Barbarian or Vanguard? : Private Equity Buyout and Physician Opioid Prescription

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Abstract

This paper studies how private equity (PE) buyouts of physician groups affect physicians' opioid prescribing behaviour. Using a difference-in-differences approach, we find that physicians in PE-owned physician groups decrease their opioid prescription rates after the buyout. We further identify regulatory and litigation risks as the primary mechanism: the reduction is more pronounced in states that adopt more stringent opioid monitoring programs and after a key False Claims Act precedent increased litigation risk for PE-backed healthcare investments. Moreover, we document heterogeneous responses across PE firms: PE firms with fewer financial constraints and stronger corporate social responsibility (CSR) preferences are associated with larger reductions in opioid prescribing intensity.

Keywords: Opioid prescribing; Private equity; Physician groups; Regulatory risk; Healthcare ownership

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1 Introduction

Private equity (PE) investment in the U.S. healthcare sector increased almost three times from $41.5 billion in 2010 to $119.9 billion in 2019, and this upward trend is expected to continue (Scheffler, Alexander, and Godwin, 2021). PE firms have been actively acquiring a wide range of healthcare providers, including hospitals, nursing homes and emergency centers.[1] More recently, they have shown growing interest in physician-owned group practices (hereafter, "physician groups"), which constitute 54% of U.S. patient care physicians in 2018 (American Medical Association, 2021). PE buyout deals of physician groups have increased more than six-fold from 2012 to 2021 (Scheffler et al., 2021), and policymakers have voiced considerable concerns about the implications of PE ownership in healthcare.[2] However, evidence to inform the ongoing policy debate is quite scarce and inconclusive.

While literature has generally agreed that PE increases shareholder value of target firms (e.g., Kaplan, 1989; Boucly, Sraer, and Thesmar, 2011), its effects on other stakeholders, especially regarding public interest, are mixed.[3] In this study, we focus on the effect of PE buyouts on physician opioid prescriptions, which caused a major "public health crisis" in the United States. According to the Centers for Disease Control and Prevention (CDC), there were almost 69,000 opioid-involved deaths in 2020, with the opioid-involved death rate increasing by 38% from 2019 to 2020 (CDC, 2021). The prescribing behavior of physicians has been identified as a major driver of the opioid epidemic (CDC, 2013), making the influence of new

[1] See: Gretchen Morgenson and Emmanuelle Saliba, "Private equity firms now control many hospitals, ERs and nursing homes. Is it good for health care? ", NBC News, May 13, 2020, https://www.nbcnews.com/health/health-care/private-equity-firms-now-control-many-hospitals-ers-nursing-homes-n1203161

[2] See: Andrew Forman, "The Importance of Vigorous Antitrust Enforcement in Health Care", U.S. Department of Justice, June 3, 2022, https://www.justice.gov/opa/speech/deputy-assistant-attorney-general-andrew-forman-delivers-keynote-abas-antitrust ; Leah Nylen and Todd Shields, "US Is Focused on Regulating Private Equity Like Never Before," Bloomberg, November 22, 2022, https://www.bloomberg.com/news/articles/2022-11-22/private-equity-regulation-becomes-biden-administration-focus

[3] For example, previous research finds that PE ownership improves food safety (Bernstein and Sheen, 2016), but lowers quality in supermarkets (Matsa, 2011), See Bernstein (2022) for a comprehensive review.

corporate owners a matter of significant public interest. Survey evidence suggests that PE owners are often actively involved in the management of acquired physician practices after acquisition, which introduces a sharp and theoretically ambiguous conflict between the pursuit of profit and the management of risk.[4]

On one hand, the profit-maximizing incentives of PE firms may push acquired physician groups to increase revenues by expanding patient volume and reimbursable services. Prior studies show that PE-acquired practices tend to increase both prices and patient volume (Singh et al., 2022; Braun et al., 2021; Scheffler et al., 2023). Patient volume matters as clinics under financial pressure have been found to have gross overtreatment of patients (Heath, Greenblatt, and Bagchi, 2020), especially PE-acquired practices (O'Grady, 2021). This volume-based incentive may also affect prescribing decisions. Unlike physician-administered drugs under the "buy-and-bill" system, prescription opioids are generally dispensed by retail or outpatient pharmacies, so physician groups typically do not earn direct drug markups or administration fees from opioid prescriptions. However, opioid prescribing may still be financially attractive: it can help retain patients seeking immediate pain relief, generate repeat visits for monitoring and refills, increase patient satisfaction, and substitute for more time-intensive non-opioid pain management. Currie et al. (2023) similarly argue that physicians facing stronger competition may prescribe controlled substances to attract and retain marginal patients. Recent U.S. telehealth cases also illustrate how volume- or subscription-based revenue models can distort controlled-substance prescribing incentives.[5] Given these

[4] National Opinion Research Center surveyed around 1,000 physicians and found that nearly 60% of physicians reported reduced autonomy after PE acquisitions.

[5] A stark illustration is the 2025 Done Global case, in which a telehealth platform prescribing Adderall (a Schedule II stimulant with addiction profiles comparable to certain opioids) was convicted of a $100 million fraud scheme. Prosecutors alleged that its business model financially rewarded high-volume, repeat prescribing and relied on the drug's addictive properties to drive recurring patient visits. See the U.S. Department of Justice press release for more details: https://www.justice.gov/opa/pr/founderceo-and-clinical-president-digital-health-company-convicted-100m-adderall?

incentives, PE-owned physician groups may have greater incentives to tolerate or encourage liberal opioid prescribing insofar as it helps sustain patient volume and revenue.[6]

On the other hand, increasing opioid prescriptions may heighten exposure to legal and regulatory risks, particularly as states are increasingly adopting more stringent regulations in response to the opioid crisis, which could entail punitive consequences for healthcare providers and their owner (Haffajee, Jena, and Weiner, 2015). Physician groups face growing opioid litigation risk in recent years.[7] Anecdotal evidence shows that these lawsuits could impose substantial financial and reputational costs for investors of PE firms.[8] Therefore, from a risk management perspective, PE firms are arguably better equipped than independent practices to decrease opioid usage, either by instilling stronger monitoring and management practices (Bloom, Sadun, and Van Reenen 2015) or by actively engaging in acquired firms' compliance to mitigate its corporate social responsibility (CSR) and environmental, social, and governance (ESG) risks (Amel-Zadeh and Serafeim, 2018). Given the tension between these competing incentives, the net effect of PE buyouts on physician opioid prescriptions is inconclusive.

The paper studies the effect of PE buyouts on physician opioid prescriptions in acquired groups. Using a difference-in-differences (DID) approach, we find that PE buyouts of physician groups are associated with a statistically significant reduction in opioid prescription intensity. Following the buyout, physicians in the PE-acquired groups significantly decreased

[6] In our Medicare Part D sample, opioid prescriptions account for 21% of total drug spending associated with prescriptions written by the average physician group, suggesting that opioid prescribing is a quantitatively important part of these groups' prescribing portfolios.

[7] See "Opioid Litigation Landslide – Are Physicians And Hospitals The Next Targets?", https://www.dickinson-wright.com/news-alerts/opioid-litigation-landslide; and "'It was a conspiracy': recovering addicts wage legal battle over prescription use", https://www.theguardian.com/us-news/2016/aug/28/opioid-addiction-west-virginia-lawsuit

[8] For example, a private equity firm was fined for overlooking fraudulent practices, despite knowing the misconduct. See "*Private Equity Firm and Former Mental Health Center Executives Pay $25 Million Over Alleged False Claims Submitted for Unlicensed and Unsupervised Patient Care*", Office of the Massachusetts Attorney General (Oct. 14, 2021), https://www.mass.gov/news/private-equity-firm-and-former-mental-health-center-executives-pay-25-million-over-alleged-false-claims-submitted-for-unlicensed-and-unsupervised-patient-care

their opioid prescription rate by 0.9 percentage points, which accounts for 9% of the average opioid prescription rate in our sample. The effect is robust to alternative measures of opioid prescribing intensity, a subsample of general medical specialties, alternative staggered-DID estimators, and matched-sample specifications. We also find no evidence of differential pre-trends, and the effect grows over time after the buyout.

We conduct several tests to address identification and selection concerns. First, we show that PE firms' acquisition decisions are not predicted by pre-buyout levels or trends in group-level opioid prescribing intensity. Second, to address concerns that PE acquisitions may change patient composition rather than physician prescribing behavior, we examine prescriber-year aggregate patient-composition measures from Medicare Part D, including average risk score, gender composition, race and ethnicity shares, and average beneficiary age. We find little evidence that PE acquisition changes observable patient complexity or demographic composition. Third, we conduct placebo tests using commonly prescribed hypertension and diabetes medications and find no evidence of changes in these chronic-disease medication prescribing rates. These tests cannot fully rule out pain-specific patient selection, but they mitigate the concern that our findings are driven by broad changes in patient case mix, chronic disease burden, or general prescribing patterns. As a complementary analysis, we also report IV estimates in the appendix using state-level variation in Corporate Practice of Medicine (CPOM) Doctrine, which prohibits PE firms from directly owning physician practices, following Liu (2021). The IV estimates are directionally consistent with the baseline results. We then examine why PE ownership reduces opioid prescribing intensity despite incentives to expand volume. We argue that opioids are distinct from many other services in outpatient care. Their financial benefits to physician groups are largely indirect, through patient retention and follow-up visits, whereas their regulatory, litigation, and reputational risks are substantial. Moreover, compared with physician owners, PE firms tend to have stronger compliance

incentives and superior capacity for legal compliance, given their centralized governance structures, reputational concerns, and professionalized management teams. These features may make them especially responsive to compliance-related shocks. We test this mechanism by studying two quasi-exogenous shocks: (1) state-level policy changes that strengthen the monitoring of physician opioid prescriptions, and (2) the first major legal settlement under the False Claims Act (FCA) involving a PE-owned healthcare provider. We find that PE-acquired physicians reduce their opioid prescribing intensity more significantly in response to both events. These results suggest that appropriate regulations and legal enforcement can incentivize compliance-oriented behaviour of PE firms, highlighting the crucial role of external governance in shaping the real effects of PE buyouts.

The degree to which a PE firm responds to regulatory risk, however, depends on its characteristics. First, we consider the role of financial constraints. While our baseline results show an overall reduction in opioid prescribing intensity following PE buyouts, the magnitude of this decline may vary depending on the financial condition of the acquiring PE firm. Profit-driven PE firms with more financial constraints may have stronger incentives to increase patient encounter volume, potentially by encouraging affiliated physicians to overprescribe opioids. In contrast, PE firms with fewer financial constraints may face less pressure to boost patient volume, invest more in monitoring systems, and enforce stricter prescribing protocols. This trade-off reflects a broader tension between regulatory risk and profit-maximizing motives, as firms with greater financial flexibility may be more inclined to internalize potential compliance costs and reputational risks. To empirically test this, we construct three proxies for financial constraints at the PE-firm level: listing status (public vs. private), fund age and size, and capital raised in the most recent fundraising round. We find that PE firms with fewer financial constraints, or in other words with more financial resources, are associated with a significantly greater reduction in opioid prescription intensity after the buyout.

Second, we explore whether social responsibility plays a role in this effect. Prior research finds socially responsible investors are more likely to improve the CSR score of the target firm (Hwang, Titman and Wang, 2022). Consistent with this view, we classify PE firms based on their CSR scores and responsible investment engagement and examine whether such differences affect post-acquisition prescribing behavior of their acquired physicians. Our results show that more socially responsible private equity funds take a more active role in reducing opioid prescription intensity. Buyouts from more socially responsible private equity funds could reduce physicians' opioid prescription intensity by additional 1.3 percentage points.

To further validate our interpretation and rule out confounding explanations, we test whether the observed effect is limited to opioid prescriptions or whether it extends to other types of addictive drugs. If our findings are indeed driven by a shift in prescribing patterns or compliance behavior due to ownership structure changes, we should observe a similar reduction in other addictive drugs. We test antipsychotic drugs, which are also prone to abuse and are often used inappropriately for off-label purposes. We find that physicians acquired by PE firms also decreased their antipsychotic drug prescription rate by 0.2%, which accounts for 9.5% of the average prescription rate. This result suggests that the impact of PE ownership is not confined to opioids alone, but may reflect a broader shift in treatment practices or risk management strategies following acquisition.

The paper contributes to several bodies of literature. First, the paper contributes to the broader debate on the real effects of PE buyout. While Kaplan and Strömberg (2009) highlight how PE ownership increases shareholder value through financial, governance and operational engineering, the literature remains inconclusive on whether these gains come at the expense of other stakeholders. Empirical evidence on the real impact of PE buyout on target firms in

various sectors is mixed.[9] We contribute to the debate on the real effects of PE buyouts by focusing on the healthcare industry, a sector with strong information asymmetry (Arrow, 1963). We complement and extend recent studies on PE in the hospital sector (e.g., Liu, 2021; Gao et al., 2025) and the nursing home sector (e.g., Gandhi, Song, and Upadrashta, 2020; Gupta et al., 2021). First, we shift the focus from inpatient settings to outpatient physician practices. Inpatient facilities such as hospitals predominantly adopt bundled payment models (e.g. Medicare's Diagnosis-Related Groups), which would logically focus more on operational efficiency and cost control. In contrast, outpatient practices operate primarily under a fee-for-service model that rewards service volume. This context uncovers a paradox: why would a profit-maximizing PE firm reduce a patient-retaining prescribing practice that may help sustain patient volume and follow-up encounters? [10] We resolve this paradox by identifying a distinct and complementary mechanism through which PE ownership influences healthcare: regulatory compliance and risk mitigation. Whereas the existing literature emphasizes PE's role in driving operational efficiency and cost reduction, we demonstrate that PE firms are highly responsive to external legal and regulatory pressures using two quasi-exogenous shocks. Moreover, the outpatient opioid prescribing also provides a perfect setting to study this channel due to the intense and targeted regulatory scrutiny and catastrophic legal liability associated with this specific clinical act compared to inpatient care[11]. Our finding suggests that the impact of PE is not monolithic; in specific, high-stakes contexts, the imperative to manage legal and

[9] See Bernstein (2022) for a comprehensive review.

[10] Under a bundled payment model, such as Medicare's Diagnosis-Related Groups (DRGs), a provider receives a single, pre-determined payment for all services related to a patient's episode of care, regardless of the actual costs incurred. This creates a strong incentive to manage resources efficiently. Under a fee-for-service (FFS) model, providers are paid for each individual service, test, or procedure they perform. This model incentivizes the quantity of services delivered, as revenue is directly tied to the volume of billable activities.

[11] The influential 2022 CDC guidelines for prescribing opioids, for example, provide detailed recommendations for outpatients but explicitly state they do not apply to hospitalized patients which has been described as a "black box" (Herzig, 2016).

reputational risks can override the PE's incentive to maximize revenue.[12] Last but not least, while previous studies focus on patient outcomes such as mortality and readmission rates, this study investigates opioid prescribing, which is not only related to patient health but also generates large societal externalities.

Second, the paper adds to the growing body of research on the opioid epidemic, particularly from the perspective of supply-side dynamics. While Dasgupta, Beletsky, and Ciccarone (2018) provide a comprehensive review of the social and economic determinants of opioid overdosage, most prior work focuses on specific supply chain actors such as physicians (Schnell, 2017; Schnell and Currie, 2018), insurance plans (Baker, Bundorf, and Kessler, 2020; Powell, Pacula, and Taylor, 2020), retail pharmacies (Janssen and Zhang, 2023), manufacturers (Hadland, Krieger, and Marshall, 2017, Alpert et al. 2022), and regulators (Buchmueller and Carey, 2018). We provide new evidence on the role of ultimate ownership of medical providers in provision of opioid drugs. Specifically, we show how PE firms as financial owners influence opioid supply through their managerial practices and strategic objectives. This ownership-level perspective is critical yet underexplored in the context of the opioid crisis.

As physician prescription behaviour is the main driver of opioid epidemic, our work is also broadly linked to the literature on physician-induced demand. Previous literature has explored this topic by studying how physician treatment decisions respond to changes in insurance reimbursement policy (e.g., Dafny, 2005; Fang and Gong, 2017) and external financial shocks to hospitals (Adelino, Lewellen and McCartney, 2022). By focusing on changes in ownership structure, we provide new insight into how organizational and financial

[12] The simpler governance structure of physician groups also offers a more direct lens into how ownership incentives impact physician-level decisions, an attribution that is notoriously difficult in complex inpatient settings. Inpatient facilities like hospitals have complex, multi-layered governance structures with various stakeholders. Decisions are influenced by hospital administrators, boards of directors, chiefs of various clinical departments (e.g., surgery, medicine, radiology), nursing leadership, and etc, which make it "noisy" and difficult to attribute specific outcomes to any single decision-maker or to a change in ownership.

incentives shape physician decisions beyond traditional regulatory or reimbursement levers. In particular, our findings suggest that financial intermediaries such as PE firms can amplify or dampen demand-inducing behavior, depending on their strategic priorities and constraints.

The remainder of the paper is structured as follows. Section 2 provides institutional background. Section 3 describes the data and methodology. Section 4 presents our main results on the effects of PE buyouts. Section 5 explores the mechanisms through which PE buyouts affect opioid prescriptions. Section 6 gives some further discussions. Finally, section 7 concludes.

2 Institutional Background

2.1 PE Buyout of Physician Groups

Physician groups are organizations composed of one or more physicians working together to provide medical services. Depending on the type of medical care they provide, physician groups can be categorized as single- or multi-specialty groups. Single-specialty groups typically provide care in one domain, like dermatology or gastroenterology. Multi-speciality groups usually constitute physicians from different disciplines and offer a range of healthcare services under one organizational umbrella. Physician groups are a cornerstone of outpatient care in the U.S., offering convenience, continuity, and specialization that meet diverse community health needs. According to the American Medical Association (AMA) survey, approximately 54% of U.S. patient care physicians worked in physician groups as of 2018 (American Medical Association, 2021), underscoring their significance in the healthcare delivery system.

Regarding ownership, physician groups may be owned and managed by individual physicians, partnerships among physicians, hospitals, or corporate entities, including private

equity firms. In recent years, PE investment in physician groups has surged, with the number of PE buyout deals increasing more than six-fold from 2012 to 2021 (Scheffler et al., 2021). PE firms are attracted by the opportunity to consolidate fragmented medical practices, drive operational efficiencies, and generate high returns through financial engineering, standardization, and revenue optimization strategies.

However, PE acquisitions in healthcare must navigate complex legal and regulatory landscapes. In particular, states that adopt the CPOM doctrine prohibit non-physician-owned corporations, including PE firms, from practicing medicine or directly employing physicians to provide professional medical services. To circumvent CPOM restrictions, PE firms often have to rely on management services organizations (MSOs) instead of directly acquiring and owning the medical group. Under this structure, the PE-backed MSO acquires the non-clinical assets of a practice and enters into a long-term management agreement with the physician group, which remains legally independent and physician-owned. The MSO typically provides administrative services such as billing, staffing, finance, IT, purchasing, revenue-cycle management, and other non-clinical support.

These ownership structures also affect the compensation and governance of the physicians who ultimately make clinical decisions. Before acquisition, physician-owners are often residual claimants of practice profits, whereas non-owner physicians are typically compensated through salary, minimum-income guarantees, and productivity-based bonuses. After acquisition, selling physician-owners commonly receive upfront cash and/or rollover equity, while their continuing compensation may be recast through salary guarantees, deferred payments, earnouts, productivity bonuses, or equity participation. In MSO structures, physicians retain formal clinical authority, but compensation is determined after management fees and other practice expenses, while the PE-backed MSO may influence the practice

environment through scheduling, staffing, capital investment, standardized protocols, and compliance programs.

These arrangements imply that the effect of PE acquisition on individual physicians' incentives is theoretically ambiguous. On the one hand, selling physician-owners may have lower direct residual claims on marginal practice profits and greater income stability after acquisition, which could dampen incentives to cater to patient demand or increase service intensity. PE-backed management may also introduce centralized monitoring and compliance controls that raise the expected cost of legally risky prescribing. On the other hand, productivity bonuses, earnouts, rollover equity, and organizational pressure to maintain patient volume may preserve incentives to expand patient encounters and reimbursable services. This ambiguity is particularly important for opioid prescribing: liberal opioid prescribing may indirectly help retain patients and generate follow-up visits, but prescription opioids generally do not generate direct drug margins for physician groups and expose providers and owners to substantial regulatory, litigation, and reputational risks. Thus, the net effect of PE acquisition on opioid prescribing intensity is not clear ex ante and is ultimately an empirical question.

2.2 Physician Opioid Prescriptions

In parallel with financial transformations in healthcare, the United States has faced a persistent and escalating opioid crisis. According to the CDC, drug overdose deaths have quintupled since 1999, with nearly 75% of the 91,799 drug overdose deaths in 2020 involving an opioid (CDC, 2021). Among these, prescription opioids have played a central role. Early CDC reports identified prescription opioids as a major driver of the opioid epidemic (CDC, 2013), with prescription opioid-involved deaths increasing by 17% from 2019 to 2020 alone (CDC, 2021).

The roots of prescription opioid abuse and overdose are complex. Multiple drivers are behind this problem, including insufficient provider training in pain management, insufficient monitoring of overprescription, aggressive pharmaceutical marketing, and widespread misconceptions among patients about the safety of prescription drugs. Among them a major driver is the aggressive promotion and marketing of opioid manufacturers. One of the most notorious examples is the marketing of *OxyContin*, a powerful opioid manufactured by Purdue Pharma. As discussed in Alpert et al. (2022), Purdue's aggressive promotional strategies in the late 1990s, particularly those targeting primary care physicians, dramatically increased opioid prescribing rates (GAO, 2003). With unprecedented spending on physician outreach and promotional events (GAO, 2003), Purdue created a market narrative that framed opioids as safe and effective for chronic pain, downplaying addiction risks.

In response to the crisis, both federal and state regulators have introduced a series of measures aimed at curbing overprescription. One of the most prominent interventions has been the implementation of Prescription Drug Monitoring Programs (PDMPs), the state-run electronic databases that collect and track prescribing and dispensing data for controlled substances, including opioids. PDMPs are designed to help healthcare providers identify patterns of high-risk prescribing, detect potential misuse by patients (such as doctor shopping), and promote safer prescribing decisions. In many states, physicians are required to consult the PDMP before issuing prescriptions for certain opioids or other high-risk medications. Other regulatory measures include updated clinical guidelines for pain management and heightened oversight of physician prescribing behavior through audits and professional board reviews. As a result, physicians now operate in a highly regulated prescribing environment, where deviations from established protocols can lead to legal, professional, and financial consequences.

Understanding this regulatory backdrop is essential when evaluating how PE ownership may influence physician behavior, particularly in contexts like opioid prescribing where both profit motives and professional standards intersect with public health priorities.

3 Data and Methodology

3.1 Data

The study relies primarily on three data sources to examine the effects of PE ownership on physician opioid prescribing patterns. The main dataset is the CMS Medicare Part D Prescribers-by-Provider dataset from 2013 to 2020, which includes detailed annual information on prescription drugs prescribed by physicians and other healthcare providers under the Medicare Part D Prescription Drug Program.[13] For each prescriber-year observation, the dataset reports the total number of prescriptions written, the number of unique Medicare beneficiaries served, total beneficiary drug expenditure, and physician's National Provider Identifier (NPI). Importantly, to actively monitor overutilization of prescription drugs, the dataset also separately provides prescriber-level statistics including the number of drug claims, value of drug expenditures, number of unique beneficiaries for three prescription drug categories that are frequently abused: opioids, antipsychotics, and antibiotics. In particular, for the highly abusive opioid drugs, the CMS Medicare Part D Prescribers-by-Provider dataset further reports the *Opioid Prescription Rate*, defined as the proportion of opioid prescriptions relative to all prescriptions written by a provider in a given year. This variable serves as our primary outcome of interest and is widely used in the public health literature as an indicator of

[13] Medicare Prescription Drug Benefit Program ("Part D") is a prescription drug insurance program targeting the elderly population. In 2017, more than 42 million people enrolled in Part D program (Kaiser Family Foundation, 2017). Zhou et al. (2016) finds that Medicare has become the largest purchaser of prescription opioids, which is about 20–30% of total U.S. spending on opioids.

opioid prescribing intensity and potential overprescription (e.g., Barnett, Olenski, and Jena 2017). The Prescribers-by-Provider file also reports prescriber-year aggregate information on the Medicare beneficiaries served by each provider, including average HCC risk score, gender composition, race and ethnicity shares, and average beneficiary age. We use these variables to examine whether PE acquisition is associated with observable changes in patient case mix. These measures are aggregated at the prescriber-year level and therefore do not allow us to observe individual diagnoses, pain-related visits, or patient-level risk adjustment directly.

Next, we identify each physician's organizational affiliation using the CarePrecise Advanced Database, a commercial medical database that covers comprehensive information on U.S. healthcare providers. This source enables us to link physicians to their affiliated medical groups and obtain relevant group-level characteristics such as practice location, medical specialty, and practice size. At the individual physician level, CarePrecise provides demographic and professional background variables including gender, medical credentials, and medical school attended. To further enrich provider background information, we manually matched medical schools to their respective rankings published by U.S. News and World Report during the relevant period. The Medicare Part D Prescribers-by-Provider dataset and CarePrecise dataset are merged using the physician's unique NPI.

Finally, to identify PE acquisitions of physician medical groups, we use the Irving Levin Associates Health Care M&A dataset. Irving Levin Associates specializes in the healthcare industry and collects information on a broad set of healthcare mergers and acquisitions. From this dataset, we identify all the physician medical group acquisitions bought by private equity firms from 2014 to 2019. This window is chosen to ensure each affected group had at least one year's observation before and after the acquisition. For each buyout, we record the target group name, practice location, merger completion date, acquirer name, and

any associated PE sponsors.[14] Deals with undisclosed target names are excluded. For buyouts that spanned distinct group names, we treat them as separate deals.

To match PE acquisitions to the physician groups covered in the CarePrecise dataset, we conduct name-based matching followed by manual verification, including internet searches to account for any post-acquisition name changes or rebranding. Overall, we identify 480 PE acquisitions of physician medical groups from 2014 to 2019. Appendix Table A1 presents the number of PE buyouts in each year and the number of physician medical groups and physicians involved in these acquisitions. The data show a significant increase in PE buyouts of physician groups from 2014 to 2018, followed by a modest decline in 2019, consistent with the trend reported in prior studies (Zhu, Hua, and Polsky, 2020). Table 1 presents summary statistics on major variables used in this paper at the physician-year level. Across more than 2 million physician-year observations in the whole sample, a physician on average served approximately 26.8 unique Medicare beneficiaries with at least one claim for opioids, wrote 79.09 opioid prescriptions, and generated $2,985 drug expenditures paid for opioid claims in one year. The average annual opioid prescription rate of a single physician is around 10%, but with great variations across provider, ranging from 0% to 100%.

[Insert Table 1]

3.2 Empirical Model

In this paper, we examine the effect of private equity buyouts on opioid prescriptions using a difference-in-differences (DID) method. We estimate the following baseline equation:

[14] We double-check and further supplement the PE buyout of physician medical groups using the PitchBook database and news reports to get a comprehensive sample.

$$Y_{i,g,t} = \alpha + \beta_1 PostPE_{i,g,t} + \gamma X_{i,g,t} + \alpha_{i,g} + \delta_t + \theta_l + \tau_s + \varepsilon_{i,g,t} \quad (1)$$

Where i denotes the physician, g denotes the medical group, and t is the year. The dependent variable $Y_{i,g,t}$ is the annual opioid prescription rate of physician i in group g in year t, defined as the share of opioid prescriptions among total prescriptions. $PostPE_{i,g,t}$ is a dummy variable equal to one if physician i is in a group g that has been acquired by a PE firm in or before year t, and 0 otherwise. The coefficient β_1 captures the average treatment effect of PE ownership on opioid prescribing behavior. $X_{i,g,t}$ is a group of control variables that includes the size of the group the physician belongs to (i.e. number of affiliated physicians) and the state-level opioid policy indicator (i.e. PDMP) to account for the evolving regulatory environment. $\alpha_{i,g}$ denotes physician-by-group fixed effects, which control for time-invariant characteristics at the individual physician level.[15] δ_t represents year fixed effects, accounting for national trends in opioid prescribing and other contemporaneous shocks (e.g., policy changes, public health events). We also include the state fixed effects θ_l and speciality fixed effects τ_s in the regression to absorb heterogeneity in opioid prescription norms across states and speciality-related medication differences. Standard errors are clustered at the medical group level to account for within-group correlation over time.

Our baseline sample is designed to capture within-physician changes around PE acquisition. Because the baseline specification includes physician-by-group fixed effects, treated physicians are required to be observed in the same acquired group at least once before the acquisition ($T < 0$) and at least once in a full post-acquisition year ($T \geq 1$). Physicians observed only before the acquisition or only after joining the acquired group are excluded from the baseline sample because they do not contribute within-spell pre/post variation. For never-

[15] Some physicians may work simultaneously at multiple groups. The results are robust if we simply delete them from the sample.

treated controls, which have no natural event date in the full sample analysis, we require continuous observation throughout the 2013–2020 sample window to construct a stable comparison panel. A natural concern is that this construction imposes a stricter stability requirement on control spells than on treated spells and excludes physician turnover around acquisition events. Section 4.4 evaluates this concern by characterizing physician mobility around the acquisition event and by re-estimating the baseline DID after relaxing the baseline sample restrictions to restore physicians who leave before or join after the acquisition. These exercises do not fully eliminate all composition concerns, but they show that the main decline in opioid prescribing is not mechanically driven by physician entry and exit and support an interpretation centered on within-physician changes in prescribing behavior.

4 PE Buyouts and Opioid Prescriptions

4.1 Baseline Results

Table 2 presents our baseline DID regression results based on equation (1). Column (1) reports the estimated effect of PE buyouts on physicians' opioid prescription rate without any controls and using the full sample. The coefficient on the DID estimator *PostPE* is -0.901 and significant at the 1% level. Considering the average opioid prescription rate of the whole sample is 9.999%, this is a sizable decline of 9.0% of the average prescription rate, indicating a meaningful decline in opioid prescribing intensity following PE acquisition. In column (2), we augment the specification by including time-varying characteristics at the group and state levels. Specifically, we control for group size (measured as the number of physicians affiliated with a medical group) and the status of state-level opioid regulation of PDMP implementation. The PDMP variable is defined categorically: it takes a value of 1 in years after the physician's

state has implemented a PDMP, and 2 in years after the state mandates mandatory access to PDMPs; it is set to 0 otherwise.[16] The estimated coefficient on *PostPE* remains negative and statistically significant, with a slightly smaller magnitude compared to column (1).

In our full sample, 94.7 percent of physicians belong to the control group (i.e., were never affiliated with a PE-acquired medical group). The parallel trends assumption could be violated if unobserved characteristics affect the control group and treatment differently. To address this concern, we implement a propensity score matching (PSM) strategy to create a more balanced control sample. Specifically, we construct a 1:1 propensity-score matched sample. The propensity score is estimated using only pre-acquisition characteristics, including specialty, state, group size, group-level gender composition, average medical-school rank, and the average number of Medicare beneficiaries per physician. For never-treated control groups, we assign pseudo-acquisition years based on the distribution of acquisition years among treated groups before matching. We then match treated and control observations within common support. This matching procedure helps ensure that treated and control groups are similar along key observable dimensions, thereby improving the comparability of pre-treatment trends.

Column (3) of Table 2 presents the effects of PE buyouts on physicians' opioid prescriptions using the matched sample. For the opioid prescription rate, the coefficient on *PostPE* remains negative and significant at the 1% level, with a magnitude similar to the whole sample estimate in column (2). In subsequent analysis, we rely mainly on this PSM-matched sample.[17] Together, these results suggest that after the PE buyout, physicians in the acquired

[16] PDMP is an electronic database which allow physicians to access the historical prescription records on controlled substances of patients to prevent drug-seeking behaviour such as doctor shopping. For some states, physicians are voluntary to participate PDMP, but some states further require mandatory access to PDMP before any prescriptions of controlled substances.
[17] All the results are robust if using the full sample.

group significantly decreased their opioid prescription intensity, as measured by the share of opioid prescriptions in a physician's total Medicare claims.

[Insert Table 2]

4.2 Robustness Checks

Test for parallel trend assumption. To validate the parallel trends assumption and explore the dynamic effects of PE buyouts, we replace the *PostPE* indicator with a series of relative-time indicators from five years before to five years after the acquisition. As shown in Figure 1 and corresponding Table 3A, the coefficients on the pre-treatment indicators *PrePE(-5)* to *PrePE(-2)* are statistically insignificant, while the omitted category is PrePE(-1). Thus, there is no evidence of differential pre-trends in opioid prescribing prior to PE buyouts. In contrast, the post-treatment coefficients on *PostPE(0)* to *PostPE(5)* are all negative and significant. Moreover, the magnitude of the coefficients on dummy indicators after the buyout is generally increasing over time, which is consistent with the causal interpretation of our results.

Furthermore, recent developments in econometric theory suggests that in the presence of staggered treatment timing and treatment effect heterogeneity, traditional two-way fixed effects (TWFE) dynamic effect estimates may not provide valid estimates because a given lead or lag can be contaminated by the effects of other relative-time periods in the estimation sample (Sun and Abraham, 2021). To address this issue, we employ the alternative estimates proposed by Sun and Abraham (2021), which is robust to treatment effect heterogeneity, and re-estimate the dynamic effect of PE buyouts on opioid prescriptions. Similar to Figure 1, the re-estimated results in Figure 2 show that there appears no significant effect before the PE buyout. The

opioid prescription rate drops after the buyout and the magnitude of the effect increases over time.

[Insert Figure 1]

[Insert Figure 2]

Limitations of TWFE model in staggered DID. Recent studies have shown that TWFE regressions would deliver consistent estimates only under assumption of homogeneous treatment effects (De Chaisemartin and d'Haultfoeuille, 2020; Callaway and Sant'Anna, 2021; Sun and Abraham, 2021; Goodman-Bacon, 2021; Borusyak et al., 2021). In the presence of treatment effect heterogeneity and staggered treatment adoption, even static TWFE DID estimators can be biased. We address the concern about the reliability of TWFE model by using the robust estimators proposed by Sun and Abraham (2021) and Callaway and Sant'Anna (2021). The results are presented in column (1) and column (2) of Panel B in Table 3, respectively. Both approaches yield consistent findings: the coefficients on *PostPE* remain negative and significant at the 1% level, confirming the robustness of our main results.

[Insert Table 3]

Alternative measure for physician opioid prescription intensity. As a robustness check, we use an alternative measure commonly used in the literature to capture physician prescribing patterns: the *Opioid Patient Rate* (e.g., McMichael, Van Horn, and Viscusi, 2020). *Opioid Patient Rate* is calculated as the proportion of unique Medicare Part D beneficiaries with at least one claim for opioids out of all unique beneficiaries served by a physician. Appendix Table A2 reports the effect of PE buyouts on this alternative measure for opioid prescription intensity. The *PostPE* coefficient remains negative and significant at the 1% level, with a point

estimate of -1.139. This translates into a 5.4% reduction relative to the average opioid patient rate.[18]

Subsample of general medical specialties. Our sample includes physicians across 185 specialties. Although the baseline specification includes specialty fixed effects, PE acquisitions may still affect opioid prescribing mechanically if acquired groups shift across specialties or if specialty-specific prescribing guidelines change over time.[19] To mitigate this concern, we re-estimate the baseline specification using a more comparable subsample of physicians in general medical specialties, including family medicine, internal medicine, emergency medicine, and general practice groups. These physicians account for approximately 60% of opioid prescriptions in our sample. Table A3 shows that the baseline result remains robust in this subsample.

Patient case mix and chronic-disease medication placebo tests. A related concern is that PE acquisitions may change patient composition rather than physician prescribing behavior. For example, PE-owned groups may attract new patients with different disease profiles or shift toward patients who require less chronic pain management. Ideally, this concern would be examined using patient-level claims data with detailed information on demographics, diagnoses, risk scores, and pain-related visits. Our data do not allow us to observe patient-level diagnoses or pain-related visits. However, the CMS Medicare Part D Prescribers-by-Provider data provide aggregate beneficiary characteristics at the prescriber-year level, which allow us to examine broad changes in patient case mix.

[18] All the results in this paper are qualitatively similar when using the opioid patient rate. We suppress the results for brevity which could be provided upon request.
[19] For example, the American Heart Association updated its CPR guideline regarding management of opioid-related emergencies. Source: https://newsroom.heart.org/news/updated-cpr-guidelines-tackle-health-disparities-management-of-opioid-related-emergencies-and-physical-emotional-recovery-6817716 (accessed on July 24th, 2023)

We first test whether PE acquisition changes the demographic and clinical composition of physicians' Medicare Part D patient panels. Panel A of Table 4 reports the results using average Hierarchical Condition Category (HCC) risk score, the share of female beneficiaries, racial and ethnic composition, and average beneficiary age as dependent variables. We find no statistically significant change in average HCC risk score, gender composition, or racial and ethnic composition after PE acquisition. The only statistically significant estimate is a small increase in average beneficiary age of about 0.18 years, which is economically modest and does not suggest a shift toward a substantially healthier or lower-risk patient panel. Overall, these results provide little evidence that PE acquisition is associated with broad changes in observable patient case mix.

We then conduct complementary placebo tests using chronic-disease medications. Specifically, we examine physicians' prescribing rates for commonly used hypertension and diabetes medications. Hypertension and diabetes are prevalent chronic conditions among Medicare beneficiaries, and prescriptions for these drugs are closely tied to ongoing chronic disease management. If PE acquisition led acquired groups to serve systematically healthier patients or patients with substantially lower chronic disease burden, we would expect changes in these chronic medication prescribing rates as well.

We identify the most commonly prescribed hypertension and diabetes drugs[20] and calculate physician-level annual prescription rates for these drugs using the Medicare Part D Prescriber dataset.[21] In Panel B of Table 4, we examine the impact of PE buyouts on physicians' prescription rates of most frequently used hypertension drugs and diabetes drugs. We find no evidence that prescription behaviour changes for hypertension drugs (column 1) or diabetes

[20] Medications most frequently prescribed in the US for hypertension and diabetes are identified following Borrescio-Higa (2015) and "Ranked: The Most Prescribed Drugs in the U.S.": https://www.visualcapitalist.com/ranked-the-most-prescribed-drugs-in-the-u-s/

[21] In Prescribers-by-Provider by Drug dataset, CMS has redacted any data lines that were based on information from 10 or fewer individual claims for privacy concerns.

drugs (column 2). This suggests that our findings are not driven by general shifts in prescribing behavior or unobserved changes affecting all prescriptions.

Taken together, the patient-composition tests and chronic-medication placebo tests suggest that our opioid findings are unlikely to be driven by broad shifts in patient health status, demographic composition, chronic disease burden, or general prescribing patterns. These tests cannot fully rule out a narrower shift away from patients requiring chronic pain management, because we do not observe patient-level pain diagnoses or visits. However, the evidence is inconsistent with a broad patient-composition explanation for the decline in opioid prescribing intensity.

[Insert Table 4]

4.3 Endogeneity of PE Selection Bias

Logit test of PE selection. Another critical concern of our baseline DID identification is that private equity firms endogenously select target physician medical groups. To address this issue, we first follow Jensen and Oster (2009) and test whether PE buyout decisions can be predicted by levels or trends in the outcome variable. In column (1) of Table 4C, we regress the PE acquisition indicator on the group's pre-acquisition opioid prescribing level and trend. The coefficient is statistically insignificant, suggesting that PE firms do not systematically target physician medical groups that initially have lower opioid prescription intensity. In column (2) and column (3), we replace the opioid prescription rate one year before the acquisition with the average prescription rate and prescription rate growth over the three years prior to the acquisition, respectively. The results remain statistically insignificant, indicating that neither the level nor the trend of opioid prescribing predicts subsequent PE acquisition.

As a complementary check, Appendix Table B1 also reports an instrumental variable (IV) analysis using state-level Corporate Practice of Medicine (CPOM) restrictions as an instrument for PE acquisition, following the spirit of Liu (2021) and Gao, Kim and Sevilir (2025).[22] The CPOM index is negatively associated with PE acquisition in the first stage, and the second-stage estimate is negative, consistent with our baseline results. Because CPOM restrictions may affect acquisition structure and physician governance in ways beyond acquisition probability, we interpret the IV estimates as supplementary evidence rather than the primary source of identification.

4.4 Physician Mobility Around PE Acquisition

Our baseline sample is designed to estimate changes in prescribing behavior among incumbent physicians. This construction allows the baseline specification, which includes physician-by-group fixed effects, to focus on within-physician changes in prescribing behavior. However, it also raises two related concerns. First, the stability requirement is stricter for control physicians than for treated physicians. Second, the baseline sample abstracts from physician turnover around acquisition events. Such turnover is not merely a nuisance: if PE owners change the physician roster after acquisition, this could be an economically meaningful channel through which ownership affects prescribing at the practice level. We therefore examine whether our estimates are sensitive to the baseline sample construction and whether physician mobility appears to be an important margin of post-acquisition adjustment.

[22] See more details of the construction of this IV in Appendix B.

We first relax the baseline sample restrictions. Appendix Table A4 re-estimates the baseline DID using all observed physicians in the matched treated and control groups, without requiring treated physicians to be observed both before and after the acquisition or requiring control physicians to appear in every year of the sample window. This expanded sample restores physicians who leave before the post-acquisition period, physicians who join after acquisition, and other partially observed physician-group spells. The coefficient on *PostPE* remains negative and statistically significant, with a magnitude close to the baseline estimate. This result suggests that the decline in opioid prescribing intensity is not an artifact of the incumbent-physician sample or the balanced-panel restriction imposed on control physicians.

We next examine physician mobility directly. Appendix Table A5 Panel A reports group-level changes in physician entry, exit, net flows, and group size using the unfiltered CarePrecise affiliation history. PE acquisition is associated with some physician reshuffling, particularly through higher physician exits. However, overall group size and net physician flows do not change significantly. These results indicate that PE acquisitions are accompanied by some turnover, but not by a large contraction in the physician workforce of acquired groups.

We then ask whether this turnover reflects a systematic shift in the prescribing profile of physicians practicing in acquired groups. Appendix Table A5 Panel B compares the pre-acquisition opioid prescription rates of stayers, leavers, and joiners. A replacement channel in which PE-owned groups reduce opioid prescribing by removing high-opioid prescribers and recruiting low-opioid prescribers would itself be an informative post-acquisition governance mechanism. In the data, however, we do not observe this pattern. Leavers in treated groups do not have significantly higher pre-acquisition opioid prescription rates than stayers, and joiners do not have lower pre-acquisition rates.

Appendix Table A5 Panel C formalizes this comparison by regressing physicians' pre-acquisition opioid prescription rates on leaver and joiner indicators and their interactions with

treated-group status. The interaction terms *Treated* × *Leaver* and *Treated* × *Joiner* are the difference-in-differences quantities of interest: a positive (negative) interaction implies that, relative to the control benchmark, treated leavers (joiners) have systematically higher (lower) pre-acquisition prescribing. The interaction estimates show little evidence that PE-acquired groups selectively lose high-opioid prescribers or selectively recruit low-opioid prescribers. Thus, while physician turnover appears to be part of the organizational changes following PE acquisition, the observed sorting of physicians does not suggest that the decline in opioid prescribing is primarily driven by replacing high-prescribing physicians with low-prescribing physicians.

Taken together, these tests clarify the interpretation of our baseline estimates. The robustness of the results in the expanded physician sample suggests that the baseline sample construction does not drive the main finding. The mobility analysis further suggests that physician roster changes, but it does not appear to be the dominant channel behind the decline in opioid prescribing. We therefore interpret the baseline estimates as primarily capturing changes in prescribing behavior among incumbent physicians, while recognizing that physician mobility may represent an additional margin of post-acquisition restructuring.

5 Mechanisms and Heterogeneous Responses of PE Buyouts

So far, our baseline results show that private equity (PE) acquisitions lead to a decline in opioid prescription rates among physicians in the acquired medical groups. In this section, we further explore the underlying mechanisms through which PE buyouts affect opioid prescription rates. We try to provide evidence that regulatory and litigation risks do serve as the primary external force incentivizing PE firms to reduce opioid prescriptions, with the effect being strongest when these risks are highest. We then explore heterogenous effects on opioid

prescription intensity shaped by PE characteristics, examining the role of financial constraints and corporate social responsibility preference.

5.1 Driver of PE Effect: Regulatory and Litigation Risk

We begin our mechanism analysis by examining the role of regulatory and litigation risk, which could be a central channel through which PE ownership reduces opioid prescribing. Compared to other ownership types, PE firms tend to exhibit stronger compliance incentives and superior capacity for legal compliance, given their centralized governance structures, reputational concerns, and professionalized management teams. These features make PE firms particularly responsive to external regulatory pressure and legal liability, especially in sectors like healthcare where the risks of non-compliance can be substantial. Krueger, Sautner, and Starks (2020) show in a survey that institutional investors such as private equity funds report that managing climate risks, especially regulatory risks, is the main reason they engage with portfolio firms. Bellon (2020) also suggests that PE-backed firms are more sensitive to regulatory risks than other privately-held companies because they have a longer investment horizon.

To test this channel, we focus on two quasi-exogenous shocks that raise the regulatory and legal risks associated with opioid prescribing. First, we take advantage of staggered adoption and variation in the strictness of Prescription Drug Monitoring Program (PDMP) across U.S. states. PDMP requires electronic databases to track prescriptions of controlled substances as a response to the abuse of prescription opioids in the US. States have evolved the PDMP over time with variations in its enforcement. Some states simply adopt PDMPs as optional tools for prescribers, while others impose mandatory access to PDMPs before prescriptions of controlled substances ("must-access PDMP"). These adoptions and mandates can entail punitive consequences for prescribers and influence court to hold physician liable

for its opioid prescription (Haffajee et al., 2015), which potentially increases the regulatory risks for PE acquirers.

During our sample period, many states tightened PDMP regulations, either by implementing a PDMP where none previously existed or by shifting from a voluntary to a mandatory PDMP system. We leverage these regulatory tightening events as quasi-natural policy shocks to test whether PE-acquired physician groups are more sensitive and responsive to compliance-related risks. We construct a variable, *PDMP Tighten*, which equals one in the years after a state adopts a more stringent PDMP policy, including both new PDMP adoption and transitions from voluntary to mandatory access. We then employ a difference-in-differences-in-differences (DDD) specification to examine whether PE-acquired physicians respond more strongly to the regulatory tightening compared to non-PE physicians in the same state. The results are presented in column (1) of Table 5. The interaction term of *PDMP Tighten* and *PostPE* yields a negative and statistically significant coefficient, indicating that PE-acquired physicians are more likely to reduce opioid prescriptions in response to heightened regulatory scrutiny. This suggests that PE firms are particularly sensitive to changes in the compliance environment and respond by curbing high-risk prescribing behavior.

To mitigate concerns that PDMP policy might influence PE acquisition decisions, in Appendix Table A6, we replicate the analysis using only PE acquisitions that occurred prior to PDMP tightening events. The results remain robust.

Second, we examine litigation risk using an exogenous event: the 2019 settlement of the first healthcare-related False Claims Act (FCA) lawsuit involving a private equity firm.[23] FCA is an American federal law that imposes liability on persons and entities who knowingly

[23] See "Compounding Pharmacy, Two of Its Executives, and Private Equity Firm Agree to Pay $21.36 Million to Resolve False Claims Act Allegations": https://www.justice.gov/opa/pr/compounding-pharmacy-two-its-executives-and-private-equity-firm-agree-pay-2136-million

defraud governmental programs. In that case, a PE firm was held liable for profiting from medically unnecessary prescriptions of high-cost pain creams. This case set a precedent for holding PE firms accountable for fraudulent medical practices, thereby increasing their exposure to future litigation. We test whether the reduction effect of PE buyouts on opioid prescriptions strengthens after the settlement of the lawsuit. In column (2) of Table 5, we introduce an interaction term between *PostPE* and a dummy *PostFCA,* which equals one for observations after 2019. The coefficient on this interaction is negative and statistically significant, which suggests that PE-acquired physician groups further reduced opioid prescribing following the FCA precedent. This finding aligns with the notion that PE firms are particularly responsive to shifts in the legal environment that threaten their reputation or financial returns.

[Insert Table 5]

5.2 Heterogeneous Effect across PE firms:

5.2.1 Role of PE Financial Constraint

Another important mechanism through which PE ownership may influence opioid prescribing behavior is the degree of financial constraint faced by the acquiring PE firm prior to the buyout. PE firms' financial constraints may shape how strongly they prioritize compliance and risk management relative to short-term revenue generation. Financially constrained PE firms may face greater pressure to preserve patient volume, maintain productivity targets, and avoid costly compliance investments that could reduce short-term cash flow. In contrast, PE firms with greater financial flexibility may be better able to absorb

short-term revenue losses, invest in monitoring systems, and enforce stricter prescribing protocols to reduce litigation and regulatory risk.

This trade-off is particularly relevant for opioid prescribing. Opioids generally do not generate direct drug margins for physician groups, but they may indirectly help retain patients seeking pain relief and support repeat encounters. At the same time, opioid prescribing exposes providers and owners to heightened regulatory scrutiny and litigation risk. We therefore expect financially less constrained PE firms to reduce opioid prescribing more aggressively after acquisition.

To test this hypothesis, we examine the heterogeneity of PE firms' ex-ante financial constraints on the effect of PE buyouts on opioid prescriptions. We use three proxies for PE firms' financial constraints: 1) public listing status, 2) fund age and size, and 3) capital raised in the most recent fund prior to the acquisition. First, we compare publicly listed PE firms to private PE firms. Listed PE groups generally enjoy greater liquidity, broader access to capital, and more diversified funding sources. Second, firm size and age are commonly used to identify firms' financial constraints or financial resources (Hadlock and Pierce, 2010). Therefore, following prior literature (e.g., Hadlock and Pierce, 2010; Fracassi, Previtero, and Sheen, 2022), we construct a variable *High size&age,* equal to one if the PE firm is in the top half of both the asset under management (AUM) and age distributions in the year before the acquisition, and zero otherwise. Third, we compare the amount of "dry powder" a PE firm had available at the time of acquisition. We collect information from CapitalIQ about the amount of capital that a PE raised for the last round of funds before the acquisition. A larger size of the most recent fundraising implies that the PE may have more money to fund their medical group acquisitions and support the future development of the acquired group. We define a dummy variable *Big last fund* that equals one if the PE falls in the top half of the last fund size distribution.

Table 6 presents the results. In column (1), we find that physicians acquired by listed PE firms experience an additional 1.503 percentage-point decline in opioid prescription rates relative to physicians acquired by non-listed PE firms. This difference is both statistically significant and economically meaningful. Column (2) shows that acquisitions by larger and more established PE firms (i.e. those with high age and AUM) are associated with an additional 1.068 percentage-point decline in opioid prescription rates. In column (3), we find that when the acquiring PE firms had raised a larger fund prior to the buyout, physicians also tend to have a lower opioid prescription rate after the acquisition. These results support our hypothesis that PE firms with fewer financial constraints will be associated with larger reductions in opioid prescribing intensity.

[Insert Table 6]

5.2.2 Role of PE Corporate Social Responsibility Preference

PE firms' intent and strategy focus can also influence how they manage their invested firms (Fracassi, Previtero, and Sheen, 2022). PE firms' corporate social responsibility (CSR) preference reflects its strategic willingness to manage regulatory and litigation risks proactively. Given the growing public concern over the opioid epidemic in the U.S., we further explore whether more socially responsible PE firms take a more active role in reducing opioid prescription intensity.

We measure PE firms' social responsibility in two ways. First, we use CSR performance scores of PE firms' portfolio companies following previous literature (e.g., Hwang, Titman, and Wang, 2022; Cao et al., 2022). Specifically, we combine the information on PE firms' portfolio holdings from the Thomson Reuters 13F database with the CSR ratings of their portfolio companies from the MSCI ESG KLD STATS database. We then compute an

institutional *CSR Score* for each PE firm, which is calculated as the weighted average CSR ratings of PE firms' portfolio companies. Second, we utilize PE firms' participation in the United Nations Principles for Responsible Investment (UN PRI) signatories at the time of acquisition as an alternative indicator for PE firms' CSR preference.

Table 7 presents the results. In column (1), we can see that physicians acquired by PE firms with higher institutional *CSR Score* experience larger reductions in opioid prescription rates. In column (2), we find that physicians acquired by UN PRI signatory PE firms reduce their opioid prescription rates significantly more than those acquired by non-signatory firms. Specifically, acquisitions by UN PRI signatories are associated with an additional 1.4% reduction in opioid prescription rate, relative to non-signatory counterparts. Considering the average opioid prescription rate is around 10%, this is a sizable difference.

Overall, these results suggest that PE firms' nonfinancial objectives and reputational concerns shape how strongly they implement compliance-oriented changes after acquisition. The larger reduction among high-CSR PE firms is consistent with the view that socially responsible investors are more willing to internalize the public-health and reputational costs of high-risk prescribing.

[Insert Table 7]

6 Further Discussions: Other Frequently-Abused Addictive Drugs

In addition to opioids, recent medical research has highlighted the rising abuse of antipsychotics, particularly through off-label or recreational use (Kim et al., 2017; Roy et al., 2022). The abuse of antipsychotic drugs is also reported to be related to pharmaceutical

company marketing practices. For example, in 2019, 13 million prescriptions for 1.97 million patients were written for Seroquel, an atypical antipsychotic drug, which still ranked 56th in the top 200 drugs in United States.[24] The manufacturer of the drug, AstraZeneca, has been fined $520 million to resolve allegations of illegally promoting Seroquel to physicians.[25]

Given these concerns, in this section, we extend our analysis to examine whether PE buyouts affect prescribing behavior for antipsychotic drugs, which are also considered high-risk and thus tracked in the CMS Medicare Part D Prescribers-by-Provider dataset. Following the same rationale as for opioids, we hypothesize that PE ownership may temper overprescription incentives for other frequently abused prescription drugs. This is based on the idea that PE firms may seek to avoid regulatory scrutiny or reputational damage by limiting physicians' reliance on controversial prescribing practices.

To our expectation, Table A7 shows that PE buyouts also lead to decreased antipsychotic prescription rates. Relative to counterparts in unaffected groups, physicians acquired by PE firms tend to decrease their antipsychotic prescription rate by 0.2%, which is also nontrivial compared to its mean (2.1%). These results suggest that the moderating effect of PE ownership on potentially inappropriate prescribing behavior may extend beyond opioids, reflecting a broader shift in physician practice patterns following PE acquisition.

7 Concluding remarks

The paper studies the impact of PE buyouts on physician opioid prescribing behavior. Utilizing a difference-in-differences approach, we find that physicians in PE-acquired

[24] Source: https://clincalc.com/DrugStats/Drugs/Quetiapine
[25] See "Pharmaceutical Giant AstraZeneca to Pay $520 Million for Off-label Drug Marketing": https://www.justice.gov/opa/pr/pharmaceutical-giant-astrazeneca-pay-520-million-label-drug-marketing#:~:text=AstraZeneca%20LP%20and%20AstraZeneca%20Pharmaceuticals,and%20Human%20Services'%20Health%20Care

physician groups significantly decreased their opioid prescription rates after the buyout. This interpretation is supported by robustness tests showing that the result is not explained by broad observable patient-composition changes, chronic-disease prescribing patterns, or physician entry and exit around acquisition events.

Our mechanism tests highlight the role of external governance in shaping this response. The reduction in opioid prescribing intensity is more pronounced in states with stronger opioid monitoring regulations, suggesting that PDMP-based scrutiny can induce PE-owned practices to curb high-risk prescribing. We also find a larger reduction after the first legal sanction involving a PE-backed healthcare investment under the False Claims Act, indicating that litigation risk can discipline PE owners and strengthen compliance-oriented governance in acquired physician groups. Heterogeneity across PE firms further suggests that financial flexibility and reputational concerns shape the extent to which PE owners internalize regulatory and public-health risks, as PE firms with more financial resources and stronger CSR preferences have a greater reduction in opioid prescribing intensity compared to other PE-acquired groups.

These findings shed light on the ongoing debate over the rapid expansion of PE ownership in physician groups. They should not be interpreted as evidence that PE ownership is uniformly beneficial or harmful. Rather, the effects of PE ownership depend on the interaction between profit incentives, physician-level governance, and external regulatory pressure. In high-risk clinical domains such as opioid prescribing, credible monitoring, legal enforcement, and litigation threats can help align PE firms' financial incentives with broader public health objectives. Policies that strengthen oversight of prescribing behavior, increase transparency in PE-owned healthcare organizations, and encourage responsible investment practices may therefore help mitigate the adverse consequences of profit-driven ownership

while preserving the potential benefits of professionalized management and compliance capacity.

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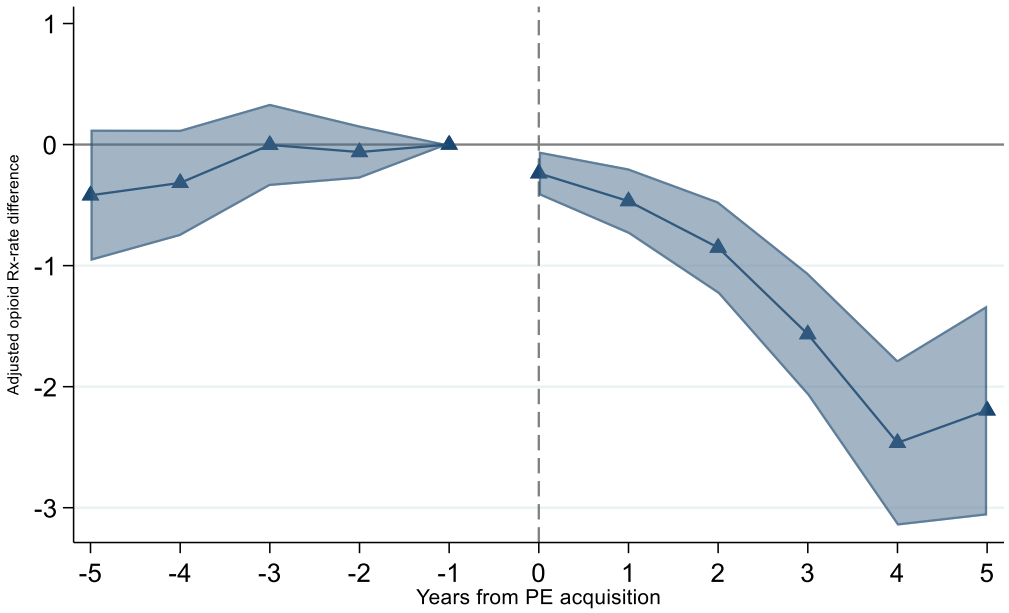


Figure 1. Dynamic effect of PE acquisition on opioid prescription rate

Notes: This figure presents the dynamic treatment effect of PE acquisition on physicians' opioid prescription rate from five years before the acquisition to five years after the acquisition (PSM sample).

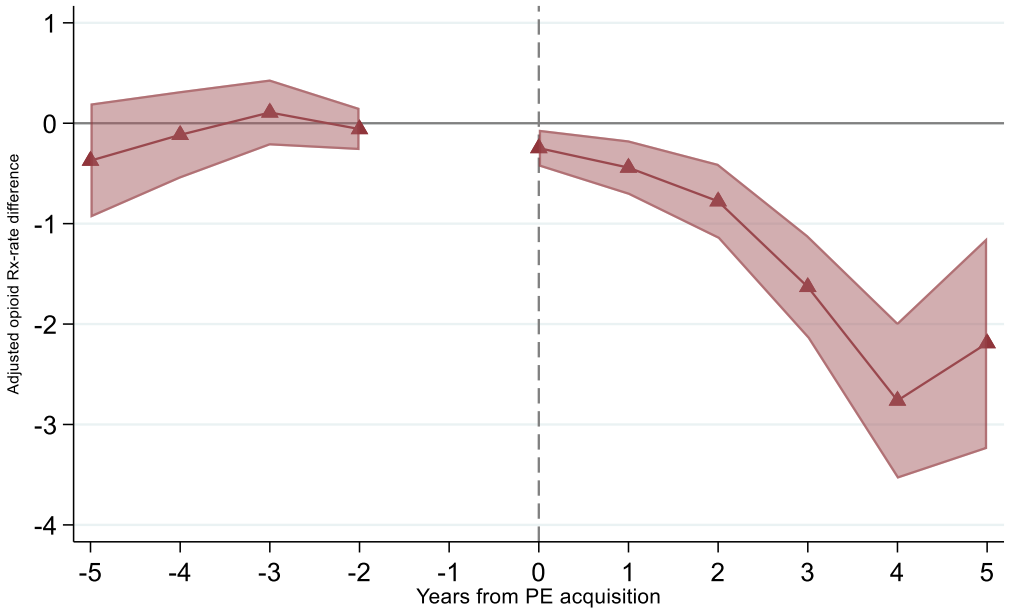


Figure 2. Dynamic effect of PE acquisition on opioid prescriptions (Sun and Abraham (2021))

Notes: This figure presents the dynamic treatment effect of PE acquisition on physicians' opioid prescription rate from five years before the acquisition to five years after the acquisition using estimations proposed by Sun and Abraham (2021) (PSM sample).

Table 1. Summary statistics

Variables	Mean	SD	Max	Min	p25	p50	p75	N
Full sample								
Opioid Prescription Rate	9.999	14.9	100	0	0.228	3.665	12.99	2,291,370
Opioid Patient Rate	21.21	25.66	100	0	2.146	12.31	28.92	2,291,370
Opioid Claims	79.09	180.6	1,164	0	5	13	62	2,291,370
Opioid Drug expenditure	2,985	9,386	67,581	0	73.68	487.1	777.8	2,291,370
Opioid Patient	26.8	41.16	225	0	5	5	34	2,291,370
Total Patient	183.1	195.4	941	5	43	111	254	2,291,370
Total Claim	1,745	3,156	17,396	15	110	357	1790	2,291,370
Total Drug expenditure	177,120	337,442	1.95E+06	131.2	3,197	22,662	197533	2,291,370
Medical Rank	0.87	0.324	1.1	0.01	0.67	1	1.1	2,291,370
Gender	0.647	0.478	1	0	0	1	1	2,291,370
Group Size	171.4	355.7	1,379	2	5	14	106	2,291,370
PDMP	1.396	0.538	2	0	1	1	2	2,291,370
PSM-matched sample								
Opioid Prescription Rate	11.56	15.5	68.9	0	0.237	4.575	18.06	175,964
Opioid Patient Rate	23.03	26.85	100	0	1.969	14	33.33	175,964
Opioid Claims	61.21	153.2	1094	0	5	12	48	175,964
Opioid Drug expenditure	2166	8144	63842	0	63.97	428	487.1	175,964
Opioid Patient	23.84	31.19	113	0	5	5	34	175,964
Total Patient	174.3	183.3	911	5	45	113	233	175,964
Total Claim	1127	2208	12958	13	107	285	948	175,964
Total Drug expenditure	124725	264531	1.59E+06	138.8	2954	13080	110754	175,964
Medical Rank	0.854	0.327	1.1	0.01	0.61	1	1.1	175,964
Gender	0.627	0.484	1	0	0	1	1	175,964
Group Size	38.74	44.52	283	1	7	25	52	175,964
PDMP	1.428	0.532	2	0	1	1	2	175,964
Antipsychotic Prescription Rate	2.103	6.059	100	0	0	0	0.69	175,964

Notes: This table presents the summary statistics of major opioid prescription measures and control variables. *Opioid Prescription Rate* is the percentage of a provider's total claims that are opioid claims. *Opioid Patient Rate* is the percentage of a provider's patients receiving any opioids. *Opioid Claims* is the total number of opioid claims prescribed by each provider. *Opioid Drug expenditure* is the total drug expenditure paid for all the opioid claims prescribed by each provider. *Opioid Patient* is the number of unique patients to whom each provider prescribed opioids. *Total Patient* is the total number of unique patients with at least one claim prescribed by each provider. *Total Claim* is the total number of claims prescribed by each provider. *Medical Rank* is the rank of each physician's initial medical school. *Gender* equals one for male physicians and zero for female physicians. *Group Size* is the total number of physicians in the physician group (in subsequent regressions, *Group Size* is in the logarithm). *PDMP* is a proxy for state-level opioid regulation strictness that equals zero if the state has not adopted a PDMP, equals one if the state adopts PDMP but does not require mandatory access to it, and equals two if the state require mandatory access to PDMP before prescriptions of controlled substances.

Antipsychotic Prescription Rate is the percentage of a provider's total claims that are antipsychotic drug claims.

Table 2. Baseline DID: PE buyout and opioid prescription rate

Variables	(1) Opioid Prescription Rate	(2) Opioid Prescription Rate	(3) Opioid Prescription Rate
PostPE	-0.901***	-0.921***	-0.513***
	[0.157]	[0.157]	[0.153]
Group Size		0.414	0.599
		[0.366]	[0.395]
PDMP		-0.252***	-0.200*
		[0.026]	[0.117]
Constant	10.012***	9.451***	10.138***
	[0.003]	[0.809]	[1.170]
Physician-Group FE	Yes	Yes	Yes
Year FE	Yes	Yes	Yes
State FE	Yes	Yes	Yes
Speciality FE	Yes	Yes	Yes
Observations	2,284,945	2,284,945	172,021
Adjusted R^2	0.861	0.861	0.852
Sample	Full	Full	Matched Sample

Notes: This table presents the results from difference-in-differences (DID) regression of PE acquisition on physicians' opioid prescription rate. An observation is a physician-year. *PostPE* is a dummy variable that equals one if physician *i* is in a group that was acquired by a PE firm at or before year *t*. Other variables are as defined in Table 1. Column (1) reports the regression result without control variables. Column (2) reports the result with the group-level and state-level control variables. Column (3) reports the result using a 1:1 PSM-matched sample. Standard errors clustered at the group level are reported in brackets. ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively.

Table 3. Robustness tests for Difference-in-Differences specification
Panel A. Dynamic effect of PE acquisition on opioid prescriptions

Variables	(1) Opioid Prescription Rate
PrePE (-5)	-0.419
	[0.277]
PrePE (-4)	-0.317
	[0.224]
PrePE (-3)	-0.003
	[0.173]
PrePE (-2)	-0.062
	[0.112]
PostPE (0)	-0.237**
	[0.092]
PostPE (1)	-0.467***
	[0.138]
PostPE (2)	-0.851***
	[0.195]
PostPE (3)	-1.566***
	[0.259]
PostPE (4)	-2.464***
	[0.349]
PostPE (5)	-2.196***
	[0.443]
Group Size	-0.404
	[0.371]
PDMP	-0.165
	[0.116]
Constant	13.141***
	[1.113]
Physician-Group FE	Yes
Year FE	Yes
State FE	Yes
Speciality FE	Yes
Observations	172,021
Adjusted R^2	0.853

Panel B. Average treatment effect of PE acquisition on opioid prescriptions (Estimates proposed by Sun and Abraham (2021) and Callaway and Sant'Anna (2021))

Variables	(1) Opioid Prescription Rate	(2) Opioid Prescription Rate
	Sun and Abraham (2021)	Callaway and Sant'Anna (2021)
PostPE	-1.341***	-0.605***
	[0.227]	[0.101]
Controls	Yes	Yes
Physician-Group FE	Yes	Yes
Year FE	Yes	No
State FE	Yes	No
Speciality FE	Yes	No
Observations	172,021	164,709
Adjusted R^2	0.853	-

Notes: Panel A presents the dynamic effects of PE acquisition on physicians' opioid prescription rate. An observation is a physician-year. *PrePE(-5)* to *PrePE(-1)* are dummy variables that equal one if physician i is in a group that will be acquired by a PE firm five years or more to one year from now. *PrePE(-1)* is the basis of this regression and omitted. *PostPE(0)* is a dummy variable that equals one if physician i is in a group that is acquired by a PE firm this year. *PostPE(1)* to *PostPE(5)* are dummy variables that equal one if physician i is in a group that was acquired by a PE firm one year to five years ago or more. Panel B presents the average treatment effects of PE acquisition on physicians' opioid prescription rate using estimations proposed by Sun and Abraham (2021) and Callaway and Sant'Anna (2021). An observation is a physician-year. *PostPE* is a dummy variable that equals one if physician *i* is in a group that was acquired by a PE firm at or before year *t*. The regression controls for a same set of controls as the baseline regression in Table 2, while the coefficients are suppressed for brevity. Column (1) reports the regression results using estimations proposed by Sun and Abraham (2021). Column (2) reports the regression results using estimations proposed by Callaway and Sant'Anna (2021). Standard errors clustered at the group level are reported in brackets. ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively.

Table 4. Robustness tests for identification concerns

Panel A. Patient case mix

Variables	(1) Avg HCC risk score	(2) % female	(3) % white	(4) % black	(5) % hispanic	(6) Avg patient age
PostPE	0.006	0.000	-0.613	0.703	-0.120	0.180***
	[0.006]	[0.082]	[0.620]	[0.538]	[0.190]	[0.066]
Group Size	0.032**	-0.020	-0.416	0.522	-0.081	-0.181
	[0.013]	[0.183]	[1.705]	[1.646]	[0.394]	[0.144]
PDMP	-0.001	-0.124*	-0.919***	0.409	0.095	-0.033
	[0.005]	[0.065]	[0.344]	[0.295]	[0.151]	[0.049]
Constant	1.451***	60.134***	73.421***	11.867***	9.547***	70.334***
	[0.040]	[0.547]	[4.665]	[4.522]	[1.103]	[0.433]
Physician-Group FE	Yes	Yes	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes	Yes	Yes
State FE	Yes	Yes	Yes	Yes	Yes	Yes
Observations	170,727	141,756	4,599	4,599	4,599	170,728
Adjusted R^2	0.795	0.827	0.983	0.967	0.996	0.836

Panel B. Placebo tests with chronic drug prescription

Variables	(1) Hypertension Prescription Rate	(2) Diabetes Prescription Rate
PostPE	0.114	-0.000
	[0.101]	[0.014]
Group Size	0.054	-0.024
	[0.207]	[0.038]
PDMP	-0.015	0.032***
	[0.066]	[0.012]
Constant	5.847***	0.685***
	[0.627]	[0.117]
Physician-Group FE	Yes	Yes
Year FE	Yes	Yes
State FE	Yes	Yes
Speciality FE	Yes	Yes
Observations	172,021	172,021
Adjusted R^2	0.684	0.763

Panel C. Logit regression of PE acquisition on pre-acquisition opioid prescribing (physician group level)

Variables	(1) PE acquisition	(2) PE acquisition	(3) PE acquisition
Opioid Prescription Rate [T-1]	0.320		
	[0.200]		
Average Opioid Prescription Rate [T-1, T-3]		-0.371	
		[0.316]	
Growth of Opioid Prescription Rate [T-1, T-3]			0.0003

			[0.001]
Initial Group Size	0.006***	0.006***	0.006***
	[0.000]	[0.001]	[0.001]
Initial PDMP	0.130**	-0.035	0.069
	[0.055]	[0.073]	[0.072]
Constant	-6.639***	-6.460***	-6.611***
	[0.083]	[0.117]	[0.109]
Observations	745,400	424,064	436,739

Notes: Panel A presents falsification tests on patient case mix. An observation is a physician-year. The dependent variables are aggregated at the prescriber-year level in the CMS Medicare Part D Prescribers-by-Provider file and capture the demographic and clinical composition of each physician's Medicare beneficiaries: the average Hierarchical Condition Category (HCC) risk score (column 1), a summary index of beneficiaries' expected clinical complexity and morbidity; the share of beneficiaries who are female (column 2); the shares who are White, Black, and Hispanic (columns 3–5); and the average beneficiary age (column 6). PostPE is a dummy variable that equals one if physician i is in a group that was acquired by a PE firm at or before year t. Because CMS suppresses beneficiary race counts derived from fewer than 11 beneficiaries, the race-composition regressions in columns (3)–(5) are estimated on a substantially smaller sample. Panel B presents the results of the placebo test on chronic drug prescriptions. Column (1) reports the regression results on physicians' hypertension drug prescription rate. *PostPE* is a dummy variable that equals one if physician *i* is in a group that was acquired by a PE firm at or before year *t*. *Hypertension Prescription Rate* is the percentage of a provider's total claims that are most frequently used hypertension-controlling drug claims. Column (2) reports the regression results on physicians' diabetes drug prescription rate. *Diabetes Prescription Rate* is the percentage of a provider's total claims that are most frequently used diabetes-treating drug claims. Panel C presents logit regressions testing whether PE acquisition can be predicted by pre-acquisition opioid prescribing. An observation is a group-year. *PE acquisition* is a dummy variable that equals one if group i is acquired by a PE firm this year and zero otherwise. *Opioid Prescription Rate [T-1]* is the percentage of a group's total claims that are opioid claims at the year before it was acquired by a PE firm. *Initial Group Size* is the total number of physicians in a group at the year before it was acquired by a PE firm. *Initial PDMP* is the state-level PDMP adoption status of a group at the year before it was acquired by a PE firm. *Average Opioid Prescription Rate [T-1, T-3]* is the average group opioid prescription rate over the three years prior to the PE acquisition. *Growth of Opioid Prescription Rate [T-1, T-3]* is the growth of group opioid prescription rate over the three years prior to the PE acquisition. Column (1) report the regression result of the initial opioid prescription rate of the medical group one year before the acquisition on the PE acquisition dummy. Column (2) and column (3) report the regression result of the average prescription rate and prescription rate growth over the three years prior to the acquisition on the PE acquisition dummy, respectively. Other variables are as defined in Table 1. Standard errors clustered at the group level are reported in brackets. ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively.

Table 5. Mechanism: Regulatory and litigation risk: State PDMP regulation, FCA legal settlement, and opioid prescription rate reduction.

	PDMP regulation	FCA
	(1)	(2)
Variables	Opioid Prescription Rate	Opioid Prescription Rate
PDMP Tighten × PostPE	-0.279***	
	[0.094]	
PDMP Tighten	-0.090	
	[0.057]	
PostFCA × PostPE		-0.315**
		[0.145]
PostPE	-0.382***	-0.377***
	[0.074]	[0.131]
Group Size	0.547***	0.497
	[0.155]	[0.397]
PDMP		-0.190
		[0.117]
Constant	10.036***	10.429***
	[0.460]	[1.178]
Physician-Group FE	Yes	Yes
Year FE	Yes	Yes
State FE	Yes	Yes
Speciality FE	Yes	Yes
Observations	172,021	172,021
Adjusted R^2	0.852	0.852

Notes: This table presents results from a difference-in-difference-in-difference (DDD) regression of the interaction of PDMP regulation / FCA legal settlement and PE acquisition on physicians' opioid prescription rate. An observation is a physician-year. Column (1) reports the impact of PDMP tightening on the reduction effect of PE acquisition on opioid prescriptions. *PDMP Tighten* is an indicator equals one after the state adopts tighter PDMP regulations, including both from no PDMP to adopting PDMP and from simply adopting PDMP to requiring mandatory access to PDMP. Column (2) presents the results from a DDD regression of the interaction of the settlement of the lawsuit and PE acquisition on physicians' opioid prescription rate. *PostPE* is a dummy variable that equals one if physician *i* is in a group that was acquired by a PE firm at or before year *t*. *PostFCA* is a dummy variable that equals one if the observation is after the first violation of the False Claims Act from a private equity firm in health care in year 2019. Other variables are as defined in Table 1. Standard errors clustered at the group level are reported in brackets. ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively.

Table 6. Heterogeneity: Role of PE Financial Constraint

Variables	(1) Opioid Prescription Rate	(2) Opioid Prescription Rate	(3) Opioid Prescription Rate
PostPE × Listed	-1.503***		
	[0.319]		
PostPE × High size&age		-1.068***	
		[0.271]	
PostPE × Big last fund			-0.543*
			[0.280]
PostPE	-0.108	0.133	-0.233
	[0.172]	[0.205]	[0.211]
Group Size	0.334	0.662*	0.615
	[0.401]	[0.389]	[0.391]
PDMP	-0.191*	-0.213*	-0.201*
	[0.116]	[0.116]	[0.116]
Constant	10.929***	9.965***	10.090***
	[1.194]	[1.152]	[1.160]
Physician-Group FE	Yes	Yes	Yes
Year FE	Yes	Yes	Yes
State FE	Yes	Yes	Yes
Speciality FE	Yes	Yes	Yes
Observations	172,021	172,021	172,021
Adjusted R^2	0.852	0.852	0.852

Notes: This table presents results from a difference-in-difference-in-difference (DDD) regression of the interaction of PE financial resources and PE acquisition on physicians' opioid prescription rate. An observation is a physician-year. *PostPE* is a dummy variable that equals one if physician *i* is in a group that was acquired by a PE firm at or before year *t*. Column (1) reports the impact of PE firms' listing status on their opioid prescription reduction effect. *Listed* is an indicator that equals one if the PE acquirer (or the sponsor of the PE acquirer) is a listed private equity firm and zero otherwise. Column (2) reports the impact of PE firms' size and age on their opioid prescription reduction effect. *High size&age* equals one if the PE lies in the top half of both PE size (asset under management) distributions and age distribution in the year before the acquisition, and zero otherwise. Column (3) reports the impact of PE firms' last fund size on their opioid prescription reduction effect. *Big last fund* equals one if the PE lies in the top half of the last fund size distributions of PE firms, and zero otherwise. Other Variables are as defined in Table 1. Standard errors clustered at the group level are reported in brackets. ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively.

Table 7. Heterogeneity: PE CSR preference

Variables	(1) Opioid Prescription Rate	(2) Opioid Prescription Rate
PostPE × CSR Score	-1.452*	
	[0.788]	
PostPE × PRI Signatory		-1.400***
		[0.384]
PostPE	-1.442***	-0.264
	[0.491]	[0.164]
Group Size	0.372	0.496
	[0.569]	[0.396]
PDMP	-0.211	-0.195*
	[0.136]	[0.116]
Constant	10.994***	10.442***
	[1.722]	[1.177]
Physician-Group FE	Yes	Yes
Year FE	Yes	Yes
State FE	Yes	Yes
Speciality FE	Yes	Yes
Observations	128,116	172,021
Adjusted R^2	0.855	0.852

Notes: This table presents results from a difference-in-difference-in-difference (DDD) regression of the interaction of PE social responsibility and PE acquisition on physicians' opioid prescriptions. An observation is a physician-year. *PostPE* is a dummy variable that equals one if physician *i* is in a group that was acquired by a PE firm at or before year *t*. Column (1) reports the impact of PE firms' institutional CSR score on their opioid prescription reduction effect. *CSR Score* is the weighted average size-adjusted MSCI KLD ratings of the portfolio firms for the PE acquirer in the year before the acquisition. Column (2) reports the impact of PE firms' PRI signatory status on their opioid prescription reduction effect. PRI *Signatory* is a dummy variable that equals one if the PE acquirer had signed the Principles for Responsible Investment at the time of the acquisition. Other variables are as defined in Table 1. Standard errors clustered at the group level are reported in brackets. ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively.

Appendix A. Additional Results

Table A1. PE acquisition of Physician Medical Groups during 2014 to 2019

Year	(1) # of Events	(2) # of Affected Groups	(3) # of Affected Physicians
2014	18	75	876
2015	30	147	1,456
2016	59	232	2,195
2017	116	498	4,005
2018	141	626	4,665
2019	116	489	2,419
Total	480	2,067	15,616

Notes: This table presents the number of PE buyouts in each year and the number of physician medical groups and physicians involved in these acquisitions. Column (1) reports the number of PE buyouts of physician medical groups in each year in our sample. Column (2) reports the number of physician medical groups acquired by PE firms in each year in our sample. Column (3) reports the number of physicians acquired in PE buyouts in each year in our sample.

Table A2. PE acquisition and opioid patient rate

Variables	(1) Opioid Patient Rate	(2) Opioid Patient Rate	(3) Opioid Patient Rate
PostPE	-1.140***	-1.164***	-0.646**
	[0.304]	[0.303]	[0.327]
Group Size		0.376	0.827
		[0.665]	[0.745]
PDMP		-0.453***	-0.235
		[0.056]	[0.240]
Constant	20.433***	20.236***	20.844***
	[0.005]	[1.471]	[2.221]
Physician-Group FE	Yes	Yes	Yes
Year FE	Yes	Yes	Yes
State FE	Yes	Yes	Yes
Speciality FE	Yes	Yes	Yes
Observations	2,284,945	2,284,945	172,021
Adjusted R^2	0.656	0.656	0.665

Notes: This table presents results from difference-in-differences (DID) regression of PE acquisition on physicians' opioid patient rate. An observation is a physician-year. *Opioid Patient Rate* is the percentage of a provider's patients receiving any opioids. *PostPE* is a dummy variable that equals one if physician *i* is in a group that was acquired by a PE firm at or before year *t*. Other variables are as defined in Table 1. Column (1) reports the regression result without control variables. Column (2) reports the result with the group-level and state-level control variables. Other variables are as defined in Table 1. Standard errors clustered at the group level are reported in brackets. ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively.

Table A3. Subsample of physicians specialized in family medicine, emergency medicine, internal medicine and general groups

Variables	(1) Opioid Prescription Rate
PostPE	-1.655***
	[0.216]
Group Size	-0.598***
	[0.073]
PDMP	-0.305***
	[0.041]
Constant	10.844***
	[0.272]
Physician-Group FE	Yes
Year FE	Yes
State FE	Yes
Speciality FE	Yes
Observations	716,469
Adjusted R^2	0.806

Notes: This table presents results from difference-in-differences (DID) regression of PE acquisition on physicians' opioid prescription rate in general groups. An observation is a physician-year. This subsample regression only contains physicians specialized in family medicine, emergency medicine, internal medicine and physicians work in general groups. *PostPE* is a dummy variable that equals one if physician *i* is in a group that was acquired by a PE firm at or before year *t*. Other variables are as defined in Table 1. Standard errors clustered at the group level are reported in brackets. ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively.

Table A4. Robustness check with an expanded sample that retains all observed physicians in the matched treated and control groups

Variables	(1) Opioid Prescription Rate
PostPE	-0.429***
	[0.146]
Group Size	0.135
	[0.249]
PDMP	-0.178
	[0.110]
Constant	11.791***
	[0.780]
Physician-Group FE	Yes
Year FE	Yes
State FE	Yes
Speciality FE	Yes
Observations	197,042
Adjusted R^2	0.866

Notes: This table presents the re-estimation of the baseline results with an expanded sample that retains all observed physicians in the matched treated and control groups, including those who are observed only before the acquisition (leavers), only after (joiners), or in only a subset of sample years. An observation is a physician-year. *PostPE* is a dummy variable that equals one if physician *i* is in a group that was acquired by a PE firm at or before year *t*. Other variables are as defined in Table 1. Standard errors clustered at the group level are reported in brackets. ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively.

Table A5. Physician mobility around PE acquisition

Panel A: Group mobility rates

Variables	(1) Log (Group Size)	(2) Entry Rate	(3) Exit Rate	(4) Net Flow
PostPE	0.005	-0.049	0.021***	-0.070
	[0.023]	[0.064]	[0.008]	[0.065]
Constant	2.155***	0.141***	0.087***	0.054
	[0.012]	[0.035]	[0.004]	[0.035]
Year FE	Yes	Yes	Yes	Yes
State FE	Yes	Yes	Yes	Yes
Group-Event FE	Yes	Yes	Yes	Yes
Observations	8,802	8,802	8,802	8,802
Adjusted R^2	0.772	0.031	0.188	0.030

Notes: This panel presents the impact of PE buyout on physician mobility. Each observation is at group-year level. *Group Size* is the count of unique physicians (NPIs) affiliated with the group in year t. *Entry Rate* equals the number of NPIs newly observed in year t divided by *Group Size* in year t-1; *Exit Rate* is defined analogously for NPIs no longer observed; *Net Flow* equals *Entry Rate* minus *Exit Rate*. *PostPE* is an indicator for years at or after the (pseudo-)acquisition. Specifications include group-by-event, year, and state fixed effects. Standard errors clustered at the (group × matched-event) level in brackets. ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively.

Panel B: Average pre-acquisition opioid prescription rate by physician roles

Physician Role	(1) Control Groups	(2) Treated Groups	(3) N (Control)	(4) N (Treated)
Stayers	8.44	13.60	3,224	8,559
Leavers	9.95	12.04	6,476	9,444
Joiners	5.49	14.41	250	1,781

Notes: Each cell reports the average pre-acquisition Medicare Part D opioid prescription rate (in percent of total claims) within a (treated × physician role) cell. Stayers are physicians observed in the matched group both before and after the (pseudo-)acquisition event; leavers are observed only before; joiners are observed only after. The pre-acquisition rate is computed at the NPI level using all observations with year less than the (pseudo-)acquisition year and Medicare Part D data available. For joiners, the rate is computed from the NPI's prescribing history in any prior year of the expanded panel, which captures their prescribing in their previous practice setting. ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively.

Panel C: Pre-acquisition opioid prescription rate of different physician roles

Variables	(1) Opioid Prescription Rate
Leaver	0.020
	[0.595]
Joiner	-1.796
	[1.460]
Treated	1.296*
	[0.696]
Treated x Leaver	0.906
	[0.806]
Treated x Joiner	3.322

	[2.349]
State FE	Yes
Speciality FE	Yes
Observations	29,259
Adjusted R^2	0.479

Notes: Each observation is at the physician-year level. The dependent variable is physicians' pre-acquisition opioid prescription rate, defined as the average of the corresponding rate in years prior to the (pseudo-)acquisition. Leavers are observed only before the (pseudo-)acquisition event; joiners are observed only after. Treated equals one if the physician is affiliated with acquired physician group and zero otherwise. Standard errors are clustered at the matched-event level. ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively.

Table A6. Regulatory and litigation risk: State PDMP regulation

	PDMP regulation
	Only keep PE acquisitions before state adopts tighter PDMP
	(1)
Variables	Opioid Prescription Rate
PDMP Tighten × PostPE	-0.513***
	[0.121]
PDMP Tighten	-0.011
	[0.074]
PostPE	-0.641***
	[0.099]
Group Size	1.012***
	[0.220]
Constant	9.121***
	[0.656]
Physician-Group FE	Yes
Year FE	Yes
State FE	Yes
Speciality FE	Yes
Observations	102,839
Adjusted R^2	0.858

Notes: This table presents results from a difference-in-difference-in-difference (DDD) regression of the interaction of regulation on PDMP and PE acquisition on physicians' opioid prescription rate. An observation is a physician-year. Column (1) presents the results in a subsample of PE acquisitions happened before the state adopted a tighter PDMP regulation. *PDMP Tighten* is an indicator equals one after the state adopts tighter PDMP regulations, including both from no PDMP to adopting PDMP and from simply adopting PDMP to requiring mandatory access to PDMP. *PostPE* is a dummy variable that equals one if physician *i* is in a group that was acquired by a PE firm at or before year *t*. Other variables are as defined in Table 1. Standard errors clustered at the group level are reported in brackets. ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively.

Table A7. PE buyout and antipsychotic drug prescriptions

	(1)
Variables	Antipsychotic Prescription Rate
PostPE	-0.243**
	[0.096]
Group Size	-0.107
	[0.215]
PDMP	-0.059
	[0.056]
Constant	2.511***
	[0.643]
Physician-Group FE	Yes
Year FE	Yes
State FE	Yes
Speciality FE	Yes
Observations	172,021
Adjusted R^2	0.374

Notes: This table presents results from difference-in-difference (DID) regression of PE acquisition on physicians' antipsychotic drug prescription rate. An observation is a physician-year. *PostPE* is a dummy variable that equals one if physician *i* is in a group that was acquired by a PE firm at or before year *t*. *Antipsychotic Prescription Rate* is the percentage of a provider's total claims that are antipsychotic drug claims. Other variables are as defined in Table 1. Standard errors clustered at the group level are reported in brackets. ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively.

Appendix B. Supplementary IV Estimation

To further mitigate concerns over selection bias, we employ an instrumental variable (IV) that exploits staggered adoption of the Corporate Practice of Medicine (CPOM) Doctrine, following the spirit of Liu (2021) and Gao, Kim and Sevilir (2025). The CPOM doctrine prohibits corporations, including PE firms, from practicing medicine or directly employing physicians to provide professional medical services. In states with strict CPOM enforcement, PE firms would have to adopt more complex acquisition structures, such as forming management services organizations (MSOs) instead of directly acquiring and owning the medical group, to circumvent the regulation. This increases the cost and legal risk associated with acquisitions, making PE investments in these states less attractive. The interpretation and enforcement of CPOM vary across states and over time, largely due to differences in state statutes, court rulings, and official opinions. Therefore, these regulatory changes provide exogenous variations in PE's cost when making acquisition decisions.

In that sense, we construct the *CPOM index* to measure that captures this variation by aggregating three components: (i) state statutes or regulations, (ii) case law, and (iii) opinions issued by the state attorney general or medical board. The construction of the index starts from a survey summary of CPOM doctrine across 50 states in 2006 by Michal et al. (2006). Following Liu (2021), starting from year 2006, State statute indicator in 2006 equals (negative) one if the statute of a state explicitly prohibits (allows) CPOM, and zero otherwise; Legal precedent indicator equals (negative) one if any previous state supreme court rulings were against (in favor of) CPOM, and zero otherwise; Board opinion indicator equals (negative) one if opinions from the attorney general or medical board of a state are against (in favor of) CPOM, and zero otherwise. For years from 2006 to 2020, we track changes in state statutes regarding CPOM based on a summary by Liu (2021) and manual web search. If any record was to relax (strengthen) the CPOM prohibition in a state of year *t*, a new value will be assigned

as the previous value minus (plus) one. Then we construct the CPOM index for each state in each year by aggregating the value of three dimensions. The CPOM regulations can make the acquisition process more complex and might require PE firms to invest more resources into structuring and completing deals. This complexity might deter some PE firms from pursuing practices in the state. Therefore, a higher value of the CPOM index implies stronger CPOM prohibition, thus a lower likelihood of PE acquisitions.

Our IV design is valid for exclusion condition as it utilize the change of state regulation largely exogenous to PE influence. It also satisfies the relevance condition as shown in the first stage result of two-stage least squares (2SLS) estimation in column (1) of Table B1. We can see a significant, negative relationship between the CPOM index and PE acquisition of physician medical groups. PE firms are less likely to acquire medical groups in states with more stringent CPOM regulations. The first stage is statistically significant, although the Kleibergen-Paap F-statistic suggests that the IV estimates should be interpreted cautiously. We therefore view the IV analysis as complementary evidence rather than the primary source of identification. The second-stage regression results are shown in column (2) of Table B1. The coefficient on the IV for the opioid prescription rate is negative and significant at the 5% level, indicating that PE buyouts reduce opioid prescribing. Compared with the baseline results in Table 2, the significance of the coefficient drops. This is reasonable because the IV estimator isolates exogenous variation in PE acquisitions driven by regulatory shifts.

Panel B1. IV estimation

	(1) IV first stage	(2) IV second stage
Variables	PE acquisition	Opioid Prescription Rate
CPOM index	-0.047**	
	[0.019]	
PostPE (IV)		-9.088**
		[4.321]
Group Size	0.148***	1.873**
	[0.045]	[0.771]
PDMP	-0.018	-0.270
	[0.015]	[0.190]
Physician-Group FE	Yes	Yes
Year FE	Yes	Yes
State FE	Yes	Yes
Speciality FE	Yes	Yes
Observations	172,021	172,021
KP F Stat	6.37	6.37

Notes: This table presents the results from an instrumental variable regression. An observation is a physician-year. Column (1) presents the first-stage result. Column (2) presents the second-stage result of the IV regression. The IV is constructed as the state-level *CPOM index*. *CPOM index* measures the strictness of state-level restrictions on corporate ownership or control of medical practices. It aggregates three components: (i) statutes or regulations, (ii) legal precedents, and (iii) official opinions from state attorneys general or medical boards. Each component is initially coded as +1 (explicitly prohibits CPOM), –1 (explicitly permits CPOM), or 0 (neutral). The index is updated annually from a 2006 baseline. If a state subsequently strengthens (relaxes) CPOM restrictions, the corresponding component increases (decreases) by 1. A higher value of *CPOM index* implies stronger CPOM prohibition. *PE acquisition* is a dummy variable that equals one if group i is owned by a PE firm this year and zero otherwise. Other variables are as defined in Table 1. Standard errors clustered at the group level are reported in brackets. ***, **, and * denote statistical significance at the 1%, 5%, and 10% levels, respectively.