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Medical marijuana policies and hospitalizations related to marijuana and opioid pain reliever

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ABSTRACT

Objectives: Twenty-eight states in the U.S have legalized medical marijuana, yet its impacts on severe health consequences such as hospitalizations remain unknown. Meanwhile, the prevalence of opioid pain reliever (OPR) use and outcomes has increased dramatically. Recent studies suggested unintended impacts of legalizing medical marijuana on OPR, but the evidence is still limited. This study examined the associations between state medical marijuana policies and hospitalizations related to marijuana and OPR.

Methods: State-level annual administrative records of hospital discharges during 1997–2014 were obtained from the State Inpatient Databases (SID). The outcome variables were rates of hospitalizations involving marijuana dependence or abuse, opioid dependence or abuse, and OPR overdose in 1000 discharges. Linear time-series regressions were used to assess the associations of implementing medical marijuana policies to hospitalizations, controlling for other marijuana- and OPR-related policies, socioeconomic factors, and state and year fixed effects.

Results: Hospitalizations related to marijuana and OPR increased sharply by 300% on average in all states. Medical marijuana legalization was associated with 23% ($p = 0.008$) and 13% ($p = 0.025$) reductions in hospitalizations related to opioid dependence or abuse and OPR overdose, respectively; lagged effects were observed after policy implementation. The operation of medical marijuana dispensaries had no independent impacts on OPR-related hospitalizations. Medical marijuana polices had no associations with marijuana-related hospitalizations.

Conclusion: Medical marijuana policies were significantly associated with reduced OPR-related hospitalizations but had no associations with marijuana-related hospitalizations. Given the epidemic of problematic use of OPR, future investigation is needed to explore the causal pathways of these findings.

1. Introduction

As voters in Arkansas, Florida, and North Dakota approved the ballots for medical marijuana legalization in November 2016 (Christensen and Senthilingam, 2016), approximately 60% of the population in the U.S. now lived in states that permitted marijuana use for medical purpose. Despite the increasing support from the public, the scientific research on the public health impacts of medical marijuana legalization has not reached a consensus. Existing evidence primarily concentrated on the changes in the prevalence of marijuana use and provided mixed findings (Sznitman and Zolotov, 2015). The use prevalence, however, is arguably not the greatest public health concern. While occasional use is not without health risks, marijuana is most harmful to regular users and early initiators and largely harmless to most occasional users (Hall, 2009). Research on stronger indicators of adverse effects of medical marijuana legalization is needed. Given that marijuana is not directly associated with mortality (Sidney et al., 1997), hospitalization probably represents one of the most serious health consequences of marijuana, which imposes substantial economic burdens to the healthcare system and the society (Pacula et al., 2008). No previous studies have investigated how medical marijuana policies were associated with marijuana-related hospitalizations.

In parallel to the heated debate on marijuana legalization, there were overwhelming concerns about the epidemic of opioid pain reliever (OPR) abuse and overdose. In the last two decades, the mortality rate related to OPR overdose and the quantity of prescribed OPR at least quadrupled in the U.S. (CDC, 2011; Warner

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et al., 2014). In 2014, more than 14,000 deaths were related to OPR overdose (CDC, 2016). States have advocated or adopted a series of policies to combat this increasing trend, such as prescription drug monitoring programs and regulations of pain management clinics. The positive effects of these policies on reducing OPR-related outcomes were reported by some studies (Bao et al., 2016; Dowell et al., 2016; Kennedy-Hendricks et al., 2016; Lyapustina et al., 2016; Patrick et al., 2016) but not all (Li et al., 2014; Paulozzi et al., 2011).

Recent studies started to investigate whether medical marijuana legalization would have any influences on the OPR abuse and overdose epidemic. Marijuana has therapeutic effects for chronic pain (Lynch and Ware, 2015) and is being used by patients prescribed with OPR. Around 14–33% patients prescribed with OPR were screened with cannabinoid-positive results (Reisfield et al., 2009). If the patients with legitimate prescriptions for OPR were substituting OPR partially or entirely with marijuana, the increased availability of marijuana as a result of medical marijuana legalizations may reduce the risks of OPR-related health consequences. On the other hand, marijuana use for recreational purpose may serve as a gateway drug to OPR and increase the risk of OPR initiation (Hall and Lynskey, 2005). Should medical marijuana policies have any impacts on marijuana use for medical or recreational purpose, they may unintentionally lead to changes in OPR use and related hospitalizations. Four recent studies reported reduced OPR-related outcomes in association with medical marijuana legalization (Bachhuber et al., 2014; Bradford and Bradford, 2016; Kim et al., 2016; Powell et al., 2015), but the evidence is still limited.

The objective of this study is to examine the associations between medical marijuana legalization and hospitalizations related to marijuana and OPR. Using state-level administrative records of hospital discharges from 1997 to 2014, we focused on the severe health consequences of medical marijuana legalization and exploited the variations of policy implementation in different states at different times. This study is expected to add to the still-limited literature regarding the intended and unintended impacts of medical marijuana legalization and provide implications to OPR policymaking.

2. Material and methods

2.1. Data

Annual state-level hospitalization data were obtained from the State Inpatient Databases (SID). Developed for Healthcare Cost and Utilization Project (HCUP) and sponsored by the Agency for Healthcare Research and Quality (AHRQ), the SID provide administrative records of hospital discharges in community hospitals in participating states. The SID cover the universe of non-federal, short-term, general and other specialty hospitals, regardless of funding sources, as well as the universe of hospitalized patients, regardless of payer (AHRQ, 2016). Containing approximately 97% of all hospital discharges in a state (AHRQ, 2016), the SID offer an almost complete overview of state-level hospitalizations. The advantage of using hospitalization records is to represent objective measures that are free of self-reporting biases commonly seen in survey data.

The annual SID data were obtained between 1997 and 2014. The 14 states that did not participate in the SID as of 2014 were excluded from the study; these states were Alaska, Alabama, Connecticut, District of Columbia, Delaware, Georgia, Idaho, Louisiana, Mississippi, Montana, Ohio, Pennsylvania, South Dakota, and Virginia. We further removed 10 states (California, Illinois, Maine, Maryland, Massachusetts, Minnesota, Nevada, New Hampshire, New Mexico, and New York) from the main analysis, because they do not have full-year observations in the SID before or after implementing medical marijuana policies. The main analysis included 27 states. We utilized all the years available in the SID for these states with the only exception of Colorado, which implemented recreational marijuana policies at the beginning of 2014. The 2014 Colorado SID data were therefore removed to avoid potential confounding from recreational marijuana legalization. The number of years that a state had the SID data available varied; on average, a state had 14 observations during the study period. There were 382 state-year observations included in the main analysis. Data availability and inclusion and exclusion of states were described in detail in the Supplementary material.

The effective dates of marijuana- and OPR-related policies were obtained from various sources of legal and policy reviews, including RAND Corporation (Pacula et al., 2014a; Powell et al., 2015), the Policy Surveillance Program at Temple University (LawAtlas), National Alliance for Model State Drug Laws (NAMSDL, 2015), and Centers for Disease Control and Prevention (Dowell et al., 2016). The effective dates of these policies for the study sample can be found at the Supplementary material. State socioeconomic data were obtained from Census, Bureau of Labor Statistics, and Tax Foundation.

2.2. Variables

The outcome variables were annual rates of hospitalizations related to marijuana and OPR. Specifically, we used International Classification of Diseases, 9th Revision, Clinical Modification [ICD-9-CM] to define 3 types of hospitalizations: those involving marijuana dependence or abuse (ICD-9-CM diagnosis codes 304.3 and 305.2), those involving opioid dependence or abuse (ICD-9-CM diagnosis codes 304.0, 305.5, and 304.7), and those involving OPR overdose (ICD-9-CM diagnosis codes 965.00, 965.02, and 965.09). We searched diagnosis codes in all-listed diagnoses including principal diagnosis as well as additional conditions diagnosed at admissions or stays. During 1997–2014, the 27 states had 2.2 million hospitalization records involved with marijuana dependence or abuse, 2.2 million records involved with opioid dependence or abuse, and 0.4 million records involved with OPR overdose. To account for the variations in healthcare utilization across states, we standardized hospitalization rates as the number of discharges for a specific category per 1000 discharges.

We assessed the implementation of medical marijuana policies, the primary policy variable of interest, in three ways. It was first coded as an indicator to represent the presence of medical marijuana policies in the state and year. All the years prior to the implementation year were assigned with value 0, and all the years after the implementation year were assigned with value 1. The value for the implementation year was coded as the number of months adopting the policy divided by 12 months (e.g., 0.25 if the policy was implemented on Oct 1st) to represent partial year of policy implementation (Bachhuber et al., 2014). Among the 27 states included in the main analysis, 9 states implemented medical marijuana policies between 1997 and 2014 (see detailed list in the Supplementary material).

In the second analysis, we allowed for independent effects of permitting medical marijuana dispensaries, the major and most common provision of medical marijuana policies (Pacula et al., 2014b; Powell et al., 2015). The open dates of the first operating medical marijuana dispensary in a state were used to code an indicator for the presence of medical marijuana dispensaries in the state and year. Among the 9 states that implemented medical marijuana policies in our sample, 8 states had operating medical marijuana dispensaries during the study period.

The third model added 1-year, 2-year, and 3-year leads and lags to the contemporary indicator of medical marijuana policy implementation. Adding the series of leads allowed us to test the assumption about identical counterfactual trends in the states adopting and non-adopting medical marijuana policies