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Retail Pharmacies and Drug Diversion during the Opioid Epidemic†

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This study investigates the role of retail pharmacy ownership in the opioid epidemic. Using data of prescription opioid orders, we show that compared with chain pharmacies, independent pharmacies dispense 39.1 percent more opioids and 60.5 percent more OxyContin. After an independent pharmacy becomes a chain pharmacy, opioid dispensing decreases. Using the OxyContin reformulation, which reduced nonmedical demand but not the legitimate medical demand, we show that at least one-third of the difference in the amount of OxyContin dispensed can be attributed to nonmedical demand. We show that differences in competitive pressure and whether pharmacists own the pharmacy drive our estimates. (*JEL* G32, I12, L22, L81)

In 2017, 11.4 million Americans misused opioids, including 11.1 million who misused prescription drugs (SAMHSA 2018). In the same year, on average 130 Americans died every day from an opioid overdose (CDC 2019a). Prescription opioid analgesics are at the root of the current opioid epidemic (Okie 2010; Dart et al. 2015), and thus it is important to analyze the roles played by different actors related to the dispensing of prescription opioids (Maclean et al. 2020).[1] While prescribers have fueled the market with prescriptions (Schnell 2017), insurers provide generous coverage of prescription opioids (Pacula and Powell 2018), and manufacturers have spent enormous resources in advertising prescription opioids

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[1] The SAMHSA (2013) reports that among heroin users between 2002 and 2011, almost 80 percent reported previous prescription opioid usage (Schnell 2019).

(Hadland et al. 2019; Nguyen, Bradford, and Simon 2019; Alpert et al. 2022), the role of dispensing pharmacies is not well understood.[2]

Drug diversion, defined as when prescription medicines are obtained or used illegally (CDC 2019b), is an important source of opioid drug abuse. In particular, police and regulatory agencies perceive that pharmacies are involved in nearly 80 percent of all prescription drug diversion (Inciardi et al. 2007).[3] As the last line of defense ensuring that prescriptions are filled and drugs are dispensed only for legitimate medical use, pharmacies play an important role in several diversion channels. In fact, surveys show that compared with physicians, pharmacists have better knowledge of whether patients abuse drugs (Cicero et al. 2011). Moreover, pharmacists perceived a larger percentage of patients (41 percent) abusing opioid pain relievers than their prescribing colleagues perceived (17 percent) (Hagemeier, Gray, and Pack 2013). By law, pharmacists have obligations to inspect prescriptions for validity and ensure that controlled substances are dispensed legally (Drug Enforcement Administration [DEA] 2005). Empirically, we know little about how pharmacies use their discretion and what factors may affect pharmacies' discretion in dispensing prescription opioids.[4]

During recent years, large chains increased their market power in the health care market in general and specifically in the pharmaceutical market (Gaynor, Ho, and Town 2015). Many existing studies reveal the downside of large chains. For example, large chains may exploit market power by increasing prices or reducing the quality of service (Cuellar and Gertler 2006; Gaynor and Town 2011; Dafny, Duggan, and Ramanarayanan 2012; Eliason et al. 2020). High concentration and monopolization are common in many markets, not just health care. In particular, concentration in digital markets has received recent interest from lawmakers as it may threaten innovation, privacy and data protection, the existence of a free and diverse press, and political and economic liberty (US House, Subcommittee on Antitrust, Commercial and Administrative Law of the Committee on the Judiciary, 2020). However, whether firm ownership affects the incentive to comply with regulations remains unexplored. If large firms are more likely to follow regulations, a full cost-benefit analysis of ownership, such as in antitrust investigations, should incorporate possible benefits of an industry's consolidation.

This paper analyzes whether pharmacy ownership affects prescription opioid dispensing and drug diversion. As a starting point, we present two stylized facts showing that independent and chain pharmacies have big differences in prescription opioid dispensing. First, we find that within a zip code, independent pharmacies, compared with chain pharmacies, dispense on average 128 (39.1 percent) more morphine equivalent doses (MED, in grams) of all prescription opioids and 16.4

[2] Prescription opioids account for a substantial share of revenue for retail pharmacies. For example, OxyContin always ranked top 20 in retail sales among all prescription drugs in the United States between 2008 and 2012, and it was one of the top 10 drugs between 2008 and 2010 (Drugs.com n.d.).

[3] Specifically, about 39.4 percent of drug diversion involves doctor shopping, 35 percent involves prescription theft or forgery, 2 percent involves insurance fraud, and 1.5 percent involves pharmacy thefts and robberies. Pharmacies are involved in all four of these sources. The rest are residential burglary (5.9 percent), physician "pill mills" (3.4 percent), internet (3 percent), smuggling (1.5 percent), in-transit losses (1 percent), theft of institutional drug supplies (2 percent), and others (5.4 percent).

[4] Small-scale interviews with both pharmacists and drug abusers show that different pharmacists treat suspicious prescriptions differently (Rigg, March, and Inciardi 2010; Hartung et al. 2018).

(60.5 percent) more MED of OxyContin, which is a type of prescription opioid especially prone to abuse and therefore diversion (Cicero et al. 2011; Alpert, Powell and Pacula 2018). Second, following the identification strategy of Eliason et al. (2020), we show that when a facility switches from being an independent pharmacy to being part of a chain, it dispenses 110.5 less MED of all opioids (33.8 percent) and 14.3 less MED of OxyContin (52.8 percent). Although both analyses reveal a large difference in dispensing between independent and chain pharmacies, we do not know what drives the differences: medical needs or drug diversion.

To examine whether diversion drives part of the difference in dispensing between independent and chain pharmacies, we exploit the quasi-experiment arising from the reformulation of OxyContin into an abuse-deterrent formula in mid-2010. The OxyContin reformulation did not change its therapeutic benefit (Mastropietro and Omidian 2015), nor did it affect prices (Coplan et al. 2016; Evans, Lieber, and Power 2019). Therefore, it mainly reduced the nonmedical demand for OxyContin.[5] By comparing the dispensing of OxyContin before and after the reformulation between independent and chain pharmacies, we find that the difference greatly narrowed after the reformulation, mainly driven by the reduction among independent pharmacies. The difference in dispensing of OxyContin shrank by approximately 5.3 MED, a 19.7 percent reduction from the average MED dispensed per pharmacy. Given that the reduction in OxyContin dispensing is almost entirely driven by independent pharmacies, this implies that part of the overall difference between independent and chain pharmacies (estimated from the analysis in ownership changes) can be attributed to their different responses to nonmedical demand. A back-of-envelope calculation shows that 37.2 percent of the higher dispensing in independent pharmacies is due to drug diversion.[6]

As more than 37 percent of the difference in dispensing between independent and chain pharmacies resulted from diversion, we identify two mechanisms behind why independent pharmacies are more likely to be involved in drug diversion: (i) competitive pressure from chains and (ii) pharmacists who are owners of independent pharmacies having stronger financial incentives to dispense than pharmacists who are employees. For the former, we show that independent pharmacies are more likely to compensate for their profit loss due to competition by dispensing more OxyContin before the reformulation than after the reformulation. Moreover, the response is mainly due to the competition from chain pharmacies but not independent pharmacies. For the latter, we compare the headquarters and branches of multistore independent pharmacies, with the presumption that independent pharmacist owners are more likely to work in the headquarters if they are still actively involved in drug dispensing.[7] We find that headquarters dispensed on average 45.6 percent more

[5] We use "nonmedical demand" to refer to the demand for recreational or abusive use. Previous research shows that the reformulation of OxyContin reduced nonmedical demand and led recreational users to substitute other drugs. For discussion, see, for example, Butler et al. (2013); Severtson et al. (2013); Havens et al. (2014); Sessler et al. (2014); Dart et al. (2015); Larochelle et al. (2015); Chilcoat et al. (2016); Coplan et al. (2016); Alpert, Powell, and Pacula (2018); Evans, Lieber, and Power (2019); and Zhang and Guth (2021).

[6] Our estimate of the difference in dispensing due to ownership change in column 9 of Table 3 indicates that on average independent pharmacies dispense 14.34 more MED than chain pharmacies. Column 4 in Table 4 shows that after the OxyContin reformulation, the difference decreases by 5.34 MED, a 37.2 percent reduction (5.34/14.34).

[7] Headquarters are identified from the Orbis database and defined as where a company is registered in the national corporation registry (Orbis 2021).

OxyContin than their branch counterparts. After the reformulation, although both headquarters and branches decreased their OxyContin dispensing, headquarters reduced their dispensing on average 7.6 more MED than branches did. As a result, the gap in OxyContin dispensing disappeared, indicating that headquarters are more likely to dispense OxyContin in response to nonmedical demand.

Our analysis suggests that we might need to reconsider competition in the retail pharmacy market. Although independent firms are often associated with high-quality services, in terms of opioid dispensing, they perform worse than their chain counterparts in deterring opioid dispensing for nonmedical demand. In addition, stricter monitoring and regulation of independent pharmacies may be important, since a pharmacist in an independent pharmacy may also be the owner of the pharmacy and thus have a stronger financial incentive to increase sales than a salaried pharmacist employee would have. Moreover, unlike large firms, which are more closely watched by stakeholders, the media, and the government, small firms attract less notice. Stricter monitoring and regulation can lower independent pharmacies' tendency toward overdispensing due to higher expected costs of misdoing.

Our study adds to the literature on the supply side's role in the opioid epidemic. Our study provides, to our knowledge, the first evidence on how pharmacies contribute to the opioid crisis. The existing literature on the supply side of prescription opioids focuses on the roles played by physicians, pain clinics, manufacturers, and the government (Meinhofer 2016, 2018; Schnell 2017; Alpert, Powell, and Pacula 2018; Alpert et al. 2022; Ayres and Jalal 2018; Buchmueller and Carey 2018; Schnell and Currie 2018; Grecu, Dave, and Saffer 2019; Maclean et al. 2020; Powell, Pacula, and Taylor 2020), but pharmacies are often overlooked (Simeone 2017). Although we may think pharmacies merely fill prescriptions from prescribers, our analysis reveals that pharmacies can significantly influence the dispensing of prescription opioids. In particular, more than one-third of the overdispensing by independent pharmacies relative to chains is to meet the nonmedical demand, and competition exacerbates their incentives to dispense for nonmedical demand.

Our paper also contributes to the literature on asymmetric competition between large and small firms by comparing the behavior of chain and independent retail pharmacies. Large chain pharmacies have increased their market share since 2000 (Zhu and Hilsenrath 2015). Similar to other industries such as physicians (Capps, Dranove, and Ody 2017), consolidation of pharmacies into chains has taken place and is continuing. We show that besides economic efficiency, the higher opportunity costs of misbehavior may cause chain pharmacies to behave closer to the social optimum. As we also investigate the effect of ownership change on pharmacy behavior, we add to the growing literature on mergers and acquisitions in the health care market. A body of literature considers hospital mergers and finds that mergers result in price increases for insurers (Dafny 2009; Gowrisankaran, Nevo, and Town 2015; Dafny, Ho, and Lee 2019). Closely related to our analysis of ownership change, Eliason et al. (2020) show that independent dialysis facilities acquired by large chains behave more similarly to the chains by replacing nurses with less-skilled technicians and wait-listing fewer patients for kidney transplants. These changes reduce health outcomes of patients. In our analysis, we find a similar effect: after independent pharmacies become part of a chain, the former independent pharmacies behave more like chain pharmacies, with less dispensing of opioids. Due to larger chains' better compliance with regulations, our article is relevant for antitrust regulators. When evaluating the costs and benefits of large chains, competition authorities should consider the possibility that large chains may be easier to regulate because of the higher opportunity costs of misbehavior.

In addition, we provide new empirical evidence on the effect of competition on illegal/unethical behavior. Under standard assumptions, competition is beneficial as it lowers prices and increases quality. However, in markets with excessive demand over the social optimum, competing for "higher quality" may lead to lower standards and social loss. A stream of oligopoly literature specifies such a mechanism in theory.[8] Empirically, there is limited evidence on the relation between competition and illegal behavior. Existing studies have examined the areas of vehicle inspection services in New York (Bennett et al. 2013) and Sweden (Habte and Holm 2017), corporate tax avoidance (Cai and Liu 2009), and the liver transplant market (Snyder 2010); these studies show that fiercer competition raises the incentive to be lax in upholding standards. The main mechanism of all these studies is that competitive pressure increases the incentive to please certain customers while diverging from a socially optimal level. We add to the literature by presenting additional evidence of the positive relationship between competition and leniency in the market of opioid-dispensing pharmacies. Furthermore, leniency results in higher drug dispensing and drug diversion for nonmedical demand, deviating from the social optimum and resulting in negative health effects.

I. Institutional Background

A. *The Retail Pharmacy Market*

Over 84,000 retail pharmacies existed in the United States between 2006 and 2012. Pharmacies filled 3.6 billion prescriptions a year, and nearly all Americans (93 percent) lived within a 5-mile radius of a pharmacy (Fein 2011a). Retail pharmacies include independent and chain pharmacies. Chain pharmacies include stand-alone pharmacy chains, supermarket pharmacies, and mass merchandiser pharmacies; the rest are independent pharmacies. During our study period, approximately 53.3 percent (44,812/84,111) of pharmacies were chain pharmacies. Since 1980, large national chains such as Walgreens, CVS, and Rite Aid have increased their market shares drastically, while the number of independent pharmacies has declined (Appold 2019). Additionally, the industry has been characterized by frequent acquisitions and mergers (Aungst 2018).

Independent pharmacies face challenges in competition with chain pharmacies. Most importantly, independent pharmacies have less power in bargaining for reimbursements with pharmacy benefit managers (PBMs) and other third-party managers of prescription drug programs for health plans (Starc and

[8] For example, Shleifer (2004) argues that an increase in competition may not necessarily discipline markets. Instead, the increasing competitive pressure can lead to a divergence from the socially optimal behavior. The pharmacy market works in a similar fashion. Branco and Villas-Boas (2015) argue that higher competition results in lower costs of illegal behavior. Dewatripont and Tirole (2019) show that competition may promote unethical behavior when firms are profit maximizing.

Swanson 2018; Appold 2019). Often, independent pharmacies get paid less than larger chains for the medicines they dispense from PBMs and insurers. In addition, independent pharmacies' bargaining power with distributors is limited (Chaffee 2019). Therefore, prices (copayments and coinsurance) in independent pharmacies are often higher (Gellad et al. 2009; Luo et al. 2019). Nevertheless, some consumers prefer independent pharmacies because of their better service. According to consumer polls, independent pharmacies have higher ratings due to their better knowledge about drugs, helpfulness, courtesy, and personalized service (Cohen 2011).

During the period of our study, between 2006 and 2012, the number of pharmacies increased by about 10 percent, almost solely due to an increase in chains. Thus, competition between pharmacies increased. In addition to the negative effect of competition on drug prices (Chen 2019), it is possible that competition also has an effect on the service or general behavior of pharmacies.

B. *Prescription Opioids and Their Distribution*

The opioid epidemic in the United States dates back to the late 1990s. While opioids have been long known, and oxycodone specifically has been in clinical use since 1917 (Kalso 2005), the entry of OxyContin, an extended-release formulation of oxycodone from Purdue Pharma, changed the medical landscape (Evans, Lieber, and Power 2019). About 100 million Americans suffered from chronic pain in 2010 (Simon 2012), and pain is the most common reason for doctor visits (Watkins et al. 2008). Starting as postsurgery and pain-management medications, opioids became commonly prescribed. In 2012, US health care providers issued more than 259 million opioid prescriptions (Paulozzi, Mack, and Hockenberry 2014), 0.8 prescriptions of opioids per capita. OxyContin specifically became one of the most successful pharmaceuticals, with worldwide sales of 35 billion (Evans, Lieber, and Power 2019). The foremost reason for the large number of prescriptions is that it became common to prescribe opioids for patients with chronic pain after medical guidelines were changed in 1999 (Berry and Dahl 2000). In addition, recommendations from medical boards increased the number of prescriptions (Soffin et al. 2017). Finally, the literature shows that Medicare Part D and promotional activities by the pharmaceutical industry boosted prescriptions (Van Zee 2009; Alpert, Lakdawalla, and Sood 2015; Quinones 2015; Haffajee and Mello 2017; Hadland et al. 2019).

The increase in prescribing went hand in hand with more drug abuse. Opioids started to be diverted from their original therapeutic use (Alexander, Kruszewski, and Webster 2012). The SAMHSA (2012) defines opioid misuse as taking a prescription opioid that was "not prescribed for you or only for the experience or feeling it caused." The 2017 National Survey on Drug Use and Health showed that 53.1 percent of people who misused pain relievers obtained their most recent pain reliever from a friend or relative (SAMHSA 2018). Drug diversion, in detail, can happen in several ways. First, patients may engage in doctor shopping, meaning that they visit numerous health care providers to receive multiple prescriptions (Peirce et al. 2012; Simeone 2017). Second, patients forge prescriptions or fill prescriptions at multiple pharmacies (Peirce et al. 2012; Yang et al. 2015). Finally, opioid theft is also a source of diversion.

Pharmacists' Role in Opioid Dispensing.—Pharmacists are legally required to ensure that controlled substances are prescribed for a medical purpose and are not diverted for nonmedical use (DEA 2010). Therefore, pharmacists should screen for prescriptions and behaviors that suggest diversion (Bach and Hartung 2019). Nevertheless, pharmacists may face a conflict of interest, as their profit depends on filling prescriptions. Small-scale interviews with both pharmacists and drug abusers show that different pharmacists treat suspicious prescriptions differently (Rigg, March, and Inciardi 2010; Hartung et al. 2018). Some pharmacists are stricter and question and reject suspicious prescriptions confidently, while others are lax in their standards and may never question or reject any prescriptions.

The OxyContin Reformulation.—During our study period, the abuse-deterrent reformulation of OxyContin took place, and we use it to investigate how independent and chain pharmacies respond when nonmedical demand plummets. Purdue Pharma, the producer of OxyContin, once the world's top-selling opioid analgesic, pleaded guilty to a felony charge of "misbranding" on May 10, 2007, meaning that the firm falsely advertised the safety of this painkiller (Alpert, Powell, and Pacula 2018; Alpert et al. 2022). On April 5, 2010, a reformulated abuse-deterrent OxyContin was approved by the Food and Drug Administration (FDA). Before 2010, OxyContin's main ingredient, oxycodone, was slowly released over the course of twelve hours. Drug abusers crushed or liquefied OxyContin pills to gain full and immediate access to the oxycodone content. Purdue Pharma marketed reformulated pills starting in August 2010 and ceased shipment of the old OxyContin (Butler et al. 2013; Evans, Lieber, and Power 2019). The new formulation cannot easily be broken, crushed, or dissolved, and thus it greatly reduces the possibility of OxyContin abuse, although it cannot eradicate oral misuse by taking more pills or higher doses (Alpert, Powell, and Pacula 2018). The reformulation resulted in an increase use of illicit drug use and overdose death (Powell and Pacula 2021).

II. Data and Summary Statistics

We use the 2006–2012 data from the Automation of Reports and Consolidated Orders System (ARCOS), maintained by the Diversion Control Division of the US DEA. Manufacturers and distributors are legally required to report their controlled substance transactions to the DEA. We observe quantities (in grams) of every controlled prescription opioid delivered to pharmacies in the United States.[9] We aggregate the data at the pharmacy level by month and convert the dosage into MED so that dosages of different opioids are comparable. We consider only retail pharmacies and exclude pharmacies that are integrated into hospitals, clinics, or other health care facilities.[10] The ARCOS data differentiate between chain and other retail pharmacies, where the chain pharmacy category includes stand-alone chain

[9] The national raw data were downloaded from the website of the *Washington Post* (Rich, Díez, and Vongkiatkajorn 2019). After adjusting for destroyed and returned orders from deliveries to pharmacies, we assume that all the deliveries from manufacturers/distributors to pharmacies are finally dispensed by pharmacies to customers. Furthermore, we exclude large outliers.

[10] Note that this exclusion also excludes "pill mills" that prescribed and dispensed opioids within one facility.

pharmacies, supermarket pharmacies, and mass merchandiser pharmacies.[11] We connect the dataset (Rich, Ba Tran, and Williams 2019) with geographical information on pharmacies offered by the *Washington Post*.

Table 1 provides basic summary statistics of our sample. We observe 84,111 pharmacies during 2006 and 2012. Of these, 44,812 are chain pharmacies while the remaining ones are independent pharmacies. Compared with chain pharmacies, independent pharmacies face more competition nearby. Panel B of Table 1 focuses on the concentration of pharmacies. We observe pharmacies in 38 percent of all zip codes. In 21 percent of zip codes, both independent and chain pharmacies are present. Panel C shows 15,056 entries and 10,752 exits over these seven years.[12] Among these entries, 6,413 (43 percent) were chain pharmacies, and 8,643 (57 percent) were independent pharmacies. However, exits among independent pharmacies (7,830) were more than double those among chain pharmacies (2,922).[13] As a result, the relative number of chains increased between 2006 and 2012. We also observe ownership changes.[14] In detail, we observe 304 independent pharmacies that became a chain. Panel D of Table 1 describes the dispensing. On average, pharmacies dispense 327 MED of all opioids and 27 MED of OxyContin each month. An independent pharmacy dispenses on average more MED, and the relative difference is higher for OxyContin. For pharmacies that started as independent and became part of a chain, the comparison between the last two rows and the first two rows in panel D shows that prior to the ownership change, they did not differ strongly in terms of opioid dispensing from other independent pharmacies that did not change ownership.

III. Differences in Dispensing between Independent and Chain Pharmacies

In this section, we document the differences in prescription opioid dispensing between chain and independent pharmacies using two empirical models. First, we use a direct comparison with rich geographic and time fixed effects. Second, we employ an analysis of ownership changes that compares independent pharmacies' dispensing before and after the facilities became chain pharmacies.

[11] In our main analyses, we use the chain and independent pharmacies (other retail pharmacies) defined in the ARCOS data directly. In online Appendix A, we conduct robustness checks by differentiating independent pharmacies with a single store, two stores, three stores, and four or more stores and compare them respectively with chain pharmacies. We find that "independent" pharmacies with four or more stores are fundamentally different from independent pharmacies with no more than three stores, and these large "independent" pharmacies are more similar to chains.

[12] We identify an entry as a new DEA license issued for a pharmacy in a geographical location without a pharmacy operating there beforehand during 2006–2012, and we only consider entries after June 2006. Exits are identified if we do not observe a pharmacy for the remaining time during our sample period and for at least six months.

[13] In online Appendix B we analyze the role of exiting and entering pharmacies. We observe decreasing opioid dispensing by both independent and chain pharmacies before exit and increasing dispensing after entry. While more independent pharmacies exit and enter, they do not drive our results for the impact of ownership, as shown in online Appendix B.

[14] We define an ownership change as the combination of changes in the DEA registration number, buyer name, and pharmacy type at the same geographical location. We further require that the change from an old to a new owner take at most three months, to reduce the likelihood of a shutdown of a pharmacy before the opening of a new pharmacy. Finally, each ownership change happened after at least six months since the beginning of the sample period. There are likely many ownership changes within the same pharmacy type, i.e., an independent pharmacy that changes owners but still maintains independent ownership. However, we cannot necessarily relate such a case to an ownership change with a new registration number alone, because a pharmacy might also update its DEA registration number occasionally without changing ownership.

Table 1—Summary Statistics

	All	Chain	Independent
Panel A. Pharmacies and concentration			
Number of pharmacies	84,111	44,812	39,299
Competitors within one-mile radius	4.47	3.7	5.57
	(9.09)	(7.18)	(11.18)
Competitors within five-mile radius	52.95	43.64	66.30
	(114.02)	(86.82)	(11.18)
Chains within one-mile radius	2.15	2.18	2.10
	(3.81)	(3.78)	(3.85)
Independent pharmacies within one-mile radius	2.33	1.52	3.48
	(6.39)	(4.28)	(8.42)
Panel B. Pharmacy concentration in zip code areas			
Share of zip code areas with at least one pharmacy	0.38	0.26	0.32
Share of zip code areas with independent and chain pharmacies	0.21	—	—
Average number of pharmacies in same zip code area	2.03	1.08	0.95
	(4.14)	(2.41)	(2.33)
Average number of pharmacies in same zip code area, conditional on both types present	8.11	4.42	3.69
	(5.49)	(3.21)	(3.79)
Panel C. Entries, exits, and ownership changes			
Entries	15,056	6,413	8,643
Exits	10,752	2,922	7,830
Ownership change from independent to chain	304	—	—
Panel D. Opioid dispensing			
Monthly MED dispensing, all opioids	327.19	306.49	356.62
	(541.11)	(342.89)	(735.15)
Monthly MED dispensing, OxyContin	27.14	23.67	32.06
	(75.91)	(50.60)	(101.36)
Monthly MED, all opioids, independent before becoming chain	—	—	355.71
			(471.54)
Monthly MED OxyContin, independent before becoming chain	—	—	36.86
			(135.67)

Notes: Panel A describes the number of pharmacies as well as the number of competing pharmacies in different radii. Panel B describes the concentration of pharmacies on the zip code level. Panel C shows the number of entries, exits, and ownership changes. Note that entries are defined by the presence of a new owner at a new location, while exits are defined as a pharmacy that closes at a location without replacement. In comparison, an ownership change is defined by a new owner at the same geographic location within three months. Panel D describes opioid dispensing. We divide dispensing into dispensing of all opioids and of OxyContin only. The last two rows describe dispensing by independent pharmacies that became chains, prior to the date of the ownership change. Standard deviations are in parentheses.

Direct Comparison of Independent and Chain Pharmacies.—Our first empirical strategy is simple and straightforward, as we directly compare independent pharmacies with chain pharmacies as shown below:

$$Y_{it} = \beta Independent_i + \mu_t + \gamma_{FE} + \epsilon_{it}, \tag{1}$$

where Y_{it} represents the amount of prescription opioids dispensed. Specifically, we consider the dispensed MED of all types of prescription opioids at a pharmacy i in month t as well as the dispensed MED of OxyContin. The variable $Independent_i$ is a dummy that takes the value one if a pharmacy is independent, μ_t is year-month

Table 2—Regression, Direct Comparison

	All				OxyContin			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Independent	50.131	51.362	107.826	128.016	8.393	8.640	14.492	16.407
	(4.908)	(4.912)	(5.551)	(5.875)	(0.577)	(0.578)	(0.657)	(0.720)
Constant	306.488				23.671			
	(2.109)				(0.269)			
Year-month fixed effects	No	Yes	Yes	Yes	No	Yes	Yes	Yes
County fixed effects	No	No	Yes	No	No	No	Yes	No
Zip code fixed effects	No	No	No	Yes	No	No	No	Yes
Mean outcome	327.19	327.19	327.19	327.19	27.14	27.14	27.14	27.14
Mean effect in percent	15.32	15.7	32.96	39.13	30.93	31.84	53.41	60.46
Observations	5,055,761	5,055,761	5,055,761	5,055,761	5,055,761	5,055,761	5,055,761	5,055,761
R^2	0.002	0.010	0.089	0.225	0.003	0.019	0.066	0.159

Notes: Results of the direct comparison between independent and chain pharmacies, presented in equation (1). One observation corresponds to a pharmacy within a month. In columns 1–4, the outcome is monthly dispensed opioids in MED. In columns 5–8 we consider monthly dispensed OxyContin in MED as an outcome. *Independent* displays the coefficient β. We show the mean outcome of the outcome variable as well as the mean effect in percent, which is defined as $\beta/\bar{y}$ where $\bar{y}$ is the mean of outcome y. Standard errors are clustered at the zip code level, adjusted for within-cluster correlation, and reported in parentheses.

fixed effects, and γ_{FE} represents different geographic fixed effects. We add county as well as zip code fixed effects successively to control for unobserved area-specific characteristics and thus to eliminate the potential bias due to possible correlation between the pharmacy ownership and area-specific factors. The estimate $\hat{\beta}$ indicates the difference between independent and chain pharmacies in prescription opioid dispensing.[15]

Table 2 presents results from regression (1). Columns 1–4 evaluate the relation between pharmacy ownership and all opioid dispensing, and columns 5–8 examine OxyContin specifically. The effects are robust to different geographic fixed effects. When we gradually add county and zip code fixed effects to compare pharmacies within a county or a zip code, the effects become stronger and the R^2 increases, supporting our hypothesis that pharmacy ownership plays a role in determining the amount of opioids dispensed (Altonji, Elder, and Taber 2005; Oster 2019). Column 4 indicates that independent pharmacies on average dispense 128 (39.1 percent) more MED of all opioids. Moreover, if independent and chain pharmacies respond differently to nonmedical demand, the type of pharmacy that is more susceptible to it would dispense disproportionately more OxyContin, one of the most popular drugs in street markets. We find that independent pharmacies on average dispense 16.4 (60.5 percent) more MED of OxyContin per month, as shown

[15] For our specification (1) as well as equations (2) and (3), we provide several robustness checks in online Appendix C. First, we replace Y_{it} with the per capita dispensed MED by each pharmacy i in month t as an alternative outcome variable. For the denominator of per capita dispensed MED, we use the zip code level population from the 2010 census of pharmacy i's location. Second, we replace the separate geographic and time fixed effects with geographic identifier × year-month fixed effects. Third, instead of month-level analysis, we also conduct quarter-level analysis in case some pharmacies do not order stock frequently. In addition, for specification (1), we also show unconditional quantile regression results in online Appendix D to examine the impact of pharmacy ownership on prescription opioid dispensing at different quantiles.

in column 8. This demonstrates that independent pharmacies on average dispense more prescription opioids, especially of the type prone to nonmedical demand.

Change in Ownership.—Independent and chain pharmacies could differ in numerous dimensions. Estimates obtained from equation (1) are not able to capture the exact difference between independent and chain pharmacies' dispensing behavior, because even within the same zip code, these two types of pharmacies may have other differences. Therefore, we employ an identification strategy which shows that ownership rather than store-specific factors drives differences in dispensing. Specifically, we are interested in pharmacies that initially were independent and became part of a chain. In those cases, the geographic location and the surrounding environment are constant, and solely the ownership changes. Therefore, we can attribute almost all of the difference before and after the ownership change to the ownership. We identify 304 ownership changes from independent pharmacies becoming chain pharmacies.

Following the difference-in-difference approach of Eliason et al. (2020), we show effects of the ownership change of an independent pharmacy becoming a chain pharmacy on dispensing of all opioids and OxyContin by comparing independent pharmacies that became a chain to those that never changed ownership. The identification assumption is that the change in ownership is uncorrelated with characteristics of the independent pharmacy. We use the following model:

$$(2) \qquad Y_{it} = \beta_0 D_{it}^{PRE} + \beta_1 D_{it}^{POST} + \beta_C CHAIN_i + \alpha_i + \mu_t + \epsilon_{it},$$

where Y_{it} is the dispensed doses of all opioids and OxyContin at pharmacy i in month t. We compare the sample of pharmacies that were chains during the entire period and the sample of pharmacies that changed from independent to chain pharmacies. The baseline is those pharmacies that were always independent. D_{it}^{PRE} is an indicator that takes the value one for independent pharmacies before the ownership change. Similarly, D_{it}^{POST} takes the value one if an independent pharmacy has changed ownership and becomes a chain. Adding the two indicators D_{it}^{PRE} and D_{it}^{POST} would be equivalent to a treatment group dummy. We decided to split the dummy as the coefficient of D_{it}^{PRE} allows us to evaluate whether independent pharmacies that become chains differ from independent pharmacies without a change in ownership before the date of the ownership change. The dummy $CHAIN_i$ takes the value one if a pharmacy has always been owned by a chain. We include facility fixed effects (α_i).[16] Note that we drop D_{it}^{PRE} and $CHAIN_i$ when including α_i due to multicollinearity. The variable μ_t are time fixed effects.[17] In our final model we use two-way fixed effects. Recent literature shows that average treatment effects from linear regressions with period and group fixed effects could be biased in case of a staggered treatment design and heterogeneous treatment effects (De Chaisemartin and d'Haultfoeuille 2020; Athey and Imbens 2022; Borusyak, Jaravel, and Spiess 2021; Callaway and Sant'Anna

[16] Note that facility fixed effects differ from pharmacy fixed effects. The former are based on location, while the latter are based on the DEA number. We can solely include facility fixed effects as we would not identify ownership changes with pharmacy fixed effects.

[17] We present an event study of the analysis in online Appendix E.

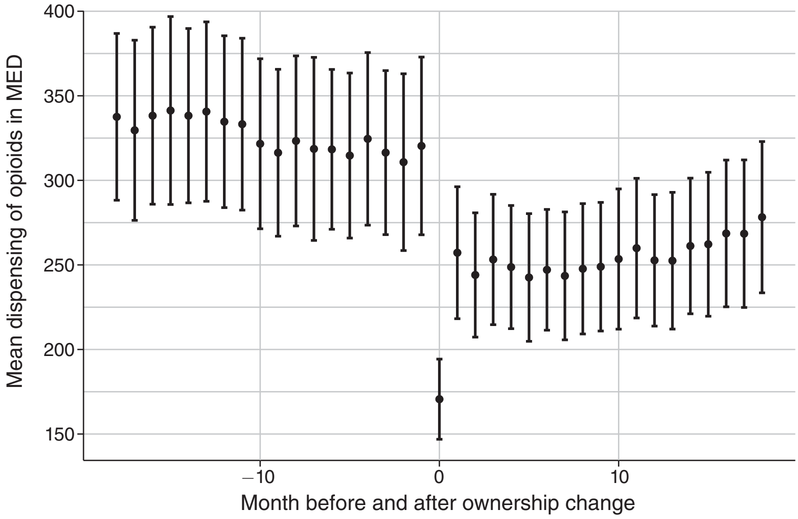

Figure 1. Dispensing of All Opioids in Months before and after Ownership Change

Notes: The figure represents monthly mean dispensing of all opioids in MED for independent pharmacies 18 months before and after becoming part of a chain. The eighteenth month before or after the ownership change includes all previous or following months. The error bars correspond to the 95 percent confidence intervals.

2021; Goodman-Bacon 2021; Baker, Larcker, and Wang 2022). We therefore also estimate a robust estimator based on De Chaisemartin and d'Haultfoeuille (2020).

If independent pharmacies that change ownership dispense similarly to independent pharmacies not changing ownership before the date of the ownership change, we expect that $\hat{\beta}_0$ would not be different from zero. Therefore the identification assumption also requires an insignificant $\hat{\beta}_0$ estimate. Further, we expect that independent pharmacies that become chain pharmacies reduce their dispensing of opioids. Thus $\hat{\beta}_1$ is expected to be negative.

Figure 1 depicts the monthly average dosage of all opioids dispensed by pharmacies before and after an ownership change. It shows a clear reduction in opioid dispensing after the ownership change. Surrounding the date of an ownership change, we observe that an independent pharmacy decreases its dispensing slightly during the months prior to the ownership change. As we measure dispensing through orders shipped to pharmacies, this can be explained by a stock reduction in anticipation of the forthcoming ownership change.

Table 3 further demonstrates that a pharmacy's ownership affects its dispensing behavior, as after independent pharmacies became chain pharmacies, they decreased their opioid dispensing. Columns 1–5 show the impact on dispensing of all opioids, while columns 6–10 solely evaluate OxyContin. As shown in columns 1–3, we observe nonsignificant coefficients of the D^{PRE} regressor, meaning that before the ownership change, those pharmacies that started as independent and then became chain pharmacies are not significantly different from the all-time independent pharmacies. However, after the ownership change, formerly independent pharmacies decreased their dispensing. Using zip code and year-month specific effects, column 3 shows that they dispense 153.2 (46.8 percent) less MED per month than

Table 3—Change in Ownership: Independent to Chain

	All				
	OLS (1)	OLS (2)	OLS (3)	OLS (4)	DID-M (5)
D^{PRE}	1.516	32.777	−1.226		
	(33.915)	(33.655)	(32.747)		
D^{POST}	−102.89	−130.867	−153.215	−110.507	−154.392
	(19.755)	(19.61)	(20.439)	(16.65)	(15.284)
CHAIN	−49.933	−50.89	−127.879		
	(4.931)	(4.934)	(5.912)		
Constant	356.624				
	(4.883)				
Year-month fixed effects	No	Yes	Yes	Yes	Yes
Zip code fixed effects	No	No	Yes	No	No
Facility fixed effects	No	No	No	Yes	Yes
Mean outcome	327.19	327.19	327.19	327.19	327.19
Mean effect in percent	−31.45	−40	−46.83	−33.77	−47.19
Observations	5,055,761	5,055,761	5,055,761	5,055,761	5,055,761
R^2	0.002	0.01	0.225	0.809	
	OxyContin				
	OLS (6)	OLS (7)	OLS (8)	OLS (9)	DID-M (10)
D^{PRE}	5.099	9.193	7.526		
	(6.886)	(6.832)	(7.314)		
D^{POST}	−9.303	−13.306	−14.604	−14.339	−15.223
	(6.886)	(6.832)	(7.314)	(4.073)	(2.641)
CHAIN	−8.362	−8.573	−16.361		
	(0.578)	(0.578)	(0.724)		
Constant	32.036				
	(0.554)				
Year-month fixed effects	No	Yes	Yes	Yes	Yes
Zip code fixed effects	No	No	Yes	No	No
Facility fixed effects	No	No	No	Yes	Yes
Mean outcome	27.14	27.14	27.14	27.14	27.14
Mean effect in percent	−34.28	−49.03	−53.82	−52.84	−56.1
Observations	5,055,761	5,055,761	5,055,761	5,055,761	5,055,761
R^2	0.003	0.019	0.159	0.649	

Notes: Results of the regression analysis in equation (2). One observation corresponds to a pharmacy within a month. In columns 1–5, the outcome is monthly dispensed opioids in MED. In columns 6–10, we consider monthly dispensed OxyContin in MED as an outcome. In columns 5 and 10 we use a two-way fixed effects estimator that is robust to heterogeneous treatment effects when weights of the average treatment effects are negative. Details of the estimator are described in De Chaisemartin and d'Haultfoeuille (2020). The indicator D^{PRE} displays the coefficient β_0, the effect of independent pharmacies before a change in ownership; D^{POST} displays the coefficient β_1, the effect of chain pharmacies that were independent before a change in ownership; *CHAIN* displays the coefficient β_C, the effect of chain pharmacies that did not change ownership. The baseline effect is independent pharmacies that did not change ownership. Facility fixed effects are based on the geographical location of a pharmacy. When using facility fixed effects, only the variation of changing ownership can be used. We show the mean outcome of the outcome variable as well as the mean effect in percent across the population, which is defined as $\beta_1/\bar{y}$ where $\bar{y}$ is the mean of outcome *y*. Standard errors are clustered at the zip code level, adjusted for within-cluster correlation, and reported in parentheses. OLS = ordinary least squares; DID-M = estimator described in De Chaisemartin and d'Haultfoeuille (2020).

their independent counterparts that do not change ownership. Including facility fixed effects in column 4 gives us a slightly smaller but still significant estimate that independent pharmacies dispense 110.5 (33.8 percent) less MED of all opioids per month after becoming chain pharmacies. Considering the estimator of De Chaisemartin and d'Haultfoeuille (2020) in column 5, our result gets stronger.

Similarly to the findings for all opioids, independent pharmacies that change ownership do not differ before the ownership change from the all-time independent pharmacies in terms of OxyContin dispensing, as shown in columns 6–10. However, after the ownership change, the former independent pharmacies reduced their OxyContin dispensing by 14.3 (52.8 percent) MED per month, as shown in column 9. Column 10 reports the estimator of De Chaisemartin and d'Haultfoeuille (2020) that corrects for a potential bias due to heterogeneous treatment effects in a staggered treatment adoption setting. Using this estimator, our results get slightly stronger. We conclude that the estimates are robust to different specifications. Therefore, we show that the differences are due to the ownership rather than facility-specific factors such as geography.

IV. The OxyContin Reformulation and Dispensing for Nonmedical Demand

Our stylized facts reveal big differences in opioid dispensing between independent and chain pharmacies. However, it is impossible to distinguish whether the differences are due to medically appropriate dispensing or dispensing for nonmedical demand. Therefore, in this section, we provide a simple conceptual framework and use the OxyContin reformulation as a quasi-experiment to identify the dispensing for nonmedical demand in the retail pharmacy market.

A. *Conceptual Framework*

Consider the retail market for OxyContin with an independent and a chain pharmacy denoted as $i \in \{I, C\}$. The market is divided into two submarkets, $j \in \{M, A\}$, where M is the market for medically appropriate and necessary usage and A is the market for recreational or abusive use (the nonmedical market). While the market for medically necessary usage is solely based on legitimate prescriptions, the market for nonmedical demand includes illicit prescriptions from patients that engage in doctor/pharmacy shopping or steal/forge prescriptions. In each market j the demand is defined by a function $D_i^j(p_i, u^j)$, where p_i is a price of an opioid in pharmacy i and u^j a factor displaying the general size of the market. The size of the medically necessary market is determined by legitimate prescriptions, while for the nonmedical use, the size of the market is based on the potential for abuse of the drug, the number of users, and black market value. The demand for both markets may be correlated, $\text{corr}(D_i^M, D_i^A) > 0$, as medically necessary usage is potentially correlated with abusive behavior.

In equilibrium, we observe dispensing q_i, which includes both markets, that is, $q_i = q_i^M + q_i^A$. In the analysis above we show that $q_I > q_C$. However, higher dispensing by independent pharmacies itself does not imply more dispensing for nonmedical demand, because market A is not the only factor that may drive the effect. Independent pharmacies may offer lower prices and better service, and thus attract more patients from both segments M and A.[18]

[18] On the other hand, chain pharmacies also have their own advantages, such as being more likely to be included in a preferred provider network, and thus may attract more insured customers (Starc and Swanson 2018; Jones 2019).

Therefore, we use the OxyContin reformulation to show that the difference in dispensing between independent and chain pharmacies is at least partly due to the market segment of abusive use. The number of legitimate prescriptions in M, u^M, is not affected by the reformulation to an abuse-deterrent formula that did not affect its medical use (Mastropietro and Omidian 2015). The abuse-deterrent formula reduces demand in market A, so $D_i^A, \forall i$ decreases due to a lower u^A. Furthermore, we assume that prices $p_i, \forall i$ are unaffected by the reformulation, as documented by existing studies (Coplan et al. 2016; Evans, Lieber, and Power 2019). Following the reformulation, we are able to evaluate which market drives the result of $q_I > q_C$, as only the demand for nonmedical use D^A decreased. If pharmacies fill only legitimate medically appropriate prescriptions, the reformulation should have no effect on the overall differences, whereas we expect to observe a decline in OxyContin dispensing if there was dispensing to the nonmedical market before the reformulation.

B. *Identification and Results*

Given our conceptual framework, we use the following model to test whether the overdispensing of independent pharmacies is partially driven by their misdoing in dispensing for nonmedical demand:

$$Y_{it} = \beta Independent_i \times Post_t + \alpha_i + \mu_t + \epsilon_{it}, \tag{3}$$

where Y_{it} represents OxyContin dispensing at pharmacy i in month t, $Post_t$ takes the value one for all months since August 2010, when the new OxyContin formulation entered the market and shipment of the old OxyContin ceased, $Independent_i$ indicates whether a pharmacy is an independent pharmacy, μ_t is year-month fixed effects, and α_i is pharmacy fixed effects. A negative $\hat{\beta}$ would suggest that independent pharmacies are more susceptible to the nonmedical demand.[19] In online Appendix E, we show the event study results.[20]

Figure 2 depicts the average dispensing of OxyContin before and after the reformulation by independent and chain pharmacies. In 2006, OxyContin dispensing by both independent and chain pharmacies remained at a similar level. We then observe an increase in OxyContin dispensing by both independent and chain pharmacies from 2007. However, the increase among independent pharmacies started more than half a year earlier than that of chain pharmacies. From 2008 to 2010, the rate of increase is similar among independent and chain pharmacies, and thus the gap remains similar, with independent pharmacies dispensing on average 15 MED more OxyContin. During the interval between the FDA approval of the new OxyContin formulation in April 2010 and its market entry in August 2010, independent pharmacies further increased their dispensing, although slightly, whereas chain pharmacies slightly decreased their dispensing. Therefore, the gap increased slightly.

[19] Since we have simultaneous treatment for all pharmacies, our two-way fixed effects model estimate does not suffer from a bias due to heterogeneous treatment effects when some weights of the average treatment effect are negative (Borusyak, Jaravel, and Spiess 2021; Baker, Larcker, and Wang 2022).

[20] Our main analysis is based on the classification of independent and chain pharmacies. In online Appendix F, we also divide chain pharmacies into small chains and large chains, and we find that large chains are least likely, small chains are more likely, and independent pharmacies are the most likely to dispense for nonmedical demand.

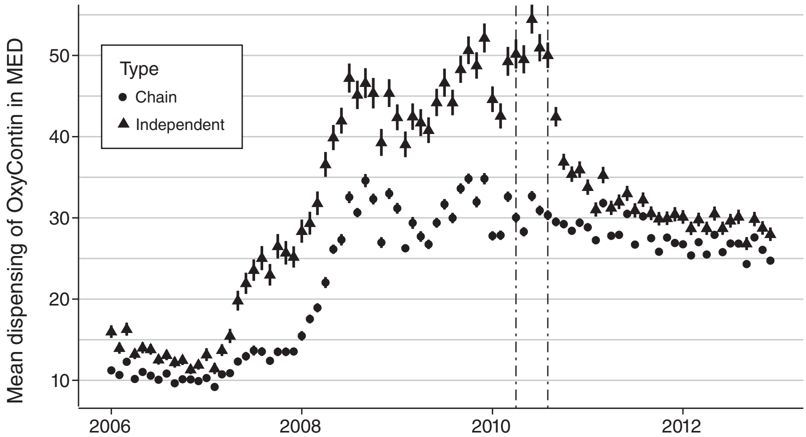

Figure 2. OxyContin Dispensing, Chain versus Independent Pharmacies

Notes: The figure shows average dispensing of OxyContin in MED for chain and independent pharmacies between 2006 and 2012. The first vertical line corresponds to April 2010, when the new OxyContin was approved by the FDA. The second vertical line corresponds to August 2010, when the new formula was delivered to pharmacies. The error bars correspond to the 95 percent confidence intervals.

However, after the new formula replaced the old formula in August 2010, we see a sharp reduction in OxyContin dispensing by independent pharmacies but only a slight decline among chain pharmacies.

Table 4 shows the regression results. Columns 1–4 show the results using the whole sample. Our key interest is the coefficient of the interaction term *Independent* × *Post*. Column 1 provides the baseline estimate, and adding year-month fixed effects and zip code fixed effects in columns 2 and 3 generate similar estimates. In our preferred specification in column 4, we find that after the OxyContin reformulation, independent pharmacies on average reduced their dispensing of OxyContin by about 5.3 MED (19.7 percent) per month. In addition, as we notice that the prereformulation parallel trends for independent and chain pharmacies in Figure 2 are more evident since 2008, we also limit the sample to 2008–2012 only and show the estimates in columns 5–8. The estimated effect in column 8 is about 70 percent $([9.0 - 5.3]/5.3)$ larger than the counterpart estimate in the whole sample.

We argue that only the reformulation affects the OxyContin dispensing. Specifically, the reformulation into the new abuse-deterrent formula reduced the possibility of abuse and therefore reduced the nonmedical demand. We have two assumptions here. First, we assume that the reformulation is uncorrelated with other concurrent factors that affect prescription opioid dispensing around the time of the reformulation. Second, we assume that the reformulation of OxyContin affects only the nonmedical demand but not medical demand. Although we cannot test these assumptions directly, relevant evidence suggests they are well suited. First, we observe a structural break in dispensing for OxyContin only. Figure 3 shows the dispensing trends for all prescription opioids except OxyContin. In contrast to the OxyContin dispensing, we do not observe a break in dispensing of other opioid analgesics among both independent and chain pharmacies, which suggests that

Table 4—Regression, OxyContin Reformulation

	OxyContin							
	Full sample: 2006–2012				Subsample: 2008–2012			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Independent × *Post*	−6.097	−6.436	−6.996	−5.339	−10.475	−10.526	−10.892	−9.048
	(0.529)	(0.529)	(0.565)	(0.484)	(0.672)	(0.672)	(0.702)	(0.596)
Independent	10.569	10.912	18.886		14.947	15.002	24.353	
	(0.681)	(0.683)	(0.832)		(0.897)	(0.897)	(1.058)	
Post	6.095				−1.332			
	(0.154)				(0.178)			
Constant	21.495				28.923			
	(0.281)				(0.357)			
Year-month fixed effects	No	Yes	Yes	Yes	No	Yes	Yes	Yes
Zip code fixed effects	No	No	Yes	No	No	No	Yes	No
Pharmacy fixed effects	No	No	No	Yes	No	No	No	Yes
Mean outcome	27.14	27.14	27.14	27.14	32.29	32.29	32.29	32.29
Mean effect in percent	−22.47	−23.72	−25.78	−19.67	−32.44	−32.60	−33.74	−28.02
Observations	5,055,761	5,055,761	5,055,761	5,054,885	3,653,388	3,653,388	3,653,388	3,652,557
R^2	0.004	0.019	0.159	0.650	0.006	0.008	0.174	0.727

Notes: Results of the OxyContin reformulation regression analysis in equation (3). One observation corresponds to a pharmacy within a month. The outcome variable is monthly OxyContin dispensing in MED at the pharmacy level. The row *Independent* × *Post* displays the coefficient $\hat{\beta}$, the change in OxyContin dispensing of independent pharmacies after the reformulation relative to chains; *Independent* displays the dispensing of independent pharmacies relative to chains; *Post* takes the value one for all months since August 2010, when the new OxyContin entered the market and shipment of the old OxyContin ceased. We show the mean of the outcome variable as well as the mean effect in percent across the population, which is defined as $\hat{\beta}/\bar{y}$ where $\bar{y}$ is the mean of outcome y. Standard errors are clustered at the zip code level, adjusted for within-cluster correlation, and reported in parentheses.

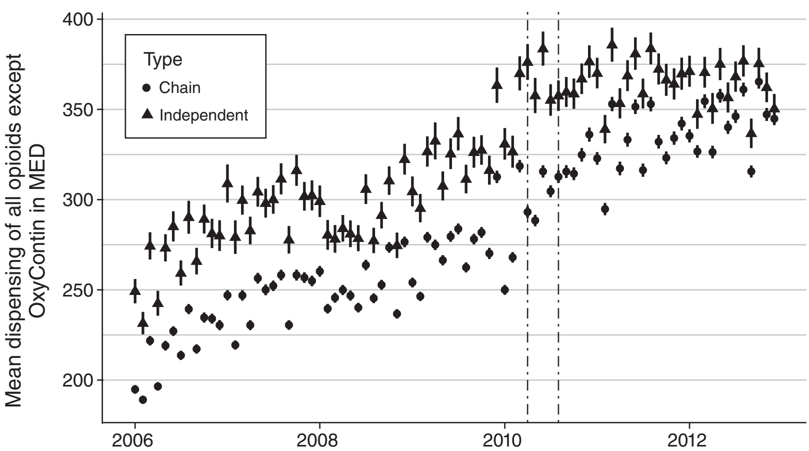

Figure 3. Opioid Dispensing except OxyContin, Chain versus Independent Pharmacies

Notes: The figure shows average dispensing of all prescription opioids except OxyContin in MED for chain and independent pharmacies between 2006 and 2012. The error bars correspond to the 95 percent confidence intervals.

there is no confounding event that affects prescription opioid dispensing in general simultaneously with the OxyContin reformulation. Second, medical demand for OxyContin remained unaffected by the reformulation, because the reformulation did not change the medical applicability (Mastropietro and Omidian 2015).

Further, prices of OxyContin did not change, either (Coplan et al. 2016; Evans, Lieber, and Power 2019).

Since it is possible that the results are driven by a small proportion of misbehaving pharmacies, we conduct robustness checks in online Appendix G by excluding Florida (the state with the highest dispensing of OxyContin in 2010) and pharmacies whose dispensing is in the top percentiles. The estimates are still negative and significant, though with smaller magnitudes, as shown in online Appendix Table G.1. Moreover, we also estimate the unconditional quantile treatment effects of the OxyContin reformulation and plot the estimates in online Appendix Figure G.2. We find that, compared with chain counterparts whose OxyContin dispensing was at or below the median, independent pharmacies in the similar quantiles did not significantly reduce their OxyContin dispensing. However, among pharmacies that dispensed more than the median level of OxyContin, independent pharmacies reduced their OxyContin dispensing significantly after the reformulation, compared with chain pharmacies. Then, we further examine the changes in dispensing of 80 milligrams of OxyContin versus other lower dosages in online Appendix Table G.2, as the former dosage is more likely to be sought for nonmedical use due to its popularity among drug abusers. We find a 33.1 percent decline in 80 milligrams of OxyContin dispensing but only a 7.5 percent decline in non-80 milligrams of OxyContin dispensing by independent pharmacies, which provides further evidence that independent pharmacies are more involved in drug dispensing for nonmedical demand. In addition, as another robustness check, in online Appendix Table C.6 we also add zip code $\times$ year-month fixed effects to control for possible neighborhood-specific time-varying characteristics that may affect pharmacies' dispensing. The estimated treatment effect is -5.1, similar to our main estimate (-5.3).

C. *Identifying Top Diverting Pharmacies via the OxyContin Reformulation*

Following the logic of our OxyContin reformulation analysis, we examine which pharmacies dispense the most OxyContin for nonmedical demand and where they are located. We calculate the changes in OxyContin dispensing using the difference in per capita monthly dispensed OxyContin one year after (August 2010–July 2011) and one year before (August 2009–July 2010) the reformulation. Not surprisingly, over one-half of the pharmacies reduced their OxyContin dispensing after the reformulation. Table 5 shows the characteristics of the top and bottom diverting pharmacies in this regard. The top diverting pharmacies are those whose change in dispensed OxyContin is very negative, i.e., reducing their dispensing the most after the reformulation. The bottom diverting pharmacies are those whose dispensing of OxyContin increased the most after the reformulation.

As shown in Table 5, 61,410 pharmacies existed from August 2009 to July 2011. Among these pharmacies, 41 percent are independent pharmacies. An average pharmacy in column 1 and an average independent pharmacy in column 2 are comparable, indicating independent pharmacies and chain pharmacies are distributed similarly. As an exception, we observe that independent pharmacies are more likely to locate in a rural area. However, consistent with our previous findings, independent pharmacies on average reduced more OxyContin dispensing after the reformulation. As a result, the shares of independent pharmacies among the top 5 percent

TABLE 5—CHARACTERISTICS OF TOP AND BOTTOM PHARMACIES DISPENSING FOR NONMEDICAL DEMAND

	All mean (SD) (1)	Independent mean (SD) (2)	Top 5% mean (SD) (3)	Bottom 5% mean (SD) (4)	Top 10% mean (SD) (5)	Bottom 10% mean (SD) (6)
Share independent pharmacies	0.41	1.00	0.70	0.53	0.60	0.47
	(0.49)	(0.00)	(0.46)	(0.50)	(0.49)	(0.50)
Change in MED	−6.29	−12.11	−114.09	28.33	−72.88	22.15
	(53.48)	(78.33)	(199.71)	(33.73)	(148.00)	(25.68)
Change in per capita MED	−0.0003	−0.0006	−0.0069	0.0027	−0.0042	0.0017
	(0.0029)	(0.0042)	(0.0100)	(0.0030)	(0.0076)	(0.0023)
Zip code level characteristics						
Population	29,176	27,111	17,939	13,033	19,832	16,529
	(18,242)	(20,173)	(14,951)	(10,917)	(15,151)	(12,321)
Median household income	55,494	50,790	51,088	52,752	52,196	53,554
	(22,030)	(20,924)	(22,346)	(21,055)	(21,624)	(21,102)
Mean household income	69,660	64,657	64,890	66,263	66,051	67,230
	(28,588)	(28,040)	(29,354)	(27,447)	(28,546)	(27,445)
Share rural	0.16	0.23	0.29	0.37	0.26	0.31
	(0.27)	(0.33)	(0.37)	(0.38)	(0.34)	(0.35)
Share White	0.66	0.64	0.72	0.79	0.72	0.77
	(0.26)	(0.29)	(0.25)	(0.19)	(0.24)	(0.20)
Share elderly	0.14	0.14	0.15	0.16	0.15	0.16
	(0.06)	(0.05)	(0.06)	(0.06)	(0.06)	(0.06)
Share house vacant	0.10	0.11	0.13	0.13	0.12	0.12
	(0.07)	(0.08)	(0.10)	(0.11)	(0.09)	(0.10)
County-level characteristics						
Prescription rate 2006	76.93	76.21	87.85	78.90	85.40	79.87
	(36.53)	(40.91)	(45.24)	(35.46)	(42.66)	(34.87)
Death rate 2006	11.94	11.78	13.95	12.22	13.53	12.24
	(5.06)	(5.20)	(6.23)	(4.83)	(5.90)	(4.82)
Prescription rate 2010	86.36	85.97	98.40	89.61	95.73	90.75
	(40.45)	(45.38)	(48.71)	(39.02)	(46.27)	(38.85)
Death rate 2010	13.02	12.80	15.56	13.84	15.03	13.80
	(5.70)	(6.00)	(7.67)	(5.44)	(7.04)	(5.34)
Observations	61,410	25,299	3,070	3,071	6,141	6,141

Notes: The top fifth/tenth and bottom fifth/tenth percentiles are in terms of the change in OxyContin dispensing between August 2009 and July 2010 (the year prior to the OxyContin reformulation) and August 2010 and July 2011 (the year after the OxyContin reformulation), using the postreformulation minus prereformulation dispensed OxyContin. Prescription rate is the opioid dispensing rate per 100 population. Death rate is model-based crude death rate for drug poisoning per 100,000 population. Standard deviations are reported in parentheses.

and top 10 percent diverting pharmacies are much higher: 70 percent and 60 percent, respectively. However, we should note that independent pharmacies account for a higher share of the bottom diverting pharmacies as well: 53 percent of the bottom 5 percent and 47 percent of the bottom 10 percent. This is consistent with the observation that the chain pharmacies' dispensing is more concentrated while the independent pharmacies' dispensing is more dispersed. The top 10 percent (5 percent) diverting pharmacies on average reduced their monthly OxyContin dispensing by 73 (114) MED, whereas the bottom 10 percent (5 percent) on average increased their monthly OxyContin dispensing by 22 (28) MED.

In terms of zip code level characteristics, both the top and bottom diverting pharmacies are more likely to be located in a less populous area compared with the average pharmacies in column 1 and have a lower median and mean household income, larger rural share, larger White share, and larger share of vacant houses. However, compared with the bottom diverting pharmacies, the top diverting pharmacies are located in areas that have a larger population, are less rural, and have a lower share of White people. When looking at the county-level characteristics, the top diverting pharmacies are located in areas with much higher opioid prescription rates and drug poisoning death rates, but a little surprisingly, the bottom pharmacies in this regard are also located in areas with slightly higher opioid prescription rates and drug poisoning death rates than the national average. In summary, the top diverting pharmacies are more likely to be located in more populous and less rural areas with high drug-related death rates than the bottom diverting pharmacies.

In addition to the descriptive characteristics, we also plot where the top diverting pharmacies are located. Figure 4 depicts the geographic distribution of the top 10 percent independent and chain pharmacies dispensing for nonmedical demand, respectively. Since independent pharmacies account for a larger share in the top 10 percent diverting pharmacies, we find a higher density of independent pharmacies in Figure 4. Furthermore, compared with the top diverting chains, the top diverting independent pharmacies are more concentrated in the following areas: (i) the intersection of Kentucky, West Virginia, and Virginia; (ii) southern Louisiana; and (iii) the west and east coasts of Florida. When we compare these two maps with the maps on county-level death rates due to drug poisoning in 2006 and 2011 in Figure 5, we find that the counties with a greater share of top diverting independent pharmacies and the counties with the highest mortality rates due to drug poisoning are quite coincident.

V. What Explains Independent Pharmacies' Larger Dispensing for Nonmedical Demand?

Our results have demonstrated that independent pharmacies on average dispense more prescription opioids than chain pharmacies, and 37.2 percent of the excessive dispensing of OxyContin is associated with the nonmedical demand. In this section, we discuss the potential reasons behind the difference in dispensing for nonmedical demand between independent and chain pharmacies.

A. *Competitive Pressure*

First, due to the consolidation of the pharmaceutical market in the past two decades, independent pharmacies have seen narrowing profit margins relative to chains and smaller market shares in total prescriptions, and thus they have a greater need to tip the balance. According to data from the National Association of Chain Drug Stores and the National Community Pharmacy Association, from 2000 to 2010, the number of chain pharmacies increased by 11 percent while the number of independent pharmacies remained about the same. In addition, the average prescription revenue per pharmacy outlet increased by 62 percent among chain pharmacies, whereas it increased by only 34 percent among independent pharmacies (Fein 2011b). This evidence implies that the market is more favorable to chains, and independent pharmacies face a tougher business environment. In addition, the gross

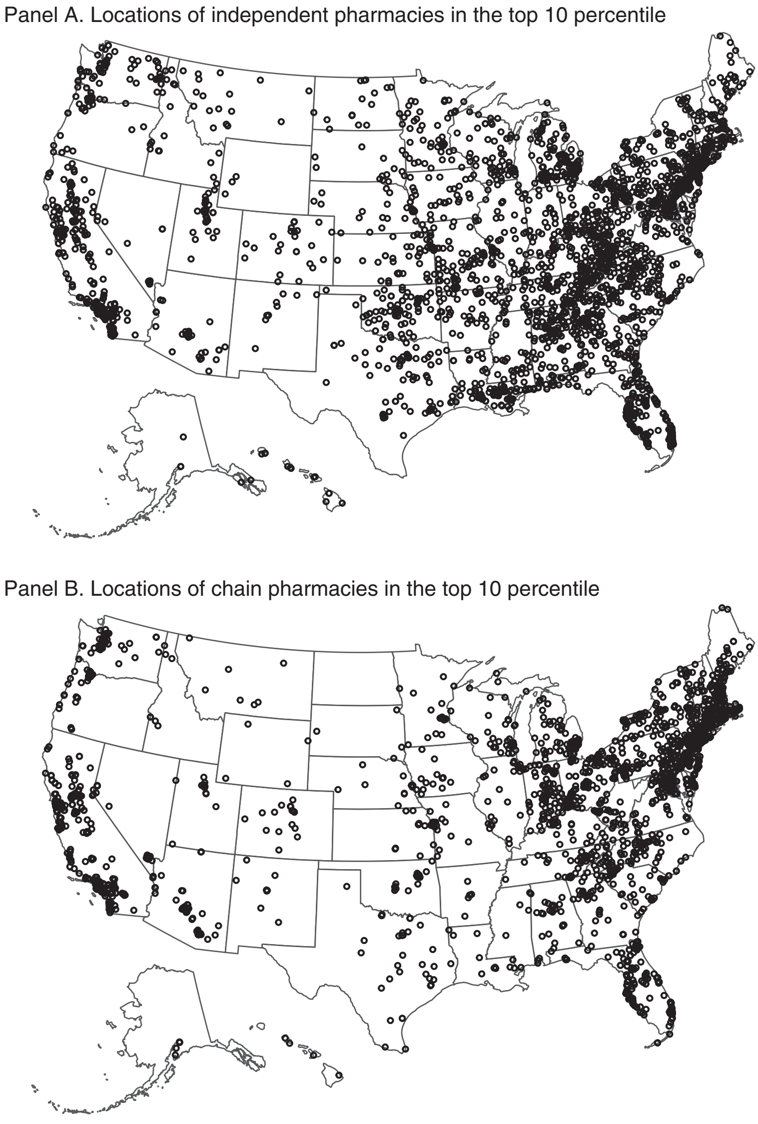

Figure 4. Locations of Top 10 Percent Diverting Pharmacies

Notes: These two maps plot locations of the top 10 percent diverting pharmacies, by independent and chain ownership separately. Degree of diverting is calculated by the average monthly dispensing of OxyContin per capita from August 2010 to July 2011 minus the average monthly dispensing of OxyContin per capita from August 2009 to July 2010. The top pharmacies in this regard are those with the most negative changes in OxyContin dispensing.

margin of independent pharmacies was 22 percent in 2014 (Fein 2019), while the gross margin for all retail pharmacies in the same year was 26.7 percent (US Census Bureau 2018), demonstrating the lower profit margin of independent pharmacies relative to chains. In the following analysis we show that compared with chains, independent pharmacies are more likely to compensate for their loss of revenue from competition by dispensing more OxyContin prior to the reformulation.

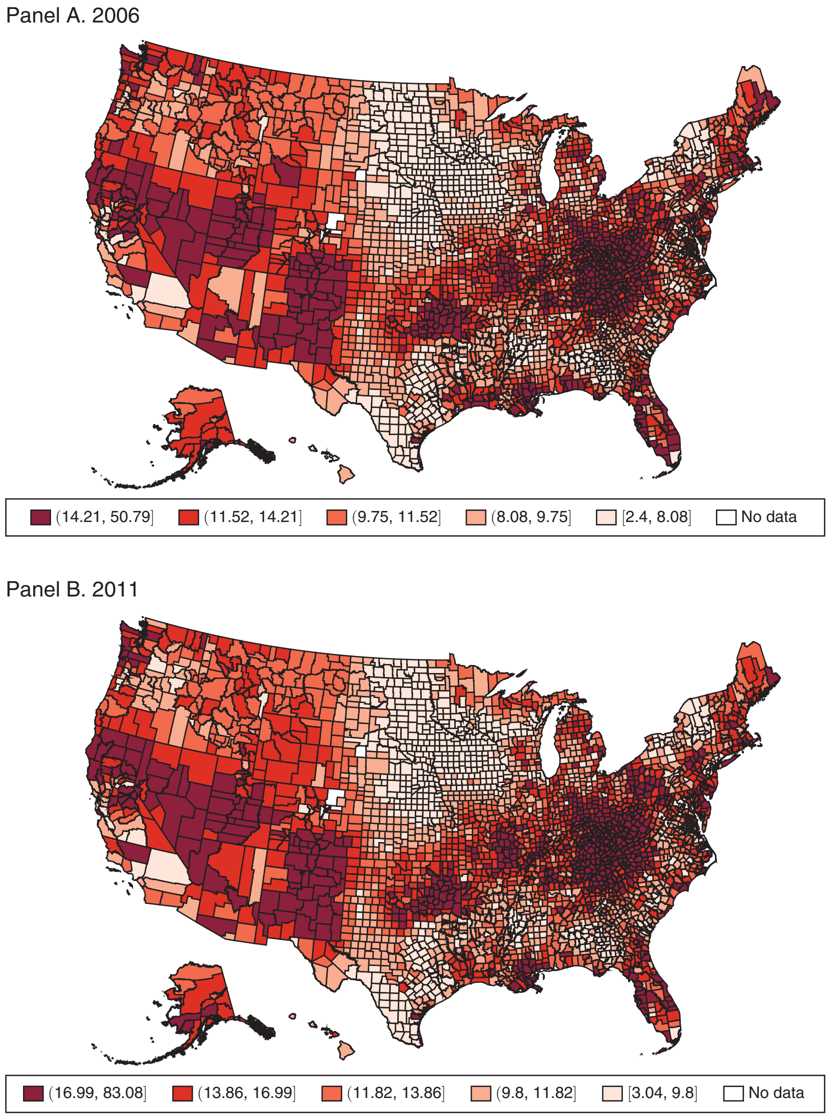

Figure 5. Estimated Crude Death Rates for Drug Poisoning by County

Notes: These maps show the quintiles of counties based on model-based crude death rates for drug poisoning per 100,000 population by county in 2006 and 2011. The darker the color, the higher the death rate is. The legend shows the range of death rates in each quintile. County-level crude death rates for drug poisoning are from National Center for Health Statistics (2021).

We evaluate the effect of competition on OxyContin dispensing using the following model:

$$Y_{it} = \beta_1 Comp_{it} + \beta_2 Comp_{it} \times Independent_i + \alpha_i + \mu_t + \epsilon_{it}, \tag{4}$$

where Y_{it} is the MED of OxyContin dispensed by pharmacy i in month t. We focus on OxyContin since the OxyContin reformulation can help us distinguish the response to the medical demand in the period after the reformulation and the response to the aggregate demand (both the medical and the nonmedical demand) in the period before the reformulation. The variable $Comp_{it}$ is the number of other pharmacies within a radius. We use different distances with the baseline level of a one-mile radius. We use $Comp_{it} \times Independent_i$ as the interaction between competition and the independent pharmacy indicator, to test whether independent pharmacies and chain pharmacies respond differently to competition; μ_t is year-month fixed effects, and α_i is pharmacy fixed effects.

We conduct the analysis both without and with pharmacy fixed effects. Without pharmacy fixed effects, we use variation within a zip code. With pharmacy fixed effects, we evaluate the effect of increased competition on a pharmacy's opioid dispensing over time. Using variation over time results in two effects. On the one hand, it simply reflects the mechanical change of lower dispensed quantity as prescriptions are divided by a larger number of pharmacies (competition effect). On the other hand, an increase in spatial competition may result in a behavioral change by pharmacies; that is, pharmacies may be more lax in dispensing opioids in response to tougher competition to compensate for their loss from the medical market (compensation effect).

Using data between 2006 and 2012, the regression with pharmacy fixed effects cannot differentiate these two effects. Therefore, we evaluate pharmacies' response in OxyContin dispensing both before and after the OxyContin reformulation. The postreformulation dispensing reflects more of the pure competition effect, as the nonmedical demand hugely declined. In comparison, the prereformulation dispensing includes both competition and compensation effects. While both analyses do not reveal a causal estimate of competition as the number of competitors within a geographical area as well as entries and exits are potentially endogenous, we argue that the result on how pharmacies respond to competition (especially the difference in response between independent and chain pharmacies) offers insights on the incentives that pharmacies face.

Table 6 shows estimates from equation (4). Panel A shows the overall competition effects, and panel B and panel C consider competition from independent pharmacies and chain pharmacies separately. In panel A, without pharmacy fixed effects, we find that higher density of pharmacies is associated with more OxyContin dispensed by independent pharmacies (at 10 percent significance level), as shown by column 2. This evidence supports our hypothesis that independent pharmacies tend to be more lenient in dispensing more opioids for nonmedical demand under greater competition pressure, as competition could lead to more unethical behavior. Compared with chain pharmacies, independent pharmacies respond to an additional competitor within a one-mile radius by increasing their dispensing of OxyContin by 0.185 MED on average. Columns 3 and 4 add pharmacy fixed effects, which estimate the effects of increased competition on each specific pharmacy's OxyContin dispensing. It is not surprising to find that competition has a negative aggregate impact on OxyContin dispensing. However, although we expect that independent pharmacies may compensate for their loss from the medical market by being more lenient in dispensing for nonmedical demand than their chain counterparts, we do not find a positive coefficient on the interaction term during the entire period in column 4.

Table 6—Regression, Competition Analysis

	OxyContin							
	Full sample				Before reformulation		After reformulation	
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
Panel A. Competition from chain and independent pharmacies								
Competition	0.138	−0.063	−1.492	−1.106	−0.609	−1.504	−0.566	−0.308
	(0.137)	(0.168)	(0.137)	(0.091)	(0.297)	(0.175)	(0.137)	(0.097)
Independent		15.275						
		(0.821)						
Competition × *Independent*		0.185		−0.611		1.546		−0.416
		(0.109)		(0.217)		(0.512)		(0.226)
Year-month fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Zip code fixed effects	Yes	Yes	No	No	No	No	No	No
Pharmacy fixed effects	No	No	Yes	Yes	Yes	Yes	Yes	Yes
Mean outcome	27.14	27.14	27.14	27.14	25.89	25.89	29.42	29.42
Observations	5,038,753	5,038,753	5,038,753	5,038,753	3,254,680	3,254,680	1,784,073	1,784,073
R^2	0.147	0.155	0.649	0.649	0.691	0.691	0.817	0.817
Panel B. Competition from independent pharmacies								
Competition	−0.245	−0.105	−1.545	−0.900	−0.628	−0.729	−0.505	−0.344
	(0.137)	(0.168)	(0.158)	(0.113)	(0.342)	(0.234)	(0.139)	(0.106)
Independent		16.154						
		(0.752)						
Competition × *Independent*		0.007		−0.972		0.162		−0.248
		(0.105)		(0.242)		(0.559)		(0.217)
Year-month fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Zip code fixed effects	Yes	Yes	No	No	No	No	No	No
Pharmacy fixed effects	No	No	Yes	Yes	Yes	Yes	Yes	Yes
Mean outcome	27.14	27.14	27.14	27.14	25.89	25.89	29.42	29.42
Observations	5,038,753	5,038,753	5,038,753	5,038,753	3,254,680	3,254,680	1,784,073	1,784,073
R^2	0.147	0.155	0.649	0.649	0.691	0.691	0.817	0.817
Panel C. Competition from chain pharmacies								
Competition	0.897	−0.048	−1.378	−1.317	−0.495	−2.210	−0.737	−0.082
	(0.303)	(0.349)	(0.279)	(0.177)	(0.447)	(0.262)	(0.301)	(0.195)
Independent		13.791						
		(0.913)						
Competition × *Independent*		0.963		−0.165		4.454		−1.608
		(0.317)		(0.650)		(1.111)		(0.691)
Year-month fixed effects	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
Zip code fixed effects	Yes	Yes	No	No	No	No	No	No
Pharmacy fixed effects	No	No	Yes	Yes	Yes	Yes	Yes	Yes
Mean outcome	27.14	27.14	27.14	27.14	25.89	25.89	29.42	29.42
Observations	5,038,753	5,038,753	5,038,753	5,038,753	3,254,680	3,254,680	1,784,073	1,784,073
R^2	0.148	0.155	0.649	0.649	0.691	0.691	0.817	0.817

Notes: Results of the competition analysis in equation (4). One observation corresponds to a pharmacy within a month. In all models we consider monthly dispensed OxyContin in MED as an outcome. In columns 1–4 we consider the full sample. In columns 5 and 6 we show results for the period before the OxyContin reformulation in mid-July 2010. In columns 7 and 8 we solely consider the period after the OxyContin reformulation. The variable *Competition* displays the coefficient β_1, the effect of an additional competitor in a one-mile radius; *Independent* displays the effect of a pharmacy being independent; *Competition* × *Independent* displays the coefficient β_2, the effect of an additional competitor in a 1-mile radius on independent pharmacies. Year-month fixed effects, zip code fixed effects, and pharmacy fixed effects indicate the use of fixed effects. We show the mean of the outcome variable. In Panel A we consider competition from chain and independent pharmacies, while panel B considers only competition of independent pharmacies and panel C considers only competition of chain pharmacies. Standard errors are clustered at the zip code level, adjusted for within-cluster correlation, and reported in parentheses.

As the OxyContin reformulation substantially decreased the nonmedical demand, we expect to see a much smaller compensation impact after the reformulation but a larger compensation impact before the reformulation among independent pharmacies. Columns 6 and 8 in Table 6 support our hypothesis. Before the reformulation, independent pharmacies suffered less from competition than chains (positive $\hat{\beta}_2$).

However, after the reformulation, the negative impact of competition was more heavily borne by independent pharmacies (negative $\hat{\beta}_2$).

When examining competition effects from independent pharmacies and chain pharmacies separately in panel B and C of Table 6, we find that our main finding, the compensation effect among independent pharmacies before the reformulation as shown in column 6, is almost solely driven by the competition from chain pharmacies. This is in line with the observed general pattern in the retail pharmacy market during 2000–2010 that independent pharmacies underwent great competitive pressure from chain pharmacies.

Our competition results are robust to different distance measures. The smaller the radius, the stronger the competition effect. In addition, the effect is stronger for more abusive opioids, such as OxyContin. Figure 6 demonstrates the effect of competition for independent pharmacies ($\hat{\beta}_2$ in equation (4)) for different distance-based competition measures before the OxyContin reformulation when controlling for pharmacy and year-month fixed effects. Considering dispensing of all opioids as well as only OxyContin, Figure 6 shows that the effect of competition for independent pharmacies relative to chain pharmacies is a decreasing function of the radius. A new competitor in geographically close areas puts strong competitive pressure on independent pharmacies, and thus leniency increases more. The relative size of the coefficients for OxyContin in Figure 6 are higher than that for all opioids, independent of the radius.

B. *The Owner of a Pharmacy*

Second, in addition to a greater incentive to dispense for nonmedical demand due to competition, one of the major differences between independent and chain pharmacies is whether a pharmacist is also the owner of a pharmacy. For chain pharmacies, pharmacists are salaried employees or employees on an hourly wage basis, so they follow corporate rules, and their compensation is mostly predetermined. However, many independent pharmacies are owned by a pharmacist, so such a pharmacist is not only working in a pharmacy but also the owner of it. Therefore, when dispensing opioids, these pharmacist owners are likely to have more discretion power and greater financial incentives to dispense more. If pharmacist ownership is an underlying factor to explain the differences in opioid dispensing for nonmedical demand, we should be able to find such a pattern within multistore independent pharmacies, because a pharmacist owner can work mostly in one store only.

If we can pinpoint which pharmacies are owned directly by a pharmacist working there, then we can compare the dispensing practices of the pharmacies with and without a pharmacist owner. However, a challenge is that it is hard to acquire such detailed information for small businesses. To provide evidence on this, we utilize an alternative approach by focusing on multistore independent pharmacies and comparing the dispensing between headquarters and nonheadquarters, with the assumption that, if a multistore pharmacy is owned by a pharmacist who still works as an active dispenser, this pharmacist owner is more likely to work in the pharmacy's headquarters. To identify headquarters, we rely on the Orbis database (Orbis 2021), a database on private companies. It has information on close to 400 million companies and entities across the globe. Its strengths include (i) comparable

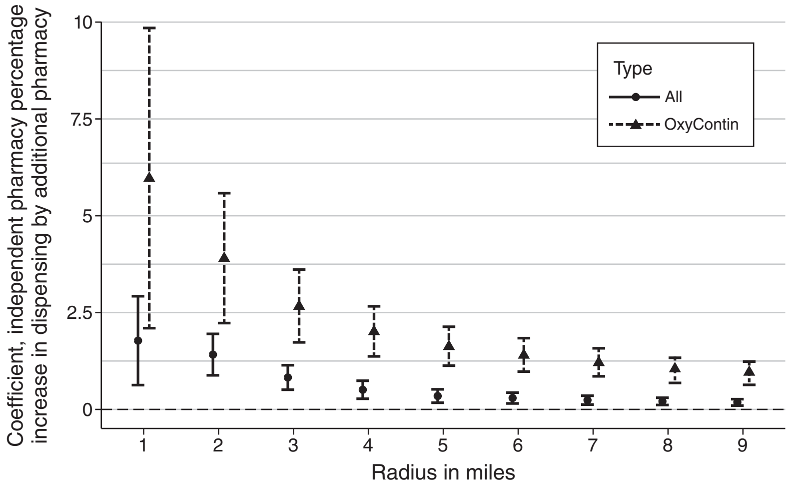

Figure 6. The Effect of Competition on Independent Pharmacies for Different Spatial Measures

Notes: The figure shows the effect of an additional competitor within a radius on an independent pharmacy's dispensing relative to a chain pharmacy before the OxyContin reformulation, divided by the average dispensing of pharmacies in the sample before reformulation. The effect is based on coefficients from a regression that estimates the effect of competition on independent pharmacies within different radii on the dispensing of (i) all opioids and (ii) OxyContin, as described by β_2 in equation (4). Each displayed coefficient corresponds to an individual regression that includes pharmacy and year-month specific fixed effects with prereformulation observations, i.e., column 6 of Table 6 panel A with different measures of competition. The error bars correspond to the 95 percent confidence intervals.

information, (ii) extensive corporate ownership structures, and (iii) a holistic view of companies. However, a weakness of the Orbis database is that it only has the latest company information as of 2021, but our ARCOS data were from 2006 to 2012. Therefore, we can only successfully find the locations of headquarters and branches for a subset of multistore independent pharmacies that are still in business.

In the ARCOS data, among the 27,974 independent pharmacy firms, 23,549 firms (84.2 percent) had only one store during the 2006–2012 period, 3,543 firms (12.7 percent) had two or three stores during the seven years, and the remaining 882 (3.2 percent) potentially had more than three stores as determined on the basis of the pharmacy name and the state identifier.[21] Among the 4,425 potential multistore independent pharmacies, we successfully found headquarters for 1,378 firms (31.1 percent).

Table 7, Figure 7, and Table 8 show the comparison between headquarters and branches when the analysis is restricted to the multistore independent pharmacies for which we successfully identify the headquarters from the Orbis database. As shown in columns 4 and 8 of Table 7, headquarters dispense 32.4 percent more

[21] We recognize the limitations of our identification of independent pharmacy firms. On the one hand, we may overestimate the number of multistore pharmacies because we use the first ten letters of pharmacy names to assign the parent company, so some independent pharmacy stores may happen to have similar names but in fact be totally independent. On the other hand, we may underestimate the number of multistore pharmacies because we define a pharmacy firm based on the pharmacy name and state combination, so a cross-state pharmacy firm may be identified as separate pharmacy firms if there is only one store in a state.

Table 7—Direct Comparison with Headquarters Found

	All				OxyContin			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
HQ	74.440	73.508	102.259	123.129	8.468	8.464	13.154	14.702
	(24.504)	(24.502)	(35.085)	(47.487)	(2.860)	(2.861)	(4.473)	(6.489)
Constant	360.246	360.502	352.638	346.921	29.944	29.945	28.656	28.232
	(13.708)	(13.708)	(9.616)	(13.014)	(1.309)	(1.308)	(1.226)	(1.778)
Year-month fixed effects	No	Yes	Yes	Yes	No	Yes	Yes	Yes
Zip code fixed effects	No	No	Yes	Yes	No	No	Yes	Yes
Firm fixed effects	No	No	No	Yes	No	No	No	Yes
Mean outcome	380.6	380.6	380.6	380.6	32.26	32.26	32.26	32.26
Mean effect in percent	19.56	19.31	26.86	32.35	26.24	26.23	40.77	45.57
Observations	280,889	280,889	280,828	280,815	280,889	280,889	280,828	280,815
R^2	0.002	0.006	0.519	0.605	0.002	0.021	0.396	0.503

Notes: The variable *HQ* represents whether a store is the headquarters of its pharmacy firm. A firm is identified using the pharmacy name-state combination. We only keep multistore independent pharmacies whose headquarters are found in the Orbis database. In columns 1–4, the outcome is monthly dispensed opioids in MED. In columns 5–8 we consider monthly dispensed OxyContin in MED as an outcome. We show the mean of the outcome variable as well as the mean effect in percent across the population, which is defined as $\hat{\beta}/\bar{y}$ where $\bar{y}$ is the mean of outcome y. Standard errors are clustered at the zip code level area, adjusted for within-cluster correlation, and reported in parentheses.

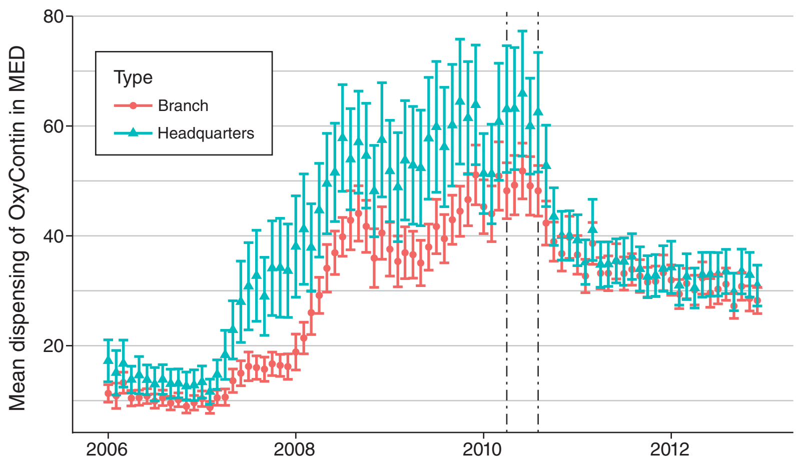

Figure 7. OxyContin Dispensing by Headquarters and Branches

Notes: This analysis includes the subset of multistore independent pharmacies that have headquarters found in the Orbis data. The first vertical line corresponds to April 2010, when the new OxyContin formulation was approved by the FDA. The second vertical line corresponds to August 2010, when the new formulation was delivered to pharmacies. The error bars correspond to the 95 percent confidence intervals.

prescription opioids and 45.6 percent more OxyContin than their branch counterparts. Figure 7 shows the dispensing of OxyContin among headquarters and branches over time. Initially, headquarters and branches dispensed similar amounts of OxyContin. Since 2007, the dispensing of OxyContin diverged between headquarters and branches, and from 2007 to August 2010, headquarters constantly

Table 8—OxyContin Reformulation with Headquarters Found

	OxyContin							
	Full sample: 2006–2012				Subsample: 2008–2012			
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
HQ × *Post*	−8.919	−8.921	−9.304	−7.602	−12.067	−11.943	−10.830	−9.304
	(2.819)	(2.812)	(3.008)	(3.151)	(4.022)	(4.020)	(4.145)	(4.076)
HQ	11.606	11.643	16.526		14.754	14.665	18.253	
	(3.501)	(3.494)	(4.870)		(4.992)	(4.991)	(6.006)	
Post	5.490				−6.298			
	(0.952)				(1.303)			
Constant	28.040				39.828			
	(1.368)				(2.060)			
Year-month fixed effects	No	Yes	Yes	Yes	No	Yes	Yes	Yes
Zip code fixed effects	No	No	Yes	No	No	No	Yes	No
Pharmacy fixed effects	No	No	No	Yes	No	No	No	Yes
Mean outcome	32.26	32.26	32.26	32.26	39.18	39.18	39.18	39.18
Mean effect in percent	−27.64	−27.65	−28.84	−23.56	−30.80	−30.48	−27.64	−23.74
Observations	280,889	280,889	280,889	280,630	202,884	202,884	202,884	202,672
R^2	0.002	0.021	0.398	0.619	0.004	0.008	0.455	0.714

Notes: The variable *HQ* represents whether a store is the headquarters of its pharmacy firm. A firm is identified using the pharmacy name-state combination. We only keep multistore independent pharmacies whose headquarters are found in the Orbis database. The dummy *Post* takes the value one for all months since August 2010, when the new OxyContin entered the market and shipment of the old OxyContin ceased. The coefficient $(\hat{\beta})$ for *HQ* × *Post* is our key parameter of interest. We show the mean of the outcome variable as well as the mean effect in percent across the population, which is defined as $\hat{\beta}/\bar{y}$ where $\bar{y}$ is the mean of outcome y. Standard errors are clustered at the zip code level area, adjusted for within-cluster correlation, and reported in parentheses.

dispensed about 20 MED more than branches. After the OxyContin reformulation, although we find reductions in OxyContin dispensing among both headquarters and branches, the decline among headquarters was much bigger than among branches. As a result, they again dispensed similar amounts of OxyContin after the reformulation. This evidence implies that both headquarters and branches of independent pharmacies dispensed OxyContin for nonmedical demand before the reformulation, but the headquarters dispensed more than their branch counterparts. Table 8 quantifies this effect by regression analysis, showing that headquarters reduced dispensing of OxyContin by 7.6 MED (23.6 percent) more than branches after the OxyContin reformulation. This evidence supports that pharmacist ownership can lead to more dispensing of prescription opioids for nonmedical demand.

Chain and independent pharmacies are also different in other aspects: (i) Compared with large chains, which may have an integrated database that covers all their locations, independent pharmacies may lack data to track patients' drug use history and thus cannot effectively identify drug abusers or drug dealers. (ii) Independent pharmacies may offer lower prices. (iii) Pharmacists in independent pharmacies may have outdated knowledge due to older age and/or may receive lower-quality on-the-job training. We discuss all these potential channels in online Appendix H. To summarize, we find little evidence that any of these differences can explain the difference in dispensing for nonmedical demand between independent and chain pharmacies.

In summary, although we are not able to investigate an exhaustive list of all possible differences between chain and independent pharmacies, we show that competitive pressure (from chains) and whether a pharmacist is an employee or owner of the pharmacy are the two likely reasons to explain why independent pharmacies dispensed more for the nonmedical demand.

VI. Conclusion

The opioid epidemic is a serious public health crisis in the United States. Although studies have documented the roles played by other suppliers, such as physicians, manufactures, and regulators, the role of retail pharmacies has not been explored in detail. In this study, we document that retail pharmacies, specifically independent pharmacies, also contribute to the opioid crisis.

The direct comparison on a granular local level indicates that independent pharmacies on average dispense 39.1 percent more MED of all prescription opioids and 60.5 percent more MED of OxyContin, one of the most popular drugs among drug abusers. Our analysis of changes in ownership further confirms that these differences are due to the pharmacy ownership, as independent pharmacies that become chains reduced dispensing in MED of all prescription opioids and OxyContin by 33.8 percent and 52.8 percent, respectively. In addition, by making use of the quasi-experiment arising from the OxyContin reformulation, which affected the nonmedical demand but not the medical market, we show that about 37.2 percent of the difference in OxyContin dispensing between independent and chain pharmacies can be explained by independent pharmacies' response to the nonmedical demand.

Although many reasons might explain why independent pharmacies are more likely to dispense for nonmedical demand, we show that competitive pressure (from chains) and whether a pharmacist is an employee or owner of the pharmacy are two likely reasons.

Given these findings, policymakers might need to reconsider the effects of competition and consolidation in the retail pharmacy industry. Chain pharmacies may have fewer incentives for drug diversion, yet their growth may spur increased pressure toward wrongdoing for the remaining independent pharmacies. To counteract this tendency, policymakers may want to consider whether there is a need to strengthen monitoring and regulation of small independent pharmacies, which are often overlooked in the larger debate over consolidation in the health care industry.

REFERENCES

Alexander, G. Caleb, Stefan P. Kruszewski, and Daniel W. Webster. 2012. "Rethinking Opioid Prescribing to Protect Patient Safety and Public Health." *JAMA* 308 (18): 1865–66.

Alpert, Abby E., William N. Evans, Ethan M.J. Lieber, and David Powell. 2022. "Origins of the Opioid Crisis and Its Enduring Impacts." *Quarterly Journal of Economics* 137 (2): 1139–79.

Alpert, Abby, Darius Lakdawalla, and Neeraj Sood. 2015. "Prescription Drug Advertising and Drug Utilization: The Role of Medicare Part D." NBER Working Paper 21714.

Alpert, Abby, David Powell, and Rosalie Liccardo Pacula. 2018. "Supply-Side Drug Policy in the Presence of Substitutes: Evidence from the Introduction of Abuse-Deterrent Opioids." *American Economic Journal: Economic Policy* 10 (4): 1–35.

Altonji, Joseph G., Todd E. Elder, and Christopher R. Taber. 2005. "Selection on Observed and Unobserved Variables: Assessing the Effectiveness of Catholic Schools." *Journal of Political Economy* 113 (1): 151–84.

Appold, Karen. 2019. "Independent Pharmacies: Not Dead Yet." *Drug Topics Report*. North Olmsted, Ohio: Drug Topics.

Athey, Susan, and Guido W. Imbens. 2022. "Design-Based Analysis in Difference-In-Differences Settings with Staggered Adoption." *Journal of Econometrics* 226 (1): 62–79.
Aungst, Timothy. 2018. "Pharmacy Wars: An Era of Acquisition, Mergers, and Losses." *Pharmacy Times*. https://www.pharmacytimes.com/view/pharmacy-wars-an-era-of-acquisition-mergers-and-losses (accessed May 9, 2022).
Ayres, Ian, and Amen Jalal. 2018. "The Impact of Prescription Drug Monitoring Programs on US Opioid Prescriptions." *Journal of Law, Medicine and Ethics* 46 (2): 387–403.
Bach, Paxton, and Daniel Hartung. 2019. "Leveraging the Role of Community Pharmacists in the Prevention, Surveillance, and Treatment of Opioid Use Disorders." *Addiction Science and Clinical Practice* 14 (1): 30.
Baker, Andrew C., David F. Larcker, and Charles C. Y. Wang. 2022. "How Much Should We Trust Staggered Difference-in-Differences Estimates?" *Journal of Financial Economics* 144 (2): 370–95.
Bennett, Victor Manuel, Lamar Pierce, Jason A Snyder, and Michael W Toffel. 2013. "Customer-Driven Misconduct: How Competition Corrupts Business Practices." *Management Science* 59 (8): 1725–42.
Berry, Patricia H., and June L. Dahl. 2000. "The New JCAHO Pain Standards: Implications for Pain Management Nurses." *Pain Management Nursing* 1 (1): 3–12.
Borusyak, Kirill, Xavier Jaravel, and Jann Spiess. 2021. "Revisiting Event Study Designs: Robust and Efficient Estimation." Unpublished.
Branco, Fernando, and J. Miguel Villas-Boas. 2015. "Competitive Vices." *Journal of Marketing Research* 52 (6): 801–16.
Buchmueller, Thomas C., and Colleen Carey. 2018. "The Effect of Prescription Drug Monitoring Programs on Opioid Utilization in Medicare." *American Economic Journal: Economic Policy* 10 (1): 77–112.
Butler, Stephen F., Theresa A. Cassidy, Howard Chilcoat, Ryan A. Black, Craig Landau, Simon H. Budman, and Paul M. Coplan. 2013. "Abuse Rates and Routes of Administration of Reformulated Extended-Release Oxycodone: Initial Findings from a Sentinel Surveillance Sample of Individuals Assessed for Substance Abuse Treatment." *Journal of Pain* 14 (4): 351–58.
Cai, Hongbin, and Qiao Liu. 2009. "Competition and Corporate Tax Avoidance: Evidence from Chinese Industrial Firms." *Economic Journal* 119 (537): 764–95.
Callaway, Brantly, and Pedro H. C. Sant'Anna. 2021. "Difference-in-Differences with Multiple Time Periods." *Journal of Econometrics* 225 (2): 200–230.
Capps, Cory, David Dranove, and Christopher Ody. 2017. "Physician Practice Consolidation Driven by Small Acquisitions, so Antitrust Agencies Have Few Tools to Intervene." *Health Affairs* 36 (9): 1556–63.
Centers for Disease Control and Prevention (CDC). 2019a. "America's Drug Overdose Epidemic: Data to Action." Centers for Disease Control and Prevention. https://www.cdc.gov/injury/features/prescription-drug-overdose/index.html (accessed May 9, 2022).
Centers for Disease Control and Prevention (CDC). 2019b. "Risks of Healthcare-Associated Infections from Drug Diversion." Centers for Disease Control and Prevention. https://www.cdc.gov/injectionsafety/drugdiversion/index.html (accessed May 9, 2022).
Centers for Disease Control and Prevention (CDC). 2020. "U.S. Opioid Prescribing Rate Maps." https://www.cdc.gov/drugoverdose/rxrate-maps/index.html (accessed July 30, 2020).
Chaffee, Betty. 2019. "Communities Are Losing Independent Pharmacies." Better My Meds. https://bettermymeds.com/2019/08/30/communities-are-losing-independent-pharmacies/ (accessed May 9, 2022).
Chen, Jihui. 2019. "The Effects of Competition on Prescription Payments in Retail Pharmacy Markets." *Southern Economic Journal* 85 (3): 865–98.
Chilcoat, Howard D., Paul M. Coplan, Venkatesh Harikrishnan, and Louis Alexander. 2016. "Decreased Diversion by Doctor-Shopping for a Reformulated Extended Release Oxycodone Product (OxyContin)." *Drug and Alcohol Dependence* 165: 221–28.
Cicero, Theodore J., Steven P. Kurtz, Hilary L. Surratt, Gladys E. Ibanez, Matthew S. Ellis, Maria A. Levi-Minzi, and James A. Inciardi. 2011. "Multiple Determinants of Specific Modes of Prescription Opioid Diversion." *Journal of Drug Issues* 41 (2): 283–304.
Cohen, Harold E. 2011. "Like a Broken Record." *U.S. Pharmacist* 36 (7): 3.
Coplan, Paul M., Howard D. Chilcoat, Stephen F. Butler, Edward M. Sellers, Aditi Kadakia, Venkatesh Harikrishnan, J. David Haddox, and Richard C. Dart. 2016. "The Effect of an Abuse-Deterrent Opioid Formulation (OxyContin) on Opioid Abuse-Related Outcomes in the Postmarketing Setting." *Clinical Pharmacology and Therapeutics* 100 (3): 275–86.
Cuellar, Alison Evans, and Paul J. Gertler. 2006. "Strategic Integration of Hospitals and Physicians." *Journal of Health Economics* 25 (1): 1–28.

Dafny, Leemore. 2009. "Estimation and Identification of Merger Effects: An Application to Hospital Mergers." *Journal of Law and Economics* 52 (3): 523–50.

Dafny, Leemore, Mark Duggan, and Subramaniam Ramanarayanan. 2012. "Paying a Premium on your Premium? Consolidation in the US Health Insurance Industry." *American Economic Review* 102 (2): 1161–85.

Dafny, Leemore, Kate Ho, and Robin S. Lee. 2019. "The Price Effects of Cross-Market Mergers: Theory and Evidence from the Hospital Industry." *RAND Journal of Economics* 50 (2): 286–325.

Dart, Richard C., Hilary L. Surratt, Theodore J. Cicero, Mark W. Parrino, S. Geoff Severtson, Becki Bucher-Bartelson, and Jody L. Green. 2015. "Trends in Opioid Analgesic Abuse and Mortality in the United States." *New England Journal of Medicine* 372 (3): 241–48.

De Chaisemartin, Clément, and Xavier d'Haultfoeuille. 2020. "Two-Way Fixed Effects Estimators with Heterogeneous Treatment Effects." *American Economic Review* 110 (9): 2964–96.

Dewatripont, Mathias, and Jean Tirole. 2019. "Incentives and Ethics: How Markets and Organizations Shape Our Moral Behavior." Unpublished.

Drug Enforcement Administration (DEA). 2005. "Title 21 Code of Federal Regulations: Purpose of Issue of Prescription." Drug Enforcement Administration. https://www.deadiversion.usdoj.gov/21cfr/cfr/1306/1306_04.htm (accessed August 12, 2020).

Drug Enforcement Administration (DEA). 2010. *Pharmacist's Manual: An Informational Outline of the Controlled Substances Act.* Washington, DC: Drug Enforcement Adminsitration.

Drugs.com. n.d. "Top 200 Prescribed Drugs by Sales in 2010." Drugs.com. https://www.drugs.com/top200.html (accessed March 31, 2022.).

Eliason, Paul J., Benjamin Heebsh, Ryan C. McDevitt, and James W. Roberts. 2020. "How Acquisitions Affect Firm Behavior and Performance: Evidence from the Dialysis Industry." *Quarterly Journal of Economics* 135 (1): 221–67.

Evans, William N., Ethan M. J. Lieber, and Patrick Power. 2019. "How the Reformulation of OxyContin Ignited the Heroin Epidemic." *Review of Economics and Statistics* 101 (1): 1–15.

Fein, Adam. 2011a. *2010-2011 Chain Pharmacy Industry Profile*. North Olmsted, OH: Drug Channels Institute Report.

Fein, Adam. 2011b. *The Pharmacy Industry's Evolution: 2000 to 2010*. North Olmsted, OH: Drug Channels Institute Report.

Fein, Adam. 2019. *The State of Retail Pharmacy: Independent Pharmacy Economics Stabilize—But Dropping, Owner Salaries Are*. North Olmsted, OH: Drug Channels Institute Report.

Gaynor, Martin, Kate Ho, and Robert J. Town. 2015. "The Industrial Organization of Health-Care Markets." *Journal of Economic Literature* 53 (2): 235–84.

Gaynor, Martin, and Robert J. Town. 2011. "Competition in Health Care Markets." In *Handbook of Health Economics*, Vol. 2, edited by Mark V. Pauly, Thomas G. McGuire, and Pedro P. Barros, 499–637. Amsterdam: Elsevier.

Gellad, Walid F., Niteesh K. Choudhry, Mark W. Friedberg, M. Alan Brookhart, Jennifer S. Haas, and William H. Shrank. 2009. "Variation in Drug Prices at Pharmacies: Are Prices Higher in Poorer Areas?" *Health Services Research* 44 (2p1): 606–17.

Goodman-Bacon, Andrew. 2021. "Difference-in-Differences with Variation in Treatment Timing." *Journal of Econometrics* 225 (2): 254–77.

Gowrisankaran, Gautam, Aviv Nevo, and Robert Town. 2015. "Mergers When Prices Are Negotiated: Evidence from the Hospital Industry." *American Economic Review* 105 (1): 172–203.

Grecu, Anca M., Dhaval M. Dave, and Henry Saffer. 2019. "Mandatory Access Prescription Drug Monitoring Programs and Prescription Drug Abuse." *Journal of Policy Analysis and Management* 38 (1): 181–209.

Habte, Osmis Areda, and Hakan J. Holm. 2022. "Competition Makes Inspectors More Lenient: Evidence from the Motor Vehicle Inspection Market." *Review of Industrial Organization* 61: 45–72.

Hadland, Scott E., Ariadne Rivera-Aguirre, Brandon D. L. Marshall, and Magdalena Cerdá. 2019. "Association of Pharmaceutical Industry Marketing of Opioid Products with Mortality from Opioid-Related Overdoses." *JAMA Network Open* 2 (1): e186007.

Haffajee, Rebecca L., and Michelle M. Mello. 2017. "Drug Companies' Liability for the Opioid Epidemic." *New England Journal of Medicine* 377 (24): 2301–2305.

Hagemeier, Nicholas E., Jeffrey A. Gray, and Robert P. Pack. 2013. "Prescription Drug Abuse: A Comparison of Prescriber and Pharmacist Perspectives." *Substance Use and Misuse* 48 (9): 761–68.

Hartung, Daniel M., Jennifer Hall, Sarah N. Haverly, David Cameron, Lindsey Alley, Christi Hildebran, Nicole O'Kane, and Deborah Cohen. 2018. "Pharmacists' Role in Opioid Safety: A Focus Group Investigation." *Pain Medicine* 19 (9): 1799–1806.

Havens, Jennifer R., Carl G. Leukefeld, Angela M. DeVeaugh-Geiss, Paul Coplan, and Howard D. Chilcoat. 2014. "The Impact of a Reformulation of Extended-Release Oxycodone Designed to Deter Abuse in a Sample of Prescription Opioid Abusers." *Drug and Alcohol Dependence* 139: 9–17.

Inciardi, James A., Hilary L. Surratt, Steven P. Kurtz, and Theodore J. Cicero. 2007. "Mechanisms of Prescription Drug Diversion among Drug-Involved Club- and Street-Based Populations." *Pain Medicine* 8 (2): 171–83.

Janssen, Aljoscha, and Xuan Zhang. 2023. "Replication Data for: Retail Pharmacies and Drug Diversion during the Opioid Epidemic." American Economic Association [publisher], Inter-university Consortium for Political and Social Research [distributor]. https://doi.org/10.3886/E170881V1.

Jones, Tim. 2019. "Preferred vs. Standard: Picking the Cost-Share Networks That Fit Your Pharmacy." *AmerisourceBergen*, September 24. https://www.amerisourcebergen.com/insights/pharmacies/picking-the-cost-share-networks-that-fit-your-pharmacy.

Kalso, Eija. 2005. "Oxycodone." *Journal of Pain and Symptom Management* 29 (5): 47–56.

Larochelle, Marc R., Fang Zhang, Dennis Ross-Degnan, and J. Frank Wharam. 2015. "Rates of Opioid Dispensing and Overdose after Introduction of Abuse-Deterrent Extended-Release Oxycodone and Withdrawal of Propoxyphene." *JAMA Internal Medicine* 175 (6): 978–87.

Luo, Jing, Martin Kulldorff, J. D. Ameet Sarpatwari, Ajinkya Pawar, and Aaron S. Kesselheim. 2019. "Variation in Prescription Drug Prices by Retail Pharmacy Type." *Annals of Internal Medicine* 171 (9): 605–11.

Maclean, Johanna Catherine, Justine Mallatt, Christopher J. Ruhm, and Kosali Simon. 2020. "Review of Economic Studies on the Opioid Crisis." NBER Working Paper 28067.

Mastropietro, David J., and Hossein Omidian. 2015. "Abuse-Deterrent Formulations: Part 2: Commercial Products and Proprietary Technologies." *Expert Opinion on Pharmacotherapy* 16 (3): 305–23.

Meinhofer, Angelica. 2016. "The War on Drugs: Estimating the Effect of Prescription Drug Supply-Side Interventions." SSRN 2716974.

Meinhofer, Angelica. 2018. "Prescription Drug Monitoring Programs: The Role of Asymmetric Information on Drug Availability and Abuse." *American Journal of Health Economics* 4 (4): 504–26.

National Center for Health Statistics. 2021. "NCHS - Drug Poisoning Mortality by County: United States." National Center for Health Statistics. https://data.cdc.gov/d/rpvx-m2md (accessed May 28, 2021).

Nguyen, Thuy, W. David Bradford, and Kosali Simon. 2019. "How Do Opioid Prescribing Restrictions Affect Pharmaceutical Promotion? Lessons from the Mandatory Access Prescription Drug Monitoring Programs." NBER Working Paper 26356.

Okie, Susan. 2010. "A Flood of Opioids, a Rising Tide of Deaths." *New England Journal of Medicine* 363 (21): 1981–85.

Orbis. 2021. "Orbis." Bureau Van Dijk Database. https://www.bvdinfo.com/en-gb/our-products/data/international/orbis (accessed June 21, 2021).

Oster, Emily. 2019. "Unobservable Selection and Coefficient Stability: Theory and Evidence." *Journal of Business and Economic Statistics* 37 (2): 187–204.

Pacula, Rosalie Liccardo, and David Powell. 2018. "A Supply-Side Perspective on the Opioid Crisis." *Journal of Policy Analysis and Management* 37 (2): 438–46.

Paulozzi, Leonard J., Karin A. Mack, and Jason M. Hockenberry. 2014. "Vital Signs: Variation among States in Prescribing of Opioid Pain Relievers and Benzodiazepines—United States, 2012." *MMWR: Morbidity and Mortality Weekly Report* 63 (26): 563–68.

Peirce, Gretchen L., Michael J. Smith, Marie A. Abate, and Joel Halverson. 2012. "Doctor and Pharmacy Shopping for Controlled Substances." *Medical Care* 50 (6): 494–500.

Powell, David, and Rosalie Liccardo Pacula. 2021. "The Evolving Consequences of Oxycontin Reformulation on Drug Overdoses." *American Journal of Health Economics* 7 (1): 41–67.

Powell, David, Rosalie Liccardo Pacula, and Erin Taylor. 2020. "How Increasing Medical Access to Opioids Contributes to the Opioid Epidemic: Evidence from Medicare Part D." *Journal of Health Economics* 71: 102286.

Quinones, Sam. 2015. *Dreamland: The True Tale of America's Opiate Epidemic.* New York: Bloomsbury Publishing.

Rich, Steven, María Sánchez Díez, and Kanyakrit Vongkiatkajorn. 2019. "How to Download and Use the DEA Pain Pills Database." *Washington Post.* https://www.washingtonpost.com/national/2019/07/18/how-download-use-dea-pain-pills-database/.

Rigg, Khary K., Samantha J. March, and James A. Inciardi. 2010. "Prescription Drug Abuse & Diversion: Role of the Pain Clinic." *Journal of Drug Issues* 40 (3): 681–702.

Schnell, Molly. 2017. "Physician Behavior in the Presence of a Secondary Market: The Case of Prescription Opioids." Unpublished.

Schnell, Molly. 2019. *The Opioid Crisis: Tragedy, Treatments and Trade-Offs*. Stanford, CA: Stanford Institute for Economic Policy Research.

Schnell, Molly, and Janet Currie. 2018. "Addressing the Opioid Epidemic: Is There a Role for Physician Education?" *American Journal of Health Economics* 4 (3): 383–410.

Sessler, Nelson E., Jerod M. Downing, Hrishikesh Kale, Howard D. Chilcoat, Todd F. Baumgartner, and Paul M. Coplan. 2014. "Reductions in Reported Deaths Following the Introduction of Extended-Release Oxycodone (OxyContin) with an Abuse-Deterrent Formulation." *Pharmacoepidemiology and Drug Safety* 23 (12): 1238–46.

Severtson, Stevan Geoffrey, Becki Bucher Bartelson, Jonathan M. Davis, Alvaro Muñoz, Michael F. Schneider, Howard Chilcoat, Paul M. Coplan, Hilary Surratt, and Richard C. Dart. 2013. "Reduced Abuse, Therapeutic Errors, and Diversion Following Reformulation of Extended-Release Oxycodone in 2010." *Journal of Pain* 14 (10): 1122–30.

Shleifer, Andrei. 2004. "Does Competition Destroy Ethical Behavior?" *American Economic Review* 94 (2): 414–18.

Simeone, Ronald. 2017. "Doctor Shopping Behavior and the Diversion of Prescription Opioids." *Substance Abuse: Research and Treatment* 11: 1178221817696077.

Simon, Lee S. 2012. "Relieving Pain in America: A Blueprint for Transforming Prevention, Care, Education, and Research." *Journal of Pain and Palliative Care Pharmacotherapy* 26 (2): 197–98.

Snyder, Jason. 2010. "Gaming the Liver Transplant Market." *Journal of Law, Economics, and Organization* 26 (3): 546–68.

Soffin, Ellen M., Seth A. Waldman, Roberta J. Stack, and Gregory A. Liguori. 2017. "An Evidence-Based Approach to the Prescription Opioid Epidemic in Orthopedic Surgery." *Anesthesia and Analgesia* 125 (5): 1704–13.

Starc, Amanda, and Ashley Swanson. 2018. "Preferred Pharmacy Networks and Drug Costs." NBER Working Paper 24862.

Substance Abuse and Mental Health Services Administration (SAMHSA). 2012. "Key Definitions for the 2011 Mental Health Detailed Tables and Mental Health Findings Report." https://www.samhsa.gov/data/sites/default/files/2011MHFDT/2k11MHFDT/HTML/NSDUH-MHDetTabsGlossary2011.htm (accessed November 18, 2021).

Substance Abuse and Mental Health Services Administration (SAMHSA). 2013. *Association of Nonmedical Pain Reliever Use and Initiation of Heroin Use in the United States*. Rockville, MD: Substance Abuse and Mental Health Services Administration.

Substance Abuse and Mental Health Services Administration (SAMHSA). 2018. *Key Substance Use and Mental Health Indicators in the United States: Results from the 2017 National Survey on Drug Use and Health*. Rockville, MD: Substance Abuse and Mental Health Services Administration.

US Census Bureau. 2018. "Annual Retail Trade Survey: 2016." US Census Bureau. https://www.census.gov/data/tables/2016/econ/arts/annual-report.html (accessed May 9, 2022).

US House, Subcommittee on Antitrust, Commercial and Administrative Law of the Committee on the Judiciary. 2020. *Investigation of Competition in Digital Markets*. Washington, DC: Subcommittee on Antitrust, Commercial and Administrative Law of the Committee on the Judiciary.

Van Zee, Art. 2009. "The Promotion and Marketing of OxyContin: Commercial Triumph, Public Health Tragedy." *American Journal of Public Health* 99 (2): 221–27.

Watkins, Emmeline A., Peter C. Wollan, L. Joseph Melton III, and Barbara P. Yawn. 2008. "A Population in Pain: Report from the Olmsted County Health Study." *Pain Medicine* 9 (2): 166–74.

Yang, Zhuo, Barth Wilsey, Michele Bohm, Meghan Weyrich, Kakoli Roy, Dominique Ritley, Christopher Jones, and Joy Melnikow. 2015. "Defining Risk of Prescription Opioid Overdose: Pharmacy Shopping and Overlapping Prescriptions among Long-Term Opioid Users in Medicaid." *Journal of Pain* 16 (5): 445–53.

Zhang, Shiyu, and Daniel Guth. 2021. "The OxyContin Reformulation Revisited: New Evidence from Improved Definitions of Markets and Substitutes." Unpublished.

Zhu, PengCheng, and Peter E. Hilsenrath. 2015. "Mergers and Acquisitions in US Retail Pharmacy." *Journal of Health Care Finance* 41 (3): 1–20.