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THE SPILLOVER EFFECTS OF OPIOID POLICIES
ON INTIMATE PARTNER VIOLENCE

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ABSTRACT

Intimate partner violence (IPV) is the most common form of violence experienced by women, and imposes adverse health consequences for victims and their children. The annual economic burden of IPV amounts to over $4.1 trillion, a substantial share of which is borne by the public sector. Despite documented associations pointing to partner violence and substance abuse being intertwined public health issues, we know very little about this connection when it comes to opioids. We address this knowledge gap, and provide the first study of the downstream effects of a key supply-side intervention – the abuse-deterrent reformulation of one of the most widely diverted opioids, OxyContin – on intimate partner violence. Capitalizing on administrative data on reported incidents by female victims to law enforcement combined with a quasi-experimental research design, we find robust evidence that the reformulation led to a significant decline in IPV exposure by females. Heterogeneity analyses suggest that sub-populations (non-Hispanic Whites; younger adults) and localities (lower-educated; high poverty) which experienced higher rates of opioid prescribing and misuse at baseline, accrued the largest benefits in terms of lower IPV rates. The overall decline in IPV, however, masks a notable uptick in heroin-involved IPV, underscoring the importance of identifying populations at a higher risk of substitution to illicit opioids post-reformulation and mitigating this risk with evidence-based policies.

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Intimate partner violence (IPV) is a significant public health problem, being the most common form of violence experienced by women and imposing adverse consequences for the health of the victims and their children.[1] According to the most recent data from the National Intimate Partner and Sexual Violence Survey (NISVS), 6.6 percent of women in the United States report experiencing IPV in the past 12 months, reaching a lifetime prevalence of 37 percent. An important risk factor associated with IPV perpetration is substance abuse, which can trigger aggressive behavior and worsen impulse control problems.[2] With the U.S. facing an epidemic of opioid misuse and overdose, one particular concern voiced by public health experts relates to the role that opioid misuse plays in facilitating IPV (Warshaw et al. 2014; Packard and Warshaw 2018).[3] While increasing trends in opioid misuse are causing a serious public health crisis across the U.S., their consequences for IPV have not been explored systematically.

In this paper, we address these knowledge gaps and shed light on the effects of opioid misuse on IPV by studying the reformulation of the main legal opiate—OxyContin—into an abuse-deterrent form in 2010, a major supply-side intervention implemented in the U.S. to curb excessive prescription of opioids and reduce their addictive potential. We provide the first study on the spillover effects of the OxyContin reformulation on domestic violence and abuse by intimate partners. To do so, we combine IPV data from the National Incident-Based Reporting System (NIBRS) from 2006 to 2019, which includes incident-based reports to law enforcement agencies that were compiled and sent to the FBI, with county-level mean opioid prescriptions prior to 2010, the year in which OxyContin was reformulated. We

[1]Experiencing abuse by an intimate partner can have profound short-term and long-term physical and mental health effects, including injuries, depression, anxiety, other trauma-related mental health conditions, unwanted pregnancies, and sexually transmitted diseases, and can also lead to death (World Health Organization 2013). Over one-half of female homicide victims, where the perpetrator is known, are killed by a current or former intimate partner in the United States (Ertl et al. 2019).

[2]A large body of empirical studies document a positive correlation between substance misuse and IPV. Most of these studies focus primarily on alcohol use (Castilla and Murphy 2022; Chalfin et al. 2021), noting that alcohol may heighten stress in the household (Angelucci and Heath 2020) and reduce self-control behaviors (Schilbach 2019), which may act as mechanisms that increase the risk of IPV perpetration.

[3]A recent review finds that among men using opioids, the prevalence of IPV perpetration ranged from 15% (past year severe/physical IPV) to 58% (lifetime prevalence of any IPV); opioid use also raises the risk of being a victim of IPV, with 32-75% of women, who had used opioids, reporting victimization in the past year (Stone and Rothman 2019).

then employ a difference-in-differences (DID) identification strategy to examine whether counties that were more exposed to prescription opioids prior to reformulation experienced differential changes in IPV outcomes after the OxyContin reformulation. We include controls for counties' time-varying demographic, health and economic attributes, and fixed effects that capture time-invariant characteristics of counties and aggregate shocks that affect all counties in a particular year.

We find that the reformulation of OxyContin into an abuse-deterrent form led to a significant relative decline in the rate of IPV experienced by women in counties with greater exposure to prescription opioids prior to reformulation. We show that these declines occur after the policy change, and that these effects are present primarily among non-Hispanic Whites. The coefficient estimates imply that a one standard deviation increase in pre-reformulation exposure yields a relative decrease of 6.2 percent annually in the IPV rate following OxyContin's reformulation. The results from heterogeneity analyses indicate that sub-populations (non-Hispanic Whites; younger adults) and localities (lower-educated; high-poverty) which experienced higher rates of opioid prescribing and misuse at baseline, accrued the largest benefits in terms of lower IPV rates. We also document corollary declines in injuries and arrests related to IPV (6.1 percent and 4.3 percent, respectively), implying an actual decline in incidence instead of a shift in reporting behaviors. The overall decline in IPV, however, masks a a significant uptick in IPV incidents where the perpetrator was suspected of using heroin, particularly in more urban areas. These findings highlight the importance of identifying populations at a higher risk of substitution to illicit opioids post-reformulation and mitigating this risk with evidence-based policies.

We show that our findings are robust to the inclusion of state policies with the potential to affect opioid use and IPV prevalence. In addition, we find that results are similar when we account for unobserved regional trends, differences in police deployment across counties, and they also hold when sample is adjusted to ensure data quality for reported incidents.

We make several contributions to the existing literature. First, we show that the reformulation of one of the most widely diverted prescription opioids resulted in a significant overall decline in women's risk of exposure to intimate partner abuse. Despite the well-known associations, most of the previous studies that document the relationship between opioid misuse and IPV are based on small sample sizes and fail to account for reverse causality (Jessell et al. 2017; Hughes et al. 2019; Stone and Rothman 2019; Pryor et al. 2021). As unobservables, such as early life trauma, childhood circumstances, and socioeconomic shocks, might affect both opioid misuse and IPV risk, establishing a causal relationship has been difficult. Our empirical setup allows us to estimate the effects of an exogenous supply-side intervention targeting opioid misuse – the abuse-deterrent reformulation of OxyContin – on the risk of IPV victimization.

Second, our study contributes to the literature on the opioid crisis, and relates to recent studies focusing on the effects of interventions targeting opioid use on child maltreatment and foster care admissions. Using county-level data on referrals to state child protective services agencies, Evans et al. (2022) find that counties with greater initial rates of prescription opioid usage experienced an increase in child maltreatment after OxyContin reformulation. On the other hand, using a state-level analysis, Gihleb et al. (2022) find that must-access Prescription Drug Monitoring Programs (PDMPs) reduce entry into foster care. Previous studies have also examined the effects of other types of substance use (e.g., methamphetamine, alcohol) on foster care admissions (Cunningham and Finlay 2013; Markowitz et al. 2014). By examining the spillover impacts of a major supply-side intervention on violence towards women, our study adds to the evidence base on the broader impacts of such policies on families.

Finally, we contribute to the growing literature on several factors that affect the incidence of IPV. Most of these studies have focused on economic shocks or other policies that may impact women's bargaining power by documenting the effects of cash transfers (Bobonis et al. 2013; Angelucci 2008), labor market shocks (Aizer 2010; Anderberg et al. 2016), education (Erten and Keskin 2018), divorce laws (Stevenson and Wolfers 2006) and trade shocks (Erten and Keskin 2021) on the risk of IPV. Evidence on the causal impacts of substance use on IPV is rare, and almost exclusively focuses on alcohol use. Using a randomized control trial that mitigates alcohol consumption in rural Kenya, Castilla et al. (2022) find that the reductions in alcohol use substantially lowers sexual violence with no significant changes in physical or emotional violence toward partners. We address this important gap in the literature by providing evidence on the impacts of reducing access to one of the most widely diverted opioids, OxyContin (Inciardi et al. 2007), on IPV victimization.

This paper is organized as follows. Section 1 provides a brief description of the OxyContin reformulation and the data used for the analysis. Section 2 presents the identification strategy and the empirical results. Section 3 concludes with a discussion of our findings.

1 Background and Data

1.1 Introduction of OxyContin Reformulation

Globally, an estimated 26.8 million individuals suffered from an opioid use disorder (OUD) in 2016, with North America having the highest prevalence (Degenhardt and Hall 2012). The North American crisis largely emerged as a consequence of inadequate regulation of pharmaceutical and health care industries that facilitated over-prescriptions of extremely potent opioids (National Academies of Sciences, Engineering, and Medicine and others 2017; Humphreys et al. 2022). In the US, the number of opioid prescriptions nearly quadrupled from 76 million in 1991 to over 250 million in 2010 (Volkow 2014). During this period, Purdue Pharma–the company that released OxyContin in 1996–invested heavily in advertising campaigns to increase the use of opioids for treating chronic non-cancer pain (Boudreau et al. 2009; Alpert et al. 2022). Purdue also advocated for the long-term use of OxyContin with gradually higher doses. However, OxyContin was highly addictive due to its formulation as a potent opioid containing oxycodone, which directly interacted with the brain's opioid receptors, leading to feelings of euphoria and pain relief. Moreover, if the pill was tampered with by crushing or dissolving, it could release a large dose of oxycodone all at once, intensifying the pleasurable effects and increasing the risk of addiction (Van Zee

2009).

In order to address the misuse of OxyContin and its diversion to illicit markets, Purdue Pharma developed an abuse deterrent formulation (ADF) of the drug that was designed to be harder to crush or dissolve. The revised version received approval from the Food and Drug Administration (FDA) in April 2010. Purdue Pharma subsequently began distributing the new formulation while discontinuing the shipment of the previous formulation in August 2010. The reformulation successfully reduced prescription opioid abuse, specifically involving OxyContin (Butler et al. 2013). As Figure 1 shows, annual opioid prescribing rates leveled off from 2010 to 2012 and then consistently declined subsequently.

While the reformulation has been found to be effective in reducing Rx opioid prescribing and misuse/overdose related to Rx opioids (Hwang et al. 2015; Evans et al. 2019; Coplan et al. 2016), several studies also find evidence of substitution from licit Rx opioids into illicit opioids such as heroin and synthetics (fentanyl), leading to an increase in overdoses related to these drugs post-reformulation (Evans et al. 2019; Powell and Pacula 2021).[4] A recent study has also documented an increase in child physical abuse and neglect after OxyContin's reformulation in impacted counties (Evans et al. 2022). In this study, we examine how the reformulation of OxyContin, and the resulting shift in opioid use from licit Rx to illicit opioids, such as heroin and fentanyl, has affected IPV. In the process, we provide some of the first causal evidence on how the opioid crisis and a key supply-side intervention have intersected with one of the most common forms of violence against women.

1.2 IPV data

Our empirical analysis leverages police-reported intimate partner violence (IPV) incidents recorded in the National Incident-Based Reporting System (NIBRS) from 2006 to 2019. NIBRS is a system that U.S. law enforcement agencies had voluntarily used to report

[4]For a comprehensive review of the literature on quasi-experimental evidence on the effects of opioid policies on health and crime outcomes, see Maclean et al. (2022). Several studies have also examined the effects of mandatory access Prescription Drug Monitoring Programs (PDMPs) on heroin use, crime, and mortality (Meinhofer 2018; Mallatt 2018; Dave et al. 2021; Kim 2021).

incident-based crime data. The FBI's Uniform Crime Reporting Program retired its traditional Summary Reporting System, and has now fully transitioned to the NIBRS. Each report in the NIBRS contains detailed information about the characteristics of the victim (age, gender, race, ethnicity, and relationship to the offender), the offender (age, gender, race, ethnicity, and whether they were suspected of using substances, including heroin), and the incident itself (date/time, injuries, arrests). This dataset represents an advancement over individual survey data as it is less reliant on self-reports, has been consistently collected over a prolonged period, and permits us to identify if an offender was suspected of using opioids.

We examine IPV experienced by female victims, including relationships that consist of spouses, common-law spouses, boyfriends/girlfriends, homosexual partners, ex-spouses, and ex-boyfriends/girlfriends. The incidents considered are aggravated assaults, simple assaults, forced sex, and intimidation. The annual IPV rate per 1,000 population at the county level forms our primary metric. We use a balanced panel of county-level data from 2006-2019 comprising over 9,000 reporting agencies. County-level granularity allows us to examine the heterogeneous effects of the OxyContin reformulation on counties with varying levels of pre-reformulation exposure to prescription opioids.

Appendix Table A1 provides summary statistics for outcomes of interest, mean opioid prescriptions pre-reformulation, and control variables used in our analysis. The average county had an IPV incident rate of 2.6 per 1,000 population annually, with 49 percent of these incidents resulting in injuries and arrests. Figure 1 illustrates that the annual IPV rate in the US followed a declining trend during our sample period from slightly over 2.7 per 1,000 in 2006 to almost 2.3 per 1,000 in 2019.

1.3 Data on opioid prescriptions and county-level covariates

Our primary explanatory variable of interest—the pre-reformulation exposure to prescription opioids—is measured by the population-weighted average number of Schedule II opioid prescriptions per capita by county from 2006 to 2009 following Evans et al. (2022).

These data are reported by the Centers for Disease Control (CDC).

In addition, we use multiple data sources to account for time-varying county characteristics that could influence the outcomes of interest. We incorporate demographic information, including each county's racial and age composition, from the Surveillance, Epidemiology, and End Results (SEER) Program, which compiles data from the U.S. Census Bureau. These data include the percentages of each county's Black, White, and Hispanic populations, as well as the percentages of the population within different age brackets: 0-19, 20-24, 25-34, 35-44, 45-54, 55-64, and 65 or older. From the American Community Survey (ACS), we use data on the percentages of female adults and adults whose highest level of education is less than a high school degree, a high school degree, or higher than a high school degree at the county level. We also use the rate of cancer deaths per 100,000 individuals in each county per year reported by the CDC. Finally, we use data on each county's annual average unemployment rate and the labor force participation rate per year, reported by the Bureau of Labor Statistics, to account for time-varying socioeconomic conditions at the county level. Appendix Table A1 provides summary statistics for these variables.

2 Empirical Analysis

2.1 Regression Specification

Our primary analysis focuses on the effects of OxyContin reformulation on the IPV rate and related outcomes by employing conditional event study and difference-in-differences methodologies, leveraging the variation in pre-intervention exposure to prescription opioids across counties. The reformulation of OxyContin serves as an exogenous shock since it occurred unexpectedly and independently in 2010 and affected all counties in our sample to varying degrees based on pre-reformulation exposure. Following Evans et al. (2022), we measure the pre-intervention exposure at the county level by calculating the population-weighted average number of opioid prescriptions per capita using CDC data from 2006 to

2009.

Using an event study analysis, we disentangle dynamics in the causal relationship between the reformulation and our outcomes by interacting indicators for single year events and the county-specific pre-intervention measure of exposure using the following specification:

$$Y_{ct} = \alpha_c + \gamma_t + \delta_t \times Exposure_c + X_{ct} + \epsilon_{ct}, \tag{1}$$

where Y_{ct} represents the outcome of IPV rate per 1,000 in county c and year t. We consider multiple outcomes, including the heroin-involved IPV rate, injury rate, and arrest rate. The variable $Exposure_c$ represents the pre-intervention exposure to prescription opioids in county c as described above. The county fixed effects α_c absorb time-invariant differences across counties that contribute to disparities in the IPV rate, while the year fixed effects γ_t account for any time-varying national shocks affecting all counties similarly. The term X_{ct} represents a vector of covariates that vary across counties and over time. These include county-level covariates (percent female, White, Black, Hispanic population; number of cancer deaths per 100,000 population; percent population under age 19, between 20 and 24, between 25 and 34, between 35 and 44, between 45 and 54, and between 55 and 64; percent population without high school diploma, with only high school diploma, and above high school completion; unemployment and labor force participation rates) and state-level policies (indicators for a Prescription Drug Monitoring Program (PDMP) of any form and a medical marijuana law). The coefficients of interest are δ_t event year coefficients, which reveal the differences in IPV between counties with higher and lower pre-intervention exposure in year t, relative to 2010, the year in which OxyContin was reformulated.

To facilitate a more standard interpretation of the average treatment effect of the reformulation on IPV over the entire post-reformulation period, we also employ a generalized difference-in-differences specification. Specifically, we estimate the following model:

$$Y_{ct} = \alpha_c + \gamma_t + \beta \times Post_c \times Exposure_c + X_{ct} + \epsilon_{ct}, \quad (2)$$

where the indicator variable $Post_t$ takes a value of 1 for the post-reformulation period, which is from 2010 to 2019. The specification also includes county fixed effects α_c, year fixed effects γ_t, and a vector of covariates X_{ct} as defined above, and the standard errors of the estimates are clustered at the county level.

2.2 Average Treatment Effects

We begin by illustrating dynamic effects of OxyContin reformulation on IPV outcomes. Figure 2 shows event-study plots by creating a series of interaction terms for each year before and after 2010, the intervention year in which OxyContin was reformulated, and the pre-reformulation exposure to prescription opioids in each county after adjusting for covariates. Panel A illustrates that in the *period prior to the intervention in 2010*, the pseudo treatment effects for the impact of OxyContin reformulation on the intimate partner violence rate is statistically indistinguishable from zero. This lack of a pre-existing differential trend, prior to the reformulation, between counties that were more (treated localities) vs. less (control localities) exposed to prescription opioids, provides validation of the parallel trends assumption and support for our difference-in-differences research design.

By contrast, declines in the IPV rate materialize only after the reformulation. Specifically, the confidence interval moves laterally in 2011 and 2012 and begins to shift down in 2013, the first year in which total opioid prescriptions start to decline, matching the patterns we observe in Figure 1. The estimated treatment effects remain negative and statistically different from zero from 2013 to 2019, indicating that counties, that had high opioid prescribing rates at baseline and thus were more exposed to the OxyContin reformulation, experience significantly larger declines in the rate of intimate partner violence relative to those that are less affected. Table 1 shows the estimated average treatment effects realized over the entire post-intervention period, and their robustness to progressively saturating the model with more extensive sets of covariates, with column (4) representing the fully saturated model. In the first row, the coefficient estimate implies that a one standard deviation increase in pre-reformulation exposure yields about a 6.2 percent annual decline in the intimate partner violence rate on average following OxyContin's reformulation.[5]

In Panel B of Figure 2, the event study plot for the heroin-involved IPV rate shows that in the years following the reformulation, there is a gradual and over-time statistically significant increase in this rate of heroin-involved IPV incidents (i.e., those that the police suspected the offender used heroin). The average treatment effects reported in the second row of Table 1 imply that a one standard deviation increase in pre-reformulation exposure is associated with a doubling of the rate of heroin-involved IPV rate per 1,000 population in the post-reformulation period. This substantial increase in heroin-involved IPV rate is consistent with some opioid-dependent individuals substituting into heroin use once it became difficult to access and abuse OxyContin (Alpert et al. 2022), and heroin use being associated with a greater risk of IPV perpetration (El-Bassel et al. 2007; Tran et al. 2014). However, since heroin-involved IPV is a small fraction of the total IPV incidents (less than 1%), the large increase in IPV incidents driven by heroin consumption for a specific, subpopulation of highly addicted individuals does not offset the decline in total IPV cases observed overall in affected counties.

The event study results for the injury rate and arrest rate per 1,000 population are consistent with the results observed for the IPV rate (Panels C and D of Figure 2). Specifically, the affected counties experience a significant decline in the rates of injury due to violent behaviors perpetrated by intimate partners as well as a decline in the arrest rates for IPV cases compared to less affected counties in the post-reformulation period. Based on the average treatment effects reported in the last two rows of Table 1, a one standard deviation increase in pre-reformulation exposure yields about a 6.1 percent annual decline in the injury rate and a 4.3 percent annual decline in the arrest rate for IPV cases over the

[5] This reduction represents a 0.17 percentage point decline as a share of the pre-reformulation outcome mean of 2.79 (-0.1729/2.7941*100).

post-intervention period. The corollary declines for injuries and arrests related to IPV, due to the OxyContin reformulation, imply that the overall decline in reported IPV incidents to law enforcement agencies (Panel A of Figure 2) reflects an actual decline in incidence in more affected localities rather than just a shift in reporting behaviors.

2.3 Heterogeneous Treatment Effects

We next examine the heterogeneity of the effects of OxyContin reformulation on IPV outcomes through subgroup analyses based on victim and county characteristics. Specifically, we construct the incident rate for each specific population subgroup (e.g., non-Hispanic White/Black, Hispanic, counties above/below the median poverty rate, etc.). While we view these subgroup analyses as exploratory given the presence of multiple comparisons and within-group sample size limitations, we highlight below some notable findings.

Figure 3 shows that the decline in the IPV rate from the reformulation is strongest among the non-Hispanic White population, with little to no effects observed for non-Hispanic Black, Hispanic, or other racial/ethnic groups (Panel A). This finding is consistent with the use prescription opioids being highest among non-Hispanic White individuals in the first wave of the opioid crisis in late 1990s and 2000s in the US (National Academies of Sciences, Engineering, and Medicine and others 2017; Humphreys et al. 2022). Moreover, the magnitude of the estimated reductions in the IPV rate is larger among younger adults (ages 30 and below) compared to those older adults, consistent with the evidence that younger adults had a higher risk of consuming prescription opioids before 2010 and thus would be impacted more intensively from the lack of access to abuse-prone opioids (Palmer et al. 2015). Panel B of Figure 3 also shows that the non-Hispanic White population experienced the largest increase in the risk of exposure to heroin-involved IPV, in the post-reformulation period in more affected counties, although the sub-population that experienced this risk was much smaller compared to the overall population. Moreover, Appendix Figure A1 reports that the reductions in injury and arrest rates in more affected counties largely followed similar patterns with respect to heterogeneous impacts.

Exploring heterogeneity by area characteristics, Panel A of Figure 4 shows that the reformulation of OxyContin had stronger impacts in terms of IPV reduction in counties with lower levels of education (e.g., counties below the median share of high school graduates) and income (e.g., counties below the median share of families at or below the poverty threshold); these localities in general were more severely impacted by the opioid epidemic (higher mortality rates related to prescription opioid overdose) during the first wave, and are expectedly more impacted by the reformulation. We find no statistically significant difference in the estimated IPV reduction estimates between more metropolitan (e.g., counties with higher than median share of metropolitan population) or micropolitan and noncore counties. Panel B further illustrates that the post-reformulation increase in the heroin-involved IPV rate is higher among more metropolitan counties, consistent with urban regions having more developed illicit drug markets that can facilitate substitution into illicit opioids.[6] Appendix Figure A2 show similar heterogeneity patterns for our other IPV-related injury and arrest rate outcomes.

2.4 Robustness checks

We conduct several additional sensitivity analyses to ensure the robustness of our findings. In Appendix Table A2, we replicate our main analyses by accounting for the introduction of additional state policies and regulations with the potential to affect opioid use and IPV prevalence. First, we control for harm reduction policies, including Good Samaritan Laws, which offer legal protection to individuals seeking help for someone experiencing an overdose, and Naloxone access laws, which expand access to Naloxone beyond the at-risk individual to facilitate its administration by friends and family in case of an overdose. Additionally, we incorporate controls for policies related to recreational marijuana legalization and decriminalization, which could potentially alter the demand for opioids and substitution between these substances. We next add controls for the physical exam requirement (PER) laws, which mandate an in-person examination or a physician-patient relationship

[6]These effects also seem larger in relatively more educated counties with higher poverty rates on average.

before prescribing controlled substances. We further account for the states' adoption of the Medicaid expansion under the Affordable Care Act (ACA), which extended Medicaid coverage and provided enhanced federal matching rates. Finally, we include controls for the Earned Income Tax Credit (EITC) coverage that vary by state during our sample period. Remarkably, each of these additional policy controls yielded consistent estimates that are very similar to those reported in Table 1 as shown in Appendix Table A2.

In Appendix Table A3, we conduct supplementary analyses to assess the sensitivity of our estimates and inferences to using alternate specifications, samples, and covariates. First, we cluster standard errors at the state level to account for spatially and temporally correlated errors across localities and over time within the same state. Second, we account for unobserved regional trends by adding census division-by-year fixed effects. Third, we account for differences in police deployment across counties by controlling for the number of officers in the police force per capita. Finally, we conduct two additional checks to ensure data quality while using incident data from the NIBRS, following prior studies (Freedman and Owens 2011; Thomas and Shihadeh 2013; Fone et al. 2023): (i) we control for the number of agencies reporting any IPV incidents within each county and year, and (ii) we use an alternate sample by excluding counties with inadequate IPV data reporting.[7] Across these various specifications and checks reported in Appendix Table A3, our main findings, estimates, and inferences are not materially altered.

[7] We follow Fone et al. (2023) and use 65% coverage rate, though results are remarkably similar for alternative cutoffs. The coverage indicator represents the effective coverage of reporting of intimate partner violence by agencies for a county in a given year. If the indicator is close to 100, the coverage is close to complete (i.e., the agencies are reporting for the whole year and they cover the whole population). If the indicator is close to 0, the coverage is very low (i.e., the agencies are reporting for only a small part of the year and/or they cover only a small part of the population). Following Fone et al. (2023), the coverage indicator is calculated using the following formula:

$$CI_{c,t} = (1 - \sum_{a=1}^{n_{c,t}} \left(\frac{A_{a,c,t}}{T_{c,t}} \cdot \frac{12 - M_{a,t}}{12} \right)) \times 100 \tag{3}$$

where $CI_{c,t}$ is the coverage indicator for county c in year t; $n_{c,t}$ is the number of agencies in county c at time t; $A_{a,c,t}$ is the population of agency a in county c in year t; $T_{c,t}$ is the total population in county c in year t; and $M_{a,t}$ is the number of months agency a reported in year t.

3 Conclusion

Despite documented associations pointing to partner violence and substance abuse being intertwined public health issues, we know very little about this connection when it comes to opioids and opioid-targeted policies. The roots of the opioid epidemic lie within the formal healthcare system, originating with the surge in the prescribing of opioid analgesics and their resulting diversion. It is unclear though how interventions restricting their access for misuse and diversion would impact broader non-targeted outcomes that would also have important implications for family and population well-being. In this study, we address this important gap in the literature, and to our knowledge, provide the first study of the spillover effects of a key supply-side intervention targeting opioid misuse – the abuse-deterrent reformulation of OxyContin, one of the most widely diverted opioids (Inciardi et al. 2007) – on intimate partner violence. In the process, we inform a key public health concern at the intersection of the opioid epidemic and its impact on violence towards women.

Capitalizing on administrative data on reported incidents by female victims to law enforcement agencies combined with a quasi-experimental research design, our results show that the reformulation led to a significant decline in exposure to intimate partner violence by females. These findings are consistent across outcomes of varying severity, including any reported IPV incidents as well as reported incidents that involve an injury and those that result in an arrest. The magnitude of the decline is not inconsequential. Our estimates indicate that, among counties which were most exposed to prescribed opioids at baseline (top quartile), the reformulation resulted in a 7.1 percent decline in the rate of IPV among women, relative to the least exposed counties (bottom quartile).[8] This impact represents an average effect realized over a post-intervention period spanning 2010 through 2019. The economic burden of IPV is staggering, amounting to over $4.1 trillion

[8] Moving from the 25th percentile to 75th percentile in the distribution of pre-reformulation OxyContin exposure yields a 19.7 percentage point decline in the IPV rate, corresponding to a 7.1 percent decline relative to the outcome mean of 2.79 ((1.14*-0.1729)/2.7941*100).

(inflated to 2022$), including $2.4 trillion in medical costs and $1.5 trillion in productivity losses and reductions in lifetime earnings (Peterson et al. 2018); a substantial share of the economic burden – almost 40% – is borne by the public sector. The annual economic burden, taking into account these medical and productivity losses, is estimated to reach $714 billion (inflated to 2022$) (Peterson et al. 2018). Monetizing the estimated decline in IPV observed for the interquartile shift of exposed localities, our results suggest that the OxyContin reformulation generated additional cost-savings on the order of $51 billion annually.

The reformulation-induced decline in IPV directed toward women was not uniformly distributed, and reflected heterogeneity across individual and area-level characteristics. It is ex post validating that this heterogeneity largely lines up with the baseline intensity of the first wave of the opioid epidemic centered around prescription opioids. In other words, groups (non-Hispanic whites; younger adults) and localities (lower educated and high poverty counties) which experienced relatively higher rates of opioid prescribing and consequently higher rates of misuse at baseline, witnessed the largest benefits in terms of lower IPV rates due to the reformulation. It is important to underscore here that, while we find an overall decline in IPV rates, our results also point to a significant uptick in IPV incidents where the perpetrator was suspected of using heroin, particularly in more urban areas. This cautionary increase in heroin-involved IPV is consistent with prior studies that find that the reformulation did generate an unintended consequence in the form of users substituting away from prescription opioids towards illicit opioids such as heroin and synthetics (Alpert et al. 2018; Evans et al. 2019; Alpert et al. 2022; Mallatt 2022).

In conclusion, we find robust evidence that the reformulation of one of most widely diverted prescription opioids resulted in a significant overall decline in women's risk of exposure to intimate partner violence. The Food and Drug Administration (FDA) continues to encourage and promote such reformulations that make the abuse and diversion of prescription opioids more difficult. The results from this study point to the important role of this public health initiative in generating positive downstream effects that can further promote the health and well-being of women. The overall decline in IPV among women, however, masks an uptick in heroin-involved IPV. This underscores the importance of identifying populations and areas where the risk of substitution to illicit opioids is high, and targeting evidence-based policies that can counteract this risk.

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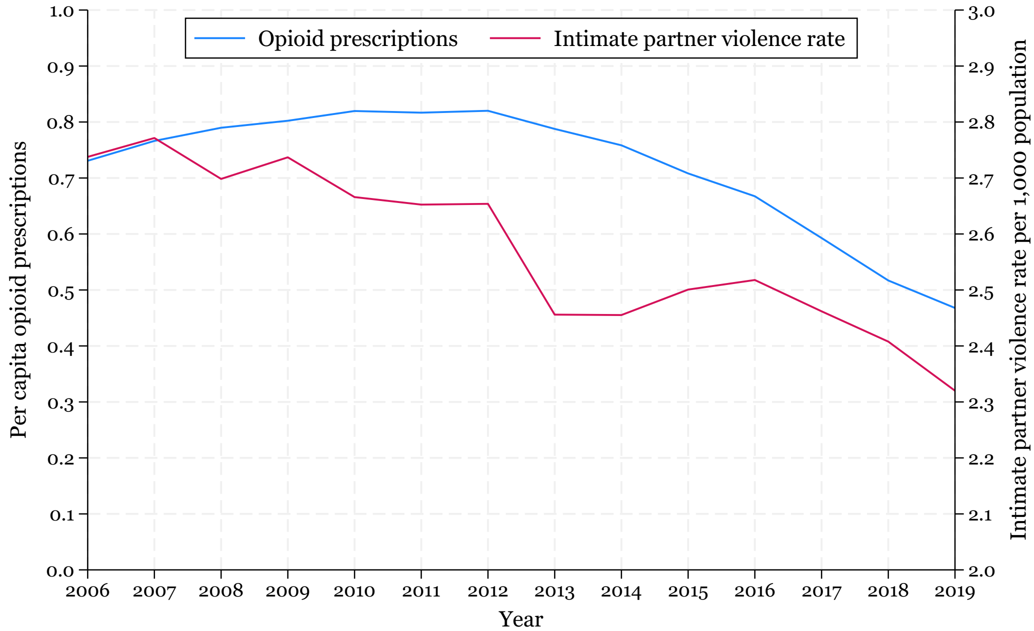
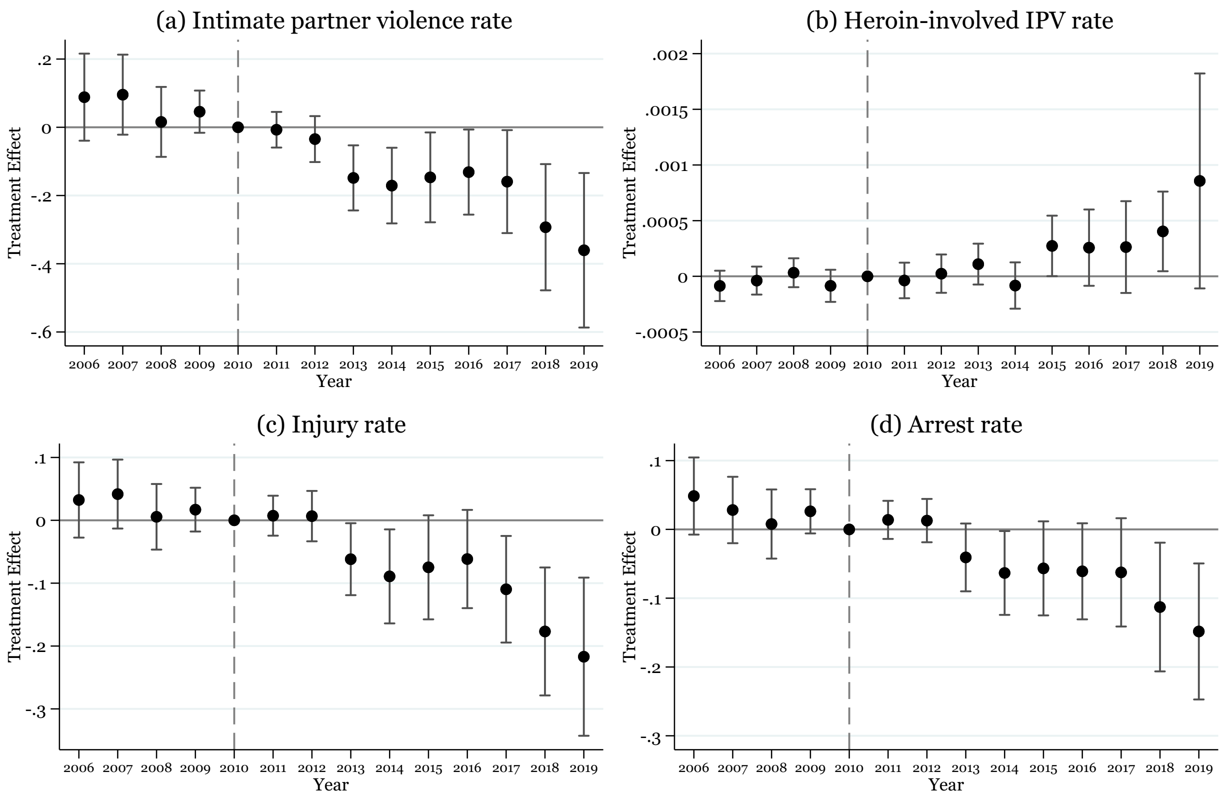
Figure 1: Opioid Prescriptions per capita and Intimate Partner Violence Rate



Note: Figure depicts annual opioid prescriptions per capita reported by the CDC and the intimate partner violence rate per 1,000 population calculated from the 2006–2019 NIBRS. Opioid prescriptions per capita refer to the population-weighted median per capita prescriptions in a given year. Intimate partner violence rate refers to the annual means based on the number of intimate partner violence incidents per 1,000 population.

Figure 2: The Effects of OxyContin Reformulation on IPV Rates over time



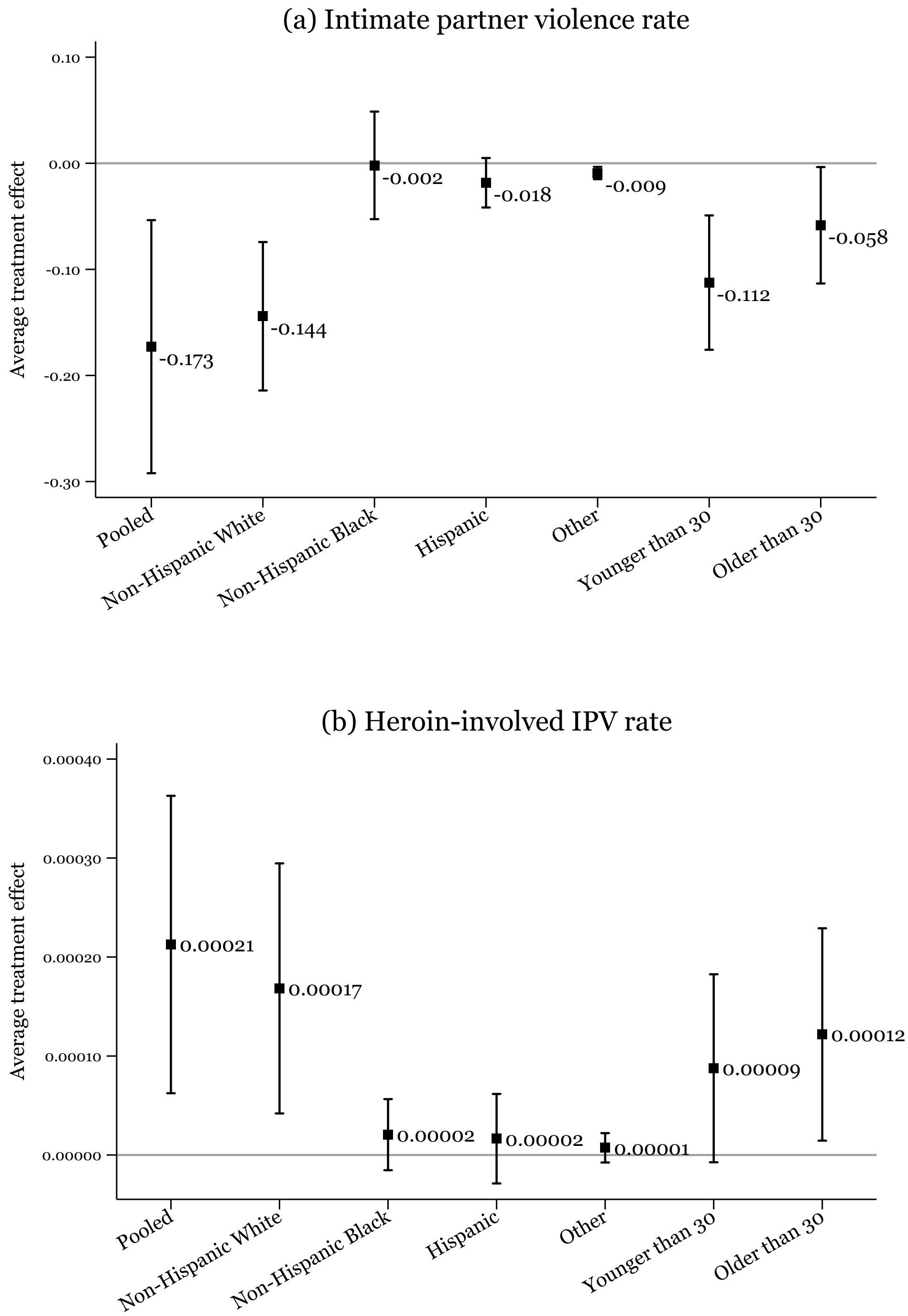
Note: Data are from the 2006–2019 NIBRS. Event-study plots showing the response of IPV rate, heroin-involved IPV rate, injury rate, and arrest rate per 1,000 population reported by female victims at the county level (N=12,516 county-years) to OxyContin reformulation in 2010. The population-weighted mean opioid prescriptions per capita during the pre-reformulation period (2006–2009) is standardized (mean=0, std=1). Each figure reports treatment effect estimates and 95 percent confidence intervals with 2010, the reformulation year, normalized to zero. Specifications include county and year fixed effects, county-level covariates (percent female, White, Black, Hispanic population; number of cancer deaths per 100,000 population; percent population under age 19, between 20 and 24, between 25 and 34, between 35 and 44, between 45 and 54, and between 55 and 64; percent population without high school diploma, with only high school diploma, and above high school completion; unemployment and labor force participation rates) and state-level policies (indicators for a PDMP of any form and a medical marijuana law). Standard errors are clustered at the county level.

Table 1: The Effects of OxyContin Reformulation on IPV Rates

	(1)	(2)	(3)	(4)
Intimate partner violence rate	-0.2030***	-0.1725***	-0.1728***	-0.1729***
	(0.0574)	(0.0606)	(0.0608)	(0.0608)
Observations	12,516	12,516	12,516	12,516
Mean in 2006-09	2.7941	2.7941	2.7941	2.7941
Heroin-involved IPV rate	0.0002**	0.0002***	0.0002***	0.0002***
	(0.0001)	(0.0001)	(0.0001)	(0.0001)
Observations	12,516	12,516	12,516	12,516
Mean in 2006-09	0.0001	0.0001	0.0001	0.0001
Injury rate	-0.0805***	-0.0830**	-0.0826**	-0.0828**
	(0.0293)	(0.0364)	(0.0363)	(0.0361)
Observations	12,516	12,516	12,516	12,516
Mean in 2006-09	1.3674	1.3674	1.3674	1.3674
Arrest rate	-0.0754***	-0.0640**	-0.0645**	-0.0643**
	(0.0252)	(0.0285)	(0.0283)	(0.0280)
Observations	12,516	12,516	12,516	12,516
Mean in 2006-09	1.4969	1.4969	1.4969	1.4969
County and year fixed effects	✓	✓	✓	✓
County demographic, health, and economic controls	×	✓	✓	✓
Any Prescription Drug Monitoring Program	×	×	✓	✓
Medical marijuana law	×	×	×	✓

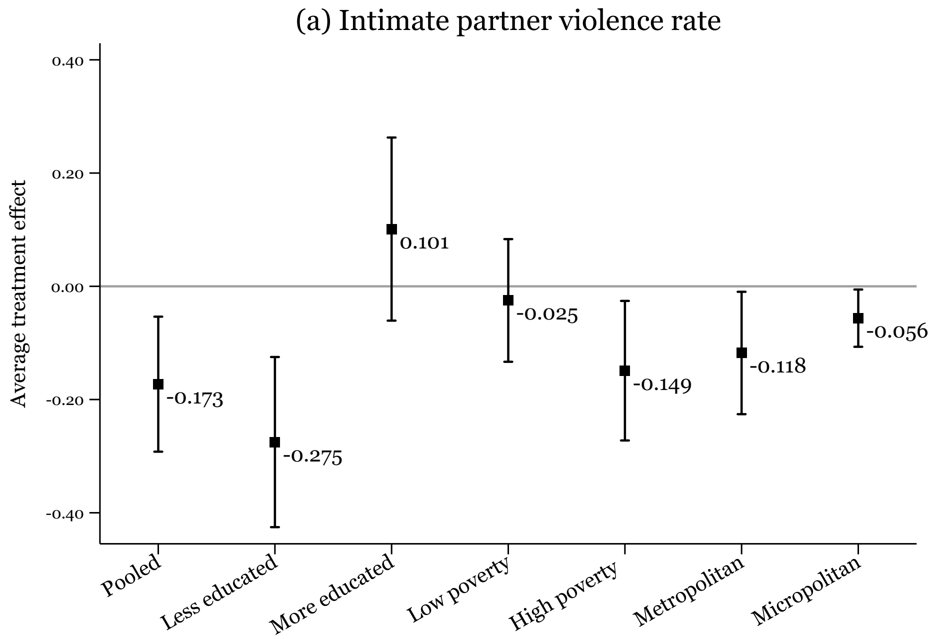
Notes: Data are from the 2006–2019 NIBRS. Estimates of average treatment effects of the OxyContin reformulation on the IPV rate, heroin-involved IPV rate, injury rate, and arrest rate per 1,000 population reported by female victims at the county level (N=12,516 county-years). The population-weighted mean opioid prescriptions per capita during the pre-reformulation period (2006–2009) is standardized (mean=0, std=1). All specifications include county and year fixed effects. Column (2) adds county-level demographic, health, and economic controls (percent female, White, Black, Hispanic population; number of cancer deaths per 100,000 population; percent population under age 19, between 20 and 24, between 25 and 34, between 35 and 44, between 45 and 54, and between 55 and 64; percent population without high school diploma, with only high school diploma, and above high school completion; unemployment and labor force participation rates), column (3) controls for whether the state has a Prescription Drug Monitoring Program (PDMP) of any form, and column (4) controls for whether the state has a medical marijuana law. Outcome means for the pre-reformulation period (2006–2009) are listed in rows under standard errors. Standard errors in parentheses are clustered at the county level. ***, **, and * denote significance at the 1, 5, and 10 percent levels.

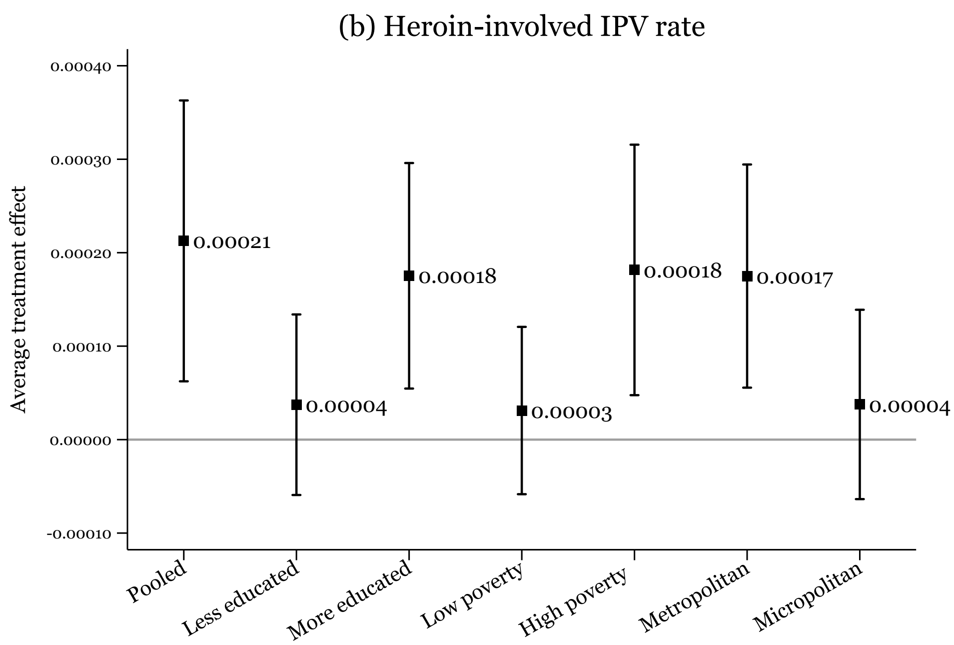
Figure 3: Heterogeneity Analyses by Victim Characteristics



Note: Data are from the 2006–2019 NIBRS. The figure presents victim-level subgroup analyses, displaying estimated treatment effects on IPV rate and heroin-involved IPV rate per 1,000 population, as reported by female victims at the county level. Vertical bars represent the respective 95% confidence intervals for these estimates.

Figure 4: Heterogeneity Analyses by County Characteristics





Note: Data are from the 2006–2019 NIBRS. The figure presents county-level subgroup analyses, displaying estimated treatment effects on IPV rate and heroin-involved IPV rate per 1,000 population, as reported by female victims at the county level. Vertical bars represent the respective 95% confidence intervals for these estimates.

APPENDIX

Additional Data Sources

Additional county-level data

For heterogeneity analysis based on county characteristics, we collected data on average educational attainment, poverty rate, and metropolitan share of population. For educational attainment, we use the percentage of adults whose highest level of education is higher than high school degree. To account for the effect of urbanization, we classified counties into three categories based on their metropolitan status: metropolitan, micropolitan, or non-core. Metropolitan counties have a core urban area of 50,000 or more people. They are generally characterized by significant economic ties throughout the area, including social and economic integration, as indicated by commuting patterns. In contrast, micropolitan counties have an urban core of at least 10,000 (but less than 50,000) people. Non-core counties do not have an urban core of 10,000 or more people and thus represent the most rural counties. We use the share of metropolitan population for our subgroup analyses.

Additional state-level data

Our baseline analysis controls for two state-level policies: indicators for whether the state has a Prescription Drug Monitoring Program (PDMP) of any form and for whether it has a medical marijuana law. Specifically, we accounted for whether a Prescription Drug Monitoring Program (PDMP) law was in effect in a given state during a particular year. These laws establish electronic databases that track controlled substance prescriptions within a state, providing valuable and timely information to health authorities about prescribing and patient behaviors that may lead to substance misuse. We accounted for the presence of a PDMP of any form, whether it involves voluntary database access or requires mandatory queries before prescribing or dispensing controlled substances. We also controlled for whether the state has a medical marijuana law in place considering marijuana as a therapeutic substitute to opioid consumption.

In our robustness analysis, we included several state policies to control for state-level differences in social welfare and health policies. Our analysis incorporated Good Samaritan Laws that protect individuals who provide emergency aid during a medical emergency or call for help during a drug-related overdose, and Naloxone Laws that give legal protection to healthcare providers who prescribe or dispense naloxone. We also added indicators for whether a state decriminalized the use of marijuana, and whether a state has passed recreational marijuana laws to reflect the legal status of marijuana in a state for a given year. We also accounted for the Physical Examination Laws, which vary among states but require a licensed practitioner to examine a patient before prescribing medication. Next, we included a binary variable that indicates whether a state expanded Medicaid coverage under the Affordable Care Act (ACA) provisions. Moreover, we incorporated the State Earned Income Tax Credit (EITC) policy as a percentage of the federal EITC. This policy reduces the tax owed by low to moderate-income working individuals and couples on a dollar-for-dollar basis. Lastly, we used the police per capita as a control variable, reflecting the number of law enforcement officers per 1,000 residents in a state for a given year.

Additional Tables

Table A1: Summary Statistics

	Pre-reformulation (2006–2009)	Post-reformulation (2010–2019)	Whole period (2006–2019)				
	Mean	Mean	Mean	SD	Min	Max	N
Intimate partner violence rate (per 1,000)	2.7581	2.543	2.6019	2.1824	0	14.9988	12516
Heroin-involved intimate partner violence rate (per 1,000)	0.0002	0.0008	0.0006	0.0024	0	0.125	12516
Injury rate (per 1,000)	1.3182	1.2508	1.2692	1.056	0	9.1175	12516
Arrest rate (per 1,000)	1.3155	1.2506	1.2684	0.9118	0	7.9778	12516
Percent female	0.509	0.508	0.5083	0.011	0.2631	0.5642	12516
Percent Black	0.1294	0.1348	0.1333	0.1225	0.0011	0.7447	12516
Percent White	0.8286	0.8137	0.8178	0.1294	0.1914	0.9961	12516
Percent Hispanic	0.1024	0.1206	0.1156	0.1158	0.0032	0.6446	12516
Percent under age 0 to 19	0.277	0.2627	0.2666	0.0305	0.1234	0.397	12516
Percent age 20 to 24	0.0696	0.0699	0.0698	0.0225	0.0262	0.2833	12516
Percent age 25 to 34	0.1312	0.1351	0.134	0.0232	0.0531	0.2832	12516
Percent age 35 to 44	0.1395	0.1273	0.1307	0.0155	0.0646	0.2031	12516
Percent age 45 to 54	0.1472	0.1348	0.1382	0.0161	0.0586	0.2219	12516
Percent age 55 to 64	0.1119	0.1264	0.1224	0.0191	0.0467	0.2139	12516
Percent age over age 64	0.1236	0.1437	0.1382	0.0372	0.0424	0.3788	12516
Cancer deaths per 100,000 population	191.0965	189.1656	189.694	54.704	35.2602	697.6744	12516
Unemployment rate	6.1107	5.7306	5.8347	2.5793	1.1	25.6	12516
Labor force participation rate	0.6446	0.6226	0.6286	0.059	0.2759	1.2668	12516
Percent without high school diploma	0.1348	0.1153	0.1206	0.0503	0.0138	0.4035	12516
Percent with only high school diploma	0.2933	0.2775	0.2818	0.0739	0.078	0.551	12516
Percent with above high school completion	0.5719	0.6072	0.5975	0.1032	0.1997	0.8654	12516
Indicator for having medical marijuana law	0	0.1059	0.0769	0.2665	0	1	12516
Indicator for having a PDMP of any form	0.8138	0.9722	0.9289	0.2571	0	1	12516

Notes: Data are from the 2006–2019 NIBRS. The table presents the means, standard deviations, minimum and maximum values, and the number of observations for variables used in the analysis at the county level (N=12,516 county-years).

Table A2: Robustness Analysis-I

	IPV rate per 1,000 population	Heroin-involved IPV rate per 1,000 population	Injury rate per 1,000 population	Arrest rate per 1,000 population
Controlling for:				
Good Samaritan Laws	-0.1783***	0.0002***	-0.0865**	-0.0660**
	(0.0613)	(0.0001)	(0.0363)	(0.0282)
Naloxone Laws	-0.1721***	0.0002***	-0.0831**	-0.0660**
	(0.0607)	(0.0001)	(0.0362)	(0.0281)
Decriminalization of Marijuana	-0.1691***	0.0002***	-0.0796**	-0.0637**
	(0.0605)	(0.0001)	(0.0356)	(0.0279)
Recreational Marijuana Laws	-0.1728***	0.0002***	-0.0833**	-0.0646**
	(0.0615)	(0.0001)	(0.0365)	(0.0282)
Physical Examination Requirements	-0.1728***	0.0002***	-0.0841**	-0.0632**
	(0.0599)	(0.0001)	(0.0360)	(0.0277)
ACA Expansion	-0.1729***	0.0002***	-0.0828**	-0.0644**
	(0.0609)	(0.0001)	(0.0362)	(0.0280)
EITC Policy	-0.1767***	0.0002***	-0.0850**	-0.0661**
	(0.0609)	(0.0001)	(0.0363)	(0.0279)

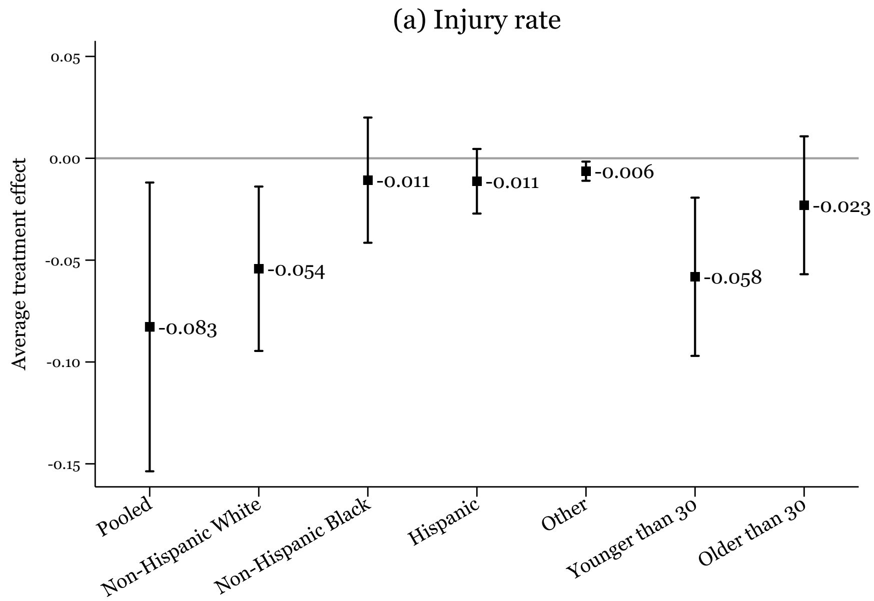
Notes: Data are from the 2006–2019 NIBRS. Analyses showing the IPV rate, heroin-involved IPV rate, injury rate, and arrest rate per 1,000 population reported by female victims at the county level (N=12,516 county-years). The population-weighted mean opioid prescriptions per capita during the pre-reformulation period (2006–2009) is standardized (mean=0, std=1). Specifications include county and year fixed effects, county-level covariates (percent female, White, Black, Hispanic population; number of cancer deaths per 100,000 population; percent population under age 19, between 20 and 24, between 25 and 34, between 35 and 44, between 45 and 54, and between 55 and 64; percent population without high school diploma, with only high school diploma, and above high school completion; unemployment and labor force participation rates) and state-level policies (indicators for a PDMP of any form and a medical marijuana law). Standard errors in parentheses are clustered at the county level. ***, **, and * denote significance at the 1, 5, and 10 percent levels.

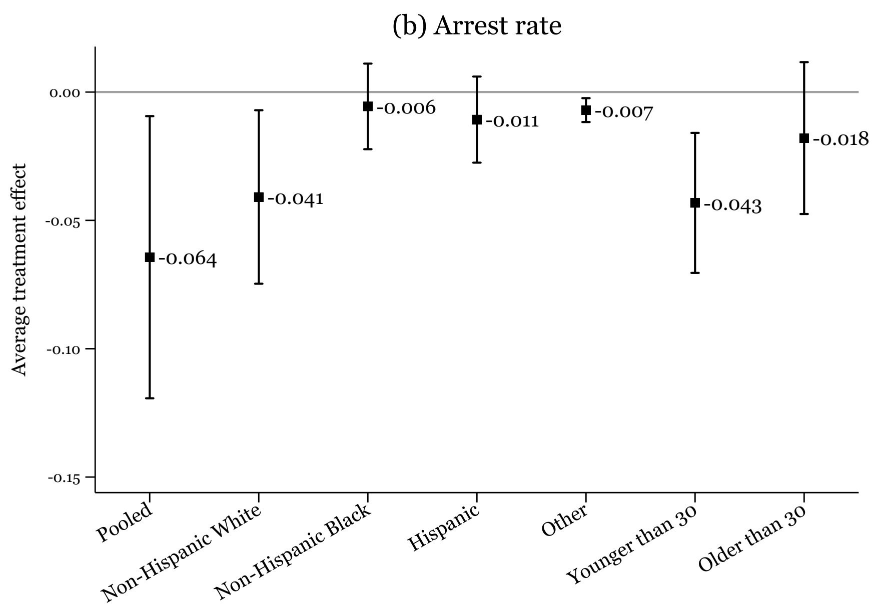
Table A3: Robustness Analysis-II

	IPV rate per 1,000 population	Heroin-involved IPV rate per 1,000 population	Injury rate per 1,000 population	Arrest rate per 1,000 population
Clustering at the state level	-0.1729*	0.0002**	-0.0828*	-0.0643*
	(0.0845)	(0.0001)	(0.0433)	(0.0329)
Controlling for:				
Census division-year fixed effects	-0.1562**	0.0003***	-0.0734	-0.1001***
	(0.0786)	(0.0001)	(0.0459)	(0.0350)
Police per capita (in logs)	-0.1634***	0.0002***	-0.0793**	-0.0610**
	(0.0615)	(0.0001)	(0.0371)	(0.0283)
Number of agencies reporting at the county	-0.1906***	0.0002***	-0.0915**	-0.0709***
	(0.0591)	(0.0001)	(0.0371)	(0.0273)
Dropping counties below 65% coverage rate	-0.1729***	0.0002***	-0.0828**	-0.0643**
	(0.0608)	(0.0001)	(0.0361)	(0.0280)

Notes: Data are from the 2006–2019 NIBRS. Analyses showing the IPV rate, heroin-involved IPV rate, injury rate, and arrest rate per 1,000 population reported by female victims at the county level (N=12,516 county-years). The population-weighted mean opioid prescriptions per capita during the pre-reformulation period (2006–2009) is standardized (mean=0, std=1). Specifications include county and year fixed effects, county-level covariates (percent female, White, Black, Hispanic population; number of cancer deaths per 100,000 population; percent population under age 19, between 20 and 24, between 25 and 34, between 35 and 44, between 45 and 54, and between 55 and 64; percent population without high school diploma, with only high school diploma, and above high school completion; unemployment and labor force participation rates) and state-level policies (indicators for a PDMP of any form and a medical marijuana law). Standard errors in parentheses are clustered at the county level. ***, **, and * denote significance at the 1, 5, and 10 percent levels.

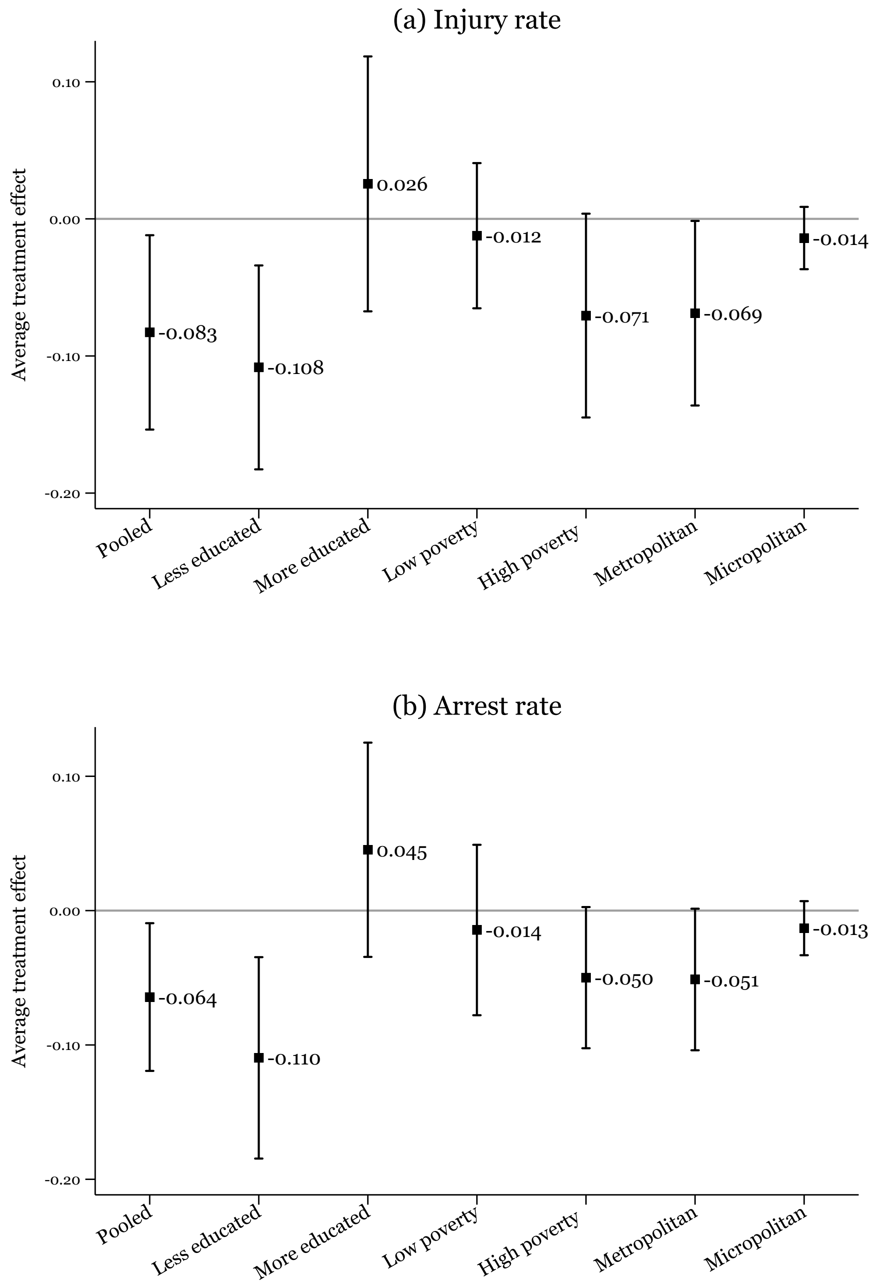
Figure A1: Heterogeneity Analyses by Victim Characteristics





Note: Data are from the 2006–2019 NIBRS. The figure presents victim-level subgroup analyses, displaying estimated treatment effects on injury rate and IPV arrest rate per 1,000 population, as reported by female victims at the county level. Vertical bars represent the respective 95% confidence intervals for these estimates.

Figure A2: Heterogeneity Analyses by County Characteristics



Note: Data are from the 2006–2019 NIBRS. The figure presents county-level subgroup analyses, displaying estimated treatment effects on injury rate and IPV arrest rate per 1,000 population, as reported by female victims at the county level. Vertical bars represent the respective 95% confidence intervals for these estimates.