Title

Longitudinal Associations Between Use of Tobacco and Cannabis Among People Who Smoke Cigarettes in Real-world Smoking Cessation Treatment

Journal

Journal of Addiction Medicine, 16(4)

ISSN

1932-0620

Authors

Nguyen, Nhung
Neilands, Torsten B
Lisha, Nadra E
et al.

Publication Date

2022-07-01

DOI

10.1097/adm.0000000000000920

HHS Public Access

Author manuscript

J Addict Med. Author manuscript; available in PMC 2023 January 01.

Published in final edited form as:

J Addict Med. 2022 ; 16(4): 413–419. doi:10.1097/ADM.0000000000000920.

Longitudinal associations between use of tobacco and cannabis among people who smoke cigarettes in real-world smoking cessation treatment

Nhung Nguyen, PhD[a], **Torsten B. Neilands, PhD**[b], **Nadra E. Lisha, PhD**[a], **Joanne Chen Lyu, PhD**[a], **Sarah S. Olson, BA**[a], **Pamela M. Ling, MD, MPH**[a]

[a]Center for Tobacco Control Research and Education, University of California San Francisco, San Francisco, CA

[b]Center for AIDS Prevention Studies, University of California San Francisco, San Francisco, CA

Abstract

Objectives: Cannabis use is common among people who use tobacco. However, little is known about the relationship between change in use of tobacco and cannabis over time. We examined the longitudinal associations between use of the two substances in a real-world smoking cessation context.

Methods: This study analyzed data from a 3-month smoking cessation program delivered via Facebook in the San Francisco Bay Area, USA during 2016–2020. The sample included 487 participants who smoke cigarettes (M_{age}=25.4 years old, 39.6% Male, 40.3% White). The regressors (i.e., frequency or number of days during the past 30 days using cigarettes, e-cigarettes, and cigars) and the outcome (i.e., frequency of cannabis use) were measured at both baseline and 3-month follow-up. Random-effects modeling examined the longitudinal associations between the regressors and the outcome controlling for alcohol use and baseline demographics.

Results: Participants who increased (or decreased) their frequency of use of cigarettes (β=0.17, 95% confidence interval [CI] =0.10, 0.24), e-cigarettes (β=0.11, 95%CI=0.05, 0.17), or cigars (β=0.19, 95%CI=0.06, 0.32) also increased (or decreased) their frequency of cannabis use after 3 months. Sexual minority participants (vs. heterosexuals) (β=2.12, 95%CI=0.01, 4.24) and those whose education attainment being high school or less (vs. higher education) (β=3.89, 95%CI=1.25, 6.53) were more likely to increase their frequency of cannabis use over time.

Conclusions: The findings indicated positive associations between change in use of tobacco and cannabis use. Promoting cessation among people who use tobacco may help to reduce their cannabis use.

Keywords

tobacco; cannabis; polysubstance; smoking cessation; longitudinal association

Correspondence: Nhung Nguyen, PhD, Center for Tobacco Control Research and Education, University of California San Francisco, 530 Parnassus Ave., San Francisco, CA 94143. Phone: (415) 476-2265 | Fax: (415) 476-2265 | Nhung.Nguyen@ucsf.edu.

Conflict of Interests: None

INTRODUCTION

Cannabis use is very common among people who use tobacco.[1] People who currently use tobacco are 3–8 times more likely to report current use of cannabis than those who do not.[2,3] The intersection of tobacco and cannabis use is a growing public health concern in the US, particularly among adolescents and young adults, the age groups with the highest rates of substance use.[4] Over the past decade, the use of cannabis has been increasing among people who smoke cigarettes,[5,6] and is associated with persistent cigarette smoking and decreased successful cessation.[3,7] Importantly, there are more than 100 compounds in cigarette and cannabis smoke known to cause negative health effects,[8] so people who use both substances receive expose to additive toxicants and potentially deleterious health problems.[9] Understanding the relationship between use of tobacco and cannabis is critical to inform treatment strategies to reduce the use of both substances.[1,10]

A clinical concern in cigarette smoking cessation treatment for people who use both tobacco and cannabis is a potential drug substitution effect, in which people might switch to or increase their cannabis use as compensation for reductions in nicotine intake.[11] However, the existing evidence for drug substitution effects is mixed.[1,11,12] Continued or increased use of cannabis among people engaged in tobacco treatment is an important, but understudied issue. More data are needed to clarify whether people who try to quit smoking cigarettes increase or decrease their cannabis use.

To date, most studies of the relationship between tobacco and cannabis use have used cross-sectional data.[13,14] Such data cannot provide trajectories of substance use or draw conclusions on dynamic relationships. There have been few longitudinal studies examining the relationship between the use of tobacco and cannabis over time.[12,15–18] Of those, only two studies specifically examined change in cannabis use in the context of smoking cessation. One study found that decreased rates of smoking were associated with a moderate decrease in cannabis use among people enrolled in a randomized clinical trial of varenicline for smoking cessation.[17] The other study found that people who used cannabis steadily decreased their cannabis use in a randomized clinical trial for smoking cessation.[18] However, there have been no studies examining this topic in real-world settings.

In addition, the evolving tobacco product landscape has resulted in a transformation of tobacco use patterns. E-cigarette vaping has surpassed cigarette smoking among young people and use of multiple tobacco products is increasingly popular.[19] Non-cigarette products (e.g., e-cigarettes and cigars) also facilitate co-use of tobacco and cannabis. For example, e-cigarettes can be modified to vape cannabis in the form of concentrated liquid hash oil or tetrahydrocannabinol (THC) wax or oil, and vaporizers are increasingly popular devices for cannabis consumption.[20] While evidence on the longitudinal associations between use of cigarettes and cannabis is mounting, less is known about longitudinal relationships between use of cannabis and non-cigarette tobacco products.

To address the aforementioned gaps, we analyzed data from 487 people enrolled in an online smoking cessation program to examine the longitudinal associations between use of tobacco products (i.e., cigarettes, e-cigarettes, cigars) and cannabis over 3 months. Based

on the previous research on this topic, we hypothesized that reduction in cigarette smoking and other tobacco use would not increase the use of cannabis. We examined the effect of cigarettes on cannabis use rather than the converse effect of cannabis on cigarette use, since all participants were actively making efforts to quit or reduce smoking.

METHODS

Design

This study is a secondary analysis of de-identified longitudinal data from an online smoking cessation program provided as a community service to increase access to evidence-based treatment for young adults who smoke cigarettes (age 18–30) in the San Francisco Bay Area (https://www.sfcancer.org/tobacco-caused-cancers). The program adapted an intervention previously tested in a randomized trial, with design enhancements and branded advertising to increase enrollment.[21] The program was advertised on social media and content and advertising were tailored to reach young adults although older participants were not excluded. Cessation supports were delivered via 58 Facebook groups during November 2016-March 2020. Groups were tailored to participants' readiness to quit smoking. Each day over a period of 90 days, participants received Facebook posts containing smoking cessation strategies.[21] Posts' content were based on the US Clinical Practice Guidelines for smoking cessation and the Transtheoretical Model of behavior change and utilized images, videos, and text designed to reflect the experience of young adults and elicit participation. In addition, participants were invited to weekly live chat sessions on Facebook with a trained smoking cessation counselor to answer questions and provide counseling in real time. The University of California San Francisco Institutional Review Board reviewed this program and determined that IRB approval and informed consents were not necessary as the program was not a research study and data were originally collected for quality improvement.

Participants

Eligible people (English-literate, adults who currently use tobacco and resides in San Francisco Bay Area Counties) were invited to enroll in private Facebook groups. Prior to starting the cessation treatment, all participants were asked to complete an online survey via Qualtrics, including their demographics, tobacco and cannabis use, and readiness to quit. After the 3-month intervention, participants were asked to complete another survey reporting tobacco and cannabis use and feedback on their experience in the program. Participants received incentives for survey completion ($20 for baseline survey, $30 for follow up survey) and $10–30 for their response to Facebook posts. Since the program was provided as a community service and not a research project, participation in the smoking cessation groups was not contingent on surveys' completion. As missingness is commonly expected in real-world datasets, only 487 (56%) of the 862 people enrolled in the program provided baseline data and were included in the analytic sample. There was no statistical difference between the analytic sample and those did not provide baseline data regarding age and frequency of cigarette smoking. Only 261 participants (54% of the analytic sample or 30% of the enrolled participants) completed the 3-month follow up survey. Participants who were male (vs. female) or had an education attainment of high school or less (vs. college or

higher) were more likely to be lost to follow-up. There was also a temporal pattern in loss to follow-up over the study years.

Measures

Outcome—Frequency of cannabis use was measured at both baseline and 3-month follow up by the item "During the past 30 days, on how many days (0–30) did you use marijuana, hash, or blunts?" reported as a continuous variable.

Independent variables—At baseline and 3-month follow up, participants reported the number of days in the past month they used each of three tobacco products (i.e., cigarettes, e-cigarettes, cigars/cigarillos). Frequency of use of each tobacco product ranged from 0 to 30 days.

Covariates—Demographic characteristics were collected at baseline. Age was calculated based on self-reported date of birth. Sex assigned at birth was self-reported as male and female. Sexual orientation was dichotomized into sexual minority (i.e., lesbian, gay, bisexual, other) and heterosexual (i.e., straight). Race/ethnicity was measured by combining two items: race (White, Black, Asian, Hawaiian/Pacific Islander, American Indian/Alaskan Native, or More than one race) and ethnicity (Hispanic or not). Participants also reported educational attainment in categories; the variable was dichotomized as "High school or less" and "College or higher" consistent with prior substance use research.[22] At baseline, participants were asked "How many cigarettes have you smoked in the past 7 days?" Based on this question, we calculated an average number of cigarettes smoked per day. In addition, participants reported substances they used in their e-cigarette devices if they reported vaping in the past 30 days, as well as reported number of days they used alcohol during the past 30 days at baseline.

Statistical analysis

Participants' demographic characteristics and substance use at baseline were summarized. Change in tobacco and cannabis use were described as proportions of increase, decrease, or no change in frequency of use over 3 months. Participants were classified as increasing their use of tobacco (or cannabis) if their reported numbers of days using tobacco (or cannabis) at the follow-up were greater than that at baseline. Conversely, participants were classified as decreasing their use of tobacco (or cannabis) if their reported numbers of days using tobacco (or cannabis) at the follow up were less than that at baseline. Those who reported the same numbers of days using tobacco (or cannabis) were classified as no change. Missing data at follow up were addressed using multiple imputation.[23] We included all variables (i.e., independent variables, covariates, and the outcome in the analysis model) in the imputation.[24] We then applied multiple imputation via chained equations to create 50 imputed datasets,[25] and analyzed them using the Generalized Least-Squares (GLS) models described below.[26,27]

Longitudinal associations between tobacco use frequency (i.e., cigarette, e-cigarette, cigar) and cannabis use frequency were examined in GLS fixed- and random-effects modeling as these approaches are recommended for panel data analysis.[26,27] The fixed-effects model

treated effects of unobserved variables as fixed constants, while they were treated as normally-distributed random variables in the random-effects model. To control for the time effect, the models included a dummy variable for survey time point (e.g., time=0 for baseline, time=1 for follow-up). Year of data collection was also included in the models to account for potential differences in substance use patterns across the study years. We then compared the two models based on the Hausman specification test, with the null hypothesis that the preferred model is random effects. We also conducted a robustness check by performing the models using only complete data (complete cases analysis).[23] All tests were two-tailed with a significance level of α less than 0.05. Data were analyzed using STATA 15.0 (StataCorp LLC, College Station, TX, US).

RESULTS

Characteristics of the study participants

Baseline characteristics of the participants were described in Table 1. The sample had a mean age of 25.35 years (SD=4.68) with 94.25% in a range of 18–30 years old. More than half were female (58.93%) and 47.23% identified as sexual minority. The majority were non-Hispanic White (40.25%) and had education attainment of college or higher (79.06%).

Tobacco and cannabis use at baseline and change after 3 months

Tobacco and cannabis use at baseline is presented in Table 1. Almost all the participants reported smoking cigarettes during the last month with an average of 19.67 smoking days. More than half also reported past 30-day use of e-cigarettes (51.95%) and 33.06% reported past 30-day use of cigars. Approximately two thirds of the sample reported past 30-day use of cannabis (68.38%) for an average of 11.86 days. More than a third smoked cigarettes daily and most of the participants smoked 5 or fewer cigarettes per day. Among participants reporting past 30-day use of e-cigarettes, 20.9% used both nicotine and THC in their vaping devices.

At 3-month follow-up, a greater proportion of participants reported decreased tobacco and cannabis use than an increase (Figure 1). Notably, 70.88% reported a decrease in frequency of cigarette smoking, while 14.94% reported an increase and 14.18% reported no change. Likewise, about one third decreased use of e-cigarettes (39.08%) and cigars (30.27%), while smaller proportions reported an increase in use of e-cigarettes (18.39%) and cigars (9.19%). Regarding change in cannabis use, 41% of the sample reported a decrease, 18% reported an increase, and 41% reported no change.

Longitudinal associations between use of tobacco and cannabis

Multivariate regression results are shown in Table 2. The Hausman test was not significant (p=0.13), favoring the random effects model. There were significant positive within-person associations between change in use of each tobacco product and change in cannabis use. Accordingly, for each day of increased smoking frequency at follow-up, cannabis use frequency also increased by 0.17 days (95% Confidence Interval [CI]=0.10, 0.24). An average decrease in smoking frequency among the participants was 11 days. As a theoretical case, when an individual decreased their smoking frequency by 11 days, this person also

decreased their cannabis use frequency by 1.87 days (11*0.17). Likewise, frequency of use of e-cigarette (β=0.11, 95%CI=0.05, 0.17) and cigar (β=0.19, 95%CI=0.06, 0.32) use were positively associated with frequency of cannabis use. In addition, sexual minority participants (vs. heterosexuals) (β=2.12, 95%CI=0.01, 4.24) and those with education attainment of high school or less (β=3.89, 95%CI=1.25, 6.53) were more likely to increase their frequency of cannabis use over time. Complete cases analysis showed similar results for associations between use of cigarettes and e-cigarettes and use of cannabis with the same significant associations but slightly larger estimated coefficients. However, there were no significant associations for cigar use, sexual minorities, and education attainment.

DISCUSSION

This study is one of the few examining longitudinal relationships between tobacco and cannabis use among people in a smoking cessation treatment outside of a clinical trial. The most important finding is that change in frequency of use of tobacco products (i.e., cigarettes, e-cigarettes, cigars) was positively associated with change in frequency of cannabis use. In our sample, more than a half of the participants who decreased their tobacco use also decreased their cannabis use after participating in the community smoking cessation program.

As our data were from those participating in an online smoking cessation program, a greater proportion of participants reduced their tobacco use than increased after the 3-month intervention. This encouraging finding coupled with the positive associations between change in tobacco and cannabis use highlight potential additional benefits from tobacco smoking cessation interventions. While one might expect an increase in cannabis use among those trying to quit tobacco use,[13,28] our data suggest the substitution effect does not occur in the context of real-world smoking cessation treatment, though it might in social contexts.[29] This finding is consistent with previous studies showing that increased use of cannabis did not occur during smoking reduction or cessation,[17,18,30] and a meta-analysis indicating that smoking cessation supports sobriety from other substance use.[31] This study adds to the literature by including a broader range of tobacco products. In addition to cigarettes, we found that change in use of e-cigarettes and cigars were positively associated with change in cannabis use. This suggests that any reduction in nicotine use, regardless of product type, was linked to a reduction in cannabis use. While the effect sizes found in our study were small, the same direction of changes in use of tobacco and cannabis has important implications to address cessation treatment for people who use both substances.

The positive associations between change in tobacco and cannabis use can be explained by different behavioral mechanisms underlying the co-use of these substances.[28] First, neurobiological evidence suggests that the practice of combining tobacco and cannabis may be an attempt to counterbalance negative and aversive states induced by either substance.[28] Accordingly, removing one substance may eliminate the need to alleviate aversive effects with the other. Second, behavioral cues from shared routes of administration (e.g., smoking or vaping one substance triggers smoking or vaping the other) may contribute to co-use of tobacco and cannabis.[28] As such, when tobacco use ceases, the cue for cannabis use might disappear. Last but not least, our sample was composed of smoking cessation treatment-

seeking people, with 73% planning to quit smoking in the next month at baseline. These motivated participants may also be motivated to reduce their cannabis use.[32] Future research should clarify mechanisms underlying change in cannabis use during smoking cessation treatment.

Our study also found that sexual minority and less-than-college educated participants were more likely to increase their cannabis use over 3 months. These findings are consistent with literature documenting disproportionately high prevalence of polysubstance use, substance-related health disparities, and low access to tobacco cessation treatment and healthcare among these groups.[32,33] In addition, the findings could be partly due to risk factors (e.g., psychological distress, targeted marketing)[33,34] that were not available in our data. The observed increase in cannabis use coupled with the increasing legalization of cannabis nationwide[35] calls for attention to cannabis use during tobacco treatment for sexual minority and low socioeconomic populations.

This study has important clinical implications. There is a growing concern that cannabis legalization may increase co-use of tobacco and cannabis, and risk for tobacco-related harms.[36] Clinicians may not counsel for cannabis cessation as routinely or as strongly as tobacco cessation, because cannabis may be used for medicinal purposes (e.g., treatment of chronic pain or chemotherapy-induced nausea and vomiting), and use is frequently perceived as helpful or reported for treatment other medical conditions despite limited scientific evidence of efficacy.[37] However, previous studies among young adults showed that the most common reason for cannabis use in this age group is recreational (e.g., social, having fun, experimenting, getting high, and relaxing).[38] Moreover, a study among young adults in California indicated that acquiring medical cannabis card was associated with more frequent use, and not associated with mental and physical health concerns.[39] While some medical providers may not actively discourage use of cannabis to alleviate symptoms in older people with chronic debilitating medical conditions, given the high rates of recreational use and the associations between cannabis use and impaired academic achievement, social functioning and mental health disorders,[37] reducing the use of both tobacco and cannabis is desirable for young people.

Our findings suggest that effective interventions for cigarette smoking may also encourage cannabis cessation among people who use both substances rather than compensatory increases in cannabis. While our program focused on smoking cessation, in the future cannabis cessation support could be added to smoking cessation interventions to help young people quit both substances. In addition, reducing non-cigarette tobacco product use was also associated with reduced cannabis use. These data suggest that screening and treatment for cigarette smoking, alternative tobacco product use including e-cigarettes, and cannabis use could be integrated and addressed together in practice. In addition, our data are from a Facebook-based intervention, which showed a positive effect in a context requiring minimal clinical management. These online cessation interventions may also increase access to cessation treatment for sexual minority and low socioeconomic populations;[40] both groups we found were at increased risk for increased cannabis use. Additional supports for cannabis cessation delivered in online smoking cessation platforms may be particularly relevant for these priority populations.

This study had several limitations. The issues of loss to follow-up and missing data are not uncommon in real-world data and longitudinal studies. As this study is a secondary analysis from a non-research longitudinal data collection effort that had no compulsory survey participation, 46% of the participants in our study did not complete the follow-up surveys, resulting in a substantial proportion of missing data, which could impact the study's internal validity. Although we conducted multiple imputation to handle the missing data and the robustness check of complete cases analysis, our study findings should be interpreted with caution and more longitudinal research is needed to confirm the positive associations between use of tobacco and cannabis found in this study. In addition, our sample of young adults who smoke cigarettes from the San Francisco Bay Area may limit generalizability of findings to other age groups and geographic regions. Our participants were motivated to quit smoking and sought out the smoking cessation program; future work should examine whether our findings extend to people less motivated to quit smoking or who are not treatment-seeking. In addition, our substance use measures were self-reported and not biologically verified, and thus may be subject to recall bias. Another limitation is a lack of detailed data on cannabis use (e.g., modes of cannabis use, cannabis use dependence, motivation to quit using cannabis, whether cannabis was simultaneously used with tobacco). We also did not collect data on intensity of use (e.g., how many times using tobacco/cannabis within a day). This may impact our results if a participant reduced numbers of using days but increased numbers of using times within a day. Future research should obtain this information to better understand changes in tobacco and cannabis use. Finally, this study measured changes in substance use in a relatively short time period (3 months). Additional work should address longer term longitudinal patterns of behavior.

CONCLUSIONS

This study indicated positive longitudinal associations between tobacco and cannabis use among people in real-world smoking cessation treatment. Providing smoking cessation supports to people with motivation to quit smoking may result in decreases in both tobacco and cannabis consumption. This effect may be enhanced by integration of tobacco and cannabis cessation programs delivered via online platforms.

Sources of support for the paper/Funding:

This project was supported by the University of California San Francisco Helen Diller Family Comprehensive Cancer Center SF CAN initiative. Authors on this manuscript were supported by the California Tobacco-Related Disease Research Program (T31FT1564), and the National Cancer Institute (T32-113710). The content is solely the responsibility of the authors and does not necessarily represent the official views of the funding agencies.

REFERENCES

1. McClure EA, Rabin RA, Lee DC, Hindocha C. Treatment Implications Associated With Cannabis and Tobacco Co-use. Curr Addict Rep. 2020;7(4):533–544. doi:10.1007/s40429-020-00334-8 [PubMed: 33777645]
2. Nguyen N, Barrington-Trimis JL, Urman R, et al. Past 30-day co-use of tobacco and marijuana products among adolescents and young adults in California. Addict Behav. 2019;98:106053. doi:10.1016/j.addbeh.2019.106053 [PubMed: 31357072]
3. Strong DR, Myers MG, Pulvers K, Noble M, Brikmanis K, Doran N. Marijuana use among US tobacco users: Findings from wave 1 of the population assessment of tobacco health (PATH)

study. Drug Alcohol Depend. 2018;186:16–22. doi:10.1016/j.drugalcdep.2017.12.044 [PubMed: 29529455]

4. Walley SC, Jenssen B, Wilson K. The Intersection of Tobacco and Marijuana Use in Adolescents and Young Adults. Pediatrics. 2019;144(6). doi:10.1542/peds.2019-3025
5. Schauer GL, Berg CJ, Kegler MC, Donovan DM, Windle M. Assessing the overlap between tobacco and marijuana: Trends in patterns of co-use of tobacco and marijuana in adults from 2003–2012. Addict Behav. 2015;49:26–32. doi:10.1016/j.addbeh.2015.05.012 [PubMed: 26036666]
6. Goodwin RD, Pacek LR, Copeland J, et al. Trends in Daily Cannabis Use Among Cigarette Smokers: United States, 2002–2014. Am J Public Health. 2017;108(1):137–142. doi:10.2105/AJPH.2017.304050 [PubMed: 29161058]
7. Weinberger AH, Delnevo CD, Wyka K, et al. Cannabis Use Is Associated With Increased Risk of Cigarette Smoking Initiation, Persistence, and Relapse Among Adults in the United States. Nicotine Tob Res. 2020;22(8):1404–1408. doi:10.1093/ntr/ntz085 [PubMed: 31112595]
8. Graves BM, Johnson TJ, Nishida RT, et al. Comprehensive characterization of mainstream marijuana and tobacco smoke. Sci Rep. 2020;10(1):7160. doi:10.1038/s41598-020-63120-6 [PubMed: 32345986]
9. Meier E, Hatsukami DK. A review of the additive health risk of cannabis and tobacco co-use. Drug Alcohol Depend. 2016;166:6–12. doi:10.1016/j.drugalcdep.2016.07.013 [PubMed: 27476751]
10. Nguyen N, Nguyen C, Thrul J. Digital Health for Assessment and Intervention Targeting Tobacco and Cannabis Co-Use. Curr Addict Rep. Published online June 19, 2020. doi:10.1007/s40429-020-00317-9
11. McClure EA, Tomko RL, Salazar CA, et al. Tobacco and cannabis co-use: Drug substitution, quit interest, and cessation preferences. Exp Clin Psychopharmacol. 2019;27(3):265–275. doi:10.1037/pha0000244 [PubMed: 30556733]
12. Choi NG, DiNitto DM, Marti CN. A longitudinal assessment of change in marijuana use with other substance use problems. Am J Drug Alcohol Abuse. 2018;44(6):642–652. doi:10.1080/00952990.2018.1461879 [PubMed: 29723073]
13. Lemyre A, Poliakova N, Belanger RE. The Relationship Between Tobacco and Cannabis Use: A Review. Subst Use Misuse. Published online October 26, 2018:1–16. doi:10.1080/10826084.2018.1512623
14. Doran N, Myers MG, Correa J, Strong DR, Tully L, Pulvers K. Marijuana Use Among Young Adult Non-Daily Cigarette Smokers Over Time. Addict Behav. 2019;95:91–97. doi:10.1016/j.addbeh.2019.03.007 [PubMed: 30875533]
15. Kristman-Valente AN, Hill KG, Epstein M, et al. The Relationship Between Marijuana and Conventional Cigarette Smoking Behavior From Early Adolescence to Adulthood. Prev Sci Off J Soc Prev Res. 2017;18(4):428–438. doi:10.1007/s11121-017-0774-4
16. Doran N, Myers MG, Correa J, Strong DR, Tully L, Pulvers K. Marijuana use among young adult non-daily cigarette smokers over time. Addict Behav. 2019;95:91–97. doi:10.1016/j.addbeh.2019.03.007 [PubMed: 30875533]
17. McClure EA, Baker NL, Hood CO, et al. Cannabis and Alcohol Co-Use in a Smoking Cessation Pharmacotherapy Trial for Adolescents and Emerging Adults. Nicotine Tob Res. 2019;22(8):1374–1382. doi:10.1093/ntr/ntz170
18. Metrik J, Spillane NS, Leventhal AM, Kahler CW. Marijuana Use and Tobacco Smoking Cessation Among Heavy Alcohol Drinkers. Drug Alcohol Depend. 2011;119(3):194–200. doi:10.1016/j.drugalcdep.2011.06.004 [PubMed: 21724341]
19. Prochaska JJ, Benowitz NL. Current advances in research in treatment and recovery: Nicotine addiction. Sci Adv. 2019;5(10):eaay9763. doi:10.1126/sciadv.aay9763 [PubMed: 31663029]
20. Kowitt SD, Osman A, Meernik C, et al. Vaping cannabis among adolescents: prevalence and associations with tobacco use from a cross-sectional study in the USA. BMJ Open. 2019;9(6):e028535. doi:10.1136/bmjopen-2018-028535
21. Ramo DE, Thrul J, Delucchi KL, et al. A randomized controlled evaluation of the tobacco status project, a Facebook intervention for young adults. Addiction. 2018;113(9):1683–1695. doi:10.1111/add.14245

22. Lenk K, Rode P, Fabian L, Bernat D, Klein E, Forster J. Cigarette use among young adults: comparisons between 2-year college students, 4-year college students, and those not in college. J Am Coll Health J ACH. 2012;60(4):303–308. doi:10.1080/07448481.2011.607481
23. Graham JW. Missing Data Analysis: Making It Work in the Real World. Annu Rev Psychol. 2009;60(1):549–576. doi:10.1146/annurev.psych.58.110405.085530 [PubMed: 18652544]
24. Moons KGM, Donders RART, Stijnen T, Harrell FE. Using the outcome for imputation of missing predictor values was preferred. J Clin Epidemiol. 2006;59(10):1092–1101. doi:10.1016/j.jclinepi.2006.01.009 [PubMed: 16980150]
25. von Hippel PT. How Many Imputations Do You Need? A Two-stage Calculation Using a Quadratic Rule. Sociol Methods Res. 2020;49(3):699–718. doi:10.1177/0049124117747303
26. Torres-Reyna O Panel Data Analysis: Fixed and Random Effects using Stata. Published online 2007.
27. Hsiao C Analysis of Panel Data. Third edition. Cambridge University Press; 2014.
28. Rabin RA, George TP. A review of co-morbid tobacco and cannabis use disorders: possible mechanisms to explain high rates of co-use. Am J Addict. 2015;24(2):105–116. doi:10.1111/ajad.12186 [PubMed: 25662704]
29. Berg CJ, Payne J, Henriksen L, et al. Reasons for Marijuana and Tobacco Co-use Among Young Adults: A Mixed Methods Scale Development Study. Subst Use Misuse. 2018;53(3):357–369. doi:10.1080/10826084.2017.1327978 [PubMed: 28792283]
30. McKelvey K, Thrul J, Ramo D. Impact of quitting smoking and smoking cessation treatment on substance use outcomes: An updated and narrative review. Addict Behav. 2017;65:161–170. doi:10.1016/j.addbeh.2016.10.012 [PubMed: 27816663]
31. Prochaska JJ, Delucchi K, Hall SM. A meta-analysis of smoking cessation interventions with individuals in substance abuse treatment or recovery. J Consult Clin Psychol. 2004;72(6):1144–1156. [PubMed: 15612860]
32. Nguyen N, McQuoid J, Neilands TB, et al. Same-day use of cigarettes, alcohol, and cannabis among sexual minority and heterosexual young adult smokers. Psychol Addict Behav. Published online 2020:No Pagination Specified-No Pagination Specified. doi:10.1037/adb0000678
33. Drope J, Liber AC, Cahn Z, et al. Who's still smoking? Disparities in adult cigarette smoking prevalence in the United States. CA Cancer J Clin. 2018;68(2):106–115. doi:10.3322/caac.21444 [PubMed: 29384589]
34. Krueger EA, Fish JN, Upchurch DM. Sexual Orientation Disparities in Substance Use: Investigating Social Stress Mechanisms in a National Sample. Am J Prev Med. 2020;58(1):59–68. doi:10.1016/j.amepre.2019.08.034 [PubMed: 31761516]
35. Jacob JA. Marijuana Use Has Doubled Among US Adults. JAMA. 2015;314(24):2607–2607. doi:10.1001/jama.2015.17171
36. Nicksic NE, Do EK, Barnes AJ. Cannabis legalization, tobacco prevention policies, and Cannabis use in E-cigarettes among youth. Drug Alcohol Depend. 2020;206:107730. doi:10.1016/j.drugalcdep.2019.107730 [PubMed: 31759233]
37. National Academies of Sciences, Engineering, and Medicine. The Health Effects of Cannabis and Cannabinoids: The Current State of Evidence and Recommendations for Research.; 2017. 10.17226/24625.
38. Kurtzman ET, Young-Wolff KC. Why do Americans use marijuana? Drug Alcohol Depend. 2021;226:108880. doi:10.1016/j.drugalcdep.2021.108880 [PubMed: 34256265]
39. Pedersen ER, Tucker JS, Seelam R, Rodriguez A, D'Amico EJ. Factors Associated With Acquiring a Medical Marijuana Card: A Longitudinal Examination of Young Adults in California. J Stud Alcohol Drugs. 2019;80(6):687–692. doi:10.15288/jsad.2019.80.687 [PubMed: 31790359]
40. Vogel EA, Ramo DE, Meacham MC, Prochaska JJ, Delucchi KL, Humfleet GL. The Put It Out Project (POP) Facebook Intervention for Young Sexual and Gender Minority Smokers: Outcomes of a Pilot, Randomized, Controlled Trial. Nicotine Tob Res Off J Soc Res Nicotine Tob. 2020;22(9):1614–1621. doi:10.1093/ntr/ntz184

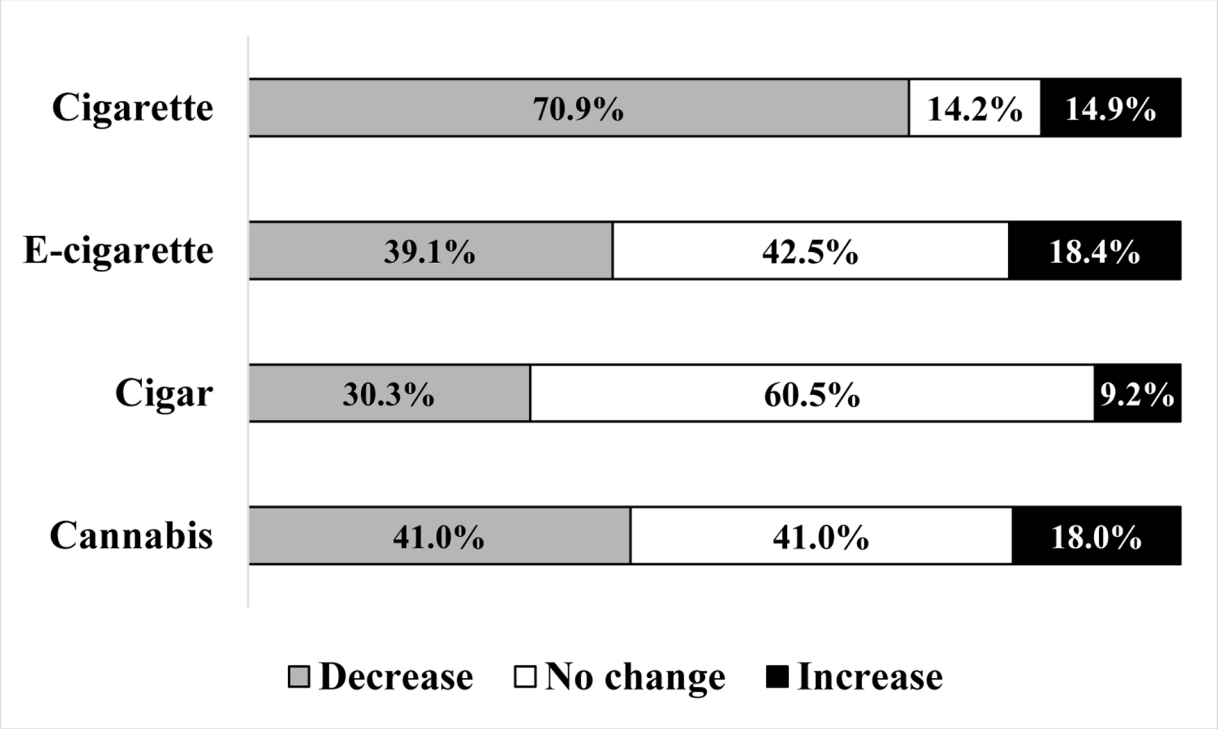

Figure 1:
Proportions of change in frequency of tobacco and cannabis use over 3 months among cigarette smokers completing both baseline and follow-up surveys (N=261)

Table 1:

Characteristics of the study sample at baseline (N=487)

Characteristics	N (%) or Mean (SD)
Demographics	
Age	
Mean (SD)	25.35 (4.68)
18–30 years old	459 (94.25)
Over 30 years old	28 (5.75)
Sex at birth	
Male	193 (39.63)
Female	287 (58.93)
Sexual identity	
Heterosexual	248 (50.92)
LGBTQ+	230 (47.23)
Race/Ethnicity	
NH White	196 (40.25)
NH Black	51 (10.47)
NH Asian	57 (11.70)
Hispanic	80 (16.43)
Other/Multi-race	96 (19.71)
Education attainment	
High school or less	94 (19.30)
College or higher	385 (79.06)
Substance use	
Past 30-day use (yes/no)	**N (%)**
Cigarette	472 (96.92)
E-cigarette	253 (51.95)
Cigar	161 (33.06)
Cannabis	333 (68.38)
Alcohol	363 (74.54)
Frequency of use (# days in the past month), Mean (SD)	
Cigarette	19.67 (10.73)
E-cigarette	7.08 (12.70)
Cigar	2.69 (6.56)
Cannabis	11.86 (12.48)
Alcohol	8.25 (7.90)
Smoking cigarettes daily	175 (35.9)
Cigarettes smoked per day	
0–5	362 (74.3)
6–19	101 (20.7)
20 or more	24 (4.9)
Substance vaped among past 30-day e-cigarette users (N=253)	

Nicotine	125 (49.4)
THC	68 (26.9)
Nicotine + THC	53 (20.9)
Without nicotine	6 (2.4)

Table 2:

Longitudinal associations between frequency of tobacco and cannabis use

Independent variables	Imputation analysis (N=487 participants, 50 imputed datasets)	Completed cases analysis (N=261 participants)
Frequency of use of each tobacco product	**β (95% CI)**	**β (95% CI)**
Cigarette	0.17 (0.10, 0.24) ***	0.19 (0.11, 0.27) ***
E-cigarette	0.11 (0.05, 0.17) **	0.12 (0.05, 0.19) **
Cigar	0.19 (0.06, 0.32) **	0.12 (−0.04, 0.28)
Covariates		
Age	−0.17 (−0.38, 0.05)	−0.06 (−0.33, 0.22)
Sex at birth (Female vs. Male)	0.67 (−1.40, 2.75)	0.42 (−2.40, 3.23)
Sexual minority (Yes vs. No)	2.12 (0.01, 4.24) *	2.24 (−0.52, 5.01)
Race/ethnicity (Ref = NH White)		
NH Black	2.08 (−1.45, 5.60)	0.13 (−4.42, 4.68)
NH Asian	−1.67 (−5.00, 1.66)	−1.87 (−5.88, 2.15)
NH Multiracial/Other	1.22 (−1.50, 3.94)	0.95 (−2.58, 4.47)
Hispanic	0.42 (−2.57, 3.40)	1.48 (−2.64, 5.60)
Education		
Highschool or less vs. College or higher	3.89 (1.25, 6.53) **	2.59 (−1.08, 6.25)
Year of data collection	0.17 (−0.86, 1.20)	−0.73 (−2.13, 0.68)
Alcohol use frequency	0.09 (−0.02, 0.19)	0.09 (−0.04, 0.22)
Time effect	−0.40 (−1.67, 0.88)	−0.34 (−1.69, 1.02)

*: p<0.05,

**: p<0.01,

***: p<0.001;

CI: Confidence Interval