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# Changes in Inpatient Healthcare Utilization after Legalization of Recreational Cannabis



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# Changes in Inpatient Healthcare Utilization after Legalization of Recreational Cannabis

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## ABSTRACT

**OBJECTIVE:** To assess the effect of cannabis legalization on health effects and healthcare utilization.

**DESIGN:** We used the 2010-2014 Healthcare Cost and Utilization Project (HCUP) inpatient databases to compare changes in rates of healthcare utilization and diagnoses in Colorado (CO) versus 2 control states, New York (NY) and Oklahoma (OK).

**SETTING:** Population-based, inpatient**.**

**PARTICIPANTS:** HCUP state-wide data comprising over 28 million individuals and over 16 million hospitalizations across 3 states.

**MAIN OUTCOME MEASURES:** We used International Classification of Diseases-9th Edition (ICD-9) codes to assess changes in healthcare utilization specific to various medical diagnoses potentially treated by or exacerbated by cannabis use. Diagnoses were classified based on weight of evidence from the National Academy of Science (NAS).

**RESULTS**: In CO compared to NY and OK, respectively, cannabis abuse increased (risk ratio [RR], 1.30; 95% confidence interval [CI], 1.26 to 1.34 and RR 1.27; 95% CI 1.27 to 1.28) post-legalization. In CO, there was a minimal reduction in total admissions (RR 0.98; 95% CI 0.98 to 0.99 and RR 0.97; 95% CI 0.92 to 1.02) and length of stay (-3.98% per year; 95% CI -4.13 to -3.82% and -2.48%, 95% CI -2.57 to -2.38%), and a small yearly increase in costs (1.83%; 95% CI 1.82 to 1.84% and 4.9%; 95% CI 4.68 to 5.13%) compared to NY and OK, respectively. Post-legalization changes most consistent with NAS-based evidence included less Tourette syndrome and post-traumatic stress disorder, but more alcohol abuse (each meeting a Bonferroni-corrected $P<0.0014$ compared to each control state).

**CONCLUSIONS:** Cannabis legalization is associated with neutral effects on healthcare utilization, and variable health effects relative to previously established evidence. Such

population-level effects may help guide future decisions regarding cannabis use, prescription, and policy.

## Strengths and limitations of this study

- The study focuses on the impact of recreational cannabis legalization on health care utilization instead of its legal or societal effects
- This study utilizes HCUP data comprising over 28 million individuals and over 16 million hospitalizations
- Stringent standards were employed to address possible false positives due to multiple hypotheses testing
- Follow up data after the 2012 Amendment 64 only includes two subsequent years
- Physician coding with ICD-9 codes does not capture potentially important mediators related to cannabis use

## INTRODUCTION

Over 147 million people, or 2.5 percent of the world's population, use cannabis (marijuana),[1] and more than 20 million Americans have reported the use of cannabis in the past 30 days.[1] Because cannabis use is a federal crime, clinical studies have been challenging to pursue, resulting in substantial knowledge gaps regarding actual health consequences. Twenty-eight states and the District of Columbia now allow cannabis for the treatment of medical conditions.[2] Of these, 9 have recently legalized cannabis for recreational use. Given such pervasive policy changes, understanding potential shifts in healthcare utilization is vital.

A rigorous summary of the evidence regarding the health effects of cannabis was recently reported by the National Academy of Science (NAS).[3] While this is a valuable starting place that makes use of the available data, we do not yet know whether that evidence, based largely on small studies, will translate into real-world ramifications after legalization of recreational cannabis.

On December 10, 2012, Colorado enacted *Colorado Amendment 64,* legalizing recreational cannabis. This change provides a unique opportunity to observe changes in healthcare utilization and diagnoses that occur when access to cannabis becomes liberalized.

## METHODS

We used Agency for Healthcare Research and Quality (AHRQ)-funded Healthcare Cost and Utilization Project (HCUP) databases to measure inpatient healthcare utilization and diagnoses in Colorado (CO) between 2010 and 2014. Comparisons were made

with 2 control states in order to address possible secular trends. New York (NY), the most populous state with inpatient HCUP data available up to 2014 was selected, and, to counter this coastal and largely urban state, we also selected Oklahoma (OK), a predominately rural state directly adjacent to CO with HCUP hospitalization data up to 2014. Annual demographic data, including age, sex, and race, was obtained from the United States Census Bureau. Only month and year were available in all HCUP databases; as legalization took effect on December 10, 2012, hospitalizations following December 2012 were considered "after" enactment of the law. Patients with missing information on age, sex, race, and year of encounter were excluded.

Age, sex, race, income level, and insurance payer were recorded at each healthcare encounter. Hispanic ethnicity was not coded in the OK State Department of Health data source. In order to use comparable categorizations across the 3 states, we separated race into white, black, Native American, and other. Income level was categorized by quartiles using the median household income for each patient's ZIP code. Income level was not available for OK.

We first performed a validation analysis to assess changes in cannabis abuse diagnoses in CO after versus before recreational cannabis legalization and compared those rates to changes in NY and OK over the same time period. To determine changes in overall healthcare utilization, we assessed changes in total number of hospitalizations, length of inpatient stay, and healthcare costs. We estimated the cost of each hospitalization by multiplying the charges by a cost-to-charge ratio for the admitting hospital for the given year. For NY and CO, we used the all-payer cost-to-charge ratios provided by HCUP. When the all-payer cost-to-charge ratio was missing,

we applied the average cost-to-charge ratio particular to state and year. As HCUP does not provide cost-to-charge ratios for OK, we assumed a constant state-wide cost-to-charge ratio (0.3119 as derived from the Institute for Health and Socio-Economic Policy calculations of federal cost reports) to estimate healthcare costs in OK;[4] we then conducted a sensitivity analysis setting the cost-to-charge ratio for OK to equal to the average for NY and CO for the corresponding year. See online supplementary eMethods and eTable 1 for additional details.

We used International Classification of Diseases-9th Edition (ICD-9) codes (see online supplementary eTable 2) to assess changes in healthcare utilization specific to various medical diagnoses potentially treated by or exacerbated by cannabis use as identified by the NAS summary. Only diagnoses with substantial, moderate, or limited evidence per the NAS were included.

Certification to use de-identified HCUP data was obtained from the University of California, San Francisco Committee on Human Research.

**Statistical Analysis**

Demographic and lifestyle characteristics are presented as mean ± standard deviation (SD) or n (% of total admissions) and were compared between states using linear, logistic, and multinomial models as appropriate. Rates of admissions for NAS diagnoses (with the population size as the denominator) were compared between states using negative binomial models.

To assess the effects of recreational cannabis legalization, we used negative binomial models for the number of admissions, both overall and for particular

diagnoses, with the log of the subgroup population sizes as an offset and the use of robust standard errors. Analogous linear models were utilized for length of stay and cost, which were both log-transformed in order to meet normality assumptions. All models were adjusted for age, race, and sex. In order to relax the linearity assumption, each 5-year age range was included as a separate category. To flexibly model secular patterns, year was included as a categorical rather than continuous variable (with a category for each year between 2010 and 2014). The crucial predictors in our model included an indicator for CO (versus the comparison state) and interactions of this indicator with 2 continuous linear spline basis functions, year-2012, and max (0, year-2012). The main effect for CO estimated the between-state risk ratio (RR) in 2012, the first interaction estimated the slope of the between-state RR in 2010-12, and the second estimated the change in slope after 2012. The first interaction was used to project the counterfactual 2013-2014 rates in CO that would be expected in the absence of legalization, while the second was used to capture the legalization effect. Like a standard interrupted time series (ITS) model, our model assumed that the between-state RR changed linearly at different rates before and after the intervention, but used the categorical indicator for year to relax the standard ITS assumption of piecewise linear trends in the underlying state-specific rates, substantially improving model fit.

A 2-tailed $P<0.05$ was considered statistically significant for the validation analyses (cannabis use), and analyses related to overall healthcare utilization. In order to minimize false positive results and to account for secular trends that might differ across different populations, we assessed for validation in comparisons versus NY and then OK separately.

In order to address possible false positives due to multiple hypotheses testing in assessing all of the diagnoses described in the NAS document, we employed stringent standards: to be considered "positive," the comparisons between CO and *each* of the other 2 states needed to be in the direction expected from the NAS report, each exhibiting statistical significance using a Bonferroni-corrected two-tailed alpha of 0.0014 ($P$=0.05 divided by 35, the number of comparisons derived from NAS-based diagnoses). A "positive" designation also required absence of a statistically significant difference between NY versus OK using a two-tailed alpha of 0.05. All analyses were performed using Stata 15 (StataCorp, College Station, TX).

**Patient and Public Involvement**

The patients and public were not involved in the study.

**RESULTS**

**Baseline Characteristics**

The total number of admissions between 2010 and 2014 are shown for each state in **table 1**. Patients in CO were generally younger, more commonly female, and less ethnically diverse. Wealth in CO was less equally distributed, with a higher proportion of individuals with lower income in CO compared to NY. Finally, admission rates were lower in CO than the control states for most NAS diagnoses, with exceptions for pre-diabetes and post-traumatic stress disorder.

**Study Validation**

Over 2010-2014, the change in rates of cannabis abuse admissions after versus before recreational cannabis legalization in 2012 was greater in CO than in NY and OK (risk ratio [RR], 1.3; 95% confidence interval [CI], 1.2 to 1.3 and RR 1.27; 95% CI 1.27 to 1.28; both *P*<0.00005, respectively) (**figure 1A-B**). No significant changes comparing the two control states, NY and OK, were observed over the same time period (RR 0.96; 95% CI 0.88 to 1.03; *P*=0.26).

**Inpatient Healthcare Utilization after Cannabis Legalization**

*Number of admissions*

In unadjusted analyses, CO, NY, and OK had a similar number of total admissions before and after cannabis legalization (**figure 2A**). After taking population demographics into account, there was a reduction of number of admissions following *Colorado Amendment 64* in CO when compared to NY (RR 0.98; 95% CI 0.98 to 0.99; *P*<0.00005)**.** The point estimate was similar when comparing CO to OK, but did not reach statistical significance (RR 0.97; 95% CI 0.92 to 1.02; *P*=0.27).

*Length of stay*

The median length of stay was also similar after cannabis legalization across the 3 states in unadjusted analyses (**figure 2B**). After adjusting for population demographics, length of inpatient stay was shorter in CO following the law change when compared with each of the 2 control states (3.98% annual reduction; 95% CI -4.13% to -3.82% in CO versus NY, and 2.48% annual reduction, 95% CI -2.57% to -2.38% versus OK; both *P*= 0.002).

*Healthcare Costs*

In unadjusted analyses, the 3 states exhibited similar total costs across the study time period (**figure 2C** and online supplementary eTable 2). In multivariate analyses accounting for population demographics**,** healthcare costs increased by 1.83% (95% CI 1.82 to 1.84%; *P*=0.0003) in CO compared to NY and by 4.9% (95% CI 4.68 to 5.13%; *P*=0.0023) versus OK after cannabis legalization. No meaningful differences were observed in the sensitivity analysis assuming the cost-to-charge ratio for OK was equal to the average of the other states.

**Changes in Specific Diagnoses Highlighted by the National Academy of Sciences**

Among the diagnoses with evidence of influence by cannabis per the NAS (**figure 3**), we distinguished between: 1) a group with no statistically significant post-legalization differences between control states (NY versus OK *P*>0.05), suggesting that secular trends unlikely explained differences between CO and control states; and 2) a group with significant differences in diagnoses post-legalization between control states (NY versus OK *P*<0.05).

In the NY versus OK *P*>0.05 group (**figure 3**), changes in rates of diagnoses after cannabis legalization did not consistently reflect NAS-based evidence. Among the diagnoses most consistent with NAS-based evidence, there was a reduction in Tourette syndrome and post-traumatic stress disorder, and an increase in alcohol abuse after cannabis legalization (each meeting the Bonferroni-corrected alpha, *P*<0.0014). Motor vehicle accidents also increased, although the *P* value compared to OK was 0.073.

Among outcomes where the direction of the effect was discordant with NAS-based evidence, most diagnoses (predominantly cardiometabolic and psychiatric) rested on limited (rather than moderate or substantial) NAS-based evidence. In the NY versus OK $P<0.05$ group (**figure 3**), changes in diagnoses that were concordant with NAS findings and met the Bonferroni alpha included a reduction in chronic pain and an increase in hallucinations. Changes of risk over time with counterfactual are shown for each NAS diagnosis in online supplementary eFigures 1-31.

## DISCUSSION

### Principal findings

Legalization of recreational cannabis was associated with more cannabis abuse, and minimal effects on overall healthcare utilization. Changes in specific medical diagnoses post-legalization did not consistently reflect previously published evidence on the health effects of cannabis.

The increased frequency of cannabis abuse diagnoses in CO helps to validate the concept that legalization would result in greater use.

Effects of cannabis legalization on healthcare utilization appeared to be overall neutral. There was no evidence that either the number of overall hospitalizations or length of stay increased. However, yearly total costs in CO increased to a small degree compared to NY and OK following cannabis legalization, potentially because changing admissions for specific medical diagnoses may have driven costs differently.

Changes in the frequency of diagnoses did not consistently reflect NAS-based evidence. Among the changes in diagnoses consistent with NAS-based evidence that

met the stringent criteria described in the Methods section, there was a reduction in Tourette syndrome and in post-traumatic stress disorder, and an increase in alcohol abuse after cannabis legalization. Motor Vehicle accidents also became more common (meeting Bonferroni-corrected *P* value versus NY, but did not reach statistical significance compared to OK). Although both cited by the NAS as based on limited evidence, cannabis has been shown to be effective in suppressing tics and associated behavioral problems in Tourette syndrome[9] and in reducing symptoms attributed to post-traumatic stress disorder.[10] Consistent with our findings, a substantial bidirectional comorbidity between cannabis use and alcohol use has been previously demonstrated, resulting in a moderate level of evidence designation for this relationship per the NAS.[11] Finally, the NAS document described strong evidence supporting a relationship between cannabis use and motor vehicle accidents, consistent with our data and findings from a meta-analysis using either self-report or laboratory evidence of cannabis use.[12]

**Strengths and Weaknesses**

Although several studies have investigated the health effects of cannabis,[5] they have relied on small sample sizes or have generated conflicting data.[6-8] In contrast, our findings are derived from HCUP state-wide data comprising over 28 million individuals and over 16 million hospitalizations across CO, site of the 2012 *Amendment 64*, and 2 controls states without cannabis legalization over the same time period.

Several limitations should be acknowledged. The HCUP database relies on physician coding; however, such coding for several medical diagnoses listed in **table 1**

have been shown to be highly specific with variable sensitivity[4, 13, 14] and HCUP has proven to be a powerful tool in large population studies.[15-19] Some potentially important mediators are not captured by ICD-9 codes, such as quantity of cannabis used or formulation (oral versus other), although these may be more relevant to identifying mechanisms and their absence would likely not lead to false positive results. As with any observational study, we cannot exclude residual confounding as an explanation of our findings. However, we adjusted for conventionally recognized confounders as appropriate and as available, and, as this was largely a study of the same populations pre- and post-legalization, many of the limitations inherent to conventional individual-level analyses are likely less relevant. The HCUP database does not capture information regarding outpatient activity and therefore these findings are restricted to hospital-based medicine. Our use of Bonferroni correction in assessing changes related to NAS diagnoses may have been too conservative, leading to a sacrifice of false negatives in order to avoid false positives. Finally, our study was limited to two-year follow-up after cannabis legalization, and we therefore cannot comment on long-term effects that may result.

## Conclusions

In conclusion, cannabis legalization is associated with an expected increase in cannabis abuse. Overall effects on inpatient healthcare utilization appear to be neutral, with subtle changes in various components of that utilization likely occurring due to changes in the types of admissions observed. Measurable effects of cannabis legalization on various inpatient diagnoses are not all consistent with previous evidence based on small

studies and experience outside the world of legalized recreational cannabis. These data provide the first description of population-level effects that may help guide future decisions regarding cannabis policy, individuals considering using cannabis, and physicians caring for those who may choose to consume it.

**Contributors** FND and GMM had full access to all of the data in the study and take responsibility for the integrity of the data and the accuracy of the data analysis. FND and GMM were responsible for the study concept and design. All authors contributed to data acquisition, analysis, and interpretation. EV, GN, and GMM completed the statistical analysis. FND and GMM drafted the manuscript and were responsible for the critical revision of the manuscript for important intellectual content. GMM obtained funding for the study. All authors contributed to the administrative, technical, and material support for the study and approved the final version of the manuscript.

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**Competing interests** None declared.

**Patient consent** Not required.

**Ethics approval** Ethical approval to use de-identified HCUP data was obtained from the University of California, San Francisco Committee on Human Research.

**Data sharing** No additional data are available.

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## FIGURE LEGENDS

**Figure 1**. Multivariate adjusted rates of admissions for cannabis abuse over 2010-2014 in Colorado, site of implementation of the 2012 recreational cannabis legalization policy, compared with New York (A) and Oklahoma (B), control states without cannabis legalization. Red lines show the predicted rates of admissions for cannabis abuse had the cannabis legalization policy not been instituted. The comparison between Colorado and the control states with regards to change of risk ratio (RR) slope within the 2010-2012 period (pre-legalization) and 2012-2014 period (post-legalization), as well of the overall RR slope change, are also represented for the Colorado versus New York (A) and Colorado versus Oklahoma (B) comparisons. Red lines show the predicted rates of admissions for cannabis abuse had the cannabis legalization policy not been instituted. Each model was adjusted for age, gender, and race (see Methods section for further details). CI = confidence interval; vs = versus.

**Figure 2**. Healthcare utilization over 2010-2014 in Colorado, site of implementation of the 2012 recreational cannabis legalization policy, and in New York and Oklahoma, control states without cannabis legalization. The total number of admissions/1000 population per year, the median length of stay per year, and the median costs per individual per year are shown in panels A, B, and C, respectively for the 3 states. Error bars denote interquartile ranges. LOS = length of stay.

**Figure 3**. Health outcomes with at least limited evidence of a statistical association with cannabis use based on the National Academy of Science (NAS) summary statement. Two main groups of medical diagnoses are identified based on a non-significant ($P$>0.05) (A) versus significant ($P$<0.05) (B) comparison between New York (NY) and

Oklahoma (OK) (control states without cannabis legalization) with regards to the change of admission rates for such diagnoses following cannabis legalization. *P* values for the comparison between Colorado (CO) (site of cannabis legalization) and NY (rhomboid symbol), or between CO and OK (circular symbol) are shown as either <0.0014 (Bonferroni), <0.05, or > 0.05 using a gray scale for evidence of cannabis benefit (risk ratio [RR] < 1 shown on the left) and cannabis harm (RR>1 shown on the right). Progressively darker shades of green or red indicate greater weight of evidence in the direction of proposed benefit versus harm, respectively, by the NAS.

**Table 1.** Baseline clinical characteristics of the 3 study states.

| | Colorado | New York | Oklahoma | *P* value |
|---|---|---|---|---|
| Total population | 5,197,237 | 19,594,599 | 3,819,383 | |
| Total admissions | 2,088,909 | 11,726,283 | 2,334,988 | |
| Total admissions/1,000 population | 402±0.27 | 598±0.17 | 611±0.40 | 0.0001 |
| **Demographics** | | | | |
| Age – yr | 45 ± 28 | 49 ± 28 | 48 ± 28 | 0.0001 |
| Male – no. (%) | 870,573 (42) | 5,087,181 (41) | 954,848 (43) | 0.0001 |
| Race – no. (%) | | | | 0.0001 |
| White | 1,548,099 (74) | 6,406,582 (55) | 1,879,727 (81) | |
| Black | 102,444 (5) | 2,083,366 (18) | 202,420 (9) | |
| Native American | 13,143 (1) | 36,216 (0.3) | 131,714 (6) | |
| Other | 425,223 (20) | 3,200,119 (27) | 121,127 (5) | |
| **Lifestyle** | | | | |
| Median Household Income, dollars (quartiles for patient ZIP code) – no. (%) | | | | 0.0001 |
| Quartile 1 | 617,537 (30) | 3,087,192 (28) | No data | |
| Quartile 2 | 558,760 (27) | 2,623,087 (24) | | |
| Quartile 3 | 470,051 (23) | 2,673,153 (24) | | |
| Tobacco use – no. (%) | 251,566 (12) | 1,717,940 (10) | 235,685 (14) | 0.0001 |
| Alcohol abuse – no. (%) | 112,715 (5) | 652,608 (6) | 71,931 (3) | 0.0001 |
| **NAS Diagnoses** | | | | |
| Non-seminoma type testicular germ cell cancer – no. (%) | 405 (0.02) | 2,487 (0.02) | 480 (0.02) | 0.0001 |
| Acute myocardial infarction – no. (%) | 39,513 (1.9) | 271,285 (2.3) | 60,413 (2.6) | 0.0001 |
| Brain hemorrhage – no. (%) | 10,963 (0.5) | 58,278 (0.5) | 10,245 (0.4) | 0.0001 |
| Ischemic stroke – no. (%) | 27,986 (1.3) | 194,478 (1.7) | 45,602 (2) | 0.0001 |

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|---|---|---|---|---|
| Metabolic syndrome & diabetes – no. (%) | 294,821 (14) | 2,301,835 (20) | 465,353 (20) | 0.0001 |
| Prediabetes – no. (%) | 42,544 (2) | 73,407 (0.6) | 24,246 (1) | 0.0001 |
| Bronchitis – no. (%) | 65,265 (3) | 429,230 (4) | 131,343 (6) | 0.0001 |
| Motor vehicle accidents – no. (%) | 14,941 (0.7) | 59,686 (0.5) | 13,692 (0.6) | 0.0001 |
| Overdose injury – no. (%) | 10,933 (0.5) | 40,226 (0.3) | 12,147 (0.5) | 0.0001 |
| Substance abuse – no. (%) | 158,244 (7.6) | 974,856 (8.3) | 109,305 (4.7) | 0.0001 |
| Anxiety disorders – no. (%) | 131,426 (6.4) | 595,478 (5.2) | 139,627 (6.1) | 0.0001 |
| Anxiety disorders (except social anxiety) – no. (%) | 51,913 (2.5) | 283,280 (2.4) | 65,279 (2.8) | 0.0016 |
| Bipolar disorders – no. (%) | 52,348 (2.5) | 287,735 (2.5) | 61,411 (2.6) | 0.0001 |
| Depressive disorders – no. (%) | 213,851 (10) | 827,932 (7) | 190,083 (8) | 0.0001 |
| Schizophrenia or other psychoses – no. (%) | 53,652 (2.6) | 352,533 (3) | 68,385 (2.9) | 0.0001 |
| Positive symptoms of schizophrenia (i.e. hallucinations) – no. (%) | 2,653 (0.1) | 9,482 (0.1) | 3,531 (0.2) | 0.0001 |
| Post-traumatic stress disorder – no. (%) | 28,582 (1.4) | 75,608 (0.6) | 17,101 (0.7) | 0.0001 |
| Social anxiety disorder – no. (%) | 295 (0.01) | 1,090 (0.01) | 135 (0.01) | 0.0295 |
| Suicide – no. (%) | 4,957 (0.2) | 15,646 (0.1) | 4,407 (0.2) | 0.0001 |
| Low offspring birthweight – no. (%) | 2,842 (0.1) | 7,462 (0.1) | 1,742 (0.1) | 0.0002 |
| Maternal pregnancy complications – no. (%) | 39,343 (1.9) | 144,353 (1.2) | 40,938 (1.8) | 0.0001 |
| Unemployment/low income – no. (%) | 3,134 (0.2) | 76,789 (0.7) | 730 (0.03) | 0.0001 |
| Nausea or vomiting – no. (%) | 63,806 (3) | 162,11(1.4) | 58,706 (2.5) | 0.0001 |
| Chronic pain – no. (%) | 140,209 (6) | 234,160 (2) | 123,563 (5) | 0.0001 |
| Spasticity – no. (%) | 5,759 (0.3) | 12,517 (0.1) | 5,371 (0.2) | 0.0001 |

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| Short-term sleep – no. (%) | 652 (0.03) | 3,364 (0.03) | 357 (0.02) | 0.0001 |
| Tourette syndrome – no. (%) | 428 (0.02) | 2,784 (0.02) | 336 (0.01) | 0.0001 |
| Increased appetite & weight gain – no. (%) | 1,022 (0.05) | 3,017 (0.03) | 651 (0.03) | 0.0001 |

NAS = National Academy of Science. All NAS diagnoses listed had at least limited evidence of a statistical association with cannabis use based on the 2017 NAS summary statement. Substance abuse includes dependence or abuse of alcohol, tobacco, or other illicit drug. All variables pertain to the 2010-2014 period. Plus-minus values are means ± SD. No. (%) indicates number of admissions with a specific demographic/lifestyle characteristic or NAS diagnosis (% of total admissions). A *P* value less than 0.05 is considered statistically significant.

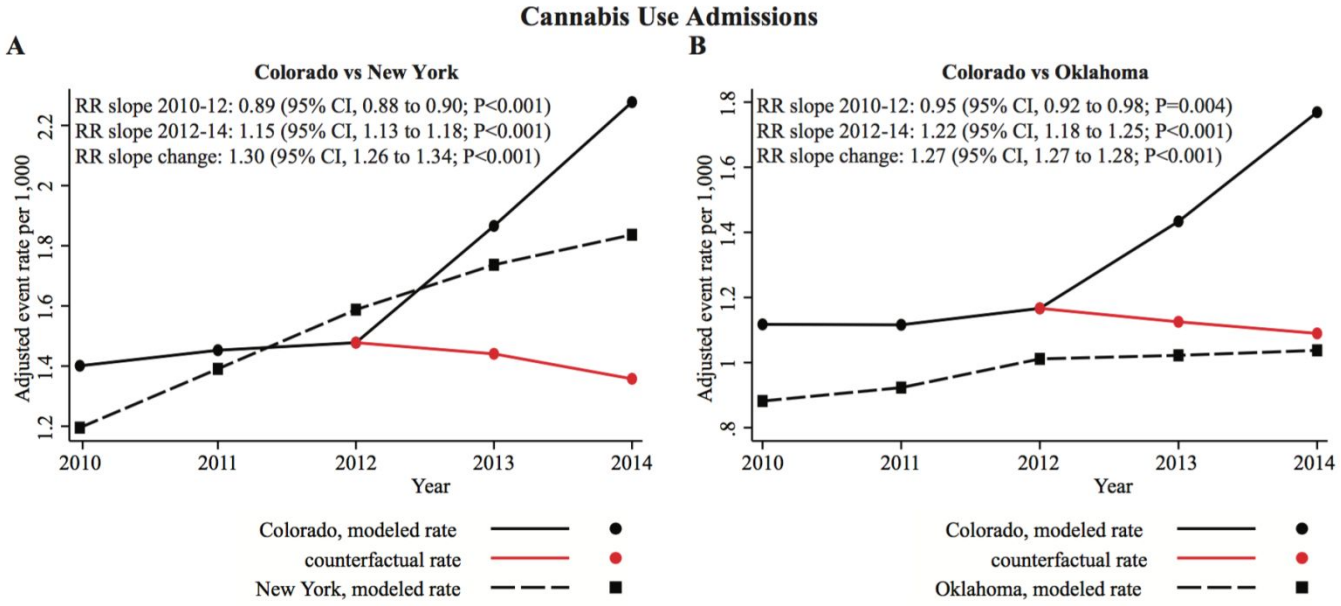
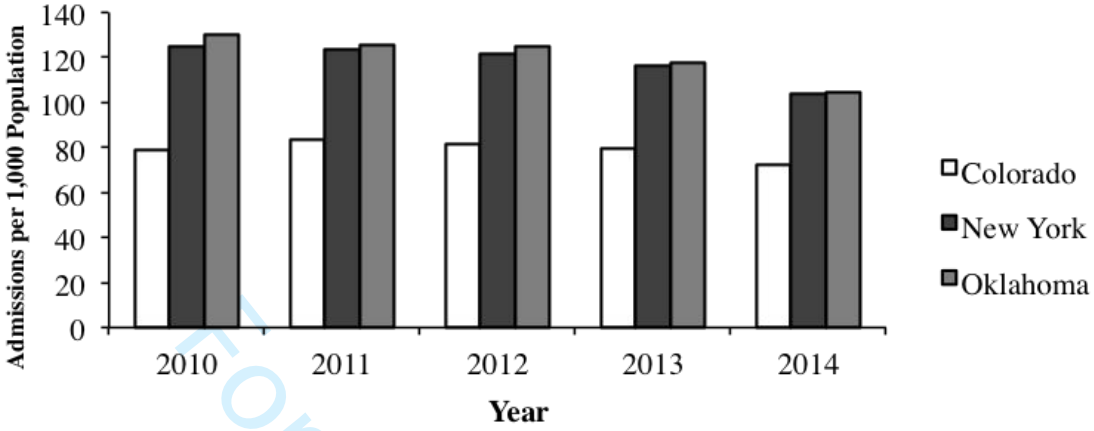
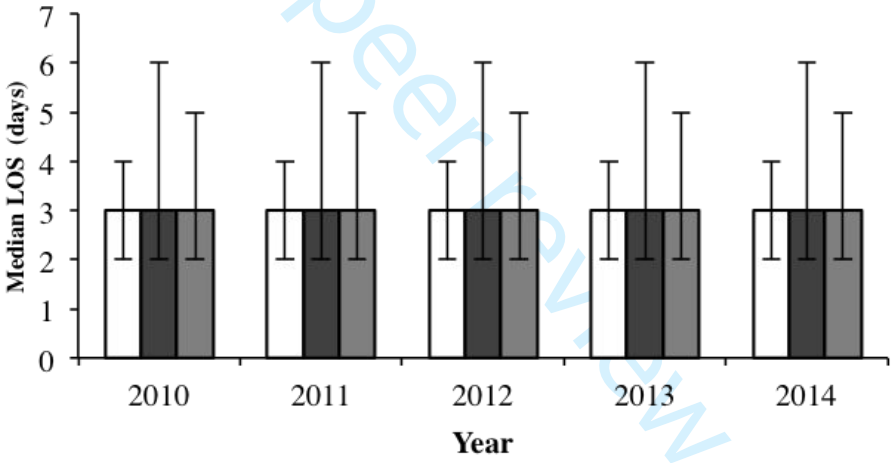



**Figure 1.** Multivariate adjusted rates of admissions for cannabis abuse over 2010-2014 in Colorado, site of implementation of the 2012 recreational cannabis legalization policy, compared with New York (A) and Oklahoma (B), control states without cannabis legalization. Red lines show the predicted rates of admissions for cannabis abuse had the cannabis legalization policy not been instituted. The comparison between Colorado and the control states with regards to change of risk ratio (RR) slope within the 2010-2012 period (pre-legalization) and 2012-2014 period (post-legalization), as well of the overall RR slope change, are also represented for the Colorado versus New York (A) and Colorado versus Oklahoma (B) comparisons. Red lines show the predicted rates of admissions for cannabis abuse had the cannabis legalization policy not been instituted. Each model was adjusted for age, gender, and race (see Methods section for further details). CI = confidence interval; vs = versus.

A




B




C

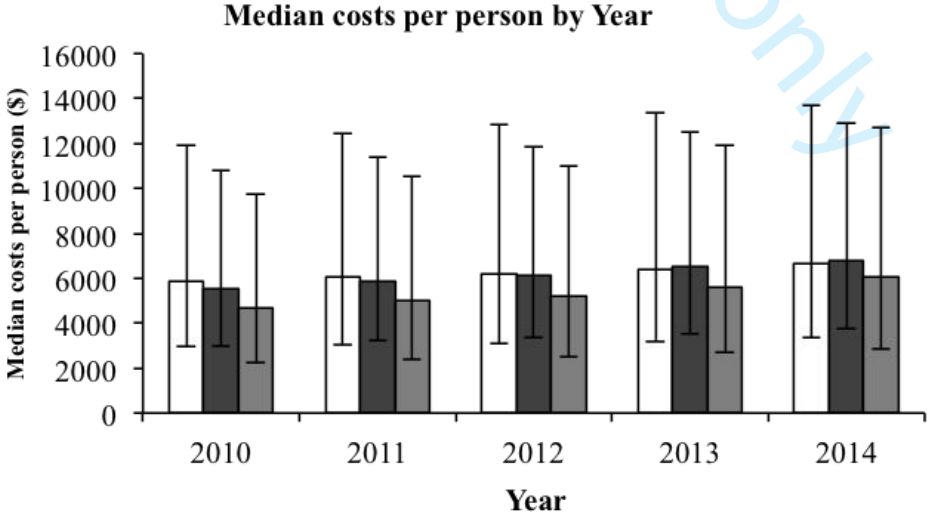


**Figure 2.** Healthcare utilization over 2010-2014 in Colorado, site of implementation of the 2012 recreational cannabis legalization policy, and in New York and Oklahoma, control states without cannabis legalization. The total number of admissions/1000 population per year, the median length of stay per year, and the median costs per individual per year are shown in panels A, B, and C, respectively for the 3 states. Error bars denote interquartile ranges. LOS = length of stay.

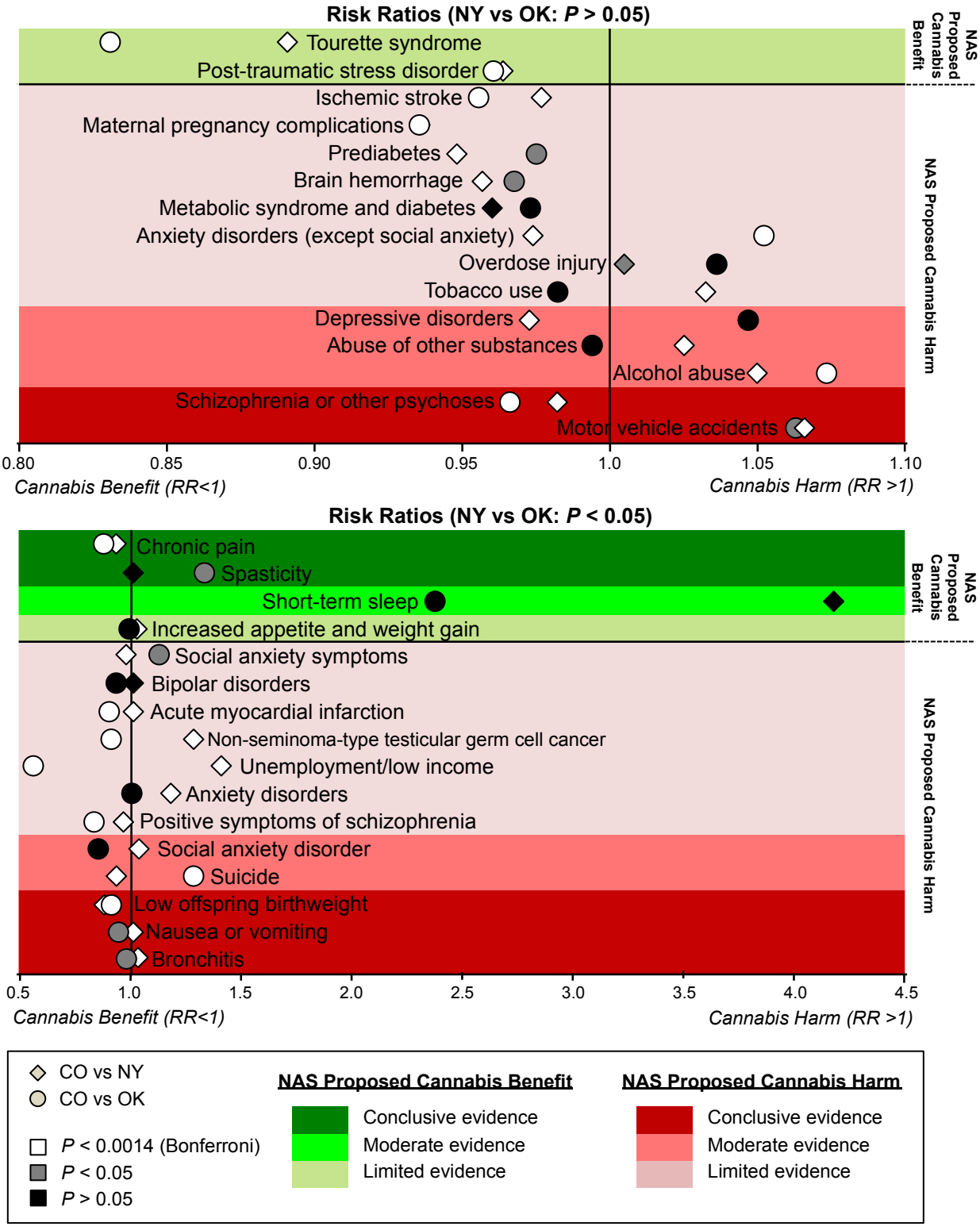



**Figure 3.** Health outcomes with at least limited evidence of a statistical association with cannabis use based on the National Academy of Science (NAS) summary statement.

Two main groups of medical diagnoses are identified based on a non-significant (*P*>0.05) (A) versus significant (*P*<0.05) (B) comparison between New York (NY) and Oklahoma (OK) (control states without cannabis legalization) with regards to the change of admission rates for such diagnoses following cannabis legalization. *P* values for the comparison between Colorado (CO) (site of cannabis legalization) and NY (rhomboid symbol), or between CO and OK (circular symbol) are shown as either <0.0014 (Bonferroni), <0.05, or >0.05 using a gray scale for evidence of cannabis benefit (risk ratio [RR] < 1 shown on the left) and cannabis harm (RR>1 shown on the right). Progressively darker shades of green or red indicate greater weight of evidence in the direction of proposed benefit versus harm, respectively, by the NAS.

# Supplementary Appendix

## Changes in Inpatient Healthcare Utilization after Legalization of Recreational Cannabis

Francesca N. Delling, MD, MPH;[1] Eric Vittinghoff, PhD;[1] Thomas A. Dewland, MD;[2] Mark J. Pletcher, MD, MPH; [1] Jeffrey E. Olgin, MD;[1] Gregory Nah, MA;[1] Kirstin Aschbacher, PhD;[1] Christina Fang, BA;[1] Emily S. Lee, BA;[1] Shannon M. Fan, BA;[1] Dhruv S. Kazi, MD, MS;[1] and Gregory M. Marcus, MD, MAS.[1]

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This supplementary material has been provided by the authors to give readers additional information about their work.

## eMethods. Cost Analysis

### Cost Estimations

The inpatient cost for each hospitalization in New York and Colorado was estimated by multiplying the total charges (TOTCHG) obtained from HCUP State Inpatient Database with the institution-specific all-payer cost-to-charge ratio (APICC) obtained from the Cost-to-Charge Ratio file. Hospital ID was used as a linkage to merge both files. Total inpatient costs were calculated as the sum of the cost for all hospitalizations in a given state for a particular year. The databases contained 186,226 (8.7%) encounters with non-matched/missing hospital ID for NY and 1,132,696 (9.6%) encounters with non-matched/missing hospital ID for Colorado; for these encounters. In order to estimate the cost of these hospitalizations (for which we had charges but no cost-to-charge ratio) we applied the average cost-to-charge ratio for that state-year. This was estimated by dividing the sum of costs for all hospitalizations for which cost-to-charge ratios were available by the sum of charges for all hospitalizations for which cost-to-charge ratios were available in a given state-year (**Table S2**).

### Oklahoma Total Cost Estimate

HCUP does not produce SID and CCR file for Oklahoma. We obtained these data from Oklahoma State Department of Health – this dataset contains information about total charges but not cost-to-charge ratios. We estimated total inpatient costs in Oklahoma in two ways. First, we used a state-wide constant cost-to-charge ratio (0.3119) to estimate the total cost (ratio derived from the Institute for Health and Socio-Economic Policy calculations of federal cost reports). We then conducted a sensitivity analysis in which we used the average of the cost-to-charge ratios of New York and Colorado for any given state-year (**Table S2**).

## eTable 1. Yearly costs and charges for the 3 study states

| Colorado | 2010 | 2011 | 2012 | 2013 | 2014 | 2010 to 2014 |
|---|---|---|---|---|---|---|
| Total hospitalizations, n | 397,505 | 428,912 | 424,640 | 418,952 | 418,900 | 2,088,909 |
| Hospitalizations for which CCR is available, n (%) | 396,433 (99.7%) | 301,586 (70.3%) | 382,021 (90.0%) | 412,483 (98.5%) | 413,160 (98.6%) | 1,905,683 (91.2%) |
| Total charges for hospitalizations for which CCR is available | $14,382,791,648 | $11,170,040,412 | $15,821,232,608 | $19,349,895,615 | $20,370,018,114 | $81,093,978,397 |
| Total costs for hospitalizations for which CCR is available | $4,104,443,164 | $3,033,915,324 | $3,963,892,093 | $4,619,884,886 | $4,700,380,255 | $20,422,515,722 |
| Average CCR* | 0.2854 | 0.2716 | 0.2505 | 0.2388 | 0.2309 | |
| Hospitalizations for which CCR is not available, n (%) | 1,072 (0.3%) | 127,326 (29.7%) | 42,619 (10.0%) | 6,469 (1.5%) | 5,740 (1.4%) | 183,226 (8.8%) |
| Total charges for hospitalizations for which CCR is not available | $55,039,614 | $5,704,285,087 | $2,494,379,901 | $241,011,451 | $211,228,665 | $8,705,944,718 |
| Total costs for hospitalizations for which CCR is not available† | $15,708,306 | $1,549,283,830 | $624,842,165 | $57,553,535 | $48,772,699 | $2,296,160,534 |
| Total inpatient costs | $4,120,151,470 | $4,583,199,154 | $4,588,734,258 | $4,677,438,421 | $4,749,152,954 | $22,718,676,256 |

*Average CCR was estimated by dividing the total of costs for all hospitalizations for which cost-to-charge ratios were available by the total charges for hospitalizations for which cost-to-charge ratios were available in a given state-year.

†Total charges for hospitalization for which CCR is not available multiplied by Average CCR in a given state-year.

| New York | 2010 | 2011 | 2012 | 2013 | 2014 | 2010 to 2014 |
|---|---|---|---|---|---|---|
| Total hospitalizations, n | 2,417,298 | 2,414,985 | 2,389,701 | 2,290,502 | 2,213,797 | 11,726,283 |
| Hospitalizations for which CCR is available, n (%) | 2,189,513 (90.6%) | 2,157,629 (89.3%) | 2,168,880 (90.8%) | 2,056,367 (89.8%) | 2,021,199 (91.3%) | 10,593,588 (90.3%) |
| Total charges for hospitalizations for which CCR is available | $66,303,900,691 | $69,885,515,755 | $74,728,795,811 | $77,680,292,105 | $79,252,368,106 | $367,850,872,468 |
| Total costs for hospitalizations for which CCR is available | $22,376,381,374 | $23,448,311,348 | $24,539,963,919 | $24,331,920,273 | $23,892,478,440 | $118,589,055,354 |
| Average CCR* | 0.3375 | 0.3355 | 0.3283 | 0.3132 | 0.3014 | |
| Hospitalizations for which CCR is not available, n (%) | 227,785 (9.4%) | 257,356 (10.7%) | 220,821 (9.2%) | 234135 (10.2%) | 192,598 (8.7%) | 1,132,695 (9.7%) |
| Total charges for hospitalizations for which CCR is not available | $4,168,104,163 | $4,821,903,339 | $4,088,909,686 | $5,687,320,556 | $5,336,461,039 | $24,102,698,783 |
| Total costs for hospitalizations for which CCR is not available† | $1,406,735,155 | $1,617,748,571 | $1,342,797,941 | $1,781,268,798 | $1,608,409,357 | $7,756,959,821 |
| Total inpatient costs | $23,783,116,529 | $25,066,059,919 | $25,882,761,860 | $26,113,189,071 | $25,500,887,797 | $126,346,015,175 |

*Average CCR was estimated by dividing the total of costs for all hospitalizations for which cost-to-charge ratios were available by the total charges for hospitalizations for which cost-to-charge ratios were available in a given state-year.

†Total charges for hospitalization for which CCR is not available multiplied by Average CCR in a given state-year.

| Oklahoma | 2010 | 2011 | 2012 | 2013 | 2014 | 2010 to 2014 |
|---|---|---|---|---|---|---|
| Total hospitalizations, n | 489,724 | 476,605 | 476,728 | 452,724 | 439,207 | 2,334,988 |
| Hospitalizations for which CCR is available, n (%) | 489724 (100%) | 476605 (100%) | 476728 (100%) | 452724 (100%) | 439207 (100%) | 2334988 (100%) |
| Total charges for hospitalizations for which CCR is available | $13,927,214,520 | $14,645,751,657 | $15,247,598,300 | $15,596,643,583 | $15,003,967,132 | $74,421,175,192 |
| Total costs for hospitalizations for which CCR is available | $4,343,898,209 | $4,568,009,942 | $4,755,725,910 | $4,864,593,134 | $5,001,131,977 | $23,533,359,171 |
| Average CCR* | 0.3119 | 0.3119 | 0.3119 | 0.3119 | 0.3119 | |

*Statewide constant CCR (0.3119) used to estimate the total cost across years.

| Oklahoma (sensitivity analysis) | 2010 | 2011 | 2012 | 2013 | 2014 | 2010 to 2014 |
|---|---|---|---|---|---|---|
| Total hospitalization, n | 489,724 | 476,605 | 476,728 | 452,724 | 439,207 | 2,334,988 |
| Hospitalization for which CCR is available, n (%) | 489724 (100%) | 476605 (100%) | 476728 (100%) | 452724 (100%) | 439207 (100%) | 2334988 (100%) |
| Total charges for hospitalization for which CCR is available | $13,927,214,520 | $14,645,751,657 | $15,247,598,300 | $15,596,643,583 | $15,003,967,132 | $74,421,175,192 |
| Total costs for hospitalization for which CCR is available | $4,337,630,962 | $4,445,717,915 | $4,413,417,328 | $4,304,673,629 | $4,267,557,794 | $21,768,997,628 |
| Average CCR* | 0.3114 | 0.3036 | 0.2895 | 0.276 | 0.2662 | |

*Average of the CCRs of New York and Colorado for any given state-year.

## eTable 2. International Classification of Diseases-9th Edition (ICD-9) codes defining each medical diagnosis.

### Chronic pain

| ICD-9 Code | Short Description | Long Description |
|---|---|---|
| 338.21 | Chronc pain d/t trauma | Chronic pain due to trauma |
| 338.22 | Chron post-thoracot pain | Chronic post-thoracotomy pain |
| 338.28 | Chronic postop pain NEC | Other chronic postoperative pain |
| 338.29 | Chronic pain NEC | Other chronic pain |
| 338.4 | Chronic pain syndrome | Chronic pain syndrome |

### Nausea or vomiting

| ICD-9 Code | Short Description | Long Description |
|---|---|---|
| 787.03 | Vomiting alone | Vomiting alone |
| 787.02 | Nausea alone | Nausea alone |
| 787.01 | Nausea with vomiting | Nausea with vomiting |

### Spasticity

| ICD-9 Code | Short Description | Long Description |
|---|---|---|
| 728.85 | Spasm of muscle | Spasm of muscle |

### Short-term sleep disorders

| ICD-9 Code | Short Description | Long Description |
|---|---|---|
| 307.4 | Nonorganic sleep dis NOS | Nonorganic sleep disorder, unspecified |
| 307.41 | Transient insomnia | Transient disorder of initiating or maintaining sleep |
| 307.42 | Persistent insomnia | Persistent disorder of initiating or maintaining sleep |
| 307.45 | Nonorganic circadian rhy | Circadian rhythm sleep disorder of nonorganic origin |
| 307.47 | Sleep stage dysfunc NEC | Other dysfunctions of sleep stages or arousal from sleep |

| | | |
|---|---|---|
| 307.49 | Nonorganic sleep dis NEC | Other specific disorders of sleep of nonorganic origin |

**Increased appetite and weight gain**

| ICD-9 Code | Short Description | Long Description |
|---|---|---|
| 783.1 | Abnormal weight gain | Abnormal weight gain |
| 783.6 | Polyphagia | Polyphagia |

**Tourette's syndrome**

| ICD-9 Code | Short Description | Long Description |
|---|---|---|
| 307.23 | Tourette's disorder | Tourette's disorder |

**Posttraumatic stress disorder**

| ICD-9 Code | Short Description | Long Description |
|---|---|---|
| 309.81 | Posttraumatic stress dis | Posttraumatic stress disorder |

**Non-seminoma-type testicular germ cell cancer**

| ICD-9 Code | Short Description | Long Description |
|---|---|---|
| 186.9 | Malig neo testis NEC | Malignant neoplasm of other and unspecified testis |

**Acute myocardial infarction**

| ICD-9 Code | Short Description | Long Description |
|---|---|---|
| 410 | AMI anterolateral,unspec | Acute myocardial infarction of anterolateral wall, episode of care unspecified |
| 410.01 | AMI anterolateral, init | Acute myocardial infarction of anterolateral wall, initial episode of care |
| 410.02 | AMI anterolateral,subseq | Acute myocardial infarction of anterolateral wall, subsequent episode of care |
| 410.1 | AMI anterior wall,unspec | Acute myocardial infarction of other anterior wall, episode of care unspecified |
| 410.11 | AMI anterior wall, init | Acute myocardial infarction of other anterior wall, |

| | | |
|---|---|---|
| | | initial episode of care |
| 410.12 | AMI anterior wall,subseq | Acute myocardial infarction of other anterior wall, subsequent episode of care |
| 410.2 | AMI inferolateral,unspec | Acute myocardial infarction of inferolateral wall, episode of care unspecified |
| 410.21 | AMI inferolateral, init | Acute myocardial infarction of inferolateral wall, initial episode of care |
| 410.22 | AMI inferolateral,subseq | Acute myocardial infarction of inferolateral wall, subsequent episode of care |
| 410.3 | AMI inferopost, unspec | Acute myocardial infarction of inferoposterior wall, episode of care unspecified |
| 410.31 | AMI inferopost, initial | Acute myocardial infarction of inferoposterior wall, initial episode of care |
| 410.32 | AMI inferopost, subseq | Acute myocardial infarction of inferoposterior wall, subsequent episode of care |
| 410.4 | AMI inferior wall,unspec | Acute myocardial infarction of other inferior wall, episode of care unspecified |
| 410.41 | AMI inferior wall, init | Acute myocardial infarction of other inferior wall, initial episode of care |
| 410.42 | AMI inferior wall,subseq | Acute myocardial infarction of other inferior wall, subsequent episode of care |
| 410.5 | AMI lateral NEC, unspec | Acute myocardial infarction of other lateral wall, episode of care unspecified |
| 410.51 | AMI lateral NEC, initial | Acute myocardial infarction of other lateral wall, initial episode of care |
| 410.52 | AMI lateral NEC, subseq | Acute myocardial infarction of other lateral wall, subsequent episode of care |
| 410.6 | True post infarct,unspec | True posterior wall infarction, episode of care unspecified |
| 410.61 | True post infarct, init | True posterior wall infarction, initial episode of care |
| 410.62 | True post infarct,subseq | True posterior wall infarction, subsequent episode of care |
| 410.7 | Subendo infarct, unspec | Subendocardial infarction, episode of care unspecified |
| 410.71 | Subendo infarct, initial | Subendocardial infarction, initial episode of care |
| 410.72 | Subendo infarct, subseq | Subendocardial infarction, subsequent episode of |

| | | |
|---|---|---|
| | | care |
| 410.8 | AMI NEC, unspecified | Acute myocardial infarction of other specified sites, episode of care unspecified |
| 410.81 | AMI NEC, initial | Acute myocardial infarction of other specified sites, initial episode of care |
| 410.82 | AMI NEC, subsequent | Acute myocardial infarction of other specified sites, subsequent episode of care |
| 410.9 | AMI NOS, unspecified | Acute myocardial infarction of unspecified site, episode of care unspecified |
| 410.91 | AMI NOS, initial | Acute myocardial infarction of unspecified site, initial episode of care |
| 410.92 | AMI NOS, subsequent | Acute myocardial infarction of unspecified site, subsequent episode of care |

**Ischemic stroke**

| ICD-9 Code | Short Description | Long Description |
|---|---|---|
| 435.8 | Trans cereb ischemia NEC | Other specified transient cerebral ischemias |
| 435.9 | Trans cereb ischemia NOS | Unspecified transient cerebral ischemia |
| 433.01 | Ocl bslr art w infrct | Occlusion and stenosis of basilar artery with cerebral infarction |
| 433.11 | Ocl crtd art w infrct | Occlusion and stenosis of carotid artery with cerebral infarction |
| 433.21 | Ocl vrtb art w infrct | Occlusion and stenosis of vertebral artery with cerebral infarction |
| 433.31 | Ocl mlt bi art w infrct | Occlusion and stenosis of multiple and bilateral precerebral arteries with cerebral infarction |
| 433.81 | Ocl spcf art w infrct | Occlusion and stenosis of other specified precerebral artery with cerebral infarction |
| 433.91 | Ocl art NOS w infrct | Occlusion and stenosis of unspecified precerebral artery with cerebral infarction |
| 434.91 | Crbl art ocl NOS w infrc | Cerebral artery occlusion, unspecified with cerebral infarction |

**Brain hemorrhage**

| ICD-9 Code | Short Description | Long Description |
|---|---|---|

| | | |
|---|---|---|
| 430 | Subarachnoid hemorrhage | Subarachnoid hemorrhage |
| 431 | Intracerebral hemorrhage | Intracerebral hemorrhage |
| 432 | Nontraum extradural hem | Nontraumatic extradural hemorrhage |
| 432.1 | Subdural hemorrhage | Subdural hemorrhage |
| 432.9 | Intracranial hemorr NOS | Unspecified intracranial hemorrhage |

**Metabolic syndrome and diabetes**

| ICD-9 Code | Short Description | Long Description |
|---|---|---|
| 277.7 | Dysmetabolic syndrome x | Dysmetabolic syndrome X |
| 250 | DMII wo cmp nt st uncntr | Diabetes mellitus without mention of complication, type II or unspecified type, not stated as uncontrolled |
| 250.02 | DMII wo cmp uncntrld | Diabetes mellitus without mention of complication, type II or unspecified type, uncontrolled |
| 250.1 | DMII keto nt st uncntrld | Diabetes with ketoacidosis, type II or unspecified type, not stated as uncontrolled |
| 250.12 | DMII ketoacd uncontrold | Diabetes with ketoacidosis, type II or unspecified type, uncontrolled |
| 250.2 | DMII hprsm nt st uncntrl | Diabetes with hyperosmolarity, type II or unspecified type, not stated as uncontrolled |
| 250.22 | DMII hprosmlr uncontrold | Diabetes with hyperosmolarity, type II or unspecified type, uncontrolled |
| 250.3 | DMII o cm nt st uncntrld | Diabetes with other coma, type II or unspecified type, not stated as uncontrolled |
| 250.32 | DMII oth coma uncontrold | Diabetes with other coma, type II or unspecified type, uncontrolled |
| 250.4 | DMII renl nt st uncntrld | Diabetes with renal manifestations, type II or unspecified type, not stated as uncontrolled |
| 250.42 | DMII renal uncntrld | Diabetes with renal manifestations, type II or unspecified type, uncontrolled |
| 250.5 | DMII ophth nt st uncntrl | Diabetes with ophthalmic manifestations, type II or unspecified type, not stated as uncontrolled |
| 250.52 | DMII ophth uncntrld | Diabetes with ophthalmic manifestations, type II or unspecified type, uncontrolled |

| | | |
|---|---|---|
| 250.6 | DMII neuro nt st uncntrl | Diabetes with neurological manifestations, type II or unspecified type, not stated as uncontrolled |
| 250.62 | DMII neuro uncntrld | Diabetes with neurological manifestations, type II or unspecified type, uncontrolled |
| 250.7 | DMII circ nt st uncntrld | Diabetes with peripheral circulatory disorders, type II or unspecified type, not stated as uncontrolled |
| 250.72 | DMII circ uncntrld | Diabetes with peripheral circulatory disorders, type II or unspecified type, uncontrolled |
| 250.8 | DMII oth nt st uncntrld | Diabetes with other specified manifestations, type II or unspecified type, not stated as uncontrolled |
| 250.82 | DMII oth uncntrld | Diabetes with other specified manifestations, type II or unspecified type, uncontrolled |
| 250.9 | DMII unspf nt st uncntrl | Diabetes with unspecified complication, type II or unspecified type, not stated as uncontrolled |
| 250.92 | DMII unspf uncntrld | Diabetes with unspecified complication, type II or unspecified type, uncontrolled |

**Prediabetes**

| ICD-9 Code | Short Description | Long Description |
|---|---|---|
| 790.29 | Abnormal glucose NEC | Other abnormal glucose |

**Bronchitis**

| ICD-9 Code | Short Description | Long Description |
|---|---|---|
| 466 | Acute bronchitis | Acute bronchitis |
| 490 | Bronchitis NOS | Bronchitis, not specified as acute or chronic |
| 491 | Simple chr bronchitis | Simple chronic bronchitis |
| 491.1 | Mucopurul chr bronchitis | Mucopurulent chronic bronchitis |
| 491.2 | Obst chr bronc w/o exac | Obstructive chronic bronchitis without exacerbation |
| 491.21 | Obs chr bronc w(ac) exac | Obstructive chronic bronchitis with (acute) exacerbation |
| 491.22 | Obs chr bronc w ac bronc | Obstructive chronic bronchitis with acute bronchitis |

| | | |
|---|---|---|
| 491.8 | Chronic bronchitis NEC | Other chronic bronchitis |
| 491.9 | Chronic bronchitis NOS | Unspecified chronic bronchitis |

**Motor vehicle accidents**

| ICD-9 Code | Short Description | Long Description |
|---|---|---|
| E812.0 | Mv collision NOS-driver | Other motor vehicle traffic accident involving collision with motor vehicle injuring driver of motor vehicle other than motorcycle |
| E812.1 | Mv collision NOS-pasngr | Other motor vehicle traffic accident involving collision with motor vehicle injuring passenger in motor vehicle other than motorcycle |
| E812.2 | Mv collis NOS-motorcycl | Other motor vehicle traffic accident involving collision with motor vehicle injuring motorcyclist |
| E812.3 | Mv coll NOS-mcycl psngr | Other motor vehicle traffic accident involving collision with motor vehicle injuring passenger on motorcycle |
| E812.4 | Mv collision NOS-st car | Other motor vehicle traffic accident involving collision with motor vehicle injuring occupant of streetcar |
| E812.5 | Mv coll NOS-anim rid | Other motor vehicle traffic accident involving collision with motor vehicle injuring rider of animal; occupant of animal-drawn vehicle |
| E812.6 | Mv coll NOS-ped cycl | Other motor vehicle traffic accident involving collision with motor vehicle injuring pedal cyclist |
| E812.7 | Mv collision NOS-pedest | Other motor vehicle traffic accident involving collision with motor vehicle injuring pedestrian |
| E812.8 | Mv collis NOS-pers NEC | Other motor vehicle traffic accident involving collision with motor vehicle injuring other specified person |
| E812.9 | Mv collis NOS-pers NOS | Other motor vehicle traffic accident involving collision with motor vehicle injuring unspecified person |
| E813.0 | Mv-oth veh coll-driver | Motor vehicle traffic accident involving collision with other vehicle injuring driver of motor vehicle other than motorcycle |
| E813.1 | Mv-oth veh coll-pasngr | Motor vehicle traffic accident involving collision with other vehicle injuring passenger in motor vehicle other than motorcycle |
| E813.2 | Mv-oth veh coll-motcycl | Motor vehicle traffic accident involving collision |

| | | |
|---|---|---|
| | | with other vehicle injuring motorcyclist |
| E813.3 | Mv-oth veh coll-mcyc psg | Motor vehicle traffic accident involving collision with other vehicle injuring passenger on motorcycle |
| E813.4 | Mv-oth veh coll-st car | Motor vehicle traffic accident involving collision with other vehicle injuring occupant of streetcar |
| E813.5 | Mv-oth veh coll-anim rid | Motor vehicle traffic accident involving collision with other vehicle injuring rider of animal; occupant of animal-drawn vehicle |
| E813.6 | Mv-oth veh coll-ped cycl | Motor vehicle traffic accident involving collision with other vehicle injuring pedal cyclist |
| E813.7 | Mv-oth veh coll-pedest | Motor vehicle traffic accident involving collision with other vehicle injuring pedestrian |
| E813.8 | Mv-oth veh coll-pers NEC | Motor vehicle traffic accident involving collision with other vehicle injuring other specified person |
| E813.9 | Mv-oth veh coll-pers NOS | Motor vehicle traffic accident involving collision with other vehicle injuring unspecified person |
| E814.0 | Mv coll w pedest-driver | Motor vehicle traffic accident involving collision with pedestrian injuring driver of motor vehicle other than motorcycle |
| E814.1 | Mv coll w pedest-pasngr | Motor vehicle traffic accident involving collision with pedestrian injuring passenger in motor vehicle other than motorcycle |
| E814.2 | Mv coll w pedest-motcycl | Motor vehicle traffic accident involving collision with pedestrian injuring motorcyclist |
| E814.3 | Mv coll w ped-mcycl psgr | Motor vehicle traffic accident involving collision with pedestrian injuring passenger on motorcycle |
| E814.4 | Mv coll w pedest-st car | Motor vehicle traffic accident involving collision with pedestrian injuring occupant of streetcar |
| E814.5 | Mv coll w ped-anim rid | Motor vehicle traffic accident involving collision with pedestrian injuring rider of animal; occupant of animal drawn vehicle |
| E814.6 | Mv coll w ped-ped cycl | Motor vehicle traffic accident involving collision with pedestrian injuring pedal cyclist |
| E814.7 | Mv coll w pedest-pedest | Motor vehicle traffic accident involving collision with pedestrian injuring pedestrian |
| E814.8 | Mv coll w pedes-pers NEC | Motor vehicle traffic accident involving collision with pedestrian injuring other specified person |

| | | |
|---|---|---|
| E814.9 | Mv coll w pedes-pers NOS | Motor vehicle traffic accident involving collision with pedestrian injuring unspecified person |
| E815.0 | Mv coll w oth obj-driver | Other motor vehicle traffic accident involving collision on the highway injuring driver of motor vehicle other than motorcycle |
| E815.1 | Mv coll w oth obj-pasngr | Other motor vehicle traffic accident involving collision on the highway injuring passenger in motor vehicle other than motorcycle |
| E815.2 | Mv coll w oth obj-mocycl | Other motor vehicle traffic accident involving collision on the highway injuring motorcyclist |
| E815.3 | Mv coll w obj-mcycl psgr | Other motor vehicle traffic accident involving collision on the highway injuring passenger on motorcycle |
| E815.4 | Mv coll w obj-st car | Other motor vehicle traffic accident involving collision on the highway injuring occupant of streetcar |
| E815.5 | Mv coll w obj-anim rider | Other motor vehicle traffic accident involving collision on the highway injuring rider of animal; occupant of animal-drawn vehicle |
| E815.6 | Mv coll w obj-ped cycl | Other motor vehicle traffic accident involving collision on the highway injuring pedal cyclist |
| E815.7 | Mv coll w obj-pedest | Other motor vehicle traffic accident involving collision on the highway injuring pedestrian |
| E815.8 | Mv coll w obj-pers NEC | Other motor vehicle traffic accident involving collision on the highway injuring other specified person |
| E815.9 | Mv coll w obj-pers NOS | Other motor vehicle traffic accident involving collision on the highway injuring unspecified person |
| E816.0 | Loss control mv acc-driv | Motor vehicle traffic accident due to loss of control, without collision on the highway, injuring driver of motor vehicle other than motorcycle |
| E816.1 | Loss control mv acc-psgr | Motor vehicle traffic accident due to loss of control, without collision on the highway, injuring passenger in motor vehicle other than motorcycle |
| E816.2 | Loss control mv-mocycl | Motor vehicle traffic accident due to loss of control, without collision on the highway, injuring motorcyclist |
| E816.3 | Loss control mv-mcyc psg | Motor vehicle traffic accident due to loss of control, without collision on the highway, injuring passenger on motorcycle |

| | | |
|---|---|---|
| E816.4 | Loss cont mv acc-st car | Motor vehicle traffic accident due to loss of control, without collision on the highway, injuring occupant of streetcar |
| E816.5 | Loss cont mv-anim rider | Motor vehicle traffic accident due to loss of control, without collision on the highway, injuring rider of animal; occupant of animal-drawn vehicle |
| E816.6 | Loss control mv-ped cycl | Motor vehicle traffic accident due to loss of control, without collision on the highway, injuring pedal cyclist |
| E816.7 | Loss control mv-pedest | Motor vehicle traffic accident due to loss of control, without collision on the highway, injuring pedestrian |
| E816.8 | Loss control mv-pers NEC | Motor vehicle traffic accident due to loss of control, without collision on the highway, injuring other specified person |
| E816.9 | Loss control mv-pers NOS | Motor vehicle traffic accident due to loss of control, without collision on the highway, injuring unspecified person |
| E819.0 | Traffic acc NOS-driver | Motor vehicle traffic accident of unspecified nature injuring driver of motor vehicle other than motorcycle |
| E819.1 | Traffic acc NOS-pasngr | Motor vehicle traffic accident of unspecified nature injuring passenger in motor vehicle other than motorcycle |
| E819.2 | Traffic acc NOS-motcycl | Motor vehicle traffic accident of unspecified nature injuring motorcyclist |
| E819.3 | Traff acc NOS-mcycl psgr | Motor vehicle traffic accident of unspecified nature injuring passenger on motorcycle |
| E819.4 | Traffic acc NOS-st car | Motor vehicle traffic accident of unspecified nature injuring occupant of streetcar |
| E819.5 | Traff acc NOS-anim rider | Motor vehicle traffic accident of unspecified nature injuring rider of animal; occupant of animal-drawn vehicle |
| E819.6 | Traffic acc NOS-ped cycl | Motor vehicle traffic accident of unspecified nature injuring pedal cyclist |
| E819.7 | Traffic acc NOS-pedest | Motor vehicle traffic accident of unspecified nature injuring pedestrian |
| E819.8 | Traffic acc NOS-pers NEC | Motor vehicle traffic accident of unspecified nature injuring other specified person |
| E819.9 | Traffic acc NOS-pers NOS | Motor vehicle traffic accident of unspecified nature injuring unspecified person |

**Overdose injuries**

| ICD-9 Code | Short Description | Long Description |
|---|---|---|
| E950.0 | Poison-analgesics | Suicide and self-inflicted poisoning by analgesics, antipyretics, and antirheumatics |
| E950.1 | Poison-barbiturates | Suicide and self-inflicted poisoning by barbiturates |
| E950.2 | Poison-sedat/hypnotic | Suicide and self-inflicted poisoning by other sedatives and hypnotics |
| E950.3 | Poison-psychotropic agt | Suicide and self-inflicted poisoning by tranquilizers and other psychotropic agents |
| E950.4 | Poison-drug/medicin NEC | Suicide and self-inflicted poisoning by other specified drugs and medicinal substances |
| E950.5 | Poison-drug/medicin NOS | Suicide and self-inflicted poisoning by unspecified drug or medicinal substance |

**Assault-based gunshot injuries**

| ICD-9 Code | Short Description | Long Description |
|---|---|---|
| E965.0 | Assault-handgun | Assault by handgun |
| E965.1 | Assault-shotgun | Assault by shotgun |
| E965.2 | Assault-hunting rifle | Assault by hunting rifle |
| E965.3 | Assault-military weapon | Assault by military firearms |
| E965.4 | Assault-firearm NEC | Assault by other and unspecified firearm |

**Low offspring birthweight**

| ICD-9 Code | Short Description | Long Description |
|---|---|---|
| 764.9 | Fet growth retard wtNOS | Fetal growth retardation, unspecified, unspecified [weight] |
| 764.91 | Fet growth retard <500g | Fetal growth retardation, unspecified, less than 500 grams |
| 764.92 | Fet growth ret 500-749g | Fetal growth retardation, unspecified, 500-749 grams |
| 764.93 | Fet growth ret 750-999g | Fetal growth retardation, unspecified, 750-999 grams |

| | | |
|---|---|---|
| 764.94 | Fet grwth ret 1000-1249g | Fetal growth retardation, unspecified, 1,000-1,249 grams |
| 764.95 | Fet grwth ret 1250-1499g | Fetal growth retardation, unspecified, 1,250-1,499 grams |
| 764.96 | Fet grwth ret 1500-1749g | Fetal growth retardation, unspecified, 1,500-1,749 grams |
| 764.97 | Fet grwth ret 1750-1999g | Fetal growth retardation, unspecified, 1,750-1,999 grams |
| 764.98 | Fet grwth ret 2000-2499g | Fetal growth retardation, unspecified, 2,000-2,499 grams |
| 764.99 | Fet growth ret 2500+g | Fetal growth retardation, unspecified, 2,500 grams and over |

**Maternal pregnancy complications**

| ICD-9 Code | Short Description | Long Description |
|---|---|---|
| 640.8 | Hem early preg NEC-unsp | Other specified hemorrhage in early pregnancy, unspecified as to episode of care or not applicable |
| 640.81 | Hem early preg NEC-deliv | Other specified hemorrhage in early pregnancy, delivered, with or without mention of antepartum condition |
| 640.83 | Hem early pg NEC-antepar | Other specified hemorrhage in early pregnancy, antepartum condition or complication |
| 640.9 | Hemorr early preg-unspec | Unspecified hemorrhage in early pregnancy, unspecified as to episode of care or not applicable |
| 640.91 | Hem early preg-delivered | Unspecified hemorrhage in early pregnancy, delivered, with or without mention of antepartum condition |
| 640.93 | Hem early preg-antepart | Unspecified hemorrhage in early pregnancy, antepartum condition or complication |
| 641 | Placenta previa-unspec | Placenta previa without hemorrhage, unspecified as to episode of care or not applicable |
| 641.01 | Placenta previa-deliver | Placenta previa without hemorrhage, delivered, with or without mention of antepartum condition |
| 641.03 | Placenta previa-antepart | Placenta previa without hemorrhage, antepartum condition or complication |
| 641.1 | Placenta prev hem-unspec | Hemorrhage from placenta previa, unspecified as to episode of care or not applicable |

| | | |
|---|---|---|
| 641.11 | Placenta prev hem-deliv | Hemorrhage from placenta previa, delivered, with or without mention of antepartum condition |
| 641.13 | Placen prev hem-antepart | Hemorrhage from placenta previa, antepartum condition or complication |
| 641.2 | Prem separ placen-unspec | Premature separation of placenta, unspecified as to episode of care or not applicable |
| 641.21 | Prem separ placen-deliv | Premature separation of placenta, delivered, with or without mention of antepartum condition |
| 641.23 | Prem separ plac-antepart | Premature separation of placenta, antepartum condition or complication |
| 642 | Essen hyperten preg-unsp | Benign essential hypertension complicating pregnancy, childbirth, and the puerperium, unspecified as to episode of care or not applicable |
| 642.01 | Essen hyperten-delivered | Benign essential hypertension complicating pregnancy, childbirth, and the puerperium, delivered, with or without mention of antepartum condition |
| 642.02 | Essen hyperten-del w p/p | Benign essential hypertension, complicating pregnancy, childbirth, and the puerperium, delivered, with mention of postpartum complication |
| 642.03 | Essen hyperten-antepart | Benign essential hypertension complicating pregnancy, childbirth, and the puerperium, antepartum condition or complication |
| 642.04 | Essen hyperten-postpart | Benign essential hypertension complicating pregnancy, childbirth, and the puerperium, postpartum condition or complication |
| 642.3 | Trans hyperten preg-unsp | Transient hypertension of pregnancy, unspecified as to episode of care or not applicable |
| 642.31 | Trans hyperten-delivered | Transient hypertension of pregnancy, delivered , with or without mention of antepartum condition |
| 642.32 | Trans hyperten-del w p/p | Transient hypertension of pregnancy, delivered, with mention of postpartum complication |
| 642.33 | Trans hyperten-antepart | Transient hypertension of pregnancy, antepartum condition or complication |
| 642.34 | Trans hyperten-postpart | Transient hypertension of pregnancy, postpartum condition or complication |
| 642.4 | Mild/NOS preeclamp-unsp | Mild or unspecified pre-eclampsia, unspecified as to episode of care or not applicable |

| | | |
|---|---|---|
| 642.41 | Mild/NOS preeclamp-deliv | Mild or unspecified pre-eclampsia, delivered, with or without mention of antepartum condition |
| 642.42 | Mild preeclamp-del w p/p | Mild or unspecified pre-eclampsia, delivered, with mention of postpartum complication |
| 642.43 | Mild/NOS preeclamp-antep | Mild or unspecified pre-eclampsia, antepartum condition or complication |
| 642.44 | Mild/NOS preeclamp-p/p | Mild or unspecified pre-eclampsia, postpartum condition or complication |
| 642.5 | Severe preeclamp-unspec | Severe pre-eclampsia, unspecified as to episode of care or not applicable |
| 642.51 | Severe preeclamp-deliver | Severe pre-eclampsia, delivered, with or without mention of antepartum condition |
| 642.52 | Sev preeclamp-del w p/p | Severe pre-eclampsia, delivered, with mention of postpartum complication |
| 642.53 | Sev preeclamp-antepartum | Severe pre-eclampsia, antepartum condition or complication |
| 642.54 | Sev preeclamp-postpartum | Severe pre-eclampsia, postpartum condition or complication |
| 642.6 | Eclampsia-unspecified | Eclampsia, unspecified as to episode of care or not applicable |
| 642.61 | Eclampsia-delivered | Eclampsia, delivered, with or without mention of antepartum condition |
| 642.62 | Eclampsia-deliv w p/p | Eclampsia, delivered, with mention of postpartum complication |
| 642.63 | Eclampsia-antepartum | Eclampsia, antepartum condition or complication |
| 642.64 | Eclampsia-postpartum | Eclampsia, postpartum condition or complication |
| 642.7 | Tox w old hyperten-unsp | Pre-eclampsia or eclampsia superimposed on pre-existing hypertension, unspecified as to episode of care or not applicable |
| 642.71 | Tox w old hyperten-deliv | Pre-eclampsia or eclampsia superimposed on pre-existing hypertension, delivered, with or without mention of antepartum condition |
| 642.72 | Tox w old hyp-del w p/p | Pre-eclampsia or eclampsia superimposed on pre-existing hypertension, delivered, with mention of postpartum complication |
| 642.73 | Tox w old hyper-antepart | Pre-eclampsia or eclampsia superimposed on pre-existing hypertension, antepartum condition or complication |

| | | |
|---|---|---|
| 642.74 | Tox w old hyper-postpart | Pre-eclampsia or eclampsia superimposed on pre-existing hypertension, postpartum condition or complication |
| 642.9 | Hyperten preg NOS-unspec | Unspecified hypertension complicating pregnancy, childbirth, or the puerperium, unspecified as to episode of care or not applicable |
| 642.91 | Hypertens NOS-delivered | Unspecified hypertension complicating pregnancy, childbirth, or the puerperium, delivered, with or without mention of antepartum condition |
| 642.92 | Hypertens NOS-del w p/p | Unspecified hypertension complicating pregnancy, childbirth, or the puerperium, delivered, with mention of postpartum complication |
| 642.93 | Hypertens NOS-antepartum | Unspecified hypertension complicating pregnancy, childbirth, or the puerperium, antepartum condition or complication |
| 642.94 | Hypertens NOS-postpartum | Unspecified hypertension complicating pregnancy, childbirth, or the puerperium, postpartum condition or complication |
| 646.8 | Preg compl NEC-unspec | Other specified complications of pregnancy, unspecified as to episode of care or not applicable |
| 646.81 | Preg compl NEC-delivered | Other specified complications of pregnancy, delivered, with or without mention of antepartum condition |
| 646.82 | Preg compl NEC-del w p/p | Other specified complications of pregnancy, delivered, with mention of postpartum complication |
| 646.83 | Preg compl NEC-antepart | Other specified complications of pregnancy, antepartum condition or complication |
| 646.84 | Preg compl NEC-postpart | Other specified complications of pregnancy, postpartum condition or complication |
| 646.9 | Preg compl NOS-unspec | Unspecified complication of pregnancy, unspecified as to episode of care or not applicable |

**Unemployment or low income**

| ICD-9 Code | Short Description | Long Description |
|---|---|---|
| V62.0 | Unemployment | Unemployment |

**Schizophrenia or other psychoses**

| ICD-9 Code | Short Description | Long Description |
|---|---|---|
| 295 | Simpl schizophren-unspec | Simple type schizophrenia, unspecified |
| 295.01 | Simpl schizophren-subchr | Simple type schizophrenia, subchronic |
| 295.02 | Simple schizophren-chr | Simple type schizophrenia, chronic |
| 295.03 | Simp schiz-subchr/exacer | Simple type schizophrenia, subchronic with acute exacerbation |
| 295.04 | Simpl schizo-chr/exacerb | Simple type schizophrenia, chronic with acute exacerbation |
| 295.05 | Simpl schizophren-remiss | Simple type schizophrenia, in remission |
| 295.1 | Hebephrenia-unspec | Disorganized type schizophrenia, unspecified |
| 295.11 | Hebephrenia-subchronic | Disorganized type schizophrenia, subchronic |
| 295.12 | Hebephrenia-chronic | Disorganized type schizophrenia, chronic |
| 295.13 | Hebephren-subchr/exacerb | Disorganized type schizophrenia, subchronic with acute exacerbation |
| 295.14 | Hebephrenia-chr/exacerb | Disorganized type schizophrenia, chronic with acute exacerbation |
| 295.15 | Hebephrenia-remission | Disorganized type schizophrenia, in remission |
| 295.2 | Catatonia-unspec | Catatonic type schizophrenia, unspecified |
| 295.21 | Catatonia-subchronic | Catatonic type schizophrenia, subchronic |
| 295.22 | Catatonia-chronic | Catatonic type schizophrenia, chronic |
| 295.23 | Catatonia-subchr/exacerb | Catatonic type schizophrenia, subchronic with acute exacerbation |
| 295.24 | Catatonia-chr/exacerb | Catatonic type schizophrenia, chronic with acute exacerbation |
| 295.25 | Catatonia-remission | Catatonic type schizophrenia, in remission |
| 295.3 | Paranoid schizo-unspec | Paranoid type schizophrenia, unspecified |
| 295.31 | Paranoid schizo-subchr | Paranoid type schizophrenia, subchronic |
| 295.32 | Paranoid schizo-chronic | Paranoid type schizophrenia, chronic |
| 295.33 | Paran schizo-subchr/exac | Paranoid type schizophrenia, subchronic with acute exacerbation |

| | | |
|---|---|---|
| 295.34 | Paran schizo-chr/exacerb | Paranoid type schizophrenia, chronic with acute exacerbation |
| 295.35 | Paranoid schizo-remiss | Paranoid type schizophrenia, in remission |
| 295.4 | Schizophreniform dis NOS | Schizophreniform disorder, unspecified |
| 295.41 | Schizophrenic dis-subchr | Schizophreniform disorder, subchronic |
| 295.42 | Schizophren dis-chronic | Schizophreniform disorder, chronic |
| 295.43 | Schizo dis-subchr/exacer | Schizophreniform disorder, subchronic with acute exacerbation |
| 295.44 | Schizophr dis-chr/exacer | Schizophreniform disorder, chronic with acute exacerbation |
| 295.45 | Schizophrenic dis-remiss | Schizophreniform disorder, in remission |
| 295.5 | Latent schizophren-unsp | Latent schizophrenia, unspecified |
| 295.51 | Lat schizophren-subchr | Latent schizophrenia, subchronic |
| 295.52 | Latent schizophren-chr | Latent schizophrenia, chronic |
| 295.53 | Lat schizo-subchr/exacer | Latent schizophrenia, subchronic with acute exacerbation |
| 295.54 | Latent schizo-chr/exacer | Latent schizophrenia, chronic with acute exacerbation |
| 295.55 | Lat schizophren-remiss | Latent schizophrenia, in remission |
| 295.6 | Schizophr dis resid NOS | Schizophrenic disorders, residual type, unspecified |
| 295.61 | Schizoph dis resid-subch | Schizophrenic disorders, residual type, subchronic |
| 295.62 | Schizophr dis resid-chr | Schizophrenic disorders, residual type, chronic |
| 295.63 | Schizo resid subchr/exac | Schizophrenic disorders, residual type, subchronic with acute exacerbation |
| 295.64 | Schizoph resid-chro/exac | Schizophrenic disorders, residual type, chronic with acute exacerbation |
| 295.65 | Schizoph dis resid-remis | Schizophrenic disorders, residual type, in remission |
| 296.2 | Depress psychosis-unspec | Major depressive affective disorder, single episode, unspecified |
| 296.21 | Depress psychosis-mild | Major depressive affective disorder, single episode, mild |

| | | |
|---|---|---|
| 296.22 | Depressive psychosis-mod | Major depressive affective disorder, single episode, moderate |
| 296.23 | Depress psychosis-severe | Major depressive affective disorder, single episode, severe, without mention of psychotic behavior |
| 296.24 | Depr psychos-sev w psych | Major depressive affective disorder, single episode, severe, specified as with psychotic behavior |
| 296.25 | Depr psychos-part remiss | Major depressive affective disorder, single episode, in partial or unspecified remission |
| 296.26 | Depr psychos-full remiss | Major depressive affective disorder, single episode, in full remission |
| 296.3 | Recurr depr psychos-unsp | Major depressive affective disorder, recurrent episode, unspecified |
| 296.31 | Recurr depr psychos-mild | Major depressive affective disorder, recurrent episode, mild |
| 296.32 | Recurr depr psychos-mod | Major depressive affective disorder, recurrent episode, moderate |
| 296.33 | Recur depr psych-severe | Major depressive affective disorder, recurrent episode, severe, without mention of psychotic behavior |
| 296.34 | Rec depr psych-psychotic | Major depressive affective disorder, recurrent episode, severe, specified as with psychotic behavior |
| 296.35 | Recur depr psyc-part rem | Major depressive affective disorder, recurrent episode, in partial or unspecified remission |
| 296.36 | Recur depr psyc-full rem | Major depressive affective disorder, recurrent episode, in full remission |
| 298 | React depress psychosis | Depressive type psychosis |
| 298.1 | Excitativ type psychosis | Excitative type psychosis |
| 298.4 | Psychogen paranoid psych | Psychogenic paranoid psychosis |
| 298.8 | React psychosis NEC/NOS | Other and unspecified reactive psychosis |
| 298.9 | Psychosis NOS | Unspecified psychosis |

**Depressive disorders**

| ICD-9 Code | Short Description | Long Description |
|---|---|---|
| 296.82 | Atypical depressive dis | Atypical depressive disorder |

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|---|---|---|
| 311 | Depressive disorder NEC | Depressive disorder, not elsewhere classified |

**Suicide**

| ICD-9 Code | Short Description | Long Description |
|---|---|---|
| E950.6 | Poison-agricult agent | Suicide and self-inflicted poisoning by agricultural and horticultural chemical and pharmaceutical preparations other than plant foods and fertilizers |
| E950.7 | Poison-corrosiv/caustic | Suicide and self-inflicted poisoning by corrosive and caustic substances |
| E950.8 | Poison-arsenic | Suicide and self-inflicted poisoning by arsenic and its compounds |
| E950.9 | Poison-solid/liquid NEC | Suicide and self-inflicted poisoning by other and unspecified solid and liquid substances |
| E951.0 | Poison-piped gas | Suicide and self-inflicted poisoning by gas distributed by pipeline |
| E951.1 | Poison-gas in container | Suicide and self-inflicted poisoning by liquefied petroleum gas distributed in mobile containers |
| E951.8 | Poison-utility gas NEC | Suicide and self-inflicted poisoning by other utility gas |
| E952.0 | Poison-exhaust gas | Suicide and self-inflicted poisoning by motor vehicle exhaust gas |
| E952.1 | Poison-co NEC | Suicide and self-inflicted poisoning by other carbon monoxide |
| E952.8 | Poison-gas/vapor NEC | Suicide and self-inflicted poisoning by other specified gases and vapors |
| E952.9 | Poison-gas/vapor NOS | Suicide and self-inflicted poisoning by unspecified gases and vapors |
| E953.0 | Injury-hanging | Suicide and self-inflicted injury by hanging |
| E953.1 | Injury-suff w plas bag | Suicide and self-inflicted injury by suffocation by plastic bag |
| E953.8 | Injury-strang/suff NEC | Suicide and self-inflicted injury by other specified means |
| E953.9 | Injury-strang/suff NOS | Suicide and self-inflicted injury by unspecified means |
| E954. | Injury-submersion | Suicide and self-inflicted injury by submersion [drowning] |

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|---|---|---|
| E955.0 | Injury-handgun | Suicide and self-inflicted injury by handgun |
| E955.1 | Injury-shotgun | Suicide and self-inflicted injury by shotgun |
| E955.2 | Injury-hunting rifle | Suicide and self-inflicted injury by hunting rifle |
| E955.3 | Injury-military firearm | Suicide and self-inflicted injury by military firearms |
| E955.4 | Injury-firearm NEC | Suicide and self-inflicted injury by other and unspecified firearm |
| E955.5 | Injury-explosives | Suicide and self-inflicted injury by explosives |
| E955.6 | Self inflict acc-air gun | Suicide and self-inflicted injury by air gun |
| E955.7 | Self inj-paintball gun | Suicide and self-inflicted injury by paintball gun |
| E955.9 | Injury-firearm/expl NOS | Suicide and self-inflicted injury by firearms and explosives, unspecified |
| E956. | Injury-cut instrument | Suicide and self-inflicted injury by cutting and piercing instrument |
| E957.0 | Injury-jump fm residence | Suicide and self-inflicted injuries by jumping from residential premises |
| E957.1 | Injury-jump fm struc NEC | Suicide and self-inflicted injuries by jumping from other man-made structures |
| E957.2 | Injury-jump fm natur sit | Suicide and self-inflicted injuries by jumping from natural sites |
| E957.9 | Injury-jump NEC | Suicide and self-inflicted injuries by jumping from unspecified site |
| E958.0 | Injury-moving object | Suicide and self-inflicted injury by jumping or lying before moving object |
| E958.1 | Injury-burn, fire | Suicide and self-inflicted injury by burns, fire |
| E958.2 | Injury-scald | Suicide and self-inflicted injury by scald |
| E958.3 | Injury-extreme cold | Suicide and self-inflicted injury by extremes of cold |
| E958.4 | Injury-electrocution | Suicide and self-inflicted injury by electrocution |
| E958.5 | Injury-motor veh crash | Suicide and self-inflicted injury by crashing of motor vehicle |
| E958.6 | Injury-aircraft crash | Suicide and self-inflicted injury by crashing of aircraft |
| E958.7 | Injury-caustic substance | Suicide and self-inflicted injury by caustic substances, except poisoning |

| | | |
|---|---|---|
| E958.8 | Injury-NEC | Suicide and self-inflicted injury by other specified means |
| E958.9 | Injury-NOS | Suicide and self-inflicted injury by unspecified means |

**Social anxiety disorder**

| ICD-9 Code | Short Description | Long Description |
|---|---|---|
| 300.23 | Social phobia | Social phobia |

**Anxiety disorders**

| ICD-9 Code | Short Description | Long Description |
|---|---|---|
| 293.84 | Anxiety disorder oth dis | Anxiety disorder in conditions classified elsewhere |
| 300 | Anxiety state NOS | Anxiety state, unspecified |

**Anxiety disorders (except social anxiety)**

| ICD-9 Code | Short Description | Long Description |
|---|---|---|
| 300.01 | Panic dis w/o agorphobia | Panic disorder without agoraphobia |
| 300.02 | Generalized anxiety dis | Generalized anxiety disorder |
| 300.09 | Anxiety state NEC | Other anxiety states |
| 300.1 | Hysteria NOS | Hysteria, unspecified |
| 300.11 | Conversion disorder | Conversion disorder |
| 300.12 | Dissociative amnesia | Dissociative amnesia |
| 300.13 | Dissociative fugue | Dissociative fugue |
| 300.14 | Dissociatve identity dis | Dissociative identity disorder |
| 300.15 | Dissociative react NOS | Dissociative disorder or reaction, unspecified |
| 300.16 | Factitious dis w symptom | Factitious disorder with predominantly psychological signs and symptoms |
| 300.19 | Factitious ill NEC/NOS | Other and unspecified factitious illness |
| 300.2 | Phobia NOS | Phobia, unspecified |
| 300.21 | Agoraphobia w panic dis | Agoraphobia with panic disorder |

| | | |
|---|---|---|
| 300.22 | Agoraphobia w/o panic | Agoraphobia without mention of panic attacks |
| 300.29 | Isolated/spec phobia NEC | Other isolated or specific phobias |
| 300.3 | Obsessive-compulsive dis | Obsessive-compulsive disorders |
| 300.4 | Dysthymic disorder | Dysthymic disorder |
| 300.5 | Neurasthenia | Neurasthenia |
| 300.6 | Depersonalization disord | Depersonalization disorder |
| 300.7 | Hypochondriasis | Hypochondriasis |
| 300.81 | Somatization disorder | Somatization disorder |
| 300.82 | Undiff somatoform disrdr | Undifferentiated somatoform disorder |
| 300.89 | Somatoform disorders NEC | Other somatoform disorders |
| 300.9 | Nonpsychotic disord NOS | Unspecified nonpsychotic mental disorder |

**Positive symptoms of schizophrenia (i.e., hallucinations)**

| ICD-9 Code | Short Description | Long Description |
|---|---|---|
| 780.1 | Hallucinations | |
| 293.81 | Psy dis w delus oth dis | Psychotic disorder with delusions in conditions classified elsewhere |
| 333.99 | Extrapyramidal dis NEC | Other extrapyramidal diseases and abnormal movement disorders |

**Bipolar disorders**

| ICD-9 Code | Short Description | Long Description |
|---|---|---|
| 296.5 | Bipol I cur depres NOS | Bipolar I disorder, most recent episode (or current) depressed, unspecified |
| 296.51 | Bipol I cur depress-mild | Bipolar I disorder, most recent episode (or current) depressed, mild |
| 296.52 | Bipol I cur depress-mod | Bipolar I disorder, most recent episode (or current) depressed, moderate |
| 296.53 | Bipol I curr dep w/o psy | Bipolar I disorder, most recent episode (or current) depressed, severe, without mention of psychotic behavior |
| 296.54 | Bipol I currnt dep w psy | Bipolar I disorder, most recent episode (or current) depressed, severe, specified as with |

| | | |
|---|---|---|
| | | psychotic behavior |
| 296.55 | Bipol I cur dep rem NOS | Bipolar I disorder, most recent episode (or current) depressed, in partial or unspecified remission |
| 296.56 | Bipol I currnt dep remis | Bipolar I disorder, most recent episode (or current) depressed, in full remission |
| 296.6 | Bipol I currnt mixed NOS | Bipolar I disorder, most recent episode (or current) mixed, unspecified |
| 296.61 | Bipol I currnt mix-mild | Bipolar I disorder, most recent episode (or current) mixed, mild |
| 296.62 | Bipol I currnt mixed-mod | Bipolar I disorder, most recent episode (or current) mixed, moderate |
| 296.63 | Bipol I cur mix w/o psy | Bipolar I disorder, most recent episode (or current) mixed, severe, without mention of psychotic behavior |
| 296.64 | Bipol I cur mixed w psy | Bipolar I disorder, most recent episode (or current) mixed, severe, specified as with psychotic behavior |
| 296.65 | Bipol I cur mix-part rem | Bipolar I disorder, most recent episode (or current) mixed, in partial or unspecified remission |
| 296.66 | Bipol I cur mixed remiss | Bipolar I disorder, most recent episode (or current) mixed, in full remission |
| 296.7 | Bipolor I current NOS | Bipolar I disorder, most recent episode (or current) unspecified |
| 296.8 | Bipolar disorder NOS | Bipolar disorder, unspecified |
| 296 | Bipol I single manic NOS | Bipolar I disorder, single manic episode, unspecified |
| 296.01 | Bipol I single manc-mild | Bipolar I disorder, single manic episode, mild |
| 296.02 | Bipol I single manic-mod | Bipolar I disorder, single manic episode, moderate |
| 296.03 | Bipol I sing-sev w/o psy | Bipolar I disorder, single manic episode, severe, without mention of psychotic behavior |
| 296.04 | Bipo I sin man-sev w psy | Bipolar I disorder, single manic episode, severe, specified as with psychotic behavior |
| 296.05 | Bipol I sing man rem NOS | Bipolar I disorder, single manic episode, in partial or unspecified remission |

| | | |
|---|---|---|
| 296.06 | Bipol I single manic rem | Bipolar I disorder, single manic episode, in full remission |
| 296.4 | Bipol I currnt manic NOS | Bipolar I disorder, most recent episode (or current) manic, unspecified |
| 296.41 | Bipol I curnt manic-mild | Bipolar I disorder, most recent episode (or current) manic, mild |
| 296.42 | Bipol I currnt manic-mod | Bipolar I disorder, most recent episode (or current) manic, moderate |
| 296.43 | Bipol I manc-sev w/o psy | Bipolar I disorder, most recent episode (or current) manic, severe, without mention of psychotic behavior |
| 296.44 | Bipol I manic-sev w psy | Bipolar I disorder, most recent episode (or current) manic, severe, specified as with psychotic behavior |
| 296.45 | Bipol I cur man part rem | Bipolar I disorder, most recent episode (or current) manic, in partial or unspecified remission |
| 296.46 | Bipol I cur man full rem | Bipolar I disorder, most recent episode (or current) manic, in full remission |

**Substance dependence or abuse of alcohol, tobacco, and other illicit drugs**

| ICD-9 Code | Short Description | Long Description |
|---|---|---|
| 303.9 | Alcoh dep NEC/NOS-unspec | Other and unspecified alcohol dependence, unspecified |
| 303.91 | Alcoh dep NEC/NOS-contin | Other and unspecified alcohol dependence, continuous |
| 303.92 | Alcoh dep NEC/NOS-episod | Other and unspecified alcohol dependence, episodic |
| 303.93 | Alcoh dep NEC/NOS-remiss | Other and unspecified alcohol dependence, in remission |
| 304 | Opioid dependence-unspec | Opioid type dependence, unspecified |
| 304.01 | Opioid dependence-contin | Opioid type dependence, continuous |
| 304.02 | Opioid dependence-episod | Opioid type dependence, episodic |
| 304.03 | Opioid dependence-remiss | Opioid type dependence, in remission |
| 304.1 | Sed,hyp,anxiolyt dep-NOS | Sedative, hypnotic or anxiolytic dependence, unspecified |
| 304.11 | Sed,hyp,anxiolyt dep-con | Sedative, hypnotic or anxiolytic dependence, continuous |

| | | |
|---|---|---|
| 304.12 | Sed,hyp,anxiolyt dep-epi | Sedative, hypnotic or anxiolytic dependence, episodic |
| 304.13 | Sed,hyp,anxiolyt dep-rem | Sedative, hypnotic or anxiolytic dependence, in remission |
| 304.2 | Cocaine depend-unspec | Cocaine dependence, unspecified |
| 304.21 | Cocaine depend-contin | Cocaine dependence, continuous |
| 304.22 | Cocaine depend-episodic | Cocaine dependence, episodic |
| 304.23 | Cocaine depend-remiss | Cocaine dependence, in remission |
| 304.3 | Cannabis depend-unspec | Cannabis dependence, unspecified |
| 304.31 | Cannabis depend-contin | Cannabis dependence, continuous |
| 304.32 | Cannabis depend-episodic | Cannabis dependence, episodic |
| 304.33 | Cannabis depend-remiss | Cannabis dependence, in remission |
| 304.4 | Amphetamin depend-unspec | Amphetamine and other psychostimulant dependence, unspecified |
| 304.41 | Amphetamin depend-contin | Amphetamine and other psychostimulant dependence, continuous |
| 304.42 | Amphetamin depend-episod | Amphetamine and other psychostimulant dependence, episodic |
| 304.43 | Amphetamin depend-remiss | Amphetamine and other psychostimulant dependence, in remission |
| 304.5 | Hallucinogen dep-unspec | Hallucinogen dependence, unspecified |
| 304.51 | Hallucinogen dep-contin | Hallucinogen dependence, continuous |
| 304.52 | Hallucinogen dep-episod | Hallucinogen dependence, episodic |
| 304.53 | Hallucinogen dep-remiss | Hallucinogen dependence, in remission |
| 304.6 | Drug depend NEC-unspec | Other specified drug dependence, unspecified |
| 304.61 | Drug depend NEC-contin | Other specified drug dependence, continuous |
| 304.62 | Drug depend NEC-episodic | Other specified drug dependence, episodic |
| 304.63 | Drug depend NEC-in rem | Other specified drug dependence, in remission |
| 304.7 | Opioid/other dep-unspec | Combinations of opioid type drug with any other drug dependence, unspecified |
| 304.71 | Opioid/other dep-contin | Combinations of opioid type drug with any other drug dependence, continuous |
| 304.72 | Opioid/other dep-episod | Combinations of opioid type drug with any other |

| | | |
|---|---|---|
| | | drug dependence, episodic |
| 304.73 | Opioid/other dep-remiss | Combinations of opioid type drug with any other drug dependence, in remission |
| 304.8 | Comb drug dep NEC-unspec | Combinations of drug dependence excluding opioid type drug, unspecified |
| 304.81 | Comb drug dep NEC-contin | Combinations of drug dependence excluding opioid type drug, continuous |
| 304.82 | Comb drug dep NEC-episod | Combinations of drug dependence excluding opioid type drug, episodic |
| 304.83 | Comb drug dep NEC-remiss | Combinations of drug dependence excluding opioid type drug, in remission |
| 304.9 | Drug depend NOS-unspec | Unspecified drug dependence, unspecified |
| 304.91 | Drug depend NOS-contin | Unspecified drug dependence, continuous |
| 304.92 | Drug depend NOS-episodic | Unspecified drug dependence, episodic |
| 304.93 | Drug depend NOS-remiss | Unspecified drug dependence, in remission |
| 305 | Alcohol abuse-unspec | Alcohol abuse, unspecified |
| 305.01 | Alcohol abuse-continuous | Alcohol abuse, continuous |
| 305.02 | Alcohol abuse-episodic | Alcohol abuse, episodic |
| 305.03 | Alcohol abuse-in remiss | Alcohol abuse, in remission |
| 305.3 | Hallucinog abuse-unspec | Hallucinogen abuse, unspecified |
| 305.31 | Hallucinog abuse-contin | Hallucinogen abuse, continuous |
| 305.32 | Hallucinog abuse-episod | Hallucinogen abuse, episodic |
| 305.33 | Hallucinog abuse-remiss | Hallucinogen abuse, in remission |
| 305.4 | Sed,hyp,anxiolytc ab-NOS | Sedative, hypnotic or anxiolytic abuse, unspecified |
| 305.41 | Sed,hyp,anxiolytc ab-con | Sedative, hypnotic or anxiolytic abuse, continuous |
| 305.42 | Sed,hyp,anxiolytc ab-epi | Sedative, hypnotic or anxiolytic abuse, episodic |
| 305.43 | Sed,hyp,anxiolytc ab-rem | Sedative, hypnotic or anxiolytic abuse, in remission |
| 305.5 | Opioid abuse-unspec | Opioid abuse, unspecified |
| 305.51 | Opioid abuse-continuous | Opioid abuse, continuous |
| 305.52 | Opioid abuse-episodic | Opioid abuse, episodic |

| | | |
|---|---|---|
| 305.53 | Opioid abuse-in remiss | Opioid abuse, in remission |
| 305.6 | Cocaine abuse-unspec | Cocaine abuse, unspecified |
| 305.61 | Cocaine abuse-continuous | Cocaine abuse, continuous |
| 305.62 | Cocaine abuse-episodic | Cocaine abuse, episodic |
| 305.63 | Cocaine abuse-in remiss | Cocaine abuse, in remission |
| 305.7 | Amphetamine abuse-unspec | Amphetamine or related acting sympathomimetic abuse, unspecified |
| 305.71 | Amphetamine abuse-contin | Amphetamine or related acting sympathomimetic abuse, continuous |
| 305.72 | Amphetamine abuse-episod | Amphetamine or related acting sympathomimetic abuse, episodic |
| 305.73 | Amphetamine abuse-remiss | Amphetamine or related acting sympathomimetic abuse, in remission |
| 305.8 | Antidepress abuse-unspec | Antidepressant type abuse, unspecified |
| 305.81 | Antidepress abuse-contin | Antidepressant type abuse, continuous |
| 305.82 | Antidepress abuse-episod | Antidepressant type abuse, episodic |
| 305.83 | Antidepress abuse-remiss | Antidepressant type abuse, in remission |

**Cannabis abuse**

| ICD-9 Code | Short Description | Long Description |
|---|---|---|
| 305.2 | Cannabis abuse-unspec | Cannabis abuse, unspecified |
| 305.21 | Cannabis abuse-contin | Cannabis abuse, continuous |
| 305.22 | Cannabis abuse-episodic | Cannabis abuse, episodic |
| 305.23 | Cannabis abuse-in remiss | Cannabis abuse, in remission |

**Tobacco use**

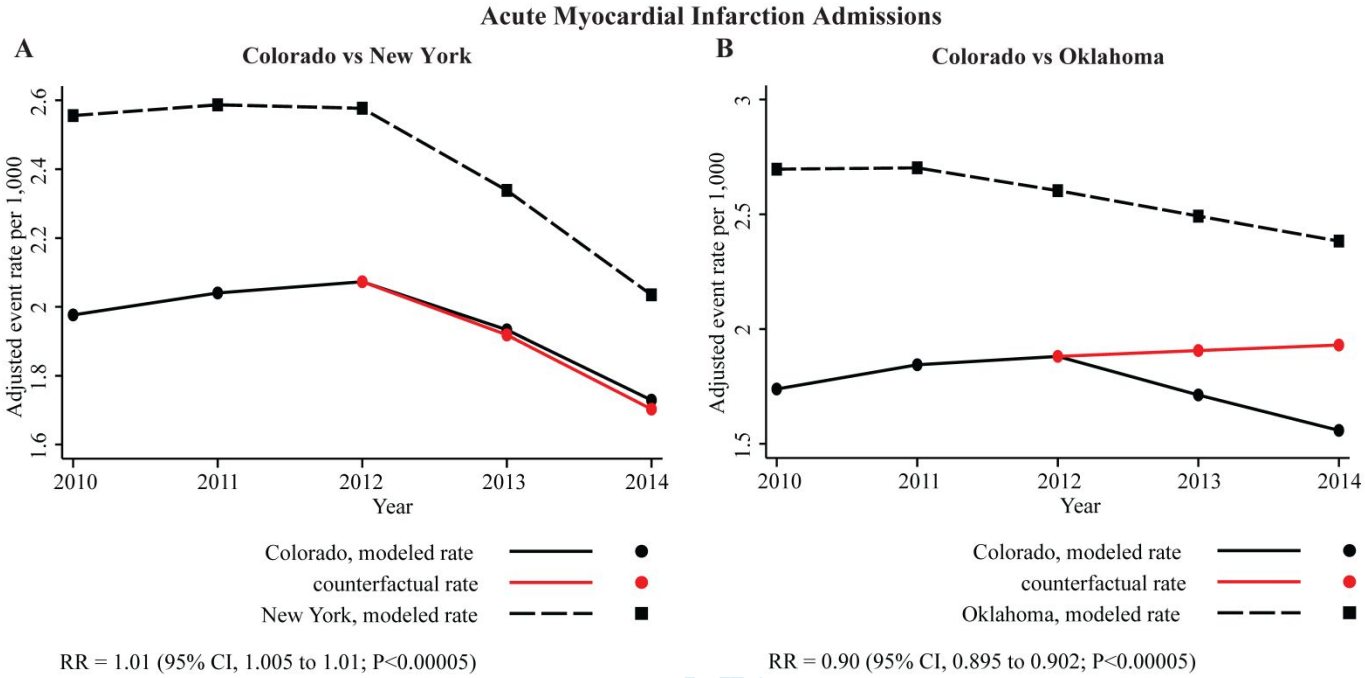
| ICD-9 Code | Short Description | Long Description |
|---|---|---|
| 305.1 | Tobacco use disorder | Tobacco use disorder |

**Alcohol abuse**

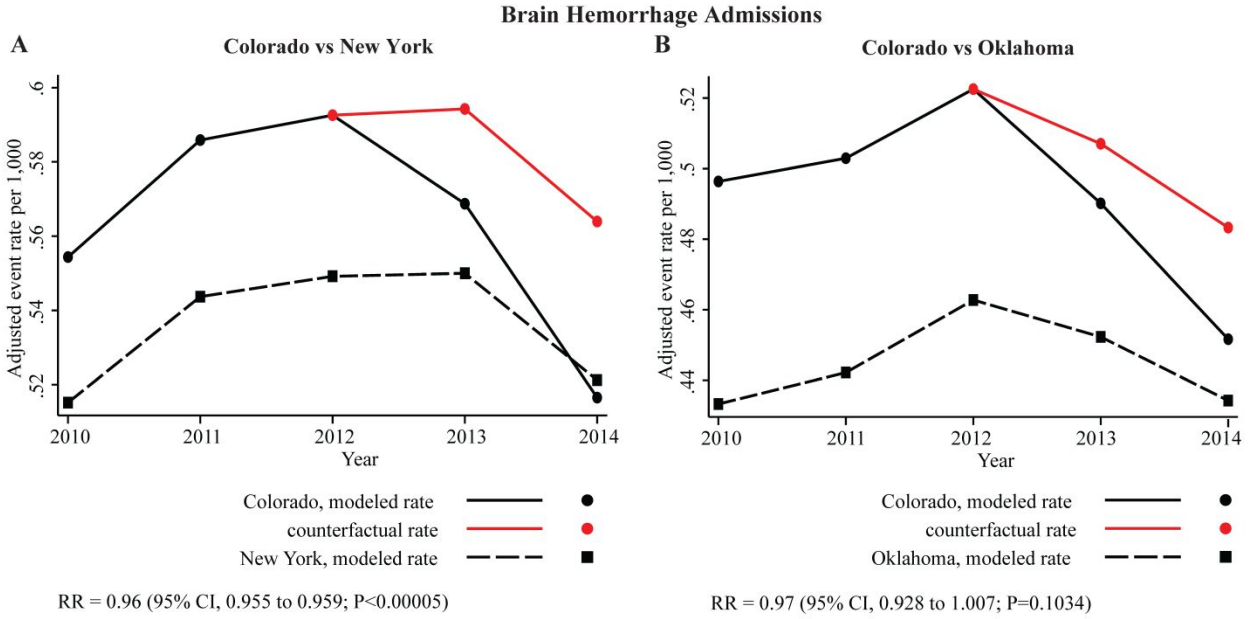
| ICD-9 Code | Short Description | Long Description |
|---|---|---|

| | | |
|---|---|---|
| 303.9 | Alcoh dep NEC/NOS-unspec | Other and unspecified alcohol dependence, unspecified |
| 303.91 | Alcoh dep NEC/NOS-contin | Other and unspecified alcohol dependence, continuous |
| 303.92 | Alcoh dep NEC/NOS-episod | Other and unspecified alcohol dependence, episodic |
| 303.93 | Alcoh dep NEC/NOS-remiss | Other and unspecified alcohol dependence, in remission |

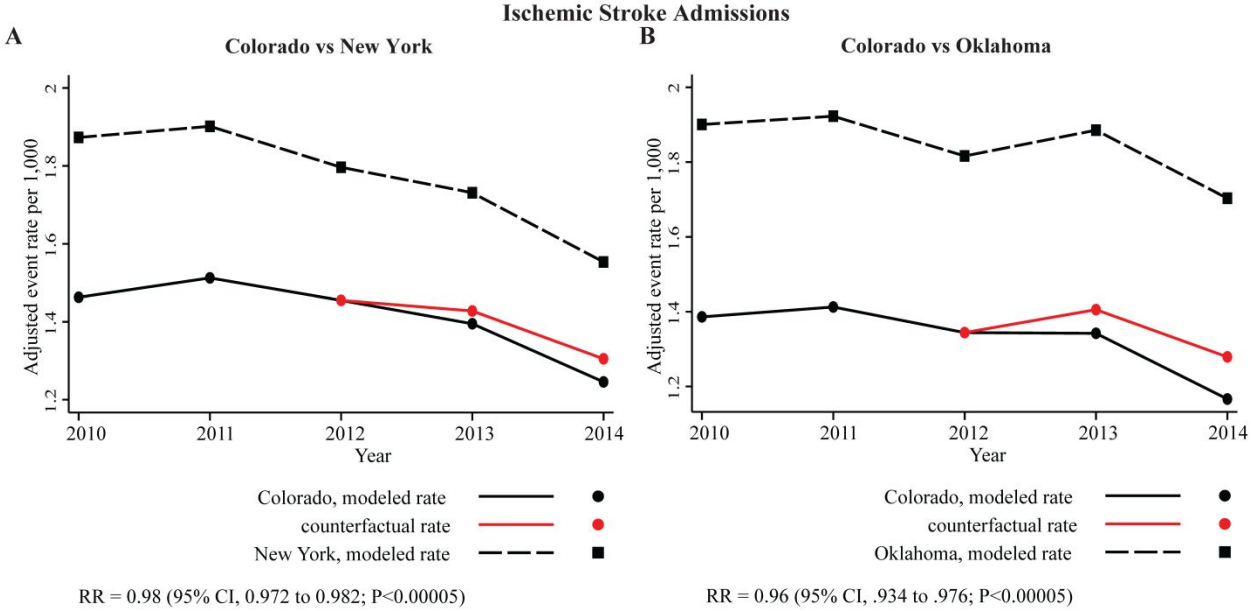
**eFigure 1.** Multivariate adjusted rates of admissions for myocardial infarction over 2010-2014 in Colorado, site of implementation of the 2012 recreational cannabis legalization policy, compared with New York (A) and Oklahoma (B), control states without cannabis legalization. Red lines show the predicted rates of admissions for myocardial infarction (and all remaining medical diagnoses plotted in Figures S2-S31) had the cannabis legalization policy not been instituted. RR = risk ratio; CI = confidence interval.



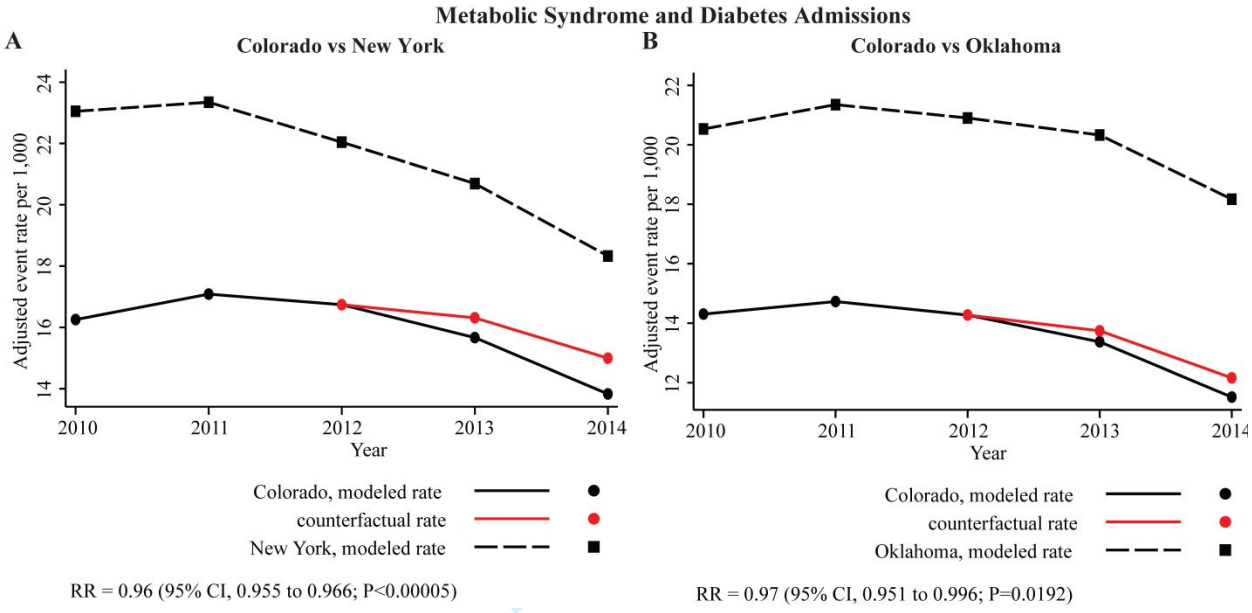
**eFigure 2.** Multivariate adjusted rates of admissions for brain hemorrhage over 2010-2014 in Colorado compared with New York (A) and Oklahoma (B). RR = risk ratio; CI = confidence interval.



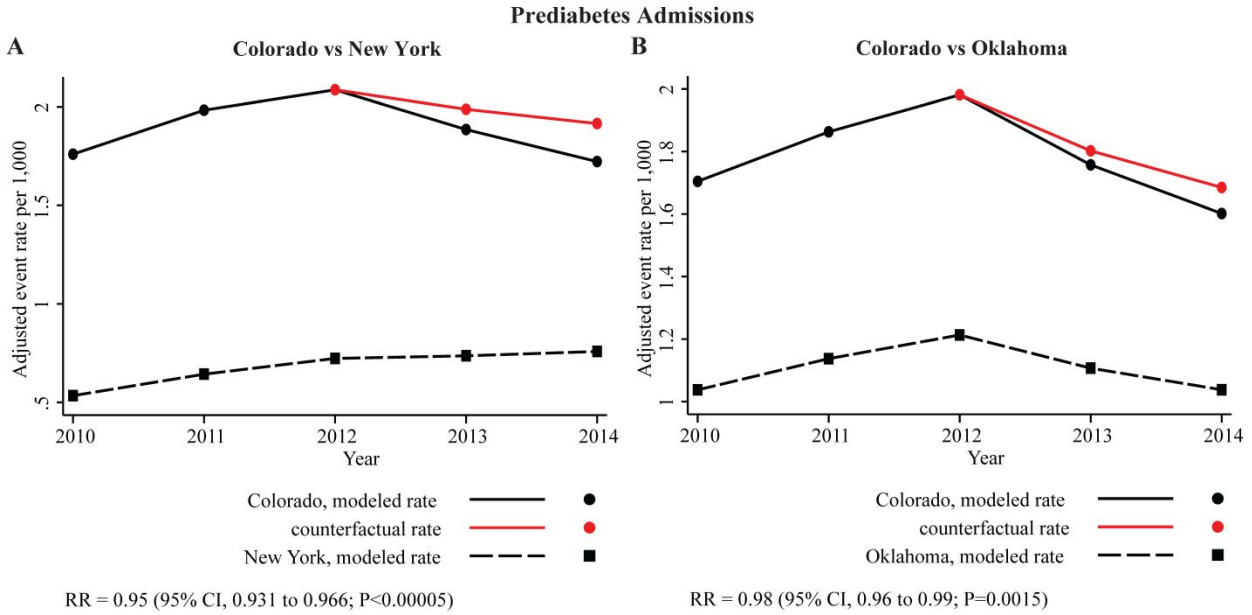

**eFigure 3.** Multivariate adjusted rates of admissions for ischemic stroke over 2010-2014 in Colorado compared with New York (A) and Oklahoma (B). RR = risk ratio; CI = confidence interval.



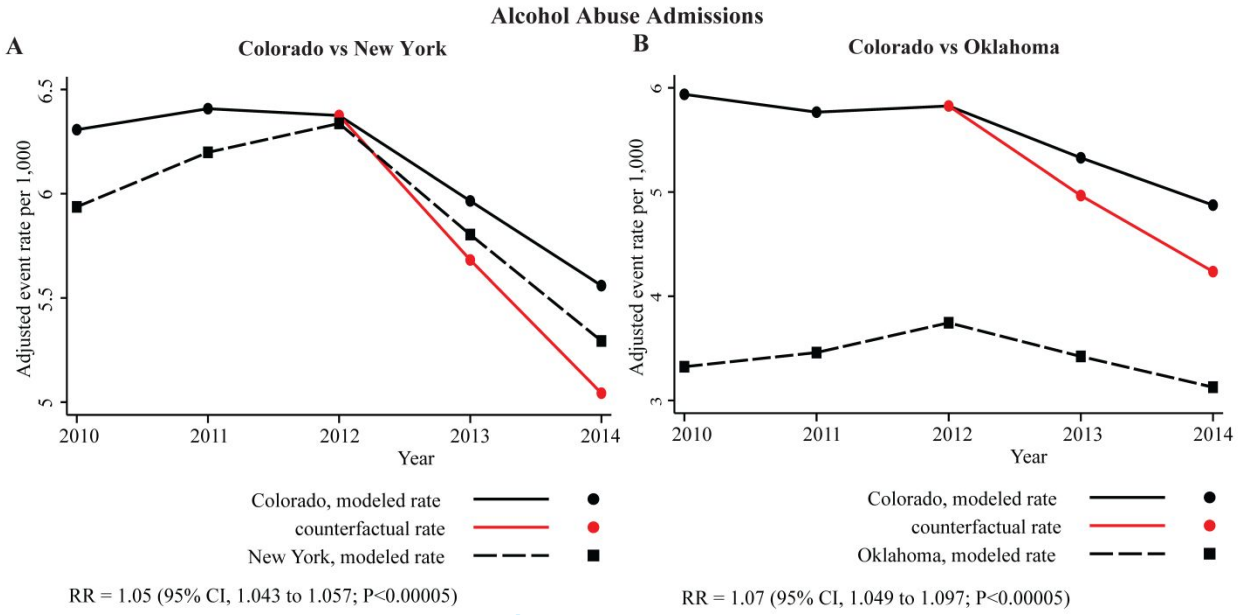
**eFigure 4.** Multivariate adjusted rates of admissions for metabolic syndrome and diabetes over 2010-2014 in Colorado compared with New York (A) and Oklahoma (B). RR = risk ratio; CI = confidence interval.



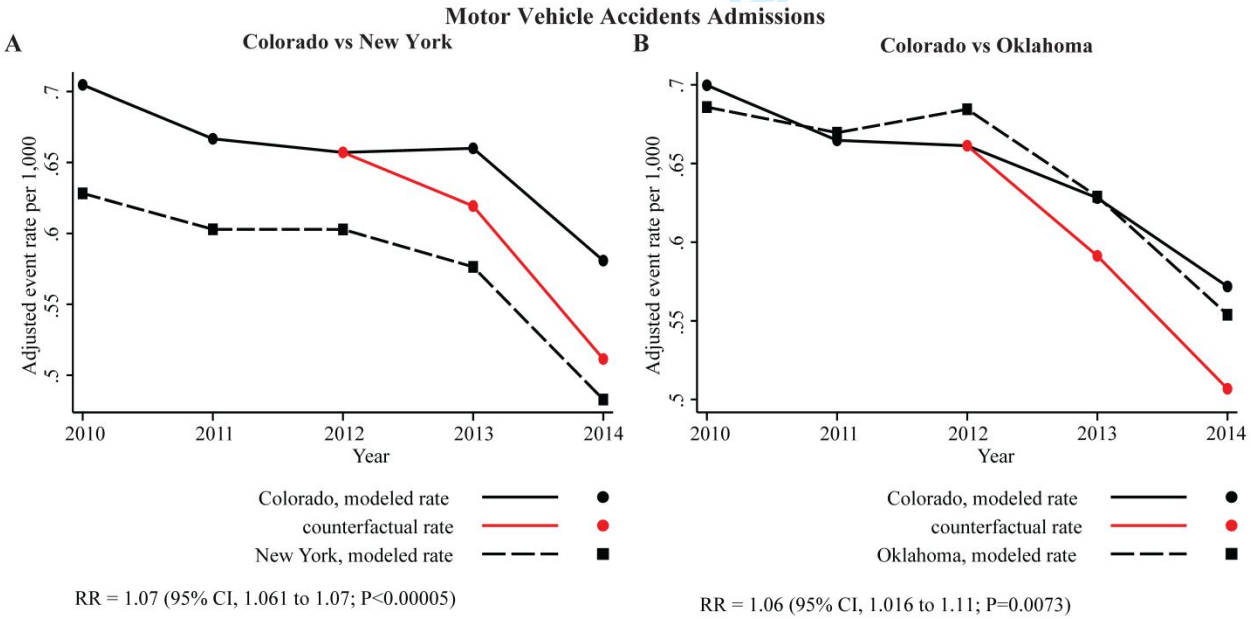

**eFigure 5.** Multivariate adjusted rates of admissions for prediabetes over 2010-2014 in Colorado compared with New York (A) and Oklahoma (B). RR = risk ratio; CI = confidence interval.



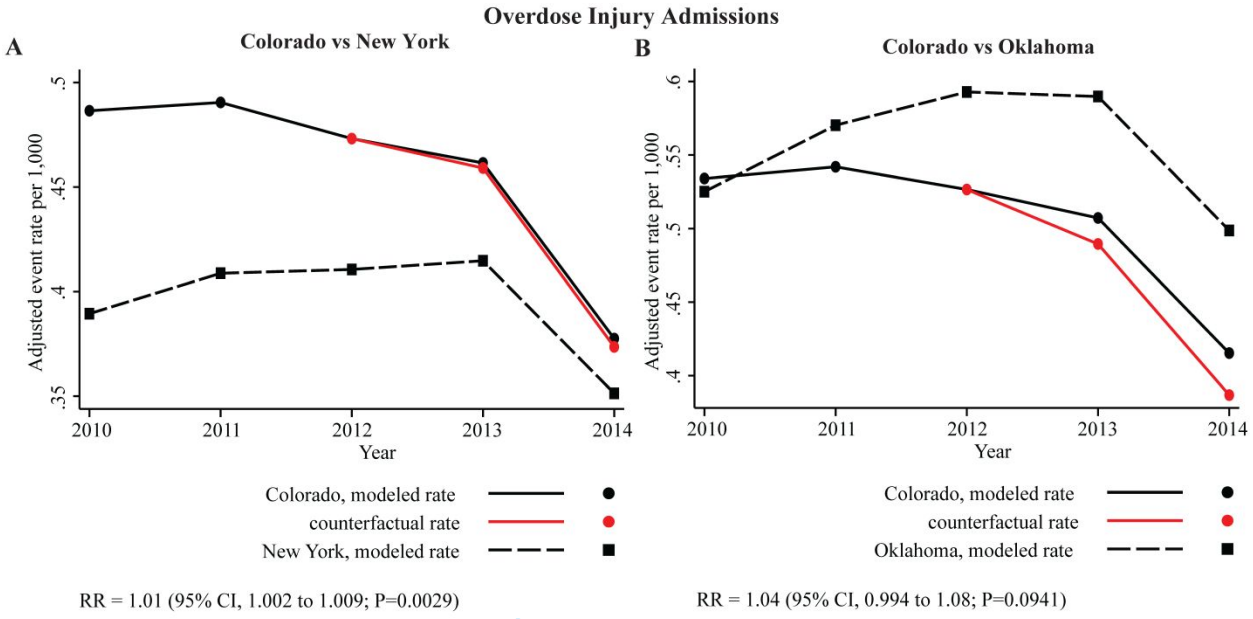
**eFigure 6.** Multivariate adjusted rates of admissions for alcohol abuse over 2010-2014 in Colorado compared with New York (A) and Oklahoma (B). RR = risk ratio; CI = confidence interval.



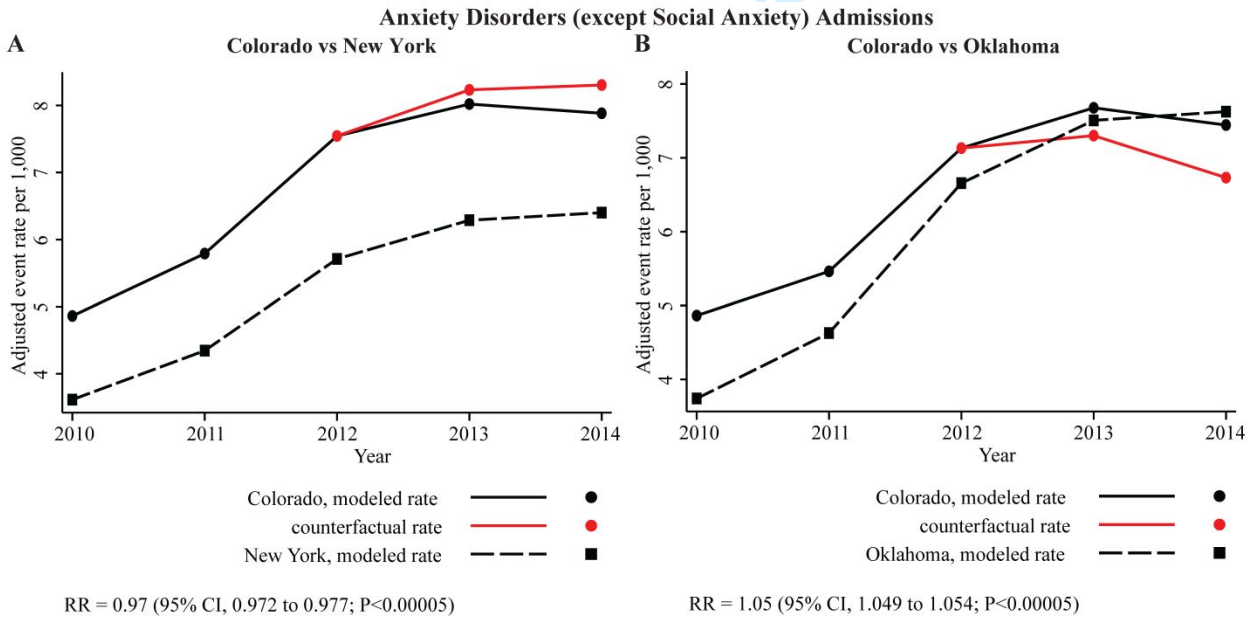

**eFigure 7.** Multivariate adjusted rates of admissions for motor vehicle accidents over 2010-2014 in Colorado compared with New York (A) and Oklahoma (B). RR = risk ratio; CI = confidence interval.



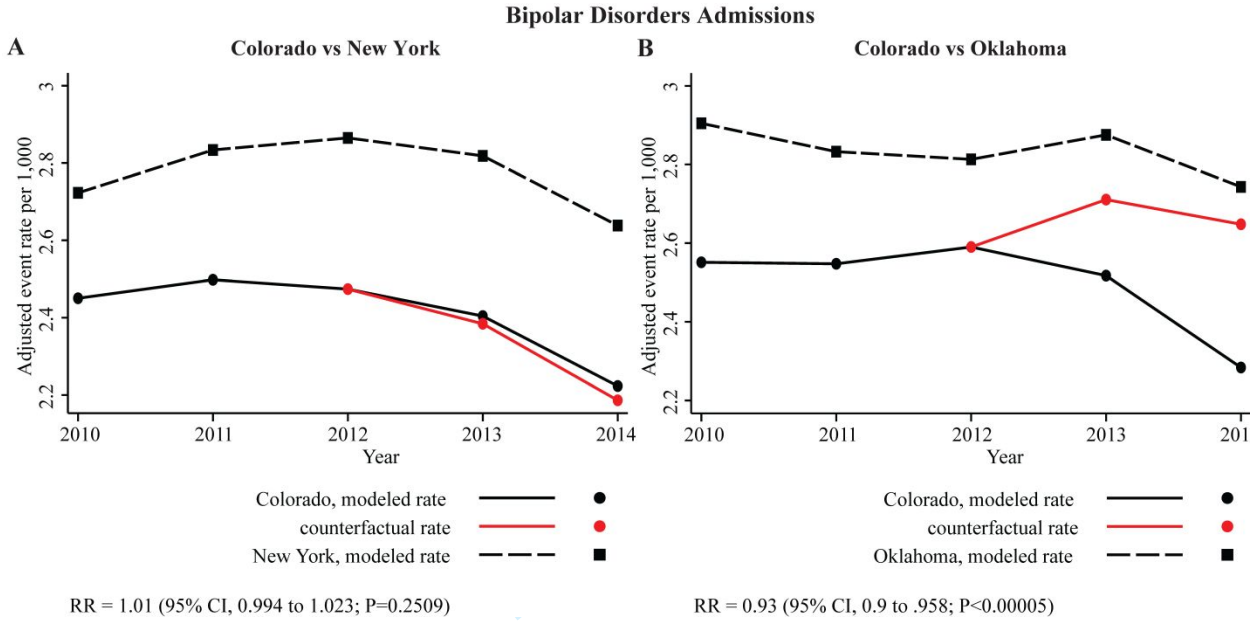
**eFigure 8.** Multivariate adjusted rates of admissions for overdose injury over 2010-2014 in Colorado compared with New York (A) and Oklahoma (B). RR = risk ratio; CI = confidence interval.



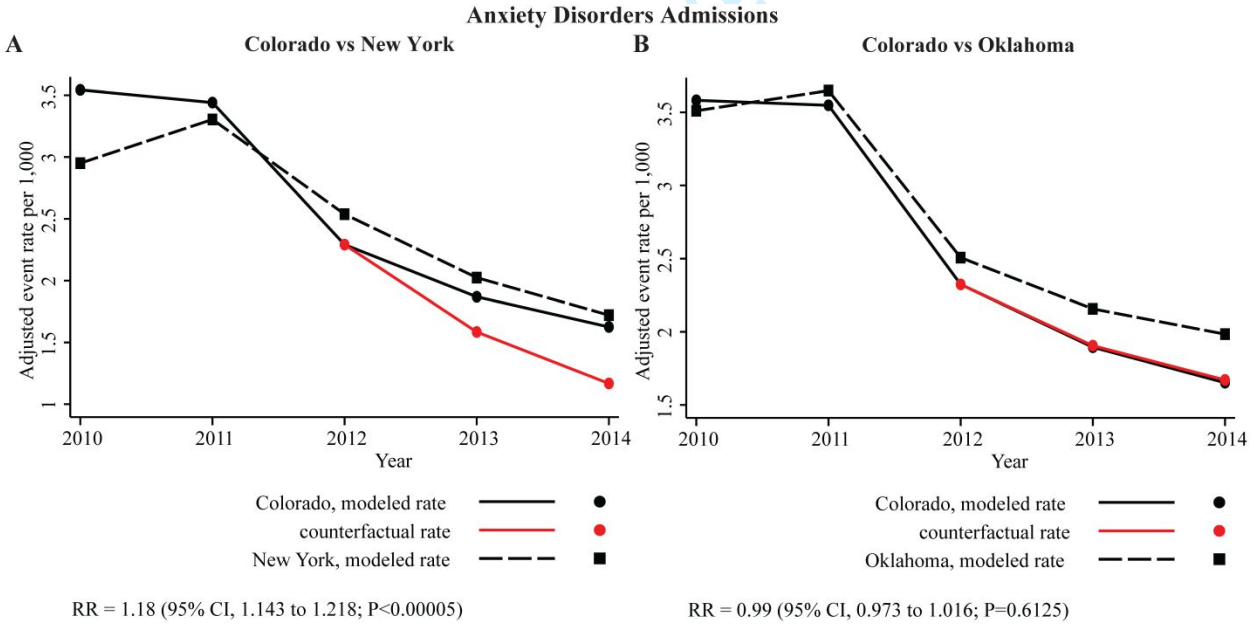

**eFigure 9.** Multivariate adjusted rates of admissions for anxiety disorders (except social anxiety) over 2010-2014 in Colorado compared with New York (A) and Oklahoma (B). RR = risk ratio; CI = confidence interval.



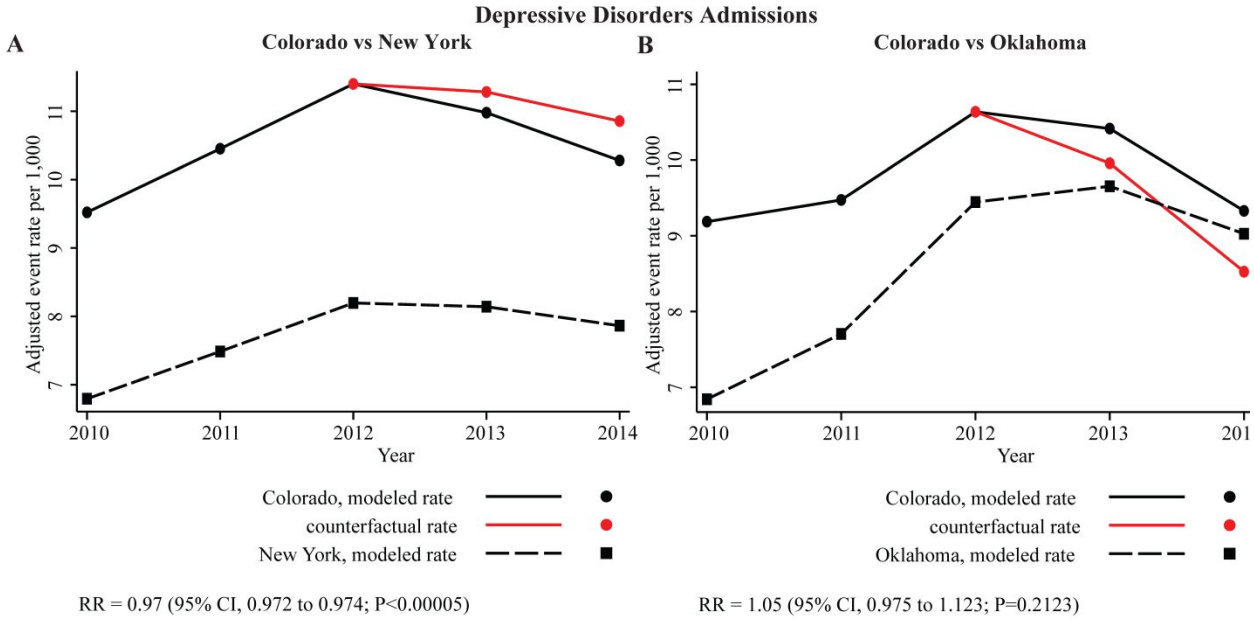
**eFigure 10.** Multivariate adjusted rates of admissions for bipolar disorders over 2010-2014 in Colorado compared with New York (A) and Oklahoma (B). RR = risk ratio; CI = confidence interval.



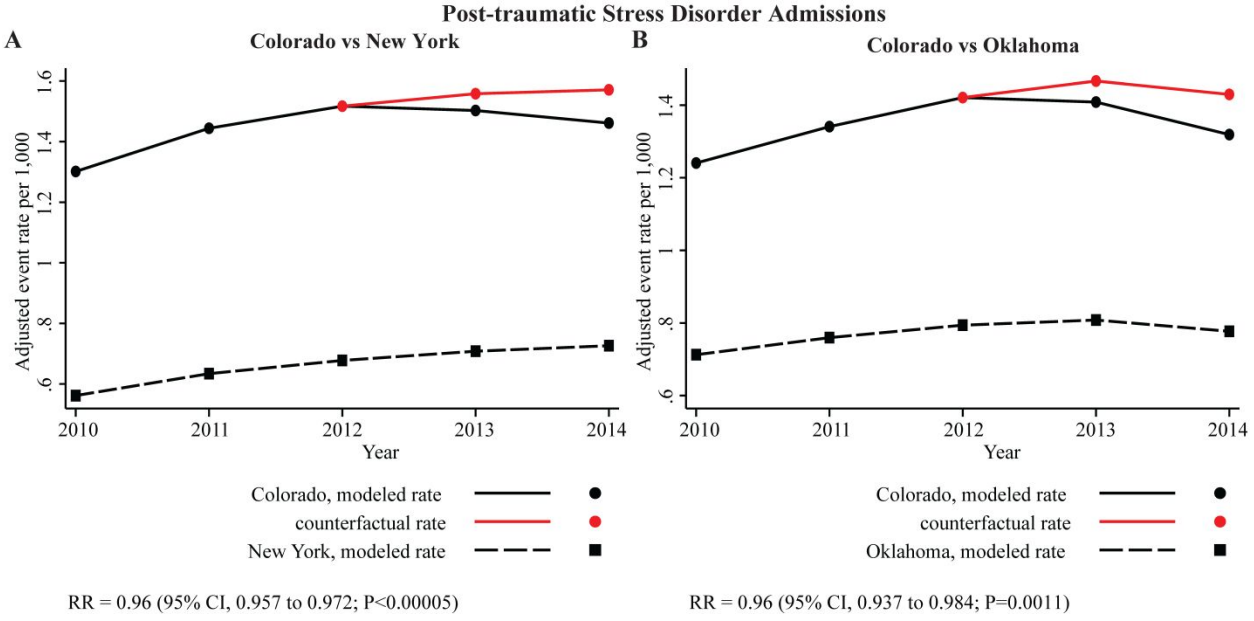

**eFigure 11.** Multivariate adjusted rates of admissions for anxiety disorders over 2010-2014 in Colorado compared with New York (A) and Oklahoma (B). RR = risk ratio; CI = confidence interval.



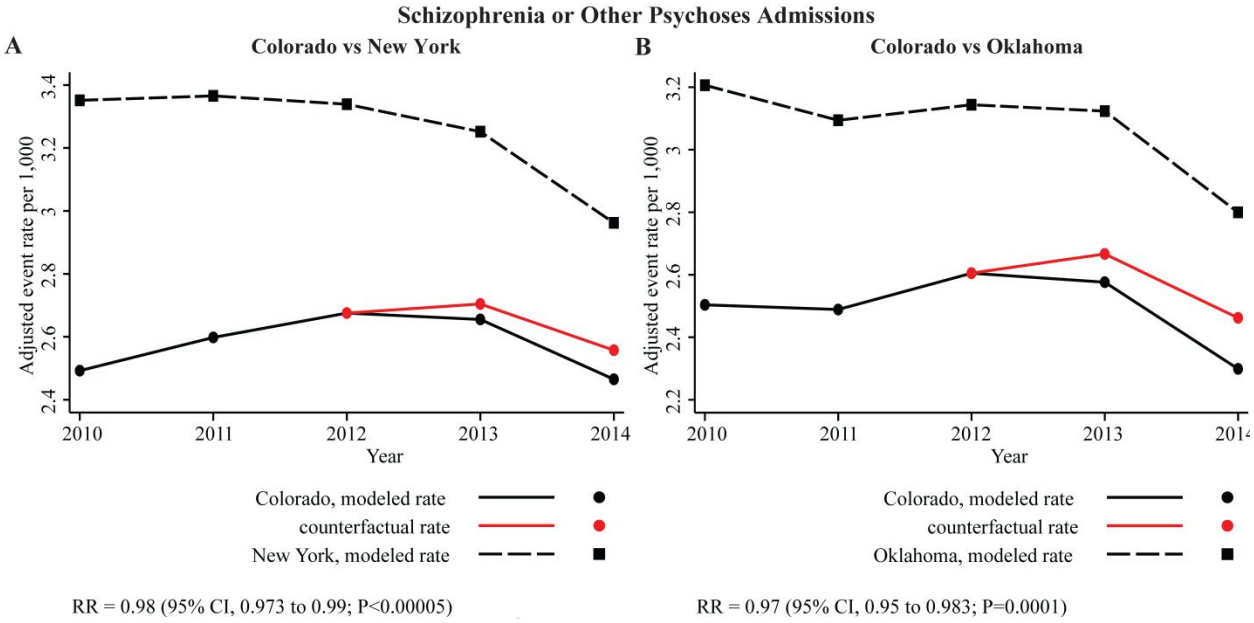
**eFigure 12.** Multivariate adjusted rates of admissions for depressive disorders over 2010-2014 in Colorado compared with New York (A) and Oklahoma (B). RR = risk ratio; CI = confidence interval.



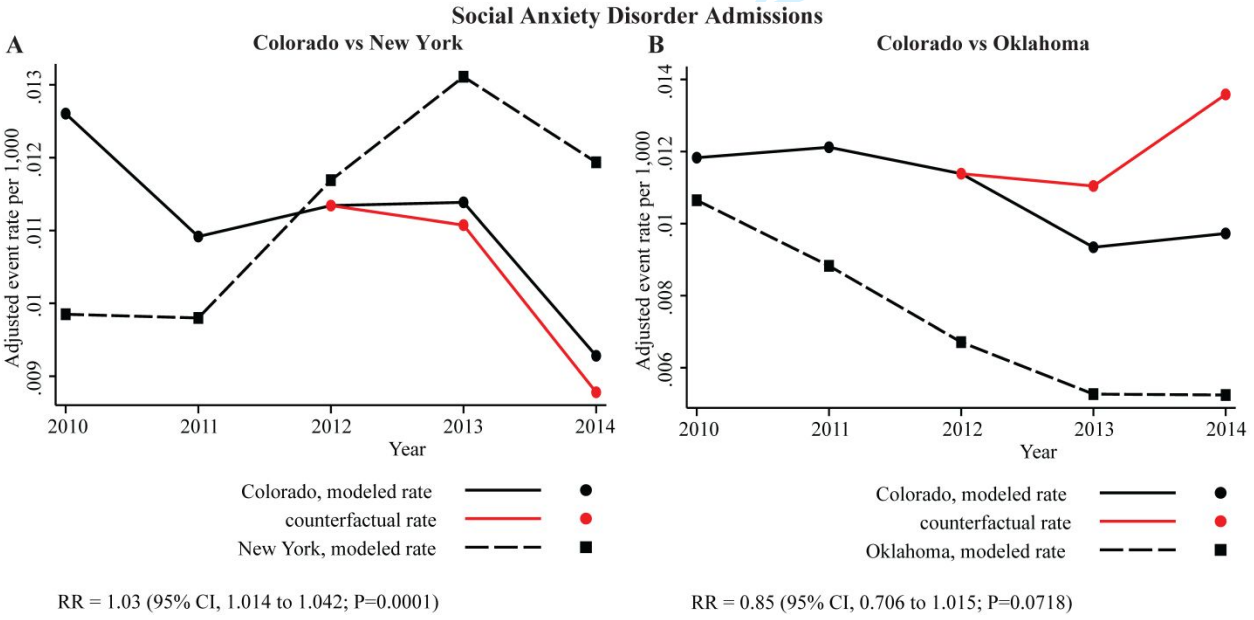

**eFigure 13.** Multivariate adjusted rates of admissions for post-traumatic stress disorder over 2010-2014 in Colorado compared with New York (A) and Oklahoma (B). RR = risk ratio; CI = confidence interval.



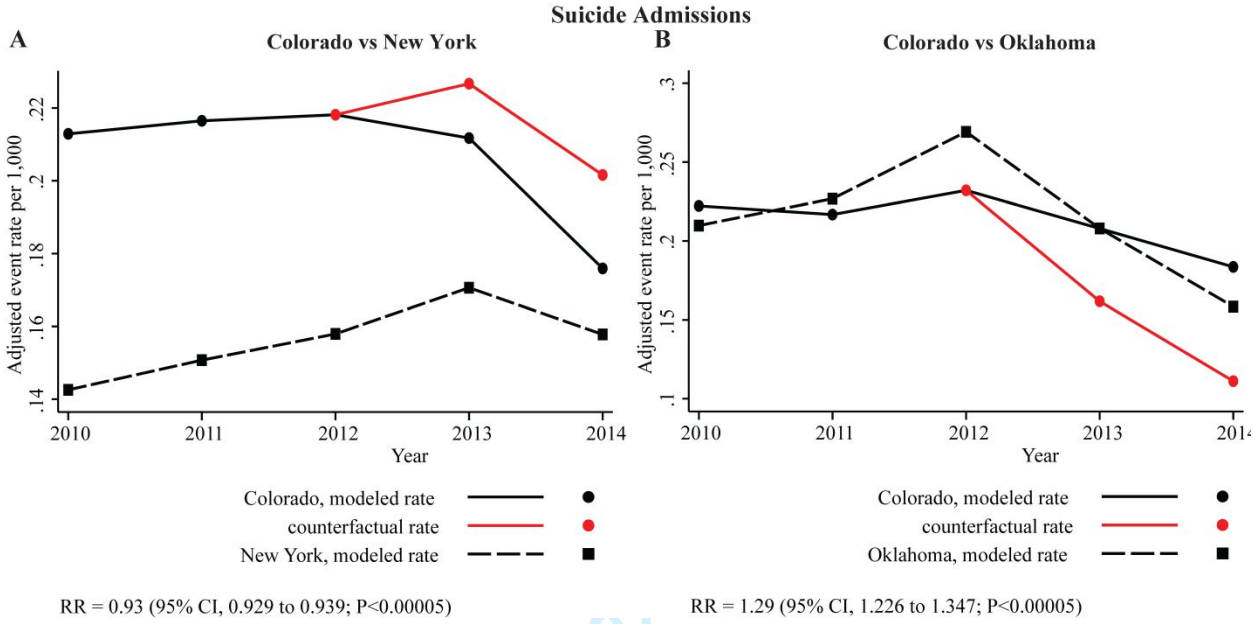
**eFigure 14.** Multivariate adjusted rates of admissions for schizophrenia or other psychoses over 2010-2014 in Colorado compared with New York (A) and Oklahoma (B). RR = risk ratio; CI = confidence interval.



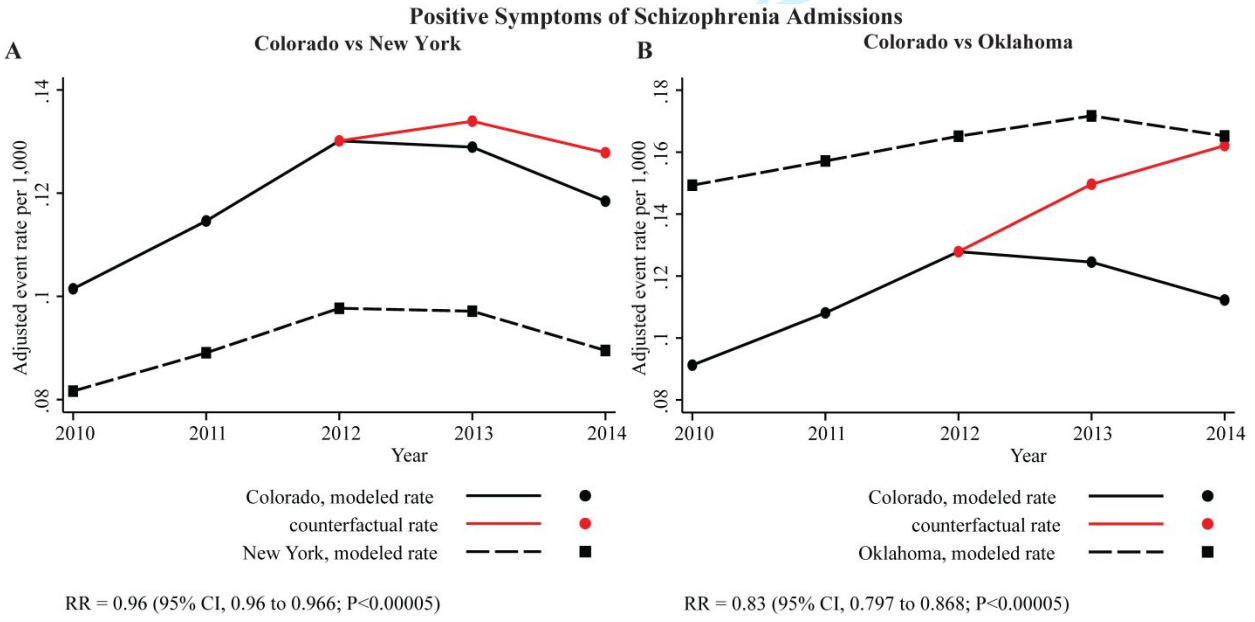

**eFigure 15.** Multivariate adjusted rates of admissions for social anxiety disorder over 2010-2014 in Colorado compared with New York (A) and Oklahoma (B). RR = risk ratio; CI = confidence interval.



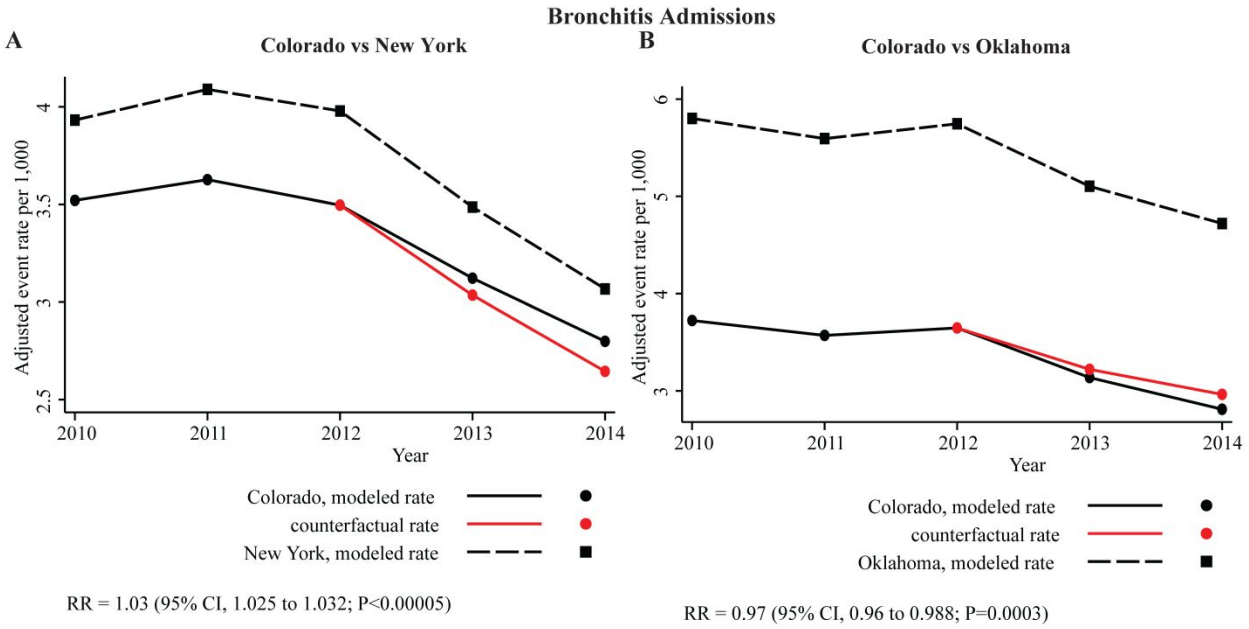
**eFigure 16.** Multivariate adjusted rates of admissions for suicide over 2010-2014 in Colorado compared with New York (A) and Oklahoma (B). RR = risk ratio; CI = confidence interval.



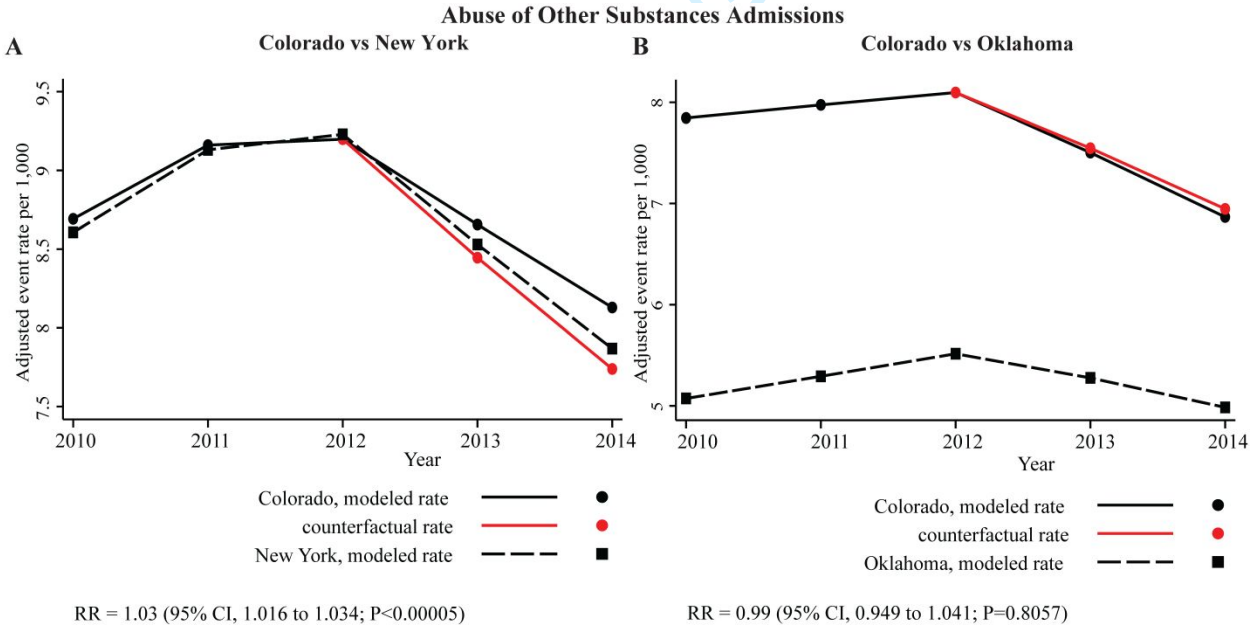

**eFigure 17.** Multivariate adjusted rates of admissions for positive symptoms of schizophrenia over 2010-2014 in Colorado compared with New York (A) and Oklahoma (B). RR = risk ratio; CI = confidence interval.



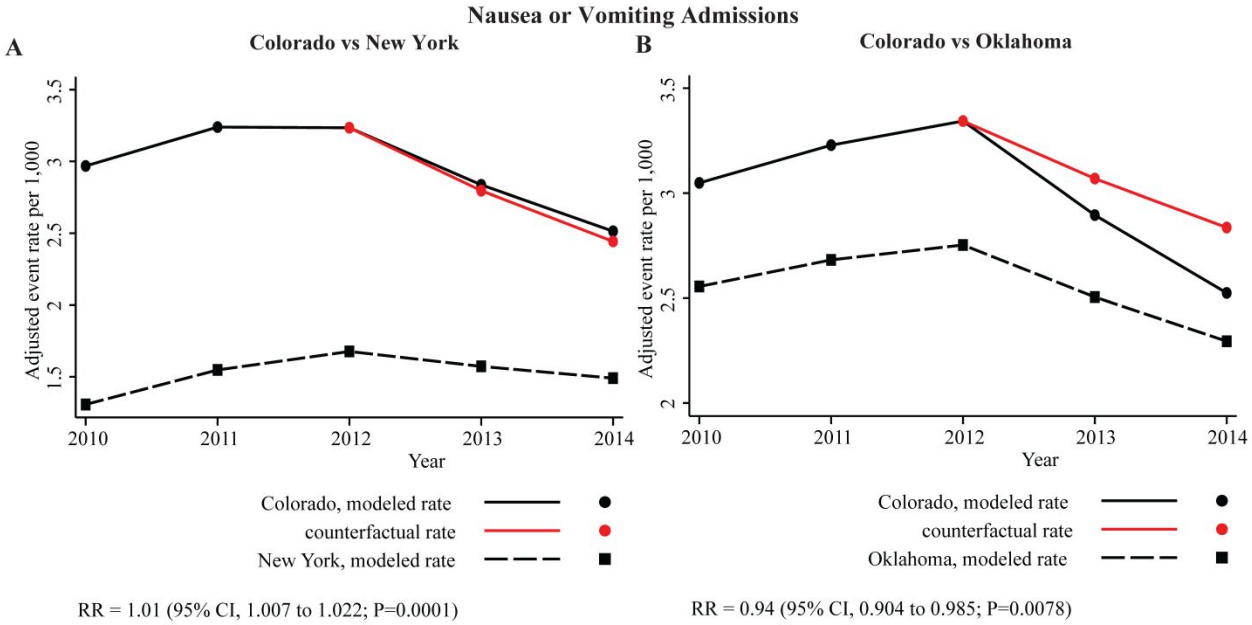
**eFigure 18.** Multivariate adjusted rates of admissions for bronchitis over 2010-2014 in Colorado compared with New York (A) and Oklahoma (B). RR = risk ratio; CI = confidence interval.



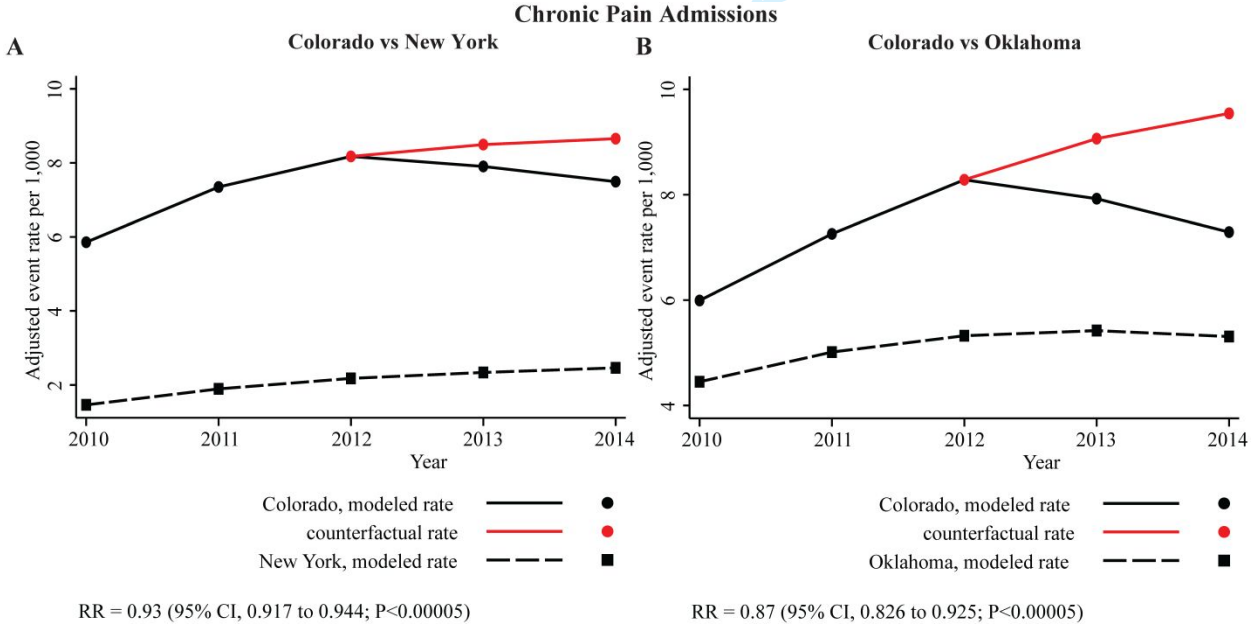

**eFigure 19.** Multivariate adjusted rates of admissions for abuse of other substances over 2010-2014 in Colorado compared with New York (A) and Oklahoma (B). RR = risk ratio; CI = confidence interval.



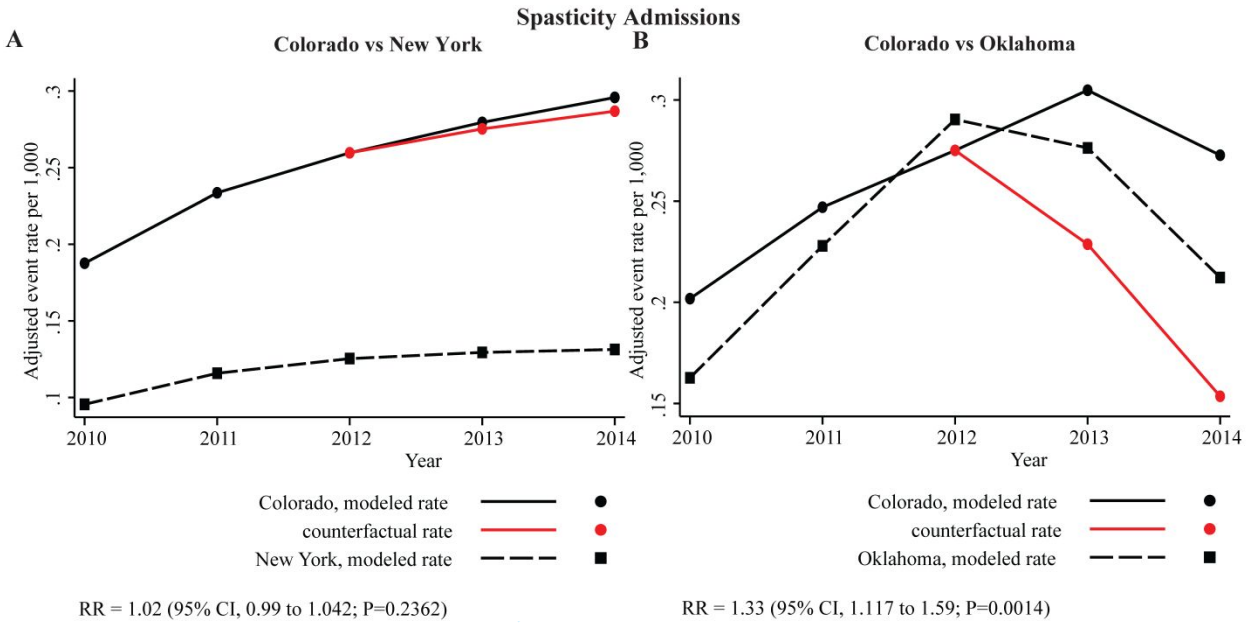
**eFigure 20.** Multivariate adjusted rates of admissions for nausea or vomiting over 2010-2014 in Colorado compared with New York (A) and Oklahoma (B). RR = risk ratio; CI = confidence interval.



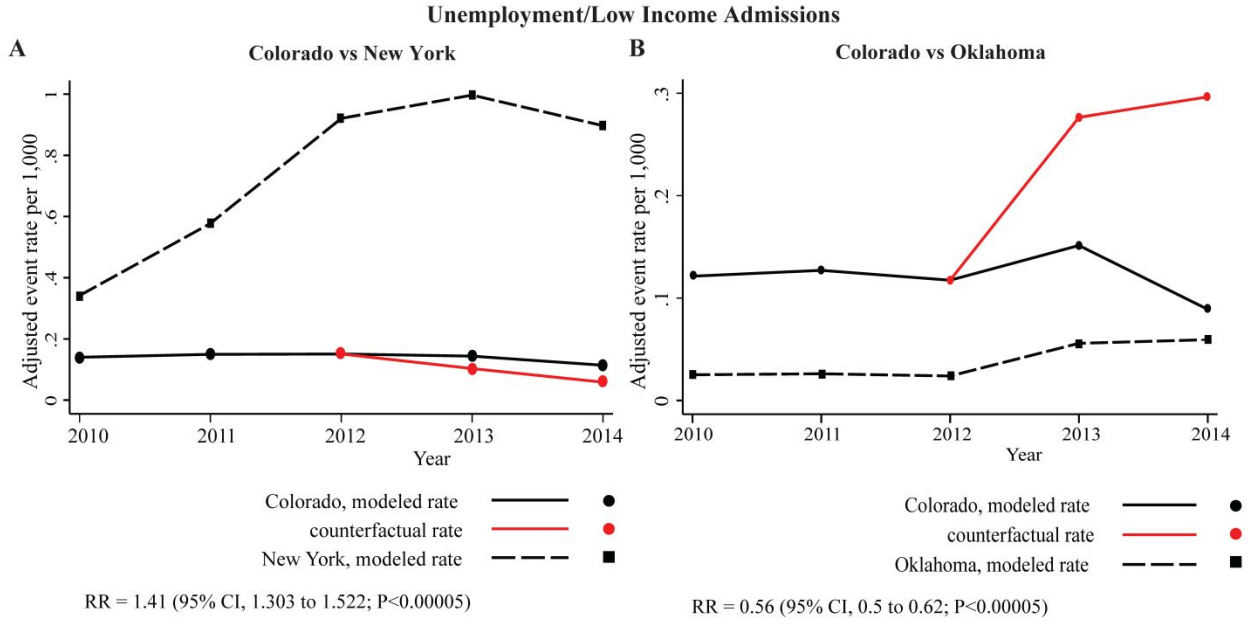

**eFigure 21.** Multivariate adjusted rates of admissions for chronic pain over 2010-2014 in Colorado compared with New York (A) and Oklahoma (B). RR = risk ratio; CI = confidence interval.



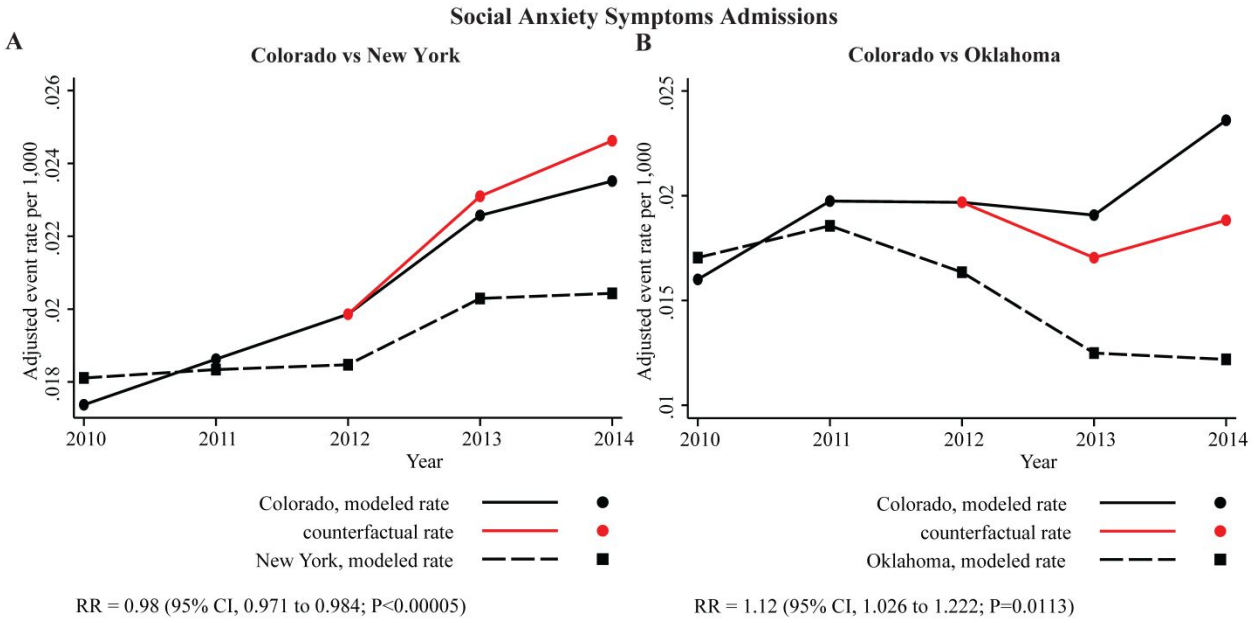
**eFigure 22.** Multivariate adjusted rates of admissions for spasticity over 2010-2014 in Colorado compared with New York (A) and Oklahoma (B). RR = risk ratio; CI = confidence interval.



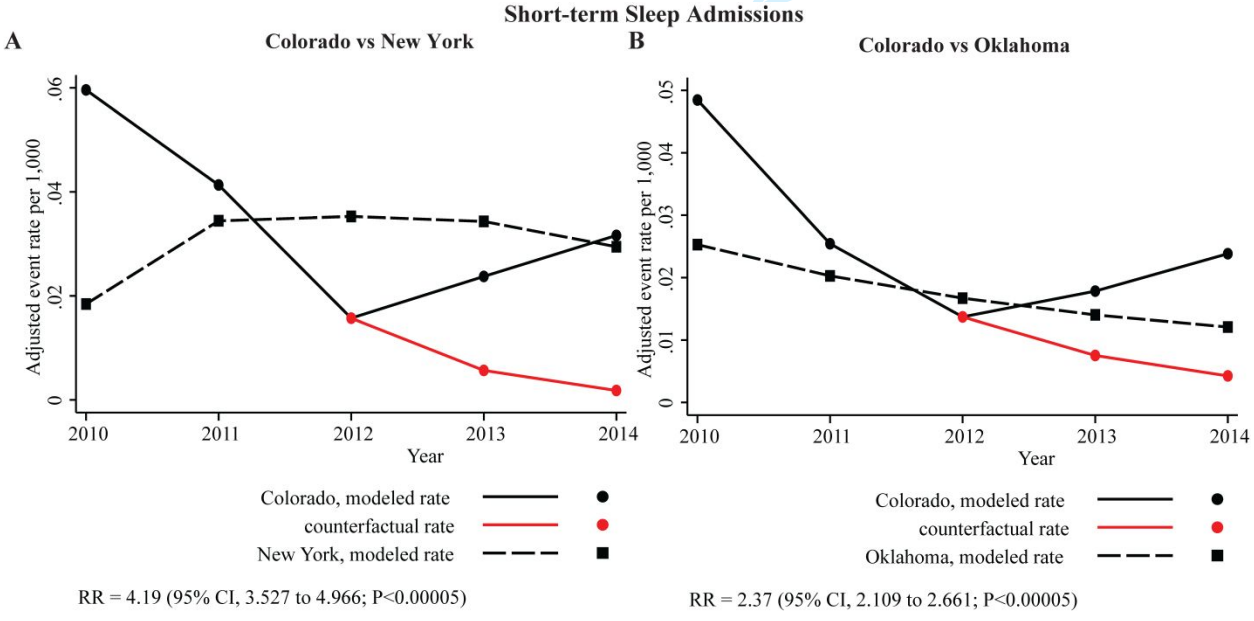

**eFigure 23.** Multivariate adjusted rates of admissions for unemployment/low income over 2010-2014 in Colorado compared with New York (A) and Oklahoma (B). RR = risk ratio; CI = confidence interval.



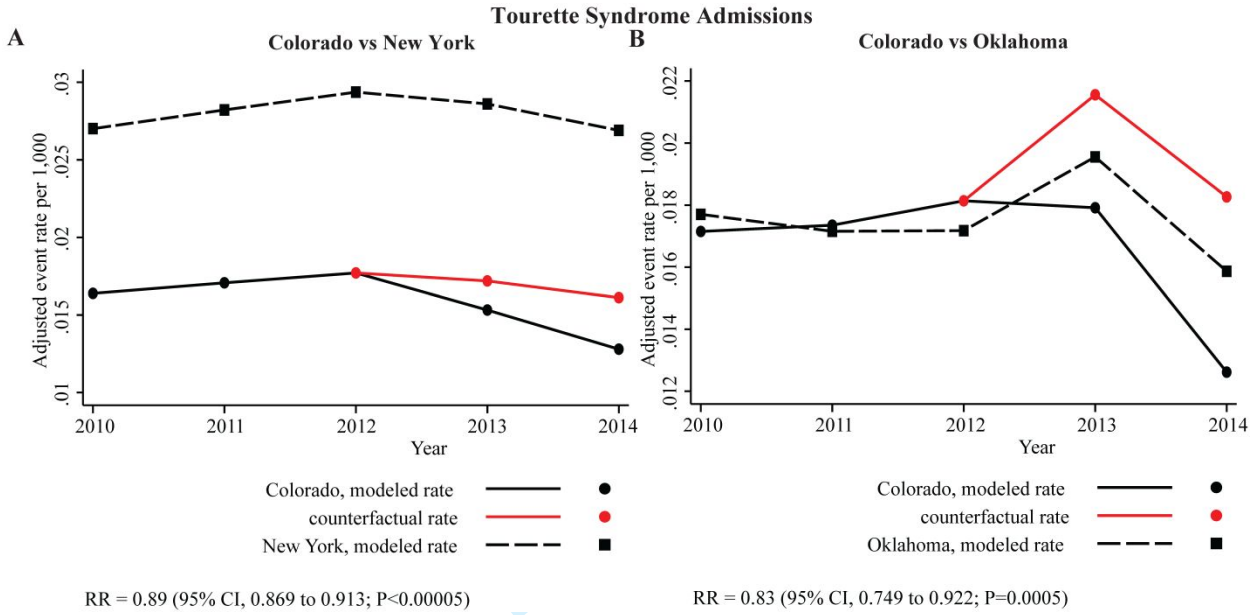
**eFigure 24.** Multivariate adjusted rates of admissions for social anxiety symptoms over 2010-2014 in Colorado compared with New York (A) and Oklahoma (B). RR = risk ratio; CI = confidence interval.



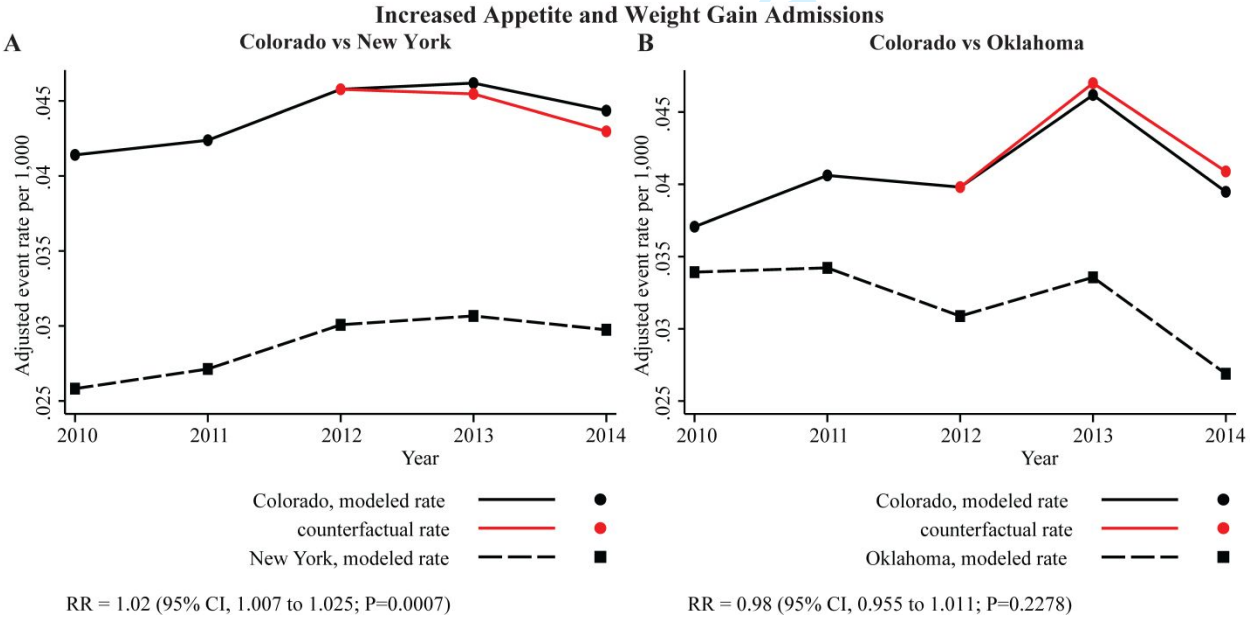

**eFigure 25.** Multivariate adjusted rates of admissions for short-term sleep disorders over 2010-2014 in Colorado compared with New York (A) and Oklahoma (B). RR = risk ratio; CI = confidence interval.



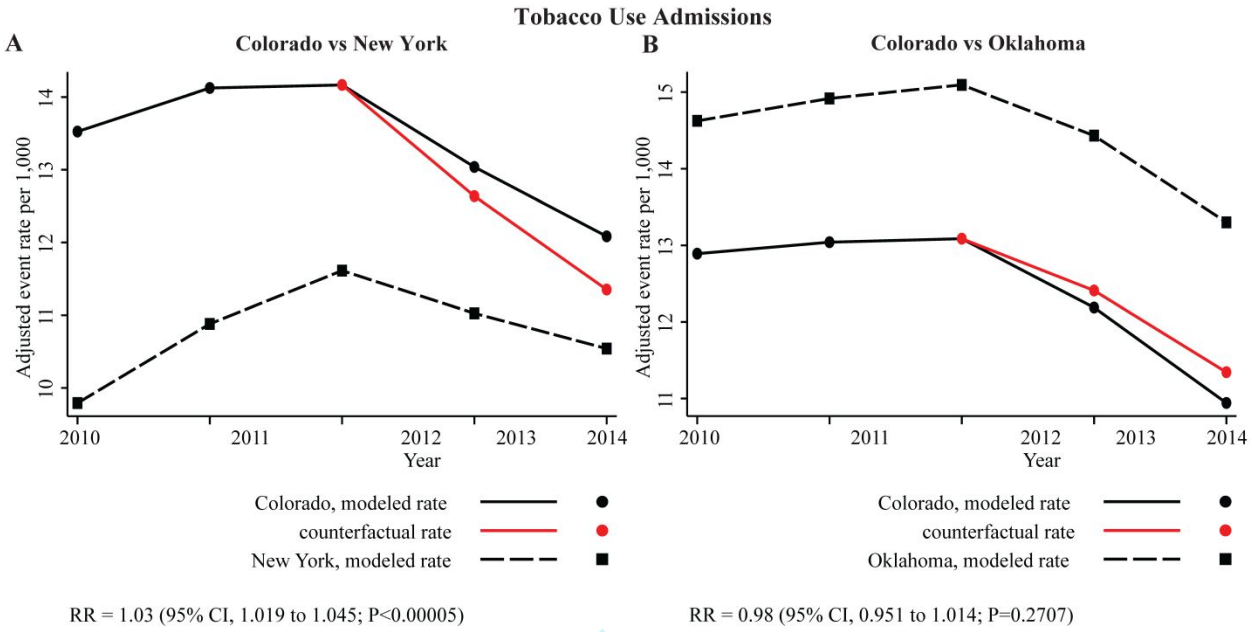
**eFigure 26.** Multivariate adjusted rates of admissions for Tourette's syndrome over 2010-2014 in Colorado compared with New York (A) and Oklahoma (B). RR = risk ratio; CI = confidence interval.



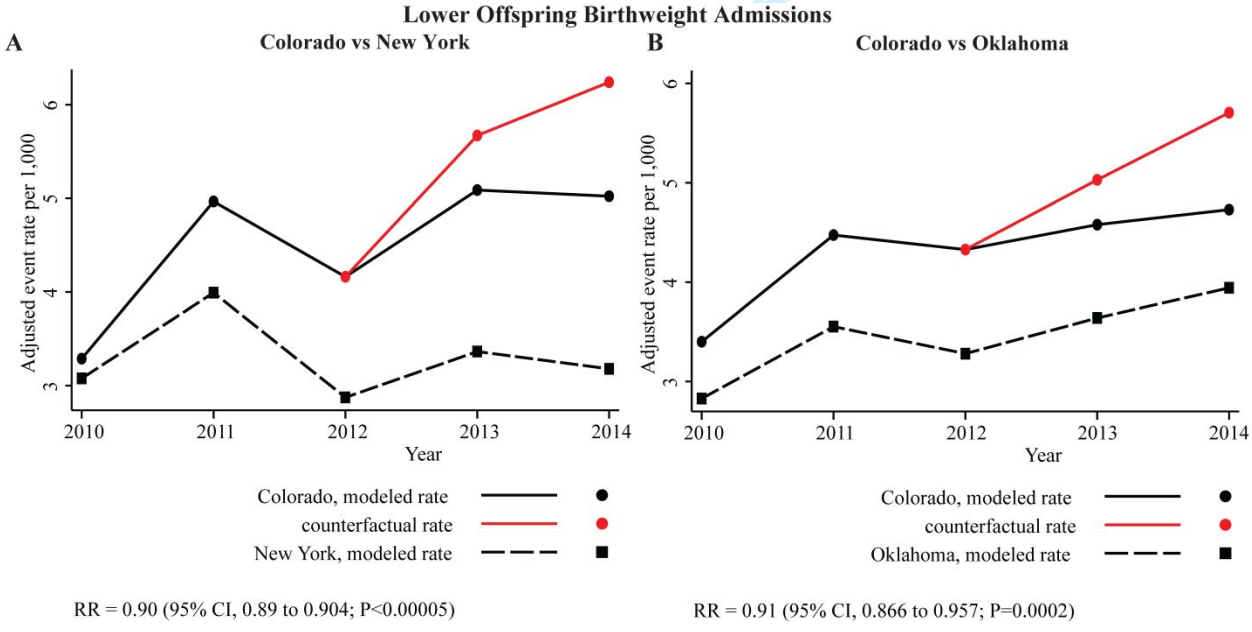

**eFigure 27.** Multivariate adjusted rates of admissions for increased appetite and weight gain over 2010-2014 in Colorado compared with New York (A) and Oklahoma (B). RR = risk ratio; CI = confidence interval.



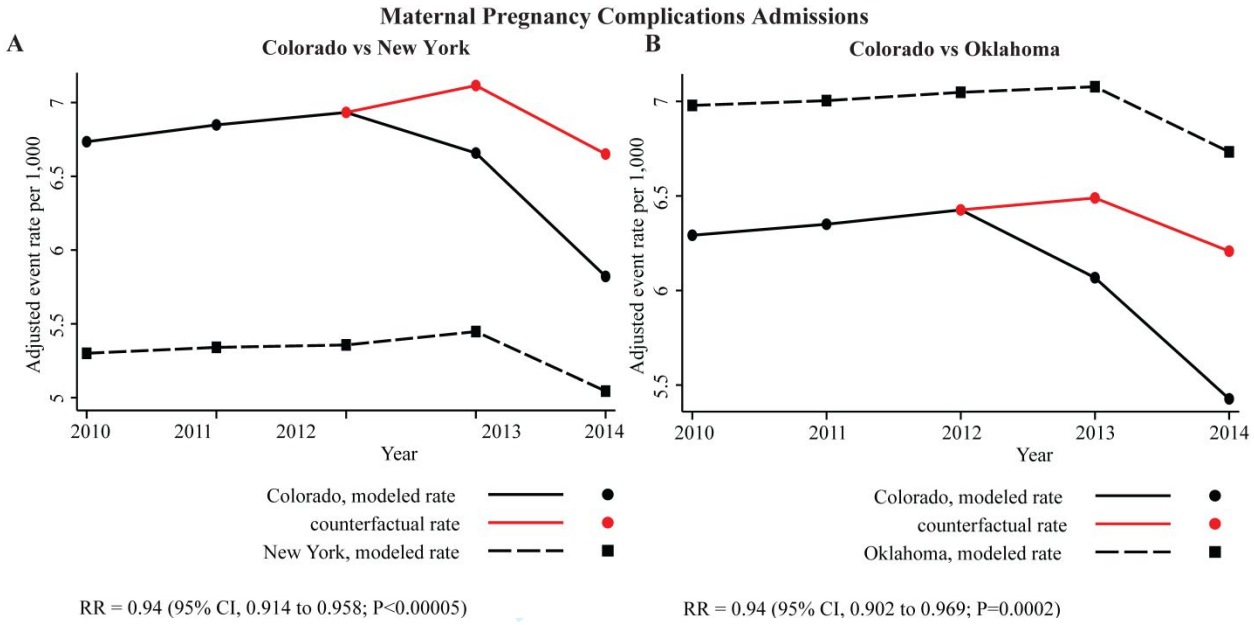
**eFigure 28.** Multivariate adjusted rates of admissions for tobacco use over 2010-2014 in Colorado compared with New York (A) and Oklahoma (B). RR = risk ratio; CI = confidence interval.



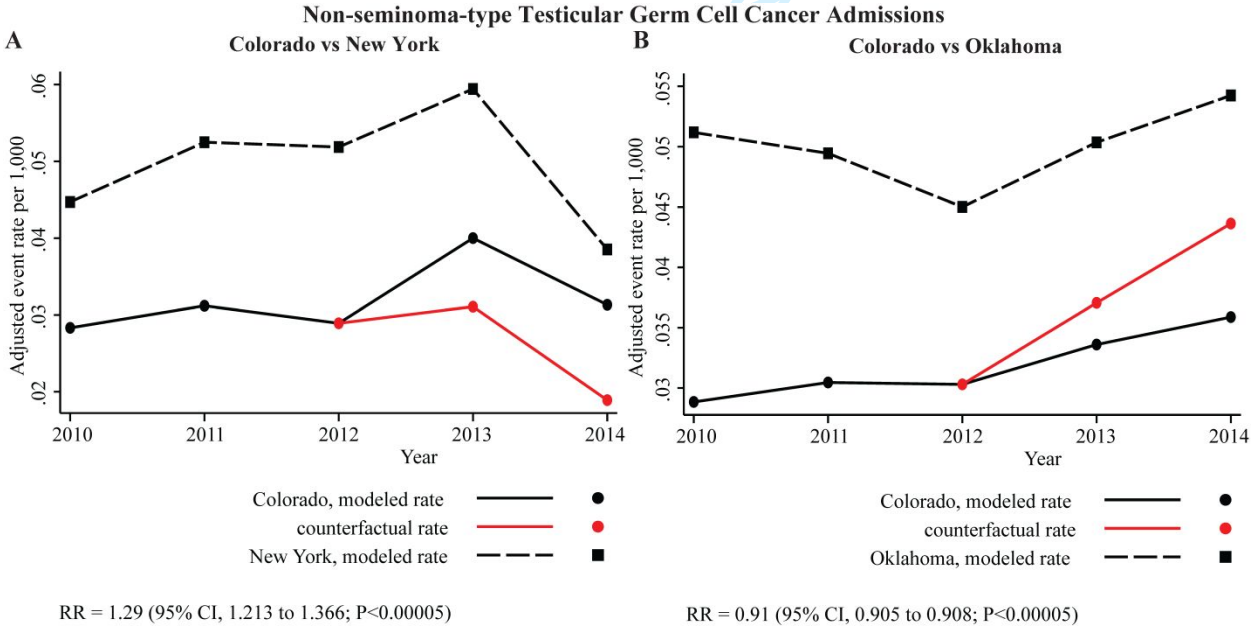

**eFigure 29.** Multivariate adjusted rates of admissions for lower offspring birthweight over 2010-2014 in Colorado compared with New York (A) and Oklahoma (B). RR = risk ratio; CI = confidence interval.



**eFigure 30.** Multivariate adjusted rates of admissions for maternal pregnancy complications over 2010-2014 in Colorado compared with New York (A) and Oklahoma (B). RR = risk ratio; CI = confidence interval.




**eFigure 31.** Multivariate adjusted rates of admissions for non-seminoma-type testicular germ cell cancer over 2010-2014 in Colorado compared with New York (A) and Oklahoma (B). RR = risk ratio; CI = confidence interval.



STROBE Statement—Checklist of items that should be included in reports of ***cohort studies***

| | Item No | Recommendation | Page No |
|---|---|---|---|
| **Title and abstract** | 1 | (*a*) Indicate the study's design with a commonly used term in the title or the abstract | 1 |
| | | (*b*) Provide in the abstract an informative and balanced summary of what was done and what was found | 2 |
| **Introduction** | | | |
| Background/rationale | 2 | Explain the scientific background and rationale for the investigation being reported | 5 |
| Objectives | 3 | State specific objectives, including any prespecified hypotheses | 5 |
| **Methods** | | | |
| Study design | 4 | Present key elements of study design early in the paper | 5, 6, 7 |
| Setting | 5 | Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection | 5, 6, 7 |
| Participants | 6 | (*a*) Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up | 5, 6 |
| | | (*b*) For matched studies, give matching criteria and number of exposed and unexposed | |
| Variables | 7 | Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable | 6, 7 |
| Data sources/ measurement | 8* | For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group | 6, 7 |
| Bias | 9 | Describe any efforts to address potential sources of bias | 7, 8 |
| Study size | 10 | Explain how the study size was arrived at | 5, 6 |
| Quantitative variables | 11 | Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why | 7, 8, 9 |
| Statistical methods | 12 | (*a*) Describe all statistical methods, including those used to control for confounding | 7, 8, 9 |
| | | (*b*) Describe any methods used to examine subgroups and interactions | |
| | | (*c*) Explain how missing data were addressed | |
| | | (*d*) If applicable, explain how loss to follow-up was addressed | |
| | | (*e*) Describe any sensitivity analyses | |
| **Results** | | | |
| Participants | 13* | (a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed | 9 |
| | | (b) Give reasons for non-participation at each stage | |
| | | (c) Consider use of a flow diagram | |
| Descriptive data | 14* | (a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders | 9 |
| | | (b) Indicate number of participants with missing data for each variable of interest | |

| | | | |
|---|---|---|---|
| | | (c) Summarise follow-up time (eg, average and total amount) | |
| Outcome data | 15* | Report numbers of outcome events or summary measures over time | 9 |

| | | | |
|---|---|---|---|
| Main results | 16 | (*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included<br>(*b*) Report category boundaries when continuous variables were categorized<br>(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period | 10, 11, 12 |
| Other analyses | 17 | Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses | 9 |
| **Discussion** | | | |
| Key results | 18 | Summarise key results with reference to study objectives | 12, 13 |
| Limitations | 19 | Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias | 13, 14 |
| Interpretation | 20 | Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence | 14, 15 |
| Generalisability | 21 | Discuss the generalisability (external validity) of the study results | 14, 15 |
| **Other information** | | | |
| Funding | 22 | Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based | 16 |

*Give information separately for exposed and unexposed groups.

**Note:** An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at http://www.strobe-statement.org.

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# Does Cannabis Legalization Change Healthcare Utilization? A Population-based Study Using the Healthcare Cost and Utilization Project

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| | |

# Does Cannabis Legalization Change Healthcare Utilization? A Population-based Study Using the Healthcare Cost and Utilization Project

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**Total Word Count:** 3760

## ABSTRACT

**OBJECTIVE:** To assess the effect of cannabis legalization on health effects and healthcare utilization in Colorado (CO), the first state to legalize recreational cannabis, when compared with 2 control states, New York (NY) and Oklahoma (OK).

**DESIGN:** We used the 2010-2014 Healthcare Cost and Utilization Project (HCUP) inpatient databases to compare changes in rates of healthcare utilization and diagnoses in CO versus NY and OK.

**SETTING:** Population-based, inpatient**.**

**PARTICIPANTS:** HCUP state-wide data comprising over 28 million individuals and over 16 million hospitalizations across 3 states.

**MAIN OUTCOME MEASURES:** We used International Classification of Diseases-9th Edition (ICD-9) codes to assess changes in healthcare utilization specific to various medical diagnoses potentially treated by or exacerbated by cannabis. Diagnoses were classified based on weight of evidence from the National Academy of Science (NAS). Negative binomial models were used to compare rates of admissions between states.

**RESULTS**: In CO compared to NY and OK, respectively, cannabis abuse increased (risk ratio [RR], 1.27; 95% confidence interval [CI], 1.26 to 1.28 and RR 1.16; 95% CI 1.15 to 1.17; both *P*<0.0005) post-legalization. In CO, there was a reduction in total admissions but only when compared to OK (RR 0.97; 95% CI 0.96 to 0.98; *P*<0.0005). Length of stay and costs did not change significantly in CO compared to NY or OK. Post-legalization changes most consistent with NAS-based evidence included an increase in motor vehicle accidents, alcohol abuse, overdose injury, and a reduction in chronic pain (all *P*<0.05 compared to each control state).

**CONCLUSIONS:** Recreational cannabis legalization is associated with neutral effects on healthcare utilization. In line with previously established evidence, cannabis liberalization is

linked to an increase in motor vehicle accidents, alcohol abuse, overdose injuries and a decrease in chronic pain. Such population-level effects may help guide future decisions regarding cannabis use, prescription, and policy.

## Strengths and limitations of this study

- The study focuses on the impact of recreational cannabis legalization on health care utilization instead of its legal or societal effects
- This study utilizes HCUP data comprising over 28 million individuals and over 16 million hospitalizations
- Stringent standards were employed to address possible false positives due to multiple hypotheses testing
- Follow up data after the 2012 Amendment 64 only includes two subsequent years
- Physician coding with ICD-9 codes does not capture potentially important mediators related to cannabis use

## INTRODUCTION

Over 147 million people, or 2.5 percent of the world's population, use cannabis (marijuana),[1] and more than 20 million Americans have reported the use of cannabis in the past 30 days.[1] Because cannabis use is a federal crime, clinical studies have been challenging to pursue, resulting in substantial knowledge gaps regarding actual health consequences. Thirty states and the District of Columbia now allow cannabis for the treatment of medical conditions.[2] Of these, 9 have recently legalized cannabis for recreational use. Given such pervasive policy changes, understanding potential shifts in healthcare utilization is vital.

Recently, an extensive and rigorous summary of the current evidence on health effects of cannabis was developed by a committee of experts appointed by the US National Academy of Science (NAS) focusing on systematic reviews and high-quality primary research.[3] The health endpoints assessed in the NAS summary included oncologic, cardiometabolic, respiratory, immunologic, and psychiatric disorders as well as outcomes related to injury and death (i.e. motor-vehicle accidents). While the NAS summary represents a valuable starting place that makes use of the available data, we do not yet know whether that evidence, based largely on small studies, will translate into real-world ramifications after legalization of recreational cannabis.

On December 10, 2012, Colorado enacted *Colorado Amendment 64,* legalizing recreational cannabis. Following this date, adults aged 21 or older could grow cannabis plants privately, legally possess all cannabis from these plants, and give cannabis as a gift to other adults aged 21 or older.[4] After January 1, 2014, recreational cannabis could be legally purchased in retail stores.[5] We hypothesized that changes in healthcare

utilization and diagnoses most consistent with NAS-based evidence occur when access to recreational cannabis becomes liberalized.

## METHODS

We used the Agency for Healthcare Research and Quality (AHRQ)-funded Healthcare Cost and Utilization Project (HCUP) database to measure inpatient healthcare utilization and diagnoses in Colorado (CO) between 2010 and 2014. HCUP is a state-wide database containing all listed inpatient diagnoses and procedures, discharge status, patient demographics, and charges for all patients, regardless of payer (e.g., Medicare, Medicaid, private insurance, uninsured).

Comparisons were made with 2 control states in order to address possible secular trends. New York (NY), the most populous state with inpatient HCUP data available up to 2014 was selected, and, to counter this coastal and largely urban state, we also selected Oklahoma (OK), a predominately rural state directly adjacent to CO with HCUP hospitalization data up to 2014. We used separate HCUP databases for CO, NY and OK. Unlike the National Inpatient Sample (NIS), which is (by definition) a sample, these state-specific databases include data from every actual admission, providing direct and complete information regarding all healthcare utilization. Both primary and secondary diagnoses were extracted from each HCUP database for each admission used: up to 30 ICD-9 codes in CO, 25 in NY, and 16 in OK were provided for each encounter. Annual demographic data, including age, sex, and race, was obtained from the United States Census Bureau. Only month and year were available in all HCUP databases; as legalization took effect on December 10, 2012, hospitalizations following December,

2012 were considered “after” enactment of the law. Patients with missing information on age, sex, race, and year of encounter were excluded.

Age, sex, race, income level, and insurance payer were recorded at each healthcare encounter. Hispanic ethnicity was not coded in the OK State Department of Health data source. In order to use comparable categorizations across the 3 states, we separated race into white, black, Native American, and other. In addition to the population-level variables age, sex and race, we obtained the following covariates at the individual level for each age, sex and race population strata: 1) income level 2) proportion of HCUP individuals living in an urban versus rural setting, 3) with tobacco use, 4) alcohol abuse, and 5) psychiatric disorders. The latter 3 covariates were available from ICD-9 codes. Income level was categorized by quartiles using the median household income for each patient’s ZIP code. Income level was not available for OK.

We first performed a validation analysis to assess changes in cannabis abuse diagnoses in CO after versus before recreational cannabis legalization and compared those rates to changes in NY and OK over the same time period. To determine changes in overall healthcare utilization, we assessed changes in total number of hospitalizations, length of inpatient stay, and healthcare costs. We estimated the cost of each hospitalization by multiplying the charges by a cost-to-charge ratio for the admitting hospital for the given year. For NY and CO, we used the all-payer cost-to-charge ratios provided by HCUP. When the all-payer cost-to-charge ratio was missing, we applied the average cost-to-charge ratio particular to state and year. As HCUP does not provide cost-to-charge ratios for OK, we assumed a constant state-wide cost-to-

charge ratio (0.3119 as derived from the Institute for Health and Socio-Economic Policy calculations of federal cost reports) to estimate healthcare costs in OK;[6] we then conducted a sensitivity analysis setting the cost-to-charge ratio for OK to equal to the average for NY and CO for the corresponding year. See online supplementary eMethods and eTable 1 for additional details.

We used International Classification of Diseases-9th Edition (ICD-9) codes (eTable 2) to assess changes in healthcare utilization specific to various medical diagnoses potentially treated by or exacerbated by cannabis use as identified by the NAS summary. For each health endpoint of interest in the NAS review, the weight of evidence regarding the statistical association of recreational cannabis with a specific health endpoint or the therapeutic use of cannabis had previously been categorized into substantial, moderate, limited or no evidence.[3] We opted to focus on NAS health endpoints with either substantial or moderate evidence.

Because diagnoses of alcohol or other substance abuse “in remission” may have been incidental and not directly responsible for the hospitalization, we performed a sensitivity analysis where we removed “in remission” diagnoses from the group of ICD-9 codes defining alcohol abuse and other substance abuse (eTable 2).

Finally, to take into account the additional effect of recreational cannabis related to availability in retail stores we performed sensitivity analyses for all health care utilization (total number of admissions, length of stay, costs) and NAS-evidence based outcomes investigations utilizing January 1, 2014 as the change of policy date.

Certification to use de-identified HCUP data was obtained from the University of California, San Francisco Committee on Human Research.

## Statistical Analysis

Demographic and lifestyle characteristics are presented as mean ± standard deviation (SD) or n (% of total admissions) and were compared between states using linear, logistic, and multinomial models as appropriate. Rates of admissions for NAS diagnoses (with the population size as the denominator) were compared between states using negative binomial models.

To assess the effects of recreational cannabis legalization, we used negative binomial models for the number of admissions, both overall and for particular diagnoses, with the log of the subgroup population sizes as an offset and the use of robust standard errors. Analogous linear models were utilized for length of stay and cost, which were both log-transformed in order to meet normality assumptions. All models were adjusted for age, race, sex, income level, urbanicity, alcohol abuse, tobacco use and psychiatric disorders. Adjustment for psychiatric disorders was not performed in the presence of a psychiatric outcome. In order to relax the linearity assumption, each 5-year age range was included as a separate category. To flexibly model secular patterns, year was included as a categorical rather than continuous variable (with a category for each year between 2010 and 2014). The crucial predictors in our model included an indicator for CO (versus the comparison state) and interactions of this indicator with 2 continuous linear spline basis functions, year-2012, and max (0, year-2012). The main effect for CO estimated the between-state risk ratio (RR) in 2012, the first interaction estimated the slope of the between-state RR in 2010-12, and the second estimated the change in slope after 2012. The first interaction was used to

project the counterfactual 2013-2014 rates in CO that would be expected in the absence of legalization, while the second was used to capture the legalization effect. Like a standard interrupted time series (ITS) model, our model assumed that the between-state RR changed linearly at different rates before and after the intervention, but used the categorical indicator for year to relax the standard ITS assumption of piecewise linear trends in the underlying state-specific rates, substantially improving model fit. The same model was used in the sensitivity analysis using January 1, 2014 (date of legal retail cannabis sales) as change of policy date.

A 2-tailed $P<0.05$ was considered statistically significant for the validation analysis (cannabis use), and analyses related to overall healthcare utilization. In order to minimize false positive results and to account for secular trends that might differ across different populations, we assessed for validation in comparisons versus NY and then OK separately.

In order to address possible false positives due to multiple hypotheses testing in assessing the diagnoses with moderate or substantial evidence described in the NAS document, we employed stringent standards: to be considered "positive," the comparisons between CO and *each* of the other 2 states needed to be in the direction expected from the NAS report, each exhibiting statistical significance using a two-tailed alpha of 0.05. A "positive" designation also required absence of a statistically significant difference between NY versus OK using a two-tailed alpha of 0.05. All analyses were performed using Stata 15 (StataCorp, College Station, TX).

**Patient and Public Involvement**

The patients and public were not involved in the study.

## RESULTS

### Baseline Characteristics

The total number of admissions between 2010 and 2014 are shown for each state in **table 1**. Patients in CO were generally younger, more commonly female, and less ethnically diverse. Wealth in CO was less equally distributed, with a higher proportion of individuals with lower income in CO compared to NY. Finally, admission rates were lower in CO than the control states for most NAS diagnoses, with exceptions for pre-diabetes and post-traumatic stress disorder.

### Study Validation

Over 2010-2014, the change in rates of cannabis abuse admissions after versus before recreational cannabis legalization in 2012 was greater in CO than in NY and OK (risk ratio [RR], 1.27; 95% confidence interval [CI], 1.26 to 1.28 and RR 1.16; 95% CI 1.15 to 1.17; both $P<0.0005$, respectively) (**figure 1A-B**). No significant changes comparing the two control states, NY and OK, were observed over the same time period (RR 0.93; 95% CI 0.87 to 1.00; $P=0.05$).

### Inpatient Healthcare Utilization after Cannabis Legalization

*Number of admissions*

In unadjusted analyses, CO, NY, and OK had a similar number of total admissions before versus after recreational cannabis legalization (**figure 2A**). After adjusting for

covariates, there was a reduction of number of admissions following cannabis legalization in CO when compared to OK (RR 0.97; 95% CI 0.96 to 0.98; *P*<0.0005)**.** The point estimate was similar when comparing CO to NY, but did not reach statistical significance (RR 0.99; 95% CI 0.98 to 1.01; *P*=0.47). Results were similar in sensitivity analysis using January 1, 2014 as change of policy date (CO versus OK: RR 0.96; 95% CI 0.96 to 0.96; *P*<0.0005, and CO versus NY: RR 0.99; 95% CI 0.96 to 1.02; *P*=0.59).

*Length of stay*

The median length of stay also remained similar after cannabis legalization across the 3 states in unadjusted analyses (**figure 2B**). After adjusting for covariates, length of inpatient stay did not change significantly in CO following the law change when compared with each of the 2 control states (1.75% annual reduction; 95% CI -12.25% to 10.01% in CO versus NY, and 3.46% annual reduction, 95% CI -16.48% to 37.90% versus OK; *P*= 0.30 and P=0.20, respectively). Length of stay did not change significantly in CO compared with the control states when we used January 1, 2014 as change of policy date.

*Healthcare Costs*

In unadjusted analyses, the 3 states exhibited similar total costs across the study time period (**figure 2C** and eTable 2). In multivariate analyses**,** healthcare costs remained similar in state comparisons (2.99%; 95% CI -7.55% to 14.74%; *P*=0.18 versus NY and 3.45%; 95% CI -7.31% to 15.46%; *P*=0.16 versus OK) after cannabis legalization. No meaningful differences of healthcare costs were observed in the sensitivity analyses

with January 1, 2014 as change of policy date or when we assumed the cost-to-charge ratio for OK was equal to the average of the other states.

**Changes in Specific Diagnoses Highlighted by the National Academy of Sciences**

Among the diagnoses with either substantial or moderate evidence of influence by cannabis per the NAS, we distinguished between: 1) a group with no statistically significant post-legalization differences between control states (NY versus OK $P>0.05$), suggesting that secular trends unlikely explained differences between CO and control states (**figure 3**); and 2) a group with significant differences in diagnoses post-legalization between control states (NY versus OK $P<0.05$) (eFigure 1).

In the NY versus OK $P>0.05$ group (**figure 3**), changes in rates of diagnoses after cannabis legalization reflected NAS-based evidence for most health outcomes. Among the diagnoses most consistent with NAS-based evidence, there was an increase in motor vehicle accidents, alcohol abuse, overdose injury and a decrease of chronic pain after recreational cannabis legalization (each meeting statistical significance for both comparisons with control states) . When using less stringent criteria ($P<0.05$ for both comparisons with NY and OK but where the relative risk for only one comparison was in the same direction as NAS), admissions for abuse of other substances and social anxiety disorder also increased with recreational cannabis legalization (**figure 3**). Effects of cannabis liberalization on psychiatric outcomes (schizophrenia and bipolar disorders) were either not consistent or weakly consistent with NAS (**figure 3**). When differences between the two control states (NY and OK) were also significantly different (suggesting effects potentially related to secular trends)(eFigure 1), changes in

diagnoses were mostly not concordant with NAS findings or one of the comparisons between CO and either NY or OK did not exhibit statistical significance. Changes of the risk over time with counterfactuals are shown for each NAS diagnosis in online supplementary eFigures 2-15.

In the sensitivity analysis using January 1, 2014 as change of policy date (eTable 3), the main findings highlighted in the primary analysis using our stringent criteria (increase of alcohol abuse, motor vehicle accidents, overdose injury and decrease of chronic pain) again met the same criteria in favor of significant associations, except for overdose injury and chronic pain (the latter meeting 2 of the 3 criteria described in the Methods). In sensitivity analyses removing "in remission" diagnoses, no meaningful changes were observed (relevant to alcohol abuse and abuse of other substances).

## DISCUSSION

### Principal findings

Legalization of recreational cannabis was associated with more cannabis abuse, and minimal effects on overall healthcare utilization. Changes in specific medical diagnoses post-legalization reflected previously published substantial or moderate evidence on the health effects of cannabis, including an increase in alcohol abuse, overdose injury and a decrease of chronic pain.

The increased frequency of cannabis abuse diagnoses in CO helps to validate the concept that legalization would result in greater use.

Effects of recreational cannabis legalization on healthcare utilization appeared to be overall neutral. There was no evidence that either the length of stay or healthcare

costs changed following liberalization of recreational cannabis. There was a reduction of overall hospitalizations in CO when compared to OK but not compared to NY, potentially because unaccounted state-level characteristics may have driven overall admissions differently.

Following legalization of recreational cannabis, changes in rates of medical diagnoses reflected NAS-based evidence for most health outcomes. The absence of statistically significant differences in these outcomes between the two control states (NY and OK) over the same time period provides some evidence that these observed differences were less likely related to broader secular trends. After legalization of recreational cannabis, there was an increase in motor vehicle accidents, alcohol abuse, overdose injury and a decrease of chronic pain. In addition to information provided in the NAS summary,[3] the association of cannabis with motor vehicle accidents has been highlighted by recent literature.[7, 8] Consistent with our findings, a substantial bidirectional comorbidity between cannabis use and alcohol use has been previously demonstrated, resulting in a moderate level of evidence designation for this relationship per the NAS.[9] Also compatible with the NAS summary, we report that recreational cannabis legalization was associated with an increasing number of admissions for overdose injury. These included overdose of analgesics, barbiturates, sedative, hypnotics and psychotropic drugs (eTable 2). This finding underlines the association of cannabis use with other behaviors of drug addiction as highlighted by a recent cross-sectional survey of over 30 thousand community-living US adults.[10] Finally, reduction of chronic pain, especially neuropathic pain, in cannabis users is well known, although prior literature has focused on medical rather than recreational cannabis.[11, 12]

Except for social anxiety, the effects of recreational cannabis legalization on psychiatric outcomes (schizophrenia, bipolar disorder, depression) were weakly or not consistent with prior NAS-evidence. This finding may be related to residual confounding by state-level characteristics, unaccounted secular trends, or insufficient longitudinal follow-up.

We demonstrate that abuse of alcohol or other substances remains higher after recreational cannabis legalization in a sensitivity analysis without "in remission" diagnoses. Overall, these findings suggest that when the substance use disorder is in remission, it does not play a significant role in overall results.

In our primary analysis, we used December 10, 2012 as the date of recreational cannabis legalization. Following this date, private possession and growth of cannabis became legal in Colorado. After January 1, 2014, recreational cannabis could be legally purchased in retail stores.[5] To take the additional effect of retail sales of recreational cannabis into account, we performed sensitivity analyses using January 2014 as the "change of policy" date. We did not observe any meaningful difference in the majority of the outcomes studied, suggesting that the effect of recreational cannabis on healthcare utilization was independent of availability in stores.

**Strengths and Weaknesses**

Although several studies have investigated the health effects of cannabis,[13] they have relied on small sample sizes or have generated conflicting data.[14-16] In contrast, our findings are derived from HCUP state-wide data comprising over 28 million individuals and over 16 million hospitalizations across CO, site of the 2012 *Amendment 64*, and 2

controls states without cannabis legalization over the same time period. As NY and OK are very different geographically and demographically, we believe their inclusion as control states represents a strength of our manuscript. Specifically, their selection allowed us to demonstrate that the effects of recreational cannabis legalization on health care utilization were likely independent of living in an urban or rural setting.

Several limitations should be acknowledged. The HCUP database relies on physician coding; however, such coding for several medical diagnoses listed in **table 1** have been shown to be highly specific with variable sensitivity[17-20] and HCUP has proven to be a powerful tool in large population studies.[20-24] Some potentially important mediators are not captured by ICD-9 codes, such as quantity of cannabis used or formulation (oral versus other), although these may be more relevant to identifying mechanisms and their absence would likely not lead to false positive results. Patients may be more likely to disclose cannabis use following legalization of recreational cannabis and clinicians may be more inclined to test for it. Hence, we cannot completely exclude detection bias in the validation analysis showing an increase in cannabis abuse diagnoses following legalization of recreational cannabis. Moreover, we cannot exclude that the increased frequency of cannabis abuse hospitalizations is simply related to severity of cannabis abuse rather than to a greater prevalence of cannabis use.

As with any observational study, we cannot exclude residual confounding as an explanation of our findings. However, we adjusted for conventionally recognized confounders as appropriate and as available, and, as this was largely a study of the same populations pre- and post-legalization, many of the limitations inherent to conventional individual-level analyses are likely less relevant.

We did not select all US states as controls. Most states do not have HCUP data up until the end of 2014, each requires a separate HCUP application, and each carries significant costs. We acknowledge this represents a limitation as we could not fully account for secular trends that might influence results. However, we have adjusted all analyses for urbanicity and other state-level differences in order to minimize the impact of secular trends. We also acknowledge that CO had legalized medical cannabis prior to legalization of recreational cannabis on December 10, 2012. However, control states NY and OK had not. We could have selected control states that had already medicalized cannabis instead of NY and OK, but we acknowledge that complex differences exist among medical legalization regimens among states.[25] Hence, we believe selection of control states with diverse medical legalization regimens would have primarily reduced our power to detect a real difference rather than contribute to any false positive spurious results. In our study, we demonstrate that legalization of recreational cannabis is associated with more cannabis abuse or cannabis use disorder. Prior large, multi-state, population-based analyses have shown that legalization of medical cannabis is associated with increased cannabis use, but not increased cannabis use disorder.[26] One could speculate that medical cannabis consumption is more controlled and rationed when compared to recreational cannabis, the latter available in both retail stores and private homes and therefore perhaps more easily abused. Further studies are needed to quantify the amount of cannabis consumption (in grams) in states where only medical cannabis is legal versus states where both medical and recreational cannabis are allowed.

The HCUP database does not capture information regarding outpatient activity and therefore these findings are restricted to hospital-based medicine.

Our use of stringent criteria in assessing changes related to NAS diagnoses may have been too conservative, leading to a sacrifice of false negatives in order to avoid false positives.

Finally, our study was limited to two-year follow-up after recreational cannabis legalization, and we therefore cannot comment on long-term effects that may result.

## Conclusions

In conclusion, recreational cannabis legalization is associated with an expected increase in cannabis abuse. Overall effects on inpatient healthcare utilization appear to be neutral, with subtle changes in various components of that utilization likely occurring due to changes in the types of admissions observed. Measurable effects of recreational cannabis legalization on increasing motor vehicle accidents, alcohol abuse, overdose injury and reducing chronic pain are consistent with previously established evidence. These data provide the first description of population-level effects that may help guide future decisions regarding cannabis policy, individuals considering using cannabis, and physicians caring for those who may choose to consume it.

**Contributors** FND and GMM had full access to all of the data in the study and take responsibility for the integrity of the data and the accuracy of the data analysis. FND and GMM were responsible for the study concept and design. All authors (FND, EV, TAD, MJP, JEO, GN, KA, CDF, ESL, SMF, DSK, and GMM) contributed to data acquisition, analysis, and interpretation. EV, GN, and GMM completed the statistical analysis. FND and GMM drafted the manuscript and were responsible for the critical revision of the manuscript for important intellectual content. GMM obtained funding for the study. All authors contributed to the administrative, technical, and material support for the study and approved the final version of the manuscript.

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**Competing interests** None declared.

**Patient consent** Not required.

**Ethics approval** Ethical approval to use de-identified HCUP data was obtained from the University of California, San Francisco Committee on Human Research.

**Data sharing** Data consist of deidentified participant data (i.e. ICD-9 admission diagnoses) available from the Healthcare Cost and Utilization Project (HCUP) for a fee. Information about how to obtain the data and for what time period can be found at: https://www.hcup-us.ahrq.gov/

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## FIGURE LEGENDS

**Figure 1**. Multivariate adjusted rates of admissions for cannabis abuse over 2010-2014 in Colorado, site of implementation of the 2012 recreational cannabis legalization policy, compared with New York (A) and Oklahoma (B), control states without cannabis legalization. Red lines show the predicted rates of admissions for cannabis abuse had the cannabis legalization policy not been instituted. The comparison between Colorado and the control states with regards to change of risk ratio (RR) slope within the 2010-2012 period (pre-legalization) and 2012-2014 period (post-legalization), as well of the overall RR slope change, are also represented for the Colorado versus New York (A) and Colorado versus Oklahoma (B) comparisons. Red lines show the predicted rates of admissions for cannabis abuse had the cannabis legalization policy not been instituted. Each model was adjusted for age, gender, and race and state-level characteristics (see Methods section for further details). CI = confidence interval; vs = versus.

**Figure 2**. Healthcare utilization over 2010-2014 in Colorado, site of implementation of the 2012 recreational cannabis legalization policy, and in New York and Oklahoma, control states without cannabis legalization. The total number of admissions/1000 population per year, the median length of stay per year, and the median costs per individual per year are shown in panels A, B, and C, respectively for the 3 states. Error bars denote interquartile ranges. LOS = length of stay.

**Figure 3**. Health outcomes with substantial or moderate evidence of a statistical association with cannabis use based on the National Academy of Science (NAS)

summary statement. Medical diagnoses are identified based on a non-significant (*P*>0.05) comparison between New York (NY) and Oklahoma (OK) (control states without cannabis legalization) with regards to the change of admission rates for such diagnoses following cannabis legalization. *P* values for the comparison between Colorado (CO) (site of cannabis legalization) and NY (rhomboid symbol), or between CO and OK (circular symbol) are shown as either <0.05, or > 0.05 using a gray scale for evidence of cannabis benefit (risk ratio [RR] < 1 shown on the left) and cannabis harm (RR>1 shown on the right); 95% confidence intervals are shown for the comparison between CO and NY and between CO and OK as solid and dotted lines, respectively. Progressively darker shades of green or red indicate greater weight of evidence in the direction of proposed benefit versus harm, respectively, by the NAS.

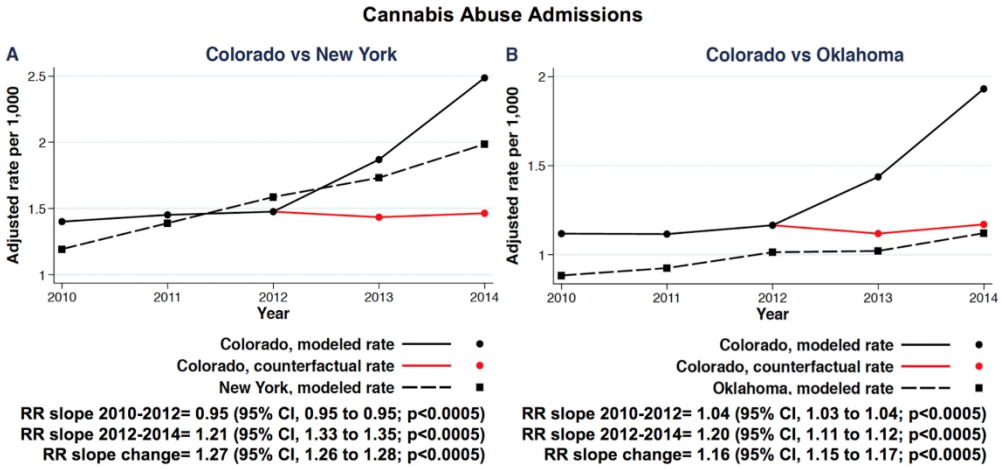
**Table 1.** Clinical characteristics of the 3 study states over the 2010-2014 period.

| | Colorado | New York | Oklahoma | *P* value |
|---|---|---|---|---|
| Total population | 5,197,237 | 19,594,599 | 3,819,383 | |
| Total admissions | 2,088,909 | 11,726,283 | 2,334,988 | |
| Total admissions/1,000 population | 402±0.27 | 598±0.17 | 611±0.40 | 0.0001 |
| **Demographics** | | | | |
| Age – yr | 45 ± 28 | 49 ± 28 | 48 ± 28 | 0.0001 |
| Male – no. (%) | 870,573 (42) | 5,087,181 (41) | 954,848 (43) | 0.0001 |
| Race – no. (%) | | | | 0.0001 |
| White | 1,548,099 (74) | 6,406,582 (55) | 1,879,727 (81) | |
| Black | 102,444 (5) | 2,083,366 (18) | 202,420 (9) | |
| Native American | 13,143 (1) | 36,216 (0.3) | 131,714 (6) | |
| Other | 425,223 (20) | 3,200,119 (27) | 121,127 (5) | |
| **Lifestyle** | | | | |
| Median Household Income, dollars (quartiles for patient ZIP code) – no. (%) | | | | 0.0001 |
| Quartile 1 | 617,537 (30) | 3,087,192 (28) | No data | |
| Quartile 2 | 558,760 (27) | 2,623,087 (24) | | |
| Quartile 3 | 470,051 (23) | 2,673,153 (24) | | |
| Tobacco use – no. (%) | 251,566 (12) | 1,717,940 (10) | 235,685 (14) | 0.0001 |
| Alcohol abuse – no. (%) | 112,715 (5) | 652,608 (6) | 71,931 (3) | 0.0001 |
| **NAS Diagnoses** | | | | |
| Non-seminoma type testicular germ cell cancer – no. (%) | 405 (0.02) | 2,487 (0.02) | 480 (0.02) | 0.0001 |
| Acute myocardial infarction – no. (%) | 39,513 (1.9) | 271,285 (2.3) | 60,413 (2.6) | 0.0001 |
| Brain hemorrhage – no. (%) | 10,963 (0.5) | 58,278 (0.5) | 10,245 (0.4) | 0.0001 |
| Ischemic stroke – no. (%) | 27,986 (1.3) | 194,478 (1.7) | 45,602 (2) | 0.0001 |

| | | | | |
|---|---|---|---|---|
| Metabolic syndrome & diabetes – no. (%) | 294,821 (14) | 2,301,835 (20) | 465,353 (20) | 0.0001 |
| Prediabetes – no. (%) | 42,544 (2) | 73,407 (0.6) | 24,246 (1) | 0.0001 |
| Bronchitis – no. (%) | 65,265 (3) | 429,230 (4) | 131,343 (6) | 0.0001 |
| Motor vehicle accidents – no. (%) | 14,941 (0.7) | 59,686 (0.5) | 13,692 (0.6) | 0.0001 |
| Overdose injury – no. (%) | 10,933 (0.5) | 40,226 (0.3) | 12,147 (0.5) | 0.0001 |
| Substance use disorder – no. (%) | 158,244 (7.6) | 974,856 (8.3) | 109,305 (4.7) | 0.0001 |
| Anxiety disorders – no. (%) | 131,426 (6.4) | 595,478 (5.2) | 139,627 (6.1) | 0.0001 |
| Anxiety disorders (except social anxiety) – no. (%) | 51,913 (2.5) | 283,280 (2.4) | 65,279 (2.8) | 0.0016 |
| Bipolar disorders – no. (%) | 52,348 (2.5) | 287,735 (2.5) | 61,411 (2.6) | 0.0001 |
| Depressive disorders – no. (%) | 213,851 (10) | 827,932 (7) | 190,083 (8) | 0.0001 |
| Schizophrenia or other psychoses – no. (%) | 53,652 (2.6) | 352,533 (3) | 68,385 (2.9) | 0.0001 |
| Positive symptoms of schizophrenia (i.e. hallucinations) – no. (%) | 2,653 (0.1) | 9,482 (0.1) | 3,531 (0.2) | 0.0001 |
| Post-traumatic stress disorder – no. (%) | 28,582 (1.4) | 75,608 (0.6) | 17,101 (0.7) | 0.0001 |
| Social anxiety disorder – no. (%) | 295 (0.01) | 1,090 (0.01) | 135 (0.01) | 0.0295 |
| Suicide – no. (%) | 4,957 (0.2) | 15,646 (0.1) | 4,407 (0.2) | 0.0001 |
| Low offspring birthweight – no. (%) | 2,842 (0.1) | 7,462 (0.1) | 1,742 (0.1) | 0.0002 |
| Maternal pregnancy complications – no. (%) | 39,343 (1.9) | 144,353 (1.2) | 40,938 (1.8) | 0.0001 |
| Unemployment/low income – no. (%) | 3,134 (0.2) | 76,789 (0.7) | 730 (0.03) | 0.0001 |
| Nausea or vomiting – no. (%) | 63,806 (3) | 162,11(1.4) | 58,706 (2.5) | 0.0001 |
| Chronic pain – no. (%) | 140,209 (6) | 234,160 (2) | 123,563 (5) | 0.0001 |
| Spasticity – no. (%) | 5,759 (0.3) | 12,517 (0.1) | 5,371 (0.2) | 0.0001 |

| | | | | |
|---|---|---|---|---|
| Short-term sleep – no. (%) | 652 (0.03) | 3,364 (0.03) | 357 (0.02) | 0.0001 |
| Tourette syndrome – no. (%) | 428 (0.02) | 2,784 (0.02) | 336 (0.01) | 0.0001 |
| Increased appetite & weight gain – no. (%) | 1,022 (0.05) | 3,017 (0.03) | 651 (0.03) | 0.0001 |

NAS = National Academy of Science. Admission diagnoses listed were based on those found influenced by cannabis in the 2017 NAS review.[3] Substance use disorder includes dependence or abuse of alcohol, tobacco, or other illicit drug. All variables pertain to the 2010-2014 period. Plus-minus values are means ± SD. No. (%) indicates number of admissions with a specific demographic/lifestyle characteristic or NAS diagnosis (% of total admissions). A *P* value less than 0.05 is considered statistically significant.




Multivariate adjusted rates of admissions for cannabis abuse over 2010-2014 in Colorado, site of implementation of the 2012 recreational cannabis legalization policy, compared with New York (A) and Oklahoma (B), control states without cannabis legalization. Red lines show the predicted rates of admissions for cannabis abuse had the cannabis legalization policy not been instituted. The comparison between Colorado and the control states with regards to change of risk ratio (RR) slope within the 2010-2012 period (pre-legalization) and 2012-2014 period (post-legalization), as well of the overall RR slope change, are also represented for the Colorado versus New York (A) and Colorado versus Oklahoma (B) comparisons. Red lines show the predicted rates of admissions for cannabis abuse had the cannabis legalization policy not been instituted. Each model was adjusted for age, gender, and race and state-level characteristics (see Methods section for further details). CI = confidence interval; vs = versus.

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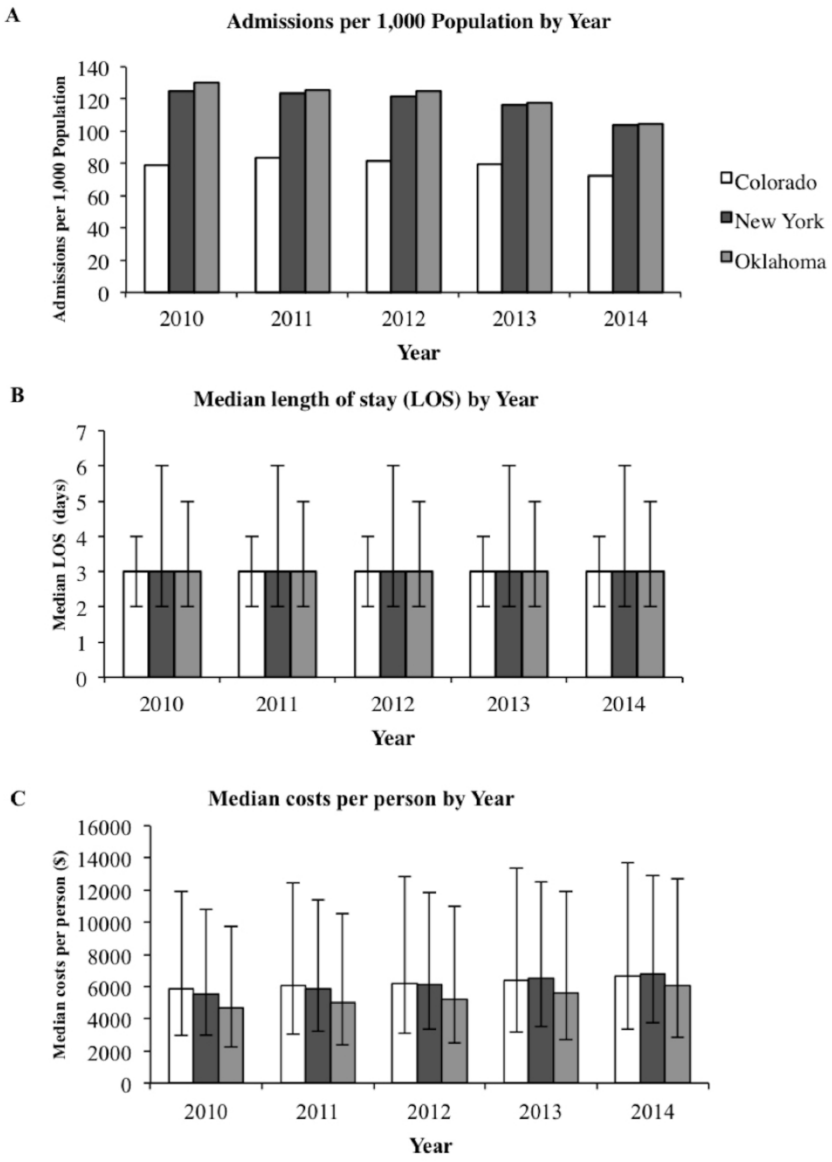


Healthcare utilization over 2010-2014 in Colorado, site of implementation of the 2012 recreational cannabis legalization policy, and in New York and Oklahoma, control states without cannabis legalization. The total number of admissions/1000 population per year, the median length of stay per year, and the median costs per individual per year are shown in panels A, B, and C, respectively for the 3 states. Error bars denote interquartile ranges. LOS = length of stay.

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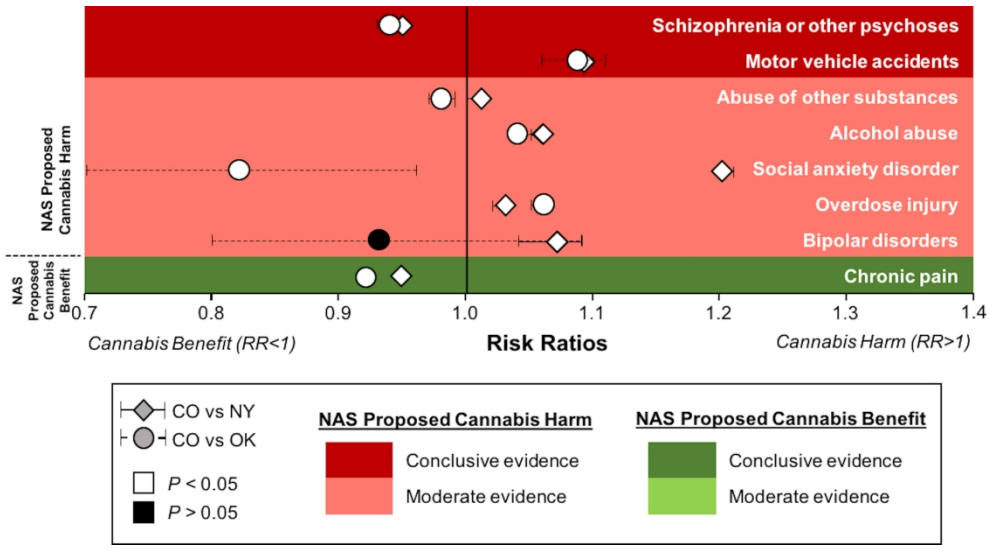


Health outcomes with substantial or moderate evidence of a statistical association with cannabis use based on the National Academy of Science (NAS) summary statement. Medical diagnoses are identified based on a non-significant (P>0.05) comparison between New York (NY) and Oklahoma (OK) (control states without cannabis legalization) with regards to the change of admission rates for such diagnoses following cannabis legalization. P values for the comparison between Colorado (CO) (site of cannabis legalization) and NY (rhomboid symbol), or between CO and OK (circular symbol) are shown as either <0.05, or > 0.05 using a gray scale for evidence of cannabis benefit (risk ratio [RR] < 1 shown on the left) and cannabis harm (RR>1 shown on the right); 95% confidence intervals are shown for the comparison between CO and NY and between CO and OK as solid and dotted lines, respectively. Progressively darker shades of green or red indicate greater weight of evidence in the direction of proposed benefit versus harm, respectively, by the NAS.

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# Supplementary Appendix

## Changes in Inpatient Healthcare Utilization after Legalization of Recreational Cannabis

Francesca N. Delling, MD, MPH;[1] Eric Vittinghoff, PhD;[1] Thomas A. Dewland, MD;[2] Mark J. Pletcher, MD, MPH; [1] Jeffrey E. Olgin, MD;[1] Gregory Nah, MA;[1] Kirstin Aschbacher, PhD;[1] Christina Fang, BA;[1] Emily S. Lee, BA;[1] Shannon M. Fan, BA;[1] Dhruv S. Kazi, MD, MS;[1] and Gregory M. Marcus, MD, MAS.[1]

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This supplementary material has been provided by the authors to give readers additional information about their work.

## **eMethods.** Cost Analysis

### Cost Estimations

The inpatient cost for each hospitalization in New York and Colorado was estimated by multiplying the total charges (TOTCHG) obtained from HCUP State Inpatient Database with the institution-specific all-payer cost-to-charge ratio (APICC) obtained from the Cost-to-Charge Ratio file. Hospital ID was used as a linkage to merge both files. Total inpatient costs were calculated as the sum of the cost for all hospitalizations in a given state for a particular year. The databases contained 186,226 (8.7%) encounters with non-matched/missing hospital ID for NY and 1,132,696 (9.6%) encounters with non-matched/missing hospital ID for Colorado; for these encounters. In order to estimate the cost of these hospitalizations (for which we had charges but no cost-to-charge ratio) we applied the average cost-to-charge ratio for that state-year. This was estimated by dividing the sum of costs for all hospitalizations for which cost-to-charge ratios were available by the sum of charges for all hospitalizations for which cost-to-charge ratios were available in a given state-year (**eTable 2**).

### Oklahoma Total Cost Estimate

HCUP does not produce SID and CCR file for Oklahoma. We obtained these data from Oklahoma State Department of Health – this dataset contains information about total charges but not cost-to-charge ratios. We estimated total inpatient costs in Oklahoma in two ways. First, we used a state-wide constant cost-to-charge ratio (0.3119) to estimate the total cost (ratio derived from the Institute for Health and Socio-Economic Policy calculations of federal cost reports). We then conducted a sensitivity analysis in which we used the average of the cost-to-charge ratios of New York and Colorado for any given state-year (**eTable 2**).

**eTable 1.** Yearly costs and charges for the 3 study states

| Colorado | 2010 | 2011 | 2012 | 2013 | 2014 | 2010 to 2014 |
|---|---|---|---|---|---|---|
| Total hospitalizations, n | 397,505 | 428,912 | 424,640 | 418,952 | 418,900 | 2,088,909 |
| Hospitalizations for which CCR is available, n (%) | 396,433 (99.7%) | 301,586 (70.3%) | 382,021 (90.0%) | 412,483 (98.5%) | 413,160 (98.6%) | 1,905,683 (91.2%) |
| Total charges for hospitalizations for which CCR is available | $14,382,791,648 | $11,170,040,412 | $15,821,232,608 | $19,349,895,615 | $20,370,018,114 | $81,093,978,397 |
| Total costs for hospitalizations for which CCR is available | $4,104,443,164 | $3,033,915,324 | $3,963,892,093 | $4,619,884,886 | $4,700,380,255 | $20,422,515,722 |
| Average CCR* | 0.2854 | 0.2716 | 0.2505 | 0.2388 | 0.2309 | |
| Hospitalizations for which CCR is not available, n (%) | 1,072 (0.3%) | 127,326 (29.7%) | 42,619 (10.0%) | 6,469 (1.5%) | 5,740 (1.4%) | 183,226 (8.8%) |
| Total charges for hospitalizations for which CCR is not available | $55,039,614 | $5,704,285,087 | $2,494,379,901 | $241,011,451 | $211,228,665 | $8,705,944,718 |
| Total costs for hospitalizations for which CCR is not available† | $15,708,306 | $1,549,283,830 | $624,842,165 | $57,553,535 | $48,772,699 | $2,296,160,534 |
| Total inpatient costs | $4,120,151,470 | $4,583,199,154 | $4,588,734,258 | $4,677,438,421 | $4,749,152,954 | $22,718,676,256 |

*Average CCR was estimated by dividing the total of costs for all hospitalizations for which cost-to-charge ratios were available by the total charges for hospitalizations for which cost-to-charge ratios were available in a given state-year.
†Total charges for hospitalization for which CCR is not available multiplied by Average CCR in a given state-year.

| New York | 2010 | 2011 | 2012 | 2013 | 2014 | 2010 to 2014 |
|---|---|---|---|---|---|---|
| Total hospitalizations, n | 2,417,298 | 2,414,985 | 2,389,701 | 2,290,502 | 2,213,797 | 11,726,283 |
| Hospitalizations for which CCR is available, n (%) | 2,189,513 (90.6%) | 2,157,629 (89.3%) | 2,168,880 (90.8%) | 2,056,367 (89.8%) | 2,021,199 (91.3%) | 10,593,588 (90.3%) |
| Total charges for hospitalizations for which CCR is available | $66,303,900,691 | $69,885,515,755 | $74,728,795,811 | $77,680,292,105 | $79,252,368,106 | $367,850,872,468 |
| Total costs for hospitalizations for which CCR is available | $22,376,381,374 | $23,448,311,348 | $24,539,963,919 | $24,331,920,273 | $23,892,478,440 | $118,589,055,354 |
| Average CCR* | 0.3375 | 0.3355 | 0.3283 | 0.3132 | 0.3014 | |
| Hospitalizations for which CCR is not available, n (%) | 227,785 (9.4%) | 257,356 (10.7%) | 220,821 (9.2%) | 234135 (10.2%) | 192,598 (8.7%) | 1,132,695 (9.7%) |
| Total charges for hospitalizations for which CCR is not available | $4,168,104,163 | $4,821,903,339 | $4,088,909,686 | $5,687,320,556 | $5,336,461,039 | $24,102,698,783 |
| Total costs for hospitalizations for which CCR is not available† | $1,406,735,155 | $1,617,748,571 | $1,342,797,941 | $1,781,268,798 | $1,608,409,357 | $7,756,959,821 |
| Total inpatient costs | $23,783,116,529 | $25,066,059,919 | $25,882,761,860 | $26,113,189,071 | $25,500,887,797 | $126,346,015,175 |

*Average CCR was estimated by dividing the total of costs for all hospitalizations for which cost-to-charge ratios were available by the total charges for hospitalizations for which cost-to-charge ratios were available in a given state-year.
†Total charges for hospitalization for which CCR is not available multiplied by Average CCR in a given state-year.

| Oklahoma | 2010 | 2011 | 2012 | 2013 | 2014 | 2010 to 2014 |
|---|---|---|---|---|---|---|
| Total hospitalizations, n | 489,724 | 476,605 | 476,728 | 452,724 | 439,207 | 2,334,988 |
| Hospitalizations for which CCR is available, n (%) | 489724 (100%) | 476605 (100%) | 476728 (100%) | 452724 (100%) | 439207 (100%) | 2334988 (100%) |
| Total charges for hospitalizations for which CCR is available | $13,927,214,520 | $14,645,751,657 | $15,247,598,300 | $15,596,643,583 | $15,003,967,132 | $74,421,175,192 |
| Total costs for hospitalizations for which CCR is available | $4,343,898,209 | $4,568,009,942 | $4,755,725,910 | $4,864,593,134 | $5,001,131,977 | $23,533,359,171 |
| Average CCR* | 0.3119 | 0.3119 | 0.3119 | 0.3119 | 0.3119 | |

*Statewide constant CCR (0.3119) used to estimate the total cost across years.

| Oklahoma (sensitivity analysis) | 2010 | 2011 | 2012 | 2013 | 2014 | 2010 to 2014 |
|---|---|---|---|---|---|---|
| Total hospitalization, n | 489,724 | 476,605 | 476,728 | 452,724 | 439,207 | 2,334,988 |
| Hospitalization for which CCR is available, n (%) | 489724 (100%) | 476605 (100%) | 476728 (100%) | 452724 (100%) | 439207 (100%) | 2334988 (100%) |
| Total charges for hospitalization for which CCR is available | $13,927,214,520 | $14,645,751,657 | $15,247,598,300 | $15,596,643,583 | $15,003,967,132 | $74,421,175,192 |
| Total costs for hospitalization for which CCR is available | $4,337,630,962 | $4,445,717,915 | $4,413,417,328 | $4,304,673,629 | $4,267,557,794 | $21,768,997,628 |
| Average CCR* | 0.3114 | 0.3036 | 0.2895 | 0.276 | 0.2662 | |

*Average of the CCRs of New York and Colorado for any given state-year.

**eTable 2.** International Classification of Diseases-9th Edition (ICD-9) codes defining each medical diagnosis.

**Chronic pain**

| ICD-9 Code | Short Description | Long Description |
|---|---|---|
| 338.21 | Chronc pain d/t trauma | Chronic pain due to trauma |
| 338.22 | Chron post-thoracot pain | Chronic post-thoracotomy pain |
| 338.28 | Chronic postop pain NEC | Other chronic postoperative pain |
| 338.29 | Chronic pain NEC | Other chronic pain |
| 338.4 | Chronic pain syndrome | Chronic pain syndrome |

**Nausea or vomiting**

| ICD-9 Code | Short Description | Long Description |
|---|---|---|
| 787.03 | Vomiting alone | Vomiting alone |
| 787.02 | Nausea alone | Nausea alone |
| 787.01 | Nausea with vomiting | Nausea with vomiting |

**Spasticity**

| ICD-9 Code | Short Description | Long Description |
|---|---|---|
| 728.85 | Spasm of muscle | Spasm of muscle |

**Short-term sleep disorders**

| ICD-9 Code | Short Description | Long Description |
|---|---|---|
| 307.4 | Nonorganic sleep dis NOS | Nonorganic sleep disorder, unspecified |
| 307.41 | Transient insomnia | Transient disorder of initiating or maintaining sleep |
| 307.42 | Persistent insomnia | Persistent disorder of initiating or maintaining sleep |
| 307.45 | Nonorganic circadian rhy | Circadian rhythm sleep disorder of nonorganic origin |
| 307.47 | Sleep stage dysfunc NEC | Other dysfunctions of sleep stages or arousal from sleep |
| 307.49 | Nonorganic sleep dis NEC | Other specific disorders of sleep of nonorganic origin |

**Increased appetite and weight gain**

| ICD-9 Code | Short Description | Long Description |
|---|---|---|
| 783.1 | Abnormal weight gain | Abnormal weight gain |
| 783.6 | Polyphagia | Polyphagia |

**Tourette's syndrome**

| ICD-9 Code | Short Description | Long Description |
|---|---|---|
| 307.23 | Tourette's disorder | Tourette's disorder |

**Posttraumatic stress disorder**

| ICD-9 Code | Short Description | Long Description |
|---|---|---|
| 309.81 | Posttraumatic stress dis | Posttraumatic stress disorder |

**Non-seminoma-type testicular germ cell cancer**

| ICD-9 Code | Short Description | Long Description |
|---|---|---|
| 186.9 | Malig neo testis NEC | Malignant neoplasm of other and unspecified testis |

**Acute myocardial infarction**

| ICD-9 Code | Short Description | Long Description |
|---|---|---|
| 410 | AMI anterolateral,unspec | Acute myocardial infarction of anterolateral wall, episode of care unspecified |
| 410.01 | AMI anterolateral, init | Acute myocardial infarction of anterolateral wall, initial episode of care |
| 410.02 | AMI anterolateral,subseq | Acute myocardial infarction of anterolateral wall, subsequent episode of care |
| 410.1 | AMI anterior wall,unspec | Acute myocardial infarction of other anterior wall, episode of care unspecified |
| 410.11 | AMI anterior wall, init | Acute myocardial infarction of other anterior wall, initial episode of care |
| 410.12 | AMI anterior wall,subseq | Acute myocardial infarction of other anterior wall, subsequent episode of care |
| 410.2 | AMI inferolateral,unspec | Acute myocardial infarction of inferolateral wall, episode of care unspecified |
| 410.21 | AMI inferolateral, init | Acute myocardial infarction of inferolateral wall, initial episode of care |
| 410.22 | AMI inferolateral,subseq | Acute myocardial infarction of inferolateral wall, subsequent episode of care |
| 410.3 | AMI inferopost, unspec | Acute myocardial infarction of inferoposterior wall, episode of care unspecified |
| 410.31 | AMI inferopost, initial | Acute myocardial infarction of inferoposterior wall, initial episode of care |
| 410.32 | AMI inferopost, subseq | Acute myocardial infarction of inferoposterior wall, subsequent episode of care |
| 410.4 | AMI inferior wall,unspec | Acute myocardial infarction of other inferior wall, episode of care unspecified |
| 410.41 | AMI inferior wall, init | Acute myocardial infarction of other inferior wall, initial episode of care |
| 410.42 | AMI inferior wall,subseq | Acute myocardial infarction of other inferior wall, subsequent episode of care |
| 410.5 | AMI lateral NEC, unspec | Acute myocardial infarction of other lateral wall, episode of care unspecified |
| 410.51 | AMI lateral NEC, initial | Acute myocardial infarction of other lateral wall, initial episode of care |
| 410.52 | AMI lateral NEC, subseq | Acute myocardial infarction of other lateral wall, subsequent episode of care |
| 410.6 | True post infarct,unspec | True posterior wall infarction, episode of care unspecified |
| 410.61 | True post infarct, init | True posterior wall infarction, initial episode of care |

| | | |
|---|---|---|
| 410.62 | True post infarct,subseq | True posterior wall infarction, subsequent episode of care |
| 410.7 | Subendo infarct, unspec | Subendocardial infarction, episode of care unspecified |
| 410.71 | Subendo infarct, initial | Subendocardial infarction, initial episode of care |
| 410.72 | Subendo infarct, subseq | Subendocardial infarction, subsequent episode of care |
| 410.8 | AMI NEC, unspecified | Acute myocardial infarction of other specified sites, episode of care unspecified |
| 410.81 | AMI NEC, initial | Acute myocardial infarction of other specified sites, initial episode of care |
| 410.82 | AMI NEC, subsequent | Acute myocardial infarction of other specified sites, subsequent episode of care |
| 410.9 | AMI NOS, unspecified | Acute myocardial infarction of unspecified site, episode of care unspecified |
| 410.91 | AMI NOS, initial | Acute myocardial infarction of unspecified site, initial episode of care |
| 410.92 | AMI NOS, subsequent | Acute myocardial infarction of unspecified site, subsequent episode of care |

**Ischemic stroke**

| ICD-9 Code | Short Description | Long Description |
|---|---|---|
| 435.8 | Trans cereb ischemia NEC | Other specified transient cerebral ischemias |
| 435.9 | Trans cereb ischemia NOS | Unspecified transient cerebral ischemia |
| 433.01 | Ocl bslr art w infrct | Occlusion and stenosis of basilar artery with cerebral infarction |
| 433.11 | Ocl crtd art w infrct | Occlusion and stenosis of carotid artery with cerebral infarction |
| 433.21 | Ocl vrtb art w infrct | Occlusion and stenosis of vertebral artery with cerebral infarction |
| 433.31 | Ocl mlt bi art w infrct | Occlusion and stenosis of multiple and bilateral precerebral arteries with cerebral infarction |
| 433.81 | Ocl spcf art w infrct | Occlusion and stenosis of other specified precerebral artery with cerebral infarction |
| 433.91 | Ocl art NOS w infrct | Occlusion and stenosis of unspecified precerebral artery with cerebral infarction |
| 434.91 | Crbl art ocl NOS w infrc | Cerebral artery occlusion, unspecified with cerebral infarction |

**Brain hemorrhage**

| ICD-9 Code | Short Description | Long Description |
|---|---|---|
| 430 | Subarachnoid hemorrhage | Subarachnoid hemorrhage |
| 431 | Intracerebral hemorrhage | Intracerebral hemorrhage |
| 432 | Nontraum extradural hem | Nontraumatic extradural hemorrhage |
| 432.1 | Subdural hemorrhage | Subdural hemorrhage |
| 432.9 | Intracranial hemorr NOS | Unspecified intracranial hemorrhage |

**Metabolic syndrome and diabetes**

| ICD-9 Code | Short Description | Long Description |
|---|---|---|
| 277.7 | Dysmetabolic syndrome x | Dysmetabolic syndrome X |
| 250 | DMII wo cmp nt st uncntr | Diabetes mellitus without mention of complication, type II or unspecified type, not stated as uncontrolled |
| 250.02 | DMII wo cmp uncntrld | Diabetes mellitus without mention of complication, type II or unspecified type, uncontrolled |
| 250.1 | DMII keto nt st uncntrld | Diabetes with ketoacidosis, type II or unspecified type, not stated as uncontrolled |
| 250.12 | DMII ketoacd uncontrold | Diabetes with ketoacidosis, type II or unspecified type, uncontrolled |
| 250.2 | DMII hprsm nt st uncntrl | Diabetes with hyperosmolarity, type II or unspecified type, not stated as uncontrolled |
| 250.22 | DMII hprosmlr uncontrold | Diabetes with hyperosmolarity, type II or unspecified type, uncontrolled |
| 250.3 | DMII o cm nt st uncntrld | Diabetes with other coma, type II or unspecified type, not stated as uncontrolled |
| 250.32 | DMII oth coma uncontrold | Diabetes with other coma, type II or unspecified type, uncontrolled |
| 250.4 | DMII renl nt st uncntrld | Diabetes with renal manifestations, type II or unspecified type, not stated as uncontrolled |
| 250.42 | DMII renal uncntrld | Diabetes with renal manifestations, type II or unspecified type, uncontrolled |
| 250.5 | DMII ophth nt st uncntrl | Diabetes with ophthalmic manifestations, type II or unspecified type, not stated as uncontrolled |
| 250.52 | DMII ophth uncntrld | Diabetes with ophthalmic manifestations, type II or unspecified type, uncontrolled |
| 250.6 | DMII neuro nt st uncntrl | Diabetes with neurological manifestations, type II or unspecified type, not stated as uncontrolled |
| 250.62 | DMII neuro uncntrld | Diabetes with neurological manifestations, type II or unspecified type, uncontrolled |
| 250.7 | DMII circ nt st uncntrld | Diabetes with peripheral circulatory disorders, type II or unspecified type, not stated as uncontrolled |
| 250.72 | DMII circ uncntrld | Diabetes with peripheral circulatory disorders, type II or unspecified type, uncontrolled |
| 250.8 | DMII oth nt st uncntrld | Diabetes with other specified manifestations, type II or unspecified type, not stated as uncontrolled |
| 250.82 | DMII oth uncntrld | Diabetes with other specified manifestations, type II or unspecified type, uncontrolled |
| 250.9 | DMII unspf nt st uncntrl | Diabetes with unspecified complication, type II or unspecified type, not stated as uncontrolled |

| | | |
|---|---|---|
| 250.92 | DMII unspf uncntrld | Diabetes with unspecified complication, type II or unspecified type, uncontrolled |

**Prediabetes**

| ICD-9 Code | Short Description | Long Description |
|---|---|---|
| 790.29 | Abnormal glucose NEC | Other abnormal glucose |

**Bronchitis**

| ICD-9 Code | Short Description | Long Description |
|---|---|---|
| 466 | Acute bronchitis | Acute bronchitis |
| 490 | Bronchitis NOS | Bronchitis, not specified as acute or chronic |
| 491 | Simple chr bronchitis | Simple chronic bronchitis |
| 491.1 | Mucopurul chr bronchitis | Mucopurulent chronic bronchitis |
| 491.2 | Obst chr bronc w/o exac | Obstructive chronic bronchitis without exacerbation |
| 491.21 | Obs chr bronc w(ac) exac | Obstructive chronic bronchitis with (acute) exacerbation |
| 491.22 | Obs chr bronc w ac bronc | Obstructive chronic bronchitis with acute bronchitis |
| 491.8 | Chronic bronchitis NEC | Other chronic bronchitis |
| 491.9 | Chronic bronchitis NOS | Unspecified chronic bronchitis |

**Motor vehicle accidents**

| ICD-9 Code | Short Description | Long Description |
|---|---|---|
| E812.0 | Mv collision NOS-driver | Other motor vehicle traffic accident involving collision with motor vehicle injuring driver of motor vehicle other than motorcycle |
| E812.1 | Mv collision NOS-pasngr | Other motor vehicle traffic accident involving collision with motor vehicle injuring passenger in motor vehicle other than motorcycle |
| E812.2 | Mv collis NOS-motorcycl | Other motor vehicle traffic accident involving collision with motor vehicle injuring motorcyclist |
| E812.3 | Mv coll NOS-mcycl psngr | Other motor vehicle traffic accident involving collision with motor vehicle injuring passenger on motorcycle |
| E812.4 | Mv collision NOS-st car | Other motor vehicle traffic accident involving collision with motor vehicle injuring occupant of streetcar |
| E812.5 | Mv coll NOS-anim rid | Other motor vehicle traffic accident involving collision with motor vehicle injuring rider of animal; occupant of animal-drawn vehicle |
| E812.6 | Mv coll NOS-ped cycl | Other motor vehicle traffic accident involving collision with motor vehicle injuring pedal cyclist |
| E812.7 | Mv collision NOS-pedest | Other motor vehicle traffic accident involving collision with motor vehicle injuring pedestrian |

| | | |
|---|---|---|
| E812.8 | Mv collis NOS-pers NEC | Other motor vehicle traffic accident involving collision with motor vehicle injuring other specified person |
| E812.9 | Mv collis NOS-pers NOS | Other motor vehicle traffic accident involving collision with motor vehicle injuring unspecified person |
| E813.0 | Mv-oth veh coll-driver | Motor vehicle traffic accident involving collision with other vehicle injuring driver of motor vehicle other than motorcycle |
| E813.1 | Mv-oth veh coll-pasngr | Motor vehicle traffic accident involving collision with other vehicle injuring passenger in motor vehicle other than motorcycle |
| E813.2 | Mv-oth veh coll-motcycl | Motor vehicle traffic accident involving collision with other vehicle injuring motorcyclist |
| E813.3 | Mv-oth veh coll-mcyc psg | Motor vehicle traffic accident involving collision with other vehicle injuring passenger on motorcycle |
| E813.4 | Mv-oth veh coll-st car | Motor vehicle traffic accident involving collision with other vehicle injuring occupant of streetcar |
| E813.5 | Mv-oth veh coll-anim rid | Motor vehicle traffic accident involving collision with other vehicle injuring rider of animal; occupant of animal-drawn vehicle |
| E813.6 | Mv-oth veh coll-ped cycl | Motor vehicle traffic accident involving collision with other vehicle injuring pedal cyclist |
| E813.7 | Mv-oth veh coll-pedest | Motor vehicle traffic accident involving collision with other vehicle injuring pedestrian |
| E813.8 | Mv-oth veh coll-pers NEC | Motor vehicle traffic accident involving collision with other vehicle injuring other specified person |
| E813.9 | Mv-oth veh coll-pers NOS | Motor vehicle traffic accident involving collision with other vehicle injuring unspecified person |
| E814.0 | Mv coll w pedest-driver | Motor vehicle traffic accident involving collision with pedestrian injuring driver of motor vehicle other than motorcycle |
| E814.1 | Mv coll w pedest-pasngr | Motor vehicle traffic accident involving collision with pedestrian injuring passenger in motor vehicle other than motorcycle |
| E814.2 | Mv coll w pedest-motcycl | Motor vehicle traffic accident involving collision with pedestrian injuring motorcyclist |
| E814.3 | Mv coll w ped-mcycl psgr | Motor vehicle traffic accident involving collision with pedestrian injuring passenger on motorcycle |
| E814.4 | Mv coll w pedest-st car | Motor vehicle traffic accident involving collision with pedestrian injuring occupant of streetcar |
| E814.5 | Mv coll w ped-anim rid | Motor vehicle traffic accident involving collision with pedestrian injuring rider of animal; occupant of animal drawn vehicle |
| E814.6 | Mv coll w ped-ped cycl | Motor vehicle traffic accident involving collision with pedestrian injuring pedal cyclist |

| | | |
|---|---|---|
| E814.7 | Mv coll w pedest-pedest | Motor vehicle traffic accident involving collision with pedestrian injuring pedestrian |
| E814.8 | Mv coll w pedes-pers NEC | Motor vehicle traffic accident involving collision with pedestrian injuring other specified person |
| E814.9 | Mv coll w pedes-pers NOS | Motor vehicle traffic accident involving collision with pedestrian injuring unspecified person |
| E815.0 | Mv coll w oth obj-driver | Other motor vehicle traffic accident involving collision on the highway injuring driver of motor vehicle other than motorcycle |
| E815.1 | Mv coll w oth obj-pasngr | Other motor vehicle traffic accident involving collision on the highway injuring passenger in motor vehicle other than motorcycle |
| E815.2 | Mv coll w oth obj-mocycl | Other motor vehicle traffic accident involving collision on the highway injuring motorcyclist |
| E815.3 | Mv coll w obj-mcycl psgr | Other motor vehicle traffic accident involving collision on the highway injuring passenger on motorcycle |
| E815.4 | Mv coll w obj-st car | Other motor vehicle traffic accident involving collision on the highway injuring occupant of streetcar |
| E815.5 | Mv coll w obj-anim rider | Other motor vehicle traffic accident involving collision on the highway injuring rider of animal; occupant of animal-drawn vehicle |
| E815.6 | Mv coll w obj-ped cycl | Other motor vehicle traffic accident involving collision on the highway injuring pedal cyclist |
| E815.7 | Mv coll w obj-pedest | Other motor vehicle traffic accident involving collision on the highway injuring pedestrian |
| E815.8 | Mv coll w obj-pers NEC | Other motor vehicle traffic accident involving collision on the highway injuring other specified person |
| E815.9 | Mv coll w obj-pers NOS | Other motor vehicle traffic accident involving collision on the highway injuring unspecified person |
| E816.0 | Loss control mv acc-driv | Motor vehicle traffic accident due to loss of control, without collision on the highway, injuring driver of motor vehicle other than motorcycle |
| E816.1 | Loss control mv acc-psgr | Motor vehicle traffic accident due to loss of control, without collision on the highway, injuring passenger in motor vehicle other than motorcycle |
| E816.2 | Loss control mv-mocycl | Motor vehicle traffic accident due to loss of control, without collision on the highway, injuring motorcyclist |
| E816.3 | Loss control mv-mcyc psg | Motor vehicle traffic accident due to loss of control, without collision on the highway, injuring passenger on motorcycle |

| | | |
|---|---|---|
| E816.4 | Loss cont mv acc-st car | Motor vehicle traffic accident due to loss of control, without collision on the highway, injuring occupant of streetcar |
| E816.5 | Loss cont mv-anim rider | Motor vehicle traffic accident due to loss of control, without collision on the highway, injuring rider of animal; occupant of animal-drawn vehicle |
| E816.6 | Loss control mv-ped cycl | Motor vehicle traffic accident due to loss of control, without collision on the highway, injuring pedal cyclist |
| E816.7 | Loss control mv-pedest | Motor vehicle traffic accident due to loss of control, without collision on the highway, injuring pedestrian |
| E816.8 | Loss control mv-pers NEC | Motor vehicle traffic accident due to loss of control, without collision on the highway, injuring other specified person |
| E816.9 | Loss control mv-pers NOS | Motor vehicle traffic accident due to loss of control, without collision on the highway, injuring unspecified person |
| E819.0 | Traffic acc NOS-driver | Motor vehicle traffic accident of unspecified nature injuring driver of motor vehicle other than motorcycle |
| E819.1 | Traffic acc NOS-pasngr | Motor vehicle traffic accident of unspecified nature injuring passenger in motor vehicle other than motorcycle |
| E819.2 | Traffic acc NOS-motcycl | Motor vehicle traffic accident of unspecified nature injuring motorcyclist |
| E819.3 | Traff acc NOS-mcycl psgr | Motor vehicle traffic accident of unspecified nature injuring passenger on motorcycle |
| E819.4 | Traffic acc NOS-st car | Motor vehicle traffic accident of unspecified nature injuring occupant of streetcar |
| E819.5 | Traff acc NOS-anim rider | Motor vehicle traffic accident of unspecified nature injuring rider of animal; occupant of animal-drawn vehicle |
| E819.6 | Traffic acc NOS-ped cycl | Motor vehicle traffic accident of unspecified nature injuring pedal cyclist |
| E819.7 | Traffic acc NOS-pedest | Motor vehicle traffic accident of unspecified nature injuring pedestrian |
| E819.8 | Traffic acc NOS-pers NEC | Motor vehicle traffic accident of unspecified nature injuring other specified person |
| E819.9 | Traffic acc NOS-pers NOS | Motor vehicle traffic accident of unspecified nature injuring unspecified person |

**Overdose injuries**

| ICD-9 Code | Short Description | Long Description |
|---|---|---|
| E950.0 | Poison-analgesics | Suicide and self-inflicted poisoning by analgesics, antipyretics, and antirheumatics |

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|---|---|---|
| E950.1 | Poison-barbiturates | Suicide and self-inflicted poisoning by barbiturates |
| E950.2 | Poison-sedat/hypnotic | Suicide and self-inflicted poisoning by other sedatives and hypnotics |
| E950.3 | Poison-psychotropic agt | Suicide and self-inflicted poisoning by tranquilizers and other psychotropic agents |
| E950.4 | Poison-drug/medicin NEC | Suicide and self-inflicted poisoning by other specified drugs and medicinal substances |
| E950.5 | Poison-drug/medicin NOS | Suicide and self-inflicted poisoning by unspecified drug or medicinal substance |

**Assault-based gunshot injuries**

| ICD-9 Code | Short Description | Long Description |
|---|---|---|
| E965.0 | Assault-handgun | Assault by handgun |
| E965.1 | Assault-shotgun | Assault by shotgun |
| E965.2 | Assault-hunting rifle | Assault by hunting rifle |
| E965.3 | Assault-military weapon | Assault by military firearms |
| E965.4 | Assault-firearm NEC | Assault by other and unspecified firearm |

**Low offspring birthweight**

| ICD-9 Code | Short Description | Long Description |
|---|---|---|
| 764.9 | Fet growth retard wtNOS | Fetal growth retardation, unspecified, unspecified [weight] |
| 764.91 | Fet growth retard <500g | Fetal growth retardation, unspecified, less than 500 grams |
| 764.92 | Fet growth ret 500-749g | Fetal growth retardation, unspecified, 500-749 grams |
| 764.93 | Fet growth ret 750-999g | Fetal growth retardation, unspecified, 750-999 grams |
| 764.94 | Fet grwth ret 1000-1249g | Fetal growth retardation, unspecified, 1,000-1,249 grams |
| 764.95 | Fet grwth ret 1250-1499g | Fetal growth retardation, unspecified, 1,250-1,499 grams |
| 764.96 | Fet grwth ret 1500-1749g | Fetal growth retardation, unspecified, 1,500-1,749 grams |
| 764.97 | Fet grwth ret 1750-1999g | Fetal growth retardation, unspecified, 1,750-1,999 grams |
| 764.98 | Fet grwth ret 2000-2499g | Fetal growth retardation, unspecified, 2,000-2,499 grams |
| 764.99 | Fet growth ret 2500+g | Fetal growth retardation, unspecified, 2,500 grams and over |

**Maternal pregnancy complications**

| ICD-9 Code | Short Description | Long Description |
|---|---|---|
| 640.8 | Hem early preg NEC-unsp | Other specified hemorrhage in early pregnancy, unspecified as to episode of care or not applicable |

| | | |
|---|---|---|
| 640.81 | Hem early preg NEC-deliv | Other specified hemorrhage in early pregnancy, delivered, with or without mention of antepartum condition |
| 640.83 | Hem early pg NEC-antepar | Other specified hemorrhage in early pregnancy, antepartum condition or complication |
| 640.9 | Hemorr early preg-unspec | Unspecified hemorrhage in early pregnancy, unspecified as to episode of care or not applicable |
| 640.91 | Hem early preg-delivered | Unspecified hemorrhage in early pregnancy, delivered, with or without mention of antepartum condition |
| 640.93 | Hem early preg-antepart | Unspecified hemorrhage in early pregnancy, antepartum condition or complication |
| 641 | Placenta previa-unspec | Placenta previa without hemorrhage, unspecified as to episode of care or not applicable |
| 641.01 | Placenta previa-deliver | Placenta previa without hemorrhage, delivered, with or without mention of antepartum condition |
| 641.03 | Placenta previa-antepart | Placenta previa without hemorrhage, antepartum condition or complication |
| 641.1 | Placenta prev hem-unspec | Hemorrhage from placenta previa, unspecified as to episode of care or not applicable |
| 641.11 | Placenta prev hem-deliv | Hemorrhage from placenta previa, delivered, with or without mention of antepartum condition |
| 641.13 | Placen prev hem-antepart | Hemorrhage from placenta previa, antepartum condition or complication |
| 641.2 | Prem separ placen-unspec | Premature separation of placenta, unspecified as to episode of care or not applicable |
| 641.21 | Prem separ placen-deliv | Premature separation of placenta, delivered, with or without mention of antepartum condition |
| 641.23 | Prem separ plac-antepart | Premature separation of placenta, antepartum condition or complication |
| 642 | Essen hyperten preg-unsp | Benign essential hypertension complicating pregnancy, childbirth, and the puerperium, unspecified as to episode of care or not applicable |
| 642.01 | Essen hyperten-delivered | Benign essential hypertension complicating pregnancy, childbirth, and the puerperium, delivered, with or without mention of antepartum condition |
| 642.02 | Essen hyperten-del w p/p | Benign essential hypertension, complicating pregnancy, childbirth, and the puerperium, delivered, with mention of postpartum complication |
| 642.03 | Essen hyperten-antepart | Benign essential hypertension complicating pregnancy, childbirth, and the puerperium, antepartum condition or complication |

| | | |
|---|---|---|
| 642.04 | Essen hyperten-postpart | Benign essential hypertension complicating pregnancy, childbirth, and the puerperium, postpartum condition or complication |
| 642.3 | Trans hyperten preg-unsp | Transient hypertension of pregnancy, unspecified as to episode of care or not applicable |
| 642.31 | Trans hyperten-delivered | Transient hypertension of pregnancy, delivered , with or without mention of antepartum condition |
| 642.32 | Trans hyperten-del w p/p | Transient hypertension of pregnancy, delivered, with mention of postpartum complication |
| 642.33 | Trans hyperten-antepart | Transient hypertension of pregnancy, antepartum condition or complication |
| 642.34 | Trans hyperten-postpart | Transient hypertension of pregnancy, postpartum condition or complication |
| 642.4 | Mild/NOS preeclamp-unsp | Mild or unspecified pre-eclampsia, unspecified as to episode of care or not applicable |
| 642.41 | Mild/NOS preeclamp-deliv | Mild or unspecified pre-eclampsia, delivered, with or without mention of antepartum condition |
| 642.42 | Mild preeclamp-del w p/p | Mild or unspecified pre-eclampsia, delivered, with mention of postpartum complication |
| 642.43 | Mild/NOS preeclamp-antep | Mild or unspecified pre-eclampsia, antepartum condition or complication |
| 642.44 | Mild/NOS preeclamp-p/p | Mild or unspecified pre-eclampsia, postpartum condition or complication |
| 642.5 | Severe preeclamp-unspec | Severe pre-eclampsia, unspecified as to episode of care or not applicable |
| 642.51 | Severe preeclamp-deliver | Severe pre-eclampsia, delivered, with or without mention of antepartum condition |
| 642.52 | Sev preeclamp-del w p/p | Severe pre-eclampsia, delivered, with mention of postpartum complication |
| 642.53 | Sev preeclamp-antepartum | Severe pre-eclampsia, antepartum condition or complication |
| 642.54 | Sev preeclamp-postpartum | Severe pre-eclampsia, postpartum condition or complication |
| 642.6 | Eclampsia-unspecified | Eclampsia, unspecified as to episode of care or not applicable |
| 642.61 | Eclampsia-delivered | Eclampsia, delivered, with or without mention of antepartum condition |
| 642.62 | Eclampsia-deliv w p/p | Eclampsia, delivered, with mention of postpartum complication |
| 642.63 | Eclampsia-antepartum | Eclampsia, antepartum condition or complication |
| 642.64 | Eclampsia-postpartum | Eclampsia, postpartum condition or complication |
| 642.7 | Tox w old hyperten-unsp | Pre-eclampsia or eclampsia superimposed on pre-existing hypertension, unspecified as to episode of care or not applicable |
| 642.71 | Tox w old hyperten-deliv | Pre-eclampsia or eclampsia superimposed on pre-existing hypertension, delivered, with or without mention of antepartum condition |

| | | |
|---|---|---|
| 642.72 | Tox w old hyp-del w p/p | Pre-eclampsia or eclampsia superimposed on pre-existing hypertension, delivered, with mention of postpartum complication |
| 642.73 | Tox w old hyper-antepart | Pre-eclampsia or eclampsia superimposed on pre-existing hypertension, antepartum condition or complication |
| 642.74 | Tox w old hyper-postpart | Pre-eclampsia or eclampsia superimposed on pre-existing hypertension, postpartum condition or complication |
| 642.9 | Hyperten preg NOS-unspec | Unspecified hypertension complicating pregnancy, childbirth, or the puerperium, unspecified as to episode of care or not applicable |
| 642.91 | Hypertens NOS-delivered | Unspecified hypertension complicating pregnancy, childbirth, or the puerperium, delivered, with or without mention of antepartum condition |
| 642.92 | Hypertens NOS-del w p/p | Unspecified hypertension complicating pregnancy, childbirth, or the puerperium, delivered, with mention of postpartum complication |
| 642.93 | Hypertens NOS-antepartum | Unspecified hypertension complicating pregnancy, childbirth, or the puerperium, antepartum condition or complication |
| 642.94 | Hypertens NOS-postpartum | Unspecified hypertension complicating pregnancy, childbirth, or the puerperium, postpartum condition or complication |
| 646.8 | Preg compl NEC-unspec | Other specified complications of pregnancy, unspecified as to episode of care or not applicable |
| 646.81 | Preg compl NEC-delivered | Other specified complications of pregnancy, delivered, with or without mention of antepartum condition |
| 646.82 | Preg compl NEC-del w p/p | Other specified complications of pregnancy, delivered, with mention of postpartum complication |
| 646.83 | Preg compl NEC-antepart | Other specified complications of pregnancy, antepartum condition or complication |
| 646.84 | Preg compl NEC-postpart | Other specified complications of pregnancy, postpartum condition or complication |
| 646.9 | Preg compl NOS-unspec | Unspecified complication of pregnancy, unspecified as to episode of care or not applicable |

**Unemployment or low income**

| ICD-9 Code | Short Description | Long Description |
|---|---|---|
| V62.0 | Unemployment | Unemployment |

**Schizophrenia or other psychoses**

| ICD-9 Code | Short Description | Long Description |
|---|---|---|
| 295 | Simpl schizophren-unspec | Simple type schizophrenia, unspecified |
| 295.01 | Simpl schizophren-subchr | Simple type schizophrenia, subchronic |
| 295.02 | Simple schizophren-chr | Simple type schizophrenia, chronic |
| 295.03 | Simp schiz-subchr/exacer | Simple type schizophrenia, subchronic with acute exacerbation |
| 295.04 | Simpl schizo-chr/exacerb | Simple type schizophrenia, chronic with acute exacerbation |
| 295.05 | Simpl schizophren-remiss | Simple type schizophrenia, in remission |
| 295.1 | Hebephrenia-unspec | Disorganized type schizophrenia, unspecified |
| 295.11 | Hebephrenia-subchronic | Disorganized type schizophrenia, subchronic |
| 295.12 | Hebephrenia-chronic | Disorganized type schizophrenia, chronic |
| 295.13 | Hebephren-subchr/exacerb | Disorganized type schizophrenia, subchronic with acute exacerbation |
| 295.14 | Hebephrenia-chr/exacerb | Disorganized type schizophrenia, chronic with acute exacerbation |
| 295.15 | Hebephrenia-remission | Disorganized type schizophrenia, in remission |
| 295.2 | Catatonia-unspec | Catatonic type schizophrenia, unspecified |
| 295.21 | Catatonia-subchronic | Catatonic type schizophrenia, subchronic |
| 295.22 | Catatonia-chronic | Catatonic type schizophrenia, chronic |
| 295.23 | Catatonia-subchr/exacerb | Catatonic type schizophrenia, subchronic with acute exacerbation |
| 295.24 | Catatonia-chr/exacerb | Catatonic type schizophrenia, chronic with acute exacerbation |
| 295.25 | Catatonia-remission | Catatonic type schizophrenia, in remission |
| 295.3 | Paranoid schizo-unspec | Paranoid type schizophrenia, unspecified |
| 295.31 | Paranoid schizo-subchr | Paranoid type schizophrenia, subchronic |
| 295.32 | Paranoid schizo-chronic | Paranoid type schizophrenia, chronic |
| 295.33 | Paran schizo-subchr/exac | Paranoid type schizophrenia, subchronic with acute exacerbation |
| 295.34 | Paran schizo-chr/exacerb | Paranoid type schizophrenia, chronic with acute exacerbation |
| 295.35 | Paranoid schizo-remiss | Paranoid type schizophrenia, in remission |
| 295.4 | Schizophreniform dis NOS | Schizophreniform disorder, unspecified |
| 295.41 | Schizophrenic dis-subchr | Schizophreniform disorder, subchronic |
| 295.42 | Schizophren dis-chronic | Schizophreniform disorder, chronic |
| 295.43 | Schizo dis-subchr/exacer | Schizophreniform disorder, subchronic with acute exacerbation |
| 295.44 | Schizophr dis-chr/exacer | Schizophreniform disorder, chronic with acute exacerbation |
| 295.45 | Schizophrenic dis-remiss | Schizophreniform disorder, in remission |
| 295.5 | Latent schizophren-unsp | Latent schizophrenia, unspecified |
| 295.51 | Lat schizophren-subchr | Latent schizophrenia, subchronic |
| 295.52 | Latent schizophren-chr | Latent schizophrenia, chronic |

| | | |
|---|---|---|
| 295.53 | Lat schizo-subchr/exacer | Latent schizophrenia, subchronic with acute exacerbation |
| 295.54 | Latent schizo-chr/exacer | Latent schizophrenia, chronic with acute exacerbation |
| 295.55 | Lat schizophren-remiss | Latent schizophrenia, in remission |
| 295.6 | Schizophr dis resid NOS | Schizophrenic disorders, residual type, unspecified |
| 295.61 | Schizoph dis resid-subch | Schizophrenic disorders, residual type, subchronic |
| 295.62 | Schizophr dis resid-chr | Schizophrenic disorders, residual type, chronic |
| 295.63 | Schizo resid subchr/exac | Schizophrenic disorders, residual type, subchronic with acute exacerbation |
| 295.64 | Schizoph resid-chro/exac | Schizophrenic disorders, residual type, chronic with acute exacerbation |
| 295.65 | Schizoph dis resid-remis | Schizophrenic disorders, residual type, in remission |
| 296.2 | Depress psychosis-unspec | Major depressive affective disorder, single episode, unspecified |
| 296.21 | Depress psychosis-mild | Major depressive affective disorder, single episode, mild |
| 296.22 | Depressive psychosis-mod | Major depressive affective disorder, single episode, moderate |
| 296.23 | Depress psychosis-severe | Major depressive affective disorder, single episode, severe, without mention of psychotic behavior |
| 296.24 | Depr psychos-sev w psych | Major depressive affective disorder, single episode, severe, specified as with psychotic behavior |
| 296.25 | Depr psychos-part remiss | Major depressive affective disorder, single episode, in partial or unspecified remission |
| 296.26 | Depr psychos-full remiss | Major depressive affective disorder, single episode, in full remission |
| 296.3 | Recurr depr psychos-unsp | Major depressive affective disorder, recurrent episode, unspecified |
| 296.31 | Recurr depr psychos-mild | Major depressive affective disorder, recurrent episode, mild |
| 296.32 | Recurr depr psychos-mod | Major depressive affective disorder, recurrent episode, moderate |
| 296.33 | Recur depr psych-severe | Major depressive affective disorder, recurrent episode, severe, without mention of psychotic behavior |
| 296.34 | Rec depr psych-psychotic | Major depressive affective disorder, recurrent episode, severe, specified as with psychotic behavior |
| 296.35 | Recur depr psyc-part rem | Major depressive affective disorder, recurrent episode, in partial or unspecified remission |

| | | |
|---|---|---|
| 296.36 | Recur depr psyc-full rem | Major depressive affective disorder, recurrent episode, in full remission |
| 298 | React depress psychosis | Depressive type psychosis |
| 298.1 | Excitativ type psychosis | Excitative type psychosis |
| 298.4 | Psychogen paranoid psych | Psychogenic paranoid psychosis |
| 298.8 | React psychosis NEC/NOS | Other and unspecified reactive psychosis |
| 298.9 | Psychosis NOS | Unspecified psychosis |

**Depressive disorders**

| ICD-9 Code | Short Description | Long Description |
|---|---|---|
| 296.82 | Atypical depressive dis | Atypical depressive disorder |
| 311 | Depressive disorder NEC | Depressive disorder, not elsewhere classified |

**Suicide**

| ICD-9 Code | Short Description | Long Description |
|---|---|---|
| E950.6 | Poison-agricult agent | Suicide and self-inflicted poisoning by agricultural and horticultural chemical and pharmaceutical preparations other than plant foods and fertilizers |
| E950.7 | Poison-corrosiv/caustic | Suicide and self-inflicted poisoning by corrosive and caustic substances |
| E950.8 | Poison-arsenic | Suicide and self-inflicted poisoning by arsenic and its compounds |
| E950.9 | Poison-solid/liquid NEC | Suicide and self-inflicted poisoning by other and unspecified solid and liquid substances |
| E951.0 | Poison-piped gas | Suicide and self-inflicted poisoning by gas distributed by pipeline |
| E951.1 | Poison-gas in container | Suicide and self-inflicted poisoning by liquefied petroleum gas distributed in mobile containers |
| E951.8 | Poison-utility gas NEC | Suicide and self-inflicted poisoning by other utility gas |
| E952.0 | Poison-exhaust gas | Suicide and self-inflicted poisoning by motor vehicle exhaust gas |
| E952.1 | Poison-co NEC | Suicide and self-inflicted poisoning by other carbon monoxide |
| E952.8 | Poison-gas/vapor NEC | Suicide and self-inflicted poisoning by other specified gases and vapors |
| E952.9 | Poison-gas/vapor NOS | Suicide and self-inflicted poisoning by unspecified gases and vapors |
| E953.0 | Injury-hanging | Suicide and self-inflicted injury by hanging |
| E953.1 | Injury-suff w plas bag | Suicide and self-inflicted injury by suffocation by plastic bag |
| E953.8 | Injury-strang/suff NEC | Suicide and self-inflicted injury by other specified means |
| E953.9 | Injury-strang/suff NOS | Suicide and self-inflicted injury by unspecified means |

| | | |
|---|---|---|
| E954. | Injury-submersion | Suicide and self-inflicted injury by submersion [drowning] |
| E955.0 | Injury-handgun | Suicide and self-inflicted injury by handgun |
| E955.1 | Injury-shotgun | Suicide and self-inflicted injury by shotgun |
| E955.2 | Injury-hunting rifle | Suicide and self-inflicted injury by hunting rifle |
| E955.3 | Injury-military firearm | Suicide and self-inflicted injury by military firearms |
| E955.4 | Injury-firearm NEC | Suicide and self-inflicted injury by other and unspecified firearm |
| E955.5 | Injury-explosives | Suicide and self-inflicted injury by explosives |
| E955.6 | Self inflict acc-air gun | Suicide and self-inflicted injury by air gun |
| E955.7 | Self inj-paintball gun | Suicide and self-inflicted injury by paintball gun |
| E955.9 | Injury-firearm/expl NOS | Suicide and self-inflicted injury by firearms and explosives, unspecified |
| E956. | Injury-cut instrument | Suicide and self-inflicted injury by cutting and piercing instrument |
| E957.0 | Injury-jump fm residence | Suicide and self-inflicted injuries by jumping from residential premises |
| E957.1 | Injury-jump fm struc NEC | Suicide and self-inflicted injuries by jumping from other man-made structures |
| E957.2 | Injury-jump fm natur sit | Suicide and self-inflicted injuries by jumping from natural sites |
| E957.9 | Injury-jump NEC | Suicide and self-inflicted injuries by jumping from unspecified site |
| E958.0 | Injury-moving object | Suicide and self-inflicted injury by jumping or lying before moving object |
| E958.1 | Injury-burn, fire | Suicide and self-inflicted injury by burns, fire |
| E958.2 | Injury-scald | Suicide and self-inflicted injury by scald |
| E958.3 | Injury-extreme cold | Suicide and self-inflicted injury by extremes of cold |
| E958.4 | Injury-electrocution | Suicide and self-inflicted injury by electrocution |
| E958.5 | Injury-motor veh crash | Suicide and self-inflicted injury by crashing of motor vehicle |
| E958.6 | Injury-aircraft crash | Suicide and self-inflicted injury by crashing of aircraft |
| E958.7 | Injury-caustic substance | Suicide and self-inflicted injury by caustic substances, except poisoning |
| E958.8 | Injury-NEC | Suicide and self-inflicted injury by other specified means |
| E958.9 | Injury-NOS | Suicide and self-inflicted injury by unspecified means |

**Social anxiety disorder**

| ICD-9 Code | Short Description | Long Description |
|---|---|---|
| 300.23 | Social phobia | Social phobia |

**Anxiety disorders**

| ICD-9 Code | Short Description | Long Description |
|---|---|---|
| 293.84 | Anxiety disorder oth dis | Anxiety disorder in conditions classified elsewhere |
| 300 | Anxiety state NOS | Anxiety state, unspecified |

**Anxiety disorders (except social anxiety)**

| ICD-9 Code | Short Description | Long Description |
|---|---|---|
| 300.01 | Panic dis w/o agorphobia | Panic disorder without agoraphobia |
| 300.02 | Generalized anxiety dis | Generalized anxiety disorder |
| 300.09 | Anxiety state NEC | Other anxiety states |
| 300.1 | Hysteria NOS | Hysteria, unspecified |
| 300.11 | Conversion disorder | Conversion disorder |
| 300.12 | Dissociative amnesia | Dissociative amnesia |
| 300.13 | Dissociative fugue | Dissociative fugue |
| 300.14 | Dissociatve identity dis | Dissociative identity disorder |
| 300.15 | Dissociative react NOS | Dissociative disorder or reaction, unspecified |
| 300.16 | Factitious dis w symptom | Factitious disorder with predominantly psychological signs and symptoms |
| 300.19 | Factitious ill NEC/NOS | Other and unspecified factitious illness |
| 300.2 | Phobia NOS | Phobia, unspecified |
| 300.21 | Agoraphobia w panic dis | Agoraphobia with panic disorder |
| 300.22 | Agoraphobia w/o panic | Agoraphobia without mention of panic attacks |
| 300.29 | Isolated/spec phobia NEC | Other isolated or specific phobias |
| 300.3 | Obsessive-compulsive dis | Obsessive-compulsive disorders |
| 300.4 | Dysthymic disorder | Dysthymic disorder |
| 300.5 | Neurasthenia | Neurasthenia |
| 300.6 | Depersonalization disord | Depersonalization disorder |
| 300.7 | Hypochondriasis | Hypochondriasis |
| 300.81 | Somatization disorder | Somatization disorder |
| 300.82 | Undiff somatoform disrdr | Undifferentiated somatoform disorder |
| 300.89 | Somatoform disorders NEC | Other somatoform disorders |
| 300.9 | Nonpsychotic disord NOS | Unspecified nonpsychotic mental disorder |

**Positive symptoms of schizophrenia (i.e., hallucinations)**

| ICD-9 Code | Short Description | Long Description |
|---|---|---|
| 780.1 | Hallucinations | |
| 293.81 | Psy dis w delus oth dis | Psychotic disorder with delusions in conditions classified elsewhere |
| 333.99 | Extrapyramidal dis NEC | Other extrapyramidal diseases and abnormal movement disorders |

**Bipolar disorders**

| ICD-9 Code | Short Description | Long Description |
|---|---|---|
| 296.5 | Bipol I cur depres NOS | Bipolar I disorder, most recent episode (or current) depressed, unspecified |

| | | |
|---|---|---|
| 296.51 | Bipol I cur depress-mild | Bipolar I disorder, most recent episode (or current) depressed, mild |
| 296.52 | Bipol I cur depress-mod | Bipolar I disorder, most recent episode (or current) depressed, moderate |
| 296.53 | Bipol I curr dep w/o psy | Bipolar I disorder, most recent episode (or current) depressed, severe, without mention of psychotic behavior |
| 296.54 | Bipol I currnt dep w psy | Bipolar I disorder, most recent episode (or current) depressed, severe, specified as with psychotic behavior |
| 296.55 | Bipol I cur dep rem NOS | Bipolar I disorder, most recent episode (or current) depressed, in partial or unspecified remission |
| 296.56 | Bipol I currnt dep remis | Bipolar I disorder, most recent episode (or current) depressed, in full remission |
| 296.6 | Bipol I currnt mixed NOS | Bipolar I disorder, most recent episode (or current) mixed, unspecified |
| 296.61 | Bipol I currnt mix-mild | Bipolar I disorder, most recent episode (or current) mixed, mild |
| 296.62 | Bipol I currnt mixed-mod | Bipolar I disorder, most recent episode (or current) mixed, moderate |
| 296.63 | Bipol I cur mix w/o psy | Bipolar I disorder, most recent episode (or current) mixed, severe, without mention of psychotic behavior |
| 296.64 | Bipol I cur mixed w psy | Bipolar I disorder, most recent episode (or current) mixed, severe, specified as with psychotic behavior |
| 296.65 | Bipol I cur mix-part rem | Bipolar I disorder, most recent episode (or current) mixed, in partial or unspecified remission |
| 296.66 | Bipol I cur mixed remiss | Bipolar I disorder, most recent episode (or current) mixed, in full remission |
| 296.7 | Bipolor I current NOS | Bipolar I disorder, most recent episode (or current) unspecified |
| 296.8 | Bipolar disorder NOS | Bipolar disorder, unspecified |
| 296 | Bipol I single manic NOS | Bipolar I disorder, single manic episode, unspecified |
| 296.01 | Bipol I single manc-mild | Bipolar I disorder, single manic episode, mild |
| 296.02 | Bipol I single manic-mod | Bipolar I disorder, single manic episode, moderate |
| 296.03 | Bipol I sing-sev w/o psy | Bipolar I disorder, single manic episode, severe, without mention of psychotic behavior |
| 296.04 | Bipo I sin man-sev w psy | Bipolar I disorder, single manic episode, severe, specified as with psychotic behavior |
| 296.05 | Bipol I sing man rem NOS | Bipolar I disorder, single manic episode, in partial or unspecified remission |
| 296.06 | Bipol I single manic rem | Bipolar I disorder, single manic episode, in full remission |

| | | |
|---|---|---|
| 296.4 | Bipol I currnt manic NOS | Bipolar I disorder, most recent episode (or current) manic, unspecified |
| 296.41 | Bipol I curnt manic-mild | Bipolar I disorder, most recent episode (or current) manic, mild |
| 296.42 | Bipol I currnt manic-mod | Bipolar I disorder, most recent episode (or current) manic, moderate |
| 296.43 | Bipol I manc-sev w/o psy | Bipolar I disorder, most recent episode (or current) manic, severe, without mention of psychotic behavior |
| 296.44 | Bipol I manic-sev w psy | Bipolar I disorder, most recent episode (or current) manic, severe, specified as with psychotic behavior |
| 296.45 | Bipol I cur man part rem | Bipolar I disorder, most recent episode (or current) manic, in partial or unspecified remission |
| 296.46 | Bipol I cur man full rem | Bipolar I disorder, most recent episode (or current) manic, in full remission |

**Substance dependence or abuse of alcohol, tobacco, and other illicit drugs**

| ICD-9 Code | Short Description | Long Description |
|---|---|---|
| 303.9 | Alcoh dep NEC/NOS-unspec | Other and unspecified alcohol dependence, unspecified |
| 303.91 | Alcoh dep NEC/NOS-contin | Other and unspecified alcohol dependence, continuous |
| 303.92 | Alcoh dep NEC/NOS-episod | Other and unspecified alcohol dependence, episodic |
| 303.93 | Alcoh dep NEC/NOS-remiss | Other and unspecified alcohol dependence, in remission |
| 304 | Opioid dependence-unspec | Opioid type dependence, unspecified |
| 304.01 | Opioid dependence-contin | Opioid type dependence, continuous |
| 304.02 | Opioid dependence-episod | Opioid type dependence, episodic |
| 304.03 | Opioid dependence-remiss | Opioid type dependence, in remission |
| 304.1 | Sed,hyp,anxiolyt dep-NOS | Sedative, hypnotic or anxiolytic dependence, unspecified |
| 304.11 | Sed,hyp,anxiolyt dep-con | Sedative, hypnotic or anxiolytic dependence, continuous |
| 304.12 | Sed,hyp,anxiolyt dep-epi | Sedative, hypnotic or anxiolytic dependence, episodic |
| 304.13 | Sed,hyp,anxiolyt dep-rem | Sedative, hypnotic or anxiolytic dependence, in remission |
| 304.2 | Cocaine depend-unspec | Cocaine dependence, unspecified |
| 304.21 | Cocaine depend-contin | Cocaine dependence, continuous |
| 304.22 | Cocaine depend-episodic | Cocaine dependence, episodic |
| 304.23 | Cocaine depend-remiss | Cocaine dependence, in remission |
| 304.3 | Cannabis depend-unspec | Cannabis dependence, unspecified |
| 304.31 | Cannabis depend-contin | Cannabis dependence, continuous |
| 304.32 | Cannabis depend-episodic | Cannabis dependence, episodic |

| | | |
|---|---|---|
| 304.33 | Cannabis depend-remiss | Cannabis dependence, in remission |
| 304.4 | Amphetamin depend-unspec | Amphetamine and other psychostimulant dependence, unspecified |
| 304.41 | Amphetamin depend-contin | Amphetamine and other psychostimulant dependence, continuous |
| 304.42 | Amphetamin depend-episod | Amphetamine and other psychostimulant dependence, episodic |
| 304.43 | Amphetamin depend-remiss | Amphetamine and other psychostimulant dependence, in remission |
| 304.5 | Hallucinogen dep-unspec | Hallucinogen dependence, unspecified |
| 304.51 | Hallucinogen dep-contin | Hallucinogen dependence, continuous |
| 304.52 | Hallucinogen dep-episod | Hallucinogen dependence, episodic |
| 304.53 | Hallucinogen dep-remiss | Hallucinogen dependence, in remission |
| 304.6 | Drug depend NEC-unspec | Other specified drug dependence, unspecified |
| 304.61 | Drug depend NEC-contin | Other specified drug dependence, continuous |
| 304.62 | Drug depend NEC-episodic | Other specified drug dependence, episodic |
| 304.63 | Drug depend NEC-in rem | Other specified drug dependence, in remission |
| 304.7 | Opioid/other dep-unspec | Combinations of opioid type drug with any other drug dependence, unspecified |
| 304.71 | Opioid/other dep-contin | Combinations of opioid type drug with any other drug dependence, continuous |
| 304.72 | Opioid/other dep-episod | Combinations of opioid type drug with any other drug dependence, episodic |
| 304.73 | Opioid/other dep-remiss | Combinations of opioid type drug with any other drug dependence, in remission |
| 304.8 | Comb drug dep NEC-unspec | Combinations of drug dependence excluding opioid type drug, unspecified |
| 304.81 | Comb drug dep NEC-contin | Combinations of drug dependence excluding opioid type drug, continuous |
| 304.82 | Comb drug dep NEC-episod | Combinations of drug dependence excluding opioid type drug, episodic |
| 304.83 | Comb drug dep NEC-remiss | Combinations of drug dependence excluding opioid type drug, in remission |
| 304.9 | Drug depend NOS-unspec | Unspecified drug dependence, unspecified |
| 304.91 | Drug depend NOS-contin | Unspecified drug dependence, continuous |
| 304.92 | Drug depend NOS-episodic | Unspecified drug dependence, episodic |
| 304.93 | Drug depend NOS-remiss | Unspecified drug dependence, in remission |
| 305 | Alcohol abuse-unspec | Alcohol abuse, unspecified |
| 305.01 | Alcohol abuse-continuous | Alcohol abuse, continuous |
| 305.02 | Alcohol abuse-episodic | Alcohol abuse, episodic |
| 305.03 | Alcohol abuse-in remiss | Alcohol abuse, in remission |
| 305.3 | Hallucinog abuse-unspec | Hallucinogen abuse, unspecified |
| 305.31 | Hallucinog abuse-contin | Hallucinogen abuse, continuous |
| 305.32 | Hallucinog abuse-episod | Hallucinogen abuse, episodic |
| 305.33 | Hallucinog abuse-remiss | Hallucinogen abuse, in remission |

| | | |
|---|---|---|
| 305.4 | Sed,hyp,anxiolytc ab-NOS | Sedative, hypnotic or anxiolytic abuse, unspecified |
| 305.41 | Sed,hyp,anxiolytc ab-con | Sedative, hypnotic or anxiolytic abuse, continuous |
| 305.42 | Sed,hyp,anxiolytc ab-epi | Sedative, hypnotic or anxiolytic abuse, episodic |
| 305.43 | Sed,hyp,anxiolytc ab-rem | Sedative, hypnotic or anxiolytic abuse, in remission |
| 305.5 | Opioid abuse-unspec | Opioid abuse, unspecified |
| 305.51 | Opioid abuse-continuous | Opioid abuse, continuous |
| 305.52 | Opioid abuse-episodic | Opioid abuse, episodic |
| 305.53 | Opioid abuse-in remiss | Opioid abuse, in remission |
| 305.6 | Cocaine abuse-unspec | Cocaine abuse, unspecified |
| 305.61 | Cocaine abuse-continuous | Cocaine abuse, continuous |
| 305.62 | Cocaine abuse-episodic | Cocaine abuse, episodic |
| 305.63 | Cocaine abuse-in remiss | Cocaine abuse, in remission |
| 305.7 | Amphetamine abuse-unspec | Amphetamine or related acting sympathomimetic abuse, unspecified |
| 305.71 | Amphetamine abuse-contin | Amphetamine or related acting sympathomimetic abuse, continuous |
| 305.72 | Amphetamine abuse-episod | Amphetamine or related acting sympathomimetic abuse, episodic |
| 305.73 | Amphetamine abuse-remiss | Amphetamine or related acting sympathomimetic abuse, in remission |
| 305.8 | Antidepress abuse-unspec | Antidepressant type abuse, unspecified |
| 305.81 | Antidepress abuse-contin | Antidepressant type abuse, continuous |
| 305.82 | Antidepress abuse-episod | Antidepressant type abuse, episodic |
| 305.83 | Antidepress abuse-remiss | Antidepressant type abuse, in remission |

**Cannabis abuse**

| ICD-9 Code | Short Description | Long Description |
|---|---|---|
| 305.2 | Cannabis abuse-unspec | Cannabis abuse, unspecified |
| 305.21 | Cannabis abuse-contin | Cannabis abuse, continuous |
| 305.22 | Cannabis abuse-episodic | Cannabis abuse, episodic |
| 305.23 | Cannabis abuse-in remiss | Cannabis abuse, in remission |

**Tobacco use**

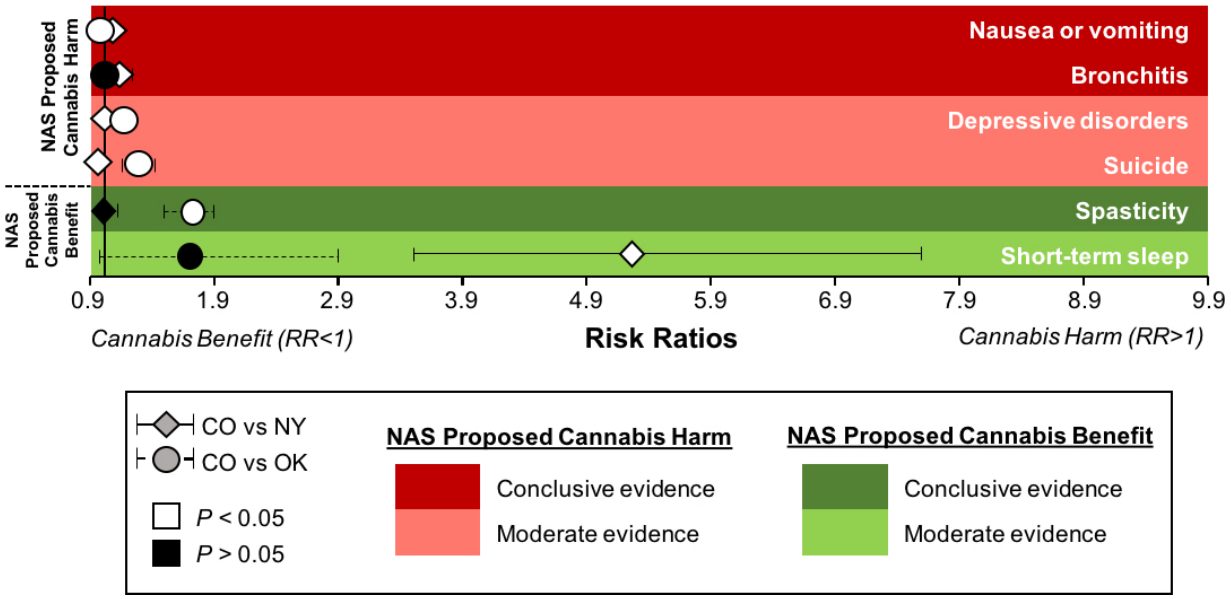
| ICD-9 Code | Short Description | Long Description |
|---|---|---|
| 305.1 | Tobacco use disorder | Tobacco use disorder |

**Alcohol abuse**

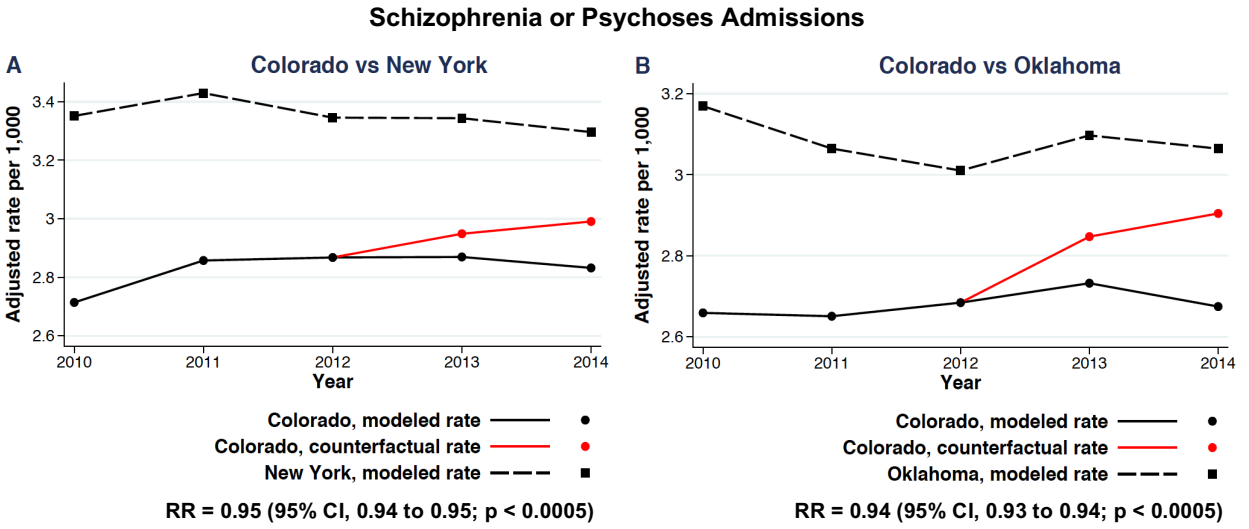
| ICD-9 Code | Short Description | Long Description |
|---|---|---|
| 303.9 | Alcoh dep NEC/NOS-unspec | Other and unspecified alcohol dependence, unspecified |
| 303.91 | Alcoh dep NEC/NOS-contin | Other and unspecified alcohol dependence, continuous |
| 303.92 | Alcoh dep NEC/NOS-episod | Other and unspecified alcohol dependence, episodic |

| | | |
|---|---|---|
| 303.93 | Alcoh dep NEC/NOS-remiss | Other and unspecified alcohol dependence, in remission |

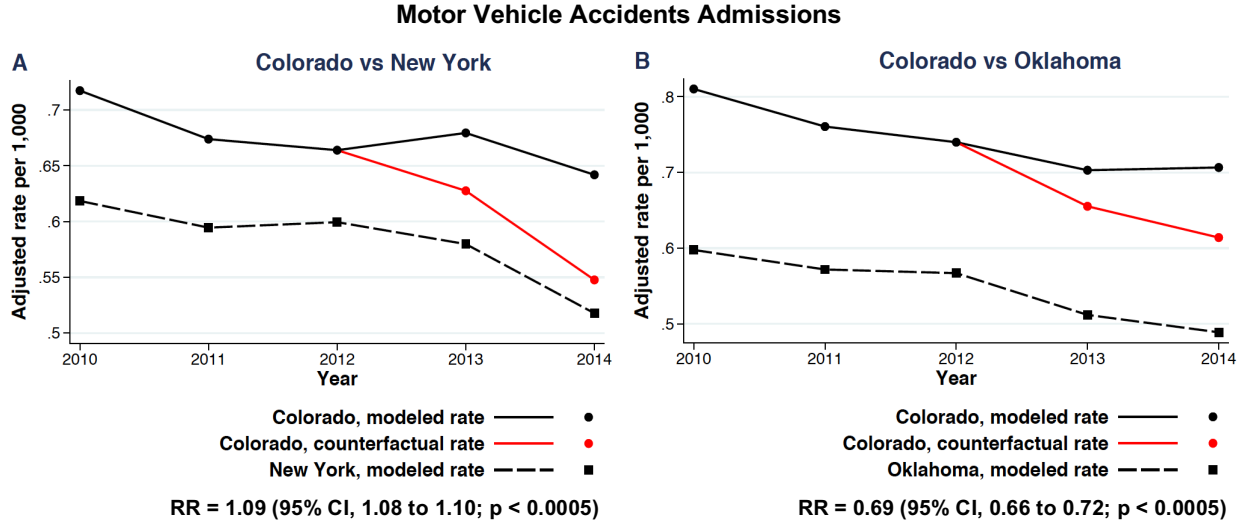
**eFigure 1.** Health outcomes with substantial or moderate evidence of a statistical association with cannabis use based on the National Academy of Science (NAS) summary statement. Medical diagnoses are identified based on a significant (P<0.05) comparison between New York (NY) and Oklahoma (OK) (control states without cannabis legalization) with regards to the change of admission rates for such diagnoses following cannabis legalization. P values for the comparison between Colorado (CO) (site of cannabis legalization) and NY (rhomboid symbol), or between CO and OK (circular symbol) are shown as either <0.05, or >0.05 using a gray scale for evidence of cannabis benefit (risk ratio [RR] < 1 shown on the left) and cannabis harm (RR>1 shown on the right); 95% confidence intervals are shown for the comparison between CO and NY and between CO and OK as solid and dotted lines, respectively. Progressively darker shades of green or red indicate greater weight of evidence in the direction of proposed benefit versus harm, respectively, by the NAS.



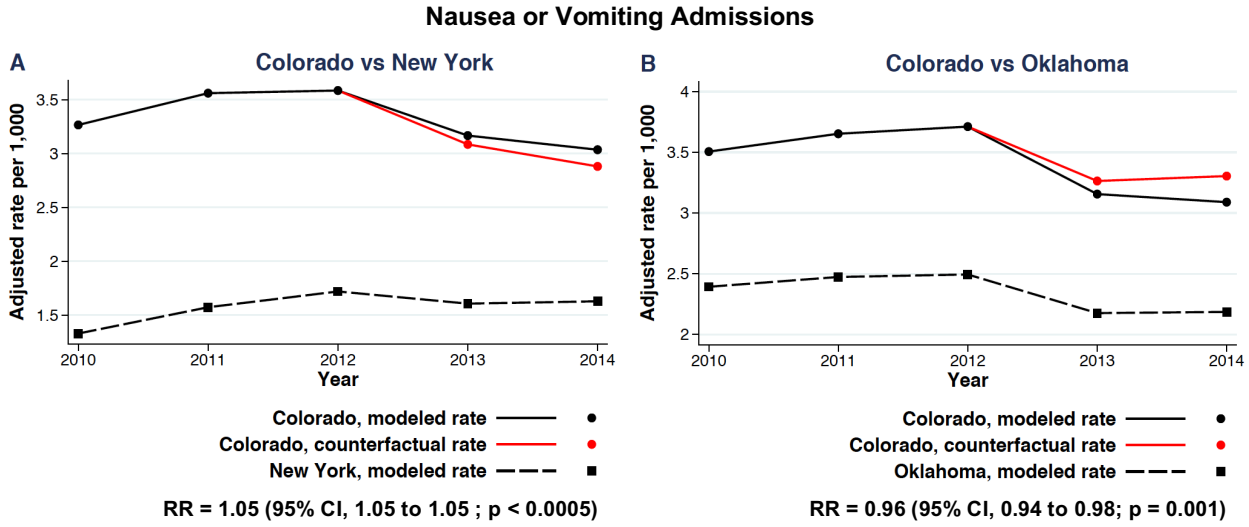
**eFigure 2.** Multivariate adjusted rates of total hospital admissions over 2010-2014 in Colorado, site of implementation of the 2012 recreational cannabis legalization policy, compared with New York (A) and Oklahoma (B), control states without cannabis legalization. Red lines show the predicted rates of admissions for schizophrenia or other psychoses (and all remaining medical diagnoses plotted in eFigures 2-15) had the cannabis legalization policy not been instituted. RR = risk ratio; CI = confidence interval.



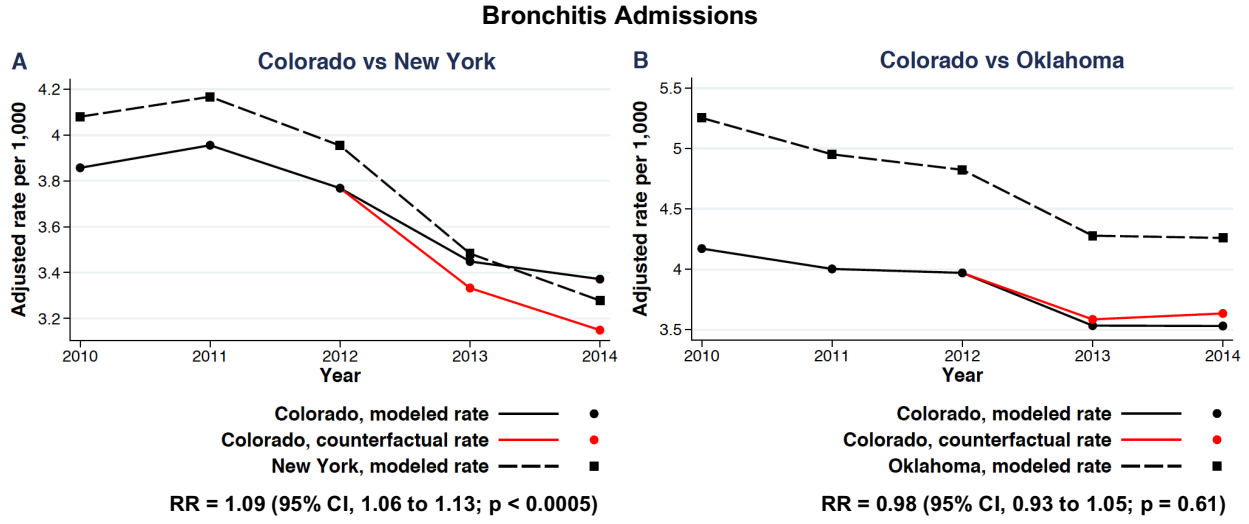

**eFigure 3.** Multivariate adjusted rates of admissions for motor vehicle accidents over 2010-2014 in Colorado compared with New York (A) and Oklahoma (B). RR = risk ratio; CI = confidence interval.



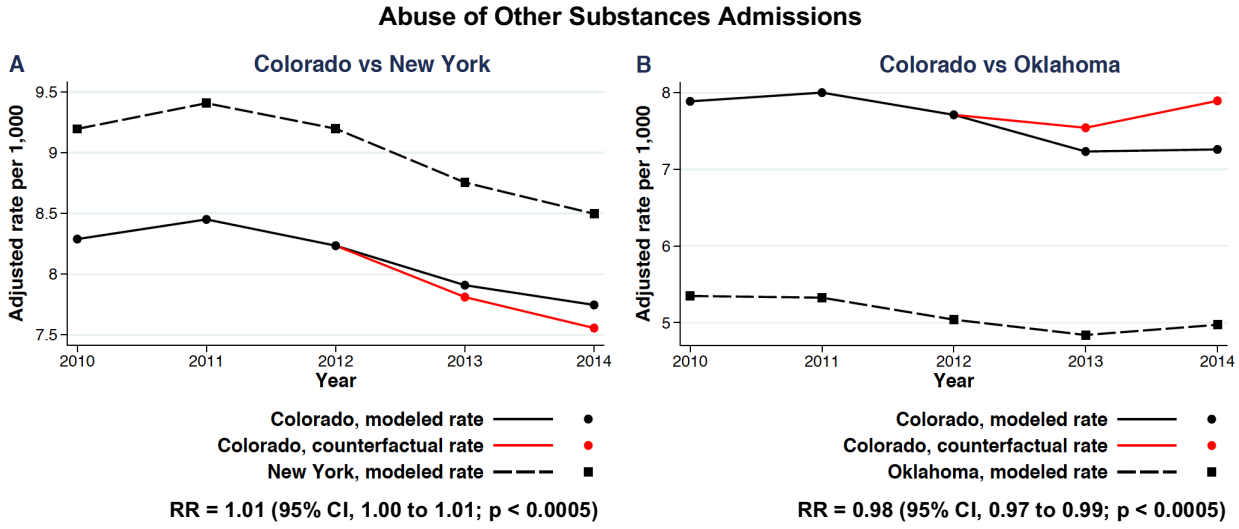
**eFigure 4.** Multivariate adjusted rates of admissions for nausea or vomiting over 2010-2014 in Colorado compared with New York (A) and Oklahoma (B). RR = risk ratio; CI = confidence interval.



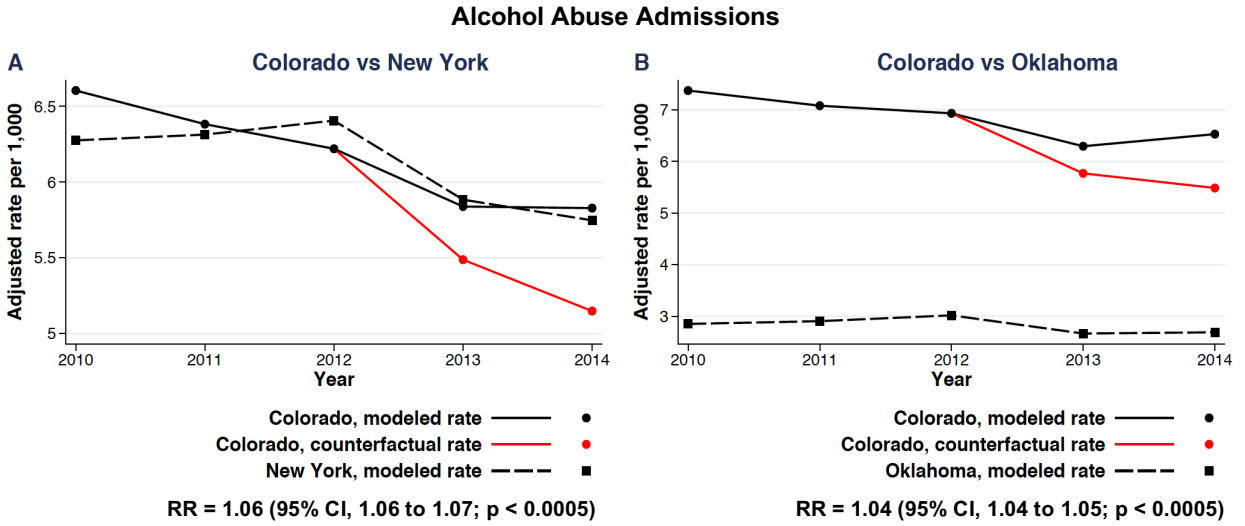

**eFigure 5.** Multivariate adjusted rates of admissions for bronchitis over 2010-2014 in Colorado compared with New York (A) and Oklahoma (B). RR = risk ratio; CI = confidence interval.



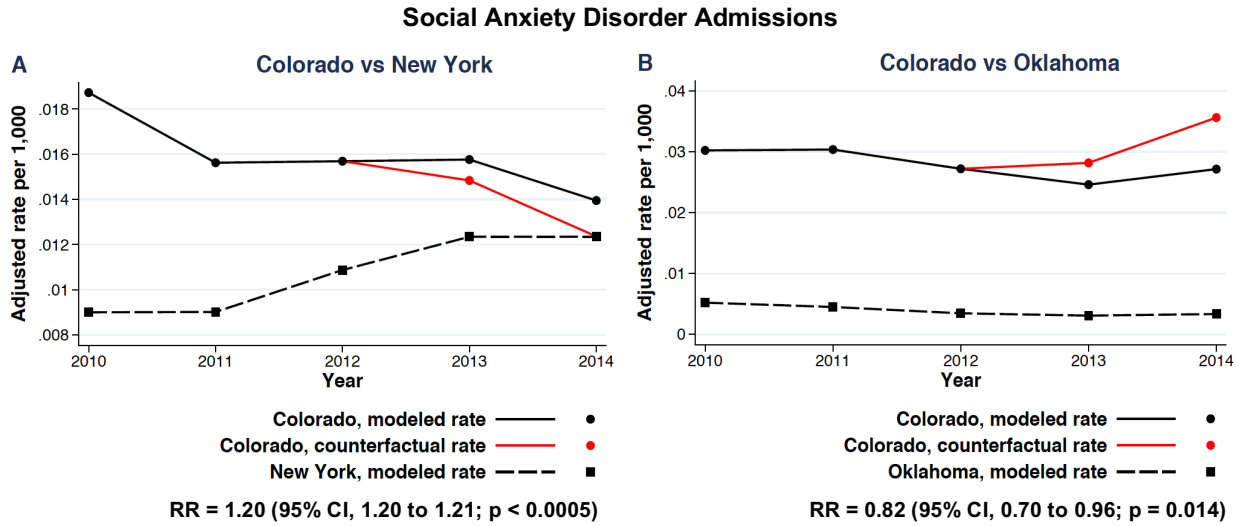
**eFigure 6.** Multivariate adjusted rates of admissions for abuse of other substances over 2010-2014 in Colorado compared with New York (A) and Oklahoma (B). RR = risk ratio; CI = confidence interval.



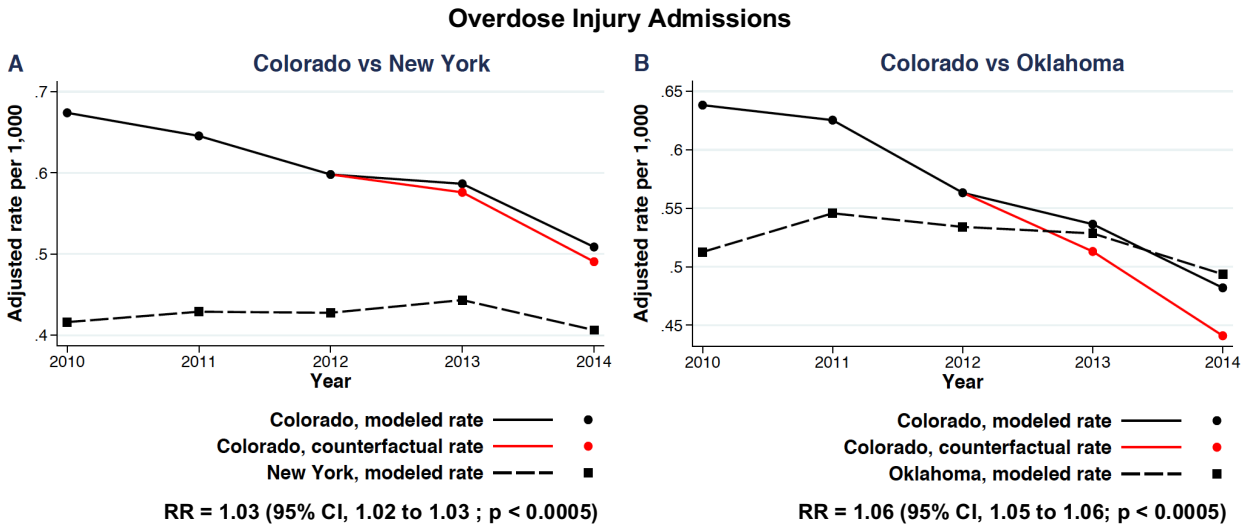

**eFigure 7.** Multivariate adjusted rates of admissions for alcohol abuse over 2010-2014 in Colorado compared with New York (A) and Oklahoma (B). RR = risk ratio; CI = confidence interval.



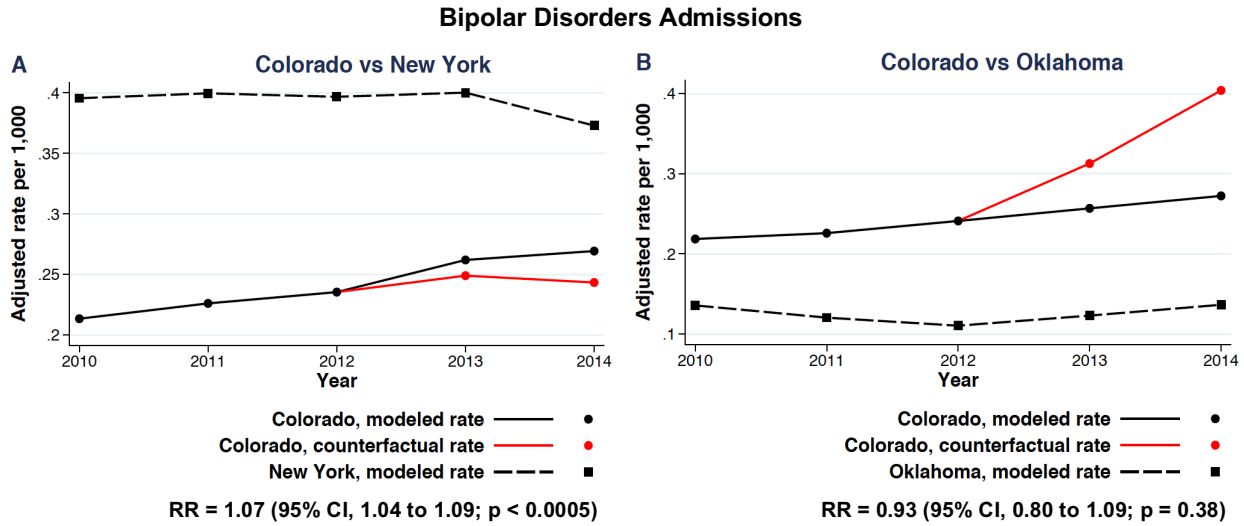
**eFigure 8.** Multivariate adjusted rates of admissions for social anxiety disorder over 2010-2014 in Colorado compared with New York (A) and Oklahoma (B). RR = risk ratio; CI = confidence interval.



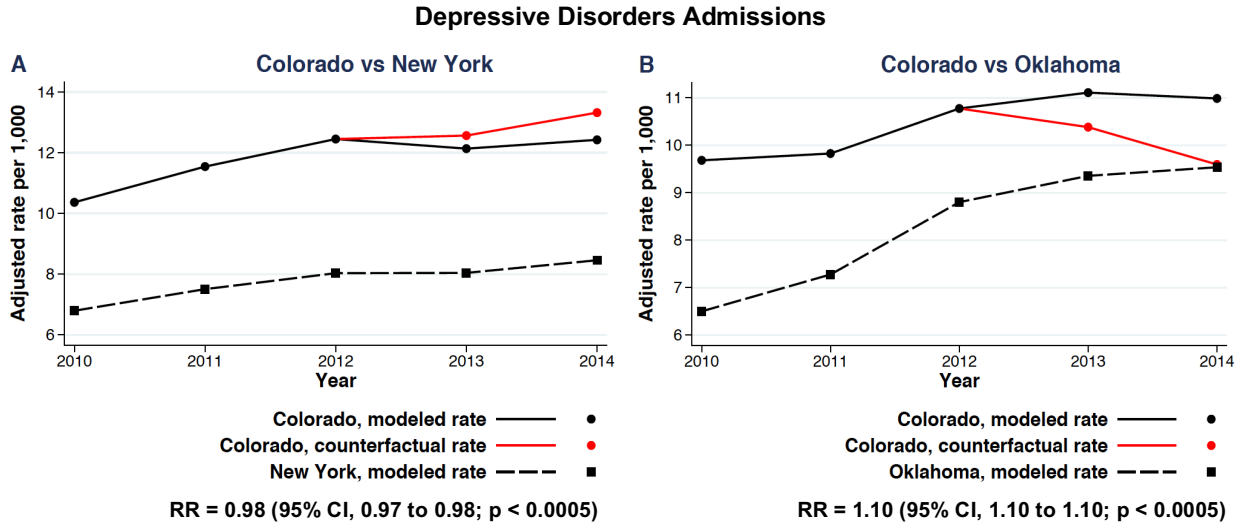

**eFigure 9.** Multivariate adjusted rates of admissions for overdose injury over 2010-2014 in Colorado compared with New York (A) and Oklahoma (B). RR = risk ratio; CI = confidence interval.



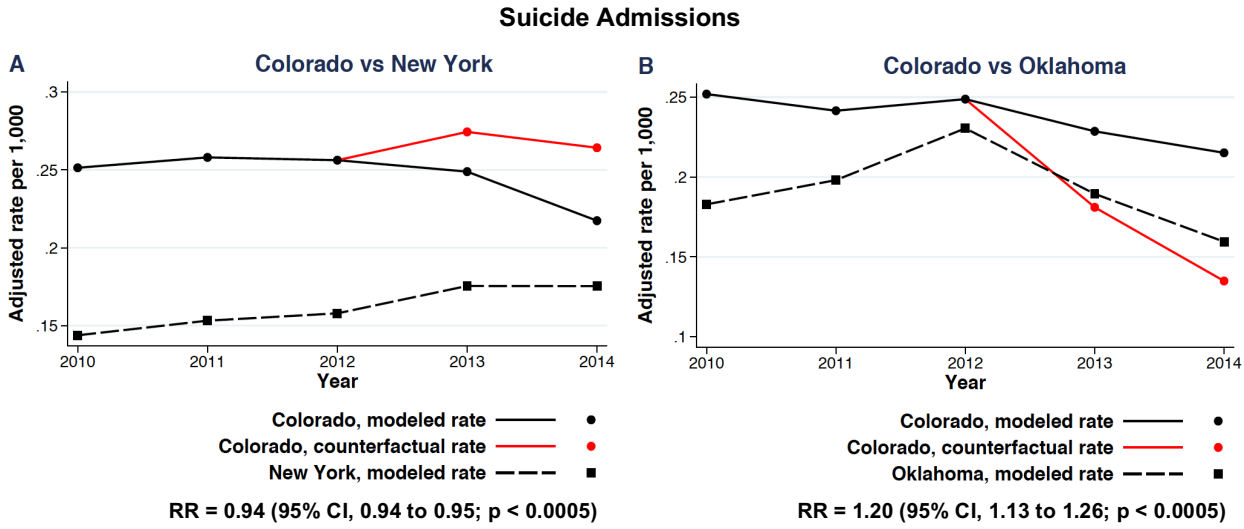
**eFigure 10.** Multivariate adjusted rates of admissions for bipolar disorders over 2010-2014 in Colorado compared with New York (A) and Oklahoma (B). RR = risk ratio; CI = confidence interval.



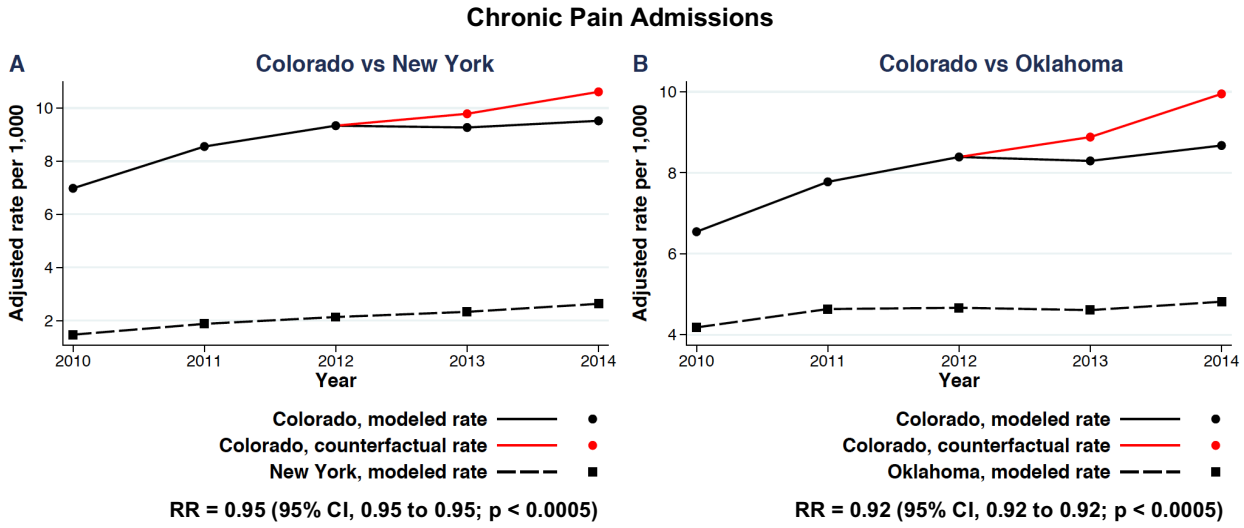

**eFigure 11.** Multivariate adjusted rates of admissions for depressive disorders over 2010-2014 in Colorado compared with New York (A) and Oklahoma (B). RR = risk ratio; CI = confidence interval.



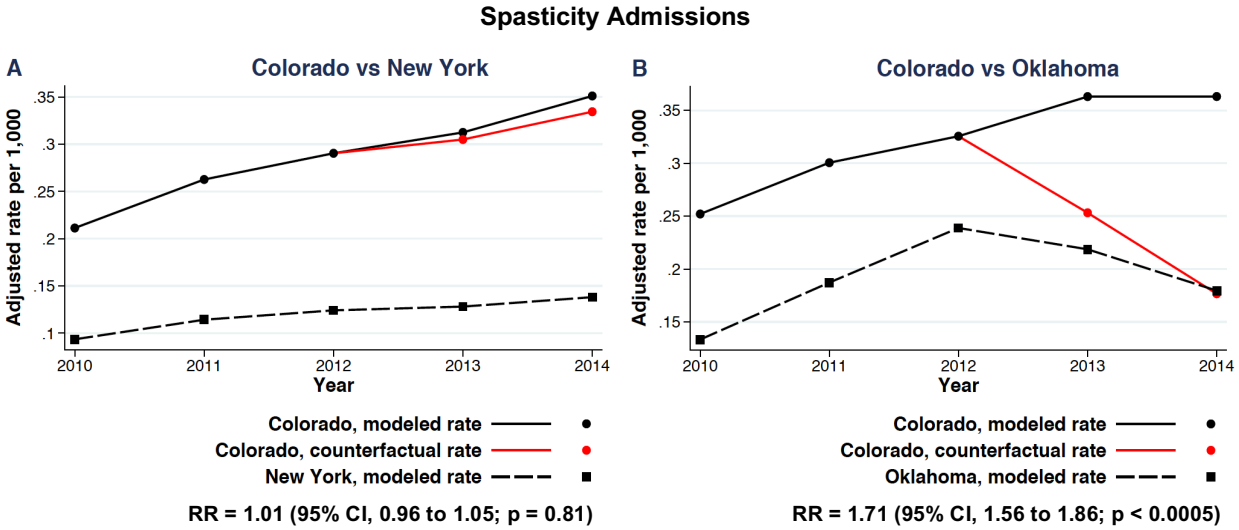
**eFigure 12.** Multivariate adjusted rates of admissions for suicide over 2010-2014 in Colorado compared with New York (A) and Oklahoma (B). RR = risk ratio; CI = confidence interval.



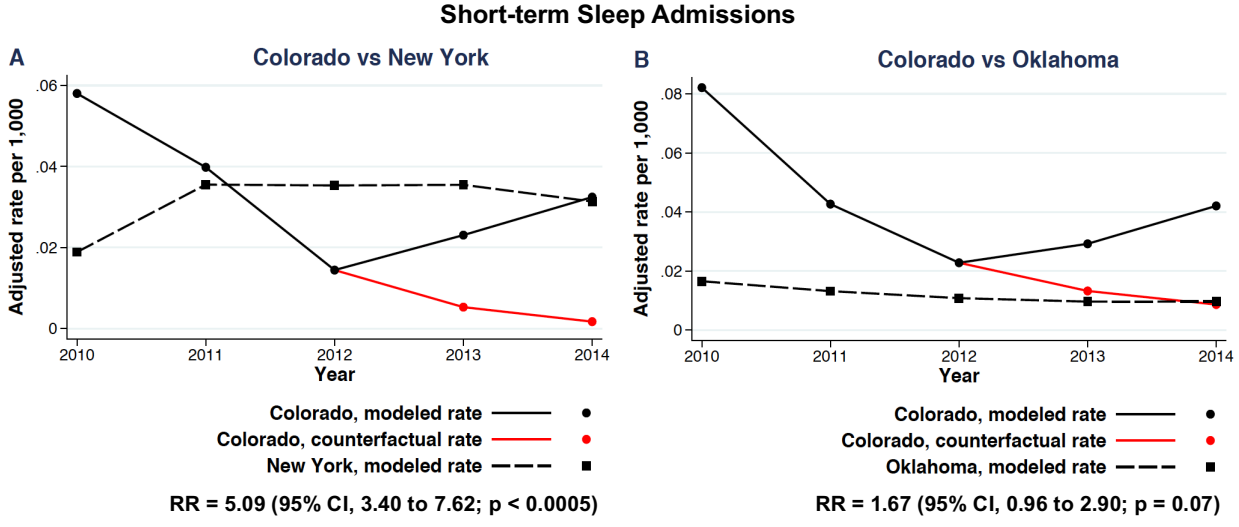

**eFigure 13.** Multivariate adjusted rates of admissions for chronic pain over 2010-2014 in Colorado compared with New York (A) and Oklahoma (B). RR = risk ratio; CI = confidence interval.



**eFigure 14.** Multivariate adjusted rates of admissions for spasticity over 2010-2014 in Colorado compared with New York (A) and Oklahoma (B). RR = risk ratio; CI = confidence interval.




**eFigure 15.** Multivariate adjusted rates of admissions for short-term sleep disorders over 2010-2014 in Colorado compared with New York (A) and Oklahoma (B). RR = risk ratio; CI = confidence interval.



**eTable 3.** Changes in specific NAS outcomes in a sensitivity analysis using January 2014 as the date of recreational cannabis legalization

| NAS Outcome | State Comparisons | RR | 95% CI | P value |
|---|---|---|---|---|
| Motor vehicle accidents | CO vs NY | 1.22 | (1.16, 1.28) | <0.0005 |
| | CO vs OK | 1.18 | (1.02, 1.37) | 0.026 |
| | NY vs OK | 1.04 | (0.77, 1.40) | 0.81 |
| Overdose injury | CO vs NY | 1.11 | (1.09, 1.14) | <0.0005 |
| | CO vs OK | 1.03 | (0.98, 1.09) | 0.25 |
| | NY vs OK | 0.98 | (0.80, 1.19) | 0.81 |
| Bipolar disorders | CO vs NY | 1.08 | (1.06, 1.09) | <0.0005 |
| | CO vs OK | 0.81 | (0.73, 0.90) | <0.0005 |
| | NY vs OK | 0.77 | (0.75, 0.78) | <0.0005 |
| Depressive disorders | CO vs NY | 1.01 | (0.99, 1.03) | 0.59 |
| | CO vs OK | 1.23 | (1.20, 1.25) | <0.0005 |
| | NY vs OK | 1.16 | (1.07, 1.26) | <0.0005 |
| Schizophrenia or psychoses | CO vs NY | 0.84 | (0.82, 0.86) | <0.0005 |
| | CO vs OK | 0.80 | (0.79, 0.80) | <0.0005 |
| | NY vs OK | 0.88 | (0.87, 0.90) | <0.0005 |
| Social anxiety disorder | CO vs NY | 1.45 | (1.43, 1.48) | <0.0005 |
| | CO vs OK | 0.58 | (0.47, 0.71) | <0.0005 |
| | NY vs OK | 0.46 | (0.29, 0.74) | 0.001 |
| Suicide | CO vs NY | 1.09 | (1.03, 1.15) | 0.002 |
| | CO vs OK | 1.26 | (1.12, 1.41) | <0.0005 |
| | NY vs OK | 1.11 | (1.04, 1.18) | 0.001 |
| Bronchitis | CO vs NY | 1.19 | (1.15, 1.23) | <0.0005 |
| | CO vs OK | 1.03 | (0.97, 1.10) | 0.33 |
| | NY vs OK | 0.82 | (0.78, 0.87) | <0.0005 |
| Abuse of other substances | CO vs NY | 1.04 | (1.03, 1.05) | <0.0005 |
| | CO vs OK | 0.99 | (0.97, 1.01) | 0.45 |
| | NY vs OK | 0.94 | (0.90, 0.98) | 0.007 |
| Nausea or vomiting | CO vs NY | 1.08 | (1.06, 1.10) | <0.0005 |
| | CO vs OK | 0.95 | (0.97, 1.01) | <0.0005 |
| | NY vs OK | 0.89 | (0.90, 0.98) | 0.01 |
| Chronic pain | CO vs NY | 0.94 | (0.93, 0.96) | <0.0005 |
| | CO vs OK | 0.92 | (0.91, 0.93) | <0.0005 |
| | NY vs OK | 0.93 | (0.90, 0.96) | <0.0005 |
| Spasticity | CO vs NY | 0.75 | (0.71, 0.79) | <0.0005 |
| | CO vs OK | 1.56 | (1.14, 2.14) | 0.006 |
| | NY vs OK | 2.12 | (1.64, 2.76) | <0.0005 |
| Short-term sleep | CO vs NY | 11.7 | (7.36, 18.59) | <0.0005 |
| | CO vs OK | 3.44 | (1.32, 8.99) | 0.012 |
| | NY vs OK | 0.45 | (0.06, 3.22) | 0.42 |

STROBE Statement—Checklist of items that should be included in reports of ***cohort studies***

| | Item No | Recommendation | Page No |
|---|---|---|---|
| **Title and abstract** | 1 | (*a*) Indicate the study's design with a commonly used term in the title or the abstract | 1 |
| | | (*b*) Provide in the abstract an informative and balanced summary of what was done and what was found | 2 |
| **Introduction** | | | |
| Background/rationale | 2 | Explain the scientific background and rationale for the investigation being reported | 5 |
| Objectives | 3 | State specific objectives, including any prespecified hypotheses | 5 |
| **Methods** | | | |
| Study design | 4 | Present key elements of study design early in the paper | 6, 7, 8 |
| Setting | 5 | Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection | 6, 7, 8 |
| Participants | 6 | (*a*) Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up | 6, 7 |
| | | (*b*) For matched studies, give matching criteria and number of exposed and unexposed | |
| Variables | 7 | Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable | 6, 7, 8 |
| Data sources/ measurement | 8* | For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group | 6, 7, 8 |
| Bias | 9 | Describe any efforts to address potential sources of bias | 7, 8 |
| Study size | 10 | Explain how the study size was arrived at | 6, 7 |
| Quantitative variables | 11 | Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why | 7, 8 |
| Statistical methods | 12 | (*a*) Describe all statistical methods, including those used to control for confounding | 9, 10 |
| | | (*b*) Describe any methods used to examine subgroups and interactions | |
| | | (*c*) Explain how missing data were addressed | 6, 7 |
| | | (*d*) If applicable, explain how loss to follow-up was addressed | |
| | | (*e*) Describe any sensitivity analyses | 8, 10 |
| **Results** | | | |
| Participants | 13* | (a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed | 11 |
| | | (b) Give reasons for non-participation at each stage | |
| | | (c) Consider use of a flow diagram | |
| Descriptive data | 14* | (a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders | 11, 12, 13 |
| | | (b) Indicate number of participants with missing data for each variable of interest | |
| | | (c) Summarise follow-up time (eg, average and total amount) | |
| Outcome data | 15* | Report numbers of outcome events or summary measures over time | 13, 14 |

| | | | |
|---|---|---|---|
| Main results | 16 | (*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included<br>(*b*) Report category boundaries when continuous variables were categorized<br>(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period | 11-14 |
| Other analyses | 17 | Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses | 12, 14 |
| **Discussion** | | | |
| Key results | 18 | Summarise key results with reference to study objectives | 14-16 |
| Limitations | 19 | Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias | 16-19 |
| Interpretation | 20 | Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence | 14-19 |
| Generalisability | 21 | Discuss the generalisability (external validity) of the study results | 19 |
| **Other information** | | | |
| Funding | 22 | Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based | 20 |

*Give information separately for exposed and unexposed groups.

**Note:** An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at http://www.strobe-statement.org.

BMJ Open

# Does Cannabis Legalization Change Healthcare Utilization? A Population-based Study Using the Healthcare Cost and Utilization Project in Colorado, USA

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| | |

# Does Cannabis Legalization Change Healthcare Utilization? A Population-based Study Using the Healthcare Cost and Utilization Project in Colorado, USA

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**Total Word Count:** 3939

## ABSTRACT

**OBJECTIVE:** To assess the effect of cannabis legalization on health effects and healthcare utilization in Colorado (CO), the first state to legalize recreational cannabis, when compared with 2 control states, New York (NY) and Oklahoma (OK).

**DESIGN:** We used the 2010-2014 Healthcare Cost and Utilization Project (HCUP) inpatient databases to compare changes in rates of healthcare utilization and diagnoses in CO versus NY and OK.

**SETTING:** Population-based, inpatient**.**

**PARTICIPANTS:** HCUP state-wide data comprising over 28 million individuals and over 16 million hospitalizations across 3 states.

**MAIN OUTCOME MEASURES:** We used International Classification of Diseases-9th Edition (ICD-9) codes to assess changes in healthcare utilization specific to various medical diagnoses potentially treated by or exacerbated by cannabis. Diagnoses were classified based on weight of evidence from the National Academy of Science (NAS). Negative binomial models were used to compare rates of admissions between states.

**RESULTS**: In CO compared to NY and OK, respectively, cannabis abuse hospitalizations increased (risk ratio [RR], 1.27; 95% confidence interval [CI], 1.26 to 1.28 and RR 1.16; 95% CI 1.15 to 1.17; both $P<0.0005$) post-legalization. In CO, there was a reduction in total admissions but only when compared to OK (RR 0.97; 95% CI 0.96 to 0.98; $P<0.0005$). Length of stay and costs did not change significantly in CO compared to NY or OK. Post-legalization changes most consistent with NAS included an increase in motor vehicle accidents, alcohol abuse, overdose injury, and a reduction in chronic pain admissions (all $P<0.05$ compared to each control state).

**CONCLUSIONS:** Recreational cannabis legalization is associated with neutral effects on healthcare utilization. In line with previous evidence, cannabis liberalization is linked to an

increase in motor vehicle accidents, alcohol abuse, overdose injuries and a decrease in chronic pain admissions. Such population-level effects may help guide future decisions regarding cannabis use, prescription, and policy.

## Strengths and limitations of this study

- The study focuses on the impact of recreational cannabis legalization on hospital admissions instead of its legal or societal effects
- This study utilizes state-wide hospital admission data comprising over 28 million individuals and over 16 million hospitalizations
- Effects on hospital admissions are evaluated in Colorado, the first state to legalize recreational cannabis, but compared with only 2 control states, New York and Oklahoma
- Follow up data after recreational cannabis legalization only includes 2 subsequent years
- Physician coding with ICD-9 codes does not capture potentially important mediators related to cannabis use

## INTRODUCTION

Over 147 million people, or 2.5 percent of the world's population, use cannabis (marijuana),[1] and more than 20 million Americans have reported the use of cannabis in the past 30 days.[1] Because cannabis use is a federal crime, clinical studies have been challenging to pursue, resulting in substantial knowledge gaps regarding actual health consequences. Thirty-three states and the District of Columbia now allow cannabis for the treatment of medical conditions.[2] Of these, 9 have recently legalized cannabis for recreational use. Given such pervasive policy changes, understanding potential shifts in healthcare utilization is vital.

Recently, an extensive and rigorous summary of the current evidence on health effects of cannabis was developed by a committee of experts appointed by the US National Academy of Science (NAS) focusing on systematic reviews and high-quality primary research.[3] The health endpoints assessed in the NAS summary included oncologic, cardiometabolic, respiratory, immunologic, and psychiatric disorders as well as outcomes related to injury and death (i.e. motor-vehicle accidents). While the NAS summary represents a valuable starting place that makes use of the available data, we do not yet know whether that evidence, based largely on small studies, will translate into real-world ramifications after legalization of recreational cannabis.

On December 10, 2012, Colorado enacted *Colorado Amendment 64,* legalizing recreational cannabis. Following this date, adults aged 21 or older could grow cannabis plants privately, legally possess all cannabis from these plants, and give cannabis as a gift to other adults aged 21 or older.[4] After January 1, 2014, recreational cannabis could be legally purchased in retail stores.[5] We hypothesized that changes in healthcare

utilization and diagnoses most consistent with NAS-based evidence occur when access to recreational cannabis becomes liberalized.

## METHODS

We used the Agency for Healthcare Research and Quality (AHRQ)-funded Healthcare Cost and Utilization Project (HCUP) database to measure inpatient healthcare utilization and diagnoses in Colorado (CO) between 2010 and 2014. HCUP is a state-wide database containing all listed inpatient diagnoses and procedures, discharge status, patient demographics, and charges for all patients, regardless of payer (e.g., Medicare, Medicaid, private insurance, uninsured).

Comparisons were made with 2 control states in order to address possible secular trends. New York (NY), the most populous state with inpatient HCUP data available up to 2014 was selected, and, to counter this coastal and largely urban state, we also selected Oklahoma (OK), a predominately rural state directly adjacent to CO with HCUP hospitalization data up to 2014. We used separate HCUP databases for CO, NY and OK. Unlike the National Inpatient Sample (NIS), which is (by definition) a sample, these state-specific databases include data from every actual admission, providing direct and complete information regarding all healthcare utilization. Both primary and secondary diagnoses were extracted from each HCUP database for each admission used: up to 30 ICD-9 codes in CO, 25 in NY, and 16 in OK were provided for each encounter. Annual demographic data, including age, sex, and race, was obtained from the United States Census Bureau. Only month and year were available in all HCUP databases; as legalization took effect on December 10, 2012, hospitalizations following December,

2012 were considered “after” enactment of the law. Patients with missing information on age, sex, race, and year of encounter were excluded.

Age, sex, race, income level, and insurance payer were recorded at each healthcare encounter. Hispanic ethnicity was not coded in the OK State Department of Health data source. In order to use comparable categorizations across the 3 states, we separated race into white, black, Native American, and other. In addition to the population-level variables age, sex and race, we obtained the following covariates at the individual level for each age, sex and race population strata: 1) income level 2) proportion of HCUP individuals living in an urban versus rural setting, 3) with a diagnosis of tobacco use, 4) alcohol abuse, and 5) psychiatric disorders. The latter 3 covariates were available from ICD-9 codes. Income level was categorized by quartiles using the median household income for each patient’s ZIP code. Income level was not available for OK.

We first performed a validation analysis to assess changes in cannabis abuse diagnoses in CO after versus before recreational cannabis legalization and compared those rates to changes in NY and OK over the same time period. To determine changes in overall healthcare utilization, we assessed changes in total number of hospitalizations, length of inpatient stay, and healthcare costs. We estimated the cost of each hospitalization by multiplying the charges by a cost-to-charge ratio for the admitting hospital for the given year. For NY and CO, we used the all-payer cost-to-charge ratios provided by HCUP. When the all-payer cost-to-charge ratio was missing, we applied the average cost-to-charge ratio particular to state and year. As HCUP does not provide cost-to-charge ratios for OK, we assumed a constant state-wide cost-to-

charge ratio (0.3119 as derived from the Institute for Health and Socio-Economic Policy calculations of federal cost reports) to estimate healthcare costs in OK;[6] we then conducted a sensitivity analysis setting the cost-to-charge ratio for OK to equal to the average for NY and CO for the corresponding year. See online supplementary eMethods and eTable 1 for additional details.

We used International Classification of Diseases-9th Edition (ICD-9) codes (eTable 2) to assess changes in healthcare utilization specific to various medical diagnoses potentially treated by or exacerbated by cannabis use as identified by the NAS summary. For each health endpoint of interest in the NAS review, the weight of evidence regarding the statistical association of recreational cannabis with a specific health endpoint or the therapeutic use of cannabis had previously been categorized into substantial, moderate, limited or no evidence.[3] We opted to focus on NAS health endpoints with either substantial or moderate evidence.

Because diagnoses of alcohol or other substance abuse “in remission” may have been incidental and not directly responsible for the hospitalization, we performed a sensitivity analysis where we removed “in remission” diagnoses from the group of ICD-9 codes defining alcohol abuse and other substance abuse (eTable 2).

Finally, to take into account the additional effect of recreational cannabis related to availability in retail stores we performed sensitivity analyses for all health care utilization (total number of admissions, length of stay, costs) and NAS-evidence based outcomes investigations utilizing January 1, 2014 as the change of policy date.

Certification to use de-identified HCUP data was obtained from the University of California, San Francisco Committee on Human Research.

## Statistical Analysis

Demographic and lifestyle characteristics are presented as mean ± standard deviation (SD) or n (% of total admissions) and were compared between states using linear, logistic, and multinomial models as appropriate. Rates of admissions for NAS diagnoses (with the population size as the denominator) were compared between states using negative binomial models.

To assess the effects of recreational cannabis legalization, we used negative binomial models for the number of admissions, both overall and for particular diagnoses, with the log of the subgroup population sizes as an offset and the use of robust standard errors. Analogous linear models were utilized for length of stay and cost, which were both log-transformed in order to meet normality assumptions. All models were adjusted for age, race, sex, income level, urbanicity, diagnosis of alcohol abuse, tobacco use and psychiatric disorders. Adjustment for diagnosis of psychiatric disorders was not performed in the presence of a psychiatric outcome. In order to relax the linearity assumption, each 5-year age range was included as a separate category. To flexibly model secular patterns, year was included as a categorical rather than continuous variable (with a category for each year between 2010 and 2014). The crucial predictors in our model included an indicator for CO (versus the comparison state) and interactions of this indicator with 2 continuous linear spline basis functions, year-2012, and max (0, year-2012). The main effect for CO estimated the between-state risk ratio (RR) in 2012, the first interaction estimated the slope of the between-state RR in 2010-12, and the second estimated the change in slope after 2012. The first interaction was

used to project the counterfactual 2013-2014 rates in CO that would be expected in the absence of legalization, while the second was used to capture the legalization effect. Like a standard interrupted time series (ITS) model, our model assumed that the between-state RR changed linearly at different rates before and after the intervention, but used the categorical indicator for year to relax the standard ITS assumption of piecewise linear trends in the underlying state-specific rates, substantially improving model fit. The same model was used in the sensitivity analysis using January 1, 2014 (date of legal retail cannabis sales) as change of policy date.

A 2-tailed $P<0.05$ was considered statistically significant for the validation analysis (cannabis use), and analyses related to overall healthcare utilization. In order to minimize false positive results and to account for secular trends that might differ across different populations, we assessed for validation in comparisons versus NY and then OK separately.

In order to address possible false positives due to multiple hypotheses testing in assessing the diagnoses with moderate or substantial evidence described in the NAS document, we employed stringent standards: to be considered "positive," the comparisons between CO and *each* of the other 2 states needed to be in the direction expected from the NAS report, each exhibiting statistical significance using a two-tailed alpha of 0.05. A "positive" designation also required absence of a statistically significant difference between NY versus OK using a two-tailed alpha of 0.05. All analyses were performed using Stata 15 (StataCorp, College Station, TX).

**Patient and Public Involvement**

The patients and public were not involved in the study.

## RESULTS

### Baseline Characteristics

The total number of admissions between 2010 and 2014 are shown for each state in **table 1**. Patients in CO were generally younger, more commonly female, and less ethnically diverse. Wealth in CO was less equally distributed, with a higher proportion of individuals with lower income in CO compared to NY. Finally, admission rates were lower in CO than the control states for most NAS diagnoses, with exceptions for pre-diabetes and post-traumatic stress disorder.

### Study Validation

Over 2010-2014, the change in rates of cannabis abuse admissions after versus before recreational cannabis legalization in 2012 was greater in CO than in NY and OK (risk ratio [RR], 1.27; 95% confidence interval [CI], 1.26 to 1.28 and RR 1.16; 95% CI 1.15 to 1.17; both $P<0.0005$, respectively) (**figure 1A-B**). No significant changes comparing the two control states, NY and OK, were observed over the same time period (RR 0.93; 95% CI 0.87 to 1.00; $P=0.05$).

### Inpatient Healthcare Utilization after Cannabis Legalization

*Number of admissions*

In unadjusted analyses, CO, NY, and OK had a similar number of total admissions before versus after recreational cannabis legalization (**figure 2A**). After adjusting for

covariates, there was a reduction of number of admissions following cannabis legalization in CO when compared to OK (RR 0.97; 95% CI 0.96 to 0.98; *P*<0.0005)**.** The point estimate was similar when comparing CO to NY, but did not reach statistical significance (RR 0.99; 95% CI 0.98 to 1.01; *P*=0.47). Results were similar in sensitivity analysis using January 1, 2014 as change of policy date (CO versus OK: RR 0.96; 95% CI 0.96 to 0.96; *P*<0.0005, and CO versus NY: RR 0.99; 95% CI 0.96 to 1.02; *P*=0.59).

*Length of stay*

The median length of stay also remained similar after cannabis legalization across the 3 states in unadjusted analyses (**figure 2B**). After adjusting for covariates, length of inpatient stay did not change significantly in CO following the law change when compared with each of the 2 control states (1.75% annual reduction; 95% CI -12.25% to 10.01% in CO versus NY, and 3.46% annual reduction, 95% CI -16.48% to 37.90% versus OK; *P*= 0.30 and P=0.20, respectively). Length of stay did not change significantly in CO compared with the control states when we used January 1, 2014 as change of policy date.

*Healthcare Costs*

In unadjusted analyses, the 3 states exhibited similar total costs across the study time period (**figure 2C** and eTable 2). In multivariate analyses**,** healthcare costs remained similar in state comparisons (2.99%; 95% CI -7.55% to 14.74%; *P*=0.18 versus NY and 3.45%; 95% CI -7.31% to 15.46%; *P*=0.16 versus OK) after cannabis legalization. No meaningful differences of healthcare costs were observed in the sensitivity analyses

with January 1, 2014 as change of policy date or when we assumed the cost-to-charge ratio for OK was equal to the average of the other states.

**Changes in Specific Diagnoses Highlighted by the National Academy of Sciences**

Among the diagnoses with either substantial or moderate evidence of influence by cannabis per the NAS, we distinguished between: 1) a group with no statistically significant post-legalization differences between control states (NY versus OK $P>0.05$), suggesting that secular trends unlikely explained differences between CO and control states (**figure 3**); and 2) a group with significant differences in diagnoses post-legalization between control states (NY versus OK $P<0.05$) (eFigure 1).

In the NY versus OK $P>0.05$ group (**figure 3**), changes in rates of diagnoses after cannabis legalization reflected NAS-based evidence for most health outcomes. Among the diagnoses most consistent with NAS-based evidence, there was an increase in hospital admissions for motor vehicle accidents, alcohol abuse, overdose injury and a decrease of chronic pain hospitalizations after recreational cannabis legalization (each meeting statistical significance for both comparisons with control states). When using less stringent criteria ($P<0.05$ for both comparisons with NY and OK but where the relative risk for only one comparison was in the same direction as NAS), admissions for abuse of other substances and social anxiety disorder also increased with recreational cannabis legalization (**figure 3**). Effects of cannabis liberalization on psychiatric outcomes (schizophrenia and bipolar disorders) were either not consistent or weakly consistent with NAS (**figure 3**). When differences between the two control states (NY and OK) were also significantly different (suggesting effects potentially related to

secular trends)(eFigure 1), changes in diagnoses were mostly not concordant with NAS findings or one of the comparisons between CO and either NY or OK did not exhibit statistical significance. Changes of the risk over time with counterfactuals are shown for each NAS diagnosis in online supplementary eFigures 2-15.

In the sensitivity analysis using January 1, 2014 as change of policy date (eTable 3), the main findings highlighted in the primary analysis using our stringent criteria (increase of admissions for alcohol abuse, motor vehicle accidents, overdose injury and decrease of chronic pain hospitalizations) again met the same criteria in favor of significant associations, except for overdose injury and chronic pain admissions (the latter meeting 2 of the 3 criteria described in the Methods). In sensitivity analyses removing "in remission" diagnoses, no meaningful changes were observed (relevant to alcohol abuse and abuse of other substances).

## DISCUSSION

### Principal findings

Legalization of recreational cannabis was associated with more cannabis abuse, and minimal effects on overall healthcare utilization. Changes in specific medical diagnoses post-legalization reflected previously published substantial or moderate evidence on the health effects of cannabis, including an increase in alcohol abuse, overdose injury and a decrease of chronic pain admissions.

The increased frequency of hospitalizations for cannabis abuse in CO helps to validate the concept that legalization would result in greater use.

Effects of recreational cannabis legalization on healthcare utilization appeared to be overall neutral. There was no evidence that either the length of stay or healthcare costs changed following liberalization of recreational cannabis. There was a reduction of overall hospitalizations in CO when compared to OK but not compared to NY, potentially because unaccounted state-level characteristics may have driven overall admissions differently. Moreover, in the US healthcare system, hospitalized individuals tend to be sicker, with more severe forms of specific illnesses and higher inpatient costs compared to outpatients. Therefore, our conclusions on overall neutral effects of recreational cannabis on healthcare costs only reflect higher inpatient costs and not overall costs. Outpatient costs may include use of specific medications or substance detoxification programs that are not captured in our study and may be more cost-effective compared to inpatient treatments.

Following legalization of recreational cannabis, changes in rates of medical diagnoses reflected NAS-based evidence for most health outcomes. The absence of statistically significant differences in these outcomes between the two control states (NY and OK) over the same time period provides some evidence that these observed differences were less likely related to broader secular trends. After legalization of recreational cannabis, there was an increase in motor vehicle accidents, alcohol abuse, overdose injury and a decrease of chronic pain admissions. In addition to information provided in the NAS summary,[3] the association of cannabis with motor vehicle accidents has been highlighted by recent literature.[7, 8] Consistent with our findings, a substantial bidirectional comorbidity between cannabis use and alcohol use has been previously demonstrated, resulting in a moderate level of evidence designation for this

relationship per the NAS.[9] Also compatible with the NAS summary, we report that recreational cannabis legalization was associated with an increasing number of admissions for overdose injury. These included overdose of analgesics, barbiturates, sedative, hypnotics and psychotropic drugs (eTable 2). This finding underlines the association of cannabis use with other behaviors of drug addiction as highlighted by a recent cross-sectional survey of over 30 thousand community-living US adults.[10] Finally, reduction of chronic pain, especially neuropathic pain, in cannabis users is well known, although prior literature has focused on medical rather than recreational cannabis.[11, 12]

Except for social anxiety, the effects of recreational cannabis legalization on admissions for psychiatric disorders (schizophrenia, bipolar disorder, depression) were weakly or not consistent with prior NAS-evidence. This finding may be related to residual confounding by state-level characteristics, unaccounted secular trends, or insufficient longitudinal follow-up.

We demonstrate that admissions for abuse of alcohol or other substances remains higher after recreational cannabis legalization in a sensitivity analysis without "in remission" diagnoses. Overall, these findings suggest that when the substance use disorder is in remission, it does not play a significant role in overall results.

In our primary analysis, we used December 10, 2012 as the date of recreational cannabis legalization. Following this date, private possession and growth of cannabis became legal in Colorado. After January 1, 2014, recreational cannabis could be legally purchased in retail stores.[5] To take the additional effect of retail sales of recreational cannabis into account, we performed sensitivity analyses using January 2014 as the "change of policy" date. We did not observe any meaningful difference in the majority of

the outcomes studied, suggesting that the effect of recreational cannabis on healthcare utilization was independent of availability in stores.

**Strengths and Weaknesses**

Although several studies have investigated the health effects of cannabis,[13] they have relied on small sample sizes or have generated conflicting data.[14-16] In contrast, our findings are derived from HCUP state-wide data comprising over 28 million individuals and over 16 million hospitalizations across CO, site of the 2012 *Amendment 64*, and 2 controls states without cannabis legalization over the same time period. As NY and OK are very different geographically and demographically, we believe their inclusion as control states represents a strength of our manuscript. Specifically, their selection allowed us to demonstrate that the effects of recreational cannabis legalization on health care utilization were likely independent of living in an urban or rural setting.

Several limitations should be acknowledged. The HCUP database relies on physician coding; however, such coding for several medical diagnoses listed in **table 1** have been shown to be highly specific with variable sensitivity[17-20] and HCUP has proven to be a powerful tool in large population studies.[20-24] Some potentially important mediators are not captured by ICD-9 codes, such as quantity of cannabis used or formulation (oral versus other), although these may be more relevant to identifying mechanisms and their absence would likely not lead to false positive results. Patients may be more likely to disclose cannabis use following legalization of recreational cannabis and clinicians may be more inclined to test for it. Hence, we cannot completely exclude detection bias in the validation analysis showing an increase in cannabis abuse

admissions following legalization of recreational cannabis. Moreover, we cannot exclude that the increased frequency of cannabis abuse hospitalizations is simply related to severity of cannabis abuse rather than to a greater prevalence of cannabis use.

As with any observational study, we cannot exclude residual confounding as an explanation of our findings. However, we adjusted for conventionally recognized confounders as appropriate and as available, and, as this was largely a study of the same populations pre- and post-legalization, many of the limitations inherent to conventional individual-level analyses are likely less relevant.

We did not select all US states as controls. Most states do not have HCUP data up until the end of 2014, each requires a separate HCUP application, and each carries significant costs. We acknowledge this represents a limitation as we could not fully account for secular trends that might influence results. However, we have adjusted all analyses for urbanicity and other state-level differences in order to minimize the impact of secular trends. We also acknowledge that CO had legalized medical cannabis prior to legalization of recreational cannabis on December 10, 2012. However, control states NY and OK had not. We could have selected control states that had already medicalized cannabis instead of NY and OK, but we acknowledge that complex differences exist among medical legalization regimens among states.[25] Hence, we believe selection of control states with diverse medical legalization regimens would have primarily reduced our power to detect a real difference rather than contribute to any false positive spurious results. In our study, we demonstrate that legalization of recreational cannabis is associated with more admissions for cannabis abuse or cannabis use disorder. Prior large, multi-state, population-based analyses have shown

that legalization of medical cannabis is associated with increased cannabis use, but not increased cannabis use disorder.[26] One could speculate that medical cannabis consumption is more controlled and rationed when compared to recreational cannabis, the latter available in both retail stores and private homes and therefore perhaps more easily abused. Further studies are needed to quantify the amount of cannabis consumption (in grams) in states where only medical cannabis is legal versus states where both medical and recreational cannabis are allowed.

The HCUP database does not capture information regarding outpatient activity and therefore these findings are restricted to hospital-based medicine. However, even inclusion of outpatient data would not capture individuals with a specific condition or diagnosis who are not in formal treatment. Indeed, treatment databases do not capture all individuals in the population. This gap may be especially large for substance use disorders. Many individuals with substance use disorders may never enter treatment; even those who do more likely receive outpatient treatment, rather than a hospitalization, so they may not have been included in our study.

Our use of stringent criteria in assessing changes related to NAS diagnoses may have been too conservative, leading to a sacrifice of false negatives in order to avoid false positives.

Finally, our study was limited to two-year follow-up after recreational cannabis legalization, and we therefore cannot comment on long-term effects that may result.

## Conclusions

In conclusion, recreational cannabis legalization is associated with an expected increase in cannabis use disorder. Overall effects on inpatient healthcare utilization appear to be neutral, with subtle changes in various components of that utilization likely occurring due to changes in the types of admissions observed. Measurable effects of recreational cannabis legalization on increasing hospitalizations for motor vehicle accidents, alcohol abuse, overdose injury and reducing chronic pain admissions are consistent with previously published evidence. These data provide the first description of population-level effects that may help guide future decisions regarding cannabis policy, individuals considering using cannabis, and physicians caring for those who may choose to consume it.

**Contributors** FND and GMM had full access to all of the data in the study and take responsibility for the integrity of the data and the accuracy of the data analysis. FND and GMM were responsible for the study concept and design. All authors (FND, EV, TAD, MJP, JEO, GN, KA, CDF, ESL, SMF, DSK, and GMM) contributed to data acquisition, analysis, and interpretation. EV, GN, and GMM completed the statistical analysis. FND and GMM drafted the manuscript and were responsible for the critical revision of the manuscript for important intellectual content. GMM obtained funding for the study. All authors contributed to the administrative, technical, and material support for the study and approved the final version of the manuscript.

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**Competing interests** None declared.

**Patient consent** Not required.

**Ethics approval** Ethical approval to use de-identified HCUP data was obtained from the University of California, San Francisco Committee on Human Research.

**Data sharing** Data consist of deidentified participant data (i.e. ICD-9 admission diagnoses) available from the Healthcare Cost and Utilization Project (HCUP) for a fee. Information about how to obtain the data and for what time period can be found at: https://www.hcup-us.ahrq.gov/

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## FIGURE LEGENDS

**Figure 1**. Multivariate adjusted rates of admissions for cannabis abuse over 2010-2014 in Colorado, site of implementation of the 2012 recreational cannabis legalization policy, compared with New York (A) and Oklahoma (B), control states without cannabis legalization. Red lines show the predicted rates of admissions for cannabis abuse had the cannabis legalization policy not been instituted. The comparison between Colorado and the control states with regards to change of risk ratio (RR) slope within the 2010-2012 period (pre-legalization) and 2012-2014 period (post-legalization), as well of the overall RR slope change, are also represented for the Colorado versus New York (A) and Colorado versus Oklahoma (B) comparisons. Red lines show the predicted rates of admissions for cannabis abuse had the cannabis legalization policy not been instituted. Each model was adjusted for age, gender, and race and state-level characteristics (see Methods section for further details). CI = confidence interval; vs = versus.

**Figure 2**. Healthcare utilization over 2010-2014 in Colorado, site of implementation of the 2012 recreational cannabis legalization policy, and in New York and Oklahoma, control states without cannabis legalization. The total number of admissions/1000 population per year, the median length of stay per year, and the median costs per individual per year are shown in panels A, B, and C, respectively for the 3 states. Error bars denote interquartile ranges. LOS = length of stay.

**Figure 3**. Health outcomes with substantial or moderate evidence of a statistical association with cannabis use based on the National Academy of Science (NAS)

summary statement. Medical diagnoses are identified based on a non-significant (*P*>0.05) comparison between New York (NY) and Oklahoma (OK) (control states without cannabis legalization) with regards to the change of admission rates for such diagnoses following cannabis legalization. *P* values for the comparison between Colorado (CO) (site of cannabis legalization) and NY (rhomboid symbol), or between CO and OK (circular symbol) are shown as either <0.05, or > 0.05 using a gray scale for evidence of cannabis benefit (risk ratio [RR] < 1 shown on the left) and cannabis harm (RR>1 shown on the right); 95% confidence intervals are shown for the comparison between CO and NY and between CO and OK as solid and dotted lines, respectively. Progressively darker shades of green or red indicate greater weight of evidence in the direction of proposed benefit versus harm, respectively, by the NAS.

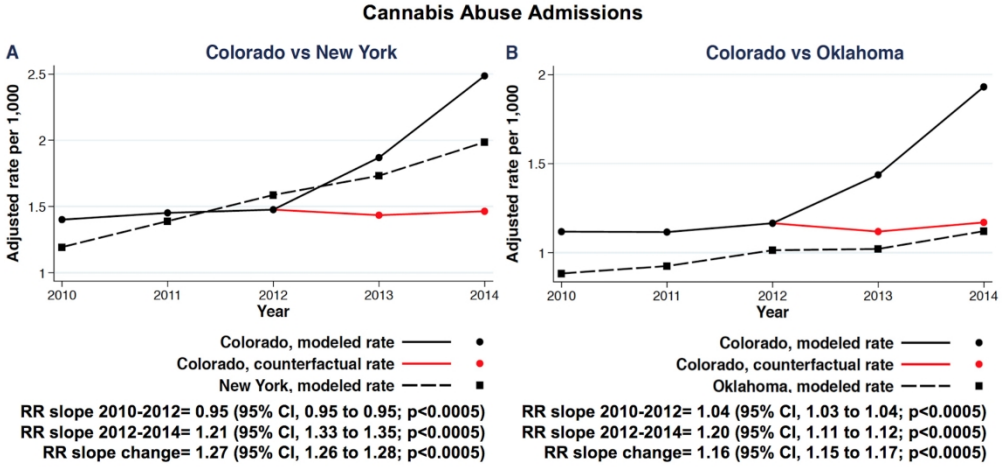
**Table 1.** Clinical characteristics of the 3 study states over the 2010-2014 period.

| | Colorado | New York | Oklahoma | *P* value |
|---|---|---|---|---|
| Total population | 5,197,237 | 19,594,599 | 3,819,383 | |
| Total admissions | 2,088,909 | 11,726,283 | 2,334,988 | |
| Total admissions/1,000 population | 402±0.27 | 598±0.17 | 611±0.40 | 0.0001 |
| **Demographics** | | | | |
| Age – yr | 45 ± 28 | 49 ± 28 | 48 ± 28 | 0.0001 |
| Male – no. (%) | 870,573 (42) | 5,087,181 (41) | 954,848 (43) | 0.0001 |
| Race – no. (%) | | | | 0.0001 |
| White | 1,548,099 (74) | 6,406,582 (55) | 1,879,727 (81) | |
| Black | 102,444 (5) | 2,083,366 (18) | 202,420 (9) | |
| Native American | 13,143 (1) | 36,216 (0.3) | 131,714 (6) | |
| Other | 425,223 (20) | 3,200,119 (27) | 121,127 (5) | |
| **Lifestyle** | | | | |
| Median Household Income, dollars (quartiles for patient ZIP code) – no. (%) | | | | 0.0001 |
| Quartile 1 | 617,537 (30) | 3,087,192 (28) | No data | |
| Quartile 2 | 558,760 (27) | 2,623,087 (24) | | |
| Quartile 3 | 470,051 (23) | 2,673,153 (24) | | |
| Tobacco use – no. (%) | 251,566 (12) | 1,717,940 (10) | 235,685 (14) | 0.0001 |
| Alcohol abuse – no. (%) | 112,715 (5) | 652,608 (6) | 71,931 (3) | 0.0001 |
| **NAS Diagnoses** | | | | |
| Non-seminoma type testicular germ cell cancer – no. (%) | 405 (0.02) | 2,487 (0.02) | 480 (0.02) | 0.0001 |
| Acute myocardial infarction – no. (%) | 39,513 (1.9) | 271,285 (2.3) | 60,413 (2.6) | 0.0001 |
| Brain hemorrhage – no. (%) | 10,963 (0.5) | 58,278 (0.5) | 10,245 (0.4) | 0.0001 |
| Ischemic stroke – no. (%) | 27,986 (1.3) | 194,478 (1.7) | 45,602 (2) | 0.0001 |

| | | | | |
|---|---|---|---|---|
| Metabolic syndrome & diabetes – no. (%) | 294,821 (14) | 2,301,835 (20) | 465,353 (20) | 0.0001 |
| Prediabetes – no. (%) | 42,544 (2) | 73,407 (0.6) | 24,246 (1) | 0.0001 |
| Bronchitis – no. (%) | 65,265 (3) | 429,230 (4) | 131,343 (6) | 0.0001 |
| Motor vehicle accidents – no. (%) | 14,941 (0.7) | 59,686 (0.5) | 13,692 (0.6) | 0.0001 |
| Overdose injury – no. (%) | 10,933 (0.5) | 40,226 (0.3) | 12,147 (0.5) | 0.0001 |
| Substance use disorder – no. (%) | 158,244 (7.6) | 974,856 (8.3) | 109,305 (4.7) | 0.0001 |
| Anxiety disorders – no. (%) | 131,426 (6.4) | 595,478 (5.2) | 139,627 (6.1) | 0.0001 |
| Anxiety disorders (except social anxiety) – no. (%) | 51,913 (2.5) | 283,280 (2.4) | 65,279 (2.8) | 0.0016 |
| Bipolar disorders – no. (%) | 52,348 (2.5) | 287,735 (2.5) | 61,411 (2.6) | 0.0001 |
| Depressive disorders – no. (%) | 213,851 (10) | 827,932 (7) | 190,083 (8) | 0.0001 |
| Schizophrenia or other psychoses – no. (%) | 53,652 (2.6) | 352,533 (3) | 68,385 (2.9) | 0.0001 |
| Positive symptoms of schizophrenia (i.e. hallucinations) – no. (%) | 2,653 (0.1) | 9,482 (0.1) | 3,531 (0.2) | 0.0001 |
| Post-traumatic stress disorder – no. (%) | 28,582 (1.4) | 75,608 (0.6) | 17,101 (0.7) | 0.0001 |
| Social anxiety disorder – no. (%) | 295 (0.01) | 1,090 (0.01) | 135 (0.01) | 0.0295 |
| Suicide – no. (%) | 4,957 (0.2) | 15,646 (0.1) | 4,407 (0.2) | 0.0001 |
| Low offspring birthweight – no. (%) | 2,842 (0.1) | 7,462 (0.1) | 1,742 (0.1) | 0.0002 |
| Maternal pregnancy complications – no. (%) | 39,343 (1.9) | 144,353 (1.2) | 40,938 (1.8) | 0.0001 |
| Unemployment/low income – no. (%) | 3,134 (0.2) | 76,789 (0.7) | 730 (0.03) | 0.0001 |
| Nausea or vomiting – no. (%) | 63,806 (3) | 162,11(1.4) | 58,706 (2.5) | 0.0001 |
| Chronic pain – no. (%) | 140,209 (6) | 234,160 (2) | 123,563 (5) | 0.0001 |
| Spasticity – no. (%) | 5,759 (0.3) | 12,517 (0.1) | 5,371 (0.2) | 0.0001 |

| | | | | |
|---|---|---|---|---|
| Short-term sleep – no. (%) | 652 (0.03) | 3,364 (0.03) | 357 (0.02) | 0.0001 |
| Tourette syndrome – no. (%) | 428 (0.02) | 2,784 (0.02) | 336 (0.01) | 0.0001 |
| Increased appetite & weight gain – no. (%) | 1,022 (0.05) | 3,017 (0.03) | 651 (0.03) | 0.0001 |

NAS = National Academy of Science. Admission diagnoses listed were based on those found influenced by cannabis in the 2017 NAS review.[3] Substance use disorder includes dependence or abuse of alcohol, tobacco, or other illicit drug. All variables pertain to the 2010-2014 period. Plus-minus values are means ± SD. No. (%) indicates number of admissions with a specific demographic/lifestyle characteristic or NAS diagnosis (% of total admissions). A *P* value less than 0.05 is considered statistically significant.




Multivariate adjusted rates of admissions for cannabis abuse over 2010-2014 in Colorado, site of implementation of the 2012 recreational cannabis legalization policy, compared with New York (A) and Oklahoma (B), control states without cannabis legalization. Red lines show the predicted rates of admissions for cannabis abuse had the cannabis legalization policy not been instituted. The comparison between Colorado and the control states with regards to change of risk ratio (RR) slope within the 2010-2012 period (pre-legalization) and 2012-2014 period (post-legalization), as well of the overall RR slope change, are also represented for the Colorado versus New York (A) and Colorado versus Oklahoma (B) comparisons. Red lines show the predicted rates of admissions for cannabis abuse had the cannabis legalization policy not been instituted. Each model was adjusted for age, gender, and race and state-level characteristics (see Methods section for further details). CI = confidence interval; vs = versus.

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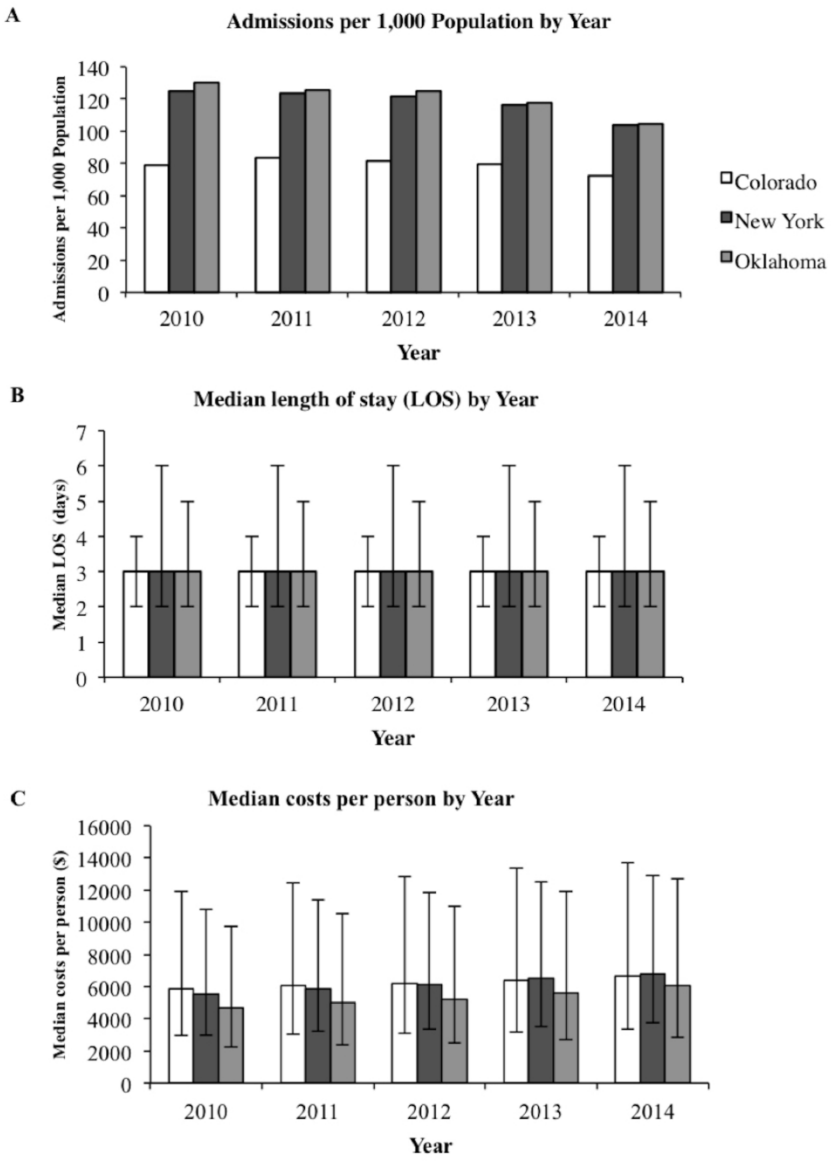


Healthcare utilization over 2010-2014 in Colorado, site of implementation of the 2012 recreational cannabis legalization policy, and in New York and Oklahoma, control states without cannabis legalization. The total number of admissions/1000 population per year, the median length of stay per year, and the median costs per individual per year are shown in panels A, B, and C, respectively for the 3 states. Error bars denote interquartile ranges. LOS = length of stay.

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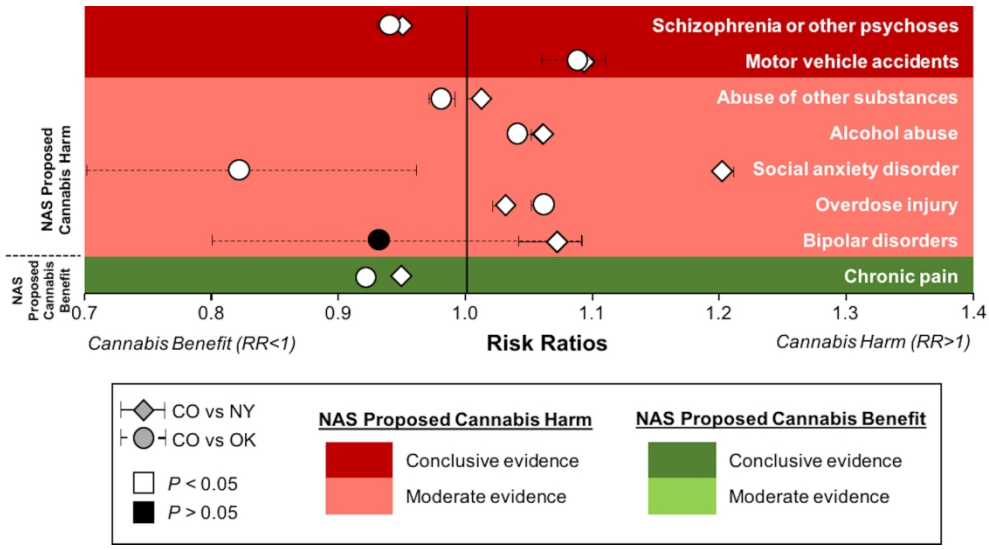


Health outcomes with substantial or moderate evidence of a statistical association with cannabis use based on the National Academy of Science (NAS) summary statement. Medical diagnoses are identified based on a non-significant (P>0.05) comparison between New York (NY) and Oklahoma (OK) (control states without cannabis legalization) with regards to the change of admission rates for such diagnoses following cannabis legalization. P values for the comparison between Colorado (CO) (site of cannabis legalization) and NY (rhomboid symbol), or between CO and OK (circular symbol) are shown as either <0.05, or > 0.05 using a gray scale for evidence of cannabis benefit (risk ratio [RR] < 1 shown on the left) and cannabis harm (RR>1 shown on the right); 95% confidence intervals are shown for the comparison between CO and NY and between CO and OK as solid and dotted lines, respectively. Progressively darker shades of green or red indicate greater weight of evidence in the direction of proposed benefit versus harm, respectively, by the NAS.

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# Supplementary Appendix

## Changes in Inpatient Healthcare Utilization after Legalization of Recreational Cannabis

Francesca N. Delling, MD, MPH;[1] Eric Vittinghoff, PhD;[1] Thomas A. Dewland, MD;[2] Mark J. Pletcher, MD, MPH; [1] Jeffrey E. Olgin, MD;[1] Gregory Nah, MA;[1] Kirstin Aschbacher, PhD;[1] Christina Fang, BA;[1] Emily S. Lee, BA;[1] Shannon M. Fan, BA;[1] Dhruv S. Kazi, MD, MS;[1] and Gregory M. Marcus, MD, MAS.[1]

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This supplementary material has been provided by the authors to give readers additional information about their work.

## **eMethods.** Cost Analysis

### Cost Estimations

The inpatient cost for each hospitalization in New York and Colorado was estimated by multiplying the total charges (TOTCHG) obtained from HCUP State Inpatient Database with the institution-specific all-payer cost-to-charge ratio (APICC) obtained from the Cost-to-Charge Ratio file. Hospital ID was used as a linkage to merge both files. Total inpatient costs were calculated as the sum of the cost for all hospitalizations in a given state for a particular year. The databases contained 186,226 (8.7%) encounters with non-matched/missing hospital ID for NY and 1,132,696 (9.6%) encounters with non-matched/missing hospital ID for Colorado; for these encounters. In order to estimate the cost of these hospitalizations (for which we had charges but no cost-to-charge ratio) we applied the average cost-to-charge ratio for that state-year. This was estimated by dividing the sum of costs for all hospitalizations for which cost-to-charge ratios were available by the sum of charges for all hospitalizations for which cost-to-charge ratios were available in a given state-year (**eTable 2**).

### Oklahoma Total Cost Estimate

HCUP does not produce SID and CCR file for Oklahoma. We obtained these data from Oklahoma State Department of Health – this dataset contains information about total charges but not cost-to-charge ratios. We estimated total inpatient costs in Oklahoma in two ways. First, we used a state-wide constant cost-to-charge ratio (0.3119) to estimate the total cost (ratio derived from the Institute for Health and Socio-Economic Policy calculations of federal cost reports). We then conducted a sensitivity analysis in which we used the average of the cost-to-charge ratios of New York and Colorado for any given state-year (**eTable 2**).

**eTable 1.** Yearly costs and charges for the 3 study states

| Colorado | 2010 | 2011 | 2012 | 2013 | 2014 | 2010 to 2014 |
|---|---|---|---|---|---|---|
| Total hospitalizations, n | 397,505 | 428,912 | 424,640 | 418,952 | 418,900 | 2,088,909 |
| Hospitalizations for which CCR is available, n (%) | 396,433 (99.7%) | 301,586 (70.3%) | 382,021 (90.0%) | 412,483 (98.5%) | 413,160 (98.6%) | 1,905,683 (91.2%) |
| Total charges for hospitalizations for which CCR is available | $14,382,791,648 | $11,170,040,412 | $15,821,232,608 | $19,349,895,615 | $20,370,018,114 | $81,093,978,397 |
| Total costs for hospitalizations for which CCR is available | $4,104,443,164 | $3,033,915,324 | $3,963,892,093 | $4,619,884,886 | $4,700,380,255 | $20,422,515,722 |
| Average CCR* | 0.2854 | 0.2716 | 0.2505 | 0.2388 | 0.2309 | |
| Hospitalizations for which CCR is not available, n (%) | 1,072 (0.3%) | 127,326 (29.7%) | 42,619 (10.0%) | 6,469 (1.5%) | 5,740 (1.4%) | 183,226 (8.8%) |
| Total charges for hospitalizations for which CCR is not available | $55,039,614 | $5,704,285,087 | $2,494,379,901 | $241,011,451 | $211,228,665 | $8,705,944,718 |
| Total costs for hospitalizations for which CCR is not available† | $15,708,306 | $1,549,283,830 | $624,842,165 | $57,553,535 | $48,772,699 | $2,296,160,534 |
| Total inpatient costs | $4,120,151,470 | $4,583,199,154 | $4,588,734,258 | $4,677,438,421 | $4,749,152,954 | $22,718,676,256 |

*Average CCR was estimated by dividing the total of costs for all hospitalizations for which cost-to-charge ratios were available by the total charges for hospitalizations for which cost-to-charge ratios were available in a given state-year.
†Total charges for hospitalization for which CCR is not available multiplied by Average CCR in a given state-year.

| New York | 2010 | 2011 | 2012 | 2013 | 2014 | 2010 to 2014 |
|---|---|---|---|---|---|---|
| Total hospitalizations, n | 2,417,298 | 2,414,985 | 2,389,701 | 2,290,502 | 2,213,797 | 11,726,283 |
| Hospitalizations for which CCR is available, n (%) | 2,189,513 (90.6%) | 2,157,629 (89.3%) | 2,168,880 (90.8%) | 2,056,367 (89.8%) | 2,021,199 (91.3%) | 10,593,588 (90.3%) |
| Total charges for hospitalizations for which CCR is available | $66,303,900,691 | $69,885,515,755 | $74,728,795,811 | $77,680,292,105 | $79,252,368,106 | $367,850,872,468 |
| Total costs for hospitalizations for which CCR is available | $22,376,381,374 | $23,448,311,348 | $24,539,963,919 | $24,331,920,273 | $23,892,478,440 | $118,589,055,354 |
| Average CCR* | 0.3375 | 0.3355 | 0.3283 | 0.3132 | 0.3014 | |
| Hospitalizations for which CCR is not available, n (%) | 227,785 (9.4%) | 257,356 (10.7%) | 220,821 (9.2%) | 234135 (10.2%) | 192,598 (8.7%) | 1,132,695 (9.7%) |
| Total charges for hospitalizations for which CCR is not available | $4,168,104,163 | $4,821,903,339 | $4,088,909,686 | $5,687,320,556 | $5,336,461,039 | $24,102,698,783 |
| Total costs for hospitalizations for which CCR is not available† | $1,406,735,155 | $1,617,748,571 | $1,342,797,941 | $1,781,268,798 | $1,608,409,357 | $7,756,959,821 |
| Total inpatient costs | $23,783,116,529 | $25,066,059,919 | $25,882,761,860 | $26,113,189,071 | $25,500,887,797 | $126,346,015,175 |

*Average CCR was estimated by dividing the total of costs for all hospitalizations for which cost-to-charge ratios were available by the total charges for hospitalizations for which cost-to-charge ratios were available in a given state-year.
†Total charges for hospitalization for which CCR is not available multiplied by Average CCR in a given state-year.

| Oklahoma | 2010 | 2011 | 2012 | 2013 | 2014 | 2010 to 2014 |
|---|---|---|---|---|---|---|
| Total hospitalizations, n | 489,724 | 476,605 | 476,728 | 452,724 | 439,207 | 2,334,988 |
| Hospitalizations for which CCR is available, n (%) | 489724 (100%) | 476605 (100%) | 476728 (100%) | 452724 (100%) | 439207 (100%) | 2334988 (100%) |
| Total charges for hospitalizations for which CCR is available | $13,927,214,520 | $14,645,751,657 | $15,247,598,300 | $15,596,643,583 | $15,003,967,132 | $74,421,175,192 |
| Total costs for hospitalizations for which CCR is available | $4,343,898,209 | $4,568,009,942 | $4,755,725,910 | $4,864,593,134 | $5,001,131,977 | $23,533,359,171 |
| Average CCR* | 0.3119 | 0.3119 | 0.3119 | 0.3119 | 0.3119 | |

*Statewide constant CCR (0.3119) used to estimate the total cost across years.

| Oklahoma (sensitivity analysis) | 2010 | 2011 | 2012 | 2013 | 2014 | 2010 to 2014 |
|---|---|---|---|---|---|---|
| Total hospitalization, n | 489,724 | 476,605 | 476,728 | 452,724 | 439,207 | 2,334,988 |
| Hospitalization for which CCR is available, n (%) | 489724 (100%) | 476605 (100%) | 476728 (100%) | 452724 (100%) | 439207 (100%) | 2334988 (100%) |
| Total charges for hospitalization for which CCR is available | $13,927,214,520 | $14,645,751,657 | $15,247,598,300 | $15,596,643,583 | $15,003,967,132 | $74,421,175,192 |
| Total costs for hospitalization for which CCR is available | $4,337,630,962 | $4,445,717,915 | $4,413,417,328 | $4,304,673,629 | $4,267,557,794 | $21,768,997,628 |
| Average CCR* | 0.3114 | 0.3036 | 0.2895 | 0.276 | 0.2662 | |

*Average of the CCRs of New York and Colorado for any given state-year.

**eTable 2.** International Classification of Diseases-9th Edition (ICD-9) codes defining each medical diagnosis.

**Chronic pain**

| ICD-9 Code | Short Description | Long Description |
|---|---|---|
| 338.21 | Chronc pain d/t trauma | Chronic pain due to trauma |
| 338.22 | Chron post-thoracot pain | Chronic post-thoracotomy pain |
| 338.28 | Chronic postop pain NEC | Other chronic postoperative pain |
| 338.29 | Chronic pain NEC | Other chronic pain |
| 338.4 | Chronic pain syndrome | Chronic pain syndrome |

**Nausea or vomiting**

| ICD-9 Code | Short Description | Long Description |
|---|---|---|
| 787.03 | Vomiting alone | Vomiting alone |
| 787.02 | Nausea alone | Nausea alone |
| 787.01 | Nausea with vomiting | Nausea with vomiting |

**Spasticity**

| ICD-9 Code | Short Description | Long Description |
|---|---|---|
| 728.85 | Spasm of muscle | Spasm of muscle |

**Short-term sleep disorders**

| ICD-9 Code | Short Description | Long Description |
|---|---|---|
| 307.4 | Nonorganic sleep dis NOS | Nonorganic sleep disorder, unspecified |
| 307.41 | Transient insomnia | Transient disorder of initiating or maintaining sleep |
| 307.42 | Persistent insomnia | Persistent disorder of initiating or maintaining sleep |
| 307.45 | Nonorganic circadian rhy | Circadian rhythm sleep disorder of nonorganic origin |
| 307.47 | Sleep stage dysfunc NEC | Other dysfunctions of sleep stages or arousal from sleep |
| 307.49 | Nonorganic sleep dis NEC | Other specific disorders of sleep of nonorganic origin |

**Increased appetite and weight gain**

| ICD-9 Code | Short Description | Long Description |
|---|---|---|
| 783.1 | Abnormal weight gain | Abnormal weight gain |
| 783.6 | Polyphagia | Polyphagia |

**Tourette's syndrome**

| ICD-9 Code | Short Description | Long Description |
|---|---|---|
| 307.23 | Tourette's disorder | Tourette's disorder |

**Posttraumatic stress disorder**

| ICD-9 Code | Short Description | Long Description |
|---|---|---|
| 309.81 | Posttraumatic stress dis | Posttraumatic stress disorder |

**Non-seminoma-type testicular germ cell cancer**

| ICD-9 Code | Short Description | Long Description |
|---|---|---|
| 186.9 | Malig neo testis NEC | Malignant neoplasm of other and unspecified testis |

**Acute myocardial infarction**

| ICD-9 Code | Short Description | Long Description |
|---|---|---|
| 410 | AMI anterolateral,unspec | Acute myocardial infarction of anterolateral wall, episode of care unspecified |
| 410.01 | AMI anterolateral, init | Acute myocardial infarction of anterolateral wall, initial episode of care |
| 410.02 | AMI anterolateral,subseq | Acute myocardial infarction of anterolateral wall, subsequent episode of care |
| 410.1 | AMI anterior wall,unspec | Acute myocardial infarction of other anterior wall, episode of care unspecified |
| 410.11 | AMI anterior wall, init | Acute myocardial infarction of other anterior wall, initial episode of care |
| 410.12 | AMI anterior wall,subseq | Acute myocardial infarction of other anterior wall, subsequent episode of care |
| 410.2 | AMI inferolateral,unspec | Acute myocardial infarction of inferolateral wall, episode of care unspecified |
| 410.21 | AMI inferolateral, init | Acute myocardial infarction of inferolateral wall, initial episode of care |
| 410.22 | AMI inferolateral,subseq | Acute myocardial infarction of inferolateral wall, subsequent episode of care |
| 410.3 | AMI inferopost, unspec | Acute myocardial infarction of inferoposterior wall, episode of care unspecified |
| 410.31 | AMI inferopost, initial | Acute myocardial infarction of inferoposterior wall, initial episode of care |
| 410.32 | AMI inferopost, subseq | Acute myocardial infarction of inferoposterior wall, subsequent episode of care |
| 410.4 | AMI inferior wall,unspec | Acute myocardial infarction of other inferior wall, episode of care unspecified |
| 410.41 | AMI inferior wall, init | Acute myocardial infarction of other inferior wall, initial episode of care |
| 410.42 | AMI inferior wall,subseq | Acute myocardial infarction of other inferior wall, subsequent episode of care |
| 410.5 | AMI lateral NEC, unspec | Acute myocardial infarction of other lateral wall, episode of care unspecified |
| 410.51 | AMI lateral NEC, initial | Acute myocardial infarction of other lateral wall, initial episode of care |
| 410.52 | AMI lateral NEC, subseq | Acute myocardial infarction of other lateral wall, subsequent episode of care |
| 410.6 | True post infarct,unspec | True posterior wall infarction, episode of care unspecified |
| 410.61 | True post infarct, init | True posterior wall infarction, initial episode of care |

| | | |
|---|---|---|
| 410.62 | True post infarct,subseq | True posterior wall infarction, subsequent episode of care |
| 410.7 | Subendo infarct, unspec | Subendocardial infarction, episode of care unspecified |
| 410.71 | Subendo infarct, initial | Subendocardial infarction, initial episode of care |
| 410.72 | Subendo infarct, subseq | Subendocardial infarction, subsequent episode of care |
| 410.8 | AMI NEC, unspecified | Acute myocardial infarction of other specified sites, episode of care unspecified |
| 410.81 | AMI NEC, initial | Acute myocardial infarction of other specified sites, initial episode of care |
| 410.82 | AMI NEC, subsequent | Acute myocardial infarction of other specified sites, subsequent episode of care |
| 410.9 | AMI NOS, unspecified | Acute myocardial infarction of unspecified site, episode of care unspecified |
| 410.91 | AMI NOS, initial | Acute myocardial infarction of unspecified site, initial episode of care |
| 410.92 | AMI NOS, subsequent | Acute myocardial infarction of unspecified site, subsequent episode of care |

**Ischemic stroke**

| ICD-9 Code | Short Description | Long Description |
|---|---|---|
| 435.8 | Trans cereb ischemia NEC | Other specified transient cerebral ischemias |
| 435.9 | Trans cereb ischemia NOS | Unspecified transient cerebral ischemia |
| 433.01 | Ocl bslr art w infrct | Occlusion and stenosis of basilar artery with cerebral infarction |
| 433.11 | Ocl crtd art w infrct | Occlusion and stenosis of carotid artery with cerebral infarction |
| 433.21 | Ocl vrtb art w infrct | Occlusion and stenosis of vertebral artery with cerebral infarction |
| 433.31 | Ocl mlt bi art w infrct | Occlusion and stenosis of multiple and bilateral precerebral arteries with cerebral infarction |
| 433.81 | Ocl spcf art w infrct | Occlusion and stenosis of other specified precerebral artery with cerebral infarction |
| 433.91 | Ocl art NOS w infrct | Occlusion and stenosis of unspecified precerebral artery with cerebral infarction |
| 434.91 | Crbl art ocl NOS w infrc | Cerebral artery occlusion, unspecified with cerebral infarction |

**Brain hemorrhage**

| ICD-9 Code | Short Description | Long Description |
|---|---|---|
| 430 | Subarachnoid hemorrhage | Subarachnoid hemorrhage |
| 431 | Intracerebral hemorrhage | Intracerebral hemorrhage |
| 432 | Nontraum extradural hem | Nontraumatic extradural hemorrhage |
| 432.1 | Subdural hemorrhage | Subdural hemorrhage |
| 432.9 | Intracranial hemorr NOS | Unspecified intracranial hemorrhage |

**Metabolic syndrome and diabetes**

| ICD-9 Code | Short Description | Long Description |
|---|---|---|
| 277.7 | Dysmetabolic syndrome x | Dysmetabolic syndrome X |
| 250 | DMII wo cmp nt st uncntr | Diabetes mellitus without mention of complication, type II or unspecified type, not stated as uncontrolled |
| 250.02 | DMII wo cmp uncntrld | Diabetes mellitus without mention of complication, type II or unspecified type, uncontrolled |
| 250.1 | DMII keto nt st uncntrld | Diabetes with ketoacidosis, type II or unspecified type, not stated as uncontrolled |
| 250.12 | DMII ketoacd uncontrold | Diabetes with ketoacidosis, type II or unspecified type, uncontrolled |
| 250.2 | DMII hprsm nt st uncntrl | Diabetes with hyperosmolarity, type II or unspecified type, not stated as uncontrolled |
| 250.22 | DMII hprosmlr uncontrold | Diabetes with hyperosmolarity, type II or unspecified type, uncontrolled |
| 250.3 | DMII o cm nt st uncntrld | Diabetes with other coma, type II or unspecified type, not stated as uncontrolled |
| 250.32 | DMII oth coma uncontrold | Diabetes with other coma, type II or unspecified type, uncontrolled |
| 250.4 | DMII renl nt st uncntrld | Diabetes with renal manifestations, type II or unspecified type, not stated as uncontrolled |
| 250.42 | DMII renal uncntrld | Diabetes with renal manifestations, type II or unspecified type, uncontrolled |
| 250.5 | DMII ophth nt st uncntrl | Diabetes with ophthalmic manifestations, type II or unspecified type, not stated as uncontrolled |
| 250.52 | DMII ophth uncntrld | Diabetes with ophthalmic manifestations, type II or unspecified type, uncontrolled |
| 250.6 | DMII neuro nt st uncntrl | Diabetes with neurological manifestations, type II or unspecified type, not stated as uncontrolled |
| 250.62 | DMII neuro uncntrld | Diabetes with neurological manifestations, type II or unspecified type, uncontrolled |
| 250.7 | DMII circ nt st uncntrld | Diabetes with peripheral circulatory disorders, type II or unspecified type, not stated as uncontrolled |
| 250.72 | DMII circ uncntrld | Diabetes with peripheral circulatory disorders, type II or unspecified type, uncontrolled |
| 250.8 | DMII oth nt st uncntrld | Diabetes with other specified manifestations, type II or unspecified type, not stated as uncontrolled |
| 250.82 | DMII oth uncntrld | Diabetes with other specified manifestations, type II or unspecified type, uncontrolled |
| 250.9 | DMII unspf nt st uncntrl | Diabetes with unspecified complication, type II or unspecified type, not stated as uncontrolled |

| | | |
|---|---|---|
| 250.92 | DMII unspf uncntrld | Diabetes with unspecified complication, type II or unspecified type, uncontrolled |

**Prediabetes**

| ICD-9 Code | Short Description | Long Description |
|---|---|---|
| 790.29 | Abnormal glucose NEC | Other abnormal glucose |

**Bronchitis**

| ICD-9 Code | Short Description | Long Description |
|---|---|---|
| 466 | Acute bronchitis | Acute bronchitis |
| 490 | Bronchitis NOS | Bronchitis, not specified as acute or chronic |
| 491 | Simple chr bronchitis | Simple chronic bronchitis |
| 491.1 | Mucopurul chr bronchitis | Mucopurulent chronic bronchitis |
| 491.2 | Obst chr bronc w/o exac | Obstructive chronic bronchitis without exacerbation |
| 491.21 | Obs chr bronc w(ac) exac | Obstructive chronic bronchitis with (acute) exacerbation |
| 491.22 | Obs chr bronc w ac bronc | Obstructive chronic bronchitis with acute bronchitis |
| 491.8 | Chronic bronchitis NEC | Other chronic bronchitis |
| 491.9 | Chronic bronchitis NOS | Unspecified chronic bronchitis |

**Motor vehicle accidents**

| ICD-9 Code | Short Description | Long Description |
|---|---|---|
| E812.0 | Mv collision NOS-driver | Other motor vehicle traffic accident involving collision with motor vehicle injuring driver of motor vehicle other than motorcycle |
| E812.1 | Mv collision NOS-pasngr | Other motor vehicle traffic accident involving collision with motor vehicle injuring passenger in motor vehicle other than motorcycle |
| E812.2 | Mv collis NOS-motorcycl | Other motor vehicle traffic accident involving collision with motor vehicle injuring motorcyclist |
| E812.3 | Mv coll NOS-mcycl psngr | Other motor vehicle traffic accident involving collision with motor vehicle injuring passenger on motorcycle |
| E812.4 | Mv collision NOS-st car | Other motor vehicle traffic accident involving collision with motor vehicle injuring occupant of streetcar |
| E812.5 | Mv coll NOS-anim rid | Other motor vehicle traffic accident involving collision with motor vehicle injuring rider of animal; occupant of animal-drawn vehicle |
| E812.6 | Mv coll NOS-ped cycl | Other motor vehicle traffic accident involving collision with motor vehicle injuring pedal cyclist |
| E812.7 | Mv collision NOS-pedest | Other motor vehicle traffic accident involving collision with motor vehicle injuring pedestrian |

| | | |
|---|---|---|
| E812.8 | Mv collis NOS-pers NEC | Other motor vehicle traffic accident involving collision with motor vehicle injuring other specified person |
| E812.9 | Mv collis NOS-pers NOS | Other motor vehicle traffic accident involving collision with motor vehicle injuring unspecified person |
| E813.0 | Mv-oth veh coll-driver | Motor vehicle traffic accident involving collision with other vehicle injuring driver of motor vehicle other than motorcycle |
| E813.1 | Mv-oth veh coll-pasngr | Motor vehicle traffic accident involving collision with other vehicle injuring passenger in motor vehicle other than motorcycle |
| E813.2 | Mv-oth veh coll-motcycl | Motor vehicle traffic accident involving collision with other vehicle injuring motorcyclist |
| E813.3 | Mv-oth veh coll-mcyc psg | Motor vehicle traffic accident involving collision with other vehicle injuring passenger on motorcycle |
| E813.4 | Mv-oth veh coll-st car | Motor vehicle traffic accident involving collision with other vehicle injuring occupant of streetcar |
| E813.5 | Mv-oth veh coll-anim rid | Motor vehicle traffic accident involving collision with other vehicle injuring rider of animal; occupant of animal-drawn vehicle |
| E813.6 | Mv-oth veh coll-ped cycl | Motor vehicle traffic accident involving collision with other vehicle injuring pedal cyclist |
| E813.7 | Mv-oth veh coll-pedest | Motor vehicle traffic accident involving collision with other vehicle injuring pedestrian |
| E813.8 | Mv-oth veh coll-pers NEC | Motor vehicle traffic accident involving collision with other vehicle injuring other specified person |
| E813.9 | Mv-oth veh coll-pers NOS | Motor vehicle traffic accident involving collision with other vehicle injuring unspecified person |
| E814.0 | Mv coll w pedest-driver | Motor vehicle traffic accident involving collision with pedestrian injuring driver of motor vehicle other than motorcycle |
| E814.1 | Mv coll w pedest-pasngr | Motor vehicle traffic accident involving collision with pedestrian injuring passenger in motor vehicle other than motorcycle |
| E814.2 | Mv coll w pedest-motcycl | Motor vehicle traffic accident involving collision with pedestrian injuring motorcyclist |
| E814.3 | Mv coll w ped-mcycl psgr | Motor vehicle traffic accident involving collision with pedestrian injuring passenger on motorcycle |
| E814.4 | Mv coll w pedest-st car | Motor vehicle traffic accident involving collision with pedestrian injuring occupant of streetcar |
| E814.5 | Mv coll w ped-anim rid | Motor vehicle traffic accident involving collision with pedestrian injuring rider of animal; occupant of animal drawn vehicle |
| E814.6 | Mv coll w ped-ped cycl | Motor vehicle traffic accident involving collision with pedestrian injuring pedal cyclist |

| | | |
|---|---|---|
| E814.7 | Mv coll w pedest-pedest | Motor vehicle traffic accident involving collision with pedestrian injuring pedestrian |
| E814.8 | Mv coll w pedes-pers NEC | Motor vehicle traffic accident involving collision with pedestrian injuring other specified person |
| E814.9 | Mv coll w pedes-pers NOS | Motor vehicle traffic accident involving collision with pedestrian injuring unspecified person |
| E815.0 | Mv coll w oth obj-driver | Other motor vehicle traffic accident involving collision on the highway injuring driver of motor vehicle other than motorcycle |
| E815.1 | Mv coll w oth obj-pasngr | Other motor vehicle traffic accident involving collision on the highway injuring passenger in motor vehicle other than motorcycle |
| E815.2 | Mv coll w oth obj-mocycl | Other motor vehicle traffic accident involving collision on the highway injuring motorcyclist |
| E815.3 | Mv coll w obj-mcycl psgr | Other motor vehicle traffic accident involving collision on the highway injuring passenger on motorcycle |
| E815.4 | Mv coll w obj-st car | Other motor vehicle traffic accident involving collision on the highway injuring occupant of streetcar |
| E815.5 | Mv coll w obj-anim rider | Other motor vehicle traffic accident involving collision on the highway injuring rider of animal; occupant of animal-drawn vehicle |
| E815.6 | Mv coll w obj-ped cycl | Other motor vehicle traffic accident involving collision on the highway injuring pedal cyclist |
| E815.7 | Mv coll w obj-pedest | Other motor vehicle traffic accident involving collision on the highway injuring pedestrian |
| E815.8 | Mv coll w obj-pers NEC | Other motor vehicle traffic accident involving collision on the highway injuring other specified person |
| E815.9 | Mv coll w obj-pers NOS | Other motor vehicle traffic accident involving collision on the highway injuring unspecified person |
| E816.0 | Loss control mv acc-driv | Motor vehicle traffic accident due to loss of control, without collision on the highway, injuring driver of motor vehicle other than motorcycle |
| E816.1 | Loss control mv acc-psgr | Motor vehicle traffic accident due to loss of control, without collision on the highway, injuring passenger in motor vehicle other than motorcycle |
| E816.2 | Loss control mv-mocycl | Motor vehicle traffic accident due to loss of control, without collision on the highway, injuring motorcyclist |
| E816.3 | Loss control mv-mcyc psg | Motor vehicle traffic accident due to loss of control, without collision on the highway, injuring passenger on motorcycle |

| | | |
|---|---|---|
| E816.4 | Loss cont mv acc-st car | Motor vehicle traffic accident due to loss of control, without collision on the highway, injuring occupant of streetcar |
| E816.5 | Loss cont mv-anim rider | Motor vehicle traffic accident due to loss of control, without collision on the highway, injuring rider of animal; occupant of animal-drawn vehicle |
| E816.6 | Loss control mv-ped cycl | Motor vehicle traffic accident due to loss of control, without collision on the highway, injuring pedal cyclist |
| E816.7 | Loss control mv-pedest | Motor vehicle traffic accident due to loss of control, without collision on the highway, injuring pedestrian |
| E816.8 | Loss control mv-pers NEC | Motor vehicle traffic accident due to loss of control, without collision on the highway, injuring other specified person |
| E816.9 | Loss control mv-pers NOS | Motor vehicle traffic accident due to loss of control, without collision on the highway, injuring unspecified person |
| E819.0 | Traffic acc NOS-driver | Motor vehicle traffic accident of unspecified nature injuring driver of motor vehicle other than motorcycle |
| E819.1 | Traffic acc NOS-pasngr | Motor vehicle traffic accident of unspecified nature injuring passenger in motor vehicle other than motorcycle |
| E819.2 | Traffic acc NOS-motcycl | Motor vehicle traffic accident of unspecified nature injuring motorcyclist |
| E819.3 | Traff acc NOS-mcycl psgr | Motor vehicle traffic accident of unspecified nature injuring passenger on motorcycle |
| E819.4 | Traffic acc NOS-st car | Motor vehicle traffic accident of unspecified nature injuring occupant of streetcar |
| E819.5 | Traff acc NOS-anim rider | Motor vehicle traffic accident of unspecified nature injuring rider of animal; occupant of animal-drawn vehicle |
| E819.6 | Traffic acc NOS-ped cycl | Motor vehicle traffic accident of unspecified nature injuring pedal cyclist |
| E819.7 | Traffic acc NOS-pedest | Motor vehicle traffic accident of unspecified nature injuring pedestrian |
| E819.8 | Traffic acc NOS-pers NEC | Motor vehicle traffic accident of unspecified nature injuring other specified person |
| E819.9 | Traffic acc NOS-pers NOS | Motor vehicle traffic accident of unspecified nature injuring unspecified person |

**Overdose injuries**

| ICD-9 Code | Short Description | Long Description |
|---|---|---|
| E950.0 | Poison-analgesics | Suicide and self-inflicted poisoning by analgesics, antipyretics, and antirheumatics |

| | | |
|---|---|---|
| E950.1 | Poison-barbiturates | Suicide and self-inflicted poisoning by barbiturates |
| E950.2 | Poison-sedat/hypnotic | Suicide and self-inflicted poisoning by other sedatives and hypnotics |
| E950.3 | Poison-psychotropic agt | Suicide and self-inflicted poisoning by tranquilizers and other psychotropic agents |
| E950.4 | Poison-drug/medicin NEC | Suicide and self-inflicted poisoning by other specified drugs and medicinal substances |
| E950.5 | Poison-drug/medicin NOS | Suicide and self-inflicted poisoning by unspecified drug or medicinal substance |

**Assault-based gunshot injuries**

| ICD-9 Code | Short Description | Long Description |
|---|---|---|
| E965.0 | Assault-handgun | Assault by handgun |
| E965.1 | Assault-shotgun | Assault by shotgun |
| E965.2 | Assault-hunting rifle | Assault by hunting rifle |
| E965.3 | Assault-military weapon | Assault by military firearms |
| E965.4 | Assault-firearm NEC | Assault by other and unspecified firearm |

**Low offspring birthweight**

| ICD-9 Code | Short Description | Long Description |
|---|---|---|
| 764.9 | Fet growth retard wtNOS | Fetal growth retardation, unspecified, unspecified [weight] |
| 764.91 | Fet growth retard <500g | Fetal growth retardation, unspecified, less than 500 grams |
| 764.92 | Fet growth ret 500-749g | Fetal growth retardation, unspecified, 500-749 grams |
| 764.93 | Fet growth ret 750-999g | Fetal growth retardation, unspecified, 750-999 grams |
| 764.94 | Fet grwth ret 1000-1249g | Fetal growth retardation, unspecified, 1,000-1,249 grams |
| 764.95 | Fet grwth ret 1250-1499g | Fetal growth retardation, unspecified, 1,250-1,499 grams |
| 764.96 | Fet grwth ret 1500-1749g | Fetal growth retardation, unspecified, 1,500-1,749 grams |
| 764.97 | Fet grwth ret 1750-1999g | Fetal growth retardation, unspecified, 1,750-1,999 grams |
| 764.98 | Fet grwth ret 2000-2499g | Fetal growth retardation, unspecified, 2,000-2,499 grams |
| 764.99 | Fet growth ret 2500+g | Fetal growth retardation, unspecified, 2,500 grams and over |

**Maternal pregnancy complications**

| ICD-9 Code | Short Description | Long Description |
|---|---|---|
| 640.8 | Hem early preg NEC-unsp | Other specified hemorrhage in early pregnancy, unspecified as to episode of care or not applicable |

| | | |
|---|---|---|
| 640.81 | Hem early preg NEC-deliv | Other specified hemorrhage in early pregnancy, delivered, with or without mention of antepartum condition |
| 640.83 | Hem early pg NEC-antepar | Other specified hemorrhage in early pregnancy, antepartum condition or complication |
| 640.9 | Hemorr early preg-unspec | Unspecified hemorrhage in early pregnancy, unspecified as to episode of care or not applicable |
| 640.91 | Hem early preg-delivered | Unspecified hemorrhage in early pregnancy, delivered, with or without mention of antepartum condition |
| 640.93 | Hem early preg-antepart | Unspecified hemorrhage in early pregnancy, antepartum condition or complication |
| 641 | Placenta previa-unspec | Placenta previa without hemorrhage, unspecified as to episode of care or not applicable |
| 641.01 | Placenta previa-deliver | Placenta previa without hemorrhage, delivered, with or without mention of antepartum condition |
| 641.03 | Placenta previa-antepart | Placenta previa without hemorrhage, antepartum condition or complication |
| 641.1 | Placenta prev hem-unspec | Hemorrhage from placenta previa, unspecified as to episode of care or not applicable |
| 641.11 | Placenta prev hem-deliv | Hemorrhage from placenta previa, delivered, with or without mention of antepartum condition |
| 641.13 | Placen prev hem-antepart | Hemorrhage from placenta previa, antepartum condition or complication |
| 641.2 | Prem separ placen-unspec | Premature separation of placenta, unspecified as to episode of care or not applicable |
| 641.21 | Prem separ placen-deliv | Premature separation of placenta, delivered, with or without mention of antepartum condition |
| 641.23 | Prem separ plac-antepart | Premature separation of placenta, antepartum condition or complication |
| 642 | Essen hyperten preg-unsp | Benign essential hypertension complicating pregnancy, childbirth, and the puerperium, unspecified as to episode of care or not applicable |
| 642.01 | Essen hyperten-delivered | Benign essential hypertension complicating pregnancy, childbirth, and the puerperium, delivered, with or without mention of antepartum condition |
| 642.02 | Essen hyperten-del w p/p | Benign essential hypertension, complicating pregnancy, childbirth, and the puerperium, delivered, with mention of postpartum complication |
| 642.03 | Essen hyperten-antepart | Benign essential hypertension complicating pregnancy, childbirth, and the puerperium, antepartum condition or complication |

| | | |
|---|---|---|
| 642.04 | Essen hyperten-postpart | Benign essential hypertension complicating pregnancy, childbirth, and the puerperium, postpartum condition or complication |
| 642.3 | Trans hyperten preg-unsp | Transient hypertension of pregnancy, unspecified as to episode of care or not applicable |
| 642.31 | Trans hyperten-delivered | Transient hypertension of pregnancy, delivered , with or without mention of antepartum condition |
| 642.32 | Trans hyperten-del w p/p | Transient hypertension of pregnancy, delivered, with mention of postpartum complication |
| 642.33 | Trans hyperten-antepart | Transient hypertension of pregnancy, antepartum condition or complication |
| 642.34 | Trans hyperten-postpart | Transient hypertension of pregnancy, postpartum condition or complication |
| 642.4 | Mild/NOS preeclamp-unsp | Mild or unspecified pre-eclampsia, unspecified as to episode of care or not applicable |
| 642.41 | Mild/NOS preeclamp-deliv | Mild or unspecified pre-eclampsia, delivered, with or without mention of antepartum condition |
| 642.42 | Mild preeclamp-del w p/p | Mild or unspecified pre-eclampsia, delivered, with mention of postpartum complication |
| 642.43 | Mild/NOS preeclamp-antep | Mild or unspecified pre-eclampsia, antepartum condition or complication |
| 642.44 | Mild/NOS preeclamp-p/p | Mild or unspecified pre-eclampsia, postpartum condition or complication |
| 642.5 | Severe preeclamp-unspec | Severe pre-eclampsia, unspecified as to episode of care or not applicable |
| 642.51 | Severe preeclamp-deliver | Severe pre-eclampsia, delivered, with or without mention of antepartum condition |
| 642.52 | Sev preeclamp-del w p/p | Severe pre-eclampsia, delivered, with mention of postpartum complication |
| 642.53 | Sev preeclamp-antepartum | Severe pre-eclampsia, antepartum condition or complication |
| 642.54 | Sev preeclamp-postpartum | Severe pre-eclampsia, postpartum condition or complication |
| 642.6 | Eclampsia-unspecified | Eclampsia, unspecified as to episode of care or not applicable |
| 642.61 | Eclampsia-delivered | Eclampsia, delivered, with or without mention of antepartum condition |
| 642.62 | Eclampsia-deliv w p/p | Eclampsia, delivered, with mention of postpartum complication |
| 642.63 | Eclampsia-antepartum | Eclampsia, antepartum condition or complication |
| 642.64 | Eclampsia-postpartum | Eclampsia, postpartum condition or complication |
| 642.7 | Tox w old hyperten-unsp | Pre-eclampsia or eclampsia superimposed on pre-existing hypertension, unspecified as to episode of care or not applicable |
| 642.71 | Tox w old hyperten-deliv | Pre-eclampsia or eclampsia superimposed on pre-existing hypertension, delivered, with or without mention of antepartum condition |

| | | |
|---|---|---|
| 642.72 | Tox w old hyp-del w p/p | Pre-eclampsia or eclampsia superimposed on pre-existing hypertension, delivered, with mention of postpartum complication |
| 642.73 | Tox w old hyper-antepart | Pre-eclampsia or eclampsia superimposed on pre-existing hypertension, antepartum condition or complication |
| 642.74 | Tox w old hyper-postpart | Pre-eclampsia or eclampsia superimposed on pre-existing hypertension, postpartum condition or complication |
| 642.9 | Hyperten preg NOS-unspec | Unspecified hypertension complicating pregnancy, childbirth, or the puerperium, unspecified as to episode of care or not applicable |
| 642.91 | Hypertens NOS-delivered | Unspecified hypertension complicating pregnancy, childbirth, or the puerperium, delivered, with or without mention of antepartum condition |
| 642.92 | Hypertens NOS-del w p/p | Unspecified hypertension complicating pregnancy, childbirth, or the puerperium, delivered, with mention of postpartum complication |
| 642.93 | Hypertens NOS-antepartum | Unspecified hypertension complicating pregnancy, childbirth, or the puerperium, antepartum condition or complication |
| 642.94 | Hypertens NOS-postpartum | Unspecified hypertension complicating pregnancy, childbirth, or the puerperium, postpartum condition or complication |
| 646.8 | Preg compl NEC-unspec | Other specified complications of pregnancy, unspecified as to episode of care or not applicable |
| 646.81 | Preg compl NEC-delivered | Other specified complications of pregnancy, delivered, with or without mention of antepartum condition |
| 646.82 | Preg compl NEC-del w p/p | Other specified complications of pregnancy, delivered, with mention of postpartum complication |
| 646.83 | Preg compl NEC-antepart | Other specified complications of pregnancy, antepartum condition or complication |
| 646.84 | Preg compl NEC-postpart | Other specified complications of pregnancy, postpartum condition or complication |
| 646.9 | Preg compl NOS-unspec | Unspecified complication of pregnancy, unspecified as to episode of care or not applicable |

**Unemployment or low income**

| ICD-9 Code | Short Description | Long Description |
|---|---|---|
| V62.0 | Unemployment | Unemployment |

**Schizophrenia or other psychoses**

| ICD-9 Code | Short Description | Long Description |
|---|---|---|
| 295 | Simpl schizophren-unspec | Simple type schizophrenia, unspecified |
| 295.01 | Simpl schizophren-subchr | Simple type schizophrenia, subchronic |
| 295.02 | Simple schizophren-chr | Simple type schizophrenia, chronic |
| 295.03 | Simp schiz-subchr/exacer | Simple type schizophrenia, subchronic with acute exacerbation |
| 295.04 | Simpl schizo-chr/exacerb | Simple type schizophrenia, chronic with acute exacerbation |
| 295.05 | Simpl schizophren-remiss | Simple type schizophrenia, in remission |
| 295.1 | Hebephrenia-unspec | Disorganized type schizophrenia, unspecified |
| 295.11 | Hebephrenia-subchronic | Disorganized type schizophrenia, subchronic |
| 295.12 | Hebephrenia-chronic | Disorganized type schizophrenia, chronic |
| 295.13 | Hebephren-subchr/exacerb | Disorganized type schizophrenia, subchronic with acute exacerbation |
| 295.14 | Hebephrenia-chr/exacerb | Disorganized type schizophrenia, chronic with acute exacerbation |
| 295.15 | Hebephrenia-remission | Disorganized type schizophrenia, in remission |
| 295.2 | Catatonia-unspec | Catatonic type schizophrenia, unspecified |
| 295.21 | Catatonia-subchronic | Catatonic type schizophrenia, subchronic |
| 295.22 | Catatonia-chronic | Catatonic type schizophrenia, chronic |
| 295.23 | Catatonia-subchr/exacerb | Catatonic type schizophrenia, subchronic with acute exacerbation |
| 295.24 | Catatonia-chr/exacerb | Catatonic type schizophrenia, chronic with acute exacerbation |
| 295.25 | Catatonia-remission | Catatonic type schizophrenia, in remission |
| 295.3 | Paranoid schizo-unspec | Paranoid type schizophrenia, unspecified |
| 295.31 | Paranoid schizo-subchr | Paranoid type schizophrenia, subchronic |
| 295.32 | Paranoid schizo-chronic | Paranoid type schizophrenia, chronic |
| 295.33 | Paran schizo-subchr/exac | Paranoid type schizophrenia, subchronic with acute exacerbation |
| 295.34 | Paran schizo-chr/exacerb | Paranoid type schizophrenia, chronic with acute exacerbation |
| 295.35 | Paranoid schizo-remiss | Paranoid type schizophrenia, in remission |
| 295.4 | Schizophreniform dis NOS | Schizophreniform disorder, unspecified |
| 295.41 | Schizophrenic dis-subchr | Schizophreniform disorder, subchronic |
| 295.42 | Schizophren dis-chronic | Schizophreniform disorder, chronic |
| 295.43 | Schizo dis-subchr/exacer | Schizophreniform disorder, subchronic with acute exacerbation |
| 295.44 | Schizophr dis-chr/exacer | Schizophreniform disorder, chronic with acute exacerbation |
| 295.45 | Schizophrenic dis-remiss | Schizophreniform disorder, in remission |
| 295.5 | Latent schizophren-unsp | Latent schizophrenia, unspecified |
| 295.51 | Lat schizophren-subchr | Latent schizophrenia, subchronic |
| 295.52 | Latent schizophren-chr | Latent schizophrenia, chronic |

| | | |
|---|---|---|
| 295.53 | Lat schizo-subchr/exacer | Latent schizophrenia, subchronic with acute exacerbation |
| 295.54 | Latent schizo-chr/exacer | Latent schizophrenia, chronic with acute exacerbation |
| 295.55 | Lat schizophren-remiss | Latent schizophrenia, in remission |
| 295.6 | Schizophr dis resid NOS | Schizophrenic disorders, residual type, unspecified |
| 295.61 | Schizoph dis resid-subch | Schizophrenic disorders, residual type, subchronic |
| 295.62 | Schizophr dis resid-chr | Schizophrenic disorders, residual type, chronic |
| 295.63 | Schizo resid subchr/exac | Schizophrenic disorders, residual type, subchronic with acute exacerbation |
| 295.64 | Schizoph resid-chro/exac | Schizophrenic disorders, residual type, chronic with acute exacerbation |
| 295.65 | Schizoph dis resid-remis | Schizophrenic disorders, residual type, in remission |
| 296.2 | Depress psychosis-unspec | Major depressive affective disorder, single episode, unspecified |
| 296.21 | Depress psychosis-mild | Major depressive affective disorder, single episode, mild |
| 296.22 | Depressive psychosis-mod | Major depressive affective disorder, single episode, moderate |
| 296.23 | Depress psychosis-severe | Major depressive affective disorder, single episode, severe, without mention of psychotic behavior |
| 296.24 | Depr psychos-sev w psych | Major depressive affective disorder, single episode, severe, specified as with psychotic behavior |
| 296.25 | Depr psychos-part remiss | Major depressive affective disorder, single episode, in partial or unspecified remission |
| 296.26 | Depr psychos-full remiss | Major depressive affective disorder, single episode, in full remission |
| 296.3 | Recurr depr psychos-unsp | Major depressive affective disorder, recurrent episode, unspecified |
| 296.31 | Recurr depr psychos-mild | Major depressive affective disorder, recurrent episode, mild |
| 296.32 | Recurr depr psychos-mod | Major depressive affective disorder, recurrent episode, moderate |
| 296.33 | Recur depr psych-severe | Major depressive affective disorder, recurrent episode, severe, without mention of psychotic behavior |
| 296.34 | Rec depr psych-psychotic | Major depressive affective disorder, recurrent episode, severe, specified as with psychotic behavior |
| 296.35 | Recur depr psyc-part rem | Major depressive affective disorder, recurrent episode, in partial or unspecified remission |

| | | |
|---|---|---|
| 296.36 | Recur depr psyc-full rem | Major depressive affective disorder, recurrent episode, in full remission |
| 298 | React depress psychosis | Depressive type psychosis |
| 298.1 | Excitativ type psychosis | Excitative type psychosis |
| 298.4 | Psychogen paranoid psych | Psychogenic paranoid psychosis |
| 298.8 | React psychosis NEC/NOS | Other and unspecified reactive psychosis |
| 298.9 | Psychosis NOS | Unspecified psychosis |

**Depressive disorders**

| ICD-9 Code | Short Description | Long Description |
|---|---|---|
| 296.82 | Atypical depressive dis | Atypical depressive disorder |
| 311 | Depressive disorder NEC | Depressive disorder, not elsewhere classified |

**Suicide**

| ICD-9 Code | Short Description | Long Description |
|---|---|---|
| E950.6 | Poison-agricult agent | Suicide and self-inflicted poisoning by agricultural and horticultural chemical and pharmaceutical preparations other than plant foods and fertilizers |
| E950.7 | Poison-corrosiv/caustic | Suicide and self-inflicted poisoning by corrosive and caustic substances |
| E950.8 | Poison-arsenic | Suicide and self-inflicted poisoning by arsenic and its compounds |
| E950.9 | Poison-solid/liquid NEC | Suicide and self-inflicted poisoning by other and unspecified solid and liquid substances |
| E951.0 | Poison-piped gas | Suicide and self-inflicted poisoning by gas distributed by pipeline |
| E951.1 | Poison-gas in container | Suicide and self-inflicted poisoning by liquefied petroleum gas distributed in mobile containers |
| E951.8 | Poison-utility gas NEC | Suicide and self-inflicted poisoning by other utility gas |
| E952.0 | Poison-exhaust gas | Suicide and self-inflicted poisoning by motor vehicle exhaust gas |
| E952.1 | Poison-co NEC | Suicide and self-inflicted poisoning by other carbon monoxide |
| E952.8 | Poison-gas/vapor NEC | Suicide and self-inflicted poisoning by other specified gases and vapors |
| E952.9 | Poison-gas/vapor NOS | Suicide and self-inflicted poisoning by unspecified gases and vapors |
| E953.0 | Injury-hanging | Suicide and self-inflicted injury by hanging |
| E953.1 | Injury-suff w plas bag | Suicide and self-inflicted injury by suffocation by plastic bag |
| E953.8 | Injury-strang/suff NEC | Suicide and self-inflicted injury by other specified means |
| E953.9 | Injury-strang/suff NOS | Suicide and self-inflicted injury by unspecified means |

| | | |
|---|---|---|
| E954. | Injury-submersion | Suicide and self-inflicted injury by submersion [drowning] |
| E955.0 | Injury-handgun | Suicide and self-inflicted injury by handgun |
| E955.1 | Injury-shotgun | Suicide and self-inflicted injury by shotgun |
| E955.2 | Injury-hunting rifle | Suicide and self-inflicted injury by hunting rifle |
| E955.3 | Injury-military firearm | Suicide and self-inflicted injury by military firearms |
| E955.4 | Injury-firearm NEC | Suicide and self-inflicted injury by other and unspecified firearm |
| E955.5 | Injury-explosives | Suicide and self-inflicted injury by explosives |
| E955.6 | Self inflict acc-air gun | Suicide and self-inflicted injury by air gun |
| E955.7 | Self inj-paintball gun | Suicide and self-inflicted injury by paintball gun |
| E955.9 | Injury-firearm/expl NOS | Suicide and self-inflicted injury by firearms and explosives, unspecified |
| E956. | Injury-cut instrument | Suicide and self-inflicted injury by cutting and piercing instrument |
| E957.0 | Injury-jump fm residence | Suicide and self-inflicted injuries by jumping from residential premises |
| E957.1 | Injury-jump fm struc NEC | Suicide and self-inflicted injuries by jumping from other man-made structures |
| E957.2 | Injury-jump fm natur sit | Suicide and self-inflicted injuries by jumping from natural sites |
| E957.9 | Injury-jump NEC | Suicide and self-inflicted injuries by jumping from unspecified site |
| E958.0 | Injury-moving object | Suicide and self-inflicted injury by jumping or lying before moving object |
| E958.1 | Injury-burn, fire | Suicide and self-inflicted injury by burns, fire |
| E958.2 | Injury-scald | Suicide and self-inflicted injury by scald |
| E958.3 | Injury-extreme cold | Suicide and self-inflicted injury by extremes of cold |
| E958.4 | Injury-electrocution | Suicide and self-inflicted injury by electrocution |
| E958.5 | Injury-motor veh crash | Suicide and self-inflicted injury by crashing of motor vehicle |
| E958.6 | Injury-aircraft crash | Suicide and self-inflicted injury by crashing of aircraft |
| E958.7 | Injury-caustic substance | Suicide and self-inflicted injury by caustic substances, except poisoning |
| E958.8 | Injury-NEC | Suicide and self-inflicted injury by other specified means |
| E958.9 | Injury-NOS | Suicide and self-inflicted injury by unspecified means |

**Social anxiety disorder**

| ICD-9 Code | Short Description | Long Description |
|---|---|---|
| 300.23 | Social phobia | Social phobia |

**Anxiety disorders**

| ICD-9 Code | Short Description | Long Description |
|---|---|---|
| 293.84 | Anxiety disorder oth dis | Anxiety disorder in conditions classified elsewhere |
| 300 | Anxiety state NOS | Anxiety state, unspecified |

**Anxiety disorders (except social anxiety)**

| ICD-9 Code | Short Description | Long Description |
|---|---|---|
| 300.01 | Panic dis w/o agorphobia | Panic disorder without agoraphobia |
| 300.02 | Generalized anxiety dis | Generalized anxiety disorder |
| 300.09 | Anxiety state NEC | Other anxiety states |
| 300.1 | Hysteria NOS | Hysteria, unspecified |
| 300.11 | Conversion disorder | Conversion disorder |
| 300.12 | Dissociative amnesia | Dissociative amnesia |
| 300.13 | Dissociative fugue | Dissociative fugue |
| 300.14 | Dissociatve identity dis | Dissociative identity disorder |
| 300.15 | Dissociative react NOS | Dissociative disorder or reaction, unspecified |
| 300.16 | Factitious dis w symptom | Factitious disorder with predominantly psychological signs and symptoms |
| 300.19 | Factitious ill NEC/NOS | Other and unspecified factitious illness |
| 300.2 | Phobia NOS | Phobia, unspecified |
| 300.21 | Agoraphobia w panic dis | Agoraphobia with panic disorder |
| 300.22 | Agoraphobia w/o panic | Agoraphobia without mention of panic attacks |
| 300.29 | Isolated/spec phobia NEC | Other isolated or specific phobias |
| 300.3 | Obsessive-compulsive dis | Obsessive-compulsive disorders |
| 300.4 | Dysthymic disorder | Dysthymic disorder |
| 300.5 | Neurasthenia | Neurasthenia |
| 300.6 | Depersonalization disord | Depersonalization disorder |
| 300.7 | Hypochondriasis | Hypochondriasis |
| 300.81 | Somatization disorder | Somatization disorder |
| 300.82 | Undiff somatoform disrdr | Undifferentiated somatoform disorder |
| 300.89 | Somatoform disorders NEC | Other somatoform disorders |
| 300.9 | Nonpsychotic disord NOS | Unspecified nonpsychotic mental disorder |

**Positive symptoms of schizophrenia (i.e., hallucinations)**

| ICD-9 Code | Short Description | Long Description |
|---|---|---|
| 780.1 | Hallucinations | |
| 293.81 | Psy dis w delus oth dis | Psychotic disorder with delusions in conditions classified elsewhere |
| 333.99 | Extrapyramidal dis NEC | Other extrapyramidal diseases and abnormal movement disorders |

**Bipolar disorders**

| ICD-9 Code | Short Description | Long Description |
|---|---|---|
| 296.5 | Bipol I cur depres NOS | Bipolar I disorder, most recent episode (or current) depressed, unspecified |

| | | |
|---|---|---|
| 296.51 | Bipol I cur depress-mild | Bipolar I disorder, most recent episode (or current) depressed, mild |
| 296.52 | Bipol I cur depress-mod | Bipolar I disorder, most recent episode (or current) depressed, moderate |
| 296.53 | Bipol I curr dep w/o psy | Bipolar I disorder, most recent episode (or current) depressed, severe, without mention of psychotic behavior |
| 296.54 | Bipol I currnt dep w psy | Bipolar I disorder, most recent episode (or current) depressed, severe, specified as with psychotic behavior |
| 296.55 | Bipol I cur dep rem NOS | Bipolar I disorder, most recent episode (or current) depressed, in partial or unspecified remission |
| 296.56 | Bipol I currnt dep remis | Bipolar I disorder, most recent episode (or current) depressed, in full remission |
| 296.6 | Bipol I currnt mixed NOS | Bipolar I disorder, most recent episode (or current) mixed, unspecified |
| 296.61 | Bipol I currnt mix-mild | Bipolar I disorder, most recent episode (or current) mixed, mild |
| 296.62 | Bipol I currnt mixed-mod | Bipolar I disorder, most recent episode (or current) mixed, moderate |
| 296.63 | Bipol I cur mix w/o psy | Bipolar I disorder, most recent episode (or current) mixed, severe, without mention of psychotic behavior |
| 296.64 | Bipol I cur mixed w psy | Bipolar I disorder, most recent episode (or current) mixed, severe, specified as with psychotic behavior |
| 296.65 | Bipol I cur mix-part rem | Bipolar I disorder, most recent episode (or current) mixed, in partial or unspecified remission |
| 296.66 | Bipol I cur mixed remiss | Bipolar I disorder, most recent episode (or current) mixed, in full remission |
| 296.7 | Bipolor I current NOS | Bipolar I disorder, most recent episode (or current) unspecified |
| 296.8 | Bipolar disorder NOS | Bipolar disorder, unspecified |
| 296 | Bipol I single manic NOS | Bipolar I disorder, single manic episode, unspecified |
| 296.01 | Bipol I single manc-mild | Bipolar I disorder, single manic episode, mild |
| 296.02 | Bipol I single manic-mod | Bipolar I disorder, single manic episode, moderate |
| 296.03 | Bipol I sing-sev w/o psy | Bipolar I disorder, single manic episode, severe, without mention of psychotic behavior |
| 296.04 | Bipo I sin man-sev w psy | Bipolar I disorder, single manic episode, severe, specified as with psychotic behavior |
| 296.05 | Bipol I sing man rem NOS | Bipolar I disorder, single manic episode, in partial or unspecified remission |
| 296.06 | Bipol I single manic rem | Bipolar I disorder, single manic episode, in full remission |

| | | |
|---|---|---|
| 296.4 | Bipol I currnt manic NOS | Bipolar I disorder, most recent episode (or current) manic, unspecified |
| 296.41 | Bipol I curnt manic-mild | Bipolar I disorder, most recent episode (or current) manic, mild |
| 296.42 | Bipol I currnt manic-mod | Bipolar I disorder, most recent episode (or current) manic, moderate |
| 296.43 | Bipol I manc-sev w/o psy | Bipolar I disorder, most recent episode (or current) manic, severe, without mention of psychotic behavior |
| 296.44 | Bipol I manic-sev w psy | Bipolar I disorder, most recent episode (or current) manic, severe, specified as with psychotic behavior |
| 296.45 | Bipol I cur man part rem | Bipolar I disorder, most recent episode (or current) manic, in partial or unspecified remission |
| 296.46 | Bipol I cur man full rem | Bipolar I disorder, most recent episode (or current) manic, in full remission |

**Substance dependence or abuse of alcohol, tobacco, and other illicit drugs**

| ICD-9 Code | Short Description | Long Description |
|---|---|---|
| 303.9 | Alcoh dep NEC/NOS-unspec | Other and unspecified alcohol dependence, unspecified |
| 303.91 | Alcoh dep NEC/NOS-contin | Other and unspecified alcohol dependence, continuous |
| 303.92 | Alcoh dep NEC/NOS-episod | Other and unspecified alcohol dependence, episodic |
| 303.93 | Alcoh dep NEC/NOS-remiss | Other and unspecified alcohol dependence, in remission |
| 304 | Opioid dependence-unspec | Opioid type dependence, unspecified |
| 304.01 | Opioid dependence-contin | Opioid type dependence, continuous |
| 304.02 | Opioid dependence-episod | Opioid type dependence, episodic |
| 304.03 | Opioid dependence-remiss | Opioid type dependence, in remission |
| 304.1 | Sed,hyp,anxiolyt dep-NOS | Sedative, hypnotic or anxiolytic dependence, unspecified |
| 304.11 | Sed,hyp,anxiolyt dep-con | Sedative, hypnotic or anxiolytic dependence, continuous |
| 304.12 | Sed,hyp,anxiolyt dep-epi | Sedative, hypnotic or anxiolytic dependence, episodic |
| 304.13 | Sed,hyp,anxiolyt dep-rem | Sedative, hypnotic or anxiolytic dependence, in remission |
| 304.2 | Cocaine depend-unspec | Cocaine dependence, unspecified |
| 304.21 | Cocaine depend-contin | Cocaine dependence, continuous |
| 304.22 | Cocaine depend-episodic | Cocaine dependence, episodic |
| 304.23 | Cocaine depend-remiss | Cocaine dependence, in remission |
| 304.3 | Cannabis depend-unspec | Cannabis dependence, unspecified |
| 304.31 | Cannabis depend-contin | Cannabis dependence, continuous |
| 304.32 | Cannabis depend-episodic | Cannabis dependence, episodic |

| | | |
|---|---|---|
| 304.33 | Cannabis depend-remiss | Cannabis dependence, in remission |
| 304.4 | Amphetamin depend-unspec | Amphetamine and other psychostimulant dependence, unspecified |
| 304.41 | Amphetamin depend-contin | Amphetamine and other psychostimulant dependence, continuous |
| 304.42 | Amphetamin depend-episod | Amphetamine and other psychostimulant dependence, episodic |
| 304.43 | Amphetamin depend-remiss | Amphetamine and other psychostimulant dependence, in remission |
| 304.5 | Hallucinogen dep-unspec | Hallucinogen dependence, unspecified |
| 304.51 | Hallucinogen dep-contin | Hallucinogen dependence, continuous |
| 304.52 | Hallucinogen dep-episod | Hallucinogen dependence, episodic |
| 304.53 | Hallucinogen dep-remiss | Hallucinogen dependence, in remission |
| 304.6 | Drug depend NEC-unspec | Other specified drug dependence, unspecified |
| 304.61 | Drug depend NEC-contin | Other specified drug dependence, continuous |
| 304.62 | Drug depend NEC-episodic | Other specified drug dependence, episodic |
| 304.63 | Drug depend NEC-in rem | Other specified drug dependence, in remission |
| 304.7 | Opioid/other dep-unspec | Combinations of opioid type drug with any other drug dependence, unspecified |
| 304.71 | Opioid/other dep-contin | Combinations of opioid type drug with any other drug dependence, continuous |
| 304.72 | Opioid/other dep-episod | Combinations of opioid type drug with any other drug dependence, episodic |
| 304.73 | Opioid/other dep-remiss | Combinations of opioid type drug with any other drug dependence, in remission |
| 304.8 | Comb drug dep NEC-unspec | Combinations of drug dependence excluding opioid type drug, unspecified |
| 304.81 | Comb drug dep NEC-contin | Combinations of drug dependence excluding opioid type drug, continuous |
| 304.82 | Comb drug dep NEC-episod | Combinations of drug dependence excluding opioid type drug, episodic |
| 304.83 | Comb drug dep NEC-remiss | Combinations of drug dependence excluding opioid type drug, in remission |
| 304.9 | Drug depend NOS-unspec | Unspecified drug dependence, unspecified |
| 304.91 | Drug depend NOS-contin | Unspecified drug dependence, continuous |
| 304.92 | Drug depend NOS-episodic | Unspecified drug dependence, episodic |
| 304.93 | Drug depend NOS-remiss | Unspecified drug dependence, in remission |
| 305 | Alcohol abuse-unspec | Alcohol abuse, unspecified |
| 305.01 | Alcohol abuse-continuous | Alcohol abuse, continuous |
| 305.02 | Alcohol abuse-episodic | Alcohol abuse, episodic |
| 305.03 | Alcohol abuse-in remiss | Alcohol abuse, in remission |
| 305.3 | Hallucinog abuse-unspec | Hallucinogen abuse, unspecified |
| 305.31 | Hallucinog abuse-contin | Hallucinogen abuse, continuous |
| 305.32 | Hallucinog abuse-episod | Hallucinogen abuse, episodic |
| 305.33 | Hallucinog abuse-remiss | Hallucinogen abuse, in remission |

| | | |
|---|---|---|
| 305.4 | Sed,hyp,anxiolytc ab-NOS | Sedative, hypnotic or anxiolytic abuse, unspecified |
| 305.41 | Sed,hyp,anxiolytc ab-con | Sedative, hypnotic or anxiolytic abuse, continuous |
| 305.42 | Sed,hyp,anxiolytc ab-epi | Sedative, hypnotic or anxiolytic abuse, episodic |
| 305.43 | Sed,hyp,anxiolytc ab-rem | Sedative, hypnotic or anxiolytic abuse, in remission |
| 305.5 | Opioid abuse-unspec | Opioid abuse, unspecified |
| 305.51 | Opioid abuse-continuous | Opioid abuse, continuous |
| 305.52 | Opioid abuse-episodic | Opioid abuse, episodic |
| 305.53 | Opioid abuse-in remiss | Opioid abuse, in remission |
| 305.6 | Cocaine abuse-unspec | Cocaine abuse, unspecified |
| 305.61 | Cocaine abuse-continuous | Cocaine abuse, continuous |
| 305.62 | Cocaine abuse-episodic | Cocaine abuse, episodic |
| 305.63 | Cocaine abuse-in remiss | Cocaine abuse, in remission |
| 305.7 | Amphetamine abuse-unspec | Amphetamine or related acting sympathomimetic abuse, unspecified |
| 305.71 | Amphetamine abuse-contin | Amphetamine or related acting sympathomimetic abuse, continuous |
| 305.72 | Amphetamine abuse-episod | Amphetamine or related acting sympathomimetic abuse, episodic |
| 305.73 | Amphetamine abuse-remiss | Amphetamine or related acting sympathomimetic abuse, in remission |
| 305.8 | Antidepress abuse-unspec | Antidepressant type abuse, unspecified |
| 305.81 | Antidepress abuse-contin | Antidepressant type abuse, continuous |
| 305.82 | Antidepress abuse-episod | Antidepressant type abuse, episodic |
| 305.83 | Antidepress abuse-remiss | Antidepressant type abuse, in remission |

**Cannabis abuse**

| ICD-9 Code | Short Description | Long Description |
|---|---|---|
| 305.2 | Cannabis abuse-unspec | Cannabis abuse, unspecified |
| 305.21 | Cannabis abuse-contin | Cannabis abuse, continuous |
| 305.22 | Cannabis abuse-episodic | Cannabis abuse, episodic |
| 305.23 | Cannabis abuse-in remiss | Cannabis abuse, in remission |

**Tobacco use**

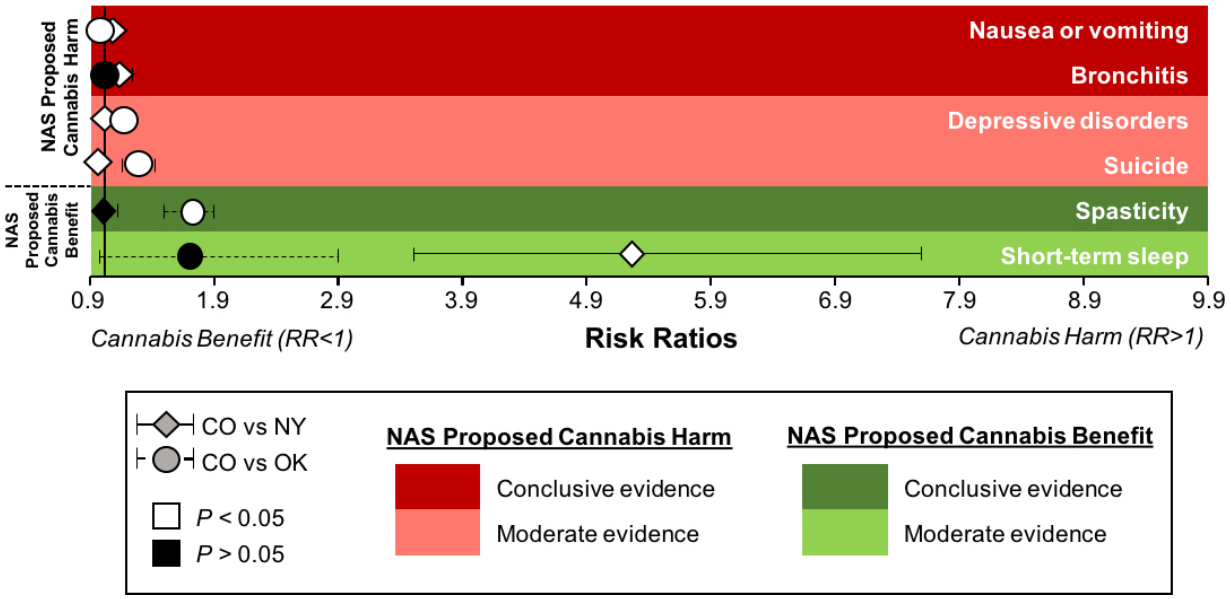
| ICD-9 Code | Short Description | Long Description |
|---|---|---|
| 305.1 | Tobacco use disorder | Tobacco use disorder |

**Alcohol abuse**

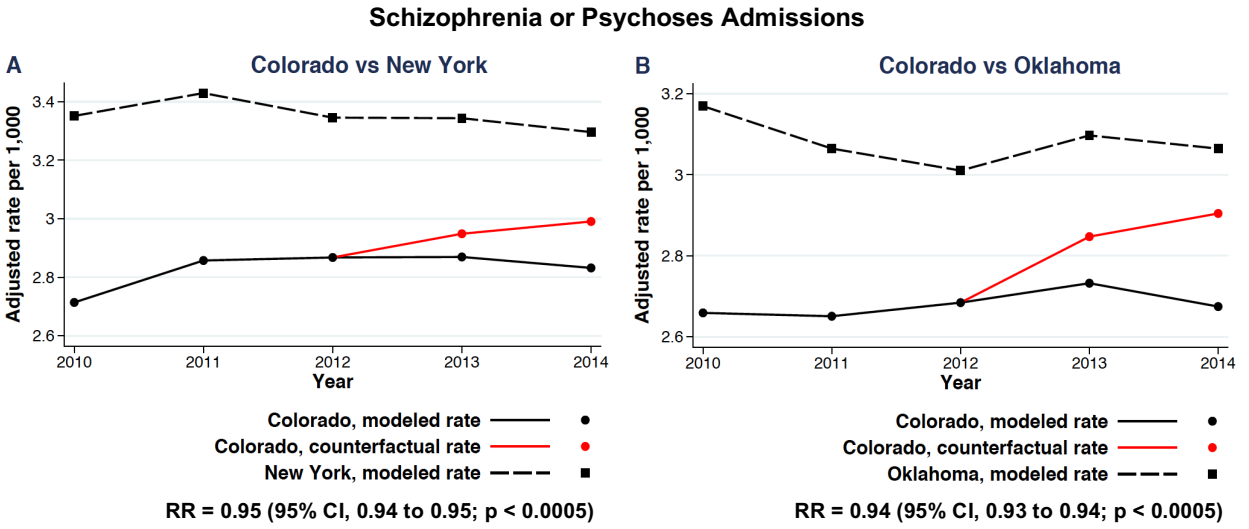
| ICD-9 Code | Short Description | Long Description |
|---|---|---|
| 303.9 | Alcoh dep NEC/NOS-unspec | Other and unspecified alcohol dependence, unspecified |
| 303.91 | Alcoh dep NEC/NOS-contin | Other and unspecified alcohol dependence, continuous |
| 303.92 | Alcoh dep NEC/NOS-episod | Other and unspecified alcohol dependence, episodic |

| | | |
|---|---|---|
| 303.93 | Alcoh dep NEC/NOS-remiss | Other and unspecified alcohol dependence, in remission |

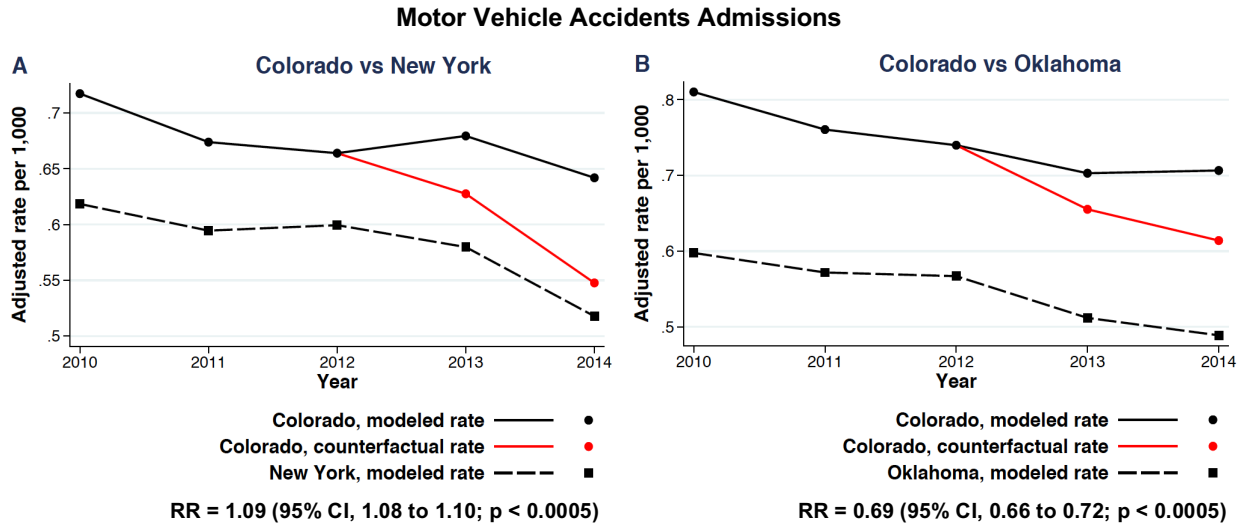
**eFigure 1.** Health outcomes with substantial or moderate evidence of a statistical association with cannabis use based on the National Academy of Science (NAS) summary statement. Medical diagnoses are identified based on a significant (P<0.05) comparison between New York (NY) and Oklahoma (OK) (control states without cannabis legalization) with regards to the change of admission rates for such diagnoses following cannabis legalization. P values for the comparison between Colorado (CO) (site of cannabis legalization) and NY (rhomboid symbol), or between CO and OK (circular symbol) are shown as either <0.05, or >0.05 using a gray scale for evidence of cannabis benefit (risk ratio [RR] < 1 shown on the left) and cannabis harm (RR>1 shown on the right); 95% confidence intervals are shown for the comparison between CO and NY and between CO and OK as solid and dotted lines, respectively. Progressively darker shades of green or red indicate greater weight of evidence in the direction of proposed benefit versus harm, respectively, by the NAS.



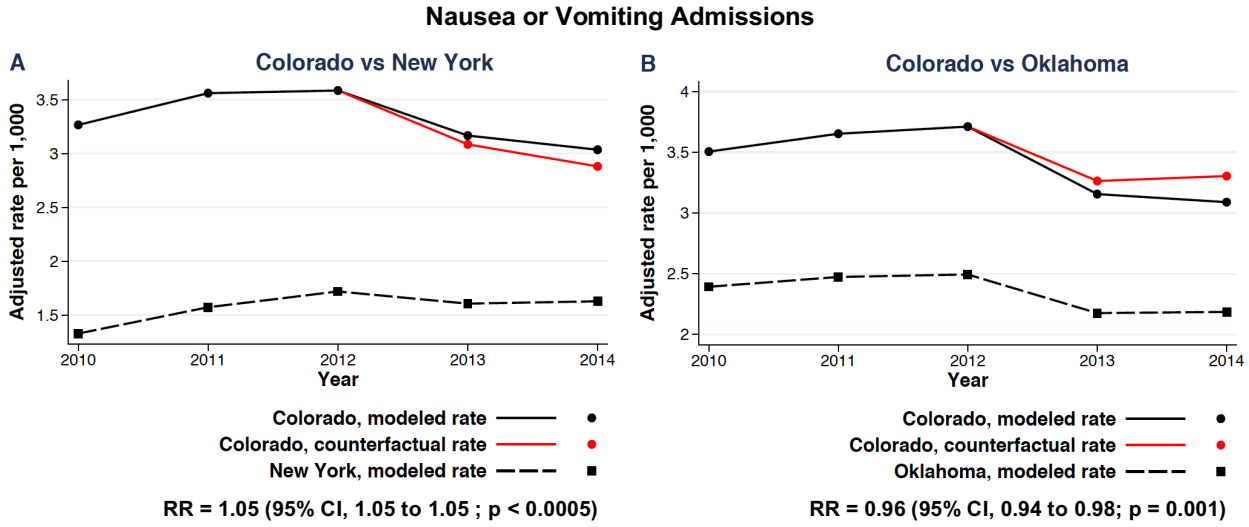
**eFigure 2.** Multivariate adjusted rates of total hospital admissions over 2010-2014 in Colorado, site of implementation of the 2012 recreational cannabis legalization policy, compared with New York (A) and Oklahoma (B), control states without cannabis legalization. Red lines show the predicted rates of admissions for schizophrenia or other psychoses (and all remaining medical diagnoses plotted in eFigures 2-15) had the cannabis legalization policy not been instituted. RR = risk ratio; CI = confidence interval.



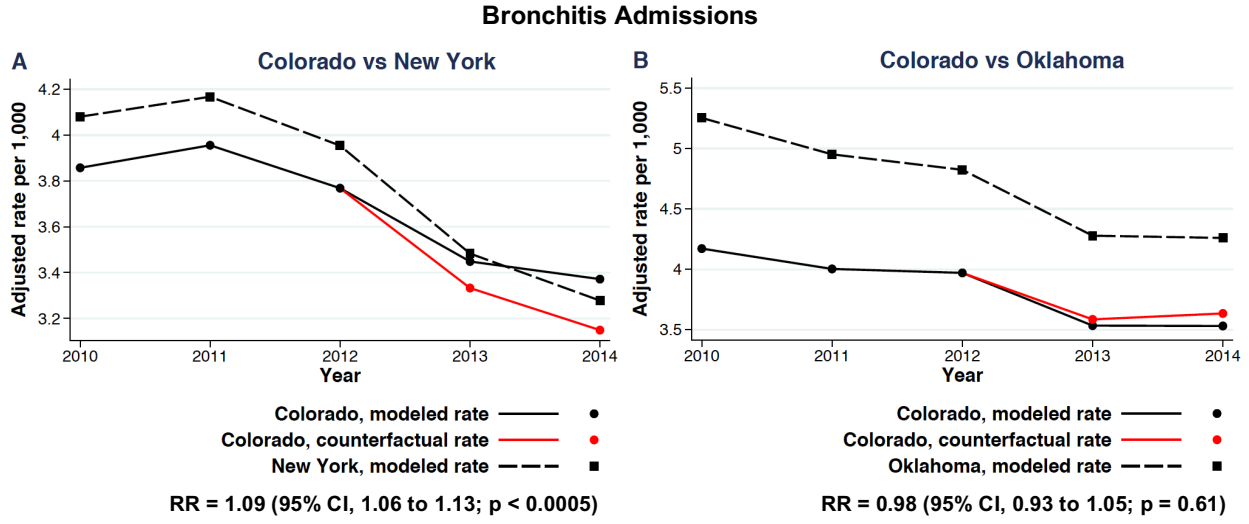

**eFigure 3.** Multivariate adjusted rates of admissions for motor vehicle accidents over 2010-2014 in Colorado compared with New York (A) and Oklahoma (B). RR = risk ratio; CI = confidence interval.



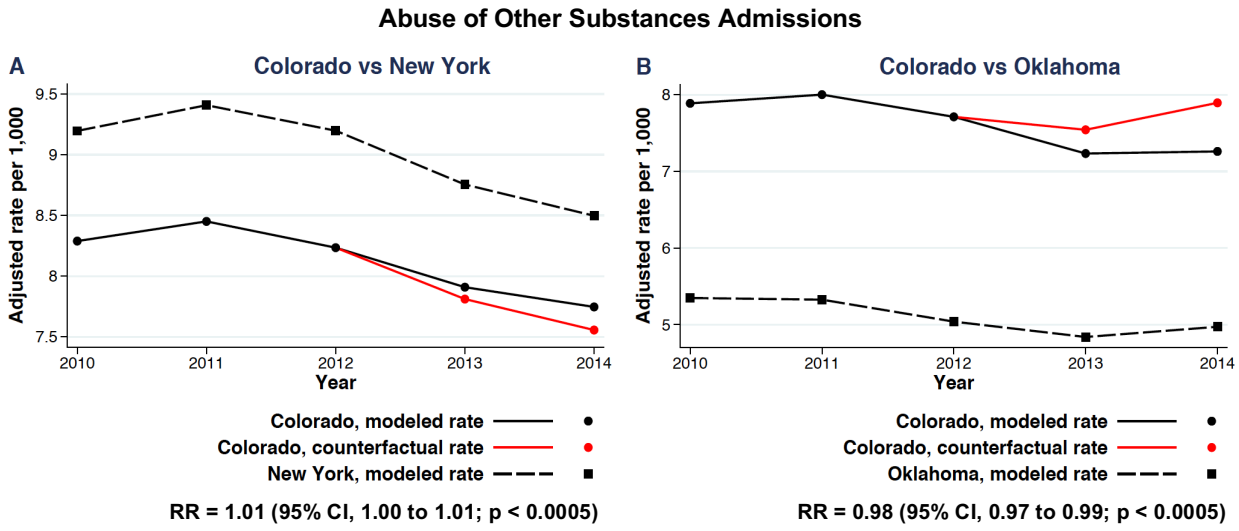
**eFigure 4.** Multivariate adjusted rates of admissions for nausea or vomiting over 2010-2014 in Colorado compared with New York (A) and Oklahoma (B). RR = risk ratio; CI = confidence interval.



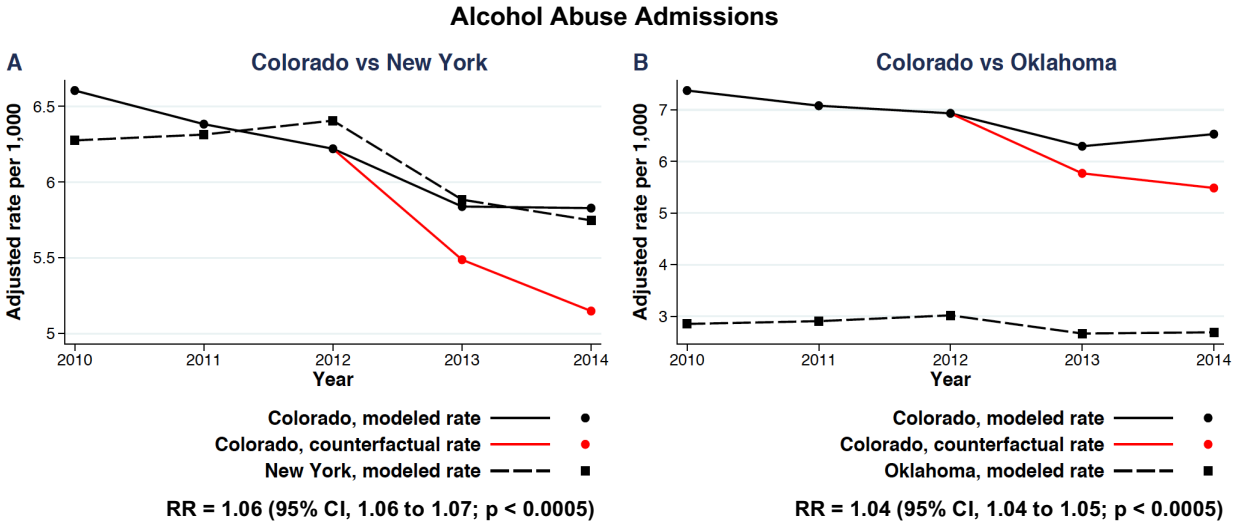

**eFigure 5.** Multivariate adjusted rates of admissions for bronchitis over 2010-2014 in Colorado compared with New York (A) and Oklahoma (B). RR = risk ratio; CI = confidence interval.



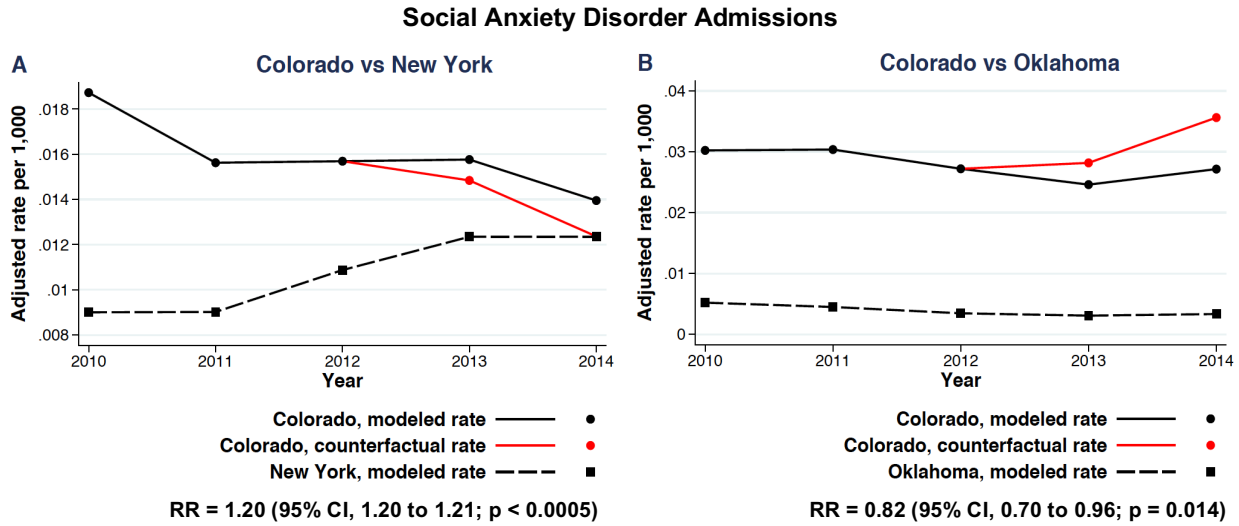
**eFigure 6.** Multivariate adjusted rates of admissions for abuse of other substances over 2010-2014 in Colorado compared with New York (A) and Oklahoma (B). RR = risk ratio; CI = confidence interval.



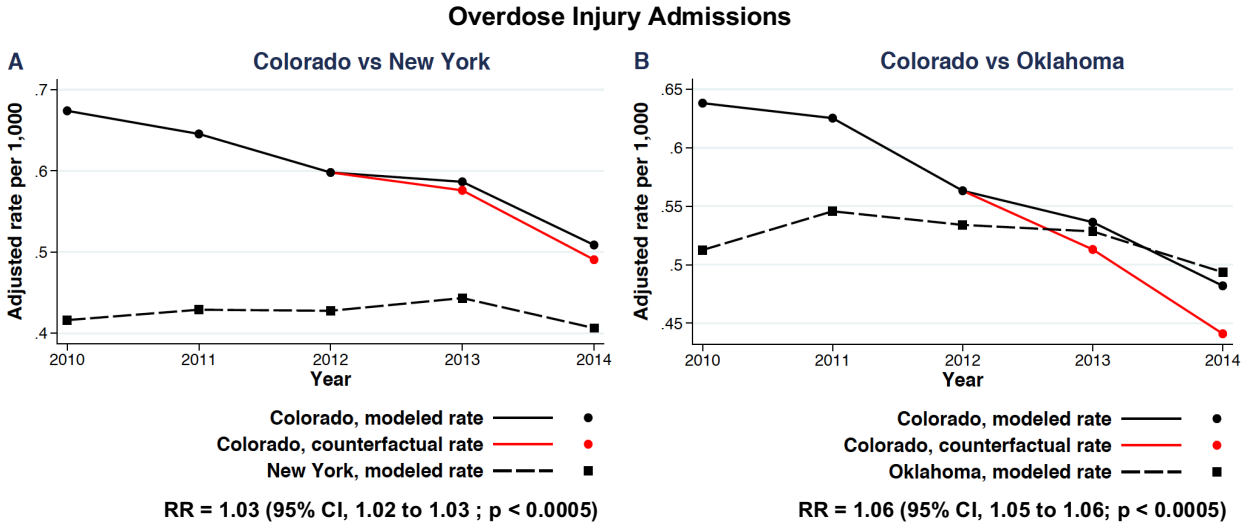

**eFigure 7.** Multivariate adjusted rates of admissions for alcohol abuse over 2010-2014 in Colorado compared with New York (A) and Oklahoma (B). RR = risk ratio; CI = confidence interval.



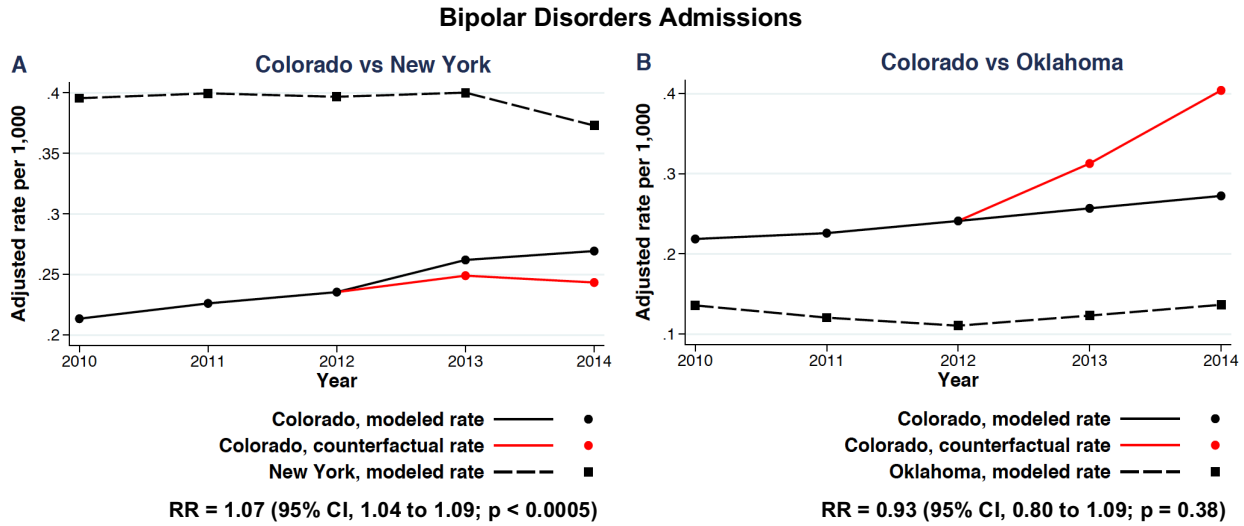
**eFigure 8.** Multivariate adjusted rates of admissions for social anxiety disorder over 2010-2014 in Colorado compared with New York (A) and Oklahoma (B). RR = risk ratio; CI = confidence interval.



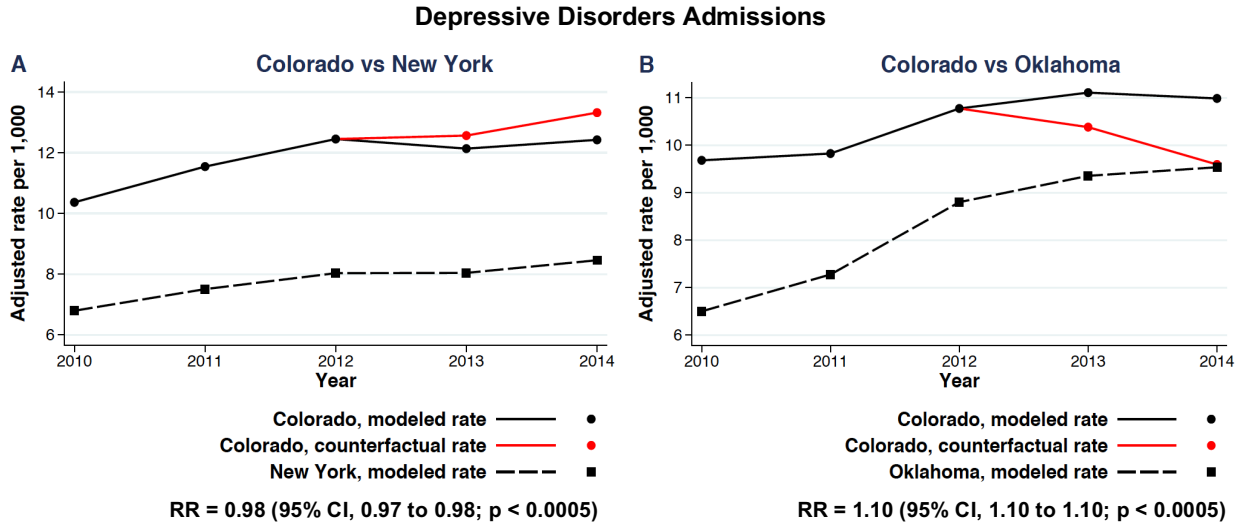

**eFigure 9.** Multivariate adjusted rates of admissions for overdose injury over 2010-2014 in Colorado compared with New York (A) and Oklahoma (B). RR = risk ratio; CI = confidence interval.



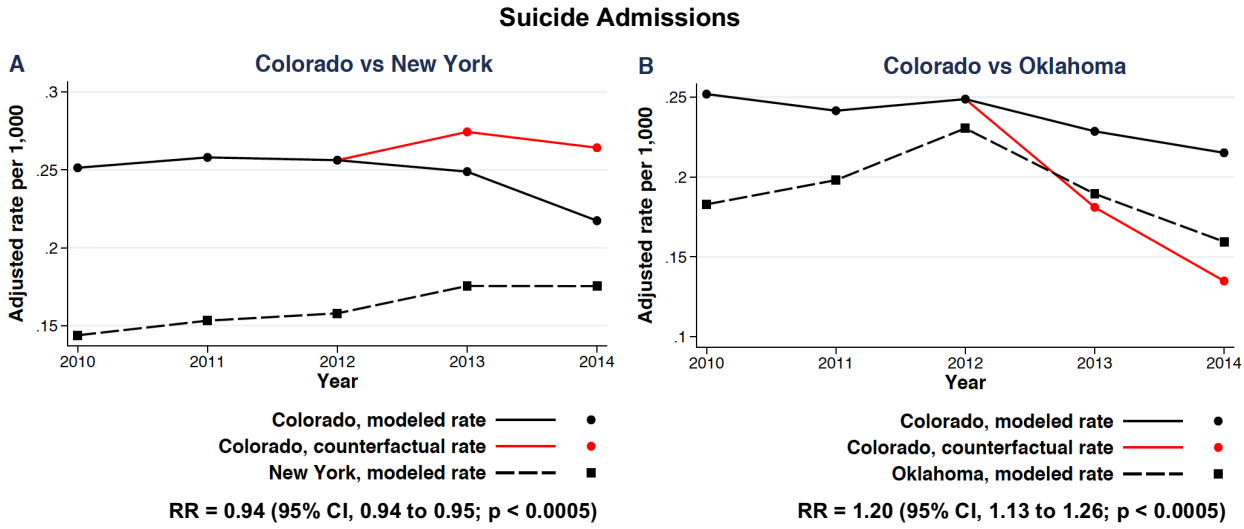
**eFigure 10.** Multivariate adjusted rates of admissions for bipolar disorders over 2010-2014 in Colorado compared with New York (A) and Oklahoma (B). RR = risk ratio; CI = confidence interval.



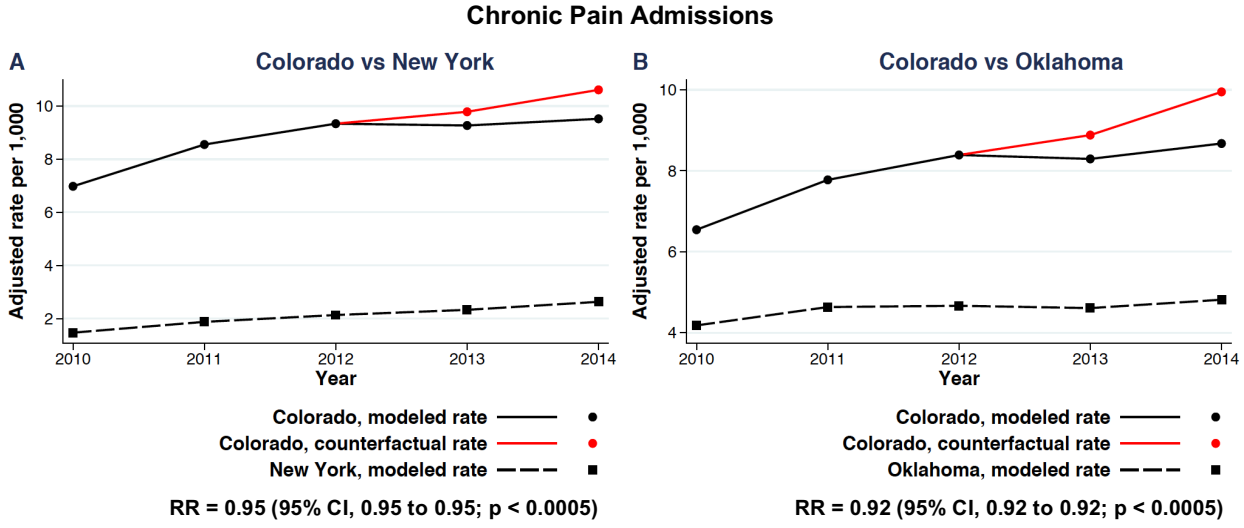

**eFigure 11.** Multivariate adjusted rates of admissions for depressive disorders over 2010-2014 in Colorado compared with New York (A) and Oklahoma (B). RR = risk ratio; CI = confidence interval.



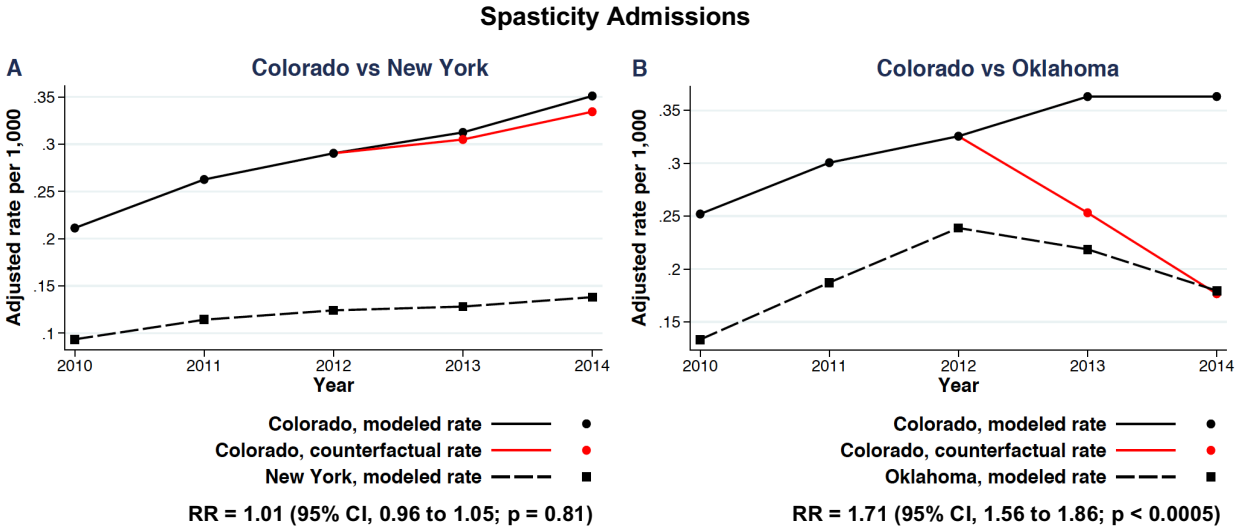
**eFigure 12.** Multivariate adjusted rates of admissions for suicide over 2010-2014 in Colorado compared with New York (A) and Oklahoma (B). RR = risk ratio; CI = confidence interval.



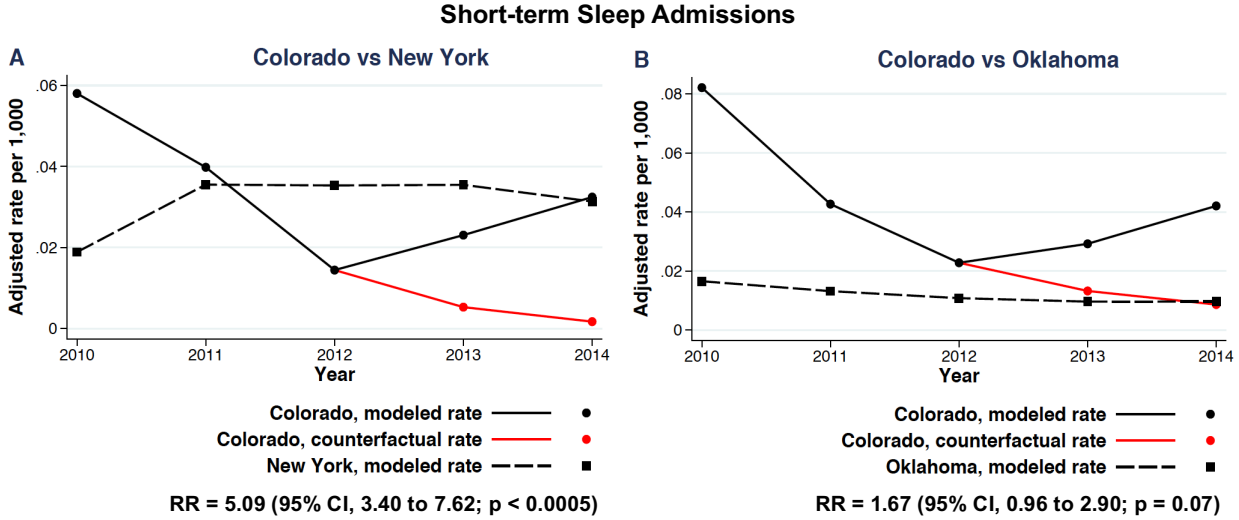

**eFigure 13.** Multivariate adjusted rates of admissions for chronic pain over 2010-2014 in Colorado compared with New York (A) and Oklahoma (B). RR = risk ratio; CI = confidence interval.



**eFigure 14.** Multivariate adjusted rates of admissions for spasticity over 2010-2014 in Colorado compared with New York (A) and Oklahoma (B). RR = risk ratio; CI = confidence interval.




**eFigure 15.** Multivariate adjusted rates of admissions for short-term sleep disorders over 2010-2014 in Colorado compared with New York (A) and Oklahoma (B). RR = risk ratio; CI = confidence interval.



**eTable 3.** Changes in specific NAS outcomes in a sensitivity analysis using January 2014 as the date of recreational cannabis legalization

| NAS Outcome | State Comparisons | RR | 95% CI | P value |
|---|---|---|---|---|
| Motor vehicle accidents | CO vs NY | 1.22 | (1.16, 1.28) | <0.0005 |
| | CO vs OK | 1.18 | (1.02, 1.37) | 0.026 |
| | NY vs OK | 1.04 | (0.77, 1.40) | 0.81 |
| Overdose injury | CO vs NY | 1.11 | (1.09, 1.14) | <0.0005 |
| | CO vs OK | 1.03 | (0.98, 1.09) | 0.25 |
| | NY vs OK | 0.98 | (0.80, 1.19) | 0.81 |
| Bipolar disorders | CO vs NY | 1.08 | (1.06, 1.09) | <0.0005 |
| | CO vs OK | 0.81 | (0.73, 0.90) | <0.0005 |
| | NY vs OK | 0.77 | (0.75, 0.78) | <0.0005 |
| Depressive disorders | CO vs NY | 1.01 | (0.99, 1.03) | 0.59 |
| | CO vs OK | 1.23 | (1.20, 1.25) | <0.0005 |
| | NY vs OK | 1.16 | (1.07, 1.26) | <0.0005 |
| Schizophrenia or psychoses | CO vs NY | 0.84 | (0.82, 0.86) | <0.0005 |
| | CO vs OK | 0.80 | (0.79, 0.80) | <0.0005 |
| | NY vs OK | 0.88 | (0.87, 0.90) | <0.0005 |
| Social anxiety disorder | CO vs NY | 1.45 | (1.43, 1.48) | <0.0005 |
| | CO vs OK | 0.58 | (0.47, 0.71) | <0.0005 |
| | NY vs OK | 0.46 | (0.29, 0.74) | 0.001 |
| Suicide | CO vs NY | 1.09 | (1.03, 1.15) | 0.002 |
| | CO vs OK | 1.26 | (1.12, 1.41) | <0.0005 |
| | NY vs OK | 1.11 | (1.04, 1.18) | 0.001 |
| Bronchitis | CO vs NY | 1.19 | (1.15, 1.23) | <0.0005 |
| | CO vs OK | 1.03 | (0.97, 1.10) | 0.33 |
| | NY vs OK | 0.82 | (0.78, 0.87) | <0.0005 |
| Abuse of other substances | CO vs NY | 1.04 | (1.03, 1.05) | <0.0005 |
| | CO vs OK | 0.99 | (0.97, 1.01) | 0.45 |
| | NY vs OK | 0.94 | (0.90, 0.98) | 0.007 |
| Nausea or vomiting | CO vs NY | 1.08 | (1.06, 1.10) | <0.0005 |
| | CO vs OK | 0.95 | (0.97, 1.01) | <0.0005 |
| | NY vs OK | 0.89 | (0.90, 0.98) | 0.01 |
| Chronic pain | CO vs NY | 0.94 | (0.93, 0.96) | <0.0005 |
| | CO vs OK | 0.92 | (0.91, 0.93) | <0.0005 |
| | NY vs OK | 0.93 | (0.90, 0.96) | <0.0005 |
| Spasticity | CO vs NY | 0.75 | (0.71, 0.79) | <0.0005 |
| | CO vs OK | 1.56 | (1.14, 2.14) | 0.006 |
| | NY vs OK | 2.12 | (1.64, 2.76) | <0.0005 |
| Short-term sleep | CO vs NY | 11.7 | (7.36, 18.59) | <0.0005 |
| | CO vs OK | 3.44 | (1.32, 8.99) | 0.012 |
| | NY vs OK | 0.45 | (0.06, 3.22) | 0.42 |

STROBE Statement—Checklist of items that should be included in reports of ***cohort studies***

| | Item No | Recommendation | Page No |
|---|---|---|---|
| **Title and abstract** | 1 | (*a*) Indicate the study's design with a commonly used term in the title or the abstract | 1 |
| | | (*b*) Provide in the abstract an informative and balanced summary of what was done and what was found | 2 |
| **Introduction** | | | |
| Background/rationale | 2 | Explain the scientific background and rationale for the investigation being reported | 5 |
| Objectives | 3 | State specific objectives, including any prespecified hypotheses | 5 |
| **Methods** | | | |
| Study design | 4 | Present key elements of study design early in the paper | 6, 7, 8 |
| Setting | 5 | Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection | 6, 7, 8 |
| Participants | 6 | (*a*) Give the eligibility criteria, and the sources and methods of selection of participants. Describe methods of follow-up | 6, 7 |
| | | (*b*) For matched studies, give matching criteria and number of exposed and unexposed | |
| Variables | 7 | Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable | 6, 7, 8 |
| Data sources/ measurement | 8* | For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group | 6, 7, 8 |
| Bias | 9 | Describe any efforts to address potential sources of bias | 7, 8 |
| Study size | 10 | Explain how the study size was arrived at | 6, 7 |
| Quantitative variables | 11 | Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why | 7, 8 |
| Statistical methods | 12 | (*a*) Describe all statistical methods, including those used to control for confounding | 9, 10 |
| | | (*b*) Describe any methods used to examine subgroups and interactions | |
| | | (*c*) Explain how missing data were addressed | 6, 7 |
| | | (*d*) If applicable, explain how loss to follow-up was addressed | |
| | | (*e*) Describe any sensitivity analyses | 8, 10 |
| **Results** | | | |
| Participants | 13* | (a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed | 11 |
| | | (b) Give reasons for non-participation at each stage | |
| | | (c) Consider use of a flow diagram | |
| Descriptive data | 14* | (a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders | 11, 12, 13 |
| | | (b) Indicate number of participants with missing data for each variable of interest | |
| | | (c) Summarise follow-up time (eg, average and total amount) | |
| Outcome data | 15* | Report numbers of outcome events or summary measures over time | 13, 14 |

| | | | |
|---|---|---|---|
| Main results | 16 | (*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were adjusted for and why they were included<br>(*b*) Report category boundaries when continuous variables were categorized<br>(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period | 11-14 |
| Other analyses | 17 | Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses | 12, 14 |
| **Discussion** | | | |
| Key results | 18 | Summarise key results with reference to study objectives | 14-16 |
| Limitations | 19 | Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias | 17-19 |
| Interpretation | 20 | Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence | 14-19 |
| Generalisability | 21 | Discuss the generalisability (external validity) of the study results | 20 |
| **Other information** | | | |
| Funding | 22 | Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based | 21 |

*Give information separately for exposed and unexposed groups.

**Note:** An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at http://www.strobe-statement.org.