

Respiratory Effects of Marijuana and Tobacco Use in a U.S. Sample

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OBJECTIVE: Although a number of studies have examined the respiratory impact of marijuana smoking, such studies have generally used convenience samples of marijuana and tobacco users. The current study examined respiratory effects of marijuana and tobacco use in a nationally representative sample while controlling for age, gender, and current asthma.

DESIGN: Analysis of the nationally representative third National Health and Nutrition Examination Survey (NHANES III).

SETTING: U.S. households.

PARTICIPANTS: A total of 6,728 adults age 20 to 59 who completed the drug, tobacco, and health sections of the NHANES III questionnaire in 1988 and 1994. Current marijuana use was defined as self-reported 100+ lifetime use and at least 1 day of use in the past month.

MEASUREMENTS AND MAIN RESULTS: Self-reported respiratory symptoms included chronic bronchitis, frequent phlegm, shortness of breath, frequent wheezing, chest sounds without a cold, and pneumonia. A medical exam also provided an overall chest finding and a measure of reduced pulmonary functioning. Marijuana use was associated with respiratory symptoms of chronic bronchitis ($P=.02$), coughing on most days ($P=.001$), phlegm production ($P=.0005$), wheezing ($P<.0001$), and chest sounds without a cold ($P=.02$).

CONCLUSION: The impact of marijuana smoking on respiratory health has some significant similarities to that of tobacco smoking. Efforts to prevent and reduce marijuana use, such as advising patients to quit and providing referrals for support and assistance, may have substantial public health benefits associated with decreased respiratory health problems.

KEY WORDS: marijuana; tobacco; smoking; respiratory symptoms; epidemiology.

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Marijuana smoking remains the second most widely smoked substance in the United States, with conservative estimates indicating that more than 11 million people smoked marijuana during the last month, and approximately 20% of these smoke almost daily.¹⁻³ Marijuana smoke contains similar levels of tar as tobacco smoke and up to 50% more carcinogens.^{4,5} Marijuana users smoke unfiltered material, inhale the smoke more deeply, and hold the smoke longer

than tobacco smokers, resulting in substantially greater tar deposits in the lungs than tobacco smokers.⁶⁻⁹ Reports from clinical samples suggest that marijuana smokers exhibit a range of chronic respiratory symptoms,¹⁰⁻¹³ although it is unclear whether these symptoms are representative of marijuana smokers as a whole. In addition, marijuana users have greater utilization of outpatient medical services for respiratory and other illnesses.¹⁴ Moreover, the histopathologic and molecular abnormalities observed in marijuana smokers are almost identical to that observed in tobacco smokers.^{10,15-17} Cellular abnormalities include reductions in the number of ciliated epithelial cells lining the trachea and bronchi. These histopathologic alterations are associated with a range of potential lung disorders such as chronic bronchitis, chronic obstructive pulmonary disease, and cancer. Although the extent of the problem remains unclear, the current literature of case reports and clinical samples suggests that marijuana-related respiratory problems may constitute a significant public health burden that could be prevented or treated by general internists.

Only two studies have attempted to quantitatively define the odds of respiratory symptoms among marijuana users in the general population. One examined respiratory symptoms in marijuana-dependent 20 year olds in a longitudinal sample from New Zealand.¹³ The other examined non-tobacco smoking individuals in a longitudinal study in Arizona.¹¹ Both studies found increased odds of respiratory symptoms such as cough, wheezing, and sputum production among users. However, the first focused only on young marijuana-dependent individuals in New Zealand. The second was limited to Tucson, AZ and did not specifically focus on marijuana use but rather on "non-tobacco" cigarette use, which was assumed to be predominately marijuana. The purpose of the present report is to provide estimates of respiratory symptoms for current marijuana use in a nationally representative sample in the United States with a broader range of ages and marijuana exposure. The third National Health and Nutrition Examination Survey (NHANES III) was used to examine the independent contributions of marijuana use and tobacco use while controlling for gender, age, and current asthma.

METHODS

Sample

The NHANES III, conducted between 1988 and 1994, used a multistage probability design with oversampling of African Americans and Mexican Americans to obtain a nationally representative sample of the U.S. population.¹⁸ Household members were initially selected and requested to complete a general health survey. Eighty-six percent of selected individuals were interviewed in person and all were invited to participate in the medical exam. All respondents signed an informed

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consent, which guaranteed that information was kept in strictest confidence. Seventy-eight percent of invited individuals completed the medical exam. The medical exam included an interview that asked a range of general health questions regarding marijuana and tobacco use, a physician's exam, and a spirometry component. Adults age 20 to 59 who completed the drug and tobacco sections of the NHANES III medical exam questionnaire were selected for this study. NHANES III restricted drug use questions to individuals younger than 60. Individuals were asked first whether they had ever used marijuana. Individuals who reported ever using marijuana were asked, "About how many times in your lifetime have you used marijuana," with the following response categories: "1 or 2 times," "3 to 10 times," "11 to 99 times," and "100 or more times."

Individuals who reported lifetime use were also asked, "During the past month, on how many days did you use marijuana?" Individuals provided a number response between 0 and 30. Current marijuana use was defined as self-reported 100+ lifetime uses and at least 1 day of use in the past month. Individuals were not asked about their daily quantity or frequency of use. For tobacco cigarette use, individuals were asked, "Have you smoked at least 100 cigarettes in your entire life," and "How many cigarettes have you smoked in the past 5 days?" Current tobacco use was defined as self-reported lifetime history of smoking 100+ tobacco cigarettes and current use as an average of 1 or more tobacco cigarettes per day. The criterion of 100+ lifetime uses for both marijuana and tobacco was implemented to exclude experimental users of either substance. Nonsmokers had never used marijuana and had not smoked tobacco cigarettes more than 100 times. The total sample consisted of 6,728 individuals: 4,789 nonsmokers, 1,525 tobacco-only smokers, and 414 marijuana smokers (320 also smoked tobacco).

Outcome Measures

Respiratory symptoms were asked about as part of the general household survey. The following respiratory symptoms were examined: chronic bronchitis, frequent phlegm, shortness of breath, frequent wheezing, chest sounds without a cold, and pneumonia (see Table 1 for the specific questions used to determine these symptoms). In addition, the medical exam provided an overall chest finding and spirometry measures. The overall chest finding summarized whether the physician noted any respiratory abnormality such as decreased breath or adventitious sounds in either lung. For the spirometry data, we calculated the FEV1/FVC ratio and used a cutoff of <70% as

Table 1. NHANES III Questions for Respiratory Symptoms

Has a doctor ever told you that you had chronic bronchitis?
Do you usually cough on most days for 3 consecutive months or more during the year?
Do you bring up phlegm on most days for 3 consecutive months or more during the year?
Are you troubled by shortness of breath when hurrying on level ground or walking up a slight hill?
Have you had wheezing or whistling in your chest at any time in the past 12 months?
Apart from when you have a cold, does your chest ever sound wheezy or whistling?
During the past 12 months, have you had pneumonia?

NHANES III, third National Health and Nutrition Examination Survey.

an indicator of obstruction.¹⁹ Height was also controlled in the analysis of the FEV1/FVC ratio cutoff.

Data Analysis

All analyses were completed using SAS, version 8.2 (SAS Institute, Cary, NC) with callable SUDAAN, version 8.0 (Research Triangle Park, NC). SUDAAN was used to adjust the standard errors in accordance with the variable selection probabilities including noncoverage and nonresponse associated with the survey sampling frame.¹⁸ For demographics, χ^2 tests were used to examine weighted proportional differences among categorical variables and ANOVAs were used for continuous measures. Demographic variables available in the NHANES III dataset included gender, age, race, education, marital status, and income. Logistic regression was employed to compare marijuana users to nonsmokers with each respiratory symptom while controlling for gender, age, and tobacco cigarettes smoked per day. Although marijuana users differed on other demographic variables in addition to gender and age, these variables were highly correlated with age and gender, such that marijuana users did not differ on the other demographic variables when age and gender were controlled. The analysis of respiratory symptoms also controlled for current asthma. Current asthma was statistically controlled because it is more likely to be a preexisting condition, and marijuana smokers may have used marijuana to treat or control their asthma. For individuals who reported that a doctor had told them they had asthma, current asthma was defined by whether participants reported that they still had asthma.

RESULTS

Marijuana smokers reported smoking on an average of 10.2 days (standard error [SE], 0.84) of the previous 30 days, with 16% ($n=68$) reporting daily or near daily use (28 or more days). Marijuana smokers were more likely to be male, white, younger, and single than nonsmokers (see Table 2). They were also more likely to have lower education levels and earn less income than nonsmokers. Seventy-seven percent of marijuana smokers also smoked tobacco. Among marijuana smokers, the mean number of tobacco cigarettes smoked per day (19.22; SE, 1.05) did not differ significantly from that of tobacco-only smokers (19.27; SE, 0.64). Tobacco-only smokers were more likely to be male, white, older, have less education, and earn less income than nonsmokers.

Table 3 presents the unadjusted comparisons of the marijuana and tobacco users and nonusers on respiratory symptoms. Compared to nonusers, both marijuana and tobacco users had higher rates of chronic bronchitis (odds ratio [OR], 2.68, 95% confidence interval [CI], 1.47 to 4.89 for marijuana users and OR, 2.69, 95% CI, 1.87 to 3.86 for tobacco users, respectively), cough on most days (OR, 7.05, 95% CI, 4.84 to 10.26 and OR, 6.17, 95% CI, 4.54 to 8.38), phlegm production (OR, 5.54, 95% CI, 3.70 to 8.30, and OR, 4.67, 95% CI, 3.19 to 6.82), shortness of breath (OR, 1.79, 95% CI, 1.14 to 2.81, and OR, 2.89, 95% CI, 2.36 to 3.54), wheezing (OR, 6.24, 95% CI, 4.51 to 8.62, and OR, 3.13, 95% CI, 2.42 to 4.05), and chest sounds (OR, 4.96, 95% CI, 3.41 to 7.21, and OR, 3.88, 95% CI, 3.01 to 5.01). A significantly higher proportion of tobacco users were found to report pneumonia in the past year (OR, 2.06, 95% CI, 1.15 to 3.72). Tobacco users were also more likely to

Table 2. Characteristics of Nonsmokers, Tobacco-only Smokers, and Marijuana Smokers: NHANES III, 1988 to 1994

Variable	Nonsmokers (n = 4,789)	Tobacco Smokers (n = 1,525)	Marijuana Smokers (n = 414)
Gender, % male*†	36.6	50.0	77.0
Race, % white*†	65.3	73.6	78.8
Education*†			
< 12 years	22.0	34.9	27.6
12 years	32.4	39.2	39.2
> 12 years	45.6	25.9	33.1
Mean age, y (± SE)*†	34.7 (0.31)	41.5 (0.52)	31.2 (0.65)
Marital status, % married*†	83.7	75.0	79.8
Income, %*†			
<\$10,000	15.8	22.3	17.6
\$10,000 to \$29,000	34.2	37.7	49.7
\$30,000 to \$59,000	23.1	19.6	18.2
>\$59,000	26.9	20.3	14.5

*Nonsmokers versus marijuana smokers, $P < .05$.

†Nonsmokers versus tobacco smokers, $P < .05$.

NHANES III, third National Health and Nutrition Examination Survey; SE, standard error.

have some respiratory abnormality as indicated by the physician's overall chest finding (OR, 8.94, 95% CI, 4.91 to 16.29), while marijuana users did not differ significantly from nonusers (OR, 2.89, 95% CI, 0.95 to 8.75). Compared to nonusers, both marijuana and tobacco users had a higher proportion of individuals with an FEV1/FVC ratio < 70% (OR, 2.56, 95% CI, 1.54 to 4.35 and OR, 6.25, 95% CI, 4.76 to 8.33, respectively). Direct comparisons between tobacco and marijuana users indicated that a greater proportion of tobacco users had shortness of breath, chest findings, and evidence of airway obstruction as indicated by an FEV1/FVC ratio < 70%, while marijuana users evidenced greater wheezing.

In general, marijuana smokers showed increased rates of respiratory symptoms similar to those of tobacco smokers. For example, 16.9% of marijuana users reported frequent phlegm production, which corresponds to a national estimate of 1,084,000 individuals. Table 3 also presents the number needed to harm (NNH) for both marijuana and tobacco users. This measure indicates how many users would be expected for each case that exhibited the symptom. For marijuana users, NNH values ranged from 3.3 (wheezing) to 20.3 (chronic bronchitis). For tobacco users, NNH values ranged from 5.4 (shortness of breath) to 37.0 (current asthma).

Because a large number of marijuana users also used tobacco, and marijuana and tobacco users differed on demographic characteristics, odds ratios for respiratory symptoms were computed comparing marijuana users to controls, controlling for gender, age, current asthma, and tobacco cigarettes used per day (Table 4). The odds of respiratory symptoms of chronic bronchitis, coughing on most days, phlegm production, wheezing, and chest sounds without a cold were greater for marijuana users. However, marijuana use was not associated with greater odds of shortness of breath, pneumonia, or objective measures of respiratory functioning, including the physician's respiratory findings and the FEV1/FCV ratio. Tobacco use was associated with increased odds of all respiratory variables (all $P < .0001$) with one exception. Tobacco use was not associated with greater odds of pneumonia when age, gender, and current asthma were controlled.

Table 3. Percent of Nonsmokers, Tobacco-only Smokers, and Marijuana Smokers with Respiratory Symptoms: NHANES III, 1988 to 1994

Variable	Nonsmokers (n = 4,789)		Tobacco Smokers (n = 1,525)		Marijuana Smokers (n = 414)	
	%	NNH	%	NNH	%	NNH
Current asthma*	3.8	37.0	6.5	37.0	5.8	50.0
Chronic bronchitis*†	3.2	20.0	8.2	20.0	8.1	20.4
Cough: most days*†	3.8	6.4	19.5	6.4	21.7	5.6
Phlegm*†	3.5	9.0	14.6	9.0	16.9	7.5
Shortness of breath*††	14.8	5.4	33.4	5.4	23.7	11.2
Wheezing*††	9.7	6.5	25.2	6.5	40.1	3.3
Chest sounds*†	5.8	7.4	19.4	7.4	23.5	5.6
Pneumonia*	1.7	55.6	3.5	55.6	2.8	90.9
Overall chest finding*†	1.1	12.7	9.0	12.7	3.1	50.0
FEV1/FVC ratio < 70%*††	3.8	6.2	20.0	6.2	9.1	19.8

*Nonsmokers versus tobacco smokers, $P < .05$.

†Nonsmokers versus marijuana smokers, $P < .05$.

††Tobacco smokers versus marijuana smokers, $P < .05$.

NHANES III, third National Health and Nutrition Examination Survey; NNH, number needed to harm.

Direct comparisons of marijuana and tobacco users with tobacco-only users were also conducted controlling for age, gender, and current asthma. The pattern of findings was the same as the results examining marijuana use while controlling for cigarettes per day. Although both groups smoked a similar number of tobacco cigarettes, smoking both marijuana and tobacco was associated with greater odds of chronic bronchitis (OR, 2.10, 95% CI, 1.07 to 4.15; $P = .03$), coughing on most days (OR, 1.87, 95% CI, 1.24 to 2.83; $P = .004$), phlegm production (OR, 1.60, 95% CI, 1.02 to 2.50; $P = .04$), wheezing (OR, 2.38, 95% CI, 1.57 to 3.61; $P = .0001$), and chest sounds without a cold (OR, 1.90, 95% CI, 1.06 to 3.39; $P = .03$), but not shortness of breath (OR, 1.10, 95% CI, 0.72 to 1.69; $P = .65$), pneumonia (OR, 2.66, 95% CI, 0.79 to 8.98; $P = .11$), the overall chest finding (OR, 0.49, 95% CI, 0.21 to 1.10; $P = .08$), or the FEV1/FVC ratio (OR, 0.89, 95% CI, 0.40 to 2.00; $P = .78$).

DISCUSSION

In a nationally representative sample, marijuana use was associated with a variety of respiratory problems including chronic bronchitis, coughing on most days, phlegm production, wheezing, and chest sounds without a cold, even when gender, age, tobacco use, and current asthma were controlled. When examined categorically, marijuana users had similar rates of respiratory symptoms as tobacco cigarette users even though they were 10 years younger. These rates of respiratory problems constitute a potentially large national public health burden. For example, based on the current analyses, an estimated 1 million marijuana users had phlegm production on most days for 3 consecutive months or more during the year.

These findings, replicated in a nationally representative sample, are consistent with other studies examining respiratory symptoms between marijuana and tobacco smokers.^{10,13,15,20} However, rates of specific respiratory symptoms were generally lower in the current study. This may be due to our inclusion of all marijuana users rather than the restriction to marijuana dependence as was done in the Taylor et al. study.¹³ Taken together, these findings suggest that marijuana-

Table 4. Odds Ratios and 95% Confidence Intervals for Respiratory Symptoms for Marijuana Users and Tobacco Users Versus Nonsmokers Controlling for Gender, Age, and Current Asthma

Respiratory Variable	Marijuana Users*	Tobacco Users
Chronic bronchitis	2.17 (1.11 to 4.26), <i>P</i> = .02	2.44 (1.66 to 3.57), <i>P</i> < .0001
Cough: most days	2.00 (1.32 to 3.01), <i>P</i> = .001	5.02 (3.58 to 7.04), <i>P</i> < .0001
Phlegm	1.89 (1.35 to 2.66), <i>P</i> = .0005	3.71 (2.45 to 5.62), <i>P</i> < .0001
Shortness of breath	1.29 (0.81 to 2.03), <i>P</i> = .26	2.70 (2.16 to 3.37), <i>P</i> < .0001
Wheezing	2.98 (2.05 to 4.34), <i>P</i> < .0001	3.39 (2.54 to 4.53), <i>P</i> < .0001
Chest sounds	2.06 (1.18 to 3.61), <i>P</i> = .02	4.25 (3.06 to 5.91), <i>P</i> < .0001
Pneumonia	1.47 (0.54 to 3.97), <i>P</i> = .44	1.57 (0.98 to 2.51), <i>P</i> = .06
Overall chest finding	0.67 (0.22 to 1.99), <i>P</i> = .46	6.48 (3.82 to 10.99), <i>P</i> < .0001
FEV1/FVC ratio < 70%	1.01 (0.51 to 1.94), <i>P</i> = .99	4.17 (3.03 to 5.88), <i>P</i> < .0001

*For marijuana users, the number of cigarettes per day was also controlled.

na use is associated with a range of respiratory problems that are likely greater with marijuana dependence.

Of note, although unadjusted comparisons indicated that marijuana users evidenced increased airway obstruction as indicated by an FEV1/FVC ratio < 70%, marijuana use was not associated with the objective indicators of respiratory functioning when age, gender, current asthma, and cigarette use were controlled. While the analyses were intended to control for group differences and examine the contribution of marijuana use, the sample of marijuana users was significantly younger and reported only an average of 10 days of use in the past 30 days. The current findings may be indicative of an earlier stage of respiratory problems for which self-reported symptoms are more sensitive. Thus, it may be important for physicians to ask marijuana-using patients about symptoms such as wheezing or cough in addition to a physical respiratory exam in order to provide a more complete picture of respiratory functioning.

Smoking both marijuana and tobacco was common among marijuana users (77%). This prevalence was higher than that noted in other studies of marijuana and tobacco use, which may be due to different definitions of marijuana and tobacco use across studies.^{3,21} However, individuals who smoked both marijuana and tobacco were found to have greater prevalence of respiratory symptoms than those who smoked only tobacco. Unfortunately, information regarding the amount of marijuana smoked per day or week was not available. A more detailed analysis of the incremental impact of marijuana smoking on respiratory health is still needed. Nonetheless, the generally high prevalence of tobacco use among marijuana smokers appears to pose increased risk for respiratory illness due to potential additive effects of smoking both substances.^{15,22}

Four methodological limitations warrant mention regarding the marijuana use information available from NHANES III. First, only three questions about marijuana use were included in the survey. No information was available regarding the frequency and amount used per day, nor are there specific questions on the history of marijuana use, such as the total number of years of use. Although we attempted to exclude casual users by limiting the sample to individuals who used marijuana more than 100 times, the current measure of days used in the past month provides only an estimate of an individual's marijuana use. Although there is no evidence that the measure is biased, the measure lacks the detail and specificity of measures of tobacco use. The fact that the 1 or more days of use in the past month alone was significantly associated with so many respiratory symptoms is somewhat surprising, and suggests that a more detailed assessment of use is needed to pro-

vide an optimal dose-response relationship. Second, the illegal nature of marijuana use may have led to underreporting, as these data were based on self-report. However, this would result in a greater number of marijuana users being classified as nonusers and tobacco users, and thus decrease the chance of finding differences between marijuana users and the comparison groups. Third, no information was available on the modality of marijuana use. Although the method of use of marijuana is overwhelmingly smoking, it is possible that in the current sample marijuana was used in other manners (e.g., ingestion). Finally, the sample was restricted to adults age 20 to 59 because NHANES III did not ask individuals 60 and older drug use questions. Thus, the marijuana-related respiratory effects correspond to a relatively young population, particularly for the marijuana-smoking groups who were found to be younger than the tobacco-only smokers and nonusers. Although the current analyses controlled for age, rates of respiratory problems would be expected to be higher for an older population of marijuana users. As a whole, these limitations suggest that the findings are conservative estimates of marijuana's respiratory effects.

In summary, marijuana use was associated with increased risk of many respiratory symptoms that are associated with disorders common to tobacco use such as chronic bronchitis, chronic obstructive pulmonary disease, and cancer.^{20,23,24} In addition, marijuana smoking may increase risk of respiratory exposure by infectious organisms, such as fungi and molds, as cannabis plants are contaminated with a range of fungal spores.^{25,26} Because more than 2 million adult Americans are heavy marijuana smokers,³ these risks represent a potentially large health burden. Marijuana smokers use more medical services for respiratory problems, and such demands are likely to increase as the population of heavy marijuana smokers ages.¹⁴ Efforts to prevent and reduce marijuana use, such as advising patients to quit and providing referrals for support and assistance, may have substantial public health benefits.²⁷

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