NBER WORKING PAPER SERIES

FROM ADDICTION TO AGGRESSION: THE SPILLOVER EFFECTS OF OPIOID POLICIES ON INTIMATE PARTNER VIOLENCE

Dhaval M. Dave
Bilge Erten
Pinar Keskin
Shuo Zhang

Working Paper 31609
http://www.nber.org/papers/w31609

NATIONAL BUREAU OF ECONOMIC RESEARCH
1050 Massachusetts Avenue
Cambridge, MA 02138
August 2023, Revised March 2024

The authors have no relevant or material financial interests that relate to the research described in this paper. The views expressed herein are those of the authors and do not necessarily reflect the views of the National Bureau of Economic Research.

From Addiction to Aggression: The Spillover Effects of Opioid Policies on Intimate Partner Violence

Dhaval M. Dave, Bilge Erten, Pinar Keskin, and Shuo Zhang

NBER Working Paper No. 31609
August 2023, Revised March 2024
JEL No. H0,I12,I18,K0

ABSTRACT

We provide the first study of the downstream effects of a key supply-side intervention – the abuse-deterrent reformulation of a widely-diverted opioid, OxyContin – on intimate partner violence (IPV), the most common form of violence experienced by women. Leveraging administrative data on victim-reported incidents to law enforcement, combined with quasi-experimental methods, we find robust evidence that the reformulation significantly reduced IPV exposure for women. This overall decline, however, masks heterogeneity across subpopulations, and a notable uptick in heroin-involved IPV, underscoring the importance of identifying populations at high risk of substitution to illicit opioids and moderating this risk with evidence-based policies.

Dhaval M. Dave
Bentley University
Department of Economics
175 Forest Street, AAC 195
Waltham, MA 02452-4705
and IZA
and also NBER
ddave@bentley.edu

Bilge Erten
Northeastern University
Economics Department
Boston, MA 02115
b.erten@northeastern.edu
erten.bilge@gmail.com

Pinar Keskin
Department of Economics
Wellesley College
106 Central Street
Wellesley, MA 02481
pkeskin@wellesley.edu

Shuo Zhang
Department of Economics
Northeastern University
43 Leon Street, 312A Lake Hall
Boston, MA 02115
s.zhang@northeastern.edu

1 Introduction

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, and in the process inform how a supply-side shock that disrupted access for one particular, albeit important, segment of the opioid

[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).

market (Rx OxyContin), generated downstream impacts on interpersonal violence and women's well-being. 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 opioid prescriptions prior to 2010, the year in which OxyContin was reformulated. We capitalize on the baseline spatial variation in treatment exposure withing a difference-in-differences (DID) framework to examine whether areas that were more exposed to prescription opioids (and in particular Oxycontin abuse) prior to reformulation experienced differential changes in IPV outcomes after the OxyContin reformulation.

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 the reformulation. We show that these declines materialize after the policy change, and that these effects are driven primarily by non-Hispanic Whites. The coefficient estimates imply that a one standard deviation increase in pre-reformulation exposure yields a relative decrease of 7.5 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 (7.4 percent and 5.1 percent, respectively), indicating that the effects are reflective of an actual decline in the incidence of IPV rather than 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. Our findings also underscore how supply shocks that disrupt one part of the opioid market may generate both beneficial and harmful effects depending on the extent to which certain individuals may seek out alternate, unreliable, and illicit sources of

supply.

We show that our findings cannot be explained by the Great Recession and the ensuing housing and financial crisis nor by differences across areas in policy deployment or law enforcement. Our results are robust to the inclusion of a rich vector of confounding state policies with the potential to affect opioid use and IPV prevalence, accounting for unobserved regional shocks, and standard sample adjustments to minimize reporting errors and ensure data quality.

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 selecion bias and 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 broader repercussions of the opioid crisis, and complements recent work 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), a similar supply-side shock that also constrained access to prescription opioids for misuse purposes, 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 and policies targeting substance use on IPV is rare, and almost exclusively focuses on alcohol use (Castilla et al. 2022; Markowitz 2000). 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 2 provides a brief description of the OxyContin reformulation and the data used for the analysis. Section 3 presents the identification strategy and the empirical results. Section 4 concludes with a discussion of our findings.

2 Background and Data

2.1 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 declined subsequently. These national trends in opioid prescription rates were also highlighted by prior studies (Guy Jr et al. 2017; Powell and Pacula 2021), with the rate of opioid prescriptions per year increasing from 0.72 to 0.81 per person from 2006 to 2010, remaining constant from 2010 to 2012, and then decreasing consistently to 0.46 in 2019.

There are several reasons why opioid prescriptions remained stable for one to two years before starting to decrease following the reformulation of OxyContin. First, while shipments of the reformulated drug ceased in August of 2010 to retail pharmacies, the original version of the drug that was easier to misuse continued to be available to some extent due

to stockpiling.[4] This meant that the reformulation's full impact in reducing prescription opioid abuse could be delayed and would unfold dynamically, as the stock of the older version of the drug in circulation becomes depleted and diversion for misuse/abuse becomes more difficult over time. Second, the reformulation reduced the demand for prescription opioids for both (the flow of) new users as well as (the stock of) existing users. For initiates and new users of OxyContin, the abuse deterrent version reduces the chance of misuse, leading to fewer new prescriptions over time. For users who are addicted and were already misusing prescription opioids pre-reformulation, substitution towards other illicit opioids such as heroin and fentanyl has been found to be more gradual as illicit markets evolved and innovated in response to the reformulation (Powell and Pacula 2021); hence, this would be expected to lead to a somewhat gradual decline in their demand for and reliance on prescription opioids.

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).[5] 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.

[4]The FDA gave the reformulated drug an "abuse-deterrent" designation in April 2013.

[5]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).

2.2 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 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.[6] 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

[6]Specifically, the following states provide a balanced panel at the county level: Alabama, Arizona, Arkansas, Colorado, Connecticut, Delaware, Idaho, Illinois, Iowa, Kansas, Kentucky, Louisiana, Maryland, Massachusetts, Michigan, Missouri, Montana, Nebraska, New Hampshire, North Dakota, Ohio, Oregon, South Carolina, South Dakota, Tennessee, Texas, Utah, Virginia, Washington, West Virginia, and Wisconsin.

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.

2.3 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).

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. We also use the rate of cancer deaths per 100,000 individuals in each county per year reported by the CDC. In addition, 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 (BLS), to account for time-varying socioeconomic conditions at the county level.

We also control for baseline (2006) values of the following county characteristics, interacting them with year fixed effects to account for time-varying spatial shocks. First, we include the share of population without any college education, from the American Community Survey, to account for counties more exposed to the introduction of labor-saving technical change and associated deaths of despair reflecting a combination of adverse social and economic outcomes that accumulate over time (Case and Deaton 2017, 2020). Second, we add the share of employment in mining, reported by the BLS, to control for the higher rates of injury in underground mining, which has been shown to increase opioid consumption and mortality rates (Monnat 2018; Metcalf and Wang 2019).

Furthermore, we also control 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 in our baseline analysis, and incorporate further state policies in robustness checks. Appendix A provides descriptions of data sources used in our analysis. Appendix Table A1 provides summary statistics for these variables.

3 Empirical Analysis

3.1 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. For ease of interpretation, we standardize this exposure measure to have a mean of 0 and a standard deviation of 1.

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:

$$\begin{aligned} Y_{ct} = &\sum_t \gamma_t 1\{year = t\} \times Exposure_c + \beta X_{ct} \\ &+ \sum_t \theta_t 1\{year = t\} \times X_c + \delta_c + \delta_t + \epsilon_{ct}, \end{aligned} \tag{1}$$

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 associated with an IPV incident. The first terms on the right-hand side are the difference-in-differences (DID) terms of interest, interactions of a full set of year dummies (excluding 2010, the year in which OxyContin was reformulated) with the (time-invariant) county-level pre-intervention exposure to prescription opioids, $Exposure_c$, as described above. The coefficients of interest are γ_t event year coefficients, which reveal the differences in IPV rates between counties with higher and lower pre-intervention exposure in year t, relative to 2010, the year in which OxyContin was reformulated. 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; unemployment and labor force participation rates—and state-level policies including indicators for a Prescription Drug Monitoring Program (PDMP) of any form and a medical marijuana law as discussed in Section 2.3. The term X_c represents two initial (2006) county characteristics discussed above: share of population without any college education and the share of employment in mining. Including interactions of these characteristics with the full set of year dummies allows their relationship with IPV rates to differ before and after the reformulation of OxyContin. The county fixed effects δ_c absorb time-invariant differences across counties that contribute to disparities in the IPV rate, while the year fixed effects δ_t account for any time-varying national shocks affecting all counties identically in a particular year. Regressions are weighted by 2006 county population. Standard errors are clustered at the county level to account for serial correlation in the error term within a county. The sample period is 2006 to 2019.

To facilitate a more standard interpretation of the average treatment effect of the reformulation on IPV over the entire post-reformulation period, we employ a generalized DID

specification. Specifically, we estimate the following model:

$$Y_{ct} = \gamma_1 Post_c \times Exposure_c + \beta X_{ct} + \sum_t \theta_t 1\{year = t\} \times X_c + \delta_c + \delta_t + \epsilon_{ct}, \qquad (2)$$

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 δ_c, year fixed effects δ_t, and a vector of covariates X_{ct} and initial county characteristics X_c interacted with year dummies as defined above. Regressions are weighted by 2006 county population and the standard errors are clustered at the county level.

An attractive feature of this DID identification strategy is its ability to isolate the role of the change in a key supply-side intervention to reduce opioid misuse. While counties with high and low pre-intervention exposure are not identical, comparing outcomes within counties over time isolates the differential impact of the OxyContin reformulation.

3.2 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 period 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 are 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 occur only after the reformulation; the post-reformulation downward trend is evident and discernibly steeper relative to the flat pre-reformulation trends for all IPV-related outcomes. While the estimated treatment effects

are relatively small in magnitude and statistically insignificant for the first couple of years post-reformulation, they become stronger and more precisely estimated over time. Effects remain negative and statistically different from zero from 2013 onwards, 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. These dynamics are consistent with, as noted earlier, patients continuing to have some access to Rx opioids for misuse due to stockpiling and availability on the street markets which became progressively constrained over time, differential effects in terms of averting new patients from misusing prescription opioids vs. steering some current users to find alternate sources, and evolution and innovation in the illicit markets which took place over time to meet the demand from former patients losing access to OxyContin for non-medical use.[7] Downstream effects from changes in the level and composition of opioid misuse to impacting inter-personal violence would also be expected to operate with a lag.

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 7.5 percent annual decline in the intimate partner violence rate on average following OxyContin's reformulation.[8]

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

[7] As a result of these considerations, effects operating with some delay and compounding over time are not uncommon in studies of the OxyContin reformulation and of opioid policies (i.e., PDMPs) that aim to restrict access (Beheshti and Kim 2022; Gihleb et al. 2022; Powell and Pacula 2021; Park and Powell 2021; Dave et al. 2021).

[8] This reduction represents a 0.2105 percentage point decline as a share of the pre-reformulation outcome mean of 2.8147 (-0.2105/2.8147*100).

is associated with a tripling 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, sub-population 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 7.4 percent annual decline in the injury rate and a 5.1 percent annual decline in the arrest rate for IPV cases over the 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.

To place our effects in context, Evans et al. (2019) document a significant short-term decline in non-heroin opioid-related mortality driven by the reformulation, on the order of about 11 percent over 12 months, which compares to the circa 7 percent annual decline in the IPV rate that we find. Both Evans et al. (2019) and Alpert et al. (2018) find that in the aggregate, however, each prevented non-heroin opioid death from the reformulation is approximately replaced by a heroin death, and subsequently the reformulation is not found to have a significant impact on the combined opioid death rate. Consistent with

these findings, our results also point to substitution from prescription opioids to heroin, which drives the increase in heroin-related IPV that we find post-reformulation; however, this substitution and the increase in heroin-related IPV is not large enough to fully replace the decline in IPV that is driven by a decrease in Rx opioid misuse, and we find an overall decline in IPV and a net benefit as result of the reformulation.[9]

The substitution from Rx opioid misuse to heroin is found to drive larger effects on child maltreatment, with Evans et al. (2022) documenting a post-reformulation increase of 3 percent in the short run and 11 percent in the medium run. Moreover, it is important to note that the rates of IPV and child maltreatment within a county are almost orthogonal to each other.[10] Furthermore, within a household, mothers are more likely to be perpetrators of child maltreatment than fathers, whereas most within-couple violence is perpetrated by men. Additionally, the factors that increase the likelihood of partner abuse differ from those of child abuse across multiple dimensions. For example, economic shocks that increase bargaining power of women relative to men have been documented to reduce women's risk of experiencing violence from their partners in the US and UK (Aizer 2010; Anderberg et al. 2016), while the same shocks do not necessarily lead to less or more abuse towards children. Hence, it remains uncertain whether an event influencing child maltreatment will similarly affect intimate partner violence. The advantage of the police data we bring to bear in this study is that they allow us to differentiate between all incidents of IPV from those that involve the use of heroin. In fact, our findings show a very large relative increase

[9]Note that the one-to-one offset in Rx opioid vs. heroin deaths in Evans et al. (2019) and Alpert et al. (2018) does not imply a one-to-one substitution from Rx opioid abusers to heroin abuse. In fact, Evans et al. (2019) impute that the fraction of recreational pain medication users who transition to heroin in a given year is likely less than 10 percent, and our back-of-the-envelope calculations combining the effects in Evans et al. (2019) with survey results from the 2019 National Survey of Drug Use and Health (NSDUH) indicate that about three to five percent of Rx opioid misusers, who were deterred by the reformulation, may have substituted into heroin. However, since the mortality rate among heroin users is substantially higher than the mortality rate among Rx opioid abusers, a less than one-to-one substitution in abuse translates into a larger offset with respect to mortality. With respect to IPV, even if the incidence of IPV perpetration varies across Rx opioid vs. heroin abusers, this variance does not appear to be large enough to drive anywhere close to a full offset for non-heroin vs. heroin-related IPV.

[10]The within county correlation of the rates of alleged child abuse or neglect reported to child protection services and intimate partner violence reported to the police is -0.05 for the overlapping counties and sample period of 2006 and 2016. For the substantiated child abuse or neglect measure, the within-county correlation with intimate partner violence rate is -0.01.

in the rates of heroin-involved IPV, providing evidence of significant substitution into illicit heroin consumption among the population dependent on prescription opioids.

The pattern of results we uncover is also consistent with the evidence from the crime literature. Studies focusing on the effects of another supply-side intervention that restricted access to prescription opioids – prescription drug monitoring programs (PDMPs) – find a decline in overall crime by 5 percent, particularly driven by assault, burglary and motor vehicle theft (Dave et al. 2021) but a substantial increase in heroin-related crime (Mallatt 2018, 2022). In a similar vein, Gihleb et al. (2022) analyze the effects of the same restrictions on prescription opioids and find that these regulations generate beneficial effects by reducing foster care admissions on the order of 10 percent on average.

3.3 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.[11] Appendix Figure A2 show similar heterogeneity patterns for our other IPV-related injury and arrest rate outcomes.

3.4 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

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

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 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 shocks that may be correlated with the timing of the treatment by adding the interactions of the census division fixed effects with the indicator for the post-reformulation periods. 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.[12] Across these various specifications and checks reported in

[12]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

Appendix Table A3, our main findings are consistent with the baseline estimates reported in Table 1.

Furthermore, we incorporated an OxyContin-specific measure of pre-intervention opioid misuse to improve the measurement of opioid abuse relying on OxyContin instead of other opioids. Specifically, we follow Evans et al. (2022) and use the population-weighted rate of OxyContin misuse at the state level from 2004 to 2009 introduced by Alpert et al. (2018). This measure has the advantage of being specific to OxyContin abuse while our measure includes all Schedule II prescription opioids, not only OxyContin, and their prescription use and misuse. However, being measured at the county-level, our measure provides a more granular variation at the local level and may therefore be a more accurate representation of real exposure. The event-study estimates reported in Appendix Figure A3 are consistent with our main estimates, but some are less precisely estimated in comparison to our primary results.

Finally, we have incorporated controls for housing market factors, considering the impact of the housing bust in 2007–2009 and the Great Recession that coincide with our study period. Specifically, we control for the housing market index (HHI) at the county level and the 90-day mortgage delinquency rates at the county and state levels in separate regressions. Our estimates reported in Appendix Table A4 are robust to accounting for housing market fluctuations.

4 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

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.

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 8.5 percent decline in the rate of IPV among women, relative to the least exposed counties (bottom quartile).[13] 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 $4.1 trillion (inflated to 2022$), 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

[13]Moving from the 25th percentile to 75th percentile in the distribution of pre-reformulation OxyContin exposure yields a 23.9 percentage point decline in the IPV rate, corresponding to a 8.5 percent decline relative to the outcome mean of 2.8147 ((1.14*-0.2105)/2.8147*100).

$714 billion (inflated to 2022$) (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 $53 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.

References

Aizer, Anna, "The Gender Wage Gap and Domestic Violence," *American Economic Review*, 2010, *100* (4), 1847–1859.

Alpert, A., W. N. Evans, E. M. J. Lieber, and D. Powell, "Origins of the opioid crisis and its enduring impacts," *The Quarterly Journal of Economics*, 2022, *137*, 1139–1179.

Alpert, Abby, David Powell, and Rosalie Liccardo Pacula, "Supply-side drug policy in the presence of substitutes: Evidence from the introduction of abuse-deterrent opioids," *American Economic Journal: Economic Policy*, 2018, *10* (4), 1–35.

Anderberg, Dan, Helmut Rainer, Jonathan Wadsworth, and Tanya Wilson, "Unemployment and Domestic Violence: Theory and Evidence," *The Economic Journal*, 2016, *125* (585).

Angelucci, M. and R. Heath, "Women Empowerment Programs and Intimate Partner Violence," *AEA papers and proceedings*, 2020, *110*, 610–614.

Angelucci, Manuela, "Love on the Rocks: Domestic Violence and Alcohol Abuse in Rural Mexico," *The BE Journal of Economic Analysis and Policy: Contributions to Economic Analysis and Policy*, 2008, *8* (1).

Beheshti, David and Bokyung Kim, "Beyond Opioids: The Effect of Prescription Drug Monitoring Programs on Non-Opioid Drug Prescribing," *Available at SSRN 4098995*, 2022.

Bobonis, Gustavo J., Melissa Gonzalez-Brenes, and Roberto Castro, "Public Transfers and Domestic Violence: The Roles of Private Information and Spousal Control," *American Economic Journal: Economic Policy*, 2013, *5* (1), 179–205.

Boudreau, D., M. Von Korff, C. M. Rutter, K. Saunders, G. T. Ray, M. D. Sullivan, C. I. Campbell, J. O. Merrill, M. J. Silverberg, C. Banta-Green et al., "Trends in long-term opioid therapy for chronic non-cancer pain," *Pharmacoepidemiology and drug safety*, 2009, *18* (12), 1166–1175.

Butler, S. F., T. A. Cassidy, H. Chilcoat, R. A. Black, C. Landau, S. H. Budman, and P. M. Coplan, "Abuse rates and routes of administration of reformulated extended-release oxycodone: initial findings from a sentinel surveillance sample of individuals assessed for substance abuse treatment," *The Journal of Pain*, 2013, *14* (4), 351–358.

Case, Anne and Angus Deaton, "Mortality and morbidity in the 21st century," *Brookings papers on economic activity*, 2017, *2017*, 397.

__ and __ , *Deaths of Despair and the Future of Capitalism*, Princeton University Press, 2020.

Castilla, C. and D. M. A. Murphy, "Bidirectional Intimate Partner Violence: Evidence from a List Experiment in Kenya," 2022. Working Paper.

_ , **F. Aqeel, and D. M. A. Murphy**, "Tipples and Quarrels in the Household: The Effect of an Alcohol Mitigation Intervention on Intimate Partner Violence," 2022. Working Paper.

Chalfin, A., S. Danagoulian, and M. Deza, "COVID-19 Has Strengthened the Relationship Between Alcohol Consumption and Domestic Violence," Technical Report, National Bureau of Economic Research 2021.

Coplan, P. M., H. D. Chilcoat, S. F. Butler, E. M. Sellers, A. Kadakia, V. Harikrishnan, J. D. Haddox, and R. C. Dart, "The effect of an abuse-deterrent opioid formulation (OxyContin) on opioid abuse-related outcomes in the postmarketing setting," *Clinical Pharmacology and Therapeutics*, 2016, *100*, 275–286.

Cunningham, Scott and Keith Finlay, "Parental substance use and foster care: Evidence from two methamphetamine supply shocks," *Economic Inquiry*, 2013, *51* (1), 764–782.

Dave, Dhaval, Monica Deza, and Brady Horn, "Prescription drug monitoring programs, opioid abuse, and crime," *Southern Economic Journal*, 2021, *87* (3), 808–848.

Degenhardt, L. and W. Hall, "Extent of illicit drug use and dependence, and their contribution to the global burden of disease," *The Lancet*, 2012, *379* (9810), 55–70.

El-Bassel, N., L. Gilbert, E. Wu, M. Chang, and J. Fontdevila, "Perpetration of Intimate Partner Violence Among Men in Methadone Treatment Programs in New York City," *American Journal of Public Health*, 2007, *97*, 1230–1232.

Erten, Bilge and Pinar Keskin, "For better or for worse?: Education and the prevalence of domestic violence in Turkey," *American Economic Journal: Applied Economics*, 2018, *10* (1), 64–105.

_ **and** _ , "Trade-offs? The impact of WTO accession on intimate partner violence in Cambodia," *The Review of Economics and Statistics*, 2021, pp. 1–40.

Ertl, A., K. J. Sheats, E. Petrosky, C. J. Betz, K. Yuan, and K. A. Fowler, "Surveillance for Violent Deaths - National Violent Death Reporting System, 32 States, 2016," *MMWR Surveillance Summaries*, 2019, *68*, 1–36.

Evans, M. F., M. C. Harris, and L. M. Kessler, "The hazards of unwinding the prescription opioid epidemic: Implications for child maltreatment," *American Economic Journal: Economic Policy*, 2022, *14* (4), 192–231.

Evans, W. N., E. M. J. Lieber, and P. Power, "How the Reformulation of OxyContin Ignited the Heroin Epidemic," *The Review of Economics and Statistics*, 2019, *101*, 1–15.

Fone, Zachary S, Joseph J Sabia, and Resul Cesur, "The unintended effects of minimum wage increases on crime," *Journal of Public Economics*, 2023, *219*, 104780.

Freedman, Matthew and Emily G Owens, "Low-income housing development and crime," *Journal of Urban Economics*, 2011, *70* (2-3), 115–131.

Gihleb, Rania, Osea Giuntella, and Ning Zhang, "The Effect of Mandatory-Access Prescription Drug Monitoring Programs on Foster Care Admissions," *Journal of Human Resources*, 2022, *57* (1), 217–240.

Hughes, A., M. Dank, L. Wood, and M. Rashid, "The Socio-Ecological Intersections of the Opioid Epidemic and Violence Against Women: A Scoping Review," 2019.

Humphreys, K., C. L. Shover, C. M. Andrews, A. S. B. Bohnert, M. L. Brandeau, J. P. Caulkins, J. H. Chen, M. F. Cuéllar, Y. L. Hurd, D. N. Juurlink et al., "Responding to the opioid crisis in North America and beyond: recommendations of the Stanford–Lancet Commission," *The Lancet*, 2022, *399* (10324), 555–604.

Hwang, C. S., H. Chang, and G. C. Alexander, "Impact of abuse-deterrent OxyContin on prescription opioid utilization," *Pharmacoepidemiology and Drug Safety*, 2015, *24*, 197–204.

Inciardi, James A, Hilary L Surratt, Yamilka Lugo, and Theodore J Cicero, "The diversion of prescription opioid analgesics," in "Law enforcement executive forum," Vol. 7 NIH Public Access 2007, p. 127.

Jessell, L., P. Mateu-Gelabert, H. Guarino, S. P. Vakharia, C. Sykes, E. Goodbody, K. V. Ruggles, and S. Friedman, "Sexual violence in the context of drug use among young adult opioid users in New York City," *Journal of interpersonal violence*, 2017, *32* (19), 2929–2954.

Jr, Gery P Guy, Kun Zhang, Michele K Bohm, Jan Losby, Brian Lewis, Randall Young, Louise B Murphy, and Deborah Dowell, "Vital signs: changes in opioid prescribing in the United States, 2006–2015," *Morbidity and Mortality Weekly Report*, 2017, *66* (26), 697.

Kim, Bokyung, "Must-access prescription drug monitoring programs and the opioid overdose epidemic: The unintended consequences," *Journal of Health Economics*, 2021, *75*, 102408.

Maclean, Johanna Catherine, Justine Mallatt, Christopher J Ruhm, and Kosali Simon, "The opioid crisis, health, healthcare, and crime: A review of quasi-experimental economic studies," *The ANNALS of the American Academy of Political and Social Science*, 2022, *703* (1), 15–49.

Mallatt, J., "The Effect of Prescription Drug Monitoring Programs on Opioid Prescriptions and Heroin Crime Rates," 2018.

Mallatt, Justine, "Policy-induced substitution to illicit drugs and implications for law enforcement activity," *American Journal of Health Economics*, 2022, *8* (1), 30–64.

Markowitz, Sara, "The price of alcohol, wife abuse, and husband abuse, 2000," *Southern Economic Journal*, 2000, *67*, 279–303.

_ , Alison Cuellar, Ryan M Conrad, and Michael Grossman, "Alcohol control and foster care," *Review of Economics of the Household*, 2014, *12*, 589–612.

Meinhofer, Angélica, "Prescription drug monitoring programs: the role of asymmetric information on drug availability and abuse," *American Journal of Health Economics*, 2018, *4* (4), 504–526.

Metcalf, Gilbert E and Qitong Wang, "Abandoned by Coal, Swallowed by Opioids?," Technical Report, National Bureau of Economic Research 2019.

Monnat, Shannon M, "Factors associated with county-level differences in US drug-related mortality rates," *American journal of preventive medicine*, 2018, *54* (5), 611–619.

National Academies of Sciences, Engineering, and Medicine and others, *Pain management and the opioid epidemic: balancing societal and individual benefits and risks of prescription opioid use*, National Academies Press, 2017.

Packard, G. and C. Warshaw, "Framing the issues: Looking at the opioid epidemic in the context of trauma and domestic violence," 2018.

Palmer, Roy E, David S Carrell, David Cronkite, Kathleen Saunders, David E Gross, Elizabeth Masters, Sean Donevan, Timothy R Hylan, and Michael Von Kroff, "The prevalence of problem opioid use in patients receiving chronic opioid therapy: computer-assisted review of electronic health record clinical notes," *Pain*, 2015, *156* (7), 1208–1214.

Park, Sujeong and David Powell, "Is the rise in illicit opioids affecting labor supply and disability claiming rates?," *Journal of Health Economics*, 2021, *76*, 102430.

Peterson, C., M. C. Kearns, W. L. McIntosh, L. F. Estefan, C. Nicolaidis, K. E. McCollister, A. Gordon, and C. Florence, "Lifetime Economic Burden of Intimate Partner Violence Among U.S. Adults," *American Journal of Preventive Medicine*, 2018, *55*, 433–444.

Powell, D. and R. L. Pacula, "The Evolving Consequences of OxyContin Reformulation on Drug Overdoses," *American Journal of Health Economics*, 2021, *7*, 41–67.

Pryor, C., J. H. Boman IV, and P. l. Hemez, "Using arrest and prescription data to examine the relationship between intimate partner violence and opioid prescriptions in the United States, 2006-2012," *Drug and alcohol dependence*, 2021, *218*, 108389.

Schilbach, F., "Alcohol and Self-Control: A Field Experiment in India," *The American Economic Review*, 2019, *109*, 1290–1322.

Stevenson, Betsey and Justin Wolfers, "Bargaining in the Shadow of the Law: Divorce Laws and Family Distress," *Quarterly Journal of Economics*, 2006, *121* (1), 267–288.

Stone, R. and E. F. Rothman, "Opioid Use and Intimate Partner Violence: A Systematic Review," *Current Epidemiology Reports*, 2019, *6*, 215–230.

Thomas, Shaun A and Edward S Shihadeh, "Institutional isolation and crime: The mediating effect of disengaged youth on levels of crime," *Social Science Research*, 2013, *42* (5), 1167–1179.

Tran, A., L. Lin, E. J. Nehl, C. L. Talley, K. L. Dunkle, and F. Y. Wong, "Prevalence of Substance Use and Intimate Partner Violence in a Sample of A/PI MSM," *Journal of Interpersonal Violence*, 2014, *29*, 2054–2067.

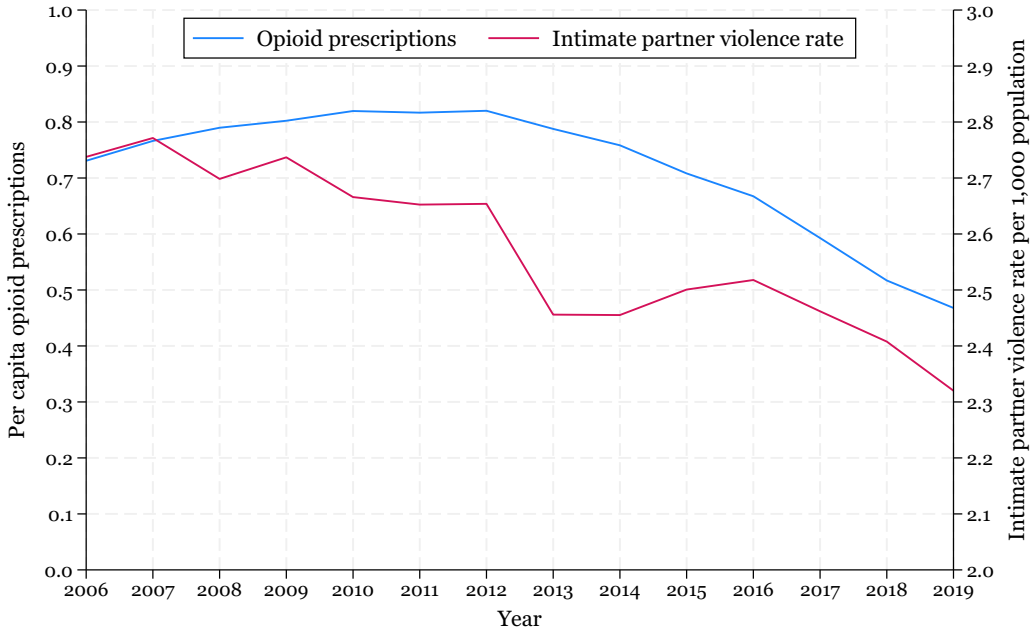
Volkow, N. D., "America's addiction to opioids: Heroin and prescription drug abuse," *Senate Caucus on International Narcotics Control*, 2014, *14*, 1–16.

Warshaw, C., E. Lyon, P. J. Bland, H. Phillips, and M. Hooper, "Mental Health and Substance Use Coercion Surveys: Report from the National Center on Domestic Violence, Trauma & Mental Health and the National Domestic Violence Hotline," Technical Report, National Center on Domestic Violence, Trauma, & Mental Health and the National Domestic Violence Hotline 2014.

World Health Organization, *Global and regional estimates of violence against women: prevalence and health effects of intimate partner violence and non-partner sexual violence* 2013.

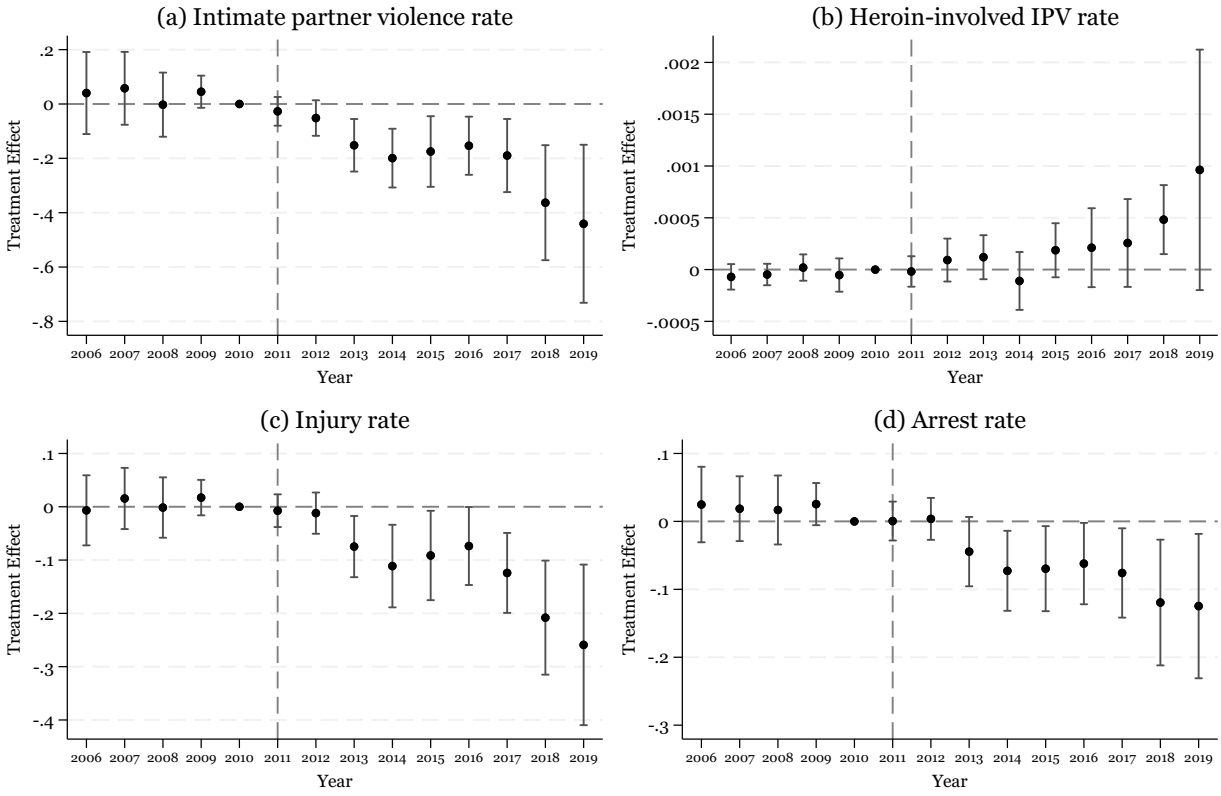
Zee, A. Van, "The promotion and marketing of oxycontin: commercial triumph, public health tragedy," *American journal of public health*, 2009, *99* (2), 221–227.

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



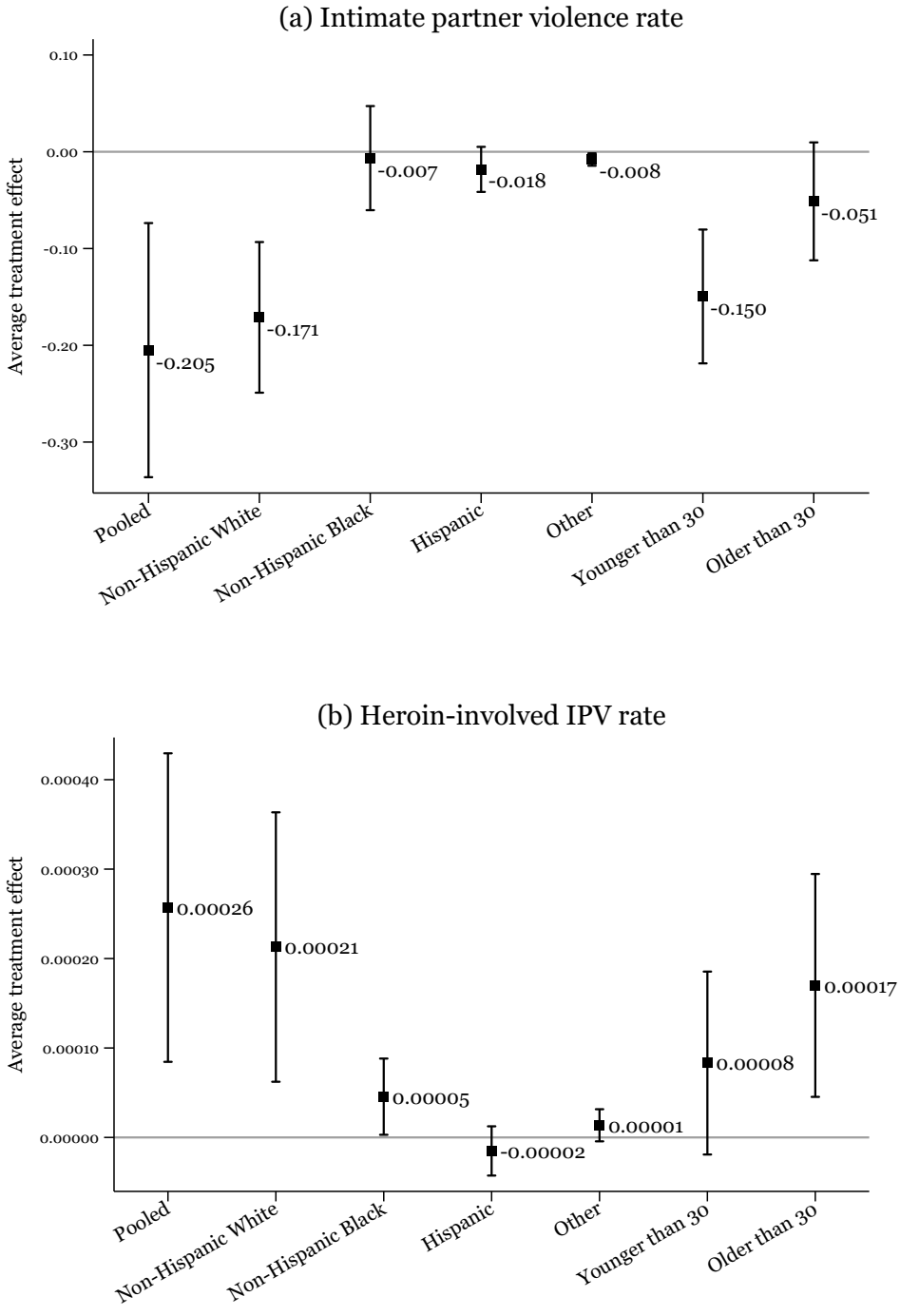
Note: Data are from the 2006–2019 NIBRS. Event-study plots showing the response of IPV rate, heroin-involved IPV rate, injury rate, and arrest rate per 1,000 population reported by female victims at the county level (N=12,516 county-years) to OxyContin reformulation in 2010. The population-weighted mean 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; unemployment and labor force participation rates), initial (2006) shares of the population without any college education and of employment share in mining, both interacted with year fixed effects, 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)	(5)
Intimate partner violence rate	-0.2081***	-0.1756***	-0.1764***	-0.1767***	-0.2105***
	(0.0558)	(0.0578)	(0.0618)	(0.0619)	(0.0663)
Observations	12,516	12,516	12,516	12,516	12,516
Mean in 2006-09	2.8147	2.8147	2.8147	2.8147	2.8147
Heroin-involved IPV rate	0.0002**	0.0002**	0.0003***	0.0003***	0.0003***
	(0.0001)	(0.0001)	(0.0001)	(0.0001)	(0.0001)
Observations	12,516	12,516	12,516	12,516	12,516
Mean in 2006-09	0.0001	0.0001	0.0001	0.0001	0.0001
Injury rate	-0.0823***	-0.0783**	-0.0918***	-0.0915***	-0.1024***
	(0.0286)	(0.0339)	(0.0349)	(0.0347)	(0.0349)
Observations	12,516	12,516	12,516	12,516	12,516
Mean in 2006-09	1.3790	1.3790	1.3790	1.3790	1.3790
Arrest rate	-0.0740***	-0.0636**	-0.0708**	-0.0712**	-0.0780***
	(0.0248)	(0.0285)	(0.0294)	(0.0293)	(0.0276)
Observations	12,516	12,516	12,516	12,516	12,516
Mean in 2006-09	1.5114	1.5114	1.5114	1.5114	1.5114
County and year fixed effects	✓	✓	✓	✓	✓
Time-varying county socioeconomic controls	×	✓	✓	✓	✓
Initial county characteristics X year fixed effects	×	×	✓	✓	✓
Any Prescription Drug Monitoring Program	×	×	×	✓	✓
Medical marijuana law	×	×	×	×	✓

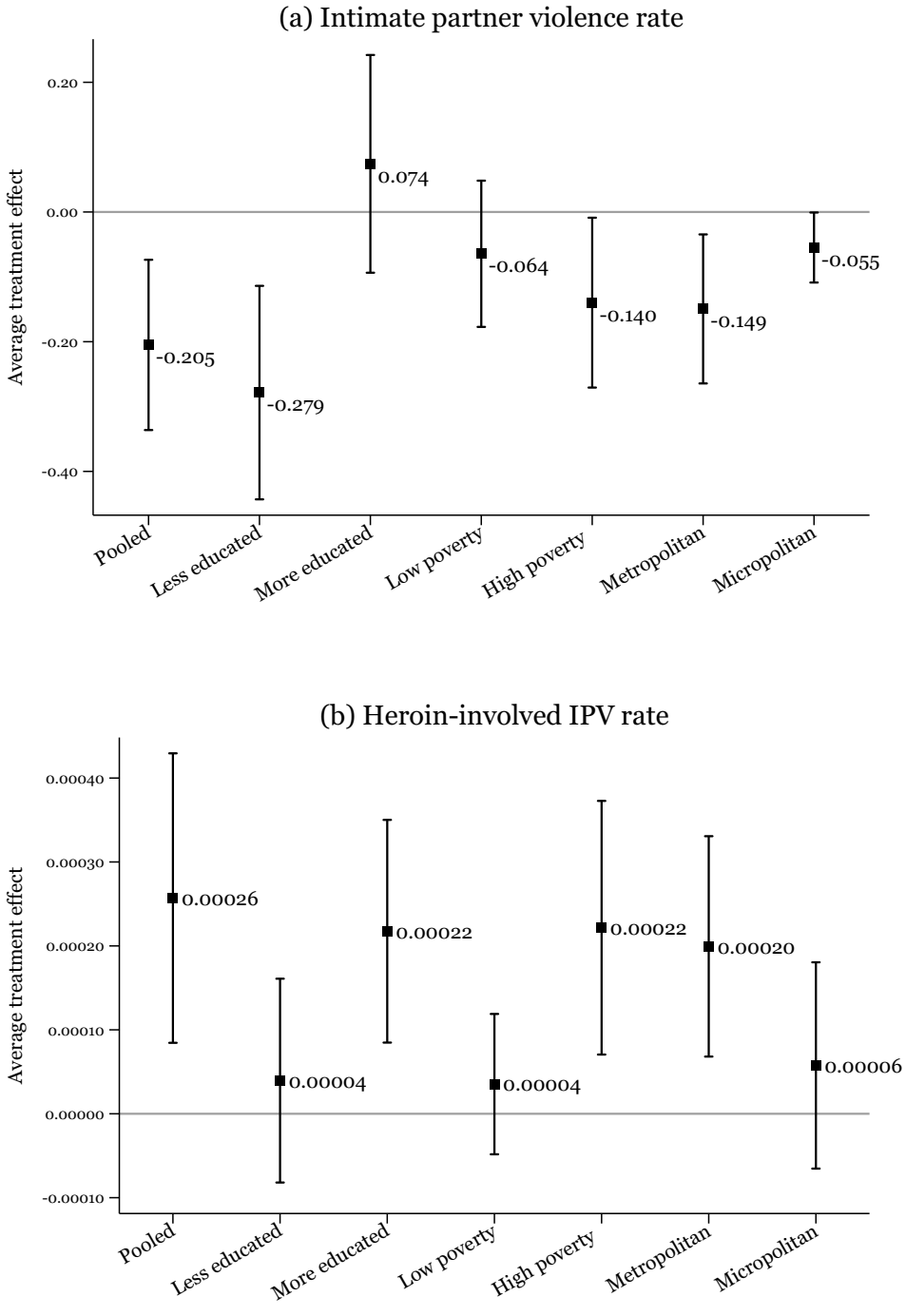
Notes: Data are from the 2006–2019 NIBRS. Estimates of average treatment effects of the OxyContin reformulation on the IPV rate, heroin-involved IPV rate, injury rate, and arrest rate per 1,000 population reported by female victims at the county level (N=12,516 county-years). The population-weighted 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; unemployment and labor force participation rates), column (3) controls for initial (2006) shares of the population without any college education and of employment share in mining, both interacted with year fixed effects, column (4) controls for whether the state has a Prescription Drug Monitoring Program (PDMP) of any form, and column (5) 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

Appendix A Additional Data Sources

A.1 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.

In conducting our robustness checks, we compiled housing market indicators at the county level. These include the Housing Market Index (HHI) from the Federal Housing Finance Agency, and the mortgage delinquency rate based on mortgages delinquent by 90 days or more from the Consumer Financial Protection Bureau. These data span the period 2008–2019.

A.2 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.

Moreover, at the state level, we have integrated controls for the rate of mortgage delinquency, specifically focusing on mortgages overdue by 90 days or more, utilizing data derived from the Residential Mortgage Performance Statistics.

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 any college education	0.4281	0.3928	0.4024	0.1135	0.1346	0.8042	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
Percent of employment in mining	0.0079	0.0071	0.0077	0.0309	0	0.4313	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	-0.1734***	0.0002**	-0.0823**	-0.0695***
	(0.0618)	(0.0001)	(0.0328)	(0.0269)
Naloxone Laws	-0.1751***	0.0002**	-0.0833**	-0.0689**
	(0.0620)	(0.0001)	(0.0327)	(0.0269)
Decriminalization of Marijuana	-0.1932***	0.0003***	-0.0938***	-0.0731***
	(0.0666)	(0.0001)	(0.0341)	(0.0275)
Recreational Marijuana Laws	-0.1742***	0.0002**	-0.0837**	-0.0686***
	(0.0618)	(0.0001)	(0.0324)	(0.0264)
Physical Examination Requirements	-0.1816***	0.0002**	-0.0856***	-0.0698***
	(0.0597)	(0.0001)	(0.0322)	(0.0262)
ACA Expansion	-0.2004***	0.0003***	-0.1014***	-0.0744***
	(0.0677)	(0.0001)	(0.0355)	(0.0272)
EITC Policy	-0.1969***	0.0003***	-0.0992***	-0.0743***
	(0.0669)	(0.0001)	(0.0352)	(0.0273)

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; unemployment and labor force participation rates), initial (2006) shares of the population without any college education and of employment share in mining, both interacted with year fixed effects, 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	-0.2050*	0.0003*	-0.1024**	-0.0780*
	(0.1026)	(0.0001)	(0.0464)	(0.0382)
Observations	12516	12516	12516	12516
Controlling for:				
Census division × post-reformulation dummy	-0.1365*	0.0003***	-0.0653	-0.0941***
	(0.0828)	(0.0001)	(0.0453)	(0.0343)
Observations	12516	12516	12516	12516
Police per capita (in logs)	-0.1924***	0.0002***	-0.0976***	-0.0738***
	(0.0658)	(0.0001)	(0.0353)	(0.0272)
Observations	12516	12516	12516	12516
Number of agencies reporting at the county	-0.2001***	0.0003***	-0.1000***	-0.0760***
	(0.0643)	(0.0001)	(0.0354)	(0.0266)
Observations	12516	12516	12516	12516
Dropping counties below 65% coverage rate	-0.2255***	0.0003***	-0.1171***	-0.0877***
	(0.0714)	(0.0001)	(0.0374)	(0.0301)
Observations	9316	9316	9316	9316

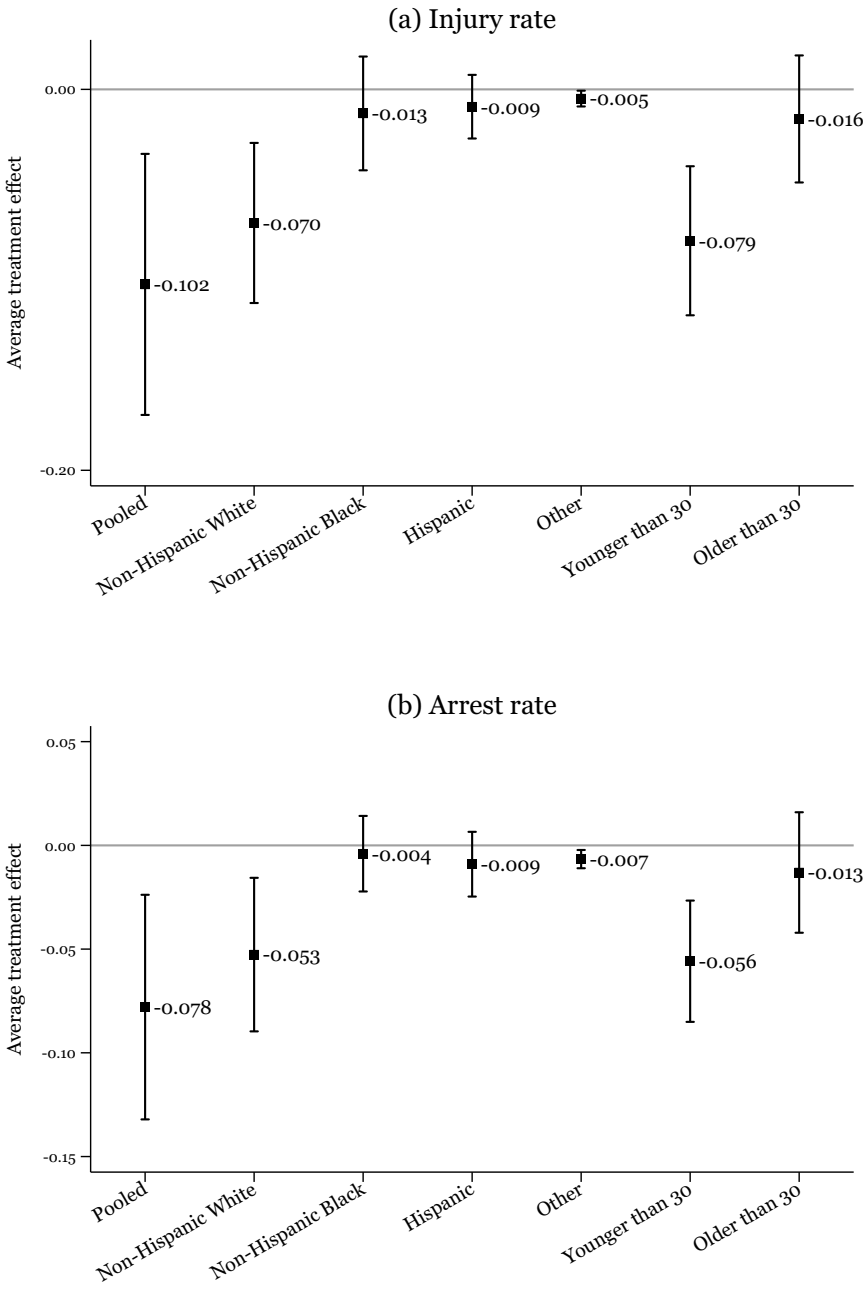
Notes: Data are from the 2006–2019 NIBRS. Analyses showing the IPV rate, heroin-involved IPV rate, injury rate, and arrest rate per 1,000 population reported by female victims at the county level. County-year observations are noted for each regression. The population-weighted mean opioid prescriptions per capita during the pre-reformulation period (2006–2009) at county level and state-level Oxycontin misuse 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; unemployment and labor force participation rates), initial (2006) shares of the population without any college education and of employment share in mining, both interacted with year fixed effects, 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 A4: ROBUSTNESS ANALYSIS-III

	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:				
Housing price index	-0.2019***	0.0002***	-0.1018***	-0.0756***
	(0.0663)	(0.0001)	(0.0358)	(0.0283)
Observations	11,072	11,072	11,072	11,072
Mortgage delinquency rate	-0.2187***	0.0003***	-0.1100***	-0.0803***
	(0.0687)	(0.0001)	(0.0360)	(0.0290)
Observations	11,072	11,072	11,072	11,072
State level mortgage delinquency rate	-0.1914***	0.0002**	-0.1064***	-0.0790***
	(0.0608)	(0.0001)	(0.0352)	(0.0269)
Observations	10,373	10,373	10,373	10,373

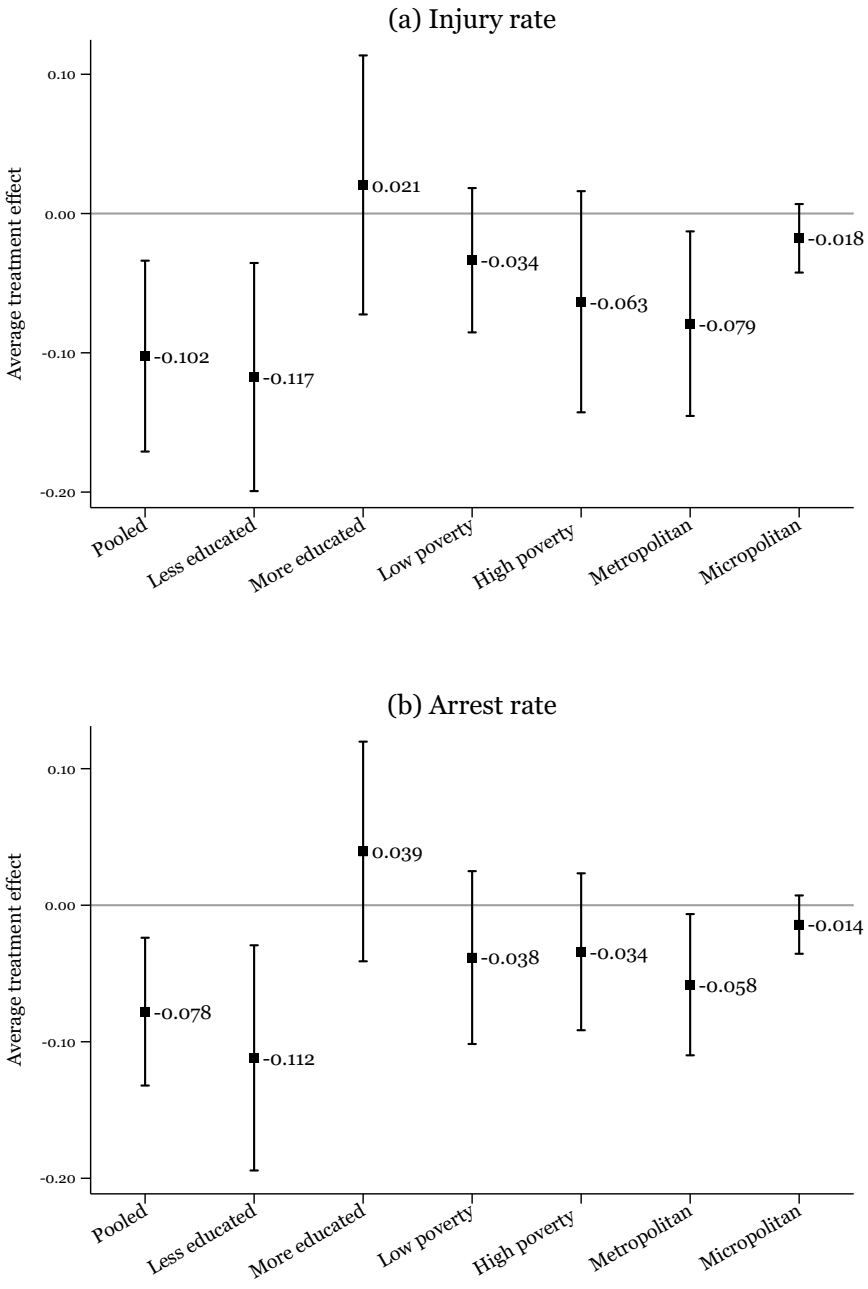
Notes: Data are from the 2006–2019 NIBRS. Analyses showing the IPV rate, heroin-involved IPV rate, injury rate, and arrest rate per 1,000 population reported by female victims at the county level. The population-weighted mean opioid prescriptions per capita during the pre-reformulation period (2006–2009) 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; unemployment and labor force participation rates), initial (2006) shares of the population without any college education and of employment share in mining, both interacted with year fixed effects, 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



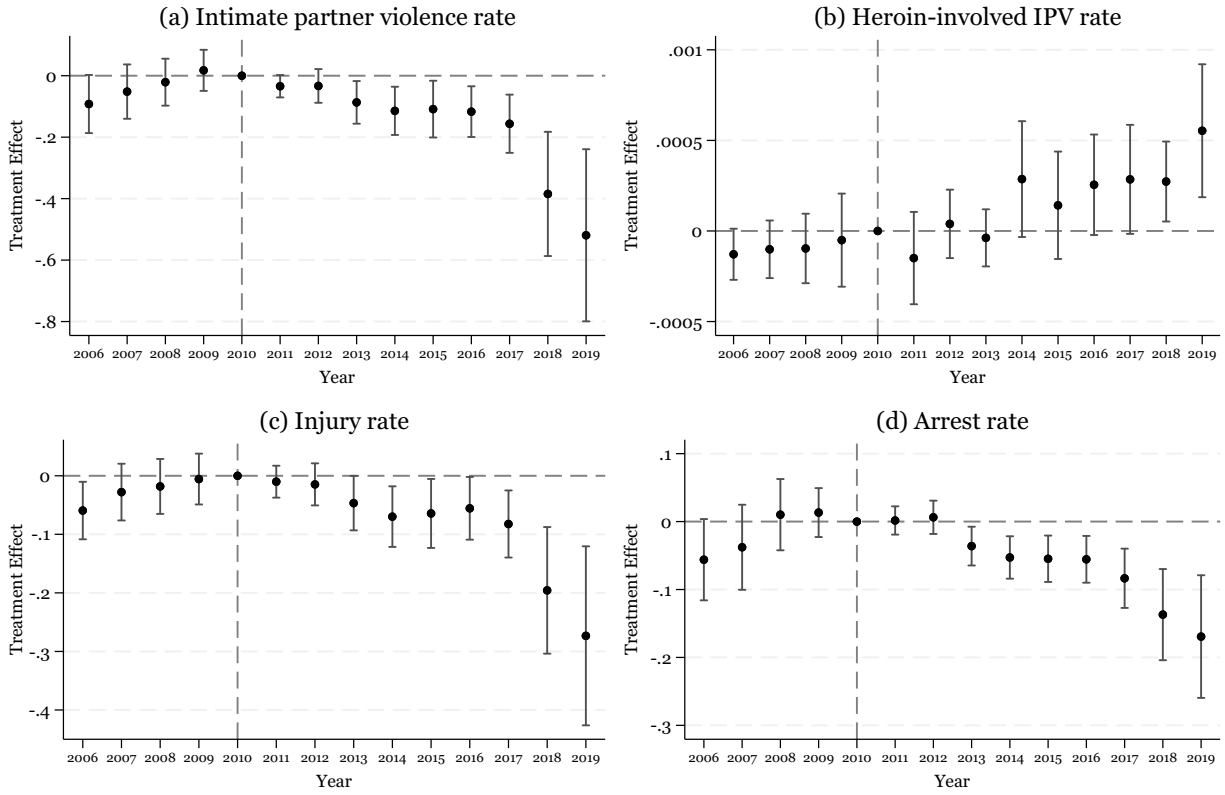
Note: Data are from the 2006–2019 NIBRS. The figure presents victim-level subgroup analyses, displaying estimated treatment effects on injury rate and IPV arrest rate per 1,000 population, as reported by female victims at the county level. Vertical bars represent the respective 95% confidence intervals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

FIGURE A3: EVENT STUDY RESULTS USING ALPERT ET AL. (2018) OXYCONTIN MISUSE MEASURE



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. State-level OxyContin misuse prior to the intervention is obtained from Alpert et al. (2018), and is standardized. 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; unemployment and labor force participation rates), initial (2006) shares of the population without any college education and of employment share in mining, both interacted with year fixed effects, and state-level policies (indicators for a PDMP of any form and a medical marijuana law). Standard errors are clustered at the county level.