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Co-occurring use of cannabis and tobacco and the presence of acute respiratory symptoms among young adult light and intermittent smokers

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Abstract

Background: Cannabis use and intermittent smoking are becoming increasingly prevalent among young adults. Thus, identifying health consequences of co-occurring use of these substances represents an emerging research priority.

Purpose/Objectives: This study evaluated the relationship between tobacco/cannabis co-use and acute symptoms of respiratory illness among young adult intermittent smokers. We hypothesized that tobacco/cannabis co-use would be more strongly associated with respiratory symptoms relative to use of neither or one product.

Methods: This study represents a secondary analysis of a three-year observational study. Non-daily smokers (n=563) aged 18–24 were recruited via social media and completed electronic surveys at baseline and annually for two years, producing three total assessments. Past-two-week use of tobacco and cannabis was measured at each assessment, as was severity of six acute respiratory symptoms. The respiratory measure was dichotomized to indicate presence or absence of symptoms.

Results: Tobacco/cannabis co-use decreased from 54.8% at baseline to 43.4% at year two (p<.001). Mean respiratory symptoms also declined significantly over time (ps<.05). At each timepoint, co-use was more strongly associated with presence of respiratory symptoms than useof neither product (aORs=2.73–4.39, ps≤.013). Co-users were also 38–183% more likely to endorse presence of respiratory symptoms than single product users at each timepoint (aORs=1.38–2.83, ps=.023-.212).

Conclusions/Importance: Although co-occurring use of tobacco and cannabis by young adults may represent experimental use of multiple substances, it may also promote or exacerbate acute symptoms of respiratory illness. Further exploration with more granular patterns of co-use and across different routes of administration is warranted.

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Data Availability

The data that support the findings of this study are available from the corresponding author, JBC, upon reasonable request.

Disclosure of Interest

The authors report no conflict of interest.

Keywords

tobacco; cannabis; respiratory symptoms; young adults; survey

Introduction

Evolving legislation, marketplaces, and social views of both substances have made co-occurring use of cannabis and tobacco a public health research priority in recent years (Hall & Kozlowski, 2018b; National Academies of Sciences, Engineering, and Medicine, 2017). Young adulthood represents a critical developmental phase within which co-occurring use of cannabis and tobacco should be studied. Recent epidemiological data indicate that nearly 20% of young adults in the United States regularly use tobacco products (Wang et al, 2018), and nearly 20% currently use cannabis (Substance Abuse and Mental Health Services Administration, 2018). Co-occurring use of tobacco and cannabis by young adults can be influenced by social contexts and intentions to experiment with substances (Berg et al., 2018), and perhaps as a result, young adults report more frequent use of both tobacco products (Kasza et al., 2017) and cannabis (Substance Abuse & Mental Health Service Administration, 2019) than other adult sub-groups. These national trends are further informed by survey data from the state of California, where both medical and recreational cannabis use are legal; in 2017–2018, 37% of young adults reported using both substances in the past year (Tucker, Pedersen, Seelam, Dunbar, Shih, & D'Amico, 2019).

Several recently published studies converge to reinforce the importance of studying co-occurring use of tobacco and cannabis among young adults. Co-use has remained relatively stable (Seaman, Green, Wang, Quinn, & Fryer, 2019), if not increased (Tucker, Rodriguez, et al., in press), in this population over time, and there seems to be a reciprocal relationship between tobacco and cannabis among young adults, with increased use of tobacco being associated with increased use of cannabis, and vice versa (Doran, Myers, Correa, Strong, Tully, & Pulvers, 2019). Given these trends, and given the longitudinal association between cannabis/tobacco co-use and the emergence of physical symptoms (Tucker, Rodriguez et al., in press), more awareness and understanding of potential physical consequences and risks of cannabis/tobacco co-use among young adults is warranted.

Cannabis and tobacco products are both commonly consumed via inhalation, and a shared route of administration may promote co-occurring use of these substances (Lemyre, Poliakova, & Bélanger, 2019). A shared route of administration might also promote potential consequences of co-use, as using multiple combustible products may heighten risk of respiratory problems, including persistent cough, wheezing, and shortness of breath. Tobacco (U.S. Department of Health and Human Services, 2014) and cannabis use (Gates, Jaffe, & Copeland, 2014) have been independently associated with the development of common respiratory symptoms, and longitudinal data suggest that co-occurring use of cannabis and tobacco can impair lung functioning in young adults (Taylor et al., 2002). Further, non-daily cigarette use has been associated with increased respiratory-related mortality (Inoue-Choi, McNeel, Hartge, Caporaso, Graubard, & Freedman, 2019), and smoking by intermittent smokers can promote exacerbation of acute respiratory symptoms

(van der Vaart et al., 2005). Finally, tobacco/cannabis co-use is associated with a history of respiratory illness (Strong, Myers, Pulvers, Noble, Brikmanis, & Doran, 2018), and the emergence of e-cigarette or vaping product use-associated lung injury (EVALI) reinforces the importance of identifying aspects of respiratory illness associated with diverse nicotine and tobacco product use – especially in the context of using these devices to consume cannabis (Siegel et al., 2019).

Despite this growing knowledge base and the attention of the nicotine and tobacco science community on issues like EVALI, more systematic research into respiratory issues associated with tobacco/cannabis co-use is warranted, especially given the evolving social climates and expanding marketplaces for both substances. It also remains unclear whether, given these socio-environmental changes, co-occurring use of cannabis and tobacco is more strongly associated with respiratory symptoms than single product use among intermittent smokers. Although low rates of tobacco use might result in low rates of acute respiratory symptoms within this population, it remains important to evaluate potential health consequences of this pattern of tobacco use, especially within the context of co-occurring cannabis use. One population of intermittent smokers with whom this could be done effectively is young adults, who are more likely to endorse intermittent cigarette use instead of daily, heavy smoking (Reyes-Guzman et al., 2017), have seen increases in cannabis use in recent years (Schulenberg, Johnston, O'Malley, Bachman, Miech, & Patrick, 2019), and are more likely to endorse past-month cannabis use than older adults (Substance Abuse and Mental Health Services Administration, 2019).

Thus, the purpose of this study was to evaluate the association between co-occurring use of tobacco products and cannabis and the presence of common respiratory symptoms among young adult intermittent smokers. Data from a longitudinal study of young adult light and intermittent cigarette smokers (Doran et al., 2017) were analyzed to determine whether there were consistent, timepoint-specific associations between tobacco/cannabis co-use and self-reported acute respiratory symptoms. We hypothesized that co-occurring use of cannabis and tobacco products would consistently be more strongly associated with the presence of acute respiratory symptoms than singular product use and abstinence from both products (Winhusen, Theobald, Kaelber, & Lewis, in press).

Material and Methods

Study Design

Data were collected from 2015–2018 as part of a longitudinal observational study of young adult light and intermittent cigarette smokers. All study procedures were approved by a university-based institutional review board. Upon confirmation of eligibility, participants received links to electronic consent forms and baseline surveys. Participants were required to provide electronic consent before they could begin participating in the study.

Demographic and tobacco-related factors were assessed at baseline, while frequencies of tobacco product use and cannabis use and respiratory symptoms were assessed at baseline and annually for a period of two years, producing three total assessments that were considered for analysis. All measures were completed electronically via SurveyMonkey (San

Mateo, CA). Participants were compensated with $25 virtual gift cards for completing each of the first two surveys and a $40 gift card for completing the third survey.

Participants

A sample of 563 participants aged 18–24 who participated in the parent study were considered for analysis. Participants were recruited via Facebook advertisements from 2015 to 2016 and were eligible to enroll if they met the following criteria: 1) lived in the United States, 2) had stable Internet access, 3) were fluent in English, 4) smoked cigarettes at least once a month for the past 6 months, and 5) denied any history of daily smoking. For the parent study, 9,109 electronic screening assessments were completed after interested individuals clicked on the Facebook ad to express interest in participating. Of those who were screened, 1,612 (17.8%) were deemed eligible to participate, and 1,433 (15.7%) were given access to the electronic informed consent form and baseline survey. Of those given access, a total of 748 baseline surveys (52.2%) were received. The final sample of 563 participants was produced after eliminating duplicate entries, incomplete entries, and entries from individuals who had passed the screening assessment but were deemed ineligible to participate upon completing the baseline assessment (e.g., intermittent smoking reported at screening, daily smoking reported at baseline; past-month smoking reported at screening, sustained abstinence reported t at baseline).

Materials

Frequency of tobacco and cannabis use were assessed via Timeline Followback procedures (TLFB; Sobell & Sobell, 1996). At each timepoint, participants retrospectively reported the number of days of use over the past two weeks for cigarettes, cannabis, and several alternative nicotine and tobacco products – e-cigarettes, cigars, cigarillos, hookah, snus, and smokeless tobacco.

Respiratory symptoms were assessed with a 6-item self-report measure developed specifically for the parent study that evaluated common respiratory sequelae of smoking. Participants were asked to report how bothersome wheezing, shortness of breath, morning cough, cough during the remainder of the day and night, productive cough, and irritation in eyes/nose/throat had been over the past month. Ratings for each symptom were made on a 5-point Likert scale: 0 = Not at all, 1 = Occasionally, 2 = About half the time, 3 = More than half the time, and 4 =most or all of the time). Individual items were then summed to produce a total respiratory symptom score ranging from 0 to 24 at each timepoint. Thus, positive scores could represent a wide range of potential respiratory complications.

Although this measure had not been previously psychometrically evaluated and no clinically relevant score thresholds have been established, the 6-item measure demonstrated adequate internal consistency at each measurement timepoint (Cronbach's α=0.83–0.86). However, as expected given the population of interest, the total score consistently demonstrated high rates of zero-inflation: 15.63% at baseline (mean=4.17, standard deviation=4.21), 19.80% at Year 1 (mean=4.55, standard deviation=4.74), and 24.44% at Year 2 (mean=3.80, standard deviation=4.22). This rate of zero-inflation represented a significant increase across timepoints, $\chi^2(3)=12.90$, $p=.002$, and when considered as a continuous measure, there were

significant differences across time, $F(2,1570)=3.93$, $p=.020$, with pairwise comparisons indicating that the mean score from Year 2 was significantly lower than the mean score from Year 1 $t(1008)=2.74$, $p=.003$.

Data Analytic Plan

All analyses were conducted in SPSS version 25 (IBM Corporation, Armonk, NY) with alpha=.05 given that a direction of effect was hypothesized. First, participants were classified into one of four product use status categories at each timepoint based on their TLFB data: neither tobacco nor cannabis use/neither product (NP), tobacco use only (TO), cannabis use only (CO), and tobacco/cannabis co-use (TC). Participants were categorized into the TO or TC group if they self-reported past-two-week use of any of the five combustible products assessed in this study – cigarettes, cigars, cigarillos, hookah, and e-cigarettes. Next, four nonparametric Cochran's Q tests evaluated changes in number of participants in each of the product use status categories over time, and six one-way ANOVAs with least Tukey post-hoc pairwise comparisons identified between-group differences in product use for co-users and single/neither product users. Three ANOVAs focused on tobacco product use outcomes, and three considered cannabis product use outcomes. Tobacco product use outcomes reflected sums for the numbers of days (maximum of 14) that participants endorsed using the seven tobacco products described earlier. This yielded a range of 0–98 for that variable, while the range for each cannabis product use outcome was 0–14.

For the primary aim of this study, which was to test the hypothesis that tobacco/cannabis co-use would be more strongly associated with respiratory symptoms than abstinence or single product use, timepoint-specific hierarchical logistic regressions were conducted. The outcome for each regression reflected a binary variable defining absence versus presence of respiratory symptoms. More specifically, at each timepoint, participants were categorized into a group that reported a score of 0 on the 6-item respiratory measure or a group that reported a score greater than 0 on the 6-item respiratory measure. Respiratory symptom endorsement was dichotomized for conceptual and measurement-related reasons. Conceptually, it was expected that this sample of young adults would endorse limited respiratory complications given their limited history of smoking and the intermittent nature of their smoking. From a measurement standpoint, the outcome was dichotomized because the frequency of zeroes yielded non-normal distributions for the outcome variables within and across timepoints. Logistic regression was utilized instead of other analyses that may account for overdispersion (e.g., negative binomial regression) because of the continuous nature of the dichotomized outcome. And finally, a timepoint-specific approach was employed for four reasons: (1) an extensive amount of time elapsed between assessments; (2) group membership shifted across assessments (Doran et al., 2019); (3) respiratory symptoms reflected acute/past-month severity, and (4) timepoint-specific analyses enabled evaluation of the consistency/replicability of differences in respiratory symptom endorsement across product use status.

For each regression, gender (male, female, other), race/ethnicity (non-Hispanic Caucasian, African-American, Hispanic/Latinx, Asian/Pacific Islander, Mixed/Other), student status

(full time, part-time/non-student) were entered as predictors in the first block of each regression. The dichotomized respiratory outcome at the previous timepoint, as well as cumulative frequency of tobacco product use and frequency of cannabis use at the previous timepoint, were all entered into the second block for the Year 1 and Year 2 regressions. The four-level categorical product use status variable was entered as a predictor into the final block of each regression, and the reference variable was adjusted to enable independent comparisons of the TC group to the NP, TO, and CO groups.

Results

Retention and Descriptive Statistics

Attrition was relatively minimal in this study: 563 participants completed the baseline survey, 517 (91.83% of the baseline sample) completed the Year 1 survey, and 495 (87.92% of the baseline sample) completed the Year 2 survey. A total of 465 participants (82.59% of the baseline sample) provided responses at all three timepoints. After correction for multiple comparisons, none of the twelve baseline demographic or tobacco-related factors that were considered for this study represented significant correlates of number of surveys completed ($ps \geq .025$).

Baseline descriptive statistics are reported in Table 1. The sample included adequate representation of men versus women and was ethnically diverse. Full-time student status was somewhat more common than part-time/non-student status, and nearly all participants reported having health insurance. On average, participants showed slight-to-moderate intentions to quit smoking and were not sure or slightly disagreed with having the intent to sustain or increase their smoking. Most participants were classified into the TC group at baseline (n = 316, or 56.1% of the sample), and only 25 participants (4.4% of the sample) denied past-two-week use of an combustible tobacco product at baseline.

Rates of Tobacco and Cannabis Use and Patterns of Use Status Groups

Timepoint-specific prevalence of product use for participants who responded to all three surveys is presented in Figure 1. Co-occurring use of tobacco and cannabis was consistently the most prevalent pattern of product use observed in this sample. However, the number of participants in the TC group (Q=19.54, df=2, $p<.001$) significantly decreased across the three timepoints, as did the number of participants in the TO group (Q=26.33, df=2, $p<.001$). In contrast, the number of participants in the CO group (Q=49.69, df=2, $p<.001$) and the NP group (Q=52.40, df=2, $p<.001$) significantly increased over time.

Table 2 reports rates of use of both tobacco and cannabis products at each timepoint, both for the whole sample and stratified across the four level use status variable. Overall, cigarettes were the most commonly used tobacco product at all three timepoints, and when considering the entire sample, cumulative use of tobacco products decreased with each subsequent timepoint. When evaluating rates of cumulative tobacco product use across use status groups, all three omnibus ANOVAs were statistically significant: Baseline – $F(3,559)=13.65$, $p<.001$; Year 1 – $F(3, 513)=48.27$, $p<.001$; Year 2 – $F(3, 491)=64.65$, $p<.001$. Predictably, pairwise comparisons showed that, at all three timepoints, the TC group

was associated with more frequent use of tobacco products than the NP group (*p*s<.001) and the CO group (*p*s < .001). However, pairwise comparisons indicated that the TC group did not endorse significantly more frequent tobacco product use than the TO group at any of the three timepoints (*p*s≥.077).

When considering frequency of cannabis use across use status groups, all three omnibus ANOVAs were again statistically significant: Baseline – $F(3, 559)=146.88$, $p<.001$; Year 1 – $F(3, 513)=154.75$, $p<.001$; Year 2 – $F(3, 491)=151.40$, $p<.001$. As with the tobacco use analyses, pairwise comparisons showed that, at all three timepoints, the TC group endorsed more frequent cannabis use than the NP group (*p*s<.001) and the TO group (*p*s<.001). Frequency of cannabis use by the TC group was not significantly different from frequency of use by the CO group at any of the three timepoints (*p*s≥.344).

Associations between Use Status and Respiratory Symptoms

Logistic regression results with the four-level product use status variable entered as a predictor are reported in Table 3. After controlling for baseline demographics, as well as respiratory symptoms and tobacco and cannabis product use at the previous timepoint where applicable, product use status was a significant predictor of the presence of respiratory symptoms at baseline and Year 1 (*p*s≤ .035) and approached significance at Year 2 ($p=.050$). Pairwise comparisons indicated that, as hypothesized, when compared to the NP group, members of the TC group were 173–339% more likely to report respiratory symptoms at all three timepoints (aORs=2.73–4.39, *p*s≤.013). Pairwise comparisons also indicated that tobacco/cannabis co-use was more strongly associated with the presence of respiratory symptoms than use of only one of the substances, although these results were less consistent in supporting our hypothesis. Participants in the TC group were more than twice as likely to report presence of respiratory symptoms when compared to the TO group at baseline (aOR=2.42, 95%CI=[1.47, 3.96], $p<.001$) but presence of respiratory symptoms within the co-use group did not differ when compared to symptom presence for either single product user group at Year 1 or Year 2 (*p*s≥.064).

Discussion

This analysis was designed to evaluate how co-occurring use of tobacco and cannabis changed over time, as well as the extent to which tobacco/cannabis co-use was associated with the presence of acute respiratory symptoms among young adult light and intermittent smokers. Prevalence of co-use and tobacco-only use significantly decreased over time, while rates of cannabis-only use and abstinence from both substances increased over time. Our hypothesis about the relationship between co-use and respiratory symptoms was partially supported, as tobacco/cannabis co-users were consistently more likely to endorse the presence of respiratory symptoms than participants who were using neither product. This relationship was less consistent when comparing participants who were cannabis/tobacco co-users to participants who were using only one of those two products.

The respiratory results described here suggest a consistent association between co-occurring use of tobacco and cannabis and presence of common respiratory problems. These findings corroborate evidence of potential respiratory impairments that have been seen in both

longitudinal (Taylor et al., 2002) and cross-sectional (Macleod, Robertson, Copeland, McKenzie, Elton, & Reid, 2015) studies evaluating young adult co-users. They also reinforce the emphasis on identifying causes of new respiratory diseases like EVALI that could be associated with concurrent tobacco and cannabis use (Siegel et al., 2019). Finally, they extend evidence of chronic respiratory illnesses among co-users (Winhusen et al., in press) by demonstrating that acute symptomology is also associated with tobacco/cannabis co-use.

Emerging adulthood represents a developmental phase during which experimentation with substances can transition to problematic substance use (Sussman & Arnett, 2014) and where patterns of co-occurring substance use are overly expressed (Palmer et al., 2009). Because behaviors during this developmental period may precede a prolonged history of substance use and chronic respiratory illnesses, the presence of respiratory symptoms within young adult co-users is concerning, especially in light of the intermittent tobacco and cannabis use endorsed by this sample. Co-occurring cannabis use has been shown to be a predictor of light and intermittent smokers identifying as a smoker (Smith, O'Connor, Collins, Hyland, & Kozlowski, in press), and it is possible that the presence of respiratory symptoms that are commonly associated with smoking might contribute to this identification. Our results also encourage further research into whether certain types of co-occurring use of cannabis and tobacco, such as concurrent use, sequential use, or simultaneous use/co-administration (Ruglass et al., in press; Tucker et al., 2019), are more strongly associated with various consequences, including respiratory impairments.

The decline in co-occurring use of tobacco and cannabis seen in this study is consistent with previous research indicating that this pattern of substance use does not significantly increase over time among young adults (Schauer, Berg, Kegler, Donovan, & Windle, 2015). Further, our results regarding use status reinforce previously reported trends among youth (Schauer & Peters, 2018) and young adults (Cohn, Johnson, Rath, & Villanti, 2016) that exclusive cannabis use is increasing over time in younger populations, while use of tobacco products seems to be decreasing. Altogether, our data suggest that desistance of tobacco use may explain declines in tobacco/cannabis co-use and increases in exclusive cannabis use. Recent divergences in public perceptions and policymaking for cannabis and tobacco products may be influencing use of these substances in young adults. More specifically, use of cannabis may be promoted by a more accepting social and legal climate, while a more stigmatizing social climate that emphasizes a diverse tobacco control agenda may discourage use of nicotine and tobacco products. Future research into understanding reasons, motives, and expectancies for use of or abstinence from these products could help identify potential mechanisms explaining these trends in use.

These results should be interpreted within the context of several limitations. First, neither tobacco nor cannabis use was verified biochemically in this study, although self-report of substance use has been shown to be a reliable method of measuring substance use (Robinson, Sobell, Sobell, & Leo, 2014). Second, respiratory symptoms were assessed via retrospective self-report, were dichotomized due to high rates of zero-inflation, and were not verified via physiological means or medical record reviews. As a result, we were unable to account for baseline history of chronic respiratory illnesses such as asthma. Additionally,

each individual respiratory symptom showed low mean ratings of past-month bothersomeness, leading to low total symptom scores and a dichotomization of the primary outcome. Dichotomization of continuous measures has several costs associated with it, including reductions in power and outcome variability. Further research with self-report respiratory outcome measures like the one utilized in this study should prioritize psychometric evaluation, biochemical validation, establishment of thresholds for clinically significant respiratory symptomology, and testing within populations that may be likely to endorse respiratory distress, such as older adults or daily smokers. Third, we did not assess method of cannabis administration in this study, making it impossible to evaluate the impact of co-occurring use of combustible cannabis and combustible tobacco products on respiratory symptoms. That said, inhalation of combustible products remains the most common route of cannabis administration among younger populations (Knapp, Lee, Borodovsky, Auty, Gabrielli, & Budney, 2019), and being inclusive of all forms of cannabis administration actually strengthens the legitimacy of the relationships in this study and generalizes the impact that tobacco/cannabis co-use may have on respiratory symptoms. Fourth, it is possible that our results were impacted by sample composition and recruitment strategy. Data for this study were collected as part of a longitudinal study of light and intermittent young adult smokers (Doran et al., 2017), and this population may be less likely to endorse acute respiratory symptoms than smokers who are older, who endorse more regular or daily tobacco use, who endorse more prevalent polytobacco use, and who have been previously diagnosed with smoking-related respiratory conditions. This potential limitation speaks to why the outcome measure for this analysis was dichotomized and reinforces further research within other smoking populations, especially those with more clinically significant presentations of respiratory illness. Further, since the parent study was a tobacco-related project, the cannabis sub-groups of participants may not be entirely representative of that particular population. Finally, there may be other unmeasured or unconsidered variables that are associated with the presence of respiratory symptoms and that are independent of tobacco and cannabis use that might impact the presence or absence of such symptoms (e.g., medical illnesses, environmental smoke exposure, etc.).

Despite these limitations, these results provide preliminary evidence of a consistent relationship between co-occurring use of cannabis and tobacco and the presence of common respiratory symptoms among young adults. These findings support the importance of incorporating public health perspectives into emerging cannabis legalization policies (Hall & Kozlowski, 2018a) and in collecting diverse types of data on cannabis outcomes to inform the public and policymakers alike (Schlienz & Lee, 2018). These data also emphasize that the emergence of acute respiratory symptoms can occur in populations that are younger, that are traditionally healthier, and that have not developed chronic tobacco-related illness, especially when considering co-occurring cannabis use. Future directions for this research area include exploring how cannabis/tobacco co-use impacts respiratory symptoms among individuals who have been diagnosed with chronic respiratory conditions, such as asthma or chronic obstructive pulmonary disease, and evaluating risk of respiratory symptom development among co-users based on use of combustible versus non-combustible tobacco products.

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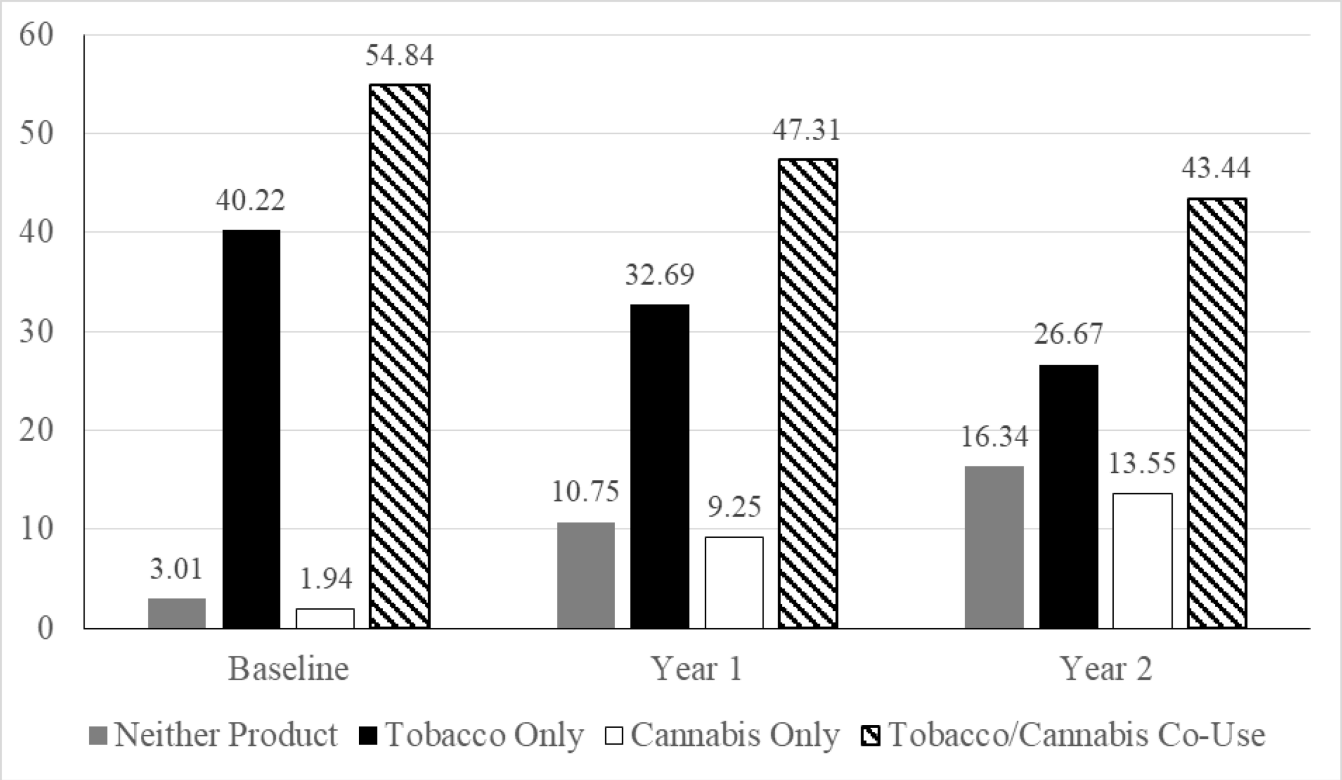

Figure 1.
Percentage of sample classified across four-level product use classification scheme at each time point.
Note: Total n = 465, which reflects all participants who completed all three assessments.

Table 1.

Baseline demographic factors, tobacco history variables, and respiratory symptoms.

Demographic Factor	Total Sample N = 563	Neither Product n = 15	Tobacco Only n = 224	Cannabis Only n = 10	Tobacco/Cannabis Co-Use n = 316
Age (*M* ± SD years)	20.4 ± 1.8	20.7 ± 1.5	20.7 ± 1.7	19.5 ± 0.9	20.3 ± 1.8
Sex (% Male)	51.9	20.0	51.4	50.0	53.8
Race/Ethnicity (% White)	43.7	33.3	33.8	70.0	50.3
Student Status (% Full Time)	61.1	80.0	55.9	40.0	64.6
Have Health Insurance (% Yes)	94.8	93.3	91.9	100.0	96.8
Tobacco History Variable					
Age at Smoking Initiation (*M* ± SD years)[a]	17.0 ± 2.2	16.8 ± 2.5	17.1 ± 2.1	17.9 ± 1.5	16.9 ± 2.3
Friends Who Smoke (*M* ± SD percentage)	44.1 ± 25.9	31.8 ± 25.9	41.9 ± 25.4	35.7 ± 24.8	46.5 ± 26.0
ARFQ Total Score (*M* ± SD)[b]	34.3 ± 15.4	34.3 ± 16.1	34.3 ± 15.0	30.9 ± 21.9	34.5 ± 15.5
Intentions to Quit Smoking[c]					
Next Year (*M* ± SD)	1.9 ± 1.4	1.6 ± 1.7	1.8 ± 1.4	1.6 ± 1.8	2.0 ± 1.3
Next Month (*M* ± SD)	1.3 ± 1.2	1.3 ± 1.6	1.3 ± 1.2	1.2 ± 1.5	1.3 ± 1.2
Likelihood Will Maintain/Increase Smoking[d]					
Next Year (*M* ± SD)	1.9 ± 1.2	1.9 ± 1.6	2.1 ± 1.2	2.0 ± 1.5	1.8 ± 1.2
Next Month (*M* ± SD)	2.3 ± 1.3	1.9 ± 1.6	2.3 ± 1.2	2.3 ± 1.6	2.3 ± 1.3
Respiratory Symptoms[e]					
Wheezing (*M* ± SD)	0.4 ± 0.8	0.2 ± 0.4	0.4 ± 0.7	0.2 ± 0.6	0.5 ± 0.9
Shortness of Breath (*M* ± SD)	0.8 ± 0.9	0.5 ± 1.3	0.9 ± 1.0	0.1 ± 0.3	0.8 ± 0.9
Morning Cough (*M* ± SD)	0.7 ± 1.0	0.4 ± 1.1	0.5 ± 0.9	0.9 ± 1.1	0.8 ± 1.1
Cough for Remainder of Day/Night (*M* ± SD)	0.6 ± 1.0	0.4 ± 1.1	0.5 ± 0.9	0.6 ± 1.0	0.7 ± 1.0
Productive Cough (*M* ± SD)	0.7 ± 1.0	0.3 ± 1.0	0.6 ± 1.0	0.6 ± 0.8	0.8 ± 1.1
Irritation in Eyes/Nose/Throat (*M* ± SD)	1.0 ± 1.0	0.4 ± 0.6	0.9 ± 1.0	0.7 ± 0.9	1.0 ± 1.0
Total Symptom Score (*M* ± SD)	4.2 ± 4.2	2.2 ± 3.1	3.8 ± 4.0	3.1 ± 3.4	4.6 ± 4.4

Notes: Neither Product = no tobacco or cannabis use over the past 14 days; Tobacco Only = at least one day of combustible tobacco product use over the past 14 days.

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Cannabis Only = at least one day of cannabis use over the past 14 days. Tobacco/Cannabis Co-Use = at least one day of both cannabis and combustible tobacco product use over the past 14 days.

[a]Data based on 517 participants (14 Neither Product, 207 Tobacco Only, 9 Cannabis Only, 287 Cannabis/Tobacco Co-Use).

[b]ARFQ = Adolescent Reason for Quitting Scale (Myers et al., 2008). Scores range from 0–108, with higher scores indicating more powerful motives for smoking cessation.

[c]Item measured on 0–4 scale (0 = No intent to quit, 1 = Slightly determined to quit, 2 = Moderately determined to quit, 3 = Pretty determined to quit, 4 = Very determined to quit).

[d]Item measured on 0–4 scale (0 = Very unlikely, 1 = Somewhat unlikely, 2 = Not sure, 3 = Somewhat likely, 4 = Very likely).

[e]Each individual respiratory symptom score reflects how bothersome the symptom had been over the past month measured on a 0–4 scale (0 = Not at all, 1 = Occasionally, 2 = About half the time, 3 = More than half the time, 4 = Most or all the time). Total Symptom Score reflects the summation of all six individual items.

Table 2.

Number of days of use of tobacco products and cannabis in the past two weeks across use status groups at each time point.

Baseline Product	**Total Sample N = 563**		**Neither Product n = 15**		**Tobacco Only n = 224**		**Cannabis Only n = 10**		**Tobacco/Cannabis Co-Use n = 316**	
	Days	% Yes	Days	% Yes	Days	% Yes	Days	% Yes	Days	% Yes
Cigarettes	5.3 ± 3.9	92.5	0.0 ± 0.0	0.0	5.4 ± 3.8	95.5	0.0 ± 0.0	0.0	5.6 ± 3.8	97.8
E-Cigarettes	1.7 ± 3.5	33.2	0.0 ± 0.0	0.0	1.4 ± 3.3	30.2	0.0 ± 0.0	0.0	2.0 ± 3.8	38.0
Hookah	0.9 ± 2.2	29.3	0.0 ± 0.0	0.0	0.7 ± 1.9	25.2	0.0 ± 0.0	0.0	1.1 ± 2.5	34.5
Cigar	0.2 ± 0.9	6.9	0.0 ± 0.0	0.0	0.2 ± 1.4	7.2	0.0 ± 0.0	0.0	0.2 ± 0.7	7.3
Cigarillo	0.4 ± 1.4	13.3	0.0 ± 0.0	0.0	0.4 ± 1.5	12.2	0.0 ± 0.0	0.0	0.4 ± 0.1	15.2
Snus	0.1 ± 0.6	2.3	0.0 ± 0.0	0.0	0.1 ± 0.8	2.3	0.0 ± 0.0	0.0	0.0 ± 0.0	2.5
Smokeless Tobacco	0.2 ± 1.4	4.8	0.0 ± 0.0	0.0	0.2 ± 1.4	4.5	0.0 ± 0.0	0.0	0.3 ± 1.5	5.4
Total Tobacco Use	8.6 ± 7.4	95.6	0.0 ± 0.0	0.0	8.4 ± 6.7	100.0	0.0 ± 0.0	0.0	9.5 ± 7.7	100.0
Cannabis	3.8 ± 4.8	57.9	0.0 ± 0.0	0.0	0.0 ± 0.0	0.0	4.6 ± 4.3	100.0	6.5 ± 4.8	100.0
Year 1 Product	Total Sample N = 517		Neither Product n = 53		Tobacco Only n = 163		Cannabis Only n = 52		Tobacco/Cannabis Co-Use n = 249	
	Days	% Yes	Days	% Yes	Days	% Yes	Days	% Yes	Days	% Yes
Cigarettes	4.1 ± 4.5	71.4	0.0 ± 0.0	0.0	5.1 ± 4.4	85.3	0.0 ± 0.0	0.0	5.3 ± 4.5	90.0
E-Cigarettes	1.5 ± 3.6	23.4	0.0 ± 0.0	0.0	1.4 ± 3.5	21.5	0.0 ± 0.0	0.0	2.2 ± 4.2	35.3
Hookah	0.5 ± 1.8	13.5	0.0 ± 0.0	0.0	0.5 ± 1.8	14.1	0.0 ± 0.0	0.0	0.7 ± 2.1	18.9
Cigar	0.1 ± 0.4	3.3	0.0 ± 0.0	0.0	0.1 ± 0.2	4.3	0.0 ± 0.0	0.0	0.1 ± 0.5	4.0
Cigarillo	0.2 ± 1.3	6.0	0.0 ± 0.0	0.0	0.1 ± 0.4	3.1	0.0 ± 0.0	0.0	0.4 ± 1.8	10.4
Snus	0.0 ± 0.6	0.6	0.0 ± 0.0	0.0	0.1 ± 0.8	1.2	0.0 ± 0.0	0.0	0.0 ± 0.6	0.0
Smokeless Tobacco	0.2 ± 1.3	3.3	0.1 ± 0.8	1.9	0.2 ± 1.5	1.9	0.0 ± 0.0	0.0	0.2 ± 1.4	5.2
Total Tobacco Use	6.6 ± 7.2	78.8	0.1 ± 0.8	1.9	7.3 ± 5.9	100.0	0.0 ± 0.0	0.0	8.9 ± 7.8	100.0
Cannabis	4.3 ± 5.3	58.2	0.0 ± 0.0	0.0	0.0 ± 0.0	0.0	7.1 ± 5.1	100.0	7.5 ± 5.0	100.0
Year 2 Product	Total Sample N = 495		Neither Product n = 80		Tobacco Only n = 133		Cannabis Only n = 67		Tobacco/Cannabis Co-Use n = 215	
	Days	% Yes	Days	% Yes	Days	% Yes	Days	% Yes	Days	% Yes
Cigarettes	3.0 ± 4.2	56.6	0.0 ± 0.0	0.0	4.2 ± 4.4	76.7	0.0 ± 0.0	0.0	4.3 ± 4.4	82.8
E-Cigarettes	2.2 ± 4.3	31.7	0.0 ± 0.0	0.0	3.5 ± 5.2	46.6	0.0 ± 0.0	0.0	2.8 ± 4.5	44.2

Baseline Product	Total Sample N = 563		Neither Product n = 15		Tobacco Only n = 224		Cannabis Only n = 10		Tobacco/Cannabis Co-Use n = 316	
Hookah	0.3 ± 1.3	8.5	0.0 ± 0.0	0.0	0.3 ± 0.7	15.8	0.0 ± 0.0	0.0	0.4 ± 1.8	9.8
Cigar	0.0 ± 0.2	3.2	0.0 ± 0.0	0.0	0.1 ± 0.3	6.0	0.0 ± 0.0	0.0	0.1 ± 0.3	3.9
Cigarillo	0.3 ± 0.1	7.1	0.0 ± 0.0	0.0	0.0 ± 0.0	1.5	0.0 ± 0.0	0.0	0.6 ± 2.1	15.3
Snus	0.1 ± 0.8	0.8	0.0 ± 0.0	0.0	0.1 ± 1.2	0.8	0.0 ± 0.0	0.0	0.1 ± 0.7	1.4
Smokeless Tobacco	0.1 ± 1.0	2.0	0.1 ± 0.6	2.5	0.3 ± 1.8	3.0	0.0 ± 0.0	0.0	0.0 ± 0.3	1.9
Total Tobacco Use	5.9 ± 7.2	70.1	0.1 ± 0.6	2.5	8.5 ± 6.7	100.0	0.0 ± 0.0	0.0	8.3 ± 7.6	100.0
Cannabis	4.1 ± 5.2	57.0	0.0 ± 0.0	0.0	0.0 ± 0.0	0.0	6.6 ± 5.3	100.0	7.4 ± 4.8	100.0

Notes: Neither Product = no tobacco or cannabis use over the past 14 days; Tobacco Only = at least one day of combustible tobacco product use over the past 14 days. Cannabis Only = at least one day of cannabis use over the past 14 days. Tobacco/Cannabis Co-Use = at least one day of both cannabis and combustible tobacco product use over the past 14 days. Values for “Days” for individual tobacco product use and for cannabis use represent means ± standard deviations, and mean values could range from 0–14. Values for “Days” in the Total Tobacco Use rows also represent means ± standard deviations but range from 0–98 and reflect sums for all seven tobacco products considered. The “% Yes” values reflect the rates of endorsement of any past-two-week use for each individual product within each group and, in the case of Total Tobacco Use, any tobacco product at each time point.

Table 3.

Hierarchical logistic regressions evaluating predictors of presence of respiratory symptoms at baseline, Year 1, and Year 2.

	Baseline			Year 1			Year 2		
Predictor	**Wald**	**aOR**	**95% CI**	**Wald**	**aOR**	**95% CI**	**Wald**	**aOR**	**95% CI**
Gender (df = 2)	1.95			0.13			0.51		
Race/Ethnicity (df = 4)	0.43			2.45			1.54		
Student Status (df = 1)	4.61*	1.75	1.05, 2.91	1.15			0.08		
Previous Tobacco Product Use (df = 1)	N/A			0.00			2.92		
Previous Cannabis Use (df = 1)	N/A			1.04			0.17		
Previous Respiratory Symptoms (df =1)	N/A			29.74***	4.49	2.62 7.70	31.31***	4.33	2.59, 7.22
Product Use Group (df = 3)	15.60**			8.60*			7.83*		
Co-Use vs. Neither Product (ref)	6.24*	4.39	1.38, 14.02	7.01**	2.84	1.31, 6.16	7.82**	2.73	1.35, 5.51
Co-Use vs. Tobacco Only (ref)	12.24*	2.42	1.47, 3.96	3.18	1.73	0.94, 3.19	2.02	1.60	0.84, 3.05
Co-Use vs. Cannabis Only (ref)	1.56	2.83	0.55, 14.45	3.42	2.05	0.96, 4.39	0.75	1.38	0.66, 2.87

Notes: df = degrees of freedom, ref = referent group, aOR = adjusted odds ratio.

Gender categories = male, female, other

Race/ethnicity = non-Hispanic Caucasian, African-American, Hispanic/Latinx, Asian/Pacific Islander, Other

Student status = full-time, part-time/non-student

Neither Product = no tobacco or cannabis use over the past 14 days; Tobacco Only = at least one day of combustible tobacco product use over the past 14 days. Cannabis Only = at least one day of cannabis use over the past 14 days. Cannabis/Tobacco Co-Use = at least one day of both cannabis and combustible tobacco product use over the past 14 days.

* $p \leq .05$,

** $p < .01$,

*** $p < .001$.