The Hazards of Unwinding the Prescription Opioid Epidemic: Implications for Child Maltreatment

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Child maltreatment has significant and long-lasting consequences. We examine how two interventions designed to curtail prescription opioid misuse, the reformulation of OxyContin and the implementation of must-access prescription drug monitoring programs (PDMPs), affected child maltreatment. Our results suggest that counties with greater initial rates of prescription opioid usage experienced relatively larger increases in child physical abuse and neglect after OxyContin's reformulation. We also find some evidence of increases in alleged physical abuse and neglect due to must-access PDMP implementation. Our results uncover unintended consequences for children of reducing the supply of an addictive good without adequate support for dependent users.

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I. Introduction

In 2017, there were more than 4.1 million cases of alleged child maltreatment in the United States. Investigations concluded that approximately 674,000 children were victims of substantiated abuse or neglect, resulting in over 1,700 child fatalities (U.S. Department of Health and Human Services, 2019).[1] Child maltreatment has far reaching consequences and can lead to a myriad of adverse health and economic outcomes. First and foremost, child maltreatment has serious implications regarding child safety and well-being. Second, it places a direct economic burden on child protective service (CPS) agencies, which spend roughly $30 billion per year on investigations, family services, and interventions (Rosinsky and Connelly 2016; Rosinsky and Williams, 2018). Finally, child maltreatment is associated with a host of adverse events later in life, all of which carry substantial economic costs. Children who suffered from maltreatment have lower levels of educational achievement, and as adults have lower rates of employment, lower earnings, fewer assets, an increased risk of substance abuse, and are more likely to engage in crime and be incarcerated later in life (Berger et al. 2016; Currie and Widom, 2010; Currie and Tekin, 2012; Cicchetti and Handley, 2019; Eckenrode et al. 1993;Lansford et al., 2002; Mersky and Topitzes 2010; Widom, 1989; Zielinski, 2009).

The factors affecting child maltreatment are complex and include parental mental health, stress from poverty or economic conditions, and the parent's history of maltreatment as a child (Lindo and Schaller, 2014). Despite the complexity of the issue, parental substance use is consistently cited as a primary risk factor associated with child maltreatment. Parents who struggle with substance use disorder (SUD) are over three times more likely to engage in child maltreatment compared to households where substance abuse is a non-factor (Reid et al., 1999).

The linkage between parental substance use and child maltreatment is multi-faceted. In some instances, it is due to parental behavior while intoxicated. If this were the only linkage, the policy prescription would be straightforward: reduce access to that substance through prices and/or regulation. In reality of course, the linkages between parental substance use and child maltreatment are more nuanced. Two findings from the law, social work, and neurobiology literatures suggest that reducing access to an addictive substance may have unintended

[1] The terms "child maltreatment" and "child abuse and neglect" are commonly used as synonyms. Later we distinguish among specific types of child maltreatment.

consequences with regards to child maltreatment. First, reducing access to a given substance may induce substitution, and the parental use of some substances can create inherently higher risk for adverse childhood events than others (Mayes and Truman, 2002).[2] Second, some aspects of parental addiction most dangerous to children are withdrawal, risks incurred while seeking drugs, and more broadly, parents prioritizing drug procurement over the well-being/development of their children (Ammerman et al., 1999; Mayes and Truman, 2002; Niccols et al., 2012). Given these factors, a regular and consistent supply of one addictive good may pose less danger than an intermittent or irregular supply of another.

In this paper, we investigate the effects of two policies that unintentionally took a population of dependent users of prescription opioids with access to relatively stable supplies, and nudged some of them towards more dangerous, uncontrolled substances with less reliable supplies. In 2010, Purdue Pharma reformulated OxyContin, one of the most widely misused prescription medications, to make it more difficult to abuse. Around the same time, states also began implementing Prescription Drug Monitoring Programs (PDMPs) in an effort to reduce over-prescribing. Of particular interest are PDMPs with "must-access" provisions, which require providers and pharmacists to consult the database on the patient's recent history before prescribing and/or filling a prescription. Prior work finds that these supply restrictions led some opioid-dependent individuals to substitute to substances with more severe addictive properties, including heroin but various other substances as well. OxyContin's reformulation is linked to the formation and maturation of heroin markets, and resulted in increased rates of heroin-related crime, hepatitis B and C infections, and overdose deaths (Buchmueller and Carey, 2018; Mallatt, 2018; Mallatt, 2020; Alpert et al., 2018; Evans et al., 2019; Powell et al., 2018a; Powell and Pacula, 2021; Beheshti, 2019). Several recent papers find adverse impacts of must-access PDMPs on heroin usage, heroin-related crime, and mortality (Meinhofer, 2019; Mallatt, 2020; Kim, 2021). We build on this literature by investigating the extent to which the substitution patterns resulting from these policy changes affected child maltreatment.

Our results indicate that supply-side measures taken to curtail the opioid epidemic are adversely affecting some children. Consistent with recent work in the economics literature, we find that the reformulation of OxyContin had stronger adverse effects than the implementation of

[2] For example, the use of illicit drugs such as cocaine and heroin exposes the substance-using parent to risk of arrest and incarceration, and the child to potential family separation. Illicit drug use can also "expose the user as well as her or his children to personal and property violence" (Mayes and Truman, 2002, p. 344).

must-access PDMPs. On the reformulation, results from both event study and difference-in-difference (DID) specifications indicate that the reformulation of OxyContin led to an increase in children with alleged and substantiated physical abuse and neglect in counties with greater exposure to prescription opioids prior to the reformulation relative to counties with lower pre-reformulation exposure. Estimates from DID specifications suggest that a one standard deviation increase in exposure to prescription opioids prior to the reformulation yields about a 3% annual increase in children with alleged and substantiated physical abuse and neglect in the years immediately following OxyContin's reformulation. In the subsequent few years (i.e., the medium-term), the estimated effect size is an annual increase of about 10%. Results of the PDMP analysis are less precise but we do find evidence of increased alleged physical abuse and neglect in some counties as a result of must-access PDMP implementation.

While restricting access is an important step in addressing substance abuse on the scale of opioids, optimally unwinding the epidemic should also involve policies that minimize unintended harms, particularly for children. Without adequate support, measures that simply restrict access can lead to adverse consequences for some substance-dependent individuals and their families. While we are unable to identify the causal impacts of policies that provide support for parents with SUD, we do investigate the possibility of heterogeneous effects of the reformulation along several measures that affect the availability of support services for parents with SUD. Results indicate that the reformulation's adverse effects on child physical abuse and neglect are muted among counties with priority admission to general substance abuse treatment programs for pregnant women with SUD, targeted treatment programs for pregnant women with SUD, or states that prohibit discrimination against pregnant women in drug treatment programs. Conversely, counties without these policies exhibited the largest adverse effects of the reformulation.

Because legal marijuana has also been found to reduce opioid addiction and overdose deaths (Powell et al., 2018b; Garín et al., 2018), we explore the extent to which the availability of medical marijuana as a therapeutic substitute mediates the effects of OxyContin's reformulation. We find that the adverse effects of OxyContin's reformulation on alleged physical abuse and neglect are concentrated in counties *without* medical marijuana access. Therefore, while increased marijuana usage may have some adverse effects (Solowij and Battisti, 2008;

Soyka 2017), our results, while associative, are consistent with increased access to marijuana dampening substitution to more destructive, uncontrolled substances.

This paper makes several contributions to the literature. First, we contribute to the sparse economics literature on substance use and child maltreatment. Almost all prior work in economics on this issue has focused on foster care and yielded mixed evidence on whether reducing access to a particular substance increases or decreases foster care admissions. Cunningham and Finlay (2013) found that reducing access to methamphetamine reduced foster care admissions, while Markowitz, et al. (2014) found that increased alcohol prices did not affect admissions into foster care. More recently, and perhaps the closest paper to ours is from Gihleb et al. (2019), which provides a state-level analysis of must-access PDMPs' impacts on engagement with the foster care system.[3] In contrast to our findings, their results suggest that, after a delay of two years, must-access PDMPs reduce entry into foster care. However, in a useful summary of the economics literature on child maltreatment, Doyle and Aizer (2018) show that rates of child maltreatment and foster care entry are nearly orthogonal to each other.[4] Additionally, even among substantiated cases of child maltreatment, only one third result in child removal (Testa and Smith, 2009). Therefore, it is unclear as to whether an event that affects foster care engagement will have the same impacts on child maltreatment.[5] Finally, the divergence in results between Gihleb et al. (2019) and our findings could also be attributable to several features of the data and research design, which we discuss in detail in Appendix C.

Second, we contribute to the literature on the opioid epidemic, not just by documenting another unintended consequence from reducing access, but by evaluating the extent to which other relevant polices may mitigate or exacerbate those adverse consequences for children. Third, the clinical literatures from social work and addiction understandably focus on the linkage between substance use and child maltreatment at the extensive margin. The overwhelming recommendation is to get parents with SUD into drug treatment therapy. This literature does not make recommendations about which substances might be most harmful to children if abused by

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[3] Bullinger and Ward (2021) also explore the relationship between opioid-related public policies, including PDMPs, and various measures of child welfare. Their analysis of child maltreatment is restricted to California.

[4] A trend-line regression of a scatterplot of foster care entry rates and reported maltreatment rates using state-level data from 2015 yields an estimated slope of 0.08. See Figure 2 of Doyle and Aizer (2018).

[5] While foster care is worth examining in its own right, it is only part of the child welfare picture. In 2017, child protective service organizations received over four million referrals involving more than seven million children, whereas approximately 270,000 children entered foster care that same year (U.S. Department of Health and Human Services, 2019; Child Welfare Information Gateway, 2019). The path from a child maltreatment allegation to a foster care placement is a long and uncertain one, suggesting that foster care engagement captures only a small share of child maltreatment.

their caregivers. Yet, if we consider policies which limit access to certain controlled substances, those policies will induce some users to substitute to other uncontrolled substances. Externalities from those substitutions, especially high stakes consequences such as child maltreatment, should be an important part of the cost-benefit analysis around joint policy choices.

The rest of the paper proceeds as follows: Section II provides institutional background on child maltreatment, the relationship between substance abuse and maltreatment, and evidence from the clinical literature on how the substitution from prescription opioids to more severe substances might impact child maltreatment. Section III describes the data we use in this analysis. Section IV details the empirical strategy and results. Section V concludes with a brief discussion and recommendations for future work.

II. Background

A. Child Maltreatment, Substance Use Disorder, And Addiction

The definition of child maltreatment varies across states, but generally refers to any acts or failures to act on the part of a parent or caregiver that result in harm or potential for harm to a child (Leeb et al., 2008). Most states recognize four types of maltreatment: neglect, physical abuse, psychological maltreatment, and sexual abuse (U.S. Department of Health and Human Services, 2019). In 2017, local child protective services (CPS) agencies received more than 4.1 million reports of possible child maltreatment involving 3.5 million children. Investigations concluded that approximately 674,000 children were victims of substantiated maltreatment, which corresponds to a national rate of 9.1 victims per 1,000 children. A supermajority of substantiated cases relate to neglect (74.9 percent). Most of the remaining cases involve physical abuse (18.3 percent of all substantiations). Approximately 8.6 percent of all cases involve sexual abuse, and 7.1 percent were victims of "other" types of abuse or neglect (U.S. Department of Health and Human Services, 2019).[6]

Controlling for other factors, there is a strong linkage between parental substance use and child maltreatment. Parents (or other caregivers) who abuse substances may have less capacity to

[6] These percentages exceed 100% as some victims may have suffered more than one type of child abuse or neglect. Types of child maltreatment that fall into the "other" category vary greatly from state to state and can vary within state over time. Examples include threats and lack of supervision.

respond to children's needs and may suffer from impaired judgement when responding (Testa and Smith, 2009). In addition to compromised caregiver ability, substance abuse is often accompanied by a life in which children are more likely to be exposed to violence, both in and outside the home (Connors-Burrow et al., 2009; Sprang et al., 2008). Further, the act of seeking *uncontrolled* substances is a risky endeavor that can put children in harm's way (Powis et al., 2000). For these and other reasons, substance abuse is categorized as a factor in up to 65 percent of all child maltreatment fatalities (Reid et al., 1999).

There is considerable evidence that the severity of the substance in question matters, and not just in the context of the opioid epidemic. In a national survey of social workers, 81.6 percent of respondents said abusive/neglectful parents usually used alcohol and uncontrolled substances. However, only 7.7 percent cited alcohol by itself (Reid et al., 1999). Additionally, while cocaine use had been prevalent in the United States throughout the 1980's, in the crack epidemic of the early 1990s child maltreatment cases more than doubled from 1.4 million to 3.0 million. In the context of opioids, there is anecdotal evidence that substitution from prescription opioids to heroin is associated with child maltreatment. In a brief to the Ohio Bar Association, Rothstein et al. (2013) note a doubling of child maltreatment cases in Butler County, OH between 2010, the year in which OxyContin was reformulated, and 2013; in the latter year, over half of cases where children were removed from their homes involved heroin. Medical guidelines also indicate that some substances are worse than others with regards to general functionality. For example, adults addicted to short-acting prescription opioids and heroin are treated with a maintenance regimen of buprenorphine, which has fewer destructive effects.[7]

The factors that make some substances fundamentally more hazardous to children than others include the intensity of the high, the duration of the effect, and the severity of the withdrawal – but also the extent to which the drug involves greater severity of *addiction*. Addiction refers to biochemical changes in the brain after some period of substance use, whereby substance use supersedes all other concerns. The neurobiological literature characterizes the relationship between parenting and addiction as a "dysregulation in the neural circuits of reward and stress reactivity and regulation" (Rutherford and Mayes, 2019). In other words, in a state of addiction, the reward system in the brain is co-opted to maintain behavior (drug seeking) for relief from the strain of addiction. In the addictive state, "parenting cues are not rewarding, but

[7] Buprenorphine is still an opioid, and can lead to dependency, but has little to no intoxicating effects and much milder withdrawal than heroin.

stressful." (Rutherford et al., 2011). The neurobiological and biochemical effects of addiction on the brain increase maladaptive behavior among parents interacting with children, even when not under the influence or in withdrawal (Molitor and Mayes, 2010; Hatzis et al., 2017). Romanowicz et al. (2019) note that direct observation studies find that "mothers with opioid use disorder, in comparison to controls, are more irritable, ambivalent, and disinterested while exhibiting greater difficulty in interpreting their children's cues" (p. 9). When addicted, seeking and procuring substances takes precedence. Addiction can affect parents' priorities and their ability to create a safe and stable environment. Additionally, when experiencing withdrawal, parents may experience higher levels of stress when engaging with small children and respond with apathy or anger to children seeking attention or physical nurturing (Wells, 2009).

B. The Rise And Reformulation Of OxyContin

From 1991 to 2010, the number of opioid prescriptions written and dispensed in the U.S. increased from 76 million to over 250 million (Volkow, 2014).[8] While there are numerous causes and consequences of this increase, the most important aspect for our context is that prescribing in the 1990s and 2000s created a population of prescription opioid-dependent users vulnerable to supply disruptions. Three features of the prescription opioid epidemic make this clear. First, with the release of OxyContin, Purdue Pharma sought to affect changes in prescribing practices. Purdue's marketing campaign targeted primary care providers to treat non-cancer chronic pain (Alpert et al., 2019; Tompkins et al., 2017; Quinones, 2015). Purdue also funded thought leadership to advocate for looser prescribing of pain medicine through the American Pain Society, which affected recommendations from Veterans Health, the Joint Commission on the Accreditation of Healthcare Organizations and others. A working paper by Alpert et al. (2019) shows that not only did Purdue's efforts expose a large number of heretofore non-users to OxyContin, but their efforts to change prescribing culture increased prescribing for most Schedule II and III opioids.

Second, OxyContin, a major catalyst of the opioid epidemic, had two features that made it a singularly strong candidate for abuse. OxyContin was designed as a 'time-release' formulation–meaning that it contained multiple doses in a single pill. However, the time release

[8] Data on 2010 prescription rates were retrieved from https://www.cdc.gov/drugoverdose/maps/rxrate-maps.html on March 22, 2019.

feature was due to the physical properties of the pill; if the pill were crushed or dissolved, then those multiple doses could be experienced all at once (Van Zee, 2009). Additionally, oxycodone, the narcotic ingredient in OxyContin, had until that point only been distributed in combination with acetaminophen. Acetaminophen, in large doses, has adverse effects on the liver and can induce liver failure. OxyContin, by contrast, was pure oxycodone, uninhibited by acetaminophen, thereby removing a pharmacological governor's switch to prevent abuse (Cicero et al., 2013).

Third, because it was designed for the treatment of chronic pain, OxyContin was purpose-built for long-term sustainable use. Kaiser Health News published documents from Purdue Pharma showing that in their promotions, they dubbed OxyContin "The Opioid to start with and stay with."[9] Together, these three factors created a large number of prescription opioid-dependent individuals at risk of substitution to more harmful substances once access became more difficult.

To curb the abuse of OxyContin, Purdue Pharma developed an abuse deterrent formula (ADF) of the drug, which was more difficult to crush or dissolve and take via non-oral routes. The Food and Drug Administration (FDA) approved this reformulated version in April 2010.[10] Purdue Pharma concurrently began shipping the new formulation while ceasing shipment of the old formulation in August 2010. The reformulation had its desired immediate effect as opioid abuse, particularly of OxyContin, decreased (Butler et al., 2013; Cicero and Ellis, 2015; Coplan et al., 2016; Havens et al., 2014; Severtson et al., 2013; Larochelle et al., 2015; Sessler et al., 2014). In fact, total opioid prescriptions leveled off between 2010 and 2012 and have decreased every year since (Guy Jr et al., 2017). Despite this decrease, opioid-related overdose deaths continued to rise throughout the most recent decade. In 2017, there were 47,600 opioid-related overdose deaths in the U.S., making it the leading cause of accidental deaths in the nation (Scholl et al., 2019).

C. Must-Access PDMP Laws

A second factor that impacted prescription opioid use during this period was increased state-level enactment and stringency of PDMPs, the state-level databases that record

[9] https://khn.org/news/how-america-got-hooked-on-a-deadly-drug/ and https://khn.org/news/purdue-and-the-oxycontin-files/
[10] Following Purdue Pharma, several pharmaceutical companies developed ADF versions of other prescription opioids. See https://www.fda.gov/drugs/postmarket-drug-safety-information-patients-and-providers/abuse-deterrent-opioid-analgesics.

prescriptions of controlled substances in order to monitor provider- and/or patient-specific prescription histories. States began enacting and implementing PDMPs in the early 2000s. Most PDMPs were initially optional and did not mandate any specific actions on the part of prescribers, a pattern that persisted for much of the 2000s.

In 2007, Nevada became the first state to include in its PDMP a “must-access” provision, which required providers to not only report all prescriptions, but also consult the PDMP to understand the patient’s history *before* writing a prescription for a controlled substance. Oklahoma and Ohio enacted must-access provisions in 2010 and 2011, respectively. A wave of other states followed suit starting around 2012. By 2016, 49 states had implemented some sort of PDMP, although only 18 included a must-access provision.[11]

D. Reduced Access To Prescription Opioids And Potential For Child Abuse And Neglect

The reformulation of OxyContin and the implementation of must-access PDMPs created the potential for unintended adverse consequences for children as they decreased the availability and increased the cost of accessing divertible oxycodone and other prescription opioids. In so doing, these policy changes affected two changes on opioid dependent caregivers, both of which bore risks for children in their care. First, some individuals substituted to heroin and other uncontrolled substances, from which withdrawals were far more severe, the supply was less reliable, and dose concentrations were of higher variance than prescription opioids. Second, in conjunction with the substitution to ‘worse’ (see below) substances, these changes migrated caregivers from the market for controlled to uncontrolled substances. Several papers have documented that overdoses, hepatitis B and C infections, and other adverse consequences increased in areas with heavy prior OxyContin use after the reformulation (Mallatt, 2018; Alpert et al., 2018; Evans et al., 2019; Powell et al., 2018a; Besheshti, 2019; Cicero and Ellis, 2015; Coplan et al., 2013; Compton et al., 2016).[12] More recently, Mallatt (2020), Powell and Pacula (2021) show that these measures led to an increase in heroin-related arrests, and more developed heroin markets in areas where oxycodone use was more prevalent, indicating that some substitution from prescription opioids to uncontrolled substances took place. Furthermore, the

[11] Missouri implemented a PDMP in 2017. See Table B1 for a list of must-access PDMP implementation dates by state through 2016.
[12] Alpert et al. (2018) and Evans et al. (2018) show a causal linkage between the drug’s reformulation and a rise in heroin overdose deaths. As a result, while deaths attributed to *prescription* opioids fell in direct response to OxyContin’s reformulation, heroin overdoses actually rose.

expansion of heroin markets could lead to adverse effects that worsen over time (Park and Powell, 2021; Powell and Pacula, 2021). Perhaps of equal importance with regards to child maltreatment, the substitution to heroin very seldom implies substitution to heroin alone. Heroin users use an average of 6.5 other substances (Hassan and Le Foll, 2019; Compton et al., 2021).

Substitution from prescription opioids, such as oxycodone, to heroin increases the risks for child maltreatment for several reasons. First, clinical and ethnographic studies documenting the transition from oxycodone to heroin all involve some version of "life began unraveling at a much faster pace after I started using heroin" (Monico and Mitchell, 2018). Heroin users reported that while withdrawal from OxyContin took more than a day to manifest, heroin withdrawal (with symptoms that include explosive diarrhea, vomiting, and pain) began within hours of non-usage and was an order of magnitude more severe than withdrawal from OxyContin. Intravenous heroin use led to even more severe and immediate withdrawal than nasal ingestion. Additionally, while heroin appeared much cheaper than prescription opioids on the surface, heterogeneity in purity/dosage, and the short acting nature of the drug meant that addicts spent more time and money seeking/procuring drugs after the switch to heroin (Mars et al., 2014; Monico and Mitchell, 2018).

While it is true that many prescription opioid users may not have significantly changed their substance use patterns after these policy changes, many of those with more severe dependency (or addiction) did. For those individuals, the reformulation of OxyContin and the implementation of must access PDMPs dramatically changed the full picture of their substance use disorder. Prior to supply restrictions, they were using substances designed (and FDA approved) for long-term sustainable use, with more reliable supply, that had less severe withdrawal symptoms (compared to heroin), and very precise dosage per pill. Those that substituted to uncontrolled substances may experience wide variation in concentration, severe and immediate withdrawal, multiple intoxicating effects from polysubstance use, and a far more dangerous and ad hoc procurement process, with a much more all-consuming addiction. Finally, and most tragically, the social work literature has consistently shown that those with substance use disorder are more likely to engage repeatedly in child maltreatment (Murphy et al., 1991; Wolock and Magura, 1996; Reid et al., 1999).[13] Therefore, even if a small number of individuals in a given time

[13] More precisely, from Reid et al. (1999) "In a national survey of social workers, almost half of all respondents (45.8 percent) say that repeated maltreatment occurs in at least half of all cases involving a substance-abusing parent."

period reach the proverbial tipping point into heroin/polysubstance use and maladaptive parenting–over time, these substitutions could lead to a substantial observed increase in child maltreatment.

III. Data And Preliminary Evidence

Our primary data source is the National Child Abuse and Neglect Data System (NCANDS), which reflects all referrals to state child protective services (CPS) agencies that receive a CPS response.[14] These data were obtained through a restricted data agreement with the National Data Archive on Child Abuse and Neglect (NDACAN). For a given year, the NCANDS data represent a census of CPS investigations and assessments that received a disposition (i.e., determination) in the federal fiscal year. State reporting under NCANDS is voluntary but most states and the District of Columbia consistently report during the period covered by our analysis. The NCANDS Child Files contain case-level information, where a case denotes a report-child pair. We use NCANDS Child Files for fiscal years 2006-2017. Because our analysis is at the county-level, we aggregate the case-level data to obtain annual county-level measures of child maltreatment.

The underlying outcome of interest for our study, the true amount of child maltreatment, is unobservable. Thus, as with other similar outcomes (e.g., crime), measurement is an important consideration. We form measures of child maltreatment using NCANDS data on reports of child maltreatment to child protective services (CPS) agencies and the outcomes of subsequent investigations. Given the extent of underreporting and the failure to substantiate valid allegations (Waldfogel, 1998), our measures likely underestimate the true amount of child maltreatment (Lindo and Schaller, 2014).

Before aggregating, we combine the NCANDS Child Files for fiscal years 2006-2017. For cases (i.e. child-report pairs) that appear in multiple Child Files, we follow the recommendation in the NCANDS User's Guides to keep only the instance in the most recent

[14] The NCANDS Child Files (FFY2006v5, FFY2007v6, FFY2008v5, FFY2009v6, FFY2010v5, FFY2011v5, FFY2012v4, FFY2013v3, FFY2014v3, FFY2015v3, FFY2016v1, FFY2017v1) were provided by the National Data Archive on Child Abuse and Neglect (NDACAN) at Cornell University, and have been used with permission. The data were originally collected under the auspices of the Children's Bureau. Funding was provided by the Children's Bureau, Administration on Children, Youth and Families, Administration for Children and Families, U.S. Department of Health and Human Services. The collector of the original data, the funding agency, NDACAN, Cornell University, and the agents or employees of these institutions bear no responsibility for the analyses and interpretations presented here. The information and opinions expressed in this paper reflect solely the opinions of the authors. Appendix D provides institutional details on NCANDS reporting.

fiscal year. For each case, we then identify the calendar year in which the suspected case was reported to the state CPS agency (as opposed to the fiscal year in which the case received a disposition). About 98 percent of cases receive a disposition within two years of being reported (e.g., a report submitted in 2006 is almost certain to appear in the 2006 or 2007 Child File). Thus, combining the Child Files for 2006 through 2017 covers almost all reports of child maltreatment received between 2006 and 2016.

One feature of the NCANDS data is that county identifiers are only available for cases coming from counties with at least 1,000 total cases in the fiscal year. For cases from counties with fewer than 1,000 total cases, county is masked.[15] Given this limitation, we use a two-step process to form our estimation sample. First, we identify 438 counties in 44 states that appeared in every Child File from 2006 to 2017 (Table A1). While these "identified" counties comprise only 15% of all U.S. counties, they contain over 62% of the U.S. population (Figure 1).[16] Second, to ensure that we can count all cases, and to minimize concerns about bias from censoring, for each state we create one "super" county consisting of all other counties in the state (i.e., all counties in the state that are masked in at least one Child File).[17] We provide more detail on the process used to construct the super counties in Appendix A. Appendix Table A2 summarizes differences between identified counties and super counties. We combine the 438 identified counties with 48 super counties to create our estimation sample, a balanced panel covering the period 2006 to 2016. We prefer this procedure to a county-level analysis using only the 438 identified counties and/or a state-level analysis. Compared to a county-level analysis of only identified counties, our sample reflects all counties and cases. Compared to a state-level analysis, our strategy allows us to exploit the significant within-state variation in child maltreatment and opioid use that would be masked with a state-level analysis. Nonetheless, we explore these alternative samples in robustness tests and find qualitatively similar results.

The NCANDS data classifies child maltreatment into different types including physical abuse, neglect, medical neglect, sexual abuse, psychological or emotional maltreatment, and other maltreatment. Prior to submitting its data each year, each state maps its own maltreatment

[15] Although our county-level analysis does not compromise confidentiality, efforts to obtain county-by-year data representing all counties from NDACAN were unsuccessful. While previous studies use county-by-year data (e.g., Orsi et al., 2018), NDACAN is unable to provide researcher access to these data (personal correspondence with Christopher Wildeman, Director of NDACAN, 12/19/18). County is also masked for cases in which the child died to protect confidentiality.
[16] This statement is based on population from the U.S. Census Bureau as of 2006, the beginning of the period covered by our sample.
[17] From this point forward, we use the term county to refer to a geographic unit in our sample (i.e., an identified county or a super county).

definitions into these categories. Some states do not use all of the NCANDS categories and there is variation in the mapping process across states and even within states over time. Our main outcomes of interest focus on neglect and physical abuse, the two most common types of child maltreatment and those with the clearest links to parental substance abuse.[18] We explore other maltreatment types in robustness tests.

We focus on two primary outcomes, both measured annually at the child-level: the number of children with at least one report of physical abuse or neglect in the county-year (*allegations*) and the number of children considered to be victims of physical abuse or neglect for at least one report in the county-year (*substantiations*). Allegations reflect only those instances of physical abuse or neglect that have received a response from a CPS agency. A child is considered to be a victim if an allegation is determined by investigation to be substantiated or indicated according to the definition under state law. We combine these measures with child population counts from the Census to create rates per 1000 children.[19] In robustness tests, we also report results for the substantiation rate, the fraction of children considered to be victims of physical abuse or neglect among those with at least one allegation in the year. Figure 1 shows the geographic distribution of allegations between 2006 and 2016 for the identified counties in our sample, specifically the median number of children with alleged physical abuse or neglect in the county.[20] The shading reflects quantiles of the distribution. As shown in Figure 2, for the mean county in our sample, allegations trend upward during the 11 years covered by our analysis. Mean substantiations fall during the early period of our sample, are fairly stable between 2011 and 2013 and then increase thereafter.

We obtain information on prescription opioids from the Centers for Disease Control (CDC). The CDC data represent an 85% sample of retail pharmacy providers but exclude hospitals. Median per capita opioid prescriptions in our sample rise until a peak in 2012 and fall thereafter. Alpert et al. (2018) and Evans et al. (2019) explore national trends in OxyContin abuse using different measures and find a peak in 2010 at the time the drug was reformulated, roughly two years earlier than the peak of median opioid prescriptions in our sample. Between 2010 and 2012, 18 states began operating PDMPs according to the dates developed by Horwitz

[18] Many previous studies of child abuse and neglect in the economics literature also focus on physical abuse and neglect (e.g., Bitler and Zavodny, 2002; Currie and Widom, 2010; Paxson and Waldfogel, 1999). While sexual abuse has been linked to substance abuse, it is found almost exclusively for methamphetamines and other stimulants, not the depressants under consideration here (Testa and Smith, 2009).
[19] Child population is calculated using the Census age categories and defined as age 0 to 19.
[20] Figure A1 provides a comparable map for substantiations.

et al. (2018), and a wave of must-access PDMP implementation began in 2012 (Sacks et al., 2021). Thus, the CDC data indicate a reduction in prescription opioid use subsequent to the two supply-side interventions we study. Finally, we collect county-level demographic data (age, race, ethnicity, and gender) from the U.S. Census Bureau, county labor force statistics from the Bureau of Labor Statistics, and a county health-related variable on the number of cancer deaths from the Centers for Disease Control (CDC).

IV. Empirical Strategy And Results

We explore the effects of two different interventions, the reformulation of OxyContin and the implementation of a must-access PDMP, using event study and difference-in-differences (DID) specifications, on child maltreatment. While we keep our empirical approaches as similar as possible when examining these two interventions, the nature of these interventions necessitates some differences in our empirical approaches.

The reformulation of OxyContin occurred at a specific point in time, for all geographic areas under consideration, resulting from an unanticipated, autonomous decision on the part of Purdue Pharmaceutical. Thus, for the purposes of identification, this intervention represents an exogenous shock. To explore the causal impact of OxyContin's reformulation on child abuse and neglect, we estimate event study and DID specifications that exploit pre-reformulation exposure to prescription opioids in the spirit of Alpert et al. (2018) and Evans et al. (2019).

By contrast, must-access PDMPs were not implemented in all states during our sample period, and different states implemented these programs at different times. These decisions resulted from states' enactment decisions as well as the actions taken by the state to operationalize the PDMP, which played out over a period of time, sometimes years. Some states initially adopted PDMPs without must-access provisions but later added such provisions. For these reasons, the intervention is fundamentally different from the reformulation of OxyContin. Consistent with related work, we estimate event study and DID specifications for the must-access PDMP analysis for the average county (Buchmueller and Carey, 2018; Sacks et al., 2021; Nguyen et al., 2019).[21]

[21] In the OxyContin reformulation analysis we exploit variation in pre-intervention exposure to prescription opioids to examine how the reformulation impacted child maltreatment in counties with higher pre-intervention exposure to prescription opioids relative to counties with lower pre-intervention exposure. In contrast, the staggered timing of must-access PDMP implementation across states makes defining the pre-

A. OxyContin Analysis

In this section we estimate the causal impact of OxyContin's reformulation on child maltreatment, exploiting variation in pre-intervention exposure to prescription opioids across counties. To do so requires a county-level measure of pre-intervention opioid exposure to align with our county-level child maltreatment measures. Prior state-level analysis by Alpert et al. (2018) measured pre-intervention exposure as the population-weighted rate of OxyContin misuse in the state from 2004 to 2009, the period just prior to OxyContin's reformulation. However, this measure is unavailable at the county level. We therefore construct a measure of pre-intervention exposure at the county level as the population-weighted mean number of all Schedule II opioid prescriptions per capita in the county for the period 2006 to 2009 from the CDC data. While Alpert et al.'s measure focuses solely on OxyContin misuse, our county-level measure of pre-intervention exposure reflects <u>all</u> uses (i.e., prescribed use and misuse) of <u>all</u> Schedule II prescription opioids (i.e., not just OxyContin).[22] Thus, our measure allows for more precise local variation in pre-intervention exposure to opioids but reflects a broader set of prescription opioids than the target of the intervention, OxyContin. We explore robustness of our results to replacing the county-level pre-intervention exposure measure with Alpert et al.'s state-level measure of misuse.

Before discussing our empirical strategy in more detail, we briefly comment on differences between the counties in our sample with higher and lower pre-intervention exposure. Table 1 provides means for outcomes and controls in the pre-intervention period for counties with per capita opioid prescriptions below (in the second column), and equal to or above (in the third column) the sample median of 0.823. We refer to the former counties as low-exposure counties and the latter as high-exposure counties. By definition, high-exposure counties have

intervention period less clear-cut. For this reason, the main PDMP analysis focuses on treatment effects for the average county instead. However, for comparison to the reformulation analysis, we do estimate differential PDMP treatment effects based on pre-intervention exposure in Section IV.B.

[22] Using Alpert et al.'s state-level measure, we confirm higher post-reformulation OxyContin misuse rates among counties with higher pre-reformulation opioid use based on our county-level measure. Figure A2 depicts the relationship between pre-intervention exposure in the county and the change in the rate of OxyContin misuse in the state between 2008 and 2012 for the counties in our sample. To generate the figure, we divide counties into quartiles based on the population-weighted mean number of opioid prescriptions per capita between 2006 and 2009. Compared to counties in the lowest two quartiles based on pre-intervention per capita opioid prescriptions, counties in the highest two quartiles experience on average larger reductions in the rate of OxyContin misuse between 2008 and 2012 as measured by Alpert et al.'s state-level measure. Overall, the reformulation had the greatest effect on reducing OxyContin misuse, and potentially creating adverse substitution patterns, in areas where pre-reformulation usage was most prevalent according to the county-level exposure measure.

higher mean opioid prescriptions per capita than low-exposure counties; they are also located in states with relatively higher pre-intervention levels of OxyContin misuse based on Alpert et al.'s measure. Compared to low-exposure counties, high-exposure counties are more rural, older, more white, less Hispanic, with higher cancer death rates and lower labor force participation in the pre-intervention period. Finally, high-exposure counties have more alleged physical abuse or neglect than low-exposure counties between 2006 and 2009 although we detect no statistically significant difference for substantiated physical abuse or neglect.

To examine the causal impact of OxyContin's reformulation on child maltreatment we consider two primary specifications, an event study and a DID model. In the event study, we interact event year indicators with the measure of pre-intervention exposure using specifications that take the following form:

$$(1) \qquad y_{ct} = \alpha_c + \gamma_t + \delta_t \times Exp_c + X'_{ct}\lambda + \varepsilon_{ct}$$

where y_{ct} denotes the child maltreatment outcome in county *c* and year *t*. We consider two primary maltreatment outcomes: the number of children with at least one allegation of physical abuse or neglect in county *c* and year *t* per 1000 children (allegations) and the number of children with at least one substantiated report of physical abuse or neglect in the county-year per 1000 children (substantiations). Exp_c represents pre-intervention exposure to prescription opioids in county *c* as described above. County-fixed effects, α_c, control for time-invariant differences across counties that contribute to differences in physical abuse and neglect. Year fixed effects, γ_t, control for time-varying national shocks to child abuse and neglect. X'_{ct} denotes a vector of county- and time-varying covariates including the percent of the county population in six age groups (0-19 , 20-24, 25-34, 35-44, 45-54, 54-64), percent female, percent white, percent Black, percent Hispanic, unemployment rate, labor force participation rate, and number of cancer deaths per 100,000 people, as well as state- and time-varying policy indicators for a PDMP of any form and a medical marijuana law.[23] Equation (1) is estimated using weighted least-squares where the weights are the average child population (aged 19 and younger) in the county during the sample period. The coefficients of interest are the set of δ_t event year coefficients, which

[23] Information on PDMPs comes from Horwitz et al. (2018). Medical marijuana law data are taken from Alpert et al. (2018) and http://www.ncsl.org/research/health/state-medical-marijuana-laws.aspx. For age, the excluded category is the percent of the county population that is age 65 and older.

identify differences in physical abuse and neglect between counties with higher and lower pre-intervention exposure in year *t* compared to 2010, the year OxyContin was reformulated.

Figure 3 presents our event study results. Panel A and B depict results for allegations and substantiations, respectively, of physical abuse and neglect. We report point estimates and 95% confidence intervals on the interaction terms from weighted least-squares regressions of (1) with 2010, the year in which OxyContin was reformulated, normalized to zero. For both allegations and substantiations, the estimated coefficients in the years prior to reformulation are statistically indistinguishable from zero consistent with no trend differences between higher- and lower-exposure counties during the pre-reformulation period. After the reformulation, the number of children per 1000 with alleged and substantiated cases of child physical abuse or neglect begins increasing in high-exposure counties relative to low-exposure counties. All of the post-intervention event study coefficients are positive, suggesting a relative increase in physical abuse and neglect following reformulation in counties with higher rates of pre-intervention exposure.

The estimated event study coefficients generally rise in each subsequent year through 2016. Part of this increase in the estimated effect size over time is to be expected given that some children are the subject of repeated instances of physical abuse and neglect. From the social work literature, estimates of the re-report rate of child maltreatment range from 13 to 50 percent, depending on the sample. However, when substance abuse is a factor, longitudinal studies have found that subsequent cases of maltreatment are between 50 and 200 percent more likely to occur than when substance abuse is not a factor (Murphy et al., 1991; Wolock and Magura, 1996; Fuller and Wells, 2003; Drake et al., 2006). Unfortunately, the severity of substance use disorder is also associated with greater likelihood of recurrent maltreatment (Reid et al., 1999). The increase in estimated effect size over time is also consistent with the notion that the reformulation of OxyContin led to the growth and maturation of illicit heroin markets in areas with higher pre-reformulation exposure to opioids as discussed in Park and Powell (2021) and Powel and Pacula (2021).

Additionally, it is important to note that while overdose deaths may be sudden, increases in child maltreatment linked to the reformulation may take more time to occur and to become visible in the data. Unlike deaths, which are quickly and consistently available in death records, child maltreatment is only observed in our data when it is sufficiently pronounced to prompt someone to report to a CPS agency *and* the agency to determine that a response is appropriate.

Suspected child maltreatment is reported most frequently by educational, legal and law enforcement, and medical personnel but also by family members, neighbors, and other individuals (Children's Bureau, 2018). To the extent that substance abuse leads to child maltreatment, these events may not immediately come to the attention of professionals. Other potential reporters (e.g., family members) may be initially reluctant to report given the potential implications of a substantiated claim of child abuse or neglect (e.g., child removal, criminal charges). We explore this issue in more detail below.

We also consider a DID specification as it allows for more straightforward interpretation when estimating the short-run (SR) and medium-run (MR) impacts of OxyContin's reformulation on child maltreatment. The DID specification takes the following form:

$$y_{ct} = \alpha_c + \gamma_t + \delta_1[Pre_t \times Exp_c] + \delta_2[(SR\ post_t) \times Exp_c] + \delta_3[(MR\ post_t) \times Exp_c] + X'_{ct}\lambda + \varepsilon_{ct} \tag{2}$$

Pre_t is an indicator variable that takes the value of one for the pre-reformulation years, 2006 to 2009. The variable $SR\ post_t$ takes a value of one for the years immediately following reformulation, 2011 to 2013. $MR\ post_t$ denotes the years 2014 to 2016, several years post-reformulation. X'_{ct} is defined as above. In all models in the main body of the paper, counties are weighted by child population.

The first column of Table 2 reports estimates of the three δ coefficients in (2) with panel A providing results for allegations and panel B doing so for substantiations. Results are consistent with the event studies. The impacts of OxyContin's reformulation are larger in the medium-run than immediately following the reformulation. The estimated short-run coefficient in panel A suggests that a one standard deviation increase in pre-reformulation exposure yields about a 3.7% annual increase in children with alleged physical abuse and neglect in the years immediately following OxyContin's reformulation. The comparable calculation based on the medium-run coefficient is about 9.5%. The estimated effect sizes for children with substantiated physical abuse and neglect are 3.3% in the short-run and 11.1% in the medium-run. The DID results align with the event study findings of no differential pre-intervention trends between high- and low-exposure counties.

Robustness tests.—We conduct several robustness checks to demonstrate that the above findings are robust to alternative sample definitions and alternative pre-exposure measures. We also utilize information on the source of the report to address concerns about measurement error and examine whether the main results likely reflect changes in true maltreatment or just changes in reporting behavior. Finally, we investigate whether these results align with previous work examining heroin deaths and conduct a falsification test using sexual abuse as an outcome.

First, we explore the potential implications of measurement error in the reporting of child maltreatment by focusing on the source of maltreatment reports.[24] Reports of child maltreatment come from various sources including professionals with whom children and families interact (e.g., teachers, physicians). All states have mandatory reporting laws related to child maltreatment. Laws in 47 states enumerate specific professionals as mandatory reporters (Child Welfare Information Gateway, 2019).[25] The professional groups most commonly required to report include social workers; educational personnel; health-care personnel such as physicians and nurses; mental health professionals such as counselors; child care providers; coroners; and law enforcement officers. Some state laws apply to additional professional groups such as members of the clergy. Most states offer training resources to assist mandatory reporters in recognizing and reporting suspected child maltreatment although the quality of such training is likely to vary (Crosson-Tower, 2002).

If mandatory reporters are better at detecting true child maltreatment than non-mandatory reporters, then their reports will be less subject to measurement error. Fitzpatrick et al. (2020) explore this issue in the context of child maltreatment reporting by educational professionals. They find that more time spent in school increases reports of child maltreatment and that the increased reporting by educational professionals represents new, high-quality reporting as opposed to over- or duplicative reporting.

To explore the implications for our analysis we use information from the NCANDS data on the report source to create a variable that distinguishes between professional and non-professional sources. We code the following report sources as professional: social services,

[24] We thank an anonymous reviewer for suggesting this.

[25] Information as of April 2019. Indiana, New Jersey, and Wyoming require all persons to report. Eighteen states require all persons to report and specify professionals in their mandatory reporting laws. The report source variable is unknown or missing for about 6% of observations in the case-level data. We code these observations as arising from non-professional report sources. The role of educational professionals in identifying and reporting child maltreatment has received significant media attention during the COVID-19 pandemic in which many students engaged in remote learning. See for example Agrawal (2020). Baron et al. (2020) find that reported maltreatment in Florida during the first two months of school closings was 27% lower than expected based on a counterfactual.

medical, mental health, legal, law enforcement, criminal justice, and education personnel as well as child day care providers. Other report source categories, for example a relative or neighbor, are coded as non-professional. We then form counts of children with allegations/substantiations of physical abuse or neglect reported by a professional and those with allegations/substantiations reported by a non-professional. The mean number of children per 1000 with physical abuse or neglect allegations reported by a professional, 19.1, is similar to the mean number of children per 1000 with allegations reported by a non-professional, about 20. However, the average county has about 6 children per 1000 with at least one substantiation of physical abuse or neglect reported by a professional. The comparable mean for substantiated physical abuse or neglect reported by a non-professional is half, about 3 per 1000 children. Thus, while the reporting of child maltreatment based on our measures is similar for professionals and non-professionals, a larger share of reports submitted by professionals are substantiated compared to those by non-professionals. If substantiated child maltreatment is closer to the unobserved, true level of child maltreatment, then the higher substantiation rate for allegations reported by professionals suggests professionals are relatively more proficient in identifying child maltreatment.

We re-estimate event studies using the resulting four outcome measures, reported in Figure 4. Figures on the left restrict attention to allegations (Panel A) or substantiations (Panel B) from professional report sources while those on the right focus on allegations/substantiations from non-professional report sources. The estimated post-reformulation event study coefficients in the right-hand figures (non-professional report source) are small in magnitude and statistically indistinguishable from zero while all of the estimated post-reformulation event study coefficients in the left-hand figures (professional report source) are positive and statistically significant. The DID results, when separated by report source, reported in the last two columns of Table 4, confirm the patterns depicted in the event studies. Overall, our results from distinguishing by report source reinforce our main findings but also underscore the importance of considering potential sources of measurement error in analyzing child maltreatment.

Second, we consider an alternative outcome measure, the substantiation rate, which measures the fraction of children with substantiated physical abuse or neglect conditional on an allegation of physical abuse or neglect. If OxyContin's reformulation leads dependent parents or other caregivers to substitute towards other harsher substances, then children might be impacted in negative ways due to decreased family functioning, for example school absenteeism (Lander et al., 2013), but in ways that do not rise to child maltreatment. If these changes are visible to mandatory or other potential reporters, then they might result in an allegation of suspected child maltreatment but would not necessarily lead to a substantiated case of maltreatment. This pattern would result in a differential impact of OxyContin's reformulation on our two primary maltreatment outcomes, allegations and substantiations.[26] On the other hand, a null impact of the reformulation on the substantiation rate implies it is less likely that the reformulation merely generated more reports of child maltreatment without changing the true rate of maltreatment. Figure 5 depicts event study results for the substantiation rate outcome. Both the estimated pre- and post-reformulation coefficients are small in magnitude and statistically insignificant. Thus, we find no evidence that OxyContin's reformulation affected the substantiation rate.

Third, we use two alternative samples to address concerns about the composition of our main sample. One alternative sample is a county-by-year panel that includes only the 438 identified counties (dropping the super-counties from our main sample) while the other is a state-by-year panel (Figures A3 and A4). Fourth, we report results based on broader measures of maltreatment, specifically the number of children with at least one allegation (or substantiation) of maltreatment of any type (Figure A5). Fifth, we replace the county-level measure of pre-intervention exposure with an alternative measure, state-level misuse of OxyContin from Alpert et al. (2018) (Figure A6). Because Alpert et al.'s measure captures misuse of OxyContin in the state during the pre-intervention period, it may more accurately reflect a county's true exposure to OxyContin if pre-intervention misuse in the county is similar to the average pre-intervention misuse of the state. On the other hand, for counties with pre-intervention misuse that differ from the state average, the county-level measure of pre-intervention exposure may be a closer approximation of actual exposure. For all of these robustness tests, the results are qualitatively similar to but in some cases less precisely estimated than our main results.

Sixth, to reconcile these results with prior findings in the literature, we explore the extent to which the impacts of OxyContin's reformulation on child maltreatment mirror those of its impact on heroin deaths and on measures of opioid use by pregnant women. To do so, we break our sample into counties below and above the median percentage white population in the county in 2006. We conduct a similar exercise using the percentage of the county that is rural based on

[26] There are of course other reasons a differential impact could arise, for example changes in resources or investigation procedures at state CPS agencies or policy changes that are associated with the timing of OxyContin's reformulation and the geographic distribution of opioid use prior to the reformulation. We are unaware of any such changes.

the 2010 Census. Alpert et al. (2018) find larger impacts of OxyContin's reformulation on heroin deaths among whites compared to non-whites while Villapiano et al. (2017) document a larger increase in the incidence of neonatal abstinence syndrome and maternal opioid use in rural counties from 2004 to 2013 relative to urban counties. Consistent with these studies, we generally find a larger impact of OxyContin's reformulation on child maltreatment among counties with a larger white population share (Figure A7) and among more rural counties (Figure A8).

Finally, as a falsification test, we examine whether the reformulation of OxyContin led to a relative increase in sexual abuse (Figure A9). Relative to physical abuse and neglect, the pathway from OxyContin's reformulation to child sexual abuse is less clear. Some substances, such as methamphetamines, can lead to hypersexuality among users. However, the pharmacological properties of depressants are far less likely to lead to sexual abuse (Wells, 2009). To the extent that OxyContin's reformulation might lead to increases in child sexual abuse those effects are most likely occurring through indirect channels (e.g., neglect by a caregiver may increase a child's risk of sexual predation). Therefore, marked increases in sexual abuse in higher exposure counties following the reformulation would raise concerns about whether our main results were spurious. However, we find no evidence of increased sexual abuse, post-reformulation, in high exposure counties compared to low exposure counties.

Heterogeneous Effects And Complementary Policies.—In this section, we explore the extent to which the reformulation's impact on child maltreatment varies across counties located in states that have adopted potentially complementary or otherwise related policies. We focus on variation in access to medical marijuana, substance abuse treatment resources for pregnant women, and the treatment of drug exposure and drug use in how states define child maltreatment.

First, we examine heterogeneity with respect to state-level policies allowing the use of medical marijuana. Powell et al. (2018b) and Garín et al. (2018), among others, provide evidence of potential substitution between prescriptions opioids and medical marijuana. If the availability of legal medical marijuana halts or slows the progression towards heroin, then we should observe differential effects of OxyContin's reformulation in counties located in states with medical marijuana laws compared to other counties. Split-sample event studies based on the presence of a state-level medical marijuana law as of 2010 are shown in Figure 6. For alleged physical abuse and neglect (Panel A), we estimate a larger adverse impact of the reformulation among counties without access to medical marijuana based on this measure. While we cannot confirm a causal link, the results for allegations are consistent with substitution towards medical marijuana, when available, muting some of the adverse consequences of OxyContin's reformulation on child maltreatment. For substantiated abuse and neglect (Panel B), the estimated event study coefficients are similar among counties with and without medical marijuana access.[27]

Next, we explore how the impact of OxyContin on child maltreatment varies based on the availability of substance abuse treatment resources for pregnant women. This is potentially important in our context given that the child maltreatment victimization rate is highest for children under age one (Child Maltreatment, 2017). Some states have drug treatment programs targeted towards pregnant women. Some states give pregnant women priority access to state-funded general drug treatment programs. Finally, some states prohibit discrimination against pregnant women by publicly funded drug treatment programs. If pregnant women are more easily able to access substance abuse treatment resources, then the adverse implications for child maltreatment of OxyContin's reformulation may be lessened. While we cannot offer causal evidence on this question, we can explore the extent to which variation across states with regards to substance abuse treatment resources for pregnant women is associated with heterogenous effects of OxyContin's reformulation on child maltreatment. Using information from the Guttmacher Institute (2020), we classify each state according to 1) whether or not the state has created a drug treatment program targeted towards pregnant women, 2) whether or not the state gives priority access to pregnant women in general drug treatment programs, and 3) whether or not the state prohibits publicly funding drug treatment programs from discriminating against pregnant women.[28]

Using these three variables, we split our sample and estimate event studies. Results are reported in Figures 7-9. Event study coefficients from the sub-sample of counties in states with more generous drug treatment resources for pregnant women, based on these three measures, are denoted with diamonds; squares denote the results for counties in states with fewer resources.

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[27] However, if we restrict attention to substantiations reported by professionals, then the event study results mimic the pattern depicted in Figure 4, Panel B. That is, the estimated impact of the reformulation on substantiated physical abuse and neglect reported by professionals is larger among counties without access to medical marijuana compared to counties with access.

[28] As of February 1, 2020. 39 states have adopted none or one of these policies; 8 states have two while 4 states have all three.

While imprecisely estimated, the post-reformulation event study coefficients from the sub-sample of counties with fewer drug treatment resources for pregnant women are consistently higher. This pattern suggests that the increase in physical abuse and neglect caused by OxyContin's reformulation was larger in counties located in states that offer fewer substance abuse treatment resources for pregnant women. Indeed, several of the event study figures show estimated post-reformulation event study coefficients close to zero for the sub-sample of counties with more generous treatment resources to pregnant women. Overall, we find heterogeneous effects of OxyContin's reformulation based on the availability of drug treatment resources for pregnant women. We cannot confirm that a causal mechanism underlies these results as the availability of substance abuse treatment resources for pregnant women is likely to be endogenous. Nevertheless, these results point to the broader policy environment as a potential key factor in mitigating or exacerbating the unintended consequences of policy changes with respect to addictive goods.

Finally, a particularly important aspect of defining child maltreatment is how state policies and procedures treat exposing a child to drugs and caregiver drug use. Unfortunately, we do not have precise information on this variation across states and over time for the period covered by our sample.[29] We do, however, have a snap shot of state-level variation as of April 2015 (Child Welfare Information Gateway, 2016). Specifically, we can identify whether or not a state includes exposure of infants to drugs in its definition of child maltreatment and whether or not a state counts use of a drug that impairs one's ability to care for a child as child maltreatment as of this date. We use these two measures to estimate split-sample event studies, which are reported in Figures A10 and A11. We do not find large differences in the reformulation's impact based on the treatment of substance-exposed newborns (Figure A10). When we explore variation in the treatment of caregiver drug use, we find no variation for alleged physical abuse and neglect but we do detect a larger impact of the reformulation on substantiated cases of abuse and neglect among counties in states that define caregiver drug use as child maltreatment (Figure A11). While these results highlight potentially important sources of heterogeneity worthy of further exploration in future studies, it is important to note that this state-level variation is also likely endogenous so no causal interpretation can be attributed to these results. As above, these

[29] The Child Welfare Information Gateway (2016) notes that "states frequently amend their laws" (p. 1).

results identify interesting associations worthy of study in future work but do not verify an underlying causal mechanism.

B. *PDMP Analysis*

We now turn to the implementation of must-access PDMPs. Must-access provisions require physicians and/or pharmacists to check the PDMP database and view the patient's prescribing history *before* writing/dispensing an opioid prescription. Examining the implementation of must-access provisions complements the OxyContin analysis because it speaks directly to the generalizability of our results. Broadly speaking, if multiple, distinct efforts to reduce prescription opioid misuse have adverse consequences for children, then these spillovers should be considered when designing interventions. We do note, however, that the results from this section should be interpreted with some caution. States may have implemented must-access PDMPs either due to unobserved factors that could be correlated with both opioid prescriptions and child maltreatment, or in direct response to reported adverse consequences of substance use. We therefore do not suggest that these policies are strictly exogenous. Furthermore, Horwitz et al. (2018) document inconsistencies in PDMP implementation dates across data sources, suggesting the potential for some degree of measurement error.

Empirical Specifications And Results.—We follow Buchmueller and Carey (2018), Nguyen et al. (2019), Sacks et al. (2021), and Gihleb et al. (2019) and estimate event studies and DID models to examine the effects of must-access PDMPs on child maltreatment for the average county. For the must-access PDMP implementation dates, we start with the dates provided in Sacks et al. (2021), which were sourced from the National Alliance for Model State Drug Laws (NAMSDL). Those dates were then cross-referenced with the implementation dates in Gihleb et al. (2019), Mallatt (2020), state profiles collated by the PDMP Training and Technical Assistance Center (TTAC), and an independent review of state statutes and medical board websites. Appendix Table B1 reports the must-access PDMP implementation dates used in our analysis as well as a discussion of any changes made to the Sacks et al. (2021) dates and citations for the relevant state statutes.[30] For our analysis, the treatment group consists of county-years in which the state has implemented a must-access PDMP. Following Buchmueller and Carey (2018), the control group includes county-years with no state PDMP and those with a state PDMP but no must-access provision.[31] We express the event study specification as in Clarke and Schythe (2020):

$$(3) \qquad y_{cst} = \alpha_c + \gamma_t + \sum_{j=2}^{J} \delta_j (Lag\ j)_{st} + \sum_{k=1}^{K} \gamma_j (Lead\ k)_{st} + X'_{cst}\lambda + \varepsilon_{cst}$$

with y_{cst} denoting the child maltreatment outcome for county *c* in state *s* and year *t*. α_c and γ_t are defined as in (1), X'_{cst} denotes a vector of county- and time-varying covariates including the county age profile, percent female, percent white, percent Black, percent Hispanic, unemployment rate, labor force participation rate, and number of cancer deaths per 100,000 people, and

$$(Lag\ J)_{st} = \mathbb{I}[t \leq PDMP_s - J]$$
$$(Lag\ j)_{st} = \mathbb{I}[t = PDMP_s - j]\ for\ j \in \{1, \dots, J-1\}$$
$$(Lead\ k)_{st} = \mathbb{I}[t = PDMP_s + k]\ for\ k \in \{1, \dots, K-1\}$$
$$(Lag\ K)_{st} = \mathbb{I}[t \geq PDMP_s + K]$$

where $PDMP_s$ denotes the year in which state *s* implements a must-access PDMP. We include four lags and four leads so $J = K = 4$. As noted in (3), we omit the first lag (i.e., for event year -1) to capture baseline differences between counties in states that adopt must-access PDMPs and those that do not.

We also consider a DID specification:

$$(4) \qquad y_{cst} = \alpha_c + \gamma_t + \beta_1 PDMP_{st} + X'_{cst}\lambda + \varepsilon_{cst}$$

where $PDMP_{st}$ is a dummy variable equal to one if a must-access PDMP has been implemented in state *s* and year *t*, and all other variables are as previously defined. Similar to the OxyContin

[30] Horwitz et al. (2018) also use a consistent and careful process to document PDMP implementation dates but unfortunately their implementation dates are in reference to any PDMP as opposed to must-access PDMPs.

[31] Buchmueller and Carey (2018) find that the implementation of must-access PDMPs reduces measures of opioid misuse, but find no such effect among states with a PDMP that has no must-access provision. More specifically, they find little difference between the states with a PDMP that has no must-access provision and states without any PDMP altogether. They therefore group these two latter categories together into a single control group.

analysis, event study and DID specifications are estimated using weighted least squares regressions in which the weight is the average child population in the county during the sample period. Standard errors are clustered by state.[32]

Figure 10 presents our main event study results. The effects of must-access PDMP implementation on allegations of physical abuse or neglect on the average county are shown in Panel A, and results for substantiations are reported in Panel B. In both panels, the estimated lag coefficients are statistically indistinguishable from zero, consistent with no pre-trend differences between treated and control counties. The estimated lead coefficients are positive, suggesting that both allegations and substantiations of physical abuse or neglect rose in the wake of must-access PDMPs. However, these estimates are statistically insignificant. The same is true of our main DID results, presented in the first column of Table 3. Although statistically insignificant, the estimate of β_1 from Panel A indicates an imprecise average treatment effect of nearly 3 allegations per 1000 children per year. Based on the sample mean of about 38 allegations per 1000 children, this represents an effect size of about 8%.

Robustness And Comparison To Results From OxyContin Analysis.—As with the OxyContin analysis, we conduct a number of robustness tests. First, we explore the role of report source by distinguishing allegations/substantiations reported by professionals and non-professionals. Figure B1 and Table 3 present the event study and DID results, respectively. We find that, consistent with results for the reformulation, any adverse effects on child maltreatment are driven entirely by those reported by professionals. The estimated *PDMP* coefficient in the second column of Table 3 (Panel A) suggests that PDMP implementation increased the annual number of children with physical abuse and neglect allegations reported by professionals by about 4 per 1000 in the average county. This is statistically and economically significant, indicating about a 20% increase at the sample mean. Second, we report event studies using two alternative samples, the identified county sample in Figure B2 and the state sample in Figure B3. Results are similar to our main event study results in Figure 10. Third, we estimate event studies with sexual abuse as a falsification test. Figure B4 confirms no impact of must-access PDMP implementation on alleged or substantiated child sexual abuse.

[32] Informed by recent advances on estimating DID models with two-way fixed effects, we examine the relative importance of differential timing of treatment using the Goodman-Bacon (2021) decomposition. We find that the overwhelming majority of our treatment effect is driven by the treated v. never treated group, which implies these concerns are not first-order in our context. This is discussed further in the next subsection.

We also implement the procedure proposed by Goodman-Bacon (2021) to determine which sources of variation drive the DID estimates. Due to the staggered timing of must-access PDMP implementation, the DID estimates represent a weighted average of all possible comparison pairs of DID estimators in the data. Results of the Bacon decomposition are presented in Table B2. For each of the possible treatment-control comparisons, the Bacon decomposition produces an average DID estimate as well as a weight. The decomposition indicates that 81 percent of the weight of the DID estimates reported in Table 3 is from the comparison between the treated observations (i.e., those with a must-access PDMP) versus the never treated observations (i.e., those with no must-access PDMP provision or no PDMP altogether). Very little variation is sourced from the staggered timing of must-access PDMP implementation (i.e. timing groups). Within the timing group, some comparison pairs include already treated states as a control group, which could be problematic. Finding, however, that the timing groups account for such a small portion of the estimated treatment effect suggests that the staggered nature of must-access PDMP implementation is not driving our estimates.

For completeness, the Goodman-Bacon decomposition also enables plots of the values of each treatment-control comparison pair (i.e., 2x2 DID estimates) for the treated versus never treated group and the timing groups for each discrete point in time in which observations are treated. Plots of estimated average effects (y-axis) and weights (x-axis) are shown in Figure B5. As discussed above, the majority of comparisons between observations treated at different points in time, depicted by circles in the figure, are associated with small weights. We therefore focus on the magnitudes and weights from the never treated verses timing (i.e. treated) comparisons (i.e., triangles in the figure). While not labeled, the largest weight is associated with the 2013 treated versus never treated 2x2 estimate, which coincides with one of the larger waves of states implementing their must-access PDMPS. The smallest weights were associated with treatment years 2007, 2010, and 2016.[33]

While it is natural to seek comparisons between the results from the OxyContin and PDMP analyses, recall that the underlying models are different, so the event study and DID results presented thus far are not directly comparable. We view the must-access PDMP results as more suggestive than those for OxyContin's reformulation but take two steps to facilitate a

[33] From 2006 to 2016, there were 18 states to implement must-access PDMPs. Four of which were implemented in 2013. Conversely, only one was implemented in 2007, one in 2010, and two in 2016. (see Appendix Table B1).

comparison between the two interventions. We focus on the interventions' impacts on alleged child abuse and neglect. First, we estimate a standard DID model for OxyContin's reformulation, which estimates the reformulation's effects for the average county. That is, we estimate a specification similar to (4) in which we replace $PDMP_{st}$ with an indicator variable for post-reformulation years (i.e., post-2010). The estimated DID coefficient is 8.516 (p-value = 0.059), suggesting that OxyContin's reformulation caused 8.516 more children per 1000 with allegations of physical abuse and neglect each year in the average county. At the sample mean value for allegations, this is an increase of about 22%, more than twice the estimated impact of must-access PDMP implementation (about 8%).

Second, we re-estimate the DID specification in (4) after splitting the sample into counties above and below the median level of pre-intervention exposure to prescription opioids.[34] Results are reported in Table B3. For allegations (Row (1)), the estimated DID coefficient for above median counties is over six times larger than for below median counties. However, neither estimate is statistically significant. The pattern of results is similar if we restrict attention to allegations reported by professionals; in this case the estimated DID coefficient for above-median counties is statistically significant. Thus, consistent with the OxyContin analysis, we find some evidence of larger adverse effects of PDMP implementation among counties with higher exposure to opioids prior to implementation.

We now offer a comparison of the two interventions' impacts in high-exposure counties. To do so, we use results from Table 2 to calculate the estimated impact of OxyContin's reformulation on allegations in the average county with above median pre-reformulation exposure to opioids. From Table 1, the pre-intervention per capita opioid prescriptions for the average high-exposure county is 1.117. Based on the average of the short- and medium-run effects reported in Table 2 Panel A, the estimated impact of the reformulation for this county is an annual increase of 8.04 children with allegations per 1000. At the mean allegations for high-exposure counties (39.399 children per 1000), this represents an effect size of over 20%. This is over twice as large as the estimated impact of must-access PDMP implementation for the

[34] The staggered timing of must-access PDMP implementation complicates the definition of a pre-intervention period. We use the same 2006-2009 period as in the OxyContin analysis because it precedes must-access PDMP implementation for almost all states (as well as OxyContin's reformulation in 2010). Our choice of a uniform pre-intervention period means that for counties in states that adopted relatively early, say in 2011, the 2006-2009 pre-intervention period will be closer to the implementation date than for counties in states that adopted later. Only one state, Nevada, adopted a must-access PDMP during the 2006-2009 period. Our results are qualitatively similar with the exclusion of Nevada.

average high-exposure county based on the estimated coefficient from row (1) of Table B3, an increase of 3.624 children per 1000 or 9.2% at the mean.

In some sense, finding a relatively larger adverse impact of the reformulation on child maltreatment than implementation of must-access PDMPs is not surprising given that the 2010 reformulation preceded must-access PDMP implementation for almost all states. That is, much of the substitution that might have occurred in response to the supply restrictions from must-access PDMPs implemented in isolation may have already occurred in response to OxyContin's reformulation. Thus, given their relative timing, a *ceteris paribus* comparison of the two interventions is not feasible. Furthermore, the more gradual roll-out of PDMPs may have given heavy abusers of prescription opioids more flexibility in seeking out substitutes or reducing/discontinuing their opioid use. Finally, while both supply restrictions relate to prescription opioids, they had different objectives. The reformulation of OxyContin was targeted at misusers and curbing the misuse of OxyContin. By comparison, must-access PDMPs were broader in nature, with an aim of affecting a state's overall opioid-prescribing environment. As a result, must-access PDMPs led to a reduction in prescription opioid misuse, but also a reduction in overall opioid prescriptions (Buchmueller and Carey, 2018; Dowell et al., 2016; Mallatt, 2018). It is therefore not surprising that the estimated PDMP effects are more mixed, given that the must-access PDMPs induced change among a more diverse set of market participants.

V. Discussion

While there is continued discussion of underlying mechanisms, numerous studies have shown a strong link between parental substance use and child maltreatment (Ammerman et al., 1999; Chaffin et al., 1996; Kelley, 2002; Wells, 2009; Waite et al., 2018). The overwhelming policy recommendation is to provide drug treatment therapy to parents with SUD, and for various treatment options to become more widely available. However, very few studies examine whether the parental use of some substances presents greater risks for children than others. To the extent that different substances provide different psychological and physical effects to the user, we would expect to see differential effects on general functioning and parental capabilities as well.

When implementing policies that affect an individual's ability to access substances, controlled or illicit, policymakers should consider how those policies might affect user substitution patterns. One should also consider how those substitution patterns could have spillover effects, sometimes to outcomes with significant and long-lasting impacts, like child maltreatment.

In this paper, we examine how two interventions that reduced the supply of an addictive substance, prescription opioids, affected child wellbeing. Prior research has shown that these interventions led some to seek out a more readily-available substitute, such as heroin (Alpert et al., 2018; Evans et al., 2019). We find that these interventions also had significant effects on the incidence of child maltreatment, especially in counties where Schedule II opioid prescribing was relatively high. If parents who are dependent on opioid prescriptions are cut off from supplies, even if they do not substitute to heroin or other substances, they may suffer physical and emotional distress, which can create friction in the home.

The optimal unwinding of the opioid epidemic will require more than restricting access, and support services could play a crucial role. Increasing the provision of medication-assisted treatment, such as buprenorphine, for individuals with opioid use disorder is one such support measure. The *Family First Prevention Services Act*, enacted in 2018, is a promising policy step in this respect as it gives states the option to use federal funds to help children at risk of entering foster care and their parents/caregivers by providing services such as substance use disorder treatment, mental health services, and in-home parenting skills training (Waite et al., 2018). Nonetheless, without adequate support for dependents and their families, measures that simply restrict access to prescription opioids risk adverse consequences.

On that front, we find differential impacts of OxyContin's reformulation on child maltreatment depending on features of the more general policy environment. OxyContin's adverse impacts are concentrated among areas without access to substitutes such as medical marijuana (also prescribed for pain) and with lower levels of support for expectant mothers with substance use disorders. While we cannot isolate a causal mechanism, our results underscore the need to better understand how the general policy environment can reduce or amplify the magnitude of unintended consequences from more targeted policies.

The findings from this study are especially important for combating substance use disorder in the long run, as children who experience maltreatment are themselves at a greater risk of developing substance use disorders later in life, and are more likely to abuse their own children (Buckingham and Daniolos, 2013; Cicchetti and Handley, 2019; Elliott et al., 2014; Huang et al., 2011; Tonmyr et al., 2010; Spatz Widom et al., 2006; White and Widom, 2008). Thus, coarse short-run measures to reduce the current supply of addictive goods may lead to substantial costs in the future.

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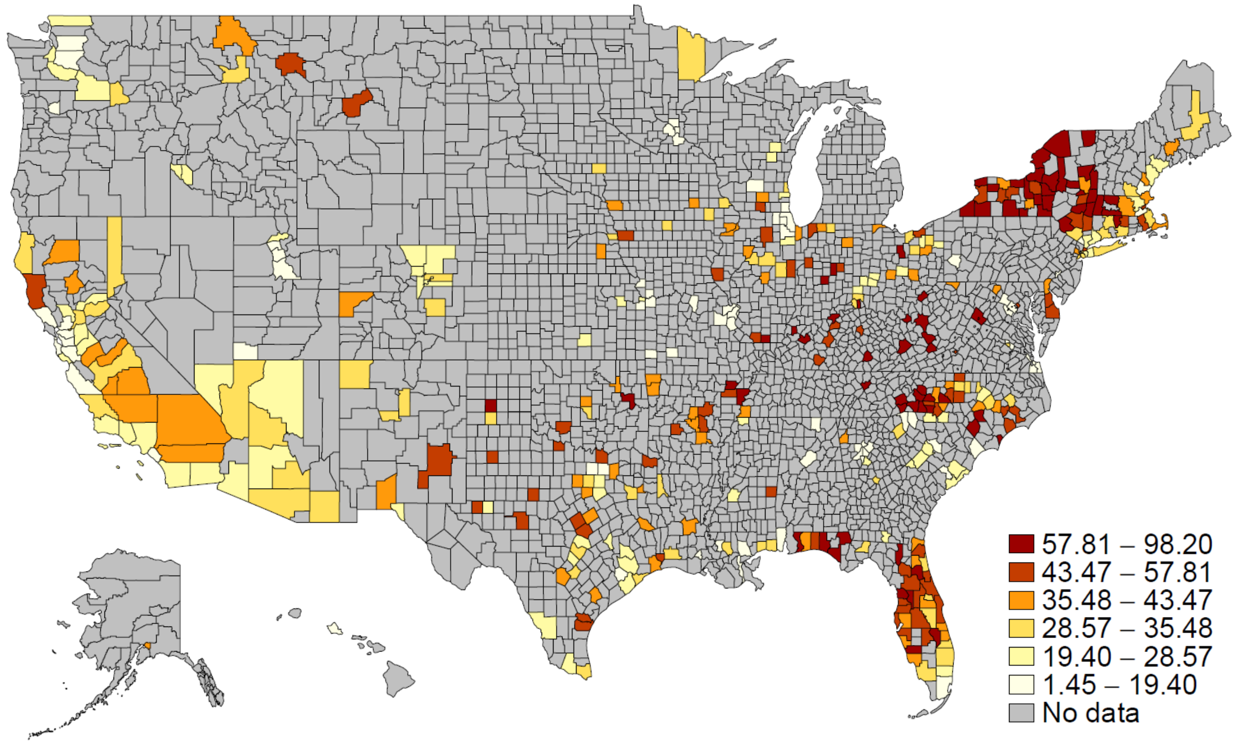


FIGURE 1. MEDIAN ALLEGATIONS OF PHYSICAL ABUSE OR NEGLECT FOR IDENTIFIED COUNTIES, 2006-2016

Notes: Figure shows the median number of children per 1000 with physical abuse or neglect allegations by county between 2006 and 2016 for 438 identified counties. Counties in grey are included in super counties. Shading reflects quantiles of the distribution.

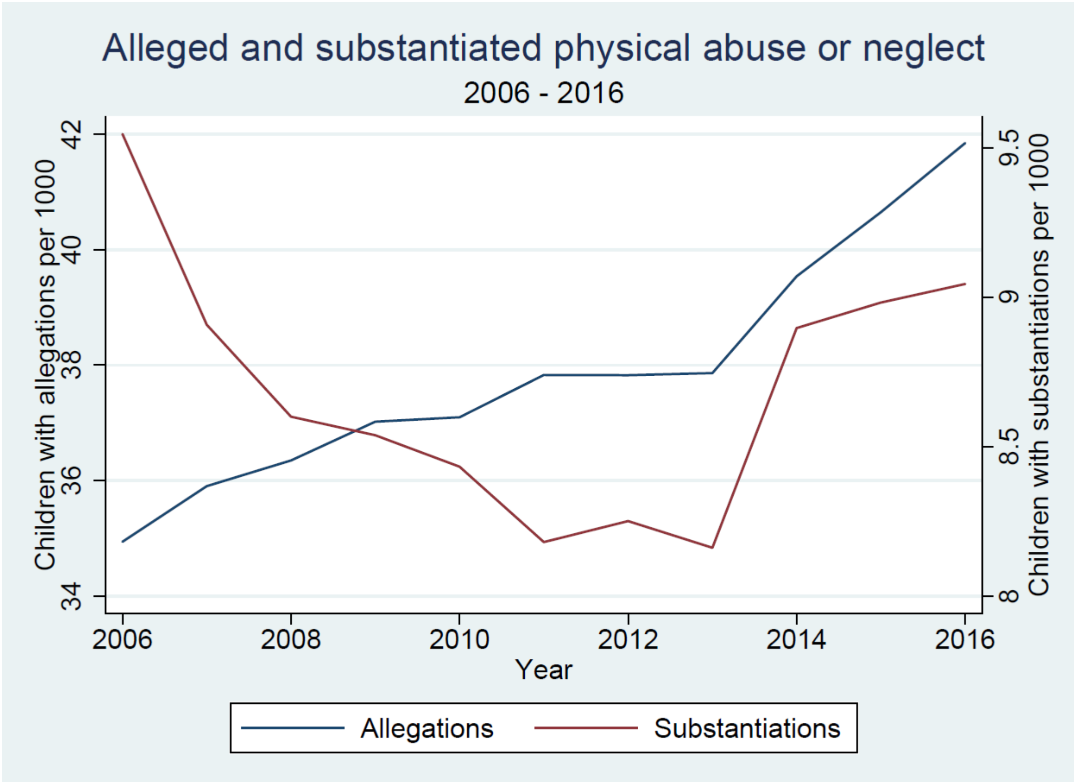
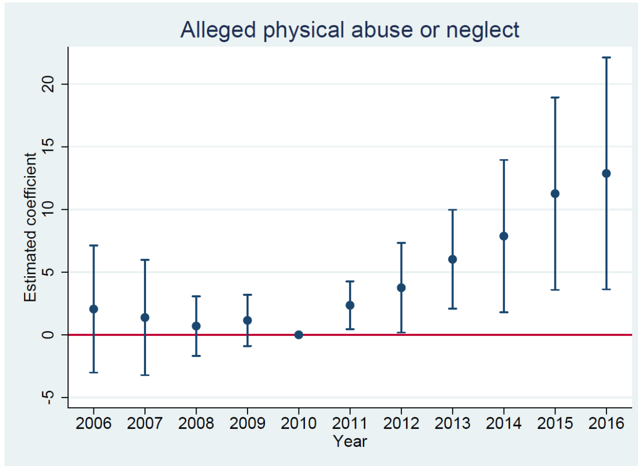


FIGURE 2. MEAN ALLEGED AND SUBSTANTIATED CHILD PHYSICAL ABUSE AND NEGLECT

Notes: Figure depicts annual means based on the sample of 438 identified counties and 48 super counties. Allegations refer to the number of children per 1000 with at least one allegation of physical abuse or neglect. Substantiations refer to the number of children per 1000 with at least one substantiated case of physical abuse or neglect.

Panel A. Alleged physical abuse and neglect



Panel B. Substantiated physical abuse and neglect

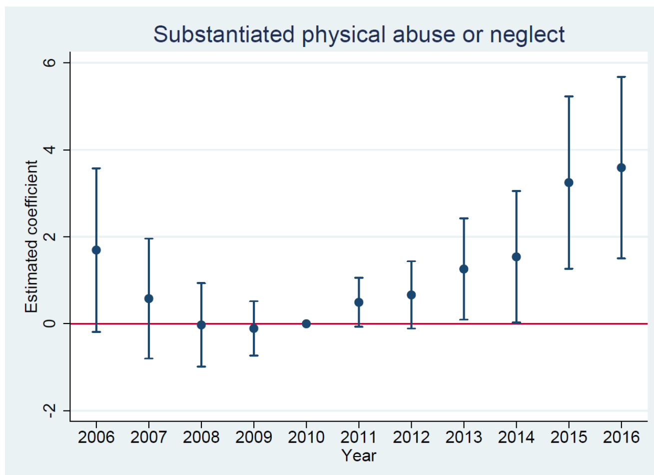
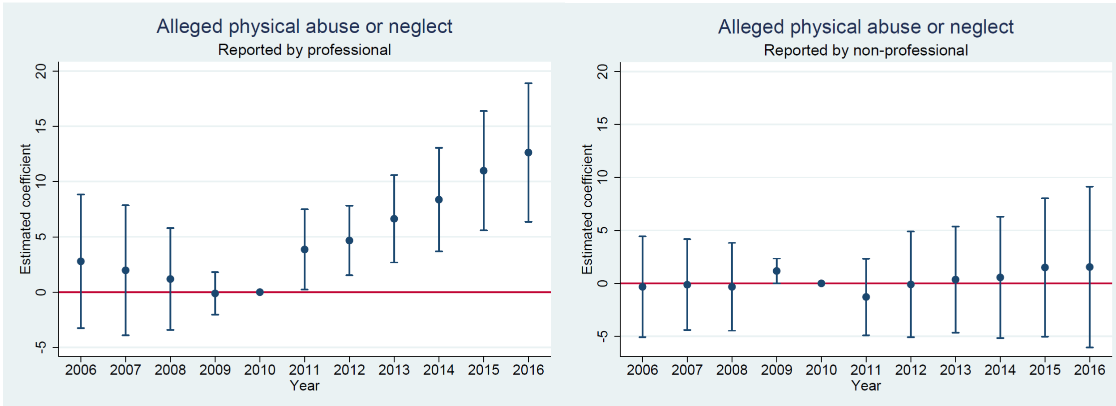


FIGURE 3. OXYCONTIN ANALYSIS: EVENT STUDY RESULTS FOR PHYSICAL ABUSE OR NEGLECT

Notes: Each figure reports point estimates and 95% confidence intervals on the interaction terms from specification (1) with 2010, the year in which OxyContin was reformulated, normalized to zero. Allegations refer to the number of children per 1000 with at least one allegation of physical abuse or neglect. Substantiations refer to the number of children per 1000 with at least one substantiated case of physical abuse or neglect. Specifications include county and year fixed effects; 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 indicators for a PDMP of any form and a medical marijuana law. Standard errors are clustered on state.

Panel A. Alleged physical abuse or neglect



Panel B. Substantiated physical abuse or neglect

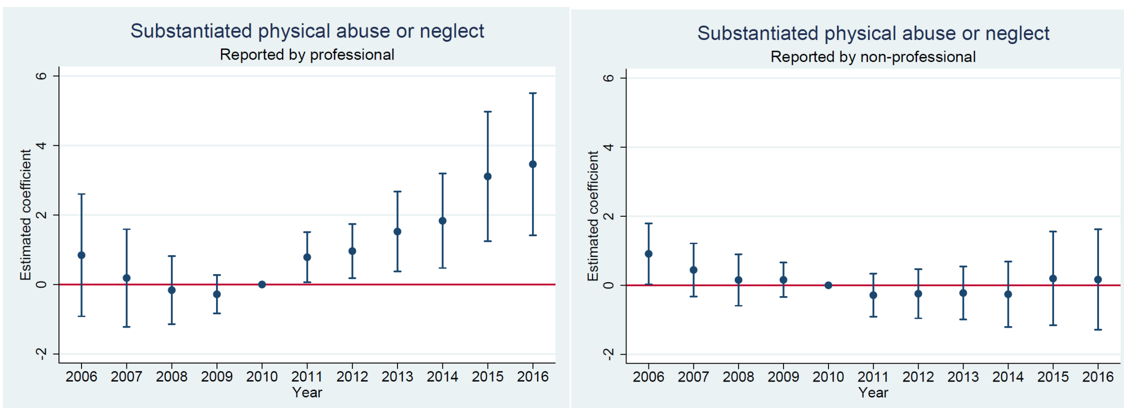


FIGURE 4. OXYCONTIN ANALYSIS: EVENT STUDY RESULTS BY REPORT SOURCE

Notes: Each figure reports point estimates and 95% confidence intervals on the interaction terms from specification (1) with 2010, the year in which OxyContin was reformulated, normalized to zero. Allegations refer to the number of children per 1000 with at least one allegation of physical abuse or neglect. Substantiations refer to the number of children per 1000 with at least one substantiated case of physical abuse or neglect. Specifications include county and year fixed effects; 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 indicators for a PDMP of any form and a medical marijuana law. Standard errors are clustered on state. Professional reporters include social services, medical, mental health, legal/law enforcement/criminal justice, education or child day care personnel. Non-professional reporters consist of friends, neighbors, family members, among other sources.

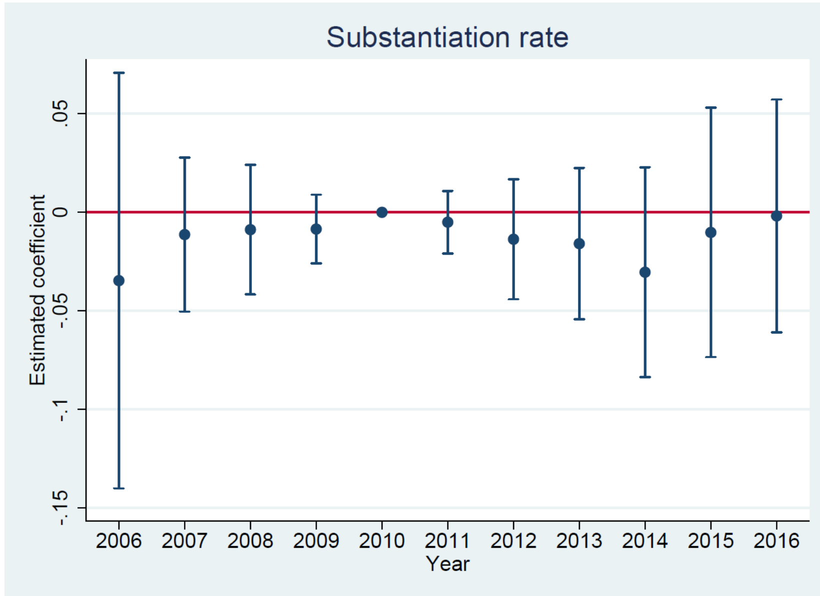
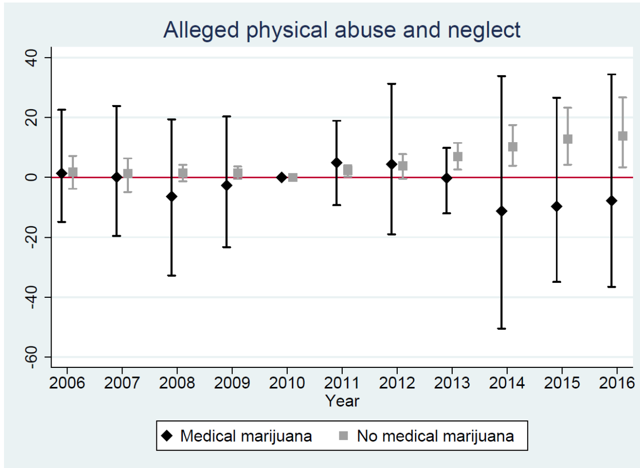


FIGURE 5. OXYCONTIN ANALYSIS: EVENT STUDY RESULTS FOR SUBSTANTIATION RATE

Notes: Each figure reports point estimates and 95% confidence intervals on the interaction terms from specification (1) with 2010, the year in which OxyContin was reformulated, normalized to zero. The substantiation rate measures the fraction of children with substantiated physical abuse or neglect among those with alleged physical abuse or neglect Specification includes county and year fixed effects; 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 indicators for a PDMP of any form and a medical marijuana law. Standard errors are clustered on state.

Panel A. Alleged physical abuse or neglect



Panel B. Substantiated physical abuse or neglect

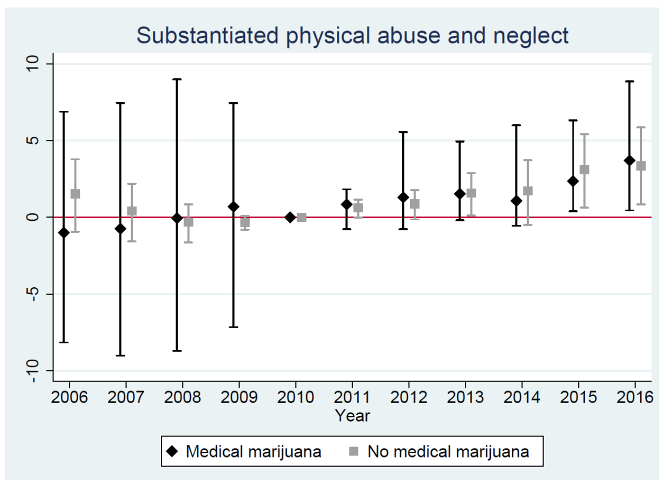
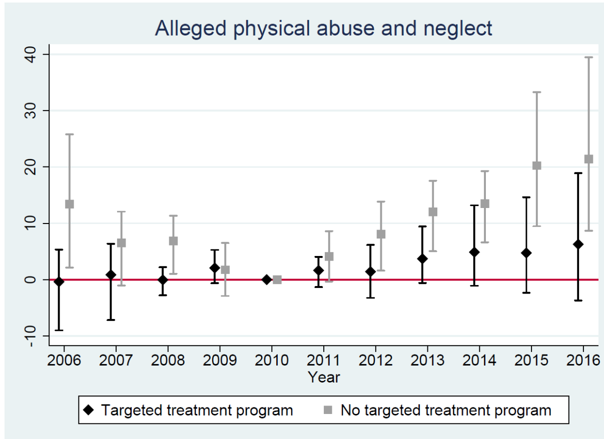


FIGURE 6. OXYCONTIN ANALYSIS—EVENT STUDY RESULTS BY STATE MEDICAL MARIJUANA LAW

Notes: Each figure reports point estimates and 95% confidence intervals on the interaction terms from specification (1) with 2010, the year in which OxyContin was reformulated, normalized to zero. Allegations refer to the number of children per 1000 with at least one allegation of physical abuse or neglect. Substantiations refer to the number of children per 1000 with at least one substantiated case of physical abuse or neglect. Specifications include county and year fixed effects; 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 indicator for a PDMP of any form. Standard errors are clustered on state and estimated using the wild cluster bootstrap procedure.

Panel A. Alleged physical abuse or neglect



Panel B. Substantiated physical abuse or neglect

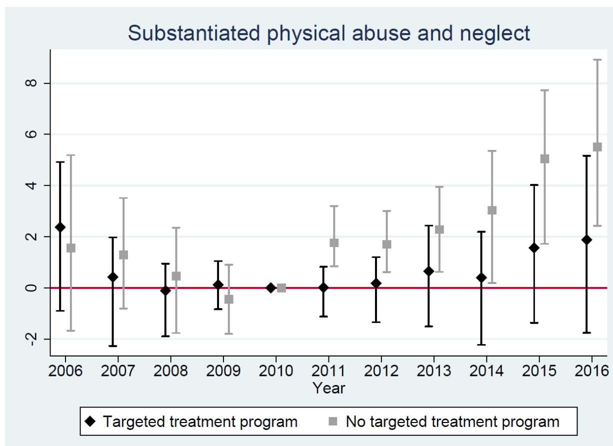
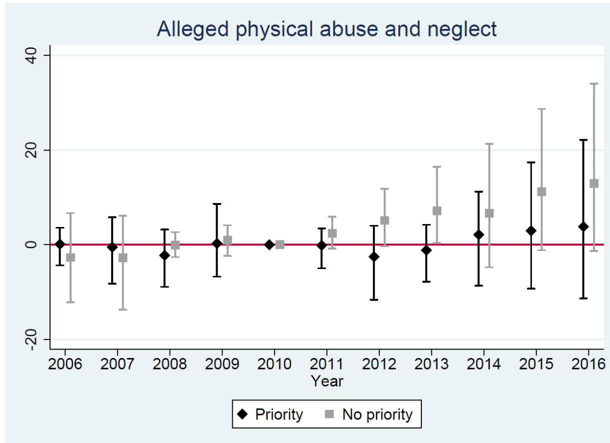


FIGURE 7. OXYCONTIN ANALYSIS—EVENT STUDY RESULTS BY DEDICATED SUBSTANCE USE PROGRAM(S) FOR PREGNANT WOMEN

Notes: Each figure reports point estimates and 95% confidence intervals on the interaction terms from specification (1) with 2010, the year in which OxyContin was reformulated, normalized to zero. Allegations refer to the number of children per 1000 with at least one allegation of physical abuse or neglect. Substantiations refer to the number of children per 1000 with at least one substantiated case of physical abuse or neglect. Specifications include county and year fixed effects; percent female population; percent Black population; percent Hispanic population; number of cancer deaths per 100,000 population; percent population under age 15, between age 15 and 19, between age 20 and 24, between age 35 to 44, between age 45 to 54, and between age 55 to 64; unemployment and labor force participation rates, and indicators for a PDMP of any form and a medical marijuana law. Standard errors are clustered on state and estimated using the wild cluster bootstrap procedure.

Panel A. Alleged physical abuse or neglect



Panel B. Substantiated physical abuse or neglect

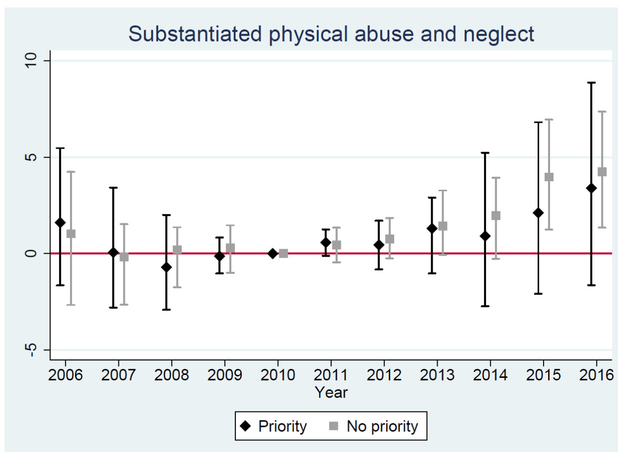
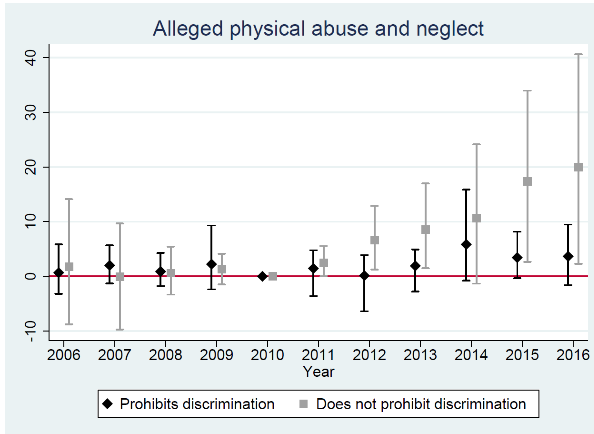


FIGURE 8. OXYCONTIN ANALYSIS—EVENT STUDY RESULTS BY PRIORITY ADMISSION FOR PREGNANT WOMEN IN GENERAL SUBSTANCE USE PROGRAMS

Notes: Each figure reports point estimates and 95% confidence intervals on the interaction terms from specification (1) with 2010, the year in which OxyContin was reformulated, normalized to zero. Allegations refer to the number of children per 1000 with at least one allegation of physical abuse or neglect. Substantiations refer to the number of children per 1000 with at least one substantiated case of physical abuse or neglect. Specifications include county and year fixed effects; percent female population; percent Black population; percent Hispanic population; number of cancer deaths per 100,000 population; percent population under age 15, between age 15 and 19, between age 20 and 24, between age 35 to 44, between age 45 to 54, and between age 55 to 64; unemployment and labor force participation rates, and indicators for a PDMP of any form and a medical marijuana law. Standard errors are clustered on state and estimated using the wild cluster bootstrap procedure.

Panel A. Alleged physical abuse or neglect



Panel B. Substantiated physical abuse or neglect

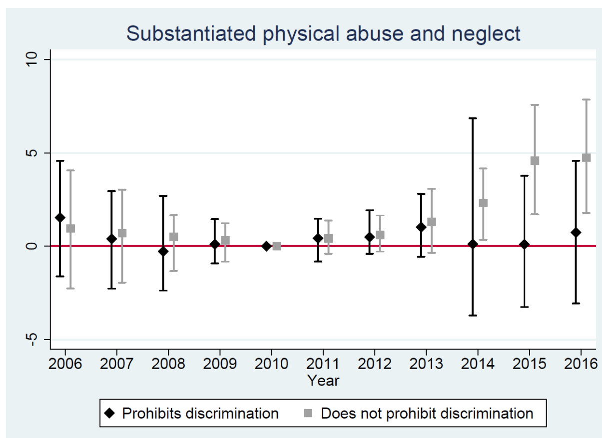
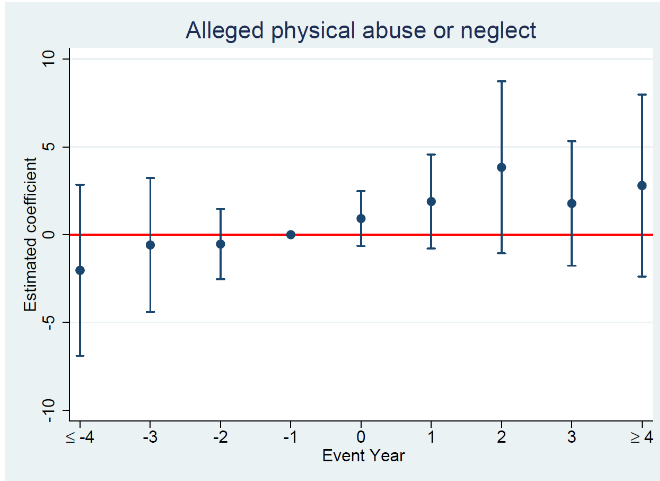


FIGURE 9. OXYCONTIN ANALYSIS—EVENT STUDY RESULTS BY PROHIBITION OF DISCRIMINATION AGAINST PREGNANT WOMEN IN DRUG TREATMENT PROGRAMS

Notes: Each figure reports point estimates and 95% confidence intervals on the interaction terms from specification (1) with 2010, the year in which OxyContin was reformulated, normalized to zero. Allegations refer to the number of children per 1000 with at least one allegation of physical abuse or neglect. Substantiations refer to the number of children per 1000 with at least one substantiated case of physical abuse or neglect. Specifications include county and year fixed effects; percent female population; percent Black population; percent Hispanic population; number of cancer deaths per 100,000 population; percent population under age 15, between age 15 and 19, between age 20 and 24, between age 35 to 44, between age 45 to 54, and between age 55 to 64; unemployment and labor force participation rates, and indicators for a PDMP of any form and a medical marijuana law. Standard errors are clustered on state and estimated using the wild cluster bootstrap procedure.

Panel A: Alleged physical abuse or neglect



Panel B: Substantiated physical abuse or neglect

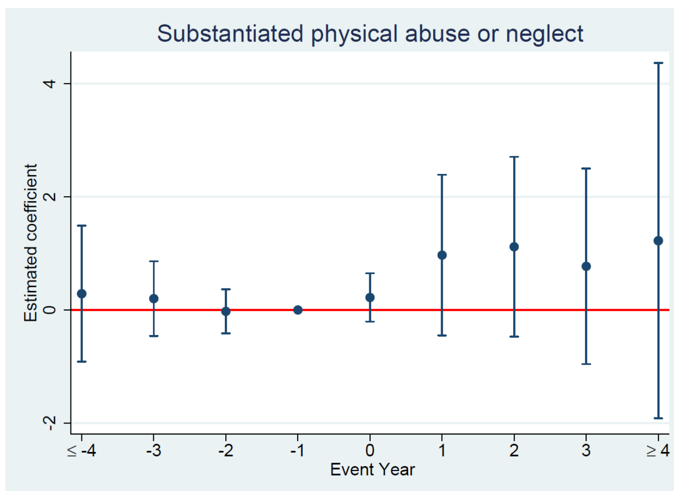


FIGURE 10. PDMP ANALYSIS—EVENT STUDY RESULTS FOR PHYSICAL ABUSE OR NEGLECT

Notes: Each figure reports weighted least squares estimates and 95% confidence intervals on the lead and lag terms from Equation (3) with the year prior to must-access PDMP implementation normalized to zero. Allegations refer to the number of children per 1000 with at least one allegation of physical abuse or neglect. Substantiations refer to the number of children per 1000 with at least one substantiated case of physical abuse or neglect. Specifications include county and year fixed effects; 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. Standard errors are clustered on state.

TABLE 1. DIFFERENCES IN THE PRE-INTERVENTION PERIOD BETWEEN LOW- AND HIGH-EXPOSURE COUNTIES

Variable	Low-exposure counties	High-exposure counties	p-value	Data source
Allegations	32.713	39.399	0.000	NCANDS
Substantiations	8.746	9.047	0.615	NCANDS
Per capita opioid prescriptions	0.625	1.117	0.000	CDC
State OxyContin misuse rate	0.535	0.654	0.000	Alpert et al.
% White	80.837	82.836	0.104	Census
% Black	10.793	12.383	0.149	Census
% Hispanic	16.956	8.005	0.000	Census
% Rural	20.255	25.215	0.005	Census
% Female	50.564	50.945	0.000	Census
% Under age 0 to 19	27.952	26.740	0.000	Census
% Age 20 to 24	7.448	7.113	0.134	Census
% Age 25 to 34	13.153	12.496	0.000	Census
% Age 35 to 44	14.025	13.246	0.000	Census
% Age 45 to 54	14.513	14.543	0.804	Census
% Age 55 to 64	10.868	11.796	0.000	Census
% Over age 64	12.041	14.068	0.000	Census
Unemployment rate	5.936	6.181	0.097	BLS
Labor force participation rate	63.805	61.273	0.000	BLS
Cancer deaths per 100,000 population	179.452	220.148	0.000	CDC

Notes: Table reports means for the pre-intervention period, 2006-2009, after breaking the sample based on pre-intervention exposure to prescription opioids. Low-exposure (high-exposure) counties are the 242 (242) counties with population-weighted per capita opioid prescriptions for 2006 to 2009 below (at or above) the sample median of 0.823. The fourth column reports p-values for equality of means tests. Allegations refer to the number of children per 1000 with at least one allegation of physical abuse or neglect. Substantiations refer to the number of children per 1000 with at least one substantiated case of physical abuse or neglect. % rural is time-invariant and based on the 2010 Census.

TABLE 2. OXYCONTIN ANALYSIS: DID RESULTS FOR CHILD PHYSICAL ABUSE AND NEGLECT

Outcome	Total	Reported by professional	Reported by non-professional
Panel A: Alleged physical abuse and neglect			
Pre-reformulation (2006-2009)	1.384 (1.281)	1.460 (2.132)	0.160 (1.514)
Short-run post-reformulation (2011-2013)	3.983*** (1.262)	5.030*** (1.711)	-0.379 (2.173)
Medium-run post-reformulation (2014-2016)	10.418*** (3.591)	10.530*** (2.573)	1.078 (3.197)
Adjusted R^2	0.881	0.835	0.892
Mean in year 2010	37.097	19.116	19.971
Panel B: Substantiated physical abuse and neglect			
Pre-reformulation (2006-2009)	0.517 (0.473)	0.142 (0.522)	0.402 (0.301)
Short-run post-reformulation (2011-2013)	0.807** (0.374)	1.085** (0.418)	-0.245 (0.330)
Medium-run post-reformulation (2014-2016)	2.758*** (0.847)	2.761*** (0.813)	0.043 (0.594)
Adjusted R^2	0.886	0.855	0.777
Mean in year 2010	8.433	5.825	2.841

Notes: Table reports weighted least squares estimates of the three δ coefficients in equation (2). In Panel A, *Total* refers to the number of children per 1000 with at least one allegation of physical abuse or neglect. In Panel B, *Total* refers to the number of children per 1000 with at least one substantiated case of physical abuse or neglect. The sample mean (standard deviation) of population-weighted mean opioid prescriptions per capita during the pre-reformulation period is 0.871 (0.342). Specifications include county and year fixed effects; 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 indicators for a PDMP of any form and a medical marijuana law. Standard errors in parentheses are clustered on state.

*** Significant at the 1 percent level.

** Significant at the 5 percent level.

* Significant at the 10 percent level.

TABLE 3. PDMP ANALYSIS: DID RESULTS FOR CHILD PHYSICAL ABUSE AND NEGLECT

Outcome	Total	Reported by professional	Reported by non-professional
Panel A: Alleged physical abuse and neglect			
PDMP	2.984 (2.377)	3.807** (1.873)	-0.365 (1.631)
Adjusted R^2	0.879	0.832	0.892
Panel B: Substantiated physical abuse and neglect			
PDMP	0.606 (0.540)	0.874 (0.687)	-0.263 (0.391)
Adjusted R^2	0.882	0.848	0.775

Notes: Table reports weighted least squares estimates of β_1 in equation (4). In Panel A, *Total* refers to the number of children per 1000 with at least one allegation of physical abuse or neglect. In Panel B, *Total* refers to the number of children per 1000 with at least one substantiated case of physical abuse or neglect. Specifications include county and year fixed effects; 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. Standard errors in parentheses are clustered on state. Samples reflect 486 unique counties in 51 states.

*** Significant at the 1 percent level.

** Significant at the 5 percent level.

* Significant at the 10 percent level.