influence nicotine addiction and because nicotine may enhance the perceived effects of cannabis.[6,7] Therefore, future studies need to identify which behaviors change first to better understand how changes in cannabis use might influence cigarette smoking cessation. Second, changes in cannabis use frequency may be associated with changes in method of use. Different methods of use influence the effects cannabis exerts on the human body.[20] As a result, changes in the method of cannabis use over time may have influenced smoking cessation behaviors in this study. Third, cigarette smokers were not asked to report the type of cannabis they used, so it was not possible to assess whether different types of cannabis (ie, those with higher tetrahydrocannabinol [THC] content) may have a greater negative impact on cigarette smoking quit success. Fourth, this study relied on self-reported behavioral measures. If the accuracy of self-reported abstinence differed across cannabis user groups, associations between cannabis transitions and smoking cessation may be biased. Furthermore, smokers may have failed to report cannabis use. However, data were collected securely and confidentially using web-based methods, which have been shown to produce valid estimates of cannabis use.[21] Finally, follow-up rates between survey waves ranged from 41% (EN) to 56% (AU). Smokers lost to attrition differed from those successfully recontacted (Supplementary Table 5). In particular, a greater percentage of smokers lost to attrition used cannabis, smoked fewer cigarettes per day, and were nondaily smokers. Differential attrition may have introduced some bias in estimated relationships. However, the analysis employed longitudinal sampling weights, which account for differential attrition across several measures used to calibrate the weights, including wave 1 user groups (cigarette smokers, exclusive e-cigarette users, dual users, and former smokers), region, sex, age group, ethnicity (US only), language (CA only), and education (excluding CA).[16,22] In spite of these limitations, a key strength of this study was that it controlled for measures of mental health, alcohol use, and chronic pain, which can cooccur with cannabis use and which might influence smoking cessation.

In conclusion, smokers who start using cannabis or increase their frequency of use over time were less likely to quit smoking cigarettes compared with smokers who do not use cannabis at all. While increased cannabis use frequency was associated with high-risk drinking and chronic pain, increased frequency of cannabis use was still associated with reduced likelihood of successful smoking cessation even after these factors were partially controlled. Reductions in cannabis use may improve the odds of successful smoking cessation while increased cannabis use may reduce the likelihood of successful smoking cessation. These findings have important public health implications. If smokers who also use cannabis are more likely to continue smoking, it is important to monitor these trends and to understand the impact, if any, on smoking cessation in jurisdictions that have legalized cannabis for nonmedical use as well as develop cessation interventions that simultaneously target tobacco and cannabis co-use.

## Supplementary Material

A Contributorship Form detailing each author's specific involvement with this content, as well as any supplementary data, are available online at https://academic.oup.com/ntr.

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## Ethics Approval

Study protocols and questionnaires received ethical approval from the Office of Research Ethics, University of Waterloo, Canada (ORE#20803/30570 and ORE#21609/30878); the Research Ethics Office, King's College London, UK (RESCM-17/18–2240); Human Research Ethics, Cancer Council Victoria, Australia (HREC1603); Human Ethics, Research Management Office, University of Queensland, Australia (2016000330/HREC1603); and the Institutional Review Board Medical University of South Carolina (waived because of minimal risk).

## Declaration of Interests

*KMC has received payment as a consultant to Pfizer, Inc., for service on an external advisory panel to assess ways to improve smoking cessation*

*delivery in health care settings. KMC also has served as a paid expert witness in litigation filed against cigarette manufacturers. GTF and DH have served as expert witnesses on behalf of governments in litigation involving the tobacco industry. AM is a UK National Institute for Health Research (NIHR) Senior Investigator. The views expressed in this article are those of the authors and not necessarily those of NIHR or the UK Department of Health and Social Care. All other authors have no conflicts of interest to declare.*

## Authors' Contributions

PD: conceptualization, methodology, formal analysis, validation, visualization, writing—original draft, and writing—review and editing; SG: conceptualization, methodology, and writing—review and editing; EW: writing—review and editing; DMS: methodology and writing—review and editing; RL: data curation, validation, and writing—review and editing; DH: funding acquisition, methodology, writing—review and editing, and supervision; LL and HA: writing—review and editing; AM: funding acquisition, writing—review and editing, and supervision; RB: funding acquisition, methodology, validation, writing—review and editing, and supervision; KMC: funding acquisition, methodology, writing—review and editing, and supervision; MET: funding acquisition, methodology, formal analysis, validation, writing—review and editing, and supervision; GTF: funding acquisition, methodology, resources, writing—review and editing, and supervision.

## Data Availability Statement

The data are jointly owned by a third party in each country that collaborates with the International Tobacco Control Policy Evaluation (ITC) Project. Data from the ITC Project are available to approved researchers 2 years after the date of issuance of cleaned data sets by the ITC Data Management Centre. Researchers interested in using ITC data are required to apply for approval by submitting an International Tobacco Control Data Repository (ITCDR) request application and subsequently to sign an ITCDR Data Usage Agreement. To avoid any real, potential, or perceived conflict of interest between researchers using ITC data and tobacco-related entities, no ITCDR data will be provided directly or indirectly to any researcher, institution, or consultant that is in current receipt of any grant monies or in-kind contribution from any tobacco manufacturer, distributor, or other tobacco-related entity. The criteria for data usage approval and the contents of the Data Usage Agreement are described online (http://www.itcproject.org). The authors of this paper obtained the data following this procedure. This is to confirm that others would be able to access these data in the same manner as the authors. The authors did not have any special access privileges that others would not have.

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