# Cross-Border Spillovers of Recreational Cannabis Legalization on Mental Health

Evidence from Pennsylvania

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**Abstract**

Recreational cannabis legalization has spread across the U.S., so that residents of states that still prohibit sales often live within driving distance of a legal market. I investigate whether New Jersey's legalization of recreational cannabis in 2021 affected psychiatric hospitalizations in neighboring Pennsylvania, which permits only medical cannabis use. Using inpatient discharge records for 2018–2022, I compare matched ZIP codes in Pennsylvania counties near New Jersey dispensaries to ZIP codes far from the New Jersey border, before and after the legalization of recreational cannabis in New Jersey. Following legalization, psychiatric hospitalizations in ZIP codes within two hours of New Jersey dispensaries increased by 0.83 per 1,000 residents per quarter, or 6.8 percent. My results indicate that the additional hospitalizations occurred for depression, alcohol- and tobacco-related disorders, dementia, and psychosis. Cost–benefit assessments of legalization should account for externalities imposed on neighboring states.

**Keywords:** cannabis legalization; cross-border spillovers; mental health; difference-in-differences

**JEL Codes:** I18; K32; R12

# 1 Introduction

Cannabis regulation in the United States is determined by the states, resulting in wide variation in legal access to cannabis across the U.S. As of 2026, twenty-four states and the District of Columbia permitted recreational sales, while the rest of the states allowed only medical use or prohibited cannabis use completely. Wherever a legalizing state borders a restrictive one, residents of the restrictive state can sometimes drive across the state line, buy cannabis legally, and bring the product home. Similar behavior occurs for cigarettes and alcohol (Lovenheim and Slemrod, 2010): when neighboring jurisdictions regulate the good differently, consumption in the stricter area responds to the price and availability in the less heavily regulated area. As with alcohol, the consumption of cannabis also affects mental health. If cross-border access raises consumption in the restrictive state, the legalizing state collects the tax revenue while its neighbor absorbs some of the health costs, leading to a negative externality.

A large literature evaluates recreational cannabis laws inside the states that adopt them. It finds that adult use rises while adolescent use changes little (Hall and Lynskey, 2020; Farrelly et al., 2023; Athanassiou et al., 2023), that cannabis-related hospitalizations, emergency department visits, and poison-control calls increase (Wang et al., 2017), and that cannabis-involved traffic injuries become more common (Hall and Lynskey, 2016; Anderson and Rees, 2023). In Colorado, for example, hospital discharges coded to cannabis dependence and poison-center calls mentioning marijuana rose after the 2009 expansion of medical marijuana access (Davis et al., 2016). Effects on crime are less consistent: some studies report higher rates of serious offenses and others find none (Athanassiou et al., 2023). As a result, much of the literature urges continued monitoring of crime and cannabis use and a cautious regulatory posture (Fischer et al., 2020; Wilkinson et al., 2016).

The evidence of the effects of cannabis regulation on mental health is mixed. Medical cannabis laws have been linked to fewer poor-mental-health days among likely medical users and people with frequent pain (Kalbfuss et al., 2024), and adults with mood or anxiety disor-

ders report greater self-medicating with cannabis (Sarvet et al., 2018). Likewise, some studies link recreational laws to lower mental health admissions (Ortega, 2023), even though cohort studies suggest cannabis use increases depression (Gobbi et al., 2019; Churchill et al., 2025) and other work ties it to greater psychiatric risk, including psychosis and mood disorders (Mahintamani et al., 2025). Studies of the effects of cannabis legalization on psychosis-related care find few effects (Elser et al., 2023). Psychiatric diagnoses appear disproportionately in cannabis-related emergency visits, which frequently involve co-occurring conditions (Hall et al., 2018); college students seem especially exposed (De Faria et al., 2021); and co-use with tobacco is common among people with mental disorders (Stewart et al., 2020).

Research on cross-border effects is more limited and concentrates on markets and enforcement rather than health. Legal access in one state can alter behavior nearby through migration, commuting, and cross-border purchasing. Hansen et al. (2020) show that a large share of retail sales in Washington's border counties went to Oregon residents, while Hao and Cowan (2020) find that self-reported cannabis use rose in states bordering Colorado and Washington, relative to non-neighboring states, after those states legalized cannabis. Neighboring states have also seen crime decline (Wu et al., 2020) and cross-border cannabis use rise where adjacent policies are permissive or revenue-driven (Neeley and Richardson, 2022). These patterns motivate closer study of specific spillover channels, especially where access differs sharply between adjacent states (Pacula and Smart, 2017). I am not aware of a study that estimates the effect of a neighbor's legalization on health care utilization in the state that did not legalize. The question has become more pressing as legalization has spread into the Northeast, where states are small, densely populated, and tied together by commuting.

My study focuses on access to cannabis across the New Jersey–Pennsylvania border. New Jersey signed recreational cannabis use into law in February 2021 and opened licensed dispensaries in April 2022. Several dispensaries are near the Pennsylvania state line, and there is no residency requirement for buyers. Pennsylvania permits cannabis only for regis-

tered medical patients, so residents without a card have no legal source of Delta-9 cannabis within the state. The two states meet along the Delaware River in a corridor that includes the Philadelphia and Lehigh Valley metropolitan areas, where crossing the border is part of daily life. I exploit the fact that ease of access to New Jersey's market for Pennsylvania residents varies depending on their travel time to the closest New Jersey dispensaries. Using a difference-in-differences design, I compare hospitalization rates for mental health conditions in ZIP codes whose county lies within two hours of a dispensary with rates in matched ZIP codes in counties more than three hours away. I exclude counties with intermediate travel times.

After legalization of recreational cannabis in New Jersey, psychiatric hospitalizations in the treated ZIP codes were higher than in the matched controls by 6.8 percent, or 0.83 admissions per 1,000 residents per quarter. The difference is not spread evenly across diagnoses. Depression accounts for the largest share of the additional admissions, increasing 13.9 percent following legalization in New Jersey, followed by alcohol- and tobacco-related disorders, anxiety, dementia and other organic mental disorders, and psychosis. The increase in psychiatric hospitalizations in Pennsylvania occurs within the first year after the law was passed. Taken together, the diagnostic pattern points to mood disorders, co-use of cannabis with alcohol and tobacco, and psychotic disorders rather than to acute intoxication, since hospitalizations coded as cannabis use itself do not change (Churchill et al., 2025; Subbaraman and Kerr, 2015; Hyatt et al., 2026).

Unlike previous studies of recreational cannabis laws, which compare adopting states with non-adopting states, I consider the policy's footprint in the neighboring state. The outcome I measure, inpatient psychiatric care in a non-legalizing state, is a cost of legalization that within-state evaluations do not capture, and it bears directly on the case for interstate coordination in cannabis regulation.

The remainder of the paper is organized as follows. Section 2 describes cannabis policy in New Jersey and Pennsylvania and two contemporaneous developments, the spread of Delta-

8 THC and the COVID-19 pandemic. Section 3 describes the data and sample, Section 4 the empirical strategy, and Section 5 contains the results and robustness checks. Section 6 discusses mechanisms, and Section 7 concludes.

# 2 Background

## 2.1 Cannabis Policy in New Jersey and Pennsylvania

New Jersey legalized recreational cannabis in stages. On February 22, 2021, the state enacted the CREAMM Act together with a companion decriminalization law, which took effect immediately and removed all penalties for possessing up to six ounces of marijuana.[1] No licensed source of supply existed at that point. Licensed adult-use sales began on April 21, 2022, after a separate regulatory process managed by the Cannabis Regulatory Commission (New Jersey Cannabis Regulatory Commission, 2022a).[2] Several dispensaries opened immediately adjacent to the Pennsylvania border, most notably in Phillipsburg, directly across the Delaware River from Easton, Pennsylvania. Adults aged 21 and older, including Pennsylvania residents, may purchase up to one ounce of cannabis per transaction at New Jersey dispensaries with valid government-issued identification (New Jersey Cannabis Regulatory Commission, 2022c), although transporting cannabis across state lines remains illegal under federal law (Savage, 2022).

Pennsylvania has not legalized recreational cannabis. Under the Medical Marijuana Act of 2016, cannabis-derived Delta-9 THC is available only through the state's Medical Marijuana Program to registered patients with qualifying conditions (Commonwealth of Pennsylvania, 2016). Pennsylvania residents without a medical card therefore had no legal in-state source of Delta-9 cannabis during my sample period, and once licensed sales began in April 2022, New Jersey's dispensaries became the nearest legal source for residents of the eastern

[1] The two laws are P.L.2021, c.16 and P.L.2021, c.19 (New Jersey Office of the Attorney General, 2021).

[2] On the first day of sales, New Jersey dispensaries sold $1.9 million worth of cannabis to over 12,000 customers (New Jersey Cannabis Regulatory Commission, 2022b).

part of the state.

## 2.2 Delta-8 THC and the COVID-19 Pandemic

Two contemporaneous developments complicate the interpretation of cannabis policy effects during my sample period. The first is the spread of hemp-derived Delta-8 THC. After the 2018 Farm Bill removed hemp from federal control, Delta-8 products appeared in convenience stores and online retailers, particularly in states without recreational legalization (Livingston et al., 2022; Harlow et al., 2024). Reported Delta-8 exposures rose steeply in 2021 and 2022 and led to advisories from the CDC and the FDA. Users frequently described favorable experiences and substitution away from Delta-9 THC or pharmaceuticals (Kruger and Kruger, 2022, 2023), whereas the absence of regulation drew attention to accidental exposures, medical emergencies, and addiction risk (Babalonis et al., 2021; LoParco et al., 2023).

The second development, the COVID-19 pandemic, altered cannabis consumption in ways that bear directly on mental health. Cannabis use increased during the pandemic and was often linked to boredom, depression, anxiety, and isolation (Bartel et al., 2020; Chong et al., 2022; Mehra et al., 2023), with patterns of use differing by age, gender, and mode of use (Newport et al., 2023). Stricter containment policies were associated with less cannabis sharing (Assaf et al., 2024), while sales shifted toward online and darknet channels (Groshkova et al., 2020). Among medical users with pre-existing conditions the pandemic coincided with heavier use (Vidot et al., 2020). Because legalization took place alongside these shocks, associational estimates are difficult to interpret unless the research design isolates the policy change.

# 3 Data and Sample Construction

## 3.1 Sample Construction

I constructed a ZIP code–quarter panel for Pennsylvania for 2018Q1–2022Q4 that links hospital discharge records to socio-demographic, health, and geographic data. The identification strategy exploits geographic variation in proximity to New Jersey's legal recreational market. I divided Pennsylvania counties into three groups according to the average driving time from their ZIP codes to the two nearest New Jersey dispensaries:

- **Treated Counties:** counties with average driving time $\leq 120$ minutes;
- **Buffer Zone of Excluded Counties:** counties with average driving time between 120 and 180 minutes;
- **Control Counties:** counties with average driving time $> 180$ minutes.

The classification separates areas with practical access to New Jersey dispensaries from areas where the trip is too long to occur with regularity. The 120- and 180-minute cutoffs correspond to natural breaks in the distribution of county-level driving times, and in Section 5.1.2 I examine alternative cutoffs.

My preferred specification excludes 2020Q2, when hospitalizations fell briefly at the onset of the COVID-19 pandemic. Section 5.1.3 reports estimates from the full sample and from samples that also exclude the Delta and Omicron waves of the pandemic.

## 3.2 Balance and Matching

Within the treated and control counties, I performed one-to-one nearest-neighbor Mahalanobis matching with replacement at the ZIP code level, using the pre-policy means of log population, log median income, the uninsurance and unemployment rates, the Black and female population shares, the share aged 65 or older, and the share holding a bachelor's

degree. All variables used in the matching were extracted from the American Community Survey (ACS) and measured at the ZIP code level. Each ZIP code in a treated county was paired with the most similar control ZIP code in a control county. Because the procedure minimizes a joint distance across the eight characteristics, it does not ensure balance on any single characteristic. Matching reduces the mean standardized bias across these variables from 46.3 to 12.1 percent, and for log population from 89.9 to 14.9 percent.[3] All quarters of each matched ZIP code enter the panel.

ZIP code-level socio-demographic variables used as control variables in the model (population, median income, educational attainment, unemployment, uninsurance, age structure, sex composition, and racial composition) are from the ACS. Using the discharge records of the Pennsylvania Health Care Cost Containment Council (PHC4), I constructed, for each ZIP code and quarter, the mean age of hospitalized patients, the share of female patients, the Medicare and Medicaid payer shares, the Charlson Comorbidity Index, and a claims-based hierarchical risk-adjustment score (HCC/DCG) using methods analogous to those applied to Medicare capitation models (Ellis et al., 1996).

Table 1 reports covariate balance in the matched sample. Patient characteristics and payer mix are similar: age, sex, the Medicare and Medicaid shares, and the two clinical risk indices are statistically indistinguishable or only marginally different across the treated and control groups, and the same holds for ZIP code-level uninsurance, unemployment, the share of Black residents, and the female share. The remaining differences lie in ZIP code-level socioeconomic composition. Treated ZIP codes have higher log population and log median income than controls (significant at the 5 and 1 percent levels, respectively), a higher share of residents with a bachelor's degree, a lower share with only a high school diploma, and a higher Asian population share. Some of these gaps, notably in log population, are sizable. Each variable enters the regression as a control, and the ZIP code fixed effects absorb time-invariant unobserved differences, so identification rests on the parallel trends assumption of

[3]The estimation sample retains each matched control ZIP code once, without frequency weights, so the differences reported in Table 1 are larger than these matched-sample figures.

Table 1: Means of Control Variables by Treatment Status

| Variable | Mean Treated | Mean Control | Difference | $p$-value |
|---|---|---|---|---|
| Charlson Comorbidity Index$_{(z)}$ | 1.70 | 1.78 | $-0.073^{*}$ | 0.081 |
| | (0.693) | (0.598) | (0.041) | |
| HCC/DCG Risk Score$_{(z)}$ | 1.46 | 1.45 | $0.012^{*}$ | 0.051 |
| | (0.123) | (0.108) | (0.006) | |
| Age$_{(z)}$ | 60.66 | 60.54 | 0.119 | 0.881 |
| | (9.00) | (6.68) | (0.793) | |
| Female Patients$_{(z)}$ | 0.532 | 0.534 | $-0.0019$ | 0.768 |
| | (0.181) | (0.156) | (0.0064) | |
| Medicare$_{(z)}$ | 0.524 | 0.524 | 0.0002 | 0.991 |
| | (0.199) | (0.160) | (0.018) | |
| Medicaid$_{(z)}$ | 0.136 | 0.134 | 0.0014 | 0.937 |
| | (0.149) | (0.125) | (0.017) | |
| Population (log)$_{(z)}$ [†] | 8.84 | 7.99 | $0.847^{**}$ | 0.012 |
| | (1.59) | (1.62) | (0.332) | |
| Median Income (log)$_{(z)}$ | 11.27 | 11.06 | $0.203^{***}$ | 0.000 |
| | (0.398) | (0.302) | (0.054) | |
| Uninsured Rate (share)$_{(z)}$ | 0.064 | 0.060 | 0.0042 | 0.773 |
| | (0.075) | (0.071) | (0.014) | |
| Unemployment Rate (share)$_{(z)}$ | 0.032 | 0.031 | 0.0008 | 0.758 |
| | (0.027) | (0.027) | (0.0025) | |
| Black (share)$_{(z)}$ | 0.083 | 0.041 | 0.042 | 0.158 |
| | (0.158) | (0.098) | (0.029) | |
| Female (share)$_{(z)}$ | 0.506 | 0.500 | 0.0052 | 0.271 |
| | (0.053) | (0.063) | (0.0047) | |
| Asian (share)$_{(z)}$ | 0.037 | 0.012 | $0.025^{***}$ | 0.008 |
| | (0.049) | (0.024) | (0.0092) | |
| Age 65+ (share)$_{(z)}$ | 0.189 | 0.205 | $-0.017^{*}$ | 0.070 |
| | (0.102) | (0.093) | (0.0090) | |
| Age under 18 (share)$_{(z)}$ | 0.206 | 0.192 | $0.014^{*}$ | 0.086 |
| | (0.074) | (0.070) | (0.0083) | |
| Bachelor+ (share)$_{(z)}$ | 0.151 | 0.123 | $0.027^{*}$ | 0.094 |
| | (0.082) | (0.070) | (0.016) | |
| HS Graduate (share)$_{(z)}$ | 0.200 | 0.261 | $-0.061^{***}$ | 0.009 |
| | (0.095) | (0.103) | (0.023) | |
| $N$ | 10,787 | 3,980 | | |

*Notes:* Standard deviations in parentheses under means; standard errors in parentheses under differences. Differences estimated from a regression of each variable on a treatment indicator, SE clustered at the Health Service Area (HSA) level. Subscript $(z)$ = ZIP code-level variable. The first six variables (Charlson Comorbidity Index through Medicaid) are constructed from PHC4 discharge records and averaged at the ZIP code–quarter level; the remaining variables are ZIP code-level ACS measures. Female Patients is the share of discharges with female patients, recovered from the mean of the coded patient-sex field. The Charlson Comorbidity Index and the HCC/DCG risk score are the two patient-level clinical risk measures. The matching variables are log population, log median income, the uninsured and unemployment rates, the Black and female shares, the share aged 65 or older, and the share with a bachelor's degree or more. Buffer-zone sample with ZIP code-level Mahalanobis matching. Sample: 2018Q1–2022Q4, 2020Q2 excluded. $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$.

[†] Not used as a control variable in the regression model; ZIP code population enters the count model as the exposure term.

the difference-in-differences (DID) model described below rather than on balance in levels.

## 3.3 Outcomes

The outcome variables are psychiatric inpatient hospitalizations extracted from the discharge files of the PHC4. Using primary and secondary ICD-10-CM diagnosis codes, I assigned each discharge to one of twelve mutually exclusive categories of mental disorder: (1) Cannabis Use, (2) Other Substance Use, (3) Alcohol & Tobacco Use, (4) Dementia and Organic Mental Disorders, (5) Psychosis, (6) PTSD, (7) Bipolar/Manic, (8) Depression, (9) Anxiety & OCD, (10) Mixed Behavior/Personality Disorders, (11) Neurodevelopmental/Childhood Disorders, and (12) Specific Personality Disorders.[4] An overall measure, All Mental Disorders, aggregates the twelve categories. Appendix Table A1 lists the ICD-10 codes assigned to each category and the hierarchy that makes the categories mutually exclusive. Each outcome is the quarterly count of hospitalizations among residents in their respective ZIP code.

Table 2 reports the means of the outcome variables, scaled to 1,000 ZIP code residents, by treatment status. Hospitalizations for any mental disorder average 11.33 per 1,000 residents per quarter in treated ZIP codes and 13.20 in control ZIP codes. Most subcategories show the same ordering; depression (2.56 versus 2.87), alcohol- and tobacco-related disorders (2.60 versus 3.51), and anxiety and OCD (2.02 versus 2.59) are all somewhat lower in treated areas. In both groups the standard deviations are large relative to the means, which reflects substantial heterogeneity across ZIP codes and over time.

## 3.4 Exposure

I define a treatment indicator that equals one when a ZIP code lies in a treated county, that is, a county whose average driving time to the two nearest New Jersey dispensaries is at most 120 minutes. In addition, I construct a measure of proximity to New Jersey dispensaries.

[4]For example, Depression includes F32 (major depressive disorder, single episode) and F33 (recurrent depressive disorder); Psychosis includes F20 (schizophrenia) and F25 (schizoaffective disorders); Alcohol & Tobacco Use includes F10 (alcohol use disorder) and F17 (nicotine dependence).

Table 2: Means of Outcome Variables per 1,000 ZIP Code Residents by Treatment Status

| Variable | Treated | Control |
|---|---|---|
| All Mental Disorders | 11.33 | 13.20 |
| | (19.76) | (13.15) |
| Cannabis Use | 0.113 | 0.195 |
| | (0.356) | (0.847) |
| Other Substance Use | 0.651 | 0.601 |
| | (2.71) | (1.75) |
| Alcohol & Tobacco Use | 2.60 | 3.51 |
| | (5.90) | (4.67) |
| Dementia and Organic Mental Disorders | 1.62 | 1.42 |
| | (6.12) | (2.30) |
| Psychosis | 0.504 | 0.531 |
| | (1.78) | (1.72) |
| PTSD | 0.072 | 0.072 |
| | (0.989) | (0.370) |
| Bipolar/Manic | 0.828 | 0.915 |
| | (2.96) | (1.97) |
| Depression | 2.56 | 2.87 |
| | (6.58) | (4.07) |
| Anxiety & OCD | 2.02 | 2.59 |
| | (4.96) | (4.57) |
| Mixed Behavior/Personality Disorders | 0.090 | 0.188 |
| | (0.254) | (1.63) |
| Neurodevelopmental/Childhood Disorders | 0.271 | 0.313 |
| | (1.79) | (1.49) |
| Specific Personality Disorders | 0.0005 | 0.0036 |
| | (0.0076) | (0.047) |
| $N$ | 10,787 | 3,980 |

*Notes:* Entries are ZIP code-quarter means of PHC4 inpatient discharge counts flagged by ICD-10 F-codes, standardized per 1,000 residents per quarter using ACS ZIP code population. Standard deviations in parentheses. Buffer-zone sample (counties between 120 and 180 minutes excluded) with ZIP code-level Mahalanobis matching. Sample: 2018Q1–2022Q4, 2020Q2 excluded.

Dispensary locations and opening dates for New Jersey come from the New Jersey Cannabis Regulatory Commission and were cross-checked against other public records.[5] With the OD Cost Matrix tool in ArcGIS Pro, I computed the driving time from each Pennsylvania ZIP code centroid to every New Jersey dispensary open in each quarter. The primary proximity measure is the average driving time to the two nearest open dispensaries, and as a robustness check, I use the average time to the three nearest dispensaries.

Table 3: Exposure to Cannabis (Driving Time to New Jersey Dispensaries) by Treatment Status

| Variable (minutes) | Treated | Control |
|---|---|---|
| Average driving time to the two nearest dispensaries | 69.74 | 282.9 |
| | (28.39) | (52.33) |
| Average driving time to the three nearest dispensaries | 74.93 | 288.0 |
| | (28.15) | (52.28) |
| *N* | 10,787 | 3,980 |

*Notes:* Drive times in minutes from ZIP code centroids to licensed New Jersey dispensaries using ArcGIS Pro OD Cost Matrix. Standard deviations in parentheses. Buffer-zone sample with ZIP code-level Mahalanobis matching. Sample: 2018Q1–2022Q4, 2020Q2 excluded.

Table 3 reports driving times to the closest New Jersey dispensaries by treatment status. Treated ZIP codes lie about 70 minutes from the two nearest New Jersey dispensaries and control ZIP codes about 283 minutes, a difference of more than 210 minutes.

# 4 Methodology

## 4.1 Identification Strategy

I estimate a difference-in-differences model that compares ZIP codes in counties close to New Jersey with matched ZIP codes in counties far from it, before and after legalization of New Jersey's recreational cannabis in 2021.

[5]New Jersey Cannabis Regulatory Commission, "Find a Dispensary," https://www.nj.gov/cannabis/dispensaries/find/.

The model uses the sample described in Section 3.1, which excludes counties with intermediate travel times (120–180 minutes) to sharpen the contrast between treated and control areas. Within the remaining areas, ZIP codes are matched on pre-policy characteristics by Mahalanobis nearest-neighbor matching.

## 4.2 Baseline DID Model

The dependent variable is a count, the number of psychiatric inpatient hospitalizations among residents of ZIP code $z$ in quarter $t$. I specify its conditional mean as exponential and estimate the following baseline difference-in-differences model by Poisson pseudo-maximum likelihood (PPML) (Correia et al., 2020):

$$E\left[Y_{zt} \mid \cdot\right] = \exp\left\{\beta\left(\text{Treat}_{c(z)} \times \text{Post}_t\right) + \mu_z + \lambda_t + W_{zt}'\Gamma + \ln \text{Pop}_{zt}\right\}, \tag{1}$$

where $Y_{zt}$ is the number of hospitalizations and $\text{Pop}_{zt}$ is the ZIP code population, which enters as an exposure term with a coefficient fixed at one, so that the model describes the hospitalization rate per resident. $\text{Treat}_{c(z)}$ equals one if ZIP code $z$ lies in a county whose average driving time to New Jersey dispensaries is at most 120 minutes. $\text{Post}_t$ equals one from 2021Q2 onward, the first full quarter after New Jersey's legalization was signed into law in February 2021. Treatment is thus defined by the change in the cannabis law rather than by the opening of licensed retail dispensaries after April 2022; the event-study estimates in Section 4.3 show how the treatment effect varies across both dates. $\mu_z$ and $\lambda_t$ are ZIP code and quarter fixed effects and $W_{zt}$ is the vector of ZIP code–quarter controls described in Section 3.2. Appendix Table A2 reports the coefficients on all control variables for each outcome. Under parallel trends, $\beta$ is the proportional post-legalization change in psychiatric hospitalizations in treated ZIP codes relative to controls. The percent change is $100\,(e^{\beta}-1)$, and $\bar{Y}_c\,(e^{\beta}-1)$ expresses the treatment effect in hospitalizations per 1,000 residents per quarter, where $\bar{Y}_c$ is the mean hospitalization rate in the control group.

I estimate the model by PPML rather than as a linear model for the hospitalization rate, for two reasons. First, many ZIP code–quarters record no hospitalizations in a given category. This occurs for 3.8 percent of All Mental Disorders admissions, 16 to 25 percent of Depression, Alcohol & Tobacco Use, Anxiety & OCD, and Dementia and Organic Mental Disorders admissions, 41 percent of Psychosis admissions, and more than half for Cannabis Use admissions. PPML handles zeros directly, such that the estimates do not depend on the choice of transformation (Chen and Roth, 2024). Second, PPML with fixed effects is consistent as long as the conditional mean is correctly specified; the counts need not follow a Poisson distribution, and the estimator is robust to heteroskedasticity (Wooldridge, 1999; Santos Silva and Tenreyro, 2006). The exponential form also expresses the treatment effect as a proportional change, which is convenient when baseline rates differ across categories. Note that ZIP codes with no hospitalizations in a category in any quarter contribute nothing to the likelihood and drop out, so the number of observations varies slightly across outcomes. In the appendix I show that estimates are slightly larger when using a linear model (Appendix Table A6; Section 5.1.5), so the choice of estimator does not drive my conclusions.

Matching and estimation take place at the ZIP code level, but the errors are likely to be correlated within the health-care markets that span groups of ZIP codes. I therefore cluster standard errors at the level of the Health Service Area (HSA), the local hospital-market unit defined by the Dartmouth Atlas, which groups ZIP codes according to where residents receive inpatient care. HSA clustering is more conservative than clustering at the ZIP code level; the latter produces smaller standard errors (Appendix Table A5).

## 4.3 Pre-trend Tests

The DID framework assumes that treated and control ZIP codes would have followed parallel trends in psychiatric hospitalizations in the absence of recreational cannabis legalization. I assess this assumption with an event study as well as placebo tests reported in Section 5.1.6. Figure 1 plots the quarter-by-quarter difference between treated and control ZIP codes from

a fully interacted version of equation (1), with 2021Q1 as the omitted reference quarter and 2020Q2 excluded. None of the eleven pre-policy coefficients is significant at the 5 percent level. Two are significant at the 10 percent level, and they have opposite signs: −0.024 in 2019Q1 and 0.030 in 2020Q1. After the policy takes effect, the treatment effects from 2021Q4 onward are statistically significant at the 1 percent level and lie between 0.069 and 0.086, or 7.1 and 9.0 percent. This suggests that cross-border access to cannabis affected hospitalization rates for psychiatric disorders several quarters following cannabis legalization in New Jersey but prior to when dispensaries were licensed.

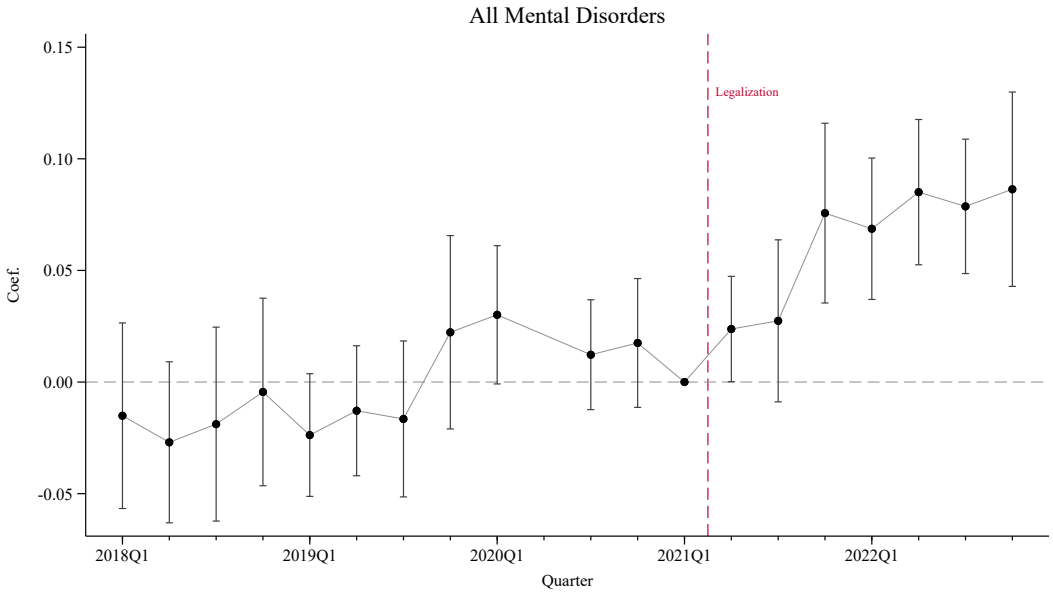



Figure 1: Event Study: All Mental Disorders

*Notes:* Each point plots the coefficient on $\text{Treat}_{c(z)} \times \mathbf{1}[\text{quarter} = t]$ from a PPML specification with ZIP code and quarter fixed effects, ZIP code–quarter controls, and ZIP code population as the exposure. The reference period is 2021Q1, and 2020Q2 is excluded. Vertical bars are 95% confidence intervals based on standard errors clustered at the Health Service Area (HSA) level. The dashed line separates the reference quarter (2021Q1) from the first post-legalization quarter (2021Q2). Event studies for all outcomes are shown in Appendix Figure A1.

# 5 Results

Table 4 reports PPML estimates of equation (1) for each of the thirteen outcome variables.

After New Jersey's legalization, hospitalizations for All Mental Disorders in nearby Penn-

Table 4: Baseline DID Results

| Outcome | $\hat{\beta}^{\text{DID}}$ | Control Mean | $N$ |
|---|---|---|---|
| All Mental Disorders | $0.065^{***}$ | 12.27 | 13,939 |
| | (0.014) | | |
| Cannabis Use | $-0.003$ | 0.22 | 11,403 |
| | (0.077) | | |
| Other Substance Use | $-0.010$ | 0.57 | 12,783 |
| | (0.035) | | |
| Alcohol & Tobacco Use | $0.042^{*}$ | 3.24 | 13,768 |
| | (0.023) | | |
| Dementia and Organic Mental Disorders | $0.060^{**}$ | 1.42 | 13,499 |
| | (0.024) | | |
| Psychosis | $0.088^{***}$ | 0.58 | 12,532 |
| | (0.029) | | |
| PTSD | 0.045 | 0.085 | 10,890 |
| | (0.058) | | |
| Bipolar/Manic | 0.028 | 0.89 | 13,334 |
| | (0.030) | | |
| Depression | $0.130^{***}$ | 2.73 | 13,805 |
| | (0.026) | | |
| Anxiety & OCD | $0.047^{**}$ | 2.35 | 13,659 |
| | (0.022) | | |
| Mixed Behavior/Personality Disorders | $0.206^{***}$ | 0.22 | 11,316 |
| | (0.048) | | |
| Neurodevelopmental/Childhood Disorders | 0.020 | 0.33 | 11,892 |
| | (0.043) | | |
| Specific Personality Disorders | $0.685^{**}$ | 0.015 | 2,078 |
| | (0.284) | | |
| Controls | Yes | | |
| Quarter FE | Yes | | |
| ZIP code FE | Yes | | |

*Notes:* Each row reports $\hat{\beta}^{\text{DID}}$, the coefficient on Treat × Post from the Poisson pseudo-maximum-likelihood (PPML) model in equation (1). The dependent variable is the quarterly count of psychiatric inpatient hospitalizations in the ZIP code, with ZIP code population as the exposure; $100\,(e^{\hat{\beta}}-1)$ is the percent change in hospitalizations. Control Mean is the mean hospitalization rate per 1,000 residents per quarter among control ZIP codes in the estimation sample. $N$ differs across outcomes because PPML drops ZIP codes with no hospitalizations for that category in any quarter, which contribute nothing to the likelihood. All specifications include ZIP code and quarter fixed effects and ZIP code–quarter controls. Standard errors (in parentheses) are clustered at the Health Service Area (HSA) level. Sample: 2018Q1–2022Q4, 2020Q2 excluded. $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$.

sylvania ZIP codes rose by 6.8 percent relative to matched controls ($\hat{\beta} = 0.065$; 95 percent confidence interval 3.8 to 9.8 percent). At the control mean of 12.27 hospitalizations per 1,000 residents per quarter, this amounts to 0.83 additional hospitalizations per 1,000 residents per quarter. Depression shows the largest response, an increase of 13.9 percent, or 0.38 per 1,000 against a control mean of 2.73, and accounts for nearly half of the overall increase. Hospitalizations for Alcohol & Tobacco Use rose by 4.3 percent (0.14 per 1,000; significant at the 10 percent level), for Dementia and Organic Mental Disorders by 6.2 percent (0.09 per 1,000; 5 percent level), and for Psychosis by 9.2 percent (0.05 per 1,000; 1 percent level). Anxiety & OCD increased by 4.8 percent (0.11 per 1,000), significant at the 5 percent level.

The coefficient for Mixed Behavior/Personality Disorders is also positive and significant. Because the base rate of this category is low (0.22 per 1,000 residents per quarter), the proportional change is large while the absolute change is small (0.05 per 1,000). Specific Personality Disorders appears in only 110 ZIP codes of the estimation sample.

None of the remaining categories changed significantly. The absence of a detectable effect on hospitalizations for Cannabis Use is consistent with the low base rate of cannabis-specific inpatient care and with the possibility that cannabis-related harms are recorded under broader diagnoses such as Depression or Anxiety & OCD.

Overall, psychiatric hospitalizations in Pennsylvania ZIP codes within two hours of New Jersey dispensaries increased after New Jersey's legalization relative to matched distant ZIP codes.

## 5.1 Robustness Checks

To assess the sensitivity of the estimates, I change the definition of the control group, the buffer-zone boundaries, the set of excluded pandemic quarters, the level of clustering, and the estimator, and I run placebo tests on pre-policy quarters. The estimates for All Mental Disorders, Depression, and Psychosis keep their sign and significance in all of these checks, whereas those for Dementia and Organic Mental Disorders and for Alcohol & Tobacco Use

are less stable. Full results for all outcomes are in the Appendix.

### 5.1.1 Alternative Control Group Definition

Table 5 compares the baseline estimates with those obtained without the buffer zone of excluded counties, when every county beyond 120 minutes serves as a control. The effect on All Mental Disorders declines from 6.8 to 5.2 percent and remains significant at the 1 percent level. The estimate for Depression is almost unchanged (13.7 percent, significant at the 1 percent level), and the estimate for Psychosis falls to 6.4 percent but remains significant at the 5 percent level. The estimates for Alcohol & Tobacco Use and for Dementia and Organic Mental Disorders fall to 1.7 and 1.5 percent and lose significance. This attenuation is expected, because adding moderately distant counties to the control group weakens the contrast on which identification relies.

### 5.1.2 Buffer Zone Sensitivity

To examine the sensitivity of the results to the buffer-zone exclusion, I re-estimate the baseline specification with eleven alternative travel-time cutoffs. These are obtained by (i) varying the lower bound, the maximum travel time that defines treated counties, with the upper bound held at 180 minutes; (ii) varying the upper bound, the minimum travel time that defines control counties, with the lower bound held at 120 minutes; and (iii) shifting both bounds together so that the buffer remains 60 minutes wide.

Appendix Table A3 and Figures A2, A3, and A4 report the estimates for all outcomes under the eleven alternative definitions. The main results change little when the boundaries move. The effect on All Mental Disorders ranges from 5.8 to 7.8 percent and is significant at the 1 percent level in every case. Depression ranges from 12.4 to 15.2 percent and is also significant at the 1 percent level throughout, and Psychosis ranges from 8.0 to 11.1 percent and is significant at the 5 percent level or better in all eleven definitions. Dementia and Organic Mental Disorders is significant at the 10 percent level or better in ten of the eleven

Table 5: Robustness: Baseline DID – All Counties

| | Buffer Zone | All Counties |
|---|---|---|
| Outcome | $\hat{\beta}^{\text{DID}}$ | $\hat{\beta}^{\text{DID}}$ |
| All Mental Disorders | 0.065*** | 0.051*** |
| | (0.014) | (0.016) |
| Cannabis Use | −0.003 | −0.044 |
| | (0.077) | (0.072) |
| Other Substance Use | −0.010 | 0.014 |
| | (0.035) | (0.039) |
| Alcohol & Tobacco Use | 0.042* | 0.017 |
| | (0.023) | (0.027) |
| Dementia and Organic Mental Disorders | 0.060** | 0.015 |
| | (0.024) | (0.026) |
| Psychosis | 0.088*** | 0.062** |
| | (0.029) | (0.031) |
| PTSD | 0.045 | 0.033 |
| | (0.058) | (0.086) |
| Bipolar/Manic | 0.028 | 0.014 |
| | (0.030) | (0.028) |
| Depression | 0.130*** | 0.129*** |
| | (0.026) | (0.034) |
| Anxiety & OCD | 0.047** | 0.043* |
| | (0.022) | (0.023) |
| Mixed Behavior/Personality Disorders | 0.206*** | 0.175*** |
| | (0.048) | (0.048) |
| Neurodevelopmental/Childhood Disorders | 0.020 | 0.021 |
| | (0.043) | (0.036) |
| Specific Personality Disorders | 0.685** | 0.341 |
| | (0.284) | (0.330) |

*Notes:* Each cell reports $\hat{\beta}^{\text{DID}}$, the coefficient on Treat × Post from the PPML model in equation (1), with ZIP code and quarter fixed effects and ZIP code–quarter controls. "Buffer Zone" drops counties in the 120–180 minute range; "All Counties" retains all counties beyond 120 minutes as controls. Both use ZIP code-level Mahalanobis matching. $N$ for All Mental Disorders is 13,939 and 14,629, respectively. Standard errors (in parentheses) are clustered at the Health Service Area (HSA) level. Sample: 2018Q1–2022Q4, 2020Q2 excluded. $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$.

definitions, and Alcohol & Tobacco Use, with point estimates between 2.0 and 5.7 percent, in six.

### 5.1.3 Sample Restrictions: Pandemic-Related Quarters

The main sample excludes 2020Q2 because hospitalizations dropped sharply in that quarter at the onset of the COVID-19 pandemic. To test sensitivity to other pandemic events, I also estimate models that drop 2021Q3 (Delta) and 2022Q1 (Omicron).

Appendix Table A4 reports the estimates for all outcomes under these alternative sample restrictions, which change the results little. Whether all quarters are retained or the Delta and Omicron waves are dropped together with 2020Q2, the effect on All Mental Disorders lies between 6.3 and 7.5 percent and is significant at the 1 percent level. The estimates for Depression lie between 13.7 and 18.3 percent, for Psychosis between 9.1 and 10.3 percent, and for Dementia and Organic Mental Disorders between 5.8 and 7.6 percent, all significant at the 5 percent level or better. The estimate for Alcohol & Tobacco Use lies between 3.4 and 4.3 percent but is significant only in the main sample and in the sample without 2022Q1. The estimates tend to be larger when the Delta wave is excluded, which suggests that the disruption of all-cause hospitalizations in that quarter attenuated the measured effect.

### 5.1.4 Standard Error Clustering

Appendix Table A5 reports the baseline estimates with standard errors clustered by ZIP code rather than by Health Service Area. Clustering changes only the variance estimator, so the point estimates are identical, and the standard errors clustered by ZIP code are smaller. All outcomes that are significant in the main specification remain significant, and Alcohol & Tobacco Use, Dementia and Organic Mental Disorders, and Anxiety & OCD become significant at the 1 percent level. The main text retains the more conservative HSA-level clustering.

### 5.1.5 Alternative Estimator

Appendix Table A6 compares the PPML estimates, converted to hospitalizations per 1,000 residents per quarter, with OLS estimates of the hospitalization rate per 1,000 residents as the dependent variable. The two estimators produce similar results. For All Mental Disorders, the OLS estimate is 1.07 per 1,000, compared with 0.83 implied by PPML; for Depression, the corresponding figures are 0.41 and 0.38, and both are significant at the 1 percent level under either estimator. Alcohol & Tobacco Use, Dementia and Organic Mental Disorders, and Psychosis are positive and significant under both estimators. The estimators differ mainly for Anxiety & OCD and Mixed Behavior/Personality Disorders, which are significant only under PPML. Because OLS gives every ZIP code the same weight regardless of population, it is more sensitive to the rates of small ZIP codes, which fluctuate widely from quarter to quarter.

### 5.1.6 Placebo Test

As a falsification test, I assign fake treatment dates to several pre-policy quarters and re-estimate the baseline model on the pre-treatment sample only. If trends in treated and control areas are parallel, as required for DID identification, these placebo dates should not produce significant effects for the outcomes that respond to the actual policy. Table 6 reports the placebo coefficients for All Mental Disorders, Alcohol & Tobacco Use, Dementia and Organic Mental Disorders, Psychosis, and Depression.

None of these five outcomes has a significant coefficient at any of the four placebo dates. These include the post-lockdown quarter (2021Q1), the last quarter before the post-policy period, and the pre-pandemic quarters of 2019. The pandemic-onset quarters of 2020 are omitted from this exercise because hospitalizations for all causes were severely disrupted in that period. Appendix Table A7 reports the placebo estimates for all thirteen outcomes. Together with the event study in Section 4.3 and the stability of the estimates when the treatment and control groups are redrawn with alternative buffer-zone cutoffs (Section 5.1.2),

Table 6: Placebo Test

| | Pre-pandemic | | | Post-lockdown |
|---|---|---|---|---|
| Outcome | 2019Q1 | 2019Q2 | 2019Q3 | 2021Q1 |
| All Mental Disorders | 0.019 | 0.024 | 0.027 | 0.001 |
| | (0.020) | (0.020) | (0.021) | (0.011) |
| Alcohol & Tobacco Use | 0.031 | 0.045 | 0.050 | −0.007 |
| | (0.029) | (0.027) | (0.033) | (0.024) |
| Dementia and Organic Mental Disorders | 0.028 | 0.023 | 0.014 | −0.015 |
| | (0.032) | (0.026) | (0.026) | (0.027) |
| Psychosis | −0.024 | −0.017 | −0.020 | 0.002 |
| | (0.031) | (0.040) | (0.043) | (0.037) |
| Depression | 0.013 | 0.020 | 0.024 | −0.030 |
| | (0.026) | (0.028) | (0.028) | (0.025) |

*Notes:* Each cell reports the coefficient on Treat × Post from the PPML model when the quarter in the column header is assigned as a fake treatment date and the model is estimated on the pre-policy sample alone (2018Q1–2021Q1, 2020Q2 excluded). The true treatment date is 2021Q2; 2021Q1 is the quarter immediately before the policy takes effect. The outcomes shown are All Mental Disorders and the four diagnostic categories discussed in the text; Appendix Table A7 reports all thirteen outcomes. All specifications include ZIP code and quarter fixed effects with ZIP code–quarter controls; standard errors (in parentheses) are clustered at the Health Service Area (HSA) level. $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$.

these results are consistent with the parallel-trends assumption on which identification rests.

### 5.1.7 Effects by Distance within the Treated Area

I also split the treatment indicator into five bands of travel time to the two nearest New Jersey dispensaries. The effect on All Mental Disorders is 1.8 percent within 30 minutes, 4.7 percent at 30–45 minutes, and about 10 percent in each band beyond 45 minutes. Philadelphia, Delaware, and Bucks, the three treated counties closest to New Jersey, have the smallest county-level effects. ZIP codes within 45 minutes of the dispensaries are the most densely populated in the treated area, and Philadelphia and Delaware County decriminalized possession of small amounts of cannabis before New Jersey's law took effect. These patterns are consistent with residents of the nearest counties having had access to cannabis before legalization. Figure B1 and Table B1 in Appendix B report the estimates and the characteristics of each band.

# 6 Discussion

After New Jersey's recreational cannabis law took effect, psychiatric hospitalizations in Pennsylvania ZIP codes in nearby counties increased relative to matched distant ZIP codes. The clearest increases are for All Mental Disorders and Depression, followed by Alcohol & Tobacco Use, Dementia and Organic Mental Disorders, and Psychosis.

## 6.1 Cross-Border Access and Cannabis-Mental Health Pathways

I interpret these estimates as the effect of legal recreational cannabis becoming available across the border. As described in Section 2.1, legalization changed access in stages. Penalties for possessing up to six ounces were removed in February 2021, more than a year before licensed sales began on April 21, 2022, and several of the first dispensaries opened directly across the Delaware River from Pennsylvania.

The timing in Figure 1 suggests that the relevant treatment is after the legal change and prior to licensing of outlets. My data do not show how Pennsylvania residents obtained cannabis in this period, but I suspect cannabis was more easily obtained between 2021Q1 and 2022Q1 from unlicensed sellers than prior to cannabis legalization.

The spatial pattern of the estimates is consistent with a cross-border access channel. The binary estimates show a post-policy increase in the Pennsylvania counties within two hours of New Jersey dispensaries, where residents face lower travel costs to dispensaries, and the increase is smaller when counties at intermediate distances are added to the control group (Section 5.1.1). Within the treated area, the effect is smaller in the counties closest to New Jersey, which is consistent with residents of those counties having had access to cannabis before legalization (Section 5.1.7 and Appendix B).

For Cannabis Use, the binary estimate is close to zero (Table 4), and the base rate of cannabis-specific inpatient care is low. The near-zero binary estimate is also consistent with the possibility, noted in Section 5, that cannabis-related harms are recorded under broader

diagnoses such as Depression rather than under cannabis-specific codes, so that easier access need not increase cannabis-coded hospitalizations in Pennsylvania.

These results add to work on cross-border spillovers from recreational legalization. Hao and Cowan (2020) show that self-reported cannabis use rose in states bordering Colorado and Washington after those states legalized cannabis, relative to non-neighboring states; adult possession arrests in border counties also rose sharply, although the authors attribute that increase mainly to changes in enforcement. Hansen et al. (2020) show that a large share of retail sales in Washington's border counties went to Oregon residents, a share that became visible when those sales fell after Oregon opened its own market. My estimates show that such spillovers reach beyond arrests and sales to health care utilization, measured here by psychiatric hospitalizations.

The geographic pattern is also consistent with the economics of sin goods under partial prohibition. When neighboring jurisdictions regulate a good asymmetrically, residents of the restrictive jurisdiction have an incentive to cross the border and buy the good where it is legal (Lovenheim and Slemrod, 2010). In this framework, the size of the response depends on the distance to the border and on the availability of close substitutes at home. In my setting, Pennsylvania residents without a medical cannabis card had no legal in-state source of Delta-9 THC cannabis, which made cross-border purchases particularly attractive for those living near New Jersey.

The findings also agree with epidemiological evidence that links cannabis use to adverse mental health outcomes. A recent meta-analysis of longitudinal studies published before March 2023 finds that cannabis users have 29% higher odds of developing depression than non-users, with some evidence of a stronger association among heavy users (Churchill et al., 2025). The associations appear stronger among younger people. A systematic review of individuals aged 15–30 reports that cannabis use is associated with 51% higher unadjusted odds of depression and 58% higher odds of anxiety (Sanz-Pérez et al., 2026), and Gobbi et al. (2019) find that adolescent cannabis use raises the risk of depression and suicidal ideation

in young adulthood, even after controlling for baseline mental health.

The result for depression is consistent with the pharmacology of THC. Low doses may have short-term anxiolytic effects through activation of CB1 receptors, whereas chronic or heavy use can dysregulate the endocannabinoid system and lead to depressive symptoms (Sorkhou et al., 2024). If occasional use is largely benign while heavier use prompted by legal access leads to adverse health outcomes, this dose dependence would be consistent with estimates based on hospitalizations.

The treatment effect of cross-border access to cannabis on Psychosis, an increase of 9.2 percent that is robust across specifications, differs from the national evidence. Elser et al. (2023) find no statistically significant association between state-level cannabis legalization and psychosis-related health care utilization in a large national cohort of commercially insured individuals, while noting that their null results do not rule out effects in specific subpopulations or over longer horizons. However, there is a strong medical link between cannabis and psychosis: the heaviest cannabis users have about four times the odds of psychosis of non-users (Marconi et al., 2016), and daily use of high-potency cannabis is associated with a nearly fivefold increase in the odds of a psychotic disorder (Di Forti et al., 2019).

Two recent studies report effects of legalization that conflict with mine in direction, and differences in what they measure may explain the conflict. Ortega (2023) finds that recreational laws reduce admissions to mental health treatment facilities in adopting states, and Bradford et al. (2024) find that both medical and recreational access reduce benzodiazepine dispensing among commercially insured patients. Both outcomes lie at the mild end of the severity distribution, where cannabis may substitute for formal treatment or for anxiolytic medication among people who manage their symptoms themselves (Sarvet et al., 2018). Inpatient psychiatric admission lies at the severe end, and the two need not move together. Self-medication with cannabis may not be as effective as treatment by medical professionals: if legalization draws some people with mild symptoms away from formal care while increasing the number whose symptoms become severe enough to require admission, treatment

admissions and prescriptions can fall while hospitalizations rise. Bradford et al. (2024) also report small increases in antidepressant and antipsychotic dispensing after medical cannabis laws, alongside the decline in benzodiazepines, a pattern closer to my result for Depression. The populations also differ. These studies observe residents of legalizing states, who obtain cannabis through a regulated market and often alongside a medical program, whereas I observe residents of a neighboring state in which recreational use remained illegal. Evidence on severe outcomes, in contrast, points in the same direction as mine. Hyatt et al. (2026) find that opening of cannabis retail outlets was associated with more emergency department use among individuals with psychosis, driven by those with recent cannabis use. My estimate for psychosis is consistent with this evidence, because some patients who seek care at the emergency room will be admitted to hospitals.

## 6.2 Substance Complementarity and Co-Use

The increase in hospitalizations for Alcohol & Tobacco Use from access to recreational cannabis (4.3 percent, or 0.14 per 1,000, significant at the 10 percent level) suggests that greater access to cannabis may complement, rather than replace, alcohol and tobacco use.

Whether cannabis and alcohol are substitutes or complements is a long-standing question in health economics, and the answer depends on the population studied and the margin of use. Anderson and Rees (2023) review the evidence and conclude that medical cannabis laws are associated with lower alcohol consumption and less binge drinking in some populations, which is consistent with substitution. Dave et al. (2023) find little evidence that recreational cannabis laws increase adult tobacco use and some evidence of a lagged reduction. At the intensive margin, however, the relationship may be different: simultaneous use of cannabis and alcohol is associated with heavier drinking and roughly double the odds of alcohol-related harms compared with alcohol use alone (Subbaraman and Kerr, 2015). I expect that co-use patterns of individuals with past inpatient psychiatric care may be more harmful to health than co-use by individuals with less severe conditions.

### 6.3 The Emergence of Delta-8 THC

Section 2.2 describes the spread of Delta-8 tetrahydrocannabinol (Delta-8 THC) products, which began in 2020 and 2021, as a potential confounder. Delta-8 THC is a psychoactive cannabinoid produced from hemp-derived cannabidiol (CBD) through chemical conversion. After the 2018 Farm Bill legalized hemp containing less than 0.3% Delta-9 THC, Delta-8 products occupied a regulatory gray area and became widely available at gas stations, smoke shops, and online retailers across the United States, including in states such as Pennsylvania where recreational cannabis remains illegal.[6]

The expansion of the Delta-8 market overlaps with my study period, and the products were widely available in states without legal recreational markets, including Pennsylvania. If Delta-8 products affected mental health hospitalizations proportionally in all Pennsylvania counties, the difference-in-differences design absorbs that influence. If their availability or use varied geographically within Pennsylvania, however, my estimates could be affected.[7]

## 7 Summary and Conclusions

Because cannabis legalization proceeds state by state, it creates borders at which the law changes while people move freely. This paper examines what cross-border access to cannabis means for the state that did not legalize. Using New Jersey's 2021 recreational legalization and Pennsylvania's inpatient discharge records, I estimate how psychiatric hospitalizations

[6]Between January 1, 2021, and February 28, 2022, national poison control centers received 2,362 exposure cases involving Delta-8 THC products. Over a similar period (December 1, 2020, to February 28, 2022), the FDA received 104 adverse event reports, 55% of which required intervention, such as evaluation by emergency medical services, or hospital admission (U.S. Food and Drug Administration, 2022). The CDC issued an alert in September 2021 warning of adverse events including hallucinations, anxiety, dizziness, confusion, and loss of consciousness (Centers for Disease Control and Prevention, 2021). Case reports document Delta-8 THC exposures presenting to emergency departments with respiratory depression and altered mental status (Gibbons and Morris, 2024), as well as psychotic episodes requiring hospitalization (Miller et al., 2023).

[7]Cannabis-derived Delta-9 THC remains illegal for recreational use in Pennsylvania; it is accessible only through the state's Medical Marijuana Program for registered patients with qualifying conditions (Commonwealth of Pennsylvania, 2016). Recreational Delta-9 cannabis obtained by Pennsylvania residents in New Jersey, whether through informal channels after legalization or from licensed dispensaries after April 2022, therefore forms part of the exposure captured by my estimates.

changed in Pennsylvania ZIP codes in counties within driving reach of New Jersey dispensaries, relative to matched ZIP codes far from them.

After legalization, psychiatric hospitalizations in the treated ZIP codes rose by 6.8 percent relative to matched controls, or about 0.83 per 1,000 residents per quarter. The increase is concentrated in depression, which rose by 13.9 percent, with smaller increases in alcohol- and tobacco-related disorders, anxiety, dementia and other organic mental disorders, and psychosis. The binary estimates for all mental disorders, depression, and psychosis are robust to alternative distance cutoffs, an alternative control group, the exclusion of pandemic quarters, a linear estimator, and placebo policy dates. Within the treated area, the effect is smaller in the counties closest to New Jersey, consistent with residents there having had access to cannabis before legalization.

Access across the border lowers the cost of cannabis for Pennsylvania residents near New Jersey, and greater use appears to affect mood disorders, and co-use with alcohol and tobacco, rather than acute intoxication. This pattern is consistent with epidemiological evidence that cannabis use raises the risk of depression (Churchill et al., 2025) and with evidence that cannabis-related hospital care usually involves other psychiatric conditions (Hall et al., 2018).

Three limitations shape how the results should be interpreted. First, the post-policy window is short, covering seven quarters after the law took effect and three after retail outlets were licensed by the state. Longer-run effects could be larger if consumption intensifies. Second, inpatient records capture only the most severe outcomes; outpatient and emergency care are not observed, and the absence of an effect on cannabis-coded hospitalizations may reflect coding norms that emphasize underlying etiology. Third, the estimates come from one border and one period, and the magnitudes need not carry over to other locations.

My results have important policy implications. Legalizing states collect the tax revenue from cannabis sales, while neighboring states with restrictive laws bear part of the health cost without a corresponding offset. A cost–benefit analysis of legalization that stops at the state

line will therefore understate its social cost, and the gap is likely to widen as legalization spreads and more of the population lives within driving distance of a legal market. This asymmetry supports interstate coordination in cannabis regulation and, at the local level, the allocation of mental health and substance-use resources to border areas of states that have not legalized cannabis use.

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# Appendix A: Additional Tables and Figures

## Appendix Tables

Table A1: ICD-10 Classification of Mental Disorders

| **Category** | **ICD-10 Codes and Description** |
|---|---|
| Cannabis use | Cannabis-related disorders (F12) |
| Other substance use | Other substance use disorders (F11, F13–F16, F18–F19) |
| Alcohol & Tobacco use | Alcohol and tobacco use disorders (F10, F17) |
| Dementia and Organic mental disorders | Organic mental disorders (F01–F09) |
| Psychosis | Psychotic disorders (F20, F21–F25, F28–F29) |
| PTSD | Post-Traumatic Stress Disorder (F43.10) |
| Bipolar/Manic | Manic and bipolar disorders (F30, F31, F39) |
| Depression | Depressive disorders (F32–F34) |
| Anxiety & OCD | Anxiety, phobic, and obsessive-compulsive disorders (F40–F43, excluding F43.10) |
| Mixed behavior/personality disorders | Complex or mixed behavioral/personality disorders (F21, F44–F69, excluding F60.2) |
| Neurodevelopmental/Childhood disorders | Neurodevelopmental and childhood behavioral disorders (F70–F99) |
| Specific personality disorders | Specific personality disorders (F60.2) |

Table A2: Full Estimates of the Main Specification by Outcome

| Variable | (1) All Mental Disorders | (2) Cannabis Use | (3) Other Substance Use | (4) Alcohol & Tobacco Use | (5) Dementia and Organic | (6) Psychosis | (7) PTSD |
|---|---|---|---|---|---|---|---|
| Treated × Post | 0.065*** | −0.003 | −0.010 | 0.042* | 0.060** | 0.088*** | 0.045 |
| | (0.014) | (0.077) | (0.035) | (0.023) | (0.024) | (0.029) | (0.058) |
| Charlson Comorbidity | 0.028*** | 0.037 | 0.014 | 0.035* | 0.082*** | −0.130*** | 0.028 |
| Index | (0.008) | (0.063) | (0.031) | (0.020) | (0.017) | (0.036) | (0.086) |
| HCC/DCG Risk Score | 0.050 | −0.969** | −0.041 | −0.088 | 0.598*** | 0.214 | −0.072 |
| | (0.047) | (0.409) | (0.140) | (0.102) | (0.105) | (0.166) | (0.508) |
| Age | −0.004** | −0.019* | −0.025*** | 0.003 | 0.044*** | −0.030*** | −0.038*** |
| | (0.002) | (0.010) | (0.004) | (0.003) | (0.003) | (0.005) | (0.010) |
| Female Patients | −0.095** | −0.595*** | −0.478*** | −0.714*** | 0.250*** | −0.540*** | −0.445 |
| | (0.041) | (0.198) | (0.114) | (0.068) | (0.079) | (0.136) | (0.319) |
| Medicare | 0.137** | −0.129 | 0.134 | −0.395*** | 0.205 | 0.889*** | 0.763** |
| | (0.065) | (0.459) | (0.165) | (0.082) | (0.128) | (0.223) | (0.386) |
| Medicaid | 0.207*** | 0.834*** | 1.249*** | 0.619*** | 0.123 | 0.299 | 0.212 |
| | (0.077) | (0.245) | (0.263) | (0.102) | (0.128) | (0.268) | (0.424) |
| Median Income | −0.054 | −0.224 | −0.057 | −0.078 | 0.009 | −0.152 | 0.234 |
| (log) | (0.053) | (0.191) | (0.086) | (0.089) | (0.077) | (0.110) | (0.225) |
| Uninsured Rate | 0.094 | 0.796 | −0.708 | 0.345 | 0.506 | 1.085 | −0.182 |
| (share) | (0.213) | (1.109) | (0.542) | (0.302) | (0.425) | (0.764) | (0.963) |
| Unemployment Rate | −0.531* | −1.105 | −1.822*** | −0.503 | −0.723 | 0.066 | 2.173 |
| (share) | (0.288) | (1.286) | (0.382) | (0.405) | (0.467) | (0.907) | (1.571) |
| Black (share) | 0.394* | 1.441** | 0.181 | 0.598** | 0.207 | 0.375 | −0.401 |
| | (0.218) | (0.707) | (0.511) | (0.282) | (0.261) | (0.403) | (0.667) |
| Female (share) | 0.145 | −0.550 | 0.911** | −0.087 | 0.261 | 0.129 | −1.239 |
| | (0.192) | (0.591) | (0.431) | (0.260) | (0.250) | (0.375) | (0.879) |
| Asian (share) | −0.348 | 1.447** | −0.848 | 0.178 | −0.192 | −1.910*** | 0.019 |
| | (0.274) | (0.691) | (0.689) | (0.372) | (0.540) | (0.609) | (1.678) |
| Age 65+ (share) | 0.594** | 0.972 | −0.079 | 0.804** | −0.019 | 0.796 | 1.738* |
| | (0.247) | (0.976) | (0.583) | (0.330) | (0.393) | (0.619) | (0.913) |
| Age under 18 | −0.138 | −0.488 | −0.116 | −0.139 | −0.298 | 0.329 | 0.346 |
| (share) | (0.332) | (0.651) | (0.672) | (0.350) | (0.391) | (0.657) | (1.133) |
| Bachelor+ (share) | 0.397 | −0.227 | 1.198 | 0.098 | −0.017 | −0.008 | 2.999** |
| | (0.255) | (1.443) | (1.022) | (0.371) | (0.447) | (0.499) | (1.356) |
| HS Graduate | 0.472** | 1.269 | 0.880* | 0.740*** | 0.796* | 0.330 | 3.236*** |
| (share) | (0.231) | (0.810) | (0.457) | (0.279) | (0.481) | (0.604) | (1.055) |
| ZIP code fixed effects | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Quarter fixed effects | Yes | Yes | Yes | Yes | Yes | Yes | Yes |
| Observations | 13,939 | 11,403 | 12,783 | 13,768 | 13,499 | 12,532 | 10,890 |
| HSA clusters | 97 | 90 | 95 | 96 | 96 | 90 | 89 |

Table A2, continued

| Variable | (8) Bipolar/ Manic | (9) Depression | (10) Anxiety & OCD | (11) Mixed Behavior/ Personality | (12) Neuro-developmental/ Childhood | (13) Specific Personality |
|---|---|---|---|---|---|---|
| Treated × Post | 0.028 | 0.130*** | 0.047** | 0.206*** | 0.020 | 0.685** |
| | (0.030) | (0.026) | (0.022) | (0.048) | (0.043) | (0.284) |
| Charlson Comorbidity Index | 0.058* | 0.058*** | −0.001 | 0.090 | 0.030 | −0.837** |
| | (0.035) | (0.020) | (0.017) | (0.078) | (0.055) | (0.419) |
| HCC/DCG Risk Score | 0.153 | −0.009 | −0.171* | −0.282 | 0.932*** | −1.771 |
| | (0.130) | (0.098) | (0.088) | (0.241) | (0.268) | (1.851) |
| Age | −0.034*** | −0.013*** | 0.007*** | −0.068*** | −0.077*** | 0.044 |
| | (0.005) | (0.003) | (0.002) | (0.008) | (0.006) | (0.080) |
| Female Patients | −0.076 | 0.161*** | 0.483*** | −0.020 | −0.889*** | −0.052 |
| | (0.086) | (0.043) | (0.058) | (0.220) | (0.197) | (2.278) |
| Medicare | 0.216 | 0.190 | 0.050 | 0.987*** | 1.989*** | 1.617 |
| | (0.199) | (0.122) | (0.099) | (0.317) | (0.240) | (2.594) |
| Medicaid | −0.219 | −0.393*** | 0.024 | −0.426 | 0.493* | 0.913 |
| | (0.166) | (0.102) | (0.134) | (0.368) | (0.262) | (3.596) |
| Median Income (log) | 0.068 | −0.028 | −0.140** | −0.018 | 0.281 | 1.071 |
| | (0.123) | (0.064) | (0.062) | (0.137) | (0.171) | (1.871) |
| Uninsured Rate (share) | 0.354 | −0.592** | −0.004 | 0.946 | 0.249 | −3.621 |
| | (0.424) | (0.244) | (0.342) | (0.963) | (0.726) | (5.923) |
| Unemployment Rate (share) | −0.377 | −0.095 | −0.826* | −0.399 | −0.551 | −12.916* |
| | (0.828) | (0.421) | (0.470) | (1.176) | (1.339) | (7.279) |
| Black (share) | 0.330 | 0.074 | 0.268 | 0.717 | 0.174 | 2.714 |
| | (0.311) | (0.304) | (0.229) | (1.002) | (0.462) | (3.891) |
| Female (share) | 0.105 | 0.373 | 0.113 | 2.336*** | −0.863 | 11.554* |
| | (0.381) | (0.288) | (0.303) | (0.748) | (0.602) | (6.907) |
| Asian (share) | −0.960 | −0.547 | 0.206 | −2.797** | −1.785** | −16.899* |
| | (0.628) | (0.369) | (0.393) | (1.103) | (0.775) | (9.529) |
| Age 65+ (share) | 1.322*** | 0.673** | 0.022 | 0.116 | 1.698** | −5.300 |
| | (0.465) | (0.317) | (0.387) | (0.677) | (0.809) | (6.142) |
| Age under 18 (share) | 0.722 | −0.369 | −0.550 | 0.382 | 0.648 | −6.981 |
| | (0.565) | (0.345) | (0.435) | (0.973) | (0.864) | (6.346) |
| Bachelor+ (share) | 0.773 | 0.512 | 0.724* | −0.163 | −0.108 | 21.450* |
| | (0.558) | (0.314) | (0.385) | (1.117) | (0.784) | (11.511) |
| HS Graduate (share) | 0.228 | 0.264 | 0.211 | 0.451 | 0.094 | 8.372 |
| | (0.404) | (0.329) | (0.425) | (0.798) | (0.639) | (8.916) |
| ZIP code fixed effects | Yes | Yes | Yes | Yes | Yes | Yes |
| Quarter fixed effects | Yes | Yes | Yes | Yes | Yes | Yes |
| Observations | 13,334 | 13,805 | 13,659 | 11,316 | 11,892 | 2,078 |
| HSA clusters | 93 | 97 | 95 | 88 | 91 | 37 |

*Notes:* Each column reports a separate Poisson pseudo-maximum likelihood (PPML) regression of equation (1) for the outcome in the column header, with ZIP code population as the exposure term. Variables are defined as in Table 1. Female Patients enters the model as the mean of the coded patient-sex field (female = 3, male = 4), which equals 4 minus the female share, so its coefficient is reported with the sign reversed. Standard errors (in parentheses) are clustered at the Health Service Area (HSA) level. Buffer-zone sample with ZIP code-level Mahalanobis matching. Sample: 2018Q1–2022Q4, 2020Q2 excluded. $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$.

Table A3: Buffer Zone Sensitivity: Baseline DID Across Alternative Cutoffs, All Outcomes

| | Vary lower (upper = 180) | | | Main | Vary upper (lower = 120) | | | | Constant 60-min width | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Outcome | [90,180] | [100,180] | [110,180] | [120,180] | [120,150] | [120,160] | [120,170] | [120,190] | [90,150] | [100,160] | [110,170] | [130,190] |
| All Mental Disorders | 0.075*** | 0.070*** | 0.071*** | 0.065*** | 0.057*** | 0.060*** | 0.059*** | 0.070*** | 0.065*** | 0.060*** | 0.061*** | 0.074*** |
| | (0.012) | (0.013) | (0.013) | (0.014) | (0.016) | (0.016) | (0.016) | (0.014) | (0.014) | (0.015) | (0.016) | (0.014) |
| Cannabis Use | 0.018 | 0.030 | 0.023 | −0.003 | 0.013 | 0.007 | 0.009 | 0.008 | 0.033 | 0.035 | 0.029 | 0.010 |
| | (0.080) | (0.076) | (0.072) | (0.077) | (0.074) | (0.072) | (0.072) | (0.075) | (0.079) | (0.073) | (0.068) | (0.071) |
| Other Substance Use | −0.011 | −0.006 | −0.007 | −0.010 | −0.007 | −0.010 | −0.008 | −0.010 | −0.005 | −0.006 | −0.006 | −0.010 |
| | (0.042) | (0.037) | (0.035) | (0.035) | (0.036) | (0.035) | (0.036) | (0.036) | (0.042) | (0.037) | (0.037) | (0.033) |
| Alcohol & Tobacco Use | 0.056*** | 0.043** | 0.044** | 0.042* | 0.025 | 0.027 | 0.026 | 0.043* | 0.039* | 0.021 | 0.020 | 0.052** |
| | (0.019) | (0.021) | (0.020) | (0.023) | (0.026) | (0.027) | (0.027) | (0.022) | (0.022) | (0.025) | (0.027) | (0.024) |
| Dementia and Organic Mental Disorders | 0.071*** | 0.058** | 0.063*** | 0.060** | 0.047** | 0.048* | 0.049** | 0.071*** | 0.054** | 0.042 | 0.045* | 0.079*** |
| | (0.023) | (0.025) | (0.024) | (0.024) | (0.024) | (0.025) | (0.025) | (0.024) | (0.026) | (0.026) | (0.026) | (0.023) |
| Psychosis | 0.105*** | 0.081*** | 0.081*** | 0.088*** | 0.088*** | 0.086*** | 0.086*** | 0.094*** | 0.094*** | 0.077** | 0.082** | 0.092*** |
| | (0.028) | (0.031) | (0.030) | (0.029) | (0.031) | (0.029) | (0.029) | (0.029) | (0.033) | (0.035) | (0.033) | (0.026) |
| PTSD | 0.014 | 0.046 | 0.060 | 0.045 | −0.008 | −0.011 | −0.019 | 0.051 | −0.013 | −0.007 | −0.021 | 0.075 |
| | (0.053) | (0.051) | (0.054) | (0.058) | (0.061) | (0.062) | (0.062) | (0.059) | (0.065) | (0.064) | (0.063) | (0.060) |
| Bipolar/Manic | 0.010 | 0.015 | 0.030 | 0.028 | 0.001 | 0.011 | 0.008 | 0.036 | −0.002 | 0.000 | 0.005 | 0.029 |
| | (0.030) | (0.029) | (0.028) | (0.030) | (0.031) | (0.031) | (0.031) | (0.031) | (0.027) | (0.029) | (0.029) | (0.031) |
| Depression | 0.128*** | 0.134*** | 0.133*** | 0.130*** | 0.123*** | 0.124*** | 0.123*** | 0.134*** | 0.116*** | 0.125*** | 0.126*** | 0.141*** |
| | (0.026) | (0.028) | (0.026) | (0.026) | (0.028) | (0.027) | (0.027) | (0.025) | (0.028) | (0.029) | (0.028) | (0.025) |
| Anxiety & OCD | 0.078*** | 0.065*** | 0.060*** | 0.047** | 0.054** | 0.061*** | 0.062*** | 0.048** | 0.078*** | 0.075*** | 0.075*** | 0.049** |
| | (0.022) | (0.023) | (0.022) | (0.022) | (0.023) | (0.023) | (0.023) | (0.022) | (0.025) | (0.026) | (0.025) | (0.024) |
| Mixed Behavior/Personality Disorders | 0.195*** | 0.185*** | 0.176*** | 0.206*** | 0.197*** | 0.213*** | 0.209*** | 0.201*** | 0.181*** | 0.164*** | 0.181*** | 0.208*** |
| | (0.053) | (0.049) | (0.052) | (0.048) | (0.043) | (0.044) | (0.043) | (0.047) | (0.049) | (0.045) | (0.045) | (0.045) |
| Neurodevelopmental/Childhood Disorders | 0.038 | 0.034 | 0.024 | 0.020 | −0.011 | −0.001 | 0.001 | 0.044 | 0.031 | −0.009 | 0.000 | 0.039 |
| | (0.051) | (0.046) | (0.043) | (0.043) | (0.045) | (0.044) | (0.044) | (0.041) | (0.049) | (0.048) | (0.046) | (0.040) |
| Specific Personality Disorders | 0.579* | 0.528* | 0.611** | 0.685** | 0.552** | 0.607** | 0.607** | 0.685** | 0.459 | 0.550* | 0.533* | 0.884*** |
| | (0.299) | (0.277) | (0.289) | (0.284) | (0.280) | (0.275) | (0.275) | (0.284) | (0.319) | (0.302) | (0.281) | (0.316) |

*Notes:* Each cell reports $\hat{\beta}^{\text{DID}}$, the coefficient on Treat × Post from the PPML model in equation (1), with ZIP code and quarter fixed effects and ZIP code–quarter controls. Column headers give the treated and control cutoffs $[c, f]$: counties with average driving time $\leq c$ minutes are treated, counties with average driving time $> f$ minutes are controls, and counties in between are excluded. The main specification is [120,180]. Standard errors (in parentheses) are clustered at the Health Service Area (HSA) level. Sample: 2018Q1–2022Q4, 2020Q2 excluded. $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$.

Table A4: Baseline DID Across Alternative Sample Restrictions: All Outcomes

| Outcome | (1) Main Sample | (2) Full Sample | (3) Excl. COVID & Delta | (4) Excl. COVID & Omicron | (5) Excl. COVID, Delta & Omicron |
|---|---|---|---|---|---|
| All Mental Disorders | 0.065*** | 0.061*** | 0.072*** | 0.065*** | 0.072*** |
| | (0.014) | (0.015) | (0.014) | (0.015) | (0.015) |
| Cannabis Use | −0.003 | −0.005 | −0.004 | −0.012 | −0.017 |
| | (0.077) | (0.071) | (0.079) | (0.081) | (0.084) |
| Other Substance Use | −0.010 | −0.010 | −0.008 | −0.008 | −0.004 |
| | (0.035) | (0.035) | (0.036) | (0.036) | (0.037) |
| Alcohol & Tobacco Use | 0.042* | 0.034 | 0.039 | 0.041* | 0.037 |
| | (0.023) | (0.025) | (0.024) | (0.024) | (0.027) |
| Dementia and Organic Mental Disorders | 0.060** | 0.057** | 0.073*** | 0.056** | 0.071*** |
| | (0.024) | (0.023) | (0.025) | (0.024) | (0.025) |
| Psychosis | 0.088*** | 0.090*** | 0.097*** | 0.087*** | 0.098*** |
| | (0.029) | (0.028) | (0.030) | (0.031) | (0.033) |
| PTSD | 0.045 | 0.034 | 0.086 | 0.053 | 0.102 |
| | (0.058) | (0.058) | (0.064) | (0.061) | (0.067) |
| Bipolar/Manic | 0.028 | 0.024 | 0.029 | 0.030 | 0.031 |
| | (0.030) | (0.031) | (0.032) | (0.030) | (0.031) |
| Depression | 0.130*** | 0.128*** | 0.156*** | 0.136*** | 0.168*** |
| | (0.026) | (0.026) | (0.030) | (0.025) | (0.030) |
| Anxiety & OCD | 0.047** | 0.045** | 0.041* | 0.039* | 0.031 |
| | (0.022) | (0.022) | (0.024) | (0.022) | (0.024) |
| Mixed Behavior/Personality Disorders | 0.206*** | 0.206*** | 0.239*** | 0.221*** | 0.263*** |
| | (0.048) | (0.046) | (0.053) | (0.051) | (0.055) |
| Neurodevelopmental/Childhood Disorders | 0.020 | 0.031 | 0.031 | 0.026 | 0.039 |
| | (0.043) | (0.043) | (0.041) | (0.041) | (0.038) |
| Specific Personality Disorders | 0.685** | 0.611** | 0.771*** | 0.655** | 0.751** |
| | (0.284) | (0.301) | (0.292) | (0.294) | (0.318) |

*Notes:* Each cell reports $\hat{\beta}^{\text{DID}}$, the coefficient on Treat × Post from the PPML model in equation (1), with ZIP code and quarter fixed effects and ZIP code–quarter controls. (1) excludes 2020Q2 (main sample); (2) keeps all quarters; (3) also excludes 2021Q3 (Delta); (4) also excludes 2022Q1 (Omicron); (5) excludes 2020Q2, 2021Q3, and 2022Q1. Standard errors (in parentheses) are clustered at the Health Service Area (HSA) level. $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$.

Table A5: Baseline DID with ZIP Code-Level Clustering

| | HSA cluster (Main) | ZIP code cluster |
|---|---|---|
| Outcome | $\hat{\beta}^{\text{DID}}$ | $\hat{\beta}^{\text{DID}}$ |
| All Mental Disorders | 0.065*** | 0.065*** |
| | (0.014) | (0.010) |
| Cannabis Use | −0.003 | −0.003 |
| | (0.077) | (0.047) |
| Other Substance Use | −0.010 | −0.010 |
| | (0.035) | (0.029) |
| Alcohol & Tobacco Use | 0.042* | 0.042*** |
| | (0.023) | (0.014) |
| Dementia and Organic Mental Disorders | 0.060** | 0.060*** |
| | (0.024) | (0.019) |
| Psychosis | 0.088*** | 0.088*** |
| | (0.029) | (0.029) |
| PTSD | 0.045 | 0.045 |
| | (0.058) | (0.061) |
| Bipolar/Manic | 0.028 | 0.028 |
| | (0.030) | (0.026) |
| Depression | 0.130*** | 0.130*** |
| | (0.026) | (0.017) |
| Anxiety & OCD | 0.047** | 0.047*** |
| | (0.022) | (0.015) |
| Mixed Behavior/Personality Disorders | 0.206*** | 0.206*** |
| | (0.048) | (0.056) |
| Neurodevelopmental/Childhood Disorders | 0.020 | 0.020 |
| | (0.043) | (0.033) |
| Specific Personality Disorders | 0.685** | 0.685* |
| | (0.284) | (0.372) |

*Notes:* Both columns report the same point estimates from the baseline PPML specification; they differ only in the level at which standard errors are clustered, the Health Service Area (HSA) in the main specification and the ZIP code in the alternative. Sample: 2018Q1–2022Q4, 2020Q2 excluded. $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$.

Table A6: Alternative Estimator: Linear Model for Hospitalization Rates

| | PPML (Main) | | OLS |
|---|---|---|---|
| Outcome | $\hat{\beta}^{\text{DID}}$ | Per 1,000 | $\hat{\beta}^{\text{DID}}$ (per 1,000) |
| All Mental Disorders | 0.065*** | 0.830*** | 1.073*** |
| | (0.014) | (0.190) | (0.243) |
| Cannabis Use | −0.003 | −0.001 | −0.009 |
| | (0.077) | (0.017) | (0.018) |
| Other Substance Use | −0.010 | −0.006 | 0.045 |
| | (0.035) | (0.020) | (0.044) |
| Alcohol & Tobacco Use | 0.042* | 0.140* | 0.273** |
| | (0.023) | (0.076) | (0.110) |
| Dementia and Organic Mental Disorders | 0.060** | 0.088** | 0.134* |
| | (0.024) | (0.037) | (0.075) |
| Psychosis | 0.088*** | 0.053*** | 0.048* |
| | (0.029) | (0.018) | (0.027) |
| PTSD | 0.045 | 0.004 | −0.003 |
| | (0.058) | (0.005) | (0.011) |
| Bipolar/Manic | 0.028 | 0.025 | 0.046 |
| | (0.030) | (0.027) | (0.050) |
| Depression | 0.130*** | 0.378*** | 0.409*** |
| | (0.026) | (0.080) | (0.101) |
| Anxiety & OCD | 0.047** | 0.113** | 0.165 |
| | (0.022) | (0.055) | (0.102) |
| Mixed Behavior/Personality Disorders | 0.206*** | 0.049*** | −0.033 |
| | (0.048) | (0.013) | (0.069) |
| Neurodevelopmental/Childhood Disorders | 0.020 | 0.007 | −0.006 |
| | (0.043) | (0.014) | (0.043) |
| Specific Personality Disorders | 0.685** | 0.015* | 0.005** |
| | (0.284) | (0.009) | (0.002) |

*Notes:* Column (1) repeats the PPML estimates of Table 4. Column (2) converts them to hospitalizations per 1,000 residents per quarter, $\bar{Y}_c\,(e^{\hat{\beta}} - 1)$, where $\bar{Y}_c$ is the control mean, with delta-method standard errors; its significance stars are based on these standard errors. Column (3) estimates the same difference-in-differences design by OLS with the hospitalization rate per 1,000 residents as the dependent variable and log population added to the controls ($N$ = 13,945). All columns include ZIP code and quarter fixed effects; standard errors (in parentheses) are clustered at the Health Service Area (HSA) level. Sample: 2018Q1–2022Q4, 2020Q2 excluded. $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$.

Table A7: Placebo Test: All Outcomes

| | Pre-pandemic | | | Post-lockdown |
|---|---|---|---|---|
| Outcome | 2019Q1 | 2019Q2 | 2019Q3 | 2021Q1 |
| All Mental Disorders | 0.019 | 0.024 | 0.027 | 0.001 |
| | (0.020) | (0.020) | (0.021) | (0.011) |
| Cannabis Use | −0.105 | −0.048 | −0.060 | 0.028 |
| | (0.075) | (0.081) | (0.077) | (0.070) |
| Other Substance Use | −0.166*** | −0.162*** | −0.133*** | −0.076** |
| | (0.038) | (0.036) | (0.029) | (0.038) |
| Alcohol & Tobacco Use | 0.031 | 0.045 | 0.050 | −0.007 |
| | (0.029) | (0.027) | (0.033) | (0.024) |
| Dementia and Organic Mental Disorders | 0.028 | 0.023 | 0.014 | −0.015 |
| | (0.032) | (0.026) | (0.026) | (0.027) |
| Psychosis | −0.024 | −0.017 | −0.020 | 0.002 |
| | (0.031) | (0.040) | (0.043) | (0.037) |
| PTSD | 0.145** | 0.150** | 0.143* | 0.070 |
| | (0.064) | (0.074) | (0.080) | (0.108) |
| Bipolar/Manic | 0.016 | 0.024 | 0.029 | 0.051 |
| | (0.026) | (0.028) | (0.034) | (0.032) |
| Depression | 0.013 | 0.020 | 0.024 | −0.030 |
| | (0.026) | (0.028) | (0.028) | (0.025) |
| Anxiety & OCD | 0.075*** | 0.062*** | 0.063*** | 0.021 |
| | (0.015) | (0.017) | (0.017) | (0.028) |
| Mixed Behavior/Personality Disorders | 0.209*** | 0.217*** | 0.226*** | 0.160** |
| | (0.065) | (0.053) | (0.048) | (0.082) |
| Neurodevelopmental/Childhood Disorders | 0.025 | 0.041 | 0.022 | 0.048 |
| | (0.030) | (0.035) | (0.039) | (0.080) |
| Specific Personality Disorders | 0.958** | 0.903** | 1.040*** | 1.504* |
| | (0.396) | (0.388) | (0.325) | (0.818) |

*Notes:* Each cell reports the coefficient on Treat × Post from the PPML model when the quarter in the column header is assigned as a fake treatment date and the model is estimated on the pre-policy sample alone (2018Q1–2021Q1, 2020Q2 excluded). The true treatment date is 2021Q2; 2021Q1 is the quarter immediately before the policy takes effect. All specifications include ZIP code and quarter fixed effects with ZIP code–quarter controls; standard errors (in parentheses) are clustered at the Health Service Area (HSA) level. $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$.

# Appendix Figures

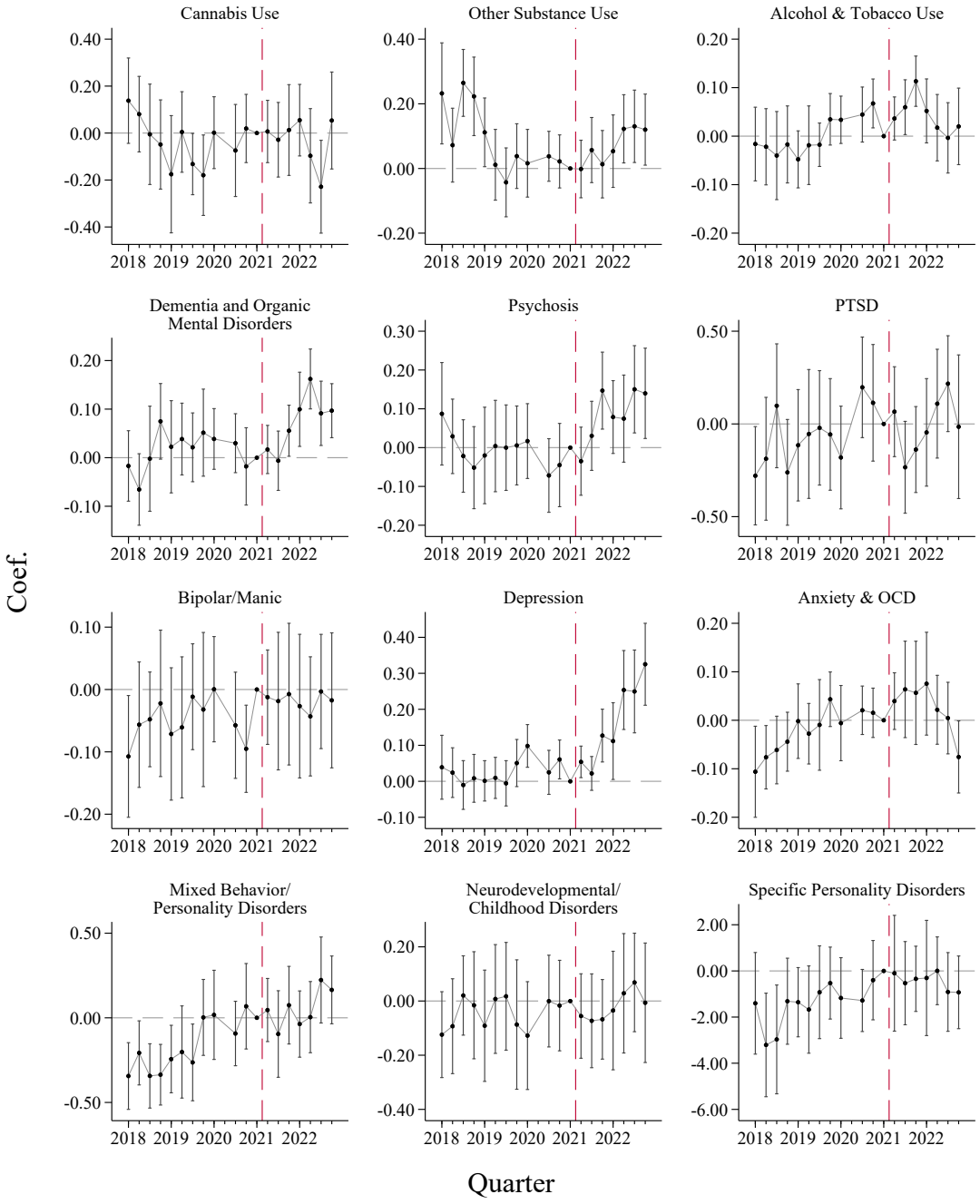
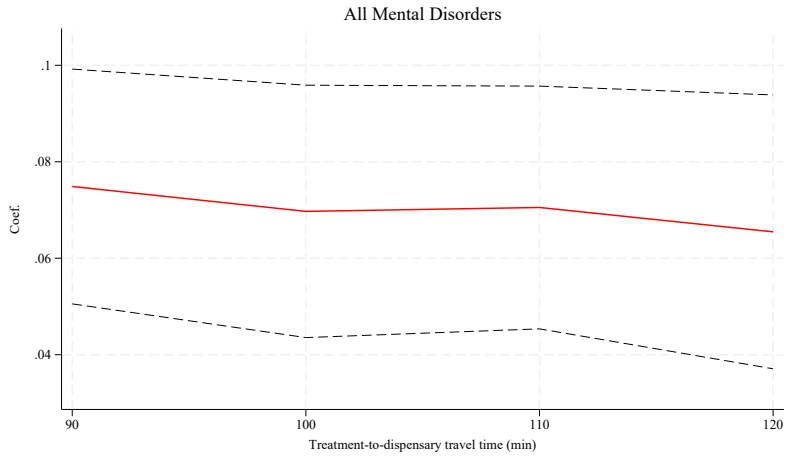
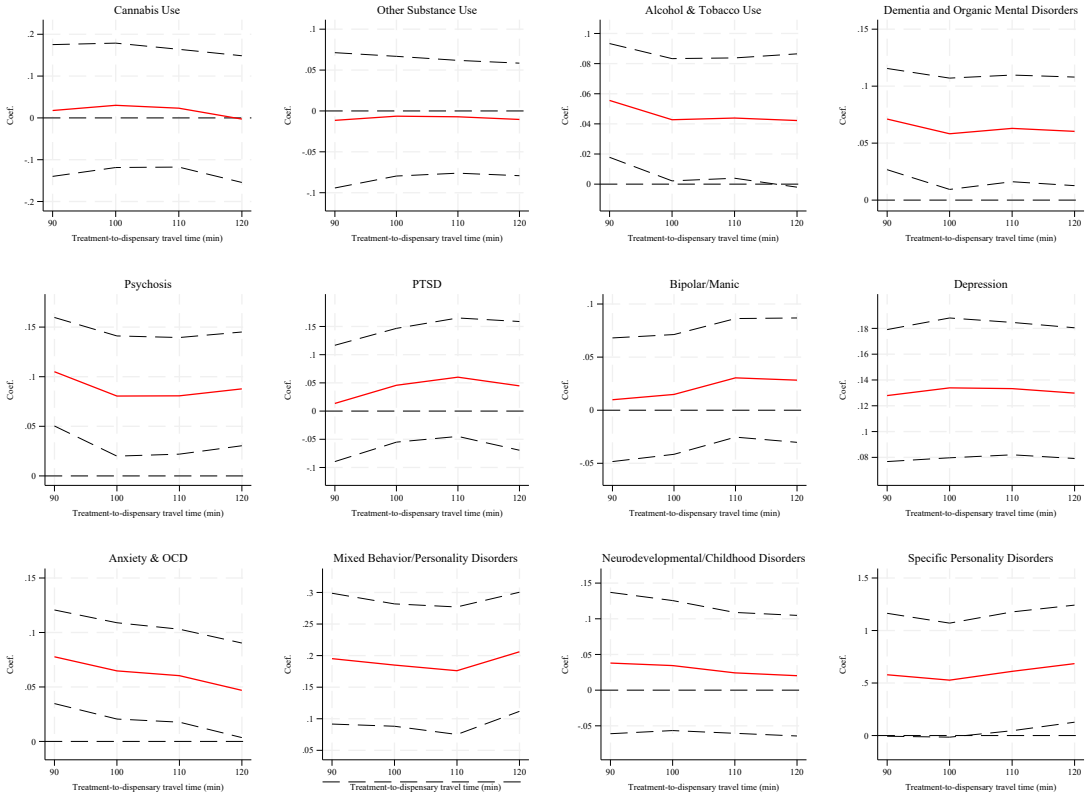



Figure A1: Event Studies by Diagnostic Category

*Notes:* Each panel plots quarter-by-quarter treatment–control differences from a fully interacted PPML specification with ZIP code and quarter fixed effects, ZIP code–quarter controls, and ZIP code population as the exposure. The reference period is 2021Q1, and 2020Q2 is excluded. Vertical bars are 95% confidence intervals based on standard errors clustered at the Health Service Area (HSA) level. The dashed line separates the reference quarter (2021Q1) from the first post-legalization quarter (2021Q2).



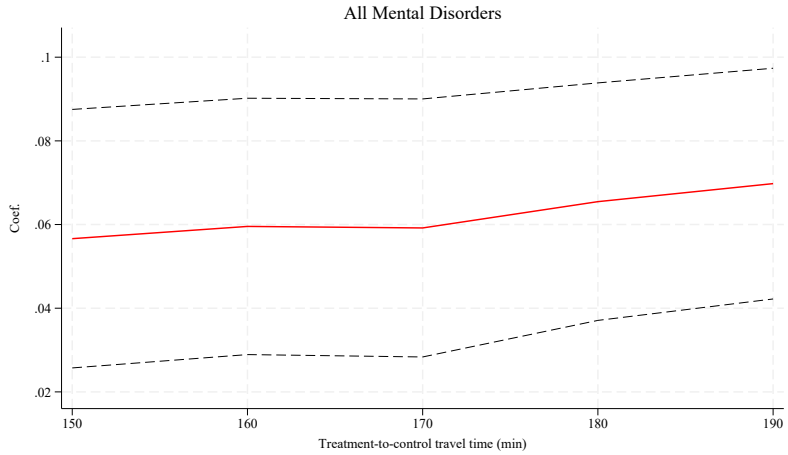

(a) All Mental Disorders



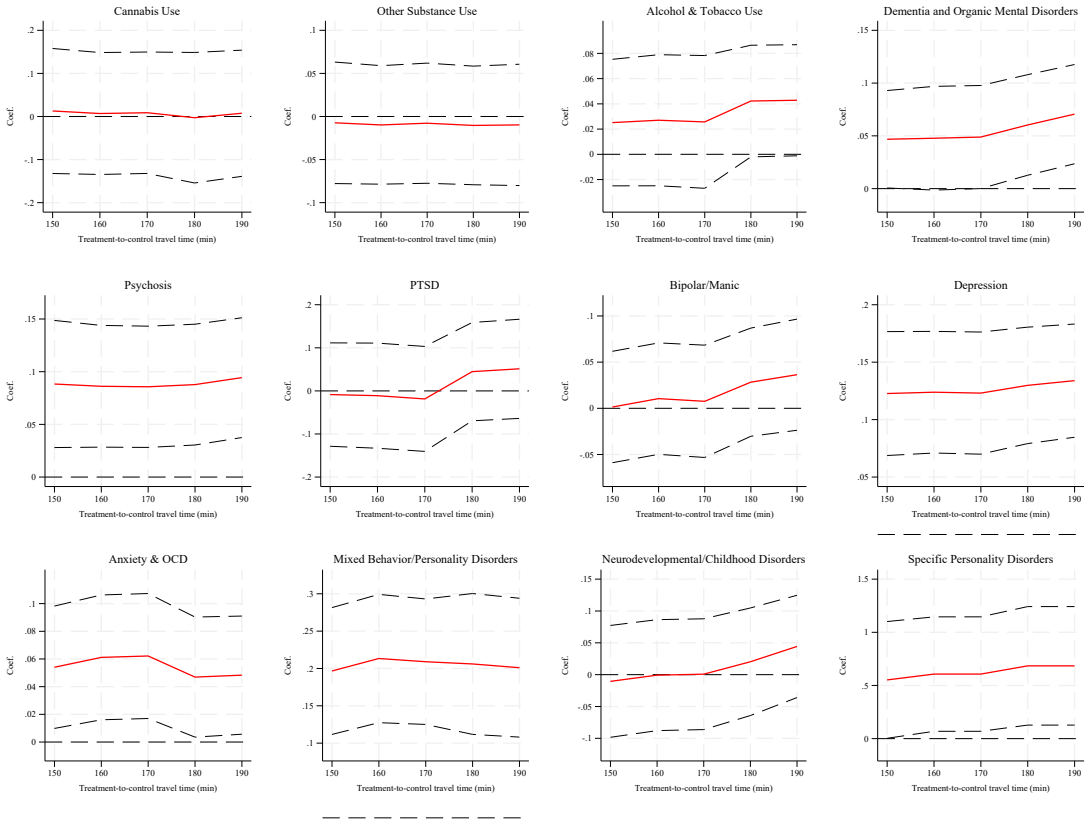

(b) By Diagnostic Category

Figure A2: Buffer Zone Sensitivity: Varying Lower Bound (Upper Fixed at 180 min)

*Notes:* The solid line plots the Treat × Post coefficient from the PPML specification as the lower bound of the buffer zone (the maximum travel time defining treated counties) varies from 90 to 120 minutes, with the upper bound fixed at 180 minutes. Dashed lines are 95% confidence intervals based on standard errors clustered at the Health Service Area (HSA) level. The main specification is [120,180].



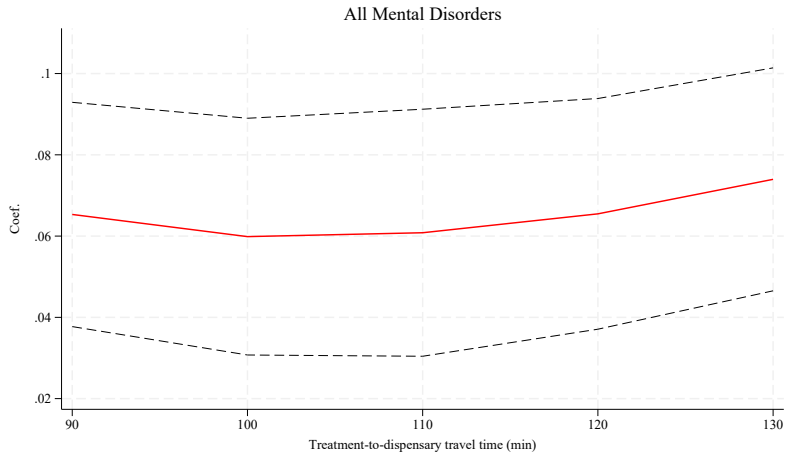

(a) All Mental Disorders



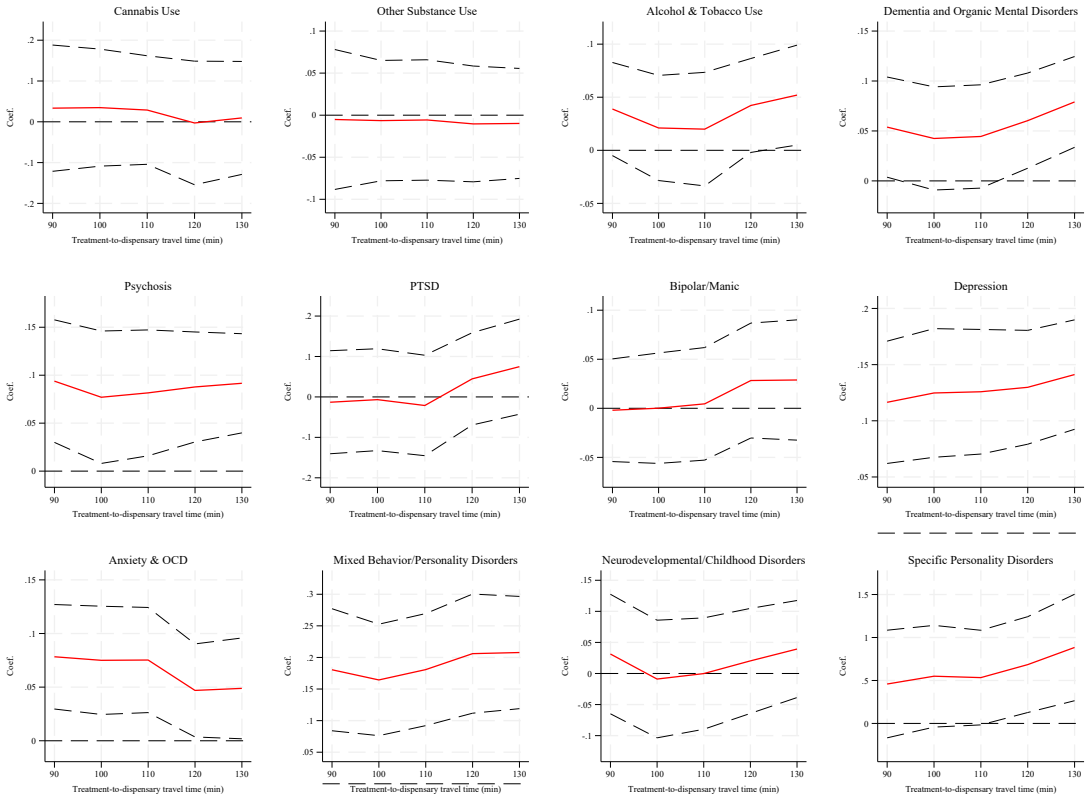

(b) By Diagnostic Category

Figure A3: Buffer Zone Sensitivity: Varying Upper Bound (Lower Fixed at 120 min)

*Notes:* Same as Figure A2 but varying the upper bound (the minimum travel time defining control counties) from 150 to 190 minutes, with the lower bound fixed at 120 minutes.




(a) All Mental Disorders




(b) By Diagnostic Category

Figure A4: Buffer Zone Sensitivity: Constant 60-Minute Buffer Width

*Notes:* Same as Figure A2 but maintaining a constant 60-minute buffer width while shifting both bounds (treated–control cutoff pairs 90–150, 100–160, 110–170, 120–180, and 130–190 minutes).

# Appendix B: Treatment Effects by Distance to New Jersey within the Treated Area

The binary treatment indicator assigns the same effect to every treated ZIP code, but the effect need not be uniform within the treated area. Residents of Philadelphia, of other highly urbanized counties, and of the counties nearest New Jersey may already have had access to cannabis before legalization. If so, legalization changed their access less, and the effect should be smaller there.

## B.1 Effects by travel-time band and by county

Figure B1 re-estimates equation (1) with the treatment indicator split into five travel-time bands (<30, 30–45, 45–60, 60–90, and 90+ minutes to the two nearest New Jersey dispensaries), each compared with the same control ZIP codes. The effect on All Mental Disorders is 1.8 percent (not significant) in the band closest to New Jersey, 4.7 percent at 30–45 minutes, and about 10 percent in each band beyond 45 minutes; the three bands beyond 45 minutes are statistically indistinguishable ($p = 0.59$). The effect is therefore not a linear function of distance: it is smaller near the border and similar across the bands beyond 45 minutes. Panel (b) estimates a separate effect for each treated county. The three counties with the shortest travel times have the smallest effects: Philadelphia (4.7 percent), Delaware ($-0.4$ percent), and Bucks (2.3 percent). The other treated counties range from 6.8 to 14.6 percent and are significant at the 1 percent level, except for Carbon (1.7 percent) and Pike (7.7 percent), the two counties with the fewest ZIP codes, whose estimates are imprecise.

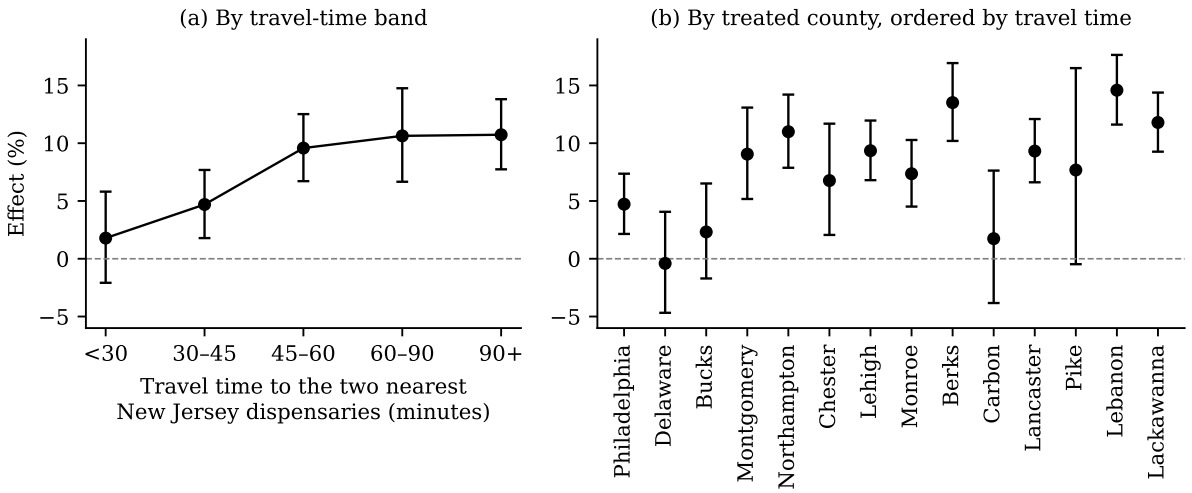



Figure B1: Treatment Effects on All Mental Disorders by Travel Time within the Treated Area

*Notes:* Panel (a) plots the Treated × Post coefficient from equation (1) estimated separately for treated ZIP codes in five travel-time bands, each relative to the same matched control ZIP codes. Panel (b) plots the coefficient from equation (1) estimated with a separate Treated × Post term for each treated county, ordered by the county's population-weighted mean travel time. Effects are expressed as $100(e^{\hat{\beta}} - 1)$ percent. Vertical bars are 95% confidence intervals based on standard errors clustered at the Health Service Area (HSA) level. All specifications include ZIP code and quarter fixed effects, ZIP code–quarter controls, and ZIP code population as the exposure. Sample: 2018Q1–2022Q4, 2020Q2 excluded.

Table B1 shows that the near-border bands differ from the rest of the treated area in ways consistent with the hypothesis. The nearest band lies entirely within urban cores, with a population density of 4,730 residents per square mile, against 260–570 in the bands beyond 45 minutes. Within the same travel-time band, ZIP codes outside urban cores have an effect that is 4.4 percentage points larger ($p = 0.02$). Before legalization, past-month cannabis use among residents aged 12 and older was 13.0 percent in Philadelphia, compared with 6.8–8.7 percent in the survey regions containing the other treated counties and 8.5 percent statewide (Substance Abuse and Mental Health Services Administration, 2020). The two counties with the smallest effects had decriminalized possession of small amounts of cannabis before New Jersey's law took effect, Philadelphia in 2014 and Delaware County in November 2020. Across the treated counties other than Philadelphia, the effect on depression and anxiety is smaller where cannabis use among 10th-grade students was higher in 2019: 2.1 percent lower per standard deviation of the county use rate, measured relative to non-psychiatric discharges in the same ZIP code and quarter ($p = 0.01$). Non-psychiatric discharges themselves show no corresponding difference. Each pattern is consistent with residents of the most urban and nearest counties having had access to cannabis before legalization.

Table B1: Treated ZIP Codes by Travel-Time Band: Pre-Legalization Characteristics and Treatment Effects

| Travel-time band (minutes) | <30 | 30–45 | 45–60 | 60–90 | 90+ |
|---|---|---|---|---|---|
| Mean travel time (minutes) | 22.9 | 37.0 | 52.2 | 73.4 | 99.5 |
| Population density (residents per square mile) | 4,730 | 1,221 | 570 | 260 | 345 |
| Share of ZIP codes in an urban core (percent) | 100 | 99 | 99 | 69 | 92 |
| Effect on All Mental Disorders (percent) | 1.8 | 4.7*** | 9.6*** | 10.6*** | 10.7*** |
| | (2.0) | (1.5) | (1.5) | (2.1) | (1.5) |

*Notes:* Bands group treated ZIP codes by their mean post-policy driving time to the two nearest New Jersey dispensaries. Population density uses ACS ZIP code population and ZCTA land area, averaged over the ZIP codes in each band; urban core is the metropolitan core category of the 2010 Rural–Urban Commuting Area codes. Effects are $100(e^{\hat{\beta}} - 1)$ percent from equation (1) with the treatment indicator split by band; standard errors of the percent effect, clustered at the Health Service Area (HSA) level, in parentheses. The three bands beyond 45 minutes are not statistically different from one another ($p = 0.59$). $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$.

## B.2 Continuous-intensity specification

A continuous exposure index points in the same direction, I estimate

$$E\left[Y_{zt} \mid \cdot\right] = \exp\left\{\beta_1 \left(\text{Post}_t \times E_{zt}\right) + \beta_2 \left(\text{Post}_t \times E_{zt}^2\right) + \mu_z + \lambda_t + W_{zt}'\Gamma + \ln \text{Pop}_{zt}\right\}, \quad (2)$$

where the exposure index $E_{zt} = 1/\bar{d}_{zt}$ is the reciprocal of the average driving time $\bar{d}_{zt}$, in minutes, from the centroid of ZIP code $z$ to the two nearest New Jersey dispensaries open in quarter $t$, so that a larger value of the index corresponds to a shorter trip. Adult cannabis sales began at existing medical alternative treatment centers (New Jersey Cannabis Regulatory Commission, 2022a), so the locations that determine the index change little at the retail opening; before April 2022, the index measures proximity to dispensaries that served only registered medical patients and later started making recreational sales. The sample includes both treated and control ZIP codes; control ZIP codes have exposure close to zero (for example, $1/283 \approx 0.004$). The index varies little within a ZIP code over the post-policy period (about 3 percent of its post-period variance is within ZIP codes) and mainly across health service areas, so this specification is estimated less precisely than the binary design. $W_{zt}$ and $\text{Pop}_{zt}$ are defined as in equation (1), the model is estimated by PPML, and standard errors are clustered by Health Service Area.

Table B2 reports the estimates. For All Mental Disorders, the linear term is positive and the quadratic term negative, which implies an inverted U in exposure, but neither coefficient is statistically significant. Figure B2 plots the implied post-policy change in the log of expected hospitalizations at driving time $d$, $\hat{\beta}_1/d + \hat{\beta}_2/d^2$, with 95 percent confidence

intervals calculated using the delta method. The prediction is positive over most of the range in which treated ZIP codes lie, reaches a maximum of about 2.8 percent near 44 minutes, and declines slowly at longer driving times; the confidence interval includes zero at every driving time. Below about 22 minutes the prediction turns negative. This is a property of the quadratic in $1/d$, not of the data. Only 31 of the 583 treated ZIP codes lie below 20 minutes, so the functional form fixes the curve's shape there, and the band estimates in Figure B1 describe the effect near the border better. Table B3 shows that the estimates are similar when exposure is measured from the three nearest dispensaries.

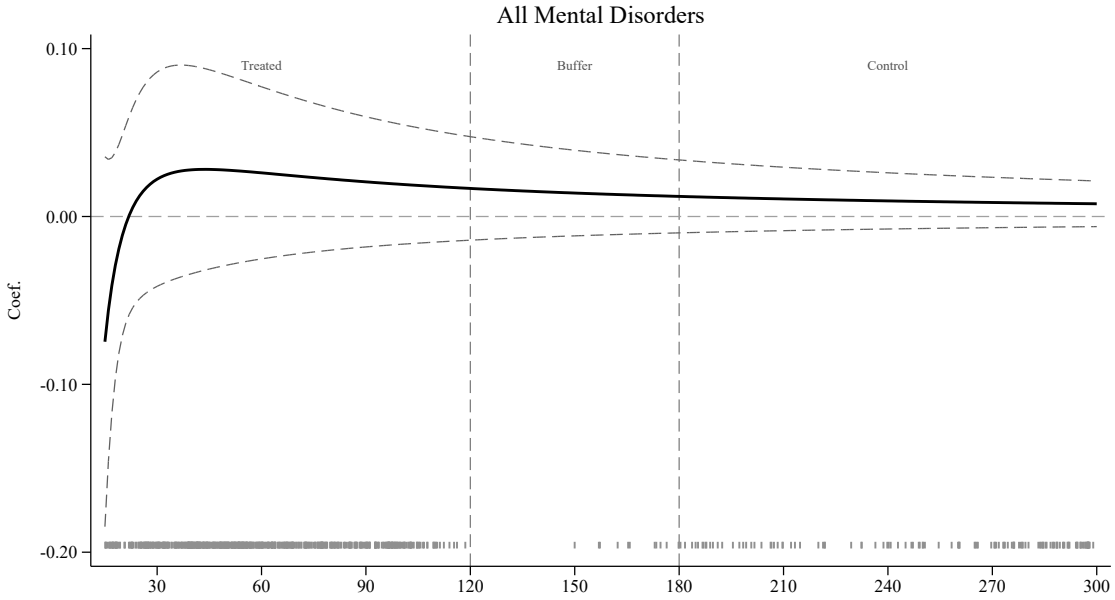



Figure B2: Dose–Response Curve: All Mental Disorders

*Notes:* The solid line plots the predicted post-legalization change in the log of expected hospitalizations for All Mental Disorders, $\hat{\beta}_1/d + \hat{\beta}_2/d^2$, as a function of driving time $d$ to the two nearest New Jersey dispensaries, based on the PPML quadratic specification in equation (2). Dashed lines are 95% confidence intervals computed via the delta method from standard errors clustered at the Health Service Area (HSA) level. Vertical dashed lines mark 120 and 180 minutes. Each tick mark along the horizontal axis is one ZIP code in the estimation sample, placed at its mean post-period driving time. Sample: 2018Q1–2022Q4, 2020Q2 excluded.

Table B2: Continuous Treatment Intensity DID Results (Quadratic Specification)

| | Quadratic specification | |
|---|---|---|
| Outcome | $\hat{\beta}_1$ | $\hat{\beta}_2$ |
| All Mental Disorders | 2.453 | −53.588 |
| | (2.212) | (40.779) |
| Cannabis Use | 4.547 | −197.349 |
| | (7.069) | (124.694) |
| Other Substance Use | −2.900 | 38.588 |
| | (2.270) | (32.381) |
| Alcohol & Tobacco Use | 2.937 | −89.283 |
| | (3.174) | (59.038) |
| Dementia and Organic Mental Disorders | 2.210 | −60.779 |
| | (2.332) | (42.102) |
| Psychosis | 2.978* | −16.185 |
| | (1.623) | (23.117) |
| PTSD | −1.175 | −30.799 |
| | (6.040) | (121.663) |
| Bipolar/Manic | −3.061 | 8.891 |
| | (2.814) | (44.115) |
| Depression | 5.042* | −68.218* |
| | (2.738) | (40.597) |
| Anxiety & OCD | 2.848 | −50.987 |
| | (2.353) | (43.656) |
| Mixed Behavior/Personality Disorders | 11.886** | −218.376** |
| | (5.867) | (102.244) |
| Neurodevelopmental/Childhood Disorders | 3.984 | −68.953 |
| | (2.840) | (44.593) |
| Specific Personality Disorders | 22.022 | −289.738 |
| | (38.727) | (661.840) |
| Controls | Yes | |
| Quarter FE | Yes | |
| ZIP code FE | Yes | |

*Notes:* Columns report $\hat{\beta}_1$ and $\hat{\beta}_2$ from the quadratic continuous-intensity model in equation (2), estimated by PPML with the hospitalization count as the dependent variable and ZIP code population as the exposure. The exposure index $E_{zt} = 1/\bar{d}_{zt}$ is the reciprocal of the average driving time (minutes) to the two nearest New Jersey dispensaries. $N$ is the same as in Table 4. Standard errors (in parentheses) are clustered at the Health Service Area (HSA) level. Sample: 2018Q1–2022Q4, 2020Q2 excluded. $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$.

Table B3: Continuous Treatment Intensity: Three Nearest Dispensaries

| | Two nearest dispensaries | | Three nearest dispensaries | |
|---|---|---|---|---|
| Outcome | $\hat{\beta}_1$ | $\hat{\beta}_2$ | $\hat{\beta}_1$ | $\hat{\beta}_2$ |
| All Mental Disorders | 2.453 | −53.588 | 3.021 | −72.840 |
| | (2.212) | (40.779) | (2.526) | (52.333) |
| Cannabis Use | 4.547 | −197.349 | 6.050 | −261.502 |
| | (7.069) | (124.694) | (8.197) | (163.058) |
| Other Substance Use | −2.900 | 38.588 | −2.913 | 39.636 |
| | (2.270) | (32.381) | (2.454) | (39.829) |
| Alcohol & Tobacco Use | 2.937 | −89.283 | 3.973 | −129.289* |
| | (3.174) | (59.038) | (3.532) | (73.965) |
| Dementia and Organic Mental Disorders | 2.210 | −60.779 | 2.804 | −82.736 |
| | (2.332) | (42.102) | (2.717) | (56.124) |
| Psychosis | 2.978* | −16.185 | 2.981 | −11.209 |
| | (1.623) | (23.117) | (1.852) | (30.838) |
| PTSD | −1.175 | −30.799 | −1.989 | −26.635 |
| | (6.040) | (121.663) | (6.554) | (141.658) |
| Bipolar/Manic | −3.061 | 8.891 | −2.607 | −6.056 |
| | (2.814) | (44.115) | (3.037) | (54.829) |
| Depression | 5.042* | −68.218* | 5.139* | −73.332 |
| | (2.738) | (40.597) | (3.068) | (52.596) |
| Anxiety & OCD | 2.848 | −50.987 | 3.536 | −67.591 |
| | (2.353) | (43.656) | (2.664) | (55.333) |
| Mixed Behavior/Personality Disorders | 11.886** | −218.376** | 14.337** | −290.436** |
| | (5.867) | (102.244) | (6.682) | (127.636) |
| Neurodevelopmental/Childhood Disorders | 3.984 | −68.953 | 3.867 | −77.860 |
| | (2.840) | (44.593) | (3.161) | (56.278) |
| Specific Personality Disorders | 22.022 | −289.738 | 44.508 | −824.545 |
| | (38.727) | (661.840) | (39.340) | (774.222) |

*Notes:* The table re-estimates the quadratic PPML continuous-intensity model in equation (2) with exposure measured from the two nearest (columns 1–2) and three nearest (columns 3–4) New Jersey dispensaries. All specifications include ZIP code and quarter fixed effects with ZIP code–quarter controls, and ZIP code population as the exposure. Standard errors (in parentheses) are clustered at the Health Service Area (HSA) level. Sample: 2018Q1–2022Q4, 2020Q2 excluded. $^{*}p < 0.10$, $^{**}p < 0.05$, $^{***}p < 0.01$.