States with legalized medical marijuana have higher marijuana use and dependence: using the legalization of medical marijuana as a proxy measure of community norms

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Abstract

Marijuana use is the most frequently used illicit substance in the United States, and marijuana use disorder is the most common substance use disorder after nicotine and alcohol. We examined marijuana use and disorder rates by prior state-level legalization of medical marijuana. We considered state medical marijuana policy to reflect existing community norms on marijuana use. Our primary data source was the NESARC, a nationally-representative survey of adults aged 18+ (n=34,520). We replicated selected analyses using the NSDUH, an annual national survey of individuals aged 12+ (n=70,000). Accounting for potential individual- and state-level confounders, residents of states that had legalized medical marijuana had higher odds of past-year marijuana use (OR:1.89; 95% CI: 1.45,2.46) and marijuana use disorder (OR:1.79; 95% CI: 1.25,2.56) than residents of non-legalizing states. These findings highlight the impact that intervening on macro-level factors, such as social norms, may have in shaping the population distribution of marijuana use.

Introduction

Marijuana use presents a highly prevalent public health problem in the United States (US) and abroad: it is the most frequently used illicit substance, and marijuana use disorder is the most common substance use disorder after nicotine and alcohol (1). Marijuana use is associated with a range of adverse public health outcomes, including abnormal cognitive development, altered brain structure and function, sleep, and mental health problems such as psychosis and depression (2-4). Identifying modifiable determinants of marijuana use is thus of primary public health importance.

Risk factors for marijuana use have been identified at the individual, peer, family and community levels (5). Despite increasing recognition that factors at the community level, from the neighborhood to schools and the broader society, may influence rates of substance use (6, 7), and increased funding for community-level prevention efforts, such as the recent $85.6 million award of the White House Drug Policy Director to local communities to prevent youth drug use (8), little research has actually assessed the impact that community-level factors have had on marijuana use.

Community norms about marijuana use may be an important driver of the population-level distribution of marijuana consumption across the United States. According to social learning theory, marijuana use may result from cognitive processes through which people anticipate the consequences associated with their actions and act accordingly (9-11). The most proximal determinants of marijuana use, then, are their personal beliefs about marijuana use, including perceptions of parental or peer disapproval of smoking, social and health risks of smoking, marijuana availability, and marijuana use by friends (12, 13). Personal beliefs about marijuana use are hypothesized to be directly influenced by community norms regarding the

acceptability of smoking marijuana (12, 13): individuals living in communities with less accepting norms will have personal beliefs that are less supportive of smoking marijuana, and in turn, they will consume less marijuana. Community norms also fit within contagion theory of health behavior transmission, which suggests that norms, as well as behaviors, are spread between persons in a dynamic manner (6, 14).

Considerable research indicates that norms are an important predictor of marijuana use (15-18). However, the bulk of this research has been conducted at the individual level, focusing on the relationship between individual perceptions of group norms and individual reports of use (12, 13, 19). Perceptions of individuals about group norms may not, however, provide an accurate reflection of aggregate community norms. A need thus exists to move beyond research at the individual level, to examine how aggregate, community-level measures of norms shape rates of marijuana use and marijuana use disorders. Community-level factors such as norms may explain why certain behaviors such as marijuana use persist in certain geographic locations over long periods of time—hence, changing community norms may have a stronger and more sustainable effects in decreasing rates of marijuana use and marijuana use disorder than attempting to change characteristics of individuals. In a related fashion, policy and program interventions could be made in communities to change social norms and thus have a population-level impact on marijuana use rates and marijuana use disorder.

In this study, we examine marijuana use and disorder rates by state-level legalization of medical marijuana. We consider state policy legalizing medical marijuana to be a proxy for community norms regarding the use of marijuana. Since 1996 up until present 2010, 14 states plus the District of Columbia have passed laws legalizing the use of marijuana for medical purposes, including Alaska, California, Colorado, Hawaii, Maine, Michigan, Montana, Nevada,

New Jersey, New Mexico, Oregon, Rhode Island, Vermont and Washington (20). We propose that state-level approval of medical marijuana legalization provides an objective indicator of community approval of marijuana use and is measured at the appropriate community, rather than individual, level. State policy as a measure of norms overcomes the same-source bias inherent to using individual reports of norms to predict the same person's use of marijuana (19)—that is, a respondent's level of marijuana use is much less likely to influence state policy on medical marijuana (hence introducing a problem of reverse causality) than it is likely to influence his/her own perception about groups norms regarding marijuana use.

Prior research provides support for the use of medical marijuana laws as a plausible proxy for community norms on marijuana use. First, a substantial relationship exists between public opinion and policymaking decisions (21-24), so that state legalization of medical marijuana use does plausibly reflect community norms about marijuana use. Second, studies focusing on other substances such as drinking and cigarette smoking have found that community norms regarding substance use are directly and positively related to policy and enforcement efforts (12, 13).

In this study, we address two objectives: 1) to examine the relationship between state-level variation in the legalization of medical marijuana up until 2004, and state-level rates of marijuana use and disorder across two large, nationally-representative U.S. samples in 2004-2005; 2) to examine the relationship between legalization of medical marijuana up until 2004 and the individual odds of using marijuana and meeting criteria for a marijuana use disorder in 2004-2005. We focus on state legalization of medical marijuana up until 2004 in order to establish a temporal relationship between the passage of state endorsement of medical marijuana and survey reports of marijuana use and marijuana use disorders.

Methods

We used two data sources to document state- and individual-level differences in reports of marijuana use and marijuana use disorders by state legalization of medical marijuana. First, we conducted an ecological analysis of state differences in rates of marijuana use and marijuana use disorder, as well as a multi-level study of state difference in individual use and risk of marijuana use disorders using the National Epidemiologic Survey on Alcohol and Related Conditions (NESARC). We then evaluated whether a consistent relationship existed between legalization of medical marijuana and past-year reports of marijuana use by using data from the National Survey on Drug Use and Health (NSDUH) to replicate the ecological analysis.

Primary marijuana use data source: NESARC

Data were drawn from the 2004-2005 NESARC, a survey of non-institutionalized adults aged 18+ in the United States residing in homes or group quarters. NESARC data was collected at two times points: initial data was collected in 2001-2002 with 43,093 participants (response rate: 81% of those eligible). A second assessment was conducted in 2004-2005 with 34,653 returning participants (86.7% of original sample; ineligible respondents included deceased, n=1403; deported, mentally or physically impaired, n=781; or on active duty in the armed forces, n=950). The cumulative response rate including both waves was 70.2%. The present study focuses on those individuals assessed in the 2004-2005 NESARC survey. More information on the study methods is found elsewhere.(25-27) The research protocol, including written informed consent procedures, received full ethical review and approval from the U.S. Census Bureau and the U.S. Office of Management and Budget.

Measures

Participants were interviewed face-to-face with the Alcohol Use Disorder and Associated Disabilities Interview Schedule DSM-IV version (AUDADIS-IV(28)), a fully-structured instrument designed for experienced lay interviewers.

Marijuana use, abuse, and dependence

NESARC assessed reports of any non-medical marijuana use in the past year. Marijuana use disorders were assessed by the AUDADIS-IV using over thirty symptoms questions to generate DSM-IV(29) diagnoses. Technically, the DSM-IV diagnosis relates to cannabis use disorder, which includes other forms of cannabis such as hashish. However, given the small proportion of users who exclusively used forms of cannabis other than marijuana, we will use the term "marijuana use disorders" throughout this paper. Following DSM-IV, marijuana abuse criteria included recurrent use resulting in one of the following during the 12 months prior to the interview: (1) use in hazardous situations; (2) failure to fulfill major role obligations at work/school/home; (3) legal problems related to use; or (4) social or interpersonal problems. DSM-IV dependence criteria included: (1) tolerance; (2) using larger amounts for longer periods than intended; (3) persistent desire or unsuccessful efforts to cut down or control use; (4) a great deal of time spent in activities to obtain marijuana, or to recover from its effects; (5) giving up or reducing important social, occupational or recreational activities in favor of use; and (6) continued use despite knowledge of a physical or psychological problem caused or exacerbated by marijuana use. Good to excellent reliability and validity of marijuana use disorder diagnoses in the AUDADIS-IV has been extensively documented in both U.S. and international samples.(30-35) In this study, we examined past year marijuana use, past year marijuana use disorder, and past year marijuana use disorder among current marijuana users.

Covariates at the individual level

At the individual level, covariates included sex, race/ethnicity (non-Hispanic White, non-Hispanic Black, non-Hispanic Native American/Alaska Native, non-Hispanic Asian/Native Hawaiian/Pacific Islander, Hispanic), age (20-29, 30-39, 40-49, 50+), past-year personal income ($0-19,999, $20-34,999, $35-69,999, >$70,000), education (some college versus high school or less), marital status (married versus single/widowed/separated/divorced), and urbanicity (living within an MSA versus not). Previous studies in these data have shown associations between these individual-level factors and marijuana use/disorder.(36, 37)

Secondary marijuana use data source: National Survey on Drug Use and Health (NSDUH)

NSDUH is an annual national survey involving interviews with approximately 70,000 civilian, noninstitutionalized individuals aged 12 or older, which has been conducted since 1971. The NSDUH collects information from residents of households, noninstitutional group quarters, and civilians living in military bases. Homeless persons who do not use shelters, active-duty military personnel, and residents of institutional group quarters (prisons and long-term hospitals) are excluded. The sample includes a 50-state design with an independent, multistage probability area sample for each state. Data is collected through in-person interviews at the place of residence. To ensure secular comparability with the NESARC sample, we combined the 2004 and 2005 samples of respondents aged 12 and older to compose the analytic sample.

Measures

The outcome measure of interest was the proportion of respondents who reported marijuana use for nonmedical purposes in the past year, for each state.

State-level data sources

Exposure of interest: Medical Marijuana Policy

Fourteen US states have approved the medical use of marijuana for qualified patients, for uses such as alleviation of nausea and vomiting resulting from chemotherapy, prevention of wasting in AIDS patients, and alleviation of chronic pain that did not respond to traditional opioids, such as morphine. We classified our exposure variable as whether a state had legalized the medical use of marijuana by 2004. Hence, the following states were defined as "exposed": Alaska, California, Colorado, Hawaii, Maine, Montana, Nevada, Oregon, Vermont and Washington. The remaining 40 states were classified as "unexposed" by 2004.

State-level covariates

At the state level, covariates included percent male, percent white race/ethnicity, percent without a high school diploma, percent under 30 years of age. Further, we controlled for income inequality at the state level using the Gini coefficient, which measures the correlation between the cumulative share of people from lowest to highest income and the cumulative share of income earned. Values range from 0 (total equality) to 1 (total inequality); high Gini coefficient scores indicates that income is unequally distributed within the state (e.g., a small proportion of people possess a large proportion of the available income). State-level demographic covariates were obtained for the year 2004 from the American Community Survey (ACS) [http://factfinder.census.gov/], which provides publically available between decennial estimates of state populations excluding the population living in institutions, college dormitories, and other group quarter facilities.

Analyses

In the current study, the target predictor of interest is a state-level indicator of legalization policy for medical marijuana. The association between this state-level predictor and marijuana outcomes was examined in two ways: 1) using an ecological regression with data aggregated at

the state-level and 2) using a multilevel model of individual level data nested within states. Using the NESARC we performed both types of analyses for the three outcomes of past year marijuana use, past year marijuana use disorder, and past year marijuana use disorder among current marijuana users. Using the NSDUH, we performed an ecological state-level analysis of past year marijuana use.

The ecological analyses used linear regression of state-level prevalence estimates (n=50) of the different outcomes either from the NESARC or the NSDUH on a dichotomous indicator of whether the state had a legalization policy for medical marijuana controlling for state level covariates. Regression adjusted mean prevalence and 95% confidence intervals are presented for comparison between states with and without policies legalizing medical marijuana. SAS 9.2 Proc GLM was used.

The multilevel analyses used hierarchical logistic regression of individual yes/no indicators of the marijuana outcomes (n= 34,520 for past year use and past year abuse outcomes, n=1453 for abuse given use outcome) on individual- and state-level covariates, including the state-level indicator of legalization policy for medical marijuana. The hierarchical logistic regression included a random intercept for state to account for correlation of individuals within the state not explained by state-level covariates. A separate model that dropped the indicator of whether a state had legalized medical marijuana was also fit for comparison in order to estimate the variability explained by state legalization of medical marijuana. SAS 9.2 Proc GLIMMIX was used.

The NESARC sample and its associated sampling weights were originally constructed in order to provide nationally representative estimates. Although state-level or multilevel analyses were not originally intended for this dataset, the sample includes individuals from all 50 states

with sample sizes ranging from (69) in Vermont 3932 in California with a median sample size across states of 490 persons. . An investigation was conducted to determine whether using the original NESARC sampling weights versus not using any weights would provide better representation of the sample at the state-level. Correlations and Bland-Altman plots [REF: Bland Altman 1986, 1999] were used to compare weighted and unweighted state-level NESARC demographic variables with the ACS state demographics. Correlations with the ACS were higher using completely unweighted state estimates rather than the weighted estimates for proportion male (0.49 unweighted vs. 0.12 weighted), proportion without high school education (0.86 unweighted vs 0.69 weighted), and the correlations for the proportion under 30 (0.66 unweighted vs 0.66 weighted) and proportion of non-Hispanic whites (0.94 unweighted vs 0.95 weighted) were practically identical.. This evidence along with a body of literature (38) that argues unweighted estimates are preferred when regression relationships (i.e. adjusted mean differences or odds ratios) are of interest, lead us to perform all statistical analyses using the NESARC without any sampling weights.]

Results

Table 1 presents characteristics of the NESARC respondents, and of the inhabitants of states that legalized vs. those that did not legalize medical marijuana by 2004. NESARC respondents reflect the gender and racial/ethnic composition of the US adult population: 47.9% of respondents were male and 52.1% were female; 70.9% were white, 11.0% black, 11.6% Hispanic, 4.3% Asian, and 2.2% American Indian/Alaska Native. Respondents also covered the socioeconomic spectrum: 56.3% of respondents had some college education, and income ranged from $20,000 to more than $70,000. No marked differences existed in the individual characteristics of respondents between states that did and did not legalize medical marijuana by

2004. At the state level, states that legalized medical marijuana had comparable levels of income inequality, gender, racial and age composition in 2000 as stated that did not legalize medical marijuana.

Table 2 presents adjusted ecological analyses using NESARC and NSDUH data, as well as adjusted multi-level analyses using NESARC data. According to the NESARC, the mean state-level rate of past-year marijuana use reported in 2004-2005 was 7.10% across states that had legalized medical marijuana by 2004 and 3.57% across the states that had not legalized medical marijuana by the same year—this difference was significant at the $p<0.05$ level. A significant aggregate difference also existed in past-year marijuana use disorder rates between states that had legalized medical marijuana by 2004 and those that had not: the average state-level prevalence of marijuana use disorder in 2004-2005 was 2.64% in legalized states and 1.26% in non-legalized states. According to the NSDUH, the average state-level rate of past-year use in 2004-2005 was 12.50% across states that legalized medical marijuana by 2004, and 10.21% across states that had not legalized medical marijuana—this difference was also significant at the $p<0.05$ level.

The individual odds of reporting past-year marijuana use and marijuana use disorder, as reported in the NESARC, also differed between respondents who resided in legalized and non-legalized states. Controlling for individual age, sex, race/ethnicity, education, income, marital status, region, urbanicity, and for the state-level proportion of youth, males, income inequality, high school graduation rates, and persons of white race/ethnicity, the individual odds of reporting past-year marijuana use in 2004-2006 was 1.89 times higher among respondents who resided in states that had legalized medical marijuana by 2004 than among those who resided in non-legalized states (95% CI: 1.45, 2.46). A comparison of the state-level variance components in a

model that adjusted for state legalization of medical marijuana, and a model that did not account for state legalization of medical marijuana, showed that 68% of the state-level variation in past-year use of marijuana was explained by the medical marijuana law (data not shown in table). The odds of meeting criteria for marijuana use disorder was 1.79 times higher among respondents living in legalized than in non-legalized states (95% CI: 1.25, 2.56). The medical marijuana use law explained 97.7% of the state-level variation in marijuana use disorder. No difference existed in the rates of past-year disorder among marijuana users by type of state of residence.

Discussion

This study indicates that independent of state-level characteristics, states that legalized medical marijuana have higher rates of marijuana use and marijuana use disorder. The state-level differences in marijuana use rates have been replicated in two of the most important data sources on drug use in the US: the NESARC and NSDUH. Further, regardless of individual- and state-level potential confounders, individuals who lived in states that legalized medical marijuana exhibited higher odds of using marijuana and meeting criteria for marijuana use disorders than individuals who lived in states that did not legalize the use of marijuana for medical purposes. State legalization of medical marijuana explained a large proportion (68-98%) of the variation across states in the individual odds of using marijuana or meeting criteria for marijuana use disorders.

Our findings do not reflect a causal effect of legalization of medical marijuana on marijuana use or marijuana use disorders. Rather, we propose that state laws on medical marijuana provide information on local norms about the use of marijuana, as reflected in the local political process to pass laws on medical marijuana, as well as in the passage of medical marijuana laws by wide margins of votes (39, 40). This is particularly true at the state level, since

states employ lawmaking processes that favor the majority, such as referenda, that enable states to update state laws to keep up with changes in societal views (39). Indeed, a sensitivity analysis we conducted using data from NSDUH indicated that states that legalized medical marijuana had a lower proportion of NSDUH respondents who reported that occasional (once a month) use of marijuana posed a great health risk, indicating a clear correlation between community norms and state legalization of medical marijuana.

These results suggest that community norms shape individual and aggregate rates of marijuana use, as well as individual vulnerability to exhibit marijuana use disorders. Multiple sociological studies have demonstrated that group norms shape individual behavior and mental health (42-45) and that social pressures to conform to the group norms influence the decision to engage in behaviors once norms are internalized. The collective power of communities to shape individual behavior has been documented for multiple health outcomes (46). In the area of substance use, parallels can be established with alcohol use and cigarette smoking. For example, "cultures" of drinking (47) in the neighborhood (48) and workplace (49) have been linked with risk for binge drinking and perceived disapproval of adolescent alcohol use has been negatively related to underage drinking (13). Permissive neighborhood smoking norms have also been associated with more smoking (50). The present study is one of the first to investigate the role of community norms in shaping marijuana use and marijuana use disorders.

This study has certain limitations. First, state laws on medical marijuana function as an indirect proxy for community norms on marijuana use. Findings from this study thus function as preliminary evidence, which will have to be replicated in future studies using direct measures of community norms on marijuana use. Second, the NESARC reported lower rates of marijuana use than the NSDUH, potentially due to the use of face-to-face interviewing methods. However, this

is offset by the availability of highly reliable and valid diagnostic variables in the NESARC, as well as by the fact that we found the same results in both data sources.

Despite these limitations, this study makes an important contribution to our understanding of the effect of community context on marijuana use. Social norms supportive of marijuana use have a robust effect on marijuana use and marijuana use disorders, which is replicated across two datasets and is independent of individual and state-level confounders. These findings point to the importance of investing in public health policy and intervention measures that focus on changing macro-level risk factors, such as social norms, in order to have a population-level impact in the distribution of marijuana use.

Table 1. NESARC respondent and state-level characteristics for the United States and by State Legalization of Medical Marijuana Use Up to 2004

	National sample	State Legal Medical Marijuana Use up to 2004	
		Yes (n=6458)	No (n=28195)
	% (N) or Mean (SD)	% (N) or Mean (SD)	% (N) or Mean (SD)
Individual-level covariates, NESARC			
Age			
20-29	21.80 (6719)	21.93 (1343)	21.77 (5376)
30-39	20.10 (7299)	21.20 (1440)	19.85 (5859)
40-49	20.77 (7146)	20.50 (1312)	20.84 (5834)
50+	37.33 (13489)	36.37 (2363)	37.54 (11126)
Sex			
Males	47.92 (14564)	49.02 (2852)	47.67 (11712)
Females	52.08 (20089)	50.98 (3606)	52.33 (16483)
Race/ethnicity			
White	70.93 (20174)	60.76 (3365)	73.19 (16809)
Black	11.04 (6577)	4.79 (485)	12.43 (6092)
Hispanic	11.56 (6356)	20.66 (2011)	9.53 (4345)
Asian	4.27 (966)	11.39 (479)	2.69 (487)
American Indian/ Alaska Native	2.20 (580)	2.41 (118)	2.15 (462)
Marital status			
Married	63.06 (18413)	62.46 (3563)	63.20 (14850)

Not married	36.94 (16240)	37.54 (2895)	36.80 (13345)
Education			
At least some college	56.32 (18954)	61.47 (3859)	55.18 (15095)
Less than college	43.68 (15699)	38.53 (2599)	44.82 (13100)
Income			
$0-19,999	46.21 (16366)	45.01 (2894)	46.47 (13472)
$20-34,999	22.84 (8110)	21.05 (1419)	23.24 (6691)
$35-69,999	22.52 (7649)	23.45 (1532)	22.31 (6117)
More than $70,000	8.43 (2528)	10.49 (613)	7.97 (1915)
Urbanicity			
Urban	79.51 (28072)	86.90 (5736)	77.86 (22336)
Rural	20.49 (6581)	13.10 (722)	22.14 (5859)
State-level covariates, ACS (Census)			
Income inequality (GINI coefficient)	0.44 (0.02)	0.43 (0.02)	0.45 (0.02)
Percent male in the state	47.99 (1.68)	49.79 (0.64)	48.91 (0.59)
Percent white race/ethnicity	80.49 (13.56)	80.86 (17.62)	81.73 (9.97)
Percent without a high school diploma	14.02 (3.28)	12.63 (3.32)	15.24 (3.89)
Percent under 30 years of age	20.23 (3.40)	20.73 (2.01)	21.26 (2.49)

Table 2. Marijuana Use and Marijuana Use Disorders by State Legalization of Medical Marijuana Use Up to 2004

Outcome of interest	Ecological state-level analyses				Multi-level analysis
	NESARC[1,3]		NSDUH[2,3]		NESARC[1]
	State Legal Medical Marijuana Use up to 2004-2005				
	Yes	No	Yes	No	OR (95% CI)[4]
	% (95% CI)	% (95% CI)	% (95% CI)	% (95% CI)	
W2 Past Year Marijuana Use	7.09 (5.97, 8.23)	3.57 (3.10, 4.05)	12.50 (11.38, 13.63)	10.26 (9.83, 10.68)	1.89 (1.45, 2.46)
W2 Past Year Marijuana Use Disorder	2.63(1.99, 3.28)	1.33 (1.10, 1.56)	-	-	1.79 (1.25, 2.56)
W2 Past Year disorder, among W2 current users	0.39 (0.25, 0.53)	0.35 (0.29, 0.41)	-	-	1.09 (0.71, 1.67)

[1]NESARC: National Epidemiologic Survey on Alcohol and Related Conditions; reports on drug use among respondents aged 18 and older

[2]National Survey on Drug Use and Health; reports on drug use among respondents aged 12 and older

[3] Adjusted for state-%-youth, state-%-males, state-income-inequality, state-high-school-graduation-rates, state-%-whites.

[4] Adjusted for age, sex, race/ethnicity, education, income, marital status, region, urbanicity, state-%-youth, state-%-males, state-income-inequality, state-high-school-graduation-rates, state-%-whites.

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