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The impacts of marijuana dispensary density and neighborhood ecology on marijuana abuse and dependence

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Abstract

Background—As an increasing number of states liberalize cannabis use and develop laws and local policies, it is essential to better understand the impacts of neighborhood ecology and marijuana dispensary density on marijuana use, abuse, and dependence. We investigated associations between marijuana abuse/dependence hospitalizations and community demographic and environmental conditions from 2001–2012 in California, as well as cross-sectional associations between local and adjacent marijuana dispensary densities and marijuana hospitalizations.

Methods—We analyzed panel population data relating hospitalizations coded for marijuana abuse or dependence and assigned to residential ZIP codes in California from 2001 through 2012 (20,219 space-time units) to ZIP code demographic and ecological characteristics. Bayesian space-time misalignment models were used to account for spatial variations in geographic unit definitions over time, while also accounting for spatial autocorrelation using conditional autoregressive priors. We also analyzed cross-sectional associations between marijuana abuse/dependence and the density of dispensaries in local and spatially adjacent ZIP codes in 2012.

Results—An additional one dispensary per square mile in a ZIP code was cross-sectionally associated with a 6.8% increase in the number of marijuana hospitalizations (95% credible interval 1.033, 1.105) with a marijuana abuse/dependence code. Other local characteristics, such as the median household income and age and racial/ethnic distributions, were associated with marijuana hospitalizations in cross-sectional and panel analyses.

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Contributors Dr. Freisthler conceptualized the study, wrote sections of the introduction and discussion, and edited multiple drafts. Dr. Mair conducted analyses, interpreted results, and wrote a first draft of the manuscript. William Ponicki and Andrew Gaidus prepared data and edited multiple drafts. All authors contributed to and have approved the final manuscript.

Conflict of Interest No conflict declared.

Conclusions—Prevention and intervention programs for marijuana abuse and dependence may be particularly essential in areas of concentrated disadvantage. Policy makers may want to consider regulations that limit the density of dispensaries.

Keywords

marijuana abuse; marijuana dispensaries; marijuana hospitalizations

1. INTRODUCTION

The legal status and subsequent availability of marijuana for both medical and recreational use is rapidly changing in the United States. In 1996, California was the first state to legalize medical marijuana with the Compassionate Use Act, which allowed physicians to prescribe cannabis for medical purposes. Since then, 22 states and the District of Columbia have enacted similar laws. The vast majority of these laws allow marijuana to be sold through medical dispensaries. Despite the growing legal availability of marijuana for medical and recreational use, much remains unresolved about the relationships between marijuana use and related problems and the impacts of dispensaries on local communities (Gorman and Charles Huber, 2007; Lynne-Landsman et al., 2013).

Certain demographic groups are more likely to use marijuana for recreational and/or medical purposes. In California, more frequent marijuana users are more likely to be male, young adult, white, and have higher incomes (Freisthler and Gruenewald, 2014; Morrison et al., 2014). Medical marijuana users are also more likely to be male and white (O'Connell and Bou-Matar, 2007; Ogborne and Smart, 2000; Reiman, 2007; Swift et al., 2005; Ware et al., 2005), but are older than frequent users (mean around 40 years old) and have lower incomes (O'Connell and Bou-Matar, 2007; Ogborne and Smart, 2000; Reiman, 2007; Swift et al., 2005; Ware et al., 2005). Rates of marijuana abuse and dependence may be higher in areas with disproportionately greater numbers of these population subgroups, making them potential targets of prevention efforts to reduce costs related to marijuana abuse and dependence hospitalizations.

Some studies suggest that legalizing medical marijuana appears to be related to higher levels of use for adults and adolescents (Cerda et al., 2012; Harper et al., 2012; Wall et al., 2011), although states that legalize marijuana had higher rates of marijuana use before legalization —suggesting that norms around use of marijuana may be more lax in those states (Wall et al., 2011). However, these findings are not universal as other studies have found no difference in marijuana use among adolescents after enactment of medical marijuana laws (Khatapoush and Hallfors, 2004; Lynne-Landsman et al., 2013; Choo et al. 2014). No differences have been found in rates of marijuana abuse and dependence among marijuana users before and after enacting legislation in states that have liberalized marijuana policies in recent years (Cerda et al., 2012). Allowing medical marijuana to be distributed through dispensaries increases the likelihood of using marijuana in the past year and using marijuana more frequently (Freisthler and Gruenewald, 2014). Past-month marijuana use is higher in states that allow distribution of medical marijuana through store-front dispensaries (Pacula et al., 2013).

Very few studies have examined where dispensaries are located. Store-front dispensaries in Denver, Colorado tend to be located in neighborhoods with higher crime rates and a higher proportion of retail jobs (Boggess et al., 2014). In California, dispensaries were located in Census block groups with higher levels of marijuana use, lower median household incomes, higher percentages of male residents, and lower percentages of Asian American residents and residents aged 30 to 39 years (Morrison et al., 2014). Thus there is limited information that areas with some disadvantage (i.e., lower income, higher crime) have higher densities of dispensaries; however, how disadvantage and dispensary density are related to overall rates of marijuana abuse and dependence is unknown.

When considering the impacts of marijuana dispensaries on local use and abuse, about which little is known, the literature on alcohol outlets is potentially useful. Greater densities of alcohol outlets, another source of a potentially addictive substance, have been linked to a range of health consequences, including incidents of crime and violent assaults (Gorman et al., 2005; Lipton and Gruenewald, 2002; Livingston, 2008), drinking and driving (Ponicki et al., 2013), intimate partner violence (Cunradi et al., 2012), and other alcohol-related problems (Campbell et al., 2009; Freisthler et al., 2007). Alcohol outlets may increase availability, or areas of high alcohol outlet density may be characterized by other conditions which produce problems (e.g., low social capital, high deprivation) and density of outlets may be correlated with these conditions. Similar to the role of alcohol outlets in communities, marijuana dispensaries may increase local availability and subsequent use of marijuana and/or may be more likely to be located in socially disorganized neighborhoods.

There are several reasons to examine the impacts of medical marijuana dispensaries on local use using population-based geographic assessments. These methods allow us to address the spatial dependence of contiguous geographic units, without which there may be substantive bias in statistical tests of dispensary and other environmental effects. Furthermore, because dispensaries within an area may serve both local residents and customers from nearby areas and many areas have no dispensaries of their own, the spatial scale of dispensary effects may be larger than any single unit. Models that measure impacts only within local areas will therefore miss effects on marijuana use in neighboring areas, understating effects. These methods allow us to examine spatial spillover effects.

It is important for us to better understand the impacts of neighborhood ecology and marijuana dispensary density on use and abuse in California as an increasing number of states follow in California’s footsteps and liberalize cannabis policies. Determining in what ways marijuana dispensaries function in roles similar to alcohol outlets and in what ways they differ is essential as other states and communities develop laws and local policies, such as zoning restrictions and limiting the number of dispensary permits. The purpose of this analysis is to first examine whether hospitalizations for marijuana abuse and dependence are related to community demographic and environmental conditions, and then to investigate cross-sectional associations between marijuana dispensary densities and hospitalizations in California.

2. MATERIAL AND METHODS

2.1 Data Sources and Variables

Annual data, including hospital discharges and Census-based registries, were aggregated over a 12-year period (2001 through 2012) across ZIP code polygon areas (ESRI, 2012) of California, for a total of 20,219 space-time units. Locations of marijuana dispensaries as of early 2012 were geocoded and aggregated to 1,702 statewide ZIP codes as defined in 2012. These data were used to conduct two population-level Bayesian analyses: (1) A space-time analysis of associations between marijuana abuse and dependence hospitalizations and ZIP code demographic and other characteristics, and (2) a cross-sectional analysis of associations between marijuana hospitalizations and marijuana dispensary densities.

2.1.1. Marijuana abuse and dependence hospitalizations—The primary outcome measure was the annual number of marijuana abuse or dependence hospitalizations per ZIP code, obtained from the California Office of Statewide Health Planning and Development patient discharge data. These records provide information on all discharges that result in at least one overnight hospital stay. We included discharges that had either a primary or secondary ICD-9 diagnostic code of 304.3 (cannabis dependence) or 305.2 (cannabis abuse). The number of such cases per year that required hospitalization with at least one overnight stay increased over the study period, from 17,469 in 2001 to 68,408 in 2012. The vast majority (>85%) of cannabis discharges were coded as abuse rather than dependence. In only 0.8% of cases was cannabis dependence/abuse the primary diagnosis; in the other 99.2% of cases the diagnosis was secondary to hospital discharge for some other medical or injury condition. The percent of primary diagnoses decreased over the study period, from 2.2% (n=427) in 2001 to 0.4% (n=294) in 2012. Each hospital discharge was linked to the ZIP code of the patient. 97.3% of all discharges included 5-digit patient ZIP codes—the remaining were homeless, lived in another state, were missing/unknown, or only provided ZIP codes masked to 3 digits due to small population sizes within their 5-digit ZIP code. These discharges were dropped from analyses.

2.1.2. Marijuana dispensary density—Locations of marijuana dispensaries were obtained from six different websites listing the information for these businesses in March–April, 2012. The six websites were chosen by conducting a comprehensive search of such databases available on the web and by asking dispensary owners where they advertise their services. These websites provide up-to-date information on locations of dispensaries, ensuring that we obtained information for newly opened dispensaries. Each dispensary was geocoded to its address and spatially joined to ZIP code polygons for the year 2012 (ESRI, 2012). Overall marijuana density estimates used in models were calculated as the number of dispensaries per square mile within each ZIP code. Dispensary densities in adjacent areas were also calculated. These densities were represented by the un-weighted averages of densities across ‘spatially lagged’ ZIP codes, those immediately adjacent to each ZIP code. Geographic adjacencies were defined as sharing a boundary or touching at a single point, allowing for a 0.5 meter tolerance to compensate for imprecision in boundary maps. The mean number of neighboring ZIP codes in 2012 was 5.6 (standard deviation 2.3), with six ZIP codes having zero neighbors.

2.1.3. Demographic and environmental covariates—Estimated annual ZIP code-level demographic data included percent white, percent Hispanic, percent African American, median household income (per $10,000), age distribution categories (percent under age 19, 20–24, 25–44, 45–64), percent with less than a high school degree and percent with greater than a Bachelor's degree, percent unemployed, and population density (per mile^2). With the exception of income, these estimates were based on publically available inter-censal projections at the Census block group level supplied by Geolytics (Geolytics, 2011). Demographic variables were aggregated from Census block group boundaries up to year-specific ZIP codes. Because block groups are not nested within ZIP codes, demographic variables had to be estimated for block groups that cross ZIP code boundaries. In these cases, the block group demographic variables were weighted based on the portion of the captured block group centroid population that falls within each ZIP code. To account for spatially variant population growth, we linearly interpolated block population from 2000 to 2010 and used year-specific block populations when weighting demographic variables. Median household income data for 2000 were obtained at the block group level from the 2000 Census, while 2010 data were estimated using 2008–2012 averages from the American Community Survey. Inter-censal estimates were constructed by assuming that 2000–2010 changes were distributed across years in proportion to those of annual county-level income estimates (U.S. Census, 2014), while 2011 and 2012 estimates assumed equal proportional growth for all block groups within a county. These block-group income estimates were converted to 2012 dollars using the Consumer Price Index and reallocated to ZIP codes in the manner described above.

Other ZIP code characteristics included the overall hospitalization rate and the density of overall retail establishments. The overall hospitalization rate, calculated as the number of discharges regardless of diagnoses per 100 persons, was included as a covariate to control for differences in access to inpatient care. A measure of the density of overall retail establishments was derived from ZIP Code Business Patterns data (Census, 2013). Using North American Industry Classification System (NAICS) codes, counts of all "retail trade" (sectors 44, 45) and "accommodations and food service" (sector 72) establishments were tallied. Density was calculated as the number of retail establishments per 100 square miles of ZIP code area.

A measure of the geographic instability of a ZIP code's population between consecutive years, calculated as the percentage of year-2000 Census block populations within a given year's ZIP code definition that would not have fallen within the boundaries of the best-matched ZIP code in the prior year (range: 0–59%), was created. This instability measure tested the assumption that ZIP code boundary shifts did not substantively bias other effects estimates.

Roughly 2% of ZIP code polygons had population values of fewer than three residents, and these were assigned a minimal population of three to allow for non-zero population risks in all areas. Census-based rate variables (e.g., percent African American) were undefined in approximately 1% of ZIP codes and were thus assigned the California state average for the year. These missing Census values typically occurred in unpopulated areas, such as national forests.

2.2. Data Analysis

Panel analyses relied on a Bayesian Space-Time Misalignment Poisson model developed by Zhu et al. (Zhu et al., 2013). This model allows us to perform panel analyses using all ZIP codes in California over a period of 12 years despite frequent changes in the size and shape of these geographic units. This approach uses a separate conditional autoregressive (CAR) random effect for each year-specific map of spatial adjacencies to account for spatial autocorrelation, assumed to have mean zero and a common standard deviation. The model also allows for a second, separate, random effect that is not spatially autocorrelated.

The outcome measure is the annual count of marijuana abuse/dependence hospitalizations by ZIP code. Poisson models were used:

$$Y_{i,t}|\mu_{i,t} \sim Poisson(E_{i,t}\exp(\mu_{i,t}))$$

where Y_{it} represents the count of hospitalizations in ZIP code i during year t and $E_{i,t}$ denotes the expected number of hospitalization visits under the assumption that statewide marijuana hospitalizations are distributed among ZIP codes in direct proportion to population. The log-relative risk, $\mu_{i,t}$, is modeled linearly as:

$$\mu_{i,t}=\alpha_t+X^{'}_{i,t}\beta+\theta_{i,t}+\phi_{i,t}$$

This is a linear combination of fixed covariate effects and random effects which may take account of spatial and/or temporal correlation. Vector αt is a set of year-specific intercepts that control for statewide changes in marijuana hospitalization risks that are not explained by other covariates. Matrix X'_{it} contains space- and time-specific covariates and β is a vector of fixed-effects estimates of the impacts of those covariates. $\theta_{i,t}$ and $\varphi_{i,t}$ denote the pair of random effects capturing spatially unstructured heterogeneity and CAR spatial dependence, respectively. Models included fixed effects for neighborhood demographics, overall hospitalization rates, population density, retail clutter, and ZIP code instability (misalignment). A similar model was used to estimate the impact of local and adjacent marijuana dispensaries on marijuana abuse/dependence hospitalizations, but this analysis included a single 2012 cross-sectional data set. Local and adjacent dispensary densities were entered simultaneously into the model.

Models were estimated using WinBUGS 1.4.3 software (Lunn et al., 2000). Uninformed priors were specified for all fixed and random effects. Models were allowed to burn-in for 50,000 Markov Chain Monte Carlo (MCMC) iterations, a sufficient number of iterations for all parameter estimates to stabilize and converge between two chains with different initial values. Posterior estimates were sampled for an additional 50,000 MCMC iterations to provide model results, until the ratio of the MC error to the standard deviation was less than 5%. Traces of MCMC iterations demonstrated good convergence for all parameters.

3. RESULTS

Table 1 presents descriptive statistics for ZIP codes in California from 2001 to 2012 (20,219 ZIP codes). The racial/ethnic distributions in average ZIP codes were 4.7% African American, 26.7% Hispanic, and 55.3% non-Hispanic white. The ranges of both population and square miles per ZIP code were large, with the resulting population density measure mean of 3,319 people/mile^2 (range: 0–56,482 people/mile^2). There were 1,650 dispensaries in California in early 2012. The number of medical marijuana dispensaries per ZIP code ranged from 0 to 40, with an average of approximately one per ZIP code and 27.0% reporting at least one dispensary. The mean density of dispensaries in both local and adjacent ZIP codes was 0.22/mile^2, with a larger range for local ZIP codes (0–11 vs. 0–6). The mean density of dispensaries in ZIP codes with at least one dispensary was 0.83/100 mile^2. Overall, 65.6% of ZIP codes had a dispensary locally or in an adjacent spatial unit.

Table 2 shows results from the Bayesian Space-Time Misalignment Poisson model from 2001–2012 and presents posterior estimates of the effects of each fixed-effect variable, expressed as relative rates (calculated as Exp[raw coefficient]). Each relative rate is calculated from the median estimate from the sampled posterior distribution and is followed in parentheses by the 95% credible interval from that distribution. Greater retail density, lower median household income, and lower population density were all associated with greater rates of marijuana hospitalizations. ZIP codes with a higher percentage of residents with greater than a Bachelor's degree had fewer marijuana hospitalizations. The CAR spatial random effect explained 93% of the overall error variance in the model, indicating that there is substantial spatial autocorrelation. Year-specific intercepts were included in all models. There was a large and steady increase in the rates of marijuana abuse/dependence hospitalizations from 2001 to 2012 even after controlling for demographic and other environmental covariates.

Cross-sectional marijuana dispensary density results are displayed in Table 3. An additional one dispensary per square mile was associated with a 6.8% increase in the number of marijuana hospitalizations (95% credible interval 1.033, 1.105). The spatial lag effect was not well supported. Results for other covariates were generally consistent with the space-time results presented in Table 2, except that the association for unemployment was negative in the cross-sectional analyses.

4. DISCUSSION

The density of local marijuana dispensaries is associated with a greater number of hospitalizations with a primary or secondary marijuana abuse/dependence code. Furthermore, other local characteristics, such as the median household income and age and racial/ethnic distributions, are associated with marijuana hospitalizations. These local characteristics do not fully explain the increase in hospitalizations over time, although we were unable to longitudinally measure dispensary density. This is the first analysis of the statewide impact of marijuana dispensaries on marijuana abuse and dependence, as well as the first look at population characteristics associated with hospitalization rates.

Increased availability of marijuana in ZIP codes with a higher density of dispensaries remains a plausible explanation for the increased hospitalizations in dispensary-dense areas. This cross-sectional association remains after adjustment for other characteristics of ZIP codes. Indicators of social disorganization were associated with hospitalizations in both the cross-sectional and panel analyses. The direction of causation remains open to debate, however. It is possible that marijuana dispensaries are more likely to locate in socially disorganized neighborhoods with higher underlying rates of marijuana use and abuse, or that the presence of these dispensaries increases local use, or perhaps both. Previous research suggests that some indicators of disorganization are related to locations of dispensaries (Boggess et al., 2014; Morrison et al., 2014) but more work is needed to fully understand this relationship.

We found some of the same characteristics to be related to marijuana use and dependence at the population level as in individual models of use for medical or recreational purposes (e.g., white populations; Freisthler and Gruenewald, 2014; Morrison et al., 2014; O'Connell and Bou-Matar, 2007; Ogborne and Smart, 2000; Reiman, 2007 ; Swift et al., 2005; Ware et al., 2005). Our population estimates suggest marijuana abuse and dependence occur at higher rates in lower income areas, similar to associations seen in individuals who use medical marijuana (O'Connell and Bou-Matar, 2007; Ogborne and Smart, 2000; Reiman, 2007 ; Swift et al., 2005; Ware et al., 2005). While this study cannot suggest inferences about individual use and likelihood of marijuana abuse and dependence, the congruence of findings across individual and population levels suggest these might be some important areas to direct future research.

A number of limitations need to be noted. Population models have the advantage that they can comprehensively identify aggregate effects across diverse populations living in many different neighborhood conditions. As an aggregate population analysis, however, it is not possible to illuminate the connecting theory that leads from a global assessment of exposures to marijuana dispensaries and other neighborhood conditions to the individual behaviors that are affected by these exposures. For this purpose, multilevel contextual data and analysis models are required. Thus, the individual behavioral mechanisms that underlie the observed effects remain to be explored further. Other limitations of the current analyses include the cross-sectional nature of dispensary information. We cannot assess whether the increase in the number and density of dispensaries across the 12 year period partially or fully explains the dramatic increase in the number of marijuana hospitalizations. However, this is the first opportunity to examine dispensaries at a statewide level, and these cross-sectional findings indicate that dispensary density matters and should be examined longitudinally once such data are available. Furthermore, the vast majority of hospitalization codes are secondary diagnoses. This is not particularly surprising since acute marijuana poisoning/ overdose is quite rare. Finally, the procedure used to estimate ZIP code demographic estimates from available block-group level projections will introduce some noise in these covariates, and this would be expected to bias the associated parameters toward zero. Despite this, the association between dispensary density and hospitalizations was well-supported.

As the first study to examine population characteristics related to marijuana abuse and dependence, more work is needed to understand the exact mechanisms underlying these relationships. Future research incorporating dynamic models of dispensary effects as they evolve may lead to greater understanding of these processes over both short- and long-term periods and at smaller scales of geographic resolution. This work suggests prevention and intervention programs for marijuana abuse and dependence should be targeted in areas of concentrated disadvantage (as measured using such economic factors as unemployment, income, and education). Despite medical marijuana being allowed by California, local jurisdictions can ban dispensaries outright or place restrictions on their locations (such as not near where child and youth populations spend time). States may also place other restrictions on who can purchase marijuana at dispensaries (e.g., adults 21 years or older) to reduce access to populations who may be vulnerable to abuse or dependence. States that are considering passing laws allowing medical or recreational use of marijuana might consider regulations that limit the density of dispensaries, particularly in disadvantaged areas, or encourage provisions for localities to make their own regulations (including bans) to prevent problems in areas at risk for high rates of marijuana abuse and dependence.

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Highlights

- We examine marijuana dispensary density and marijuana hospitalizations
- We study marijuana hospitalizations and neighborhood ecology from 2001–2012
- Dispensaries were cross-sectionally associated with greater marijuana hospitalizations
- Indicators of concentrated disadvantage were associated with marijuana hospitalizations

Table 1

Descriptive statistics, ZIP codes in California 2001–2012 (n=20,219 ZIP codes)

	Mean	SD	Minimum	Maximum	Mean Change, 2012 vs. 2001
Population	21,630.46	21,834.58	3.00	126,941.40	1,353.19
Area ($mile^2$)	93.47	247.91	0.01	3,805.23	−2.47
Percent age 0–19	26.06	6.71	0.00	70.67	−4.03
Percent age 20–24	6.94	2.78	0.00	48.48	−0.01
Percent age 25–44	27.12	6.93	0.00	100.00	−3.96
Percent age 45–64	25.71	6.34	0.00	100.00	2.98
Retail Clutter/$mile^2$	24.76	96.11	0.00	2,246.50	0.46
Percent with less than high school degree	21.47	15.44	0.00	93.22	−0.27
Percent with greater than Bachelor's Degree	9.39	8.19	0.00	100.00	0.65
Median household Income ($10,000)	6.74	2.86	0.00	24.23	0.02
Overall hospitalization rate (per 100 people)	22.22	228.78	0.00	14,800.00	−12.44
Percent African American	4.66	8.23	0.00	88.01	−1.24
Percent Hispanic	26.68	22.41	0.00	98.49	2.89
Percent white	55.29	25.33	0.00	100.00	−12.71
Unemployment (%)	9.67	9.56	0.00	100.00	7.16
Population Density (people/$mile^2$)	3,319.39	5,477.06	0.01	56,482.36	101.37
ZIP code instability	0.60	3.27	0.00	59.42	
Cannabis abuse/dependence hospitalizations	21.71	31.87	0.00	441.00	29.63
Marijuana Dispensary Densities (2012 only)					
Number of dispensaries	0.97	2.64	0.00	40.00	
Dispensaries/$mile^2$	0.22	0.87	0.00	15.48	
Spatially lagged dispensaries/$mile^2$	0.22	0.55	0.00	5.58	

Table 2

Relative Rates (95% credible intervals) and Ln (Relative Rates), marijuana abuse and dependence hospitalizations, Bayesian Spatial Misalignment Models (n=20,219 ZIP codes)

	Relative Rate (95% credible interval)	**Ln (RR)**
Demographic Characteristics		
Percent age 0–19	1.023 (1.019,1.028)[a]	0.0225
Percent age 20–24	0.981 (0.977,0.987)[a]	−0.0187
Percent age 25–44	0.994 (0.992,0.997)[a]	−0.0057
Percent age 45–64	1.030 (1.025,1.034)[a]	0.0291
Retail Clutter/mile^2 (×100)	1.074 (1.062,1.086)[a]	0.0717
Percent with less than high school degree	1.001 (0.999,1.003)	0.0014
Percent with greater than Bachelor's Degree	0.992 (0.989,0.994)[a]	−0.0084
Median household Income ($10,000)	0.879 (0.872,0.885)[a]	−0.1285
Overall hospitalization rate (per 100 people)	1.066 (1.061,1.071)[a]	0.0642
Percent African American	1.025 (1.023,1.026)[a]	0.0243
Percent Hispanic	1.003 (1.002,1.004)[a]	0.0032
Percent white	1.014 (1.013,1.015)[a]	0.0142
Unemployment (%)	1.001 (0.999,1.003)	0.0013
Population Density (people/mile^2) (×100)	0.897 (0.877,0.918)[a]	−0.1084
Misalignment Effects		
ZIP code instability	1.004(1.001,1.008)	0.0044
Random Effects	**Median (95% Credible**	
Spatial Random Effects (s.d. CAR process)	0.575 (0.560, 0.588)	
ZIP code-Level Random Effects (s.d.)	0.162 (0.144, 0.181)	
Proportion of error variance that is spatial	0.926 (0.907, 0.943)	

Iterations: 50,001–100,000

[a] Indicates findings that are well-supported by the data as evidenced by credible intervals that exclude one for relative risks

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Table 3

Relative Rates (95% credible intervals) and Ln (Relative Rates), marijuana abuse and dependence hospitalizations, 2012 cross-sectional analysis with marijuana dispensary density (n=1,702 ZIP codes)

	Relative Rate (95% credible interval)	Ln(RR)
Marijuana Dispensary Density		
Dispensaries/mile^2	1.068 (1.033,1.105)[a]	0.0655
Spatially lagged dispensaries/mile^2	1.034 (0.949,1.123)	0.0339
Demographic Characteristics		
Percent age 0–19	1.022 (1.010,1.033)[a]	0.0221
Percent age 20–24	1.028 (0.983,1.068)	0.0272
Percent age 25–44	0.991 (0.984,0.998)[a]	−0.0086
Percent age 45–64	1.031 (1.023,1.039)[a]	0.0307
Retail Clutter/mile^2 (×100)	1.060 (1.019,1.101)[a]	0.0583
Percent with less than high school degree	1.004 (1.000,1.009)[a]	0.0044
Percent with greater than Bachelor's Degree	0.998 (0.992,1.005)	−0.0021
Median household Income ($10,000)	0.863 (0.840,0.882)[a]	−0.1469
Overall hospitalization rate (/100 people)	1.806 (1.656,1.960)[a]	0.0046
Percent African American	1.022 (1.018,1.027)[a]	0.0218
Percent Hispanic	1.003 (0.999,1.006)	0.0027
Percent white	1.013 (1.010,1.015)[a]	0.0127
Unemployment (%)	0.988 (0.984,0.992)[a]	−0.0122
Population Density (people/mile^2) (×100)	0.862 (0.799,0.938)[a]	−0.0015
Random Effects	**Median (95% Credible Interval)**	
Spatial Random Effects (s.d. CAR process)	0.543 (0.502, 0.580)	
ZIP code-Level Random Effects (s.d.)	0.145 (0.072, 0.207)	
Proportion of error variance that is spatial	0.933 (0.861, 0.984)	

Iterations: 50,001–100,000

[a]Indicates findings that are well-supported by the data as evidenced by credible intervals that exclude one for relative risks