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A reexamination of medical marijuana policies in relation to suicide risk

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ABSTRACT

Objectives: Previous research has suggested that medical marijuana policies lead to reductions in suicide rates. In this study, we further investigate the association between these policies and within-state changes in suicide risk.
Methods: Data on suicide deaths (n = 662,993) from the National Vital Statistics System Multiple Cause of Death files were combined with living population data. Fixed-effects regression methods were employed to control for state differences in suicide rates and national and state secular trends. Analyses extended prior research that suggested a protective effect of medical marijuana policies by incorporating newer data and additional covariates.
Results: After adjustment for race/ethnicity, tobacco control policies, and other covariates, we found no association between medical marijuana policy and suicide risk in the population ages 15 and older (OR = 1.000; 95% CI: 0.956, 1.045; p = 0.98), among men overall (OR = 0.996; 95% CI: 0.951, 1.043; p = 0.87) or for any other age-by-sex groups.
Conclusion: We find no statistically significant association between medical marijuana policy and suicide risk. These results contradict prior analyses which did not control for race/ethnicity and certain state characteristics such as tobacco control policies. Failure to control for these factors in future analyses would likely bias estimates of the associations between medical marijuana policy and health outcomes.

1. Introduction

Over the past two decades, 23 states and the District of Columbia have legalized marijuana for medical use in the U.S. (Anderson et al., 2014; Pacula et al., 2013). These policies were adopted at different times, allowing researchers to analyze the effects of policy changes as a natural experiment: differences in medical marijuana policies between states over time allow investigators to draw inferences about whether policy that could facilitate access to marijuana are causally associated with key public health outcomes (Anderson et al., 2013, 2014; Cerdá et al., 2012; Choo et al., 2014; Gorman and Charles Huber, 2007; Harper et al., 2012; Lynne-Landsman et al., 2013; Pacula et al., 2013; Rylander et al., 2014; Schuermeyer et al., 2014; Wall et al., 2011). In one of the more intriguing examples of such a study, Anderson and colleagues examined the association between legalization of medical marijuana and changes in state suicide rates over the period 1990–2007 (Anderson et al., 2014). Their results suggested that legalization of medical marijuana led to a *decrease* in suicide rates. Specifically, they reported that legalization was associated with a 5% decrease in the suicide rate for men overall, about a 10% decrease in the suicide rate of men aged 20 through 29, and a nearly 14% decrease in men aged 30 through 39.

If the legalization of marijuana for medical purposes truly leads to reductions in suicide rates, this would have important implications for public health and policy. Suicide is among the ten leading causes of death in the United States and the 4th leading contributor to years of potential life lost among people under 65 (Centers for Disease Control and Prevention, 2014; Murphy et al., 2013). Any true effect on suicide rates should be seriously considered in the policy debates surrounding both medical and recreational marijuana. However, a *protective* effect against

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suicide is surprising given that neurodevelopmental and psychiatric effects—including suicide risk—are among the primary health concerns associated with regular marijuana use (Batalla et al., 2013; Hall and Degenhardt, 2009; Meier et al., 2012; Moore et al., 2007; Price et al., 2009; Van Ours et al., 2013; Volkow et al., 2014). Given the relevance of such a finding to policy, the suggestion that medical marijuana policies might lead to *lower* rates of suicide warrants closer scrutiny.

In the present study, we sought to extend the work exploring the association between medical marijuana policy and reduced suicide risk (Anderson et al., 2014). We utilized data from individual death records, which allowed us to adjust for demographic variables at an individual level. This was not possible in the prior study, which analyzed state suicide rates instead of individual death records. Yet adjusting for demographic variables could be important because they may be associated with suicide rates, and, as key characteristics of state electorates, could influence state policy change. For example, race and educational attainment, which were not addressed in the prior study, are well known to be associated with suicide rates (Centers for Disease Control and Prevention (CDC), 2013; Crosby et al., 2013, 2011). We also adjusted for several additional state policies and characteristics that past research suggests could be relevant. For example, we have recently shown that state tobacco control policies may influence suicide risk (Grucza et al., 2014). Tobacco control policies also likely influence the prevalence of marijuana use (Chaloupka et al., 1999; Farrelly et al., 2001; Williams et al., 2004), and may influence alcohol use which could be an important determinant of suicide risk (Kaplan et al., 2014; Krauss et al., 2014; Young-Wolff et al., 2013a,b). We also included measures of state political orientation, per-capita mental health spending, and health insurance coverage, all of which may be associated with suicide risk (Kposowa, 2013; Tondo et al., 2006; Yoon and Bruckner, 2009) and are plausibly related to state policy environments. If these factors changed concurrently with adoption of medical marijuana policy, lack of explicit control for them could lead to biased estimates of the association between medical marijuana policy and suicide. Finally, we incorporated more recent data into our analyses, reflecting newly adopted state medical marijuana policies.

2. Methods

2.1. Overview

As an initial step, we conducted analyses comparable to those used in the prior report on medical marijuana policy and suicide, employing data from the same time period and including the same set of covariates (Anderson et al., 2014). However, our analyses utilized individual-level data modeled via logistic regression, whereas the previous report described the association between log-transformed state-level suicides rates modeled from aggregated data using linear regression. Because of these differences, we refer to our initial analyses as "comparison analyses" rather than "replication analyses." In these comparison analyses, we used the same medical marijuana policy coding and the same set of covariates as the previous report: average annual unemployment rate, per-capita income, beer excise taxes, zero-tolerance policies for youth driving under the influence, blood-alcohol content limits of 0.08 for drivers (vs. 0.10), and marijuana decriminalization policy indicators. In the main set of analyses, we extended the observation period from 1990–2007 to 1990–2010; four additional states (Arizona, Michigan, New Jersey, and New Mexico) and the District of Columbia passed medical marijuana policies during this time (Lynne-Landsman et al., 2013). Initial models were based on the same covariates as the comparison analyses, while subsequent models included individual-level demographic covariates (age, sex, race/ethnicity and educational attainment) and several additional state-level covariates (citizen political orientation, per-capita mental health spending, percentage of uninsured adults, cigarette excise taxes and a smoke-free air policy score).

2.2. Data

Individual-level data on suicide deaths were obtained from the Multiple Cause of Death files for 1990–2010, collected by the National Center for Health Statistics. Customized files including geographic data were obtained through the National Association for Public Health Statistics and Information Systems (NAPHSIS). From the complete set of death records, we selected observations for which suicide was either the underlying cause or among the contributing causes of death, using codes from the International Classification of Disease, versions 9 and 10 (codes E950–E959 and X60–X84, Y87, respectively). These records were combined with data on the living population obtained from the annual American Community Survey (ACS) for the years 2001–2010. For living population data prior to 2001 (when the ACS was initiated), we used data from 1% samples of the 1990 and 2000 Census. In order to estimate data for years 1991 through 1999, we used a linear interpolation procedure described elsewhere (Grucza et al., 2012, 2014). Briefly, this was done by determining the weights for records representing each possible combination of covariate parameters in each Census data set (i.e., each combination of year, state, race/ethnicity, sex, age group and education). Weights for intracensal years were estimated as: $[(2000\text{-year}) \times (1990\ \text{weight}) + (\text{year-}1990) \times (2000\ \text{weight})]/10$. These data sets were obtained from the Integrated Public Use Microdata Series maintained by the Minnesota Population Center (Ruggles et al., 2010). This process is described in more detail in Part II of the Supplemental Material. Analyses to support the validity of this approach are described there as well.

2.3. Variables

Medical marijuana policy was coded as "1" for years when use of marijuana for medical purposes was legally sanctioned and "0" for years when it was not. When the policy was in place for only part of the year, we coded the value for the fraction of the year during which the policy was in place; for example, if the policy in a state was implemented on July 1, we coded a value of 0.5 for that year. Sources for policy data included Anderson et al. (2014) for the years 1990–2007 and Lynne-Landsman et al. (2013) for subsequent years. Individual-level covariates extracted from mortality and living population records included state of residence, age, race/ethnicity, and education. Race/ethnicity was coded as non-Hispanic white, non-Hispanic black, Hispanic, and other. Age was grouped into the categories used by Anderson et al. (2014): 15–19, 20–29, 30–39, 40–49, 50–59, 60 and above. Education was dichotomized, with individuals classified as having a high-school diploma or less versus having had some post-secondary education.

The unemployment, per-capita income and insurance coverage variables were obtained from the United Health Foundation (2013). Alcohol policy variables (excise taxes, zero-tolerance laws, and BAC limit policies) were obtained from the Alcohol Policy Information System for years 1998-present and from the Statewide Data Availability System for earlier years (National Institute on Alcohol Abuse and Alcoholism, 2013; Ponicki, 2004). Indicators for marijuana decriminalization policy were coded from (Pacula et al., 2003) with updated data provided by a coauthor of that report (Chriqui, 2013). Data on smoke-free air policies were obtained from the State Cancer Legislative Database (2013). Cigarette excise taxes were obtained from "The Tax Burden on Tobacco" (Orzechowski and Walker, 2012). Development of the state political orientation measure was described by Berry et al. (1998) and updated data was obtained from Fording (2014). State per-capita mental health spending was obtained from the National Association of State Mental Health Directors Research Institute (2013). State unemployment rate and health insurance coverage were coded as percentages. BAC limit policies, marijuana decriminalization policy, and zero-tolerance policies were coded using dichotomous indicators. Beer and cigarette excise taxes, per-capita income and per-capita mental health spending were coded as dollar amounts. Mental health spending data were available only for years 1990, 1997 and 2001–2010; missing years were estimated via linear interpolation. The smoke-free air policy measure was obtained by summing scores for policies covering private worksites, restaurants, and bars and ranged from 0 to 6, representing the sum of a two point scale for each domain (0 for no policy, 1 for restrictions with less than a complete ban, and 2 for a complete ban; International Agency for Research on Cancer, 2009). The political orientation measure was coded as described in (Berry et al., 1998).

2.4. Statistical analysis

All models used logistic regression in which individual suicide outcomes were modeled from medical marijuana legalization policy within all 50 states and Washington, DC. Parameter estimates and standard errors were calculated using the SAS statistical package "surveylogistic" procedure, treating states as sampling clusters to account for intra-correlation of outcomes within states when estimating standard errors (Angrist and Pischke, 2008).

The comparison analyses paralleled those described in the prior report analyzing suicide rates in relation to medical marijuana policy (Anderson et al., 2014). Data from years 1990–2007 were analyzed; the most basic model included medical marijuana policy and categorical indicators for state and year. State covariates were added in the second model, and state-specific linear time trends were added in the third model. State-specific linear time-trends are modeled as state by year interactions, with year specified as a continuous, rather than a categorical variable.

Model development is summarized in Table 1. The main analyses incorporated data on state suicides and medical marijuana policy through 2010. Model 1 of the main analyses included state and year indicators, state time-trends, and the six state covariates that were included in the comparison analyses. Model 2 included individual-level demographic covariates. The full model (Model 3) included the additional state covariates and a refined model (Model 4) removed covariates that