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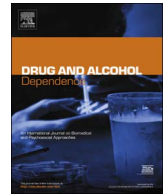Myers, Mark G
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# Marijuana use among US tobacco users: Findings from wave 1 of the population assessment of tobacco health (PATH) study

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## ARTICLE INFO

## ABSTRACT

*Background:* With an increase in marijuana use among adults in the United States (US), understanding the potential impact of marijuana use on tobacco use and associated behavioral and health consequences, including respiratory conditions, is necessary.

*Method:* Survey responses from Wave 1 of the nationally representative Population Assessment of Tobacco and Health (PATH) Study were used to assess tobacco use and marijuana use among non-current tobacco users (n = 17,952) and current established tobacco-users classified as: cigarette only users (n = 8689), e-cigarette only users (n = 437), cigar only (traditional, cigarillo, or filtered) users (n = 706), hookah only users (n = 461), smokeless tobacco only users (n = 971), cigarette + e-cigarette users (n = 709), and users of multiple tobacco products (n = 2314).

*Results:* When compared to non-current tobacco users, each tobacco user group except smokeless only users had higher odds (odds ratios ranging from 3.86–8.07) of reporting current marijuana use. Among current tobacco users, higher levels of tobacco dependence did not explain the relationship between tobacco use and marijuana use. Additionally, concurrent marijuana use was associated with lower odds of attempts to quit tobacco (OR = 0.86, 95% CI = 0.79, 0.94, p < 0.001) and a higher probability (OR = 1.35, 95CI = 1.21, 1.51, p < 0.01) of reporting a history of respiratory disease.

*Conclusions:* The association between concurrent use of tobacco and marijuana and higher tobacco dependence and lower rates of quit attempts suggests the potential for sustained tobacco use and deleterious health effects. Further, marijuana use may represent an additive risk for respiratory harm among concurrent users of tobacco and marijuana.

## 1. Introduction

Rates of adult marijuana use have grown substantially in the US over the past decade, particularly among those aged 26 years or older (Azofeifa et al., 2016) and those that are daily cigarette smokers (Goodwin et al., 2017). This is of concern, as evidence indicates that marijuana use can lead to addiction and use of other substances, motor vehicle accidents, impaired brain development, psychiatric conditions, and respiratory problems (Volkow et al., 2014). Concurrent use of tobacco and marijuana (i.e., lifetime or past month use of both substances) is common, although not uniform across tobacco products (Schauer et al., 2016). Estimates indicate that between 25% and 52% of

tobacco smokers use cannabis (Leatherdale et al., 2006) and, among past month marijuana users, 68% also reported tobacco use (Schauer et al., 2016). Further, concurrent use of marijuana and tobacco increased from 2003 to 2012 (Schauer et al., 2015).

Use of marijuana and cigarettes or cigars is commonly reported among tobacco users (Schauer et al., 2016), though less is known about the relationship between marijuana use and multiple tobacco products. About 40% of current tobacco users in the US report use of multiple products, and cigarettes + e-cigarettes are the most common combination (Kasza et al., 2017). Among multiple product users, there are also differences in types of products used and prevalence of use by age, gender, and race/ethnic group (Agrawal and Lynskey, 2009; Hindocha et al., 2016; Kennedy et al., 2016).

The opportunities for co-administration provided by modification of tobacco products may represent one source of interest in tobacco products among marijuana concurrent users (Agrawal et al., 2012; Agrawal and Lynskey, 2009). For example, electronic devices engineered to aerosolize tobacco, marijuana, and other substances may be marketed to promote co-occurring use (Hindocha et al., 2016). Tobacco products that can be readily modified for marijuana use may not only increase tobacco use among marijuana users, but also expand the types of tobacco products used by an individual.

Frequent use of marijuana has been linked with persistent tobacco use and greater tobacco dependence among youth and adults (Degenhardt et al., 2010; Ford et al., 2002; Patton et al., 2005; Ramo et al., 2012; Timberlake et al., 2007) and higher expectancies that each substance promotes the use of the other (Ramo et al., 2013). Among concurrent users, motivation to reduce marijuana (Ramo et al., 2014) and the relative perception of harm from use of marijuana (Berg et al., 2015) have been lower than for tobacco. Concurrent use of marijuana and tobacco products may promote persistent tobacco use and decreased motivation to alter use of marijuana (Amos et al., 2004), reduce users' interest in quitting tobacco (Ford et al., 2002; Gourlay et al., 1994; Metrik et al., 2011), and reduce success in cessation (Schauer et al., 2017). By impairing cessation efforts, concurrent use may serve to exacerbate the negative consequences from both tobacco and marijuana.

The health effects of persistent tobacco use and use of marijuana show clear associations with acute and chronic respiratory symptoms (Moore et al., 2005; Wu et al., 1988). When combusted, both inhaled tobacco and marijuana smoke deposit tar and other constituents in the lung (Moir et al., 2008; Wu et al., 1988). Cellular abnormalities associated with respiratory disorders including bronchitis and chronic obstructive pulmonary disease have been observed in both tobacco and marijuana users (Sparacino et al., 1990). A US population examination of respiratory symptoms among marijuana smokers suggested higher rates of bronchitis, coughing, phlegm production, and wheezing after statistically adjusting for cigarette smoking (Moore et al., 2005). The effects of marijuana use on respiratory health among other and multiple tobacco product user groups, including users of aerosolized products in the US population, have not been examined.

The rapidly changing landscape of tobacco and marijuana products and consumption devices, particularly in the context of marijuana legalization and increasing use, indicate the importance of characterizing patterns of tobacco and marijuana use. Our primary aim is to describe the relationship between current marijuana use and pattern of current tobacco product use using a comprehensive assessment of tobacco products. We hypothesized (H1) that users of tobacco would have higher rates of current marijuana use than those not currently using tobacco products and that effects would be strongest for current users of tobacco products with inhaled routes of administration that accommodate co-administration (e.g., cigarette only, e-cigarette only, cigar only, hookah only, and cigarette + e-cigarettes) relative to current non-inhaled (e.g., smokeless) tobacco product users. We also hypothesized (H2) that among current tobacco users, concurrent use of any tobacco product and marijuana would be associated with increased tobacco dependence and a decreased motivation to quit tobacco use. Finally, we hypothesized (H3) that concurrent users of inhaled tobacco products (aerosol or combusted) and marijuana would have higher rates of respiratory conditions relative to those not currently using tobacco products.

## 2. Methods

### 2.1. Data

Data are from Wave 1 of the Population Assessment of Tobacco and Health (PATH) Study conducted from September 12, 2013 to December 15, 2014 (n = 32,320). Combined with the use of a probability sample, the data were weighted for oversampling and nonresponse to allow the estimates produced by the PATH Study to be representative of the non-

institutionalized, civilian US population. Further details regarding the PATH Study design and methods are published elsewhere (Hyland et al., 2017).

### 2.2. Study measures

Assessment domains for the current study included demographic characteristics, patterns of tobacco product and marijuana use, tobacco dependence, intention to quit tobacco, and respiratory disease.

#### 2.2.1. Demographics

We categorized respondents into age groups of 18–24, 25–34, 35–44, 45–54, and 55 or older. Respondents' gender and race/ethnicity (Non-Hispanic White; Hispanic, Non-Hispanic Black, or Other) were examined. Missing data on age, gender, race, Hispanic ethnicity, and adult education were imputed as described in the User Guide to the PATH Study RUF (United States Department of Health and Human Services et al., 2017).

#### 2.2.2. Current tobacco use

Respondents in the PATH Study were asked questions about the following tobacco products: cigarettes, e-cigarettes, cigars (including traditional cigars, cigarillos, and filtered cigars), pipes, hookah, and smokeless tobacco. For cigarettes, a current established user was defined as an adult who has smoked at least 100 cigarettes in his/her lifetime and currently smokes every day or some days. For all other tobacco products, a current established user was an adult who had ever used the product "fairly regularly" and now used it every day or some days. Current established tobacco-user groups were categorized into the following: cigarette only users (n = 8689), e-cigarette only users (n = 437), cigar only (traditional, cigarillo, or filtered) users (n = 706), hookah only users (n = 461), smokeless tobacco only users (n = 971), cigarette + e-cigarette users (n = 709), and users of multiple tobacco products (n = 2314). Those reporting no current established tobacco use in the past 12 months were classified as not current tobacco users (n = 17,952). Respondents with incomplete information on tobacco use (n = 81) were assigned as missing.

#### 2.2.3. Current marijuana use

Marijuana use was assigned using a positive response to either of the following questions: 1) "*Have you ever used marijuana, hash, THC, grass, pot or weed?*", or 2) "*Have you ever smoked part or all of a cigar, cigarillo or filtered cigar with marijuana in it?*". Those that reported marijuana use within the last 30 days (n = 4393) were classified as current users. Respondents with incomplete information on marijuana use (n = 253) were assigned as missing. Among non-tobacco users 1413 respondents reported marijuana use.

#### 2.2.4. Symptoms of tobacco dependence (TD)

The PATH Study instrument included 16 TD symptoms derived from the Wisconsin Inventory of Smoking Dependence Motives (WISDM—11 items) (Smith et al., 2010), Nicotine Dependence Syndrome Scale (NDSS—4 items) (Shiffman et al., 2004), Hooked on Nicotine Checklist (HONC—3 items) (DiFranza et al., 2002), and the Diagnostic and Statistical Manual (DSM) Criteria (1 item) (American Psychiatric Association, 2013). Items were scaled to produce TD scores ranging from 0 to 100. Details of the psychometric validation of the PATH Instrument for TD are described elsewhere (Strong et al., 2017).

#### 2.2.5. Intention to quit tobacco

Current users were asked: "*In the past 12 months have you tried to quit [product]? Choose all that apply.*" An attempt to quit was assigned if they marked either: "*Yes, I have tried to quit completely*" or: "*Yes, I have tried to quit by reducing or cutting back*". Respondents who marked: "*No, I have reduced or cut back instead of trying to quit*", or "*No, I have not tried to quit at all*" were considered to have not made a quit attempt. We assessed

current intention to quit using the following question: "*Do you plan to quit for good?*". If a respondent responded '*Yes,*' they were then asked: "*When do you plan to quit for good*". Responses were collapsed indicating an intention to quit within either the next 6 months or a year or more. Intention to quit was asked to current users; however, data collection error caused some current users who had not made an attempt to quit in the past 12-months to be skipped.

### 2.2.6. Respiratory disease

Respondents were asked "*Has a doctor or other health professional ever told you that you had any of the following lung or respiratory conditions?*" and were given the option to select: chronic obstructive pulmonary disease (COPD), chronic bronchitis, emphysema, asthma, or some other respiratory condition. Respondents selecting any condition were classified as having a history of respiratory disease (n = 5894).

### 2.3. Analysis plan

We used logistic regression to estimate the relationship between current marijuana use among users and non-users of tobacco products, with non-tobacco-users as the reference group (Hypothesis 1, Model A). Planned covariates for all models included age, gender, and racial/ethnic group. With a focus on current tobacco users, Hypothesis 2 evaluated reports of marijuana use for each user group using cigarette only users as the reference (Model B). We then added a term reflecting levels of tobacco dependence and re-evaluated the independent association between tobacco use group and current marijuana use (Model C). Logistic regression models were also used to explore relationships between current marijuana use, past quit attempts, and current intentions to quit among current users of tobacco products. Lastly, for Hypothesis 3, logistic regression models were used to estimate the odds of a respiratory condition for current tobacco users relative to those not currently using tobacco. A dummy coded term for current marijuana use was used in interaction terms to assess potential moderating effects of marijuana use on relationships between tobacco product use and respiratory conditions.

## 3. Results

### 3.1. Descriptive analyses

Among the 32,320 adults, the analytic sample included those who were identified as current marijuana users (n = 4393), current established users of any tobacco product (n = 14,287), and those reporting no current established tobacco use in the past 12 months (n = 17,952). Weighted demographic characteristics (gender, age, and race/ethnicity) of current marijuana users and current established users of each tobacco product group are presented in Table 1.

### 3.2. Current marijuana use among users and non-users of tobacco products

Rates of current marijuana use were 3.7% among non-users of tobacco, 16.2% among cigarette only, 14.6% among e-cigarette only, 28.1% among cigar only, 28.8% among hookah only, 5.3% among smokeless only, 19.3% among cigarette + e-cigarette, and 33.4% among multiple product users. Rates of current marijuana use decreased as age of tobacco users increased ($F_{(4,84)} = 147.07$, $p < 0.01$). Rates of current marijuana use were lower for women ($F_{(1,84)} = 48.65$, $p < 0.01$) than men (OR = 0.70, 95% CI = 0.64,0.78), and there were significant differences in reports of current marijuana use across racial-ethnic groups ($F_{(3,84)} = 18.46$, $p < 0.01$). When compared to non-Hispanic whites, Hispanics had similar reports of current marijuana use (OR = 0.91, 95% CI = 0.77,1.06, p = 0.22), and reports were higher among Blacks (OR = 1.47, 95%CI = 1.28,1.69, p < 0.01) and lower among those in the other racial-ethnic groups (OR = 0.77, 95%CI = 0.65, 0.91,

**Table 1**
Demographics of Tobacco Product Users.

| Variable | Not Current User | | | Cigarette Only | | | E-Cigarette Only | | | Cigar Only | | | Hookah Only | | | Smokeless Only | | | Cigarette + E-Cigarette | | | Multiple Products | | | Current Marijuana | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | n | % | se% | n | % | se% | n | % | se% | n | % | se% | n | % | se% | n | % | se% | n | % | se% | n | % | se% | n | % | se% |
| *Gender* | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Male | 8099 | 44.5% | 0.2% | 4149 | 51.2% | 0.6% | 199 | 46.7% | 2.8% | 533 | 79.1% | 1.4% | 244 | 56.1% | 2.4% | 926 | 95.9% | 0.9% | 318 | 46.7% | 1.7% | 1764 | 79.2% | 1.1% | 2612 | 61.3% | 1.0% |
| Female | 9831 | 55.5% | 0.2% | 4536 | 48.8% | 0.6% | 237 | 53.3% | 2.8% | 173 | 20.9% | 1.4% | 217 | 43.9% | 2.4% | 43 | 4.1% | 0.9% | 391 | 53.3% | 1.7% | 550 | 20.8% | 1.1% | 1780 | 38.7% | 1.0% |
| *Age Group* | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 18–24 | 5557 | 12.0% | 0.1% | 1493 | 10.8% | 0.3% | 103 | 15.8% | 2.1% | 257 | 22.7% | 2.3% | 356 | 68.3% | 3.1% | 187 | 11.6% | 0.7% | 138 | 13.2% | 1.5% | 1011 | 32.0% | 1.5% | 2033 | 32.0% | 1.0% |
| 25–34 | 3194 | 15.9% | 0.3% | 1919 | 22.9% | 0.5% | 96 | 26.2% | 2.7% | 136 | 22.0% | 2.0% | 83 | 25.2% | 2.8% | 171 | 19.4% | 1.6% | 189 | 29.1% | 1.8% | 540 | 28.3% | 1.5% | 995 | 25.5% | 0.8% |
| 35–44 | 2469 | 15.9% | 0.3% | 1590 | 19.2% | 0.5% | 70 | 15.7% | 1.9% | 89 | 16.0% | 1.5% | 15 | – | – | 200 | 21.6% | 1.3% | 153 | 22.5% | 1.8% | 337 | 17.5% | 1.0% | 562 | 15.4% | 0.8% |
| 45–54 | 2371 | 17.6% | 0.3% | 1734 | 21.6% | 0.4% | 87 | 20.9% | 1.8% | 89 | 15.6% | 1.3% | 4 | – | – | 211 | 23.8% | 2.2% | 110 | 15.7% | 1.2% | 233 | 12.3% | 1.0% | 459 | 15.1% | 0.9% |
| 55+ | 4352 | 38.5% | 0.3% | 1951 | 25.5% | 0.7% | 81 | 21.5% | 2.5% | 135 | 23.7% | 2.5% | 3 | – | – | 202 | 23.7% | 1.9% | 119 | 19.5% | 1.5% | 193 | 10.0% | 0.9% | 344 | 11.9% | 0.8% |
| *Racial Ethnic Group* | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| Non-Hispanic White | 10030 | 64.5% | 0.1% | 5756 | 69.2% | 0.6% | 320 | 75.4% | 2.8% | 334 | 53.5% | 2.1% | 219 | 48.1% | 3.1% | 843 | 89.2% | 1.0% | 543 | 79.7% | 2.4% | 1473 | 68.2% | 1.1% | 2474 | 62.4% | 1.3% |
| Black | 2780 | 11.2% | 0.1% | 1169 | 13.3% | 0.4% | 32 | 7.1% | 1.2% | 225 | 27.9% | 1.9% | 52 | 11.0% | 1.9% | 36 | 3.9% | 0.5% | 48 | 7.3% | 1.3% | 334 | 14.3% | 0.9% | 817 | 17.0% | 0.9% |
| Hispanic | 3732 | 16.2% | 0.1% | 1150 | 11.6% | 0.3% | 44 | 8.9% | 1.5% | 104 | 13.2% | 1.5% | 141 | 28.8% | 1.7% | 29 | 2.7% | 0.5% | 61 | 6.9% | 1.1% | 294 | 10.7% | 0.8% | 729 | 14.1% | 0.8% |
| Other Non-Hispanic | 1410 | 8.2% | 0.1% | 614 | 6.0% | 0.3% | 41 | 8.6% | 1.3% | 43 | 5.3% | 1.3% | 49 | 12.1% | 2.5% | 63 | 4.1% | 0.4% | 57 | 6.1% | 1.0% | 213 | 6.7% | 0.6% | 373 | 6.5% | 0.4% |

Population are not displayed when fewer than 30 respondents were observed. This resulted in Hookah Only users in the 35–44, 45–54, and 55+ age groups not being displayed.

**Fig. 1.** Percent Current Marijuana Use Among US Adult Tobacco Use Groups, by Age.
**Note:** Population estimates for marijuana use are not displayed when fewer than 50 respondents were observed. This resulted in Hookah Only users in the 35–44, 45–54, and 55+ age groups not being displayed.
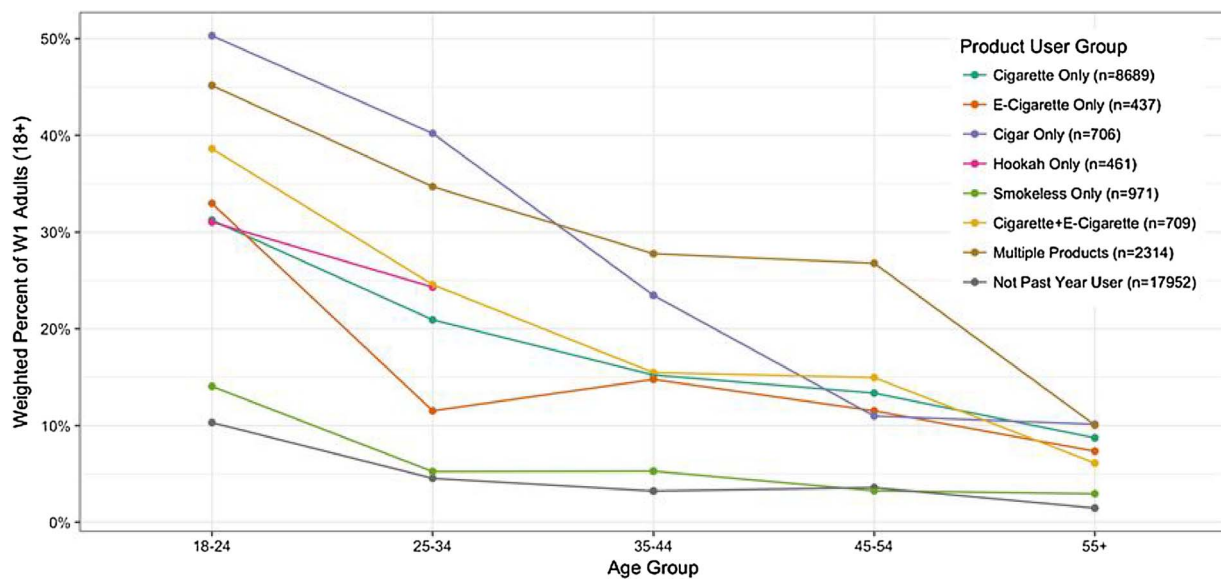
**Table 2**
Association of Tobacco Product User Group and Current Marijuana Use among Current and Non-Current Tobacco Users.

| | Non-Users and Users of Tobacco Products | | | | Users of Tobacco Products | | | | Users of Tobacco Products | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Model A | | | | Model B | | | | Model C | | | |
| Variable | OR | Lower 95% | Upper 95% | p | OR | Lower 95% | Upper 95% | p | OR | Lower 95% | Upper 95% | p |
| *User Group* | | | | | | | | | | | | |
| Not Past Year | – | – | – | | – | – | – | | – | – | – | |
| Cigarette Only | **4.77** | **4.24** | **5.36** | **< .001** | – | – | – | | – | – | – | |
| E-Cigarette Only | **3.86** | **2.90** | **5.12** | **< .001** | 0.81 | 0.61 | 1.08 | 0.16 | 0.92 | 0.68 | 1.25 | 0.60 |
| Cigar Only | **7.29** | **5.88** | **9.03** | **< .001** | **1.59** | **1.32** | **1.93** | **< .001** | **1.90** | **1.56** | **2.31** | **< .001** |
| Hookah Only | **4.73** | **3.69** | **6.07** | **< .001** | 1.03 | 0.80 | 1.33 | 0.81 | 1.28 | 0.97 | 1.67 | 0.08 |
| Smokeless | 1.16 | 0.85 | 1.57 | 0.35 | **0.28** | **0.21** | **0.37** | **< .001** | **0.29** | **0.21** | **0.39** | **< .001** |
| Cigarette + E-Cigarette | **5.58** | **4.51** | **6.89** | **< .001** | 1.17 | 0.98 | 1.40 | 0.08 | 1.13 | 0.95 | 1.35 | 0.16 |
| Multple Products | **8.07** | **7.00** | **9.31** | **< .001** | **1.82** | **1.62** | **2.05** | **< .001** | **1.79** | **1.59** | **2.01** | **< .001** |
| *Addiction* | | | | | | | | | | | | |
| **Tobacco Dependence** | | | | | | | | | **1.80** | **1.48** | **2.18** | **< .001** |

Bold indicates significant value.
Logistic regression models are adjusted for planned covariates including age, gender and race/ethnic groups.
Model A compares tobacco user groups to non-tobacco user groups.
Model B compares tobacco user groups to cigarette only user groups.
Model C compares tobacco user groups to cigarette only user group along with levels of tobacco dependence.

p < 0.01). Given the known decreases in use with age (Chen and Kandel, 1995; Compton et al., 2007; Vergés et al., 2013), Fig. 1 presents differences in reports of current marijuana use between each tobacco product user group (F(7,84) = 169.63, p = < 0.01) for each age group. When compared to those with no current tobacco use in the past year, inhaled tobacco product users including multiple product, cigar only, e-cigarette only, cigarette only, hookah only, and cigarette + e-cigarette users had significantly higher odds of reporting current marijuana use. Odds ratios ranged from 3.86 to 8.07 (see Table 2; Model A). As hypothesized, smokeless only users did not have significantly higher odds (OR = 1.16, 95% CI = 0.85, 1.57, p = 0.35) of reporting marijuana use than those with no current tobacco use.

### 3.3. Risk factors for use of marijuana among current users of tobacco products

Among current tobacco users, we first estimated any increase in odds of marijuana use of each user group in reference to cigarette only

users (Table 2; Model B). E-cigarette only, hookah only, and cigarette + e-cigarette users did not differ significantly from cigarette only users in the odds of reporting current marijuana use. Cigar only and multiple product users had significantly greater odds of reporting current marijuana use than cigarette only users. Smokeless only users had significantly reduced odds of marijuana use compared to cigarette only users.

We examined the hypothesis that tobacco dependence (TD) may account for significant differences in current marijuana use across tobacco user groups by adding the TD scale to the demographically adjusted model (see Table 2; Model C). This hypothesis was not supported, as each significant association noted in Model B remained significant in Model C, and each effect size remained largely unchanged. Level of tobacco dependence was a significant and independent predictor of current marijuana use (p < 0.01). Follow-up exploratory analysis did not suggest any moderated relationship between tobacco user groups and TD scores, as the set of interaction terms when added after all other lower-order terms was not significant (F(6,76) = 0.53, p = 0.78).

**Table 3**
Quit Attempts and Intentions to Quit, by Marijuana Use and Tobacco Product Groups.

| | Users of Tobacco Products | | | | | | | |
| | Past 12-month Quit Attempt | | | | Current Intention to Quit | | | |
| Variable | OR | Lower 95% | Upper 95% | p | OR | Lower 95% | Upper 95% | p |
|---|---|---|---|---|---|---|---|---|
| *User Group* | | | | | | | | |
| Cigarette Only | – | – | – | – | – | – | – | – |
| E-Cigarette Only | **1.72** | **1.35** | **2.19** | **< .001** | **1.40** | **1.09** | **1.80** | **0.01** |
| Cigar Only | **0.48** | **0.38** | **0.60** | **< .001** | 0.84 | 0.64 | 1.12 | 0.24 |
| Hookah Only | **0.34** | **0.26** | **0.43** | **< .001** | **0.55** | **0.35** | **0.84** | **0.01** |
| Smokeless | **0.80** | **0.65** | **0.98** | **0.03** | **0.80** | **0.64** | **1.00** | **0.05** |
| Cigarette + E-Cigarette | **2.92** | **2.39** | **3.58** | **< .001** | 1.03 | 0.85 | 1.24 | 0.78 |
| Multple Products | 1.01 | 0.90 | 1.13 | 0.92 | **0.71** | **0.61** | **0.83** | **< .001** |
| *Addiction* | | | | | | | | |
| Tobacco Dependence | **1.61** | **1.42** | **1.83** | **< .001** | **0.49** | **0.39** | **0.61** | **< .001** |
| *Current Marijuana Use* | | | | | | | | |
| No | – | – | – | – | – | – | – | – |
| Yes | **0.86** | **0.79** | **0.94** | **< .001** | 0.94 | 0.81 | 1.09 | 0.43 |

*Bold indicates significant value.

### 3.4. Association with history and intention to quit tobacco

Current users of both tobacco and marijuana did not differ significantly from tobacco-only users in reports of current intentions to make a tobacco quit attempt in the next 6 months (OR = 0.94, 95% CI = 0.81,1.09, p = 0.14). Levels of intent in quitting tobacco differed significantly across tobacco use groups (F(6,80) = 8.23, p < 0.01). Table 3 reports odds ratios, confidence intervals, and significance for each planned comparison of tobacco user groups with cigarette only users. E-cigarette only users had higher odds of reporting a current intention to make an attempt to quit than cigarette only users. Hookah only and multiple product users had lower odds of reporting an intention to quit than cigarette only users. Among current tobacco users, current marijuana users had significantly lower odds of reporting an attempt to quit tobacco in the past 12-months (OR = 0.86, 95% CI = 0.79, 0.94, p < 0.01) compared to those reporting no current marijuana use. Reports of quit attempts also differed significantly across tobacco user groups (F(6,81) = 48.52, p = < 0.01). When compared to cigarette only users, e-cigarette only (OR = 1.72, 95%CI = 1.35, 2.19, p < 0.01) and cigarette + e-cigarette (OR = 2.92, 95% CI = 2.39, 3.58, p < 0.01) users reported higher odds of making a quit attempt in the past 12-months (See Table 3). Cigar only, hookah only, and smokeless only users reported lower odds of reporting a quit attempt in the past 12-months relative to cigarette only users. Multiple product users and cigarette only users were not significantly different in reports of a quit attempt in the past 12-months.

### 3.5. Association with respiratory disease

In logistic regression models that adjusted for the significant effects of age (F(4,83) = 27.31, p < 0.001), sex (F(1,83) = 66.26, p < 0.001), and race-ethnicity (F(3,83) = 3.63, p = 0.02), both tobacco user group (F(7,83) = 24.44, p < 0.001) and current marijuana use (F(1,83) = 27.37, p < 0.001) were associated with higher odds of reporting a history of a respiratory disease. When compared to non-current users of tobacco products, cigarette only (OR = 1.54, 95% CI = 1.43–1.66, p < 0.001), e-cigarette only (OR = 1.39, 95% CI = 1.09–1.76, p = 0.008), cigar only (OR = 1.38, 95%CI = 1.08–1.75, p = 0.01), hookah only (OR = 1.34, 95% CI = 1.02–1.76, p = 0.04), e-cigarette + cigarette (OR = 2.07, 95% CI = 1.71–2.51, p < 0.001), and multiple product users (OR = 1.59, 95% CI = 1.41–1.80, p < 0.001) had higher odds of reporting a history of a respiratory disease. Smokeless only (OR = 1.17, 95%CI = 0.97–1.40, p = 0.09) users reported rates of respiratory disease that were similar to current non-users of tobacco. After accounting

for demographics and current tobacco product use, current use of marijuana was independently associated with higher odds of reporting a history of a respiratory disease (OR = 1.35, 95% CI = 1.27–1.51, p < 0.001). The examined statistical interaction of marijuana and tobacco use group did not support a difference in the relationship between current marijuana use and increased odds of respiratory diseases across tobacco use groups (F(7,76) = 0.67, p = 0.70). Across tobacco user groups, those with concurrent marijuana use demonstrated higher probability of reporting a history of a respiratory disease than those without concurrent marijuana use, and the highest probability was among concurrent marijuana and cigarette + e-cigarette users (see Fig. 2).

### 4. Discussion

The present study examined the differential prevalence of co-use of marijuana among distinct types of tobacco product user groups, impacts on tobacco dependence, efforts to stop tobacco, and current respiratory problems. Cigar only and multiple product users consistently had the highest rates of marijuana use. These product-specific patterns were maintained after adjusting for differences in demographics and after accounting for the strong relationship between tobacco dependence and current marijuana use. Tobacco product characteristics (e.g., cigars) that may afford opportunity for delivery of marijuana may increase their appeal to concurrent users of marijuana. Alternatively, concurrent use may serve to promote expanded use of tobacco products (e.g., leading to multiple tobacco product use patterns).

Rates of concurrent use decreased steadily across age groups for all tobacco product users except smokeless only users, whose rates remained similar to non-users across age groups. While we adjust statistically for the influence of age on the relationship between product use and increased current marijuana use, the increase in concurrent use of these products among youth, where cigar and multiple product use is most common, is of particular concern. However, the extent to which the currently observed greater rates of concurrent use among youth differ from historical patterns is unknown.

Differences in product user groups also reflect, in part, differences in tobacco dependence (Strong et al., 2017). Associations between concurrent use and dependence are well documented (Castane et al., 2005; Maldonado et al., 2006; Peters et al., 2012) and have plausible mechanisms via enhanced reinforcement, conditioned pairings to strengthen cues for concurrent use, and amelioration of cognitive deficits of marijuana use alone (Schuster et al., 2016). When examining the relative impact of levels of dependence, no observed relationship between product user group and concurrent use of marijuana was
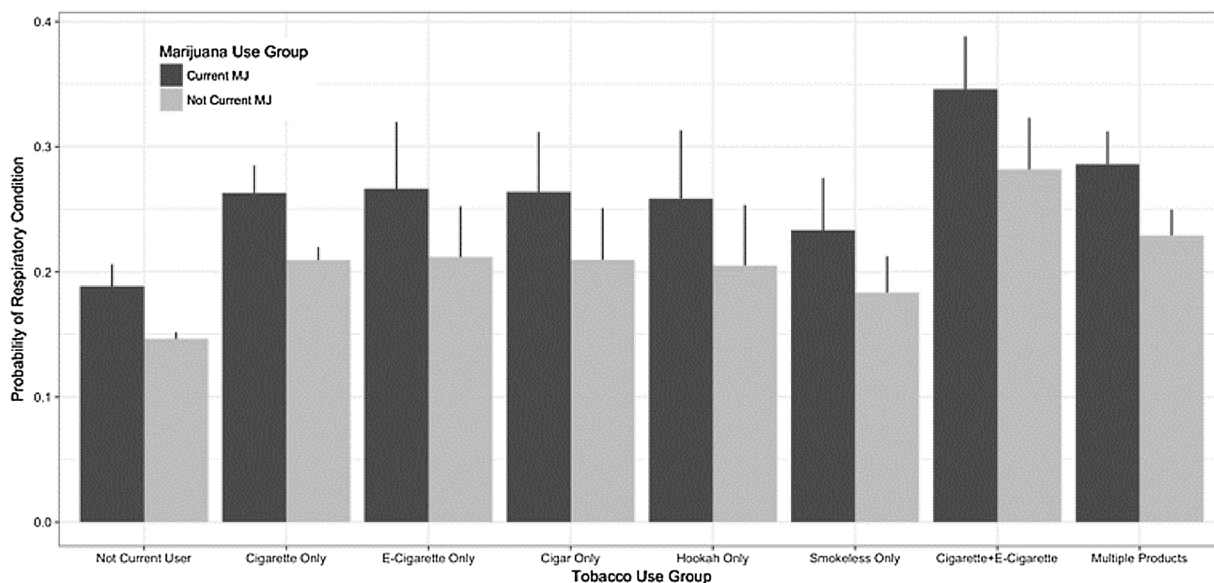
**Fig. 2.** Reports of Respiratory Conditions According to Current Tobacco or Marijuana Use.

affected. This suggests an additive effect of dependence rather than a sole common causal relationship.

Previous studies have suggested that marijuana use is associated with persistent tobacco use and decreased efforts to quit tobacco (Agrawal et al., 2012). Present findings indicate that although concurrent marijuana use did not correspond with reduced intentions to quit tobacco, it was associated with lower likelihood of reporting a past year quit attempt among some user groups. Concurrent users may be more dependent on marijuana (Agrawal et al., 2012; Peters et al., 2012), may have an increased difficulty with marijuana cessation when they continue to use tobacco (Peters et al., 2012), may have more psychosocial impairments (Peters et al., 2012), and may be less motivated to reduce tobacco use (Hindocha et al., 2016). Current marijuana use may be a barrier to tobacco cessation, not because it interferes directly with intentions to quit, but because it is associated with reduced chances that a concurrent user will be attempting to quit.

### 4.1. Implications

Additive effects of concurrent use of marijuana and tobacco on respiratory symptoms heighten public health concerns over potential exacerbation of health effects of marijuana on lung disorders (Ribeiro and Ind, 2016) and increased odds of respiratory conditions among both users and non-users of tobacco products (Moore et al., 2005; Taylor et al., 2002). Additive effects also were observed among e-cigarette only tobacco users. In addition, dual users of cigarettes and e-cigarettes had notably elevated probability of reporting respiratory conditions relative to other tobacco user groups. The increased respiratory symptoms among e-cigarette and cigarette users in particular may reflect the potential motivating influence of respiratory conditions on encouraging cigarette smokers to use e-cigarettes for cessation or to cut down on cigarettes.

### 4.2. Limitations

One limitation of this study is that users of traditional cigars, cigarillos, and filtered cigars were grouped together into cigar users rather than explored as separate product user groups. As cigar products are tied to use of blunts, this is an important group to explore in discrete sub-groups in future research. In addition, neither the frequency nor quantity of use of marijuana were available in Wave 1 of the PATH Study. Further, wave 1 participants were not asked about the specific

marijuana product used (e.g., joint, pipe, vaporized, edibles) limiting our ability to establish the specific contribution of inhaled marijuana to respiratory problems. Available data suggest that combusted marijuana is preferred by a large majority of users (Borodovsky et al., 2016), but further study of the relative contribution of inhaled tobacco and inhaled marijuana to lung health is needed (National Academies of Sciences Engineering and Board on Population Health and Public Health Practice, 2017; Tashkin, 2013; Van Dyke et al., 2017). Lastly, this study used cross-sectional data, thus precluding our understanding of temporal interactions of product use. Longitudinal examination of the role of efforts to quit tobacco use are needed among concurrent tobacco and marijuana users to understand whether continued use of marijuana decreases the likelihood of tobacco quit attempts or impacts the likelihood of success in quitting.

### 5. Conclusions

Ongoing decriminalization of marijuana use in the US may lead to increasing prevalence of use, which may in turn lead to future increases in tobacco and tobacco concurrent use. As indicated by the present findings, concurrent use of tobacco and marijuana represents a potential public health concern. The current cross-sectional findings indicate that concurrent use is associated with higher tobacco dependence and lower rates of quit attempts, both of which may lead to sustained tobacco use and its deleterious health effects. Further, marijuana use may represent an additive risk for respiratory harm among tobacco marijuana concurrent users. Additional longitudinal research on tobacco marijuana concurrent use is clearly indicated to further inform this issue. However, existing evidence is sufficient to commend prevention efforts specifically targeting tobacco and marijuana concurrent use.

### Conflict of interest

No conflict declared.

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## Contributors

Dr. Strong conceptualized and designed the study including the study instruments, carried out analyses, critically reviewed the manuscript and approved the final manuscript as submitted. Drs. Myers, Pulvers and Doran assisted with the initial proposed analyses, as well as reviewed and approved all analyses. Ms. Noble and Ms. Brikmanis reviewed and approved the initial proposed analyses, as well as reviewed and revised the manuscript, and approved the final manuscript as submitted. All authors have contributed to and approved the final article.

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