Does Private Equity Investment in Healthcare Benefit Patients? Evidence from Nursing Homes*

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This version: November, 2020

Abstract

The past two decades have seen a dramatic increase in private equity investment in healthcare, a sector in which intensive government subsidy and market frictions could lead high-powered for-profit incentives to be misaligned with the social goals of quality care at a reasonable cost. This paper studies the effects of private equity ownership on patient welfare and spending at nursing homes. With administrative patient-level data, we use a within-facility differences-in-differences design to address non-random targeting of facilities. As patient composition changes after buyouts, we use an instrumental variables strategy to control for the selection of patients into nursing homes. The estimates show that private equity ownership increases short-term mortality by 10%, which implies about 21,000 lives lost due to private equity ownership over our sample period. Private equity ownership also increases spending by 19%, the vast majority of which is billed to taxpayers. We observe several channels

*We are grateful to Abby Alpert, Pierre Azoulay, Liran Einav, Matthew Grennan, Arpit Gupta, Jarrad Harford, Adam Sacarny, Arthur Robin Williams, and participants at the NBER Aging Summer Institute, UBC Winter Finance Conference, Whistler Junior Health Economics Summit, Virtual Corporate Finance Seminar, ESSEC, Norwegian School of Economics, Oklahoma, Private Equity Research Consortium (PERC) Annual Symposium, Tulane, NYU Stern, Wharton, Yale Health Policy, and Johns Hopkins Carey for their comments and suggestions. Jun Wong, Mei-Lynn Hua, and Sarah Schutz provided excellent research assistance. We thank Christianna Williams of Abt Associates for insights into CMS quality measures, Liz Liberman for industry information, and Mohan Ramanujan at NBER for assistance with the CMS data. Funding from the Dean's Research Fund and the Mack Institute at Wharton (Gupta), the Kauffman Foundation (Howell), and the Fama Miller Center at the University of Chicago (Yannelis) is greatly appreciated. We gratefully acknowledge funding through National Institute of Aging pilot grant P01AG005842-31. All remaining errors are our own.

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that help explain the increase in mortality: declines in patient-level health measures, such as worsening mobility and elevated use of anti-psychotic medications; declines in nurse availability per patient; and declines in compliance with federal and state standards of care.

1 Introduction

It is well-documented that the US has higher healthcare spending and growth than other developed countries, without delivering comparable health outcomes (Garber and Skinner, 2008). Private equity ownership of healthcare providers may serve to mitigate these trends, because empirical evidence from other sectors suggests that private equity owners deploy new technology and improve the target firm's productivity and product quality (Kaplan, 1989; Lerner et al., 2011; Boucly et al., 2011; Davis et al., 2014; Agrawal and Tambe, 2016; Gupta and Van Nieuwerburgh, 2019). Private equity funds have dramatically increased their footprint in the healthcare sector over the last two decades (see Figure 1) and are well poised to drive systemic change. Indeed, private equity-owned firms provide the staffing for more than one-third of emergency rooms in the US (Morgenson and Saliba, 2020), owned the largest hospital and nursing home chains in the US for several years, and are rapidly growing their ownership of physician practices across multiple specialties (Bruch et al., 2020; Brown et al., 2020; Casalino, 2020).[1]

Why would we expect differential performance under private equity ownership? While private firms seek to maximize profits, private equity ownership confers distinct incentives to quickly and substantially increase the value of their portfolio firms. This is because fund managers are compensated through a call option-like share of the profits, employ large amounts of leverage, aim to liquidate investments within a short time frame, and do not have existing relationships with target firm stakeholders (Kaplan and Stromberg, 2009). Private equity funds acquire companies primarily using debt that is placed on the target company's balance sheet and managers typically do not earn returns if the business continues as-is, which help explain the aggressive value-creation strategies. In contrast, a traditional business owner running the firm as a long-term going concern with a lower debt burden may prefer lower but more stable profits.

[1]Private equity firm Kohlberg, Kravis and Roberts (KKR) led a leveraged buyout of the largest hospital chain, Hospital Corporation of America (HCA), in 2006 and exited by taking it public in 2011. Formation Capital led a buyout of the largest nursing home chain, Genesis Healthcare, in 2007 and exited its stake in 2014 when Genesis was merged with a publicly listed firm.

The healthcare sector is somewhat peculiar due to the presence of information frictions, large and inefficient government payers, and relatively low competition (Cutler, 2011; Skinner, 2011). Noisy quality signals and generous insurance coverage weaken consumer demand responses that would otherwise regulate the growth of poor quality firms (Chandra et al., 2016). These factors could lead the particularly high-powered profit-maximizing incentives that characterize private equity to have detrimental implications for consumer welfare (Hansmann, 1980; Hart, Shleifer and Vishny, 1997). Critics argue that private equity managers aggressively drive profits at the patient's expense and capture government subsidies. Policymaker concern over the role of private equity in healthcare is wide-ranging, for example, surprise medical bills (Brown et al., 2019; Cooper et al., 2020), nursing home quality (Doggett et al., 2020), and predatory acquisitions of physician practices (King, 2020).[2] Policymakers' concern about private equity extends internationally; for example, in 2019 a member of the British Parliament argued that private equity-owned nursing homes in the UK pursue "profiteering, cost and corner cutting, all the while their owners are loading them up on debt with high interest rates and expecting the taxpayer to pay when it fails" (Hodgson, 2020). Unfortunately, evidence to inform this animated policy debate is limited and inconclusive, with little known about the effects nationally on patient outcomes and spending (Gondi and Song, 2019; Casalino, 2020).

This paper attempts to address this gap by providing new empirical evidence on the causal effects of private equity ownership in healthcare from the setting of nursing homes—a large sector with $166 billion in spending (Martin et al., 2018) that is interesting to study in and of itself. Its size and importance is expected to grow rapidly as the U.S. population ages—nearly 70% of adults aged 65 and older experience the need for long-term care at least once, and this group is expected to increase from 13% of the population in 2010 to 20% in 2030 (CBO, 2012; Johnson, 2019). Further, this sector has two unique features suited to answering our research question. First, private equity firms have substantial presence in this

[2]The US Congress held hearings in 2019 on the role of private equity in the economy. Three U.S. Senators asked questions about "the role of private equity firms in the nursing home care industry, and the extent to which these firms' emphasis on profits and short-term return is responsible for declines in quality of care." A different set of US Congress members argued that a private equity firm sought to "enrich wealthy investors at the expense of health care workers and the quality of patient care." Also see Flood (2019) and Lewis (2019).

sector and have bought out both several large chains and independent facilities. Hence, we can make progress in isolating the effects of private equity ownership distinctly from the related phenomenon of the corporatization of medical care (Eliason et al., 2020). Second, nursing homes have historically had a very high rate of for-profit ownership (about 70%).[3] Hence, we can quantify the effects of private equity ownership distinctly from those of generic for-profit ownership.

We use patient- and facility-level administrative data on nursing homes from the Centers for Medicare & Medicaid Services (CMS), which we match to private equity deal data. The data include 18,485 unique nursing homes between 2000 and 2017. Of these, 1,674 were acquired by private equity firms in 118 unique deals.[4] Our patient-level sample is limited to short-stay elderly Medicare patients sent for skilled nursing care following a hospital stay. We observe about seven million unique patients.

We overcome two challenges to estimating causal effects of ownership. The first is selection of patients; the composition of patients may change endogenously, perhaps reflecting new advertising, hospital ties, or patient reactions to quality. We control for the patient-firm match with a differential distance instrumental variables (IV) strategy (McClellan, McNeil and Newhouse (1994); Card, Fenizia and Silver (2019)), taking advantage of patients' tendency to prefer a facility close to their home—the 90^{th} percentile distance to facility is less than 20 miles, and the median distance is 4.6 miles. The second challenge is the non-random selection of acquisition targets. To address this we include facility fixed effects, which also address any cross-sectional differences in the types of locations where private equity firms tend to buy nursing homes. To our knowledge, no single previous study on private equity or on ownership in healthcare has simultaneously addressed both challenges.

The gold-standard measure of patient welfare is the effect of care on short-term survival. We find that going to a private equity-owned nursing home increases the probability of death

[3] In 2017, about 70% of nursing homes were for-profit owned, while the corresponding figure was 18% in case of hospitals (MedPAC, 2019).

[4] PE firms often acquire entire chains in one deal, hence a single deal can sometimes involve hundreds of facilities. See Table B.4 for a list of the top 10 deals in our sample and their corresponding deal years and numbers of facilities involved. The top 10 deals account for about 1,300 facilities.

during the stay and the following 90 days by 1.8 percentage points, about 10% of the mean. This estimate implies about 21,000 lives and 205,000 life-years lost due to private equity ownership of nursing homes during our sample period. The mortality effect is concentrated among older patients, especially those with relatively low disease burdens. This effect is robust to a battery of specification checks, and does not appear in a placebo analysis where we test for effects prior to the buyout. The estimate is unaffected when we restrict our attention to the largest chains acquired by private equity, where chain size remained constant over the sample period. Hence, we interpret this as the effect of a change in ownership, and not driven by consolidation or corporatization.

Using a conventional value of a life-year from the literature, we value this mortality cost at about $27 billion in 2016 dollars (Cutler and McClellan, 2001). To put the magnitude of this mortality cost in perspective, it far exceeds the total reimbursements received by private equity nursing homes from Medicare in our sample (about $17 billion). In contrast with a narrative in which private equity ownership improves the efficiency of care provision, we find that the amount billed per stay increases by 19%.

To investigate the possible mechanisms driving this mortality effect, we examine three channels. The first is composed of measures of patient well-being. We find that going to a private equity-owned nursing home increases the probability of taking anti-psychotic medications by 50%. These drugs are increasingly discouraged in the elderly due to their association with greater mortality. We also find differential worsening of pain and declining mobility for patients at private equity owned homes.

The next two channels employ facility-level data, where we use a differences-in-differences research design.[5] The first set of outcomes measure nurse availability, which has been recognized as the most important determinant of quality of care (Zhang and Grabowski, 2004; Lin, 2014). We find that private equity ownership leads to a 3% decline in the per-patient availability of front line caregivers such as Certified

[5]The first difference compares private equity-owned facilities before and after acquisition, and the second difference compares target facilities to those that were never private equity-owned. Facility and year fixed effects eliminate time-invariant unobserved heterogeneity across facilities and secular trends. For all outcomes using this approach, we provide evidence on dynamic effects to assess the parallel trends assumption.

Nursing Assistants (CNAs) and Licensed Practical Nurses (LPNs). These nurses provide the most time-intensive caregiving, including the day-to-day crucial tasks for well-being of providing mobility assistance, personal interaction, and cleaning to minimize infection risk and ensure sanitary conditions.

The loss of front-line staff is most problematic for older but relatively less sick patients, who drive the mortality result. There may be less scope to reduce the costs of care for the sicker patients, as they have explicit medical needs. The elevated use of anti-psychotics discussed earlier may also be partly explained as a substitution response to lower nurse availability (Cawley, Grabowski and Hirth (2006)). By applying previously published mortality effects of using anti-psychotics (Schneider et al., 2005) and lower nurse availability (Tong, 2011) and assuming these factors are additive, we can explain about a third of the mortality effect. However, this may be an understatement if these factors are more harmful when they interact, as is the case here.

Finally, we find negative effects on facility Five Star ratings, which are constructed by CMS to provide summary information on quality of care.[6] Specifically, we find declines in compliance with state and federal operating standards as well as on a composite measure of patient quality outcomes, even though our main quality measure (mortality) does not contribute to five star ratings.

This paper contributes to three strands of the literature. First, we add to growing evidence on the role of private equity managers in target firm operations. Our results strengthen the view that fund managers actively intervene in portfolio company management (Davis et al. (2014); Bernstein and Sheen (2016) ;Biesinger, Bircan and Ljungqvist (2020)). We overcome most limitations of previous studies on private equity in healthcare, such as limited geographies or a short sample period (Pradhan et al., 2013, 2014; Huang and Bowblis, 2019) or a small number of large deals (Stevenson and Grabowski, 2008; Harrington et al., 2012; Cadigan et al., 2015). In a contemporaneous paper, Gandhi et al. (2020) use facility-level data and focus on the interaction of private equity ownership of nursing homes and the level

[6]The apparent disconnect between demand and quality of care may reflect information frictions in nursing home quality transparency. Prior studies have found weak or no demand response to information about nursing home care quality, in particular CMS' Five Star Ratings (Grabowski and Town, 2011; Werner et al., 2012).

of market competition.

In contrast with much of the existing literature, and likely reflecting the considerable market imperfections in healthcare, our results suggest that private equity owners may breach implicit contracts with stakeholders to maximize profits (Shleifer and Summers, 1988). Eaton, Howell and Yannelis (2019) come to the same conclusion in their study of private equity ownership of colleges. While both healthcare and education are characterized by information frictions, lack of competition, and pervasive subsidies, it is noteworthy that nursing homes operate under much more intense regulatory scrutiny of their daily operations than do colleges. Hence, these results also raise concerns about the effectiveness of the elaborate state and federal oversight infrastructure in place to ensure nursing home quality.

Second, this paper adds to the literature studying the responses of healthcare firms to price incentives and regulation (Duggan, 2000; Grabowski and Hirth, 2003; Grabowski et al., 2013; Clemens and Gottlieb, 2014; Adelino et al., 2015).[7] The findings are mixed, but some work points to non-pecuniary objectives of nonprofits as one reason nonprofit providers can outperform for-profits. This is consistent with our suggestion of a misalignment between high-powered for-profit incentives and heavily subsidized and inflexible healthcare markets. Our findings also strengthen the concern over information frictions in healthcare since we find little or no demand response to quality declines at private equity facilities.

Third, this paper adds to the nascent literature on the industrial organization of the nursing home sector (Lin, 2015; Hackmann and Pohl, 2018; Hackmann, 2019; Gandhi, 2020), a large and important sector which has received comparatively little attention in economics relative to hospitals. Previous work has focused on the role of competition and payment rates in determining quality. Our results imply that owner incentives are of first-order importance, and their effects on quality are only partially regulated by both market competition and payer mix. The COVID pandemic has exposed several flaws in the

[7] There is also a related literature on competition in healthcare markets (Grabowski and Hirth, 2003; Dafny et al., 2012; Cooper et al., 2018; Pelech, 2018; Ho and Lee, 2019).

regulation and financing of long-term care facilities in the US, which have accounted for 6% of all cases nationally, but nearly 40% of deaths.[8] This paper helps build evidence for policymakers as they consider changes in regulating this important sector.

The remainder of this paper is organized as follows. Section 2 provides the necessary institutional background on nursing homes and private equity firms. Section 3 describes the data used in the paper and presents descriptive statistics, including evidence on how private equity firms target particular facilities. The empirical strategies are described in Section 4. The main results on mortality and spending, as well as evidence for channels, are in Section 5. Section 6 concludes.

2 Background

2.1 The Economics of Nursing Homes

Nursing homes provide both short-term rehabilitative stays (usually following a hospital procedure) as well as long-term custodial stays for patients unable to live independently. Relative to the rest of the healthcare sector, there are two unique features of the long-term care market in the US. First, there is limited take-up of private insurance coverage—only 11% of adults over 65 had private coverage in 2014 (Johnson, 2016). Consequently, more than other types of healthcare firms, nursing homes largely rely on public health insurance programs—Medicaid and Medicare—for revenue. Medicaid is a means-tested insurance program targeted at low income and disabled non-elderly individuals. It is the primary payer for custodial care and accounts for about 60% of nursing home patient-days in our data. Medicare is an entitlement health insurance program for individuals older than age 65, but it covers limited short-term rehab care following hospital inpatient care. Accordingly, Medicare accounts for only 15% of patient-days.[9] Second, about 70% of nursing homes are

[8] Source: Data obtained from the New York Times Coronavirus tracker, available at https://www.nytimes.com/interactive/2020/us/coronavirus-nursing-homes.html. Updated as of October 30, 2020.

[9] Individuals can get coverage through Medicare fee-for-service or through Medicare Advantage (MA). Under the former, the federal government directly pays providers for care utilized by beneficiaries. Under the latter, individuals sign up with a private insurer which receives a fixed monthly premium from the government

for-profit owned. This dominance of for-profits differs dramatically from the hospital sector, where less than one-third are for-profit owned. Policymakers have long been concerned about low quality care at nursing homes in the US and for-profit ownership has often been proposed as a causal factor (Institute of Medicine, 1986; Grabowski et al., 2013).

As with any business, the economics of nursing homes are shaped by the nature of demand, the cost structure, and the regulatory environment. On the demand side, nursing homes serve elderly patients but are paid by third-party, largely government payers. Both Medicare and Medicaid pay a prospectively set amount per day of care for each covered patient ('per diem'), which is adjusted for patient severity, but not for quality of care, reputation, or other standard determinants of price. These rates are non-negotiable, and facilities simply choose whether they will accept beneficiaries of these programs. Medicare fee-for-service pays much more – roughly $515 per patient day – relative to just $209 per patient day from Medicaid.[10] While nursing home finances are remarkably opaque, the federal government estimates that they enjoy double digit margins on Medicare fee-for-service patients, while their overall margins are in the low single digits (MedPAC, 2017). Over 95% of facilities treat both Medicare and Medicaid patients (Harrington et al., 2018), hence they typically serve both rehab and custodial patients. Payments are adjusted for patient risk, so there is an incentive to misrepresent their severity—a practice known as 'up-coding.' Since nursing homes are paid on a daily basis, there is also an incentive to increase the patient's stay beyond what is clinically necessary, particularly for higher revenue Medicare patients (Carter, Garrett and Wissoker (2012)).

Like all healthcare services, nursing home care is a credence good. Hence, patients cannot accurately assess provider quality prior to purchase or even after they experience it. This important information friction is a defining characteristic of the healthcare sector, distinguishing it from many other sectors (Arrow, 1963). This friction manifests itself in

and bears the insurance risk. This 15% figure pertains only to fee-for-service Medicare, since MA patients are typically counted as privately insured in these statistics.

[10] https://skillednursingnews.com/2019/03/medicare-advantage-eats-into-margin-gains-for-skilled-nursing-facilities/. Medicaid still pays more than the marginal cost of treatment per day. Hackmann (2019) calculates that the marginal cost of treatment per-day is about $160 on average.

the form of weak demand responses to poor quality of care, allowing poor quality firms to persist. Prior studies have found that low scores on government mandated report cards do not seem to affect patient demand for nursing homes (Grabowski and Town, 2011; Werner et al., 2012), nor do they stimulate a broader improvement in quality (Werner et al., 2009). Firms accordingly decide their optimal level of quality inputs to maximize profits. In equilibrium, the presence of information frictions will lead to lower investments in quality.

Nursing homes provide institutional care and hence have a high fixed cost business model. Accordingly, occupancy rate is an important driver of profitability. Nurse staff is the largest component of operating cost, accounting for about 50% (Dummit, 2002). Broadly speaking, there are three types of nurses. Low-skill CNAs account for about 60% of total staff hours and provide most of the direct patient care. LPNs have more training and experience than CNAs but cannot manage patients independently. Registered Nurses (RNs) have the highest skill and experience levels, and can independently determine care plans for patients. LPNs and RNs each account for about 20% of nurse hours. Nurse availability is crucial to the quality of care and there is a consensus that low ratios of nursing staff to residents are associated with higher patient mortality and other adverse clinical outcomes (Harrington et al., 2018). Staffing ratios are therefore standard metrics to examine nursing home quality (Hackmann, 2019).

The combination of opaque quality of care, persistent concerns about poor quality, and public suspicion of profit motives leading to cuts to nursing staff have led federal and state regulators to impose on firms an elaborate monitoring and reporting infrastructure regarding nurse availability, care process standards, and adverse patient outcomes. In particular, states gather data from independent inspectors through a system of surprise inspections. In addition to inspecting the facility, auditors interview staff and patients, and flag specific areas where the facility has failed to meet CMS' stipulated care standard.[11] Regulators report poor performance on all three dimensions publicly and, since 2009, CMS has assigned a Five Star rating to each facility aggregating performance across these

[11]CMS provides surveyors with a lengthy manual running into hundreds of pages, describing each stipulation and how to determine non-compliance. As an example, see the manual for 2011 at https://www.cms.gov/Regulations-and-Guidance/Guidance/Transmittals/Downloads/R70SOMA.pdf.

dimensions (CMS, 2016).

2.2 Private Equity Control

PE firms conduct leveraged buyouts, under which a target firm is acquired using a small portion of equity and larger portion of debt financing.[12] A large literature in finance beginning with Kaplan (1989) and Kaplan and Schoar (2005) has shown that PE buyouts increase efficiency, generate higher returns and lead to greater operational efficiency. There are a number of non-mutually exclusive mechanisms through which PE may lead to operational changes, which are distinct from other forms of ownership control. While all of these channels would predict increases in firm value, some channels could lead to gains in profitability and efficiency, either to the benefit or detriment of consumers. We discuss possible channels in the remainder of this section.

First, PE buyouts can change the incentives of managers and employees. PE fund partners' compensation is linked to deal exit, and hence they are incentivized to create firm value. PE buyouts typically also lead to performance-based changes in managerial compensation, which may induce greater effort. Davis et al. (2014) further show that PE buyouts are linked to greater labor market churn, and the expansion of efficient operations and closure of inefficient operations. The threat of termination and the benefit of expansion or promotion may also change managerial and employee incentives. Under his channel we would expect target nursing home profitability to increase, which may or may not create value depending on the incentive structure of managers. For example, stronger incentives could lead to either cost-cutting or quality improvements, which could have different effects on customer outcomes.

PE buyouts may also lead to improvements in management practices, creating efficiency gains. PE buyouts often lead to the old management being replaced (Davis et al., 2014) . Bloom et al. (2015) find that surveyed management practices improve following PE buyouts, and that PE own firms have significantly better management practices relative to other ownership types. PE buyouts changing contracts may also solve agency conflicts,

[12] Kaplan and Stromberg (2009) provide a detailed discussion of PE for non-specialists.

which can distort managerial incentives and lower firm value (Jensen, 1986). Better management may also be associated with specific expertise being brought in by new management. In the case of health care and other heavily subsidized industries, this expertise could be related to billing and capturing government aid rather than quality improvements. For example, Eaton et al. (2019) find that in higher education, PE buyouts lead to quality declines and greater reliance on federal loans and grants. Thus, like changes in incentives, better management would lead to increased profitability, and value to consumers would depend on the specific revenue creating actions taken by managers.

Private equity buyouts may also create value by alleviating credit constraints. Consistent with buyouts alleviating liquidity constraints and expanding growth opportunities, Boucly et al. (2011) find that post-buyout growth is stronger for firms operating in industries dependent on external finance. Under this channel, we would see increases in investment and efficiency gains in operational practices.

PE buyouts may also create value in ways to that do not increase operational efficiency. For example, greater use of debt financing can create returns through the tax code, a channel which would not directly affect operations. Under this channel, we could expect no effect on nursing home operations. Recent work has also argued that private equity funds can act as arbitrageurs, selling to investors with higher valuations. For example, Spaenjers and Steiner (2020) find limited operational efficiency gains in the hotel industry, but find that equity returns are boosted by cheap financing. Under this channel, we would expect no changes in operating efficiency.

While prior work on PE has shown that changes in ownership control create value for firms and increase profitability, little work has focused on subsidized industries like health care. The effects on nursing home patients are thus theoretically ambiguous. On the one hand, better management and incentives, as well as alleviating liquidity constraints may lead to improvements for patients. On the other hand, if cost cutting measures come at the expense of quality, and management focuses on subsidy capture, patient outcomes could deteriorate.

3 Data and Descriptive Statistics

This paper uses three primary data sources: nursing home-level administrative data, patient-level administrative claims data, both of which were obtained from CMS, and Pitchbook data on private equity deals.

3.1 Nursing Home Data

Our data source on nursing home-level operations and performance is a compilation of information obtained during annual surprise CMS inspector audits and data on nursing home attributes and patient characteristics reported by the facilities themselves.[13] The data span 2000 through 2017. In each year we observe about 15,000 unique nursing homes, for a total of approximately 280,000 observations. Of these, about 29,000 observations represent facilities acquired by private equity firms. The aggregate files provides annual data on basic facility attributes, patient volume and case mix, nurse availability, and various components of the Five Star ratings.[14] These ratings started in 2009, so we cannot observe ratings pre-buyout for deals before 2010. Fortunately, half of the private equity deals in our sample, accounting for 365 nursing homes, occurred post-2009.

Table 1 Panel A presents summary statistics on the Overall Five Star rating as well as the other key nursing home-level variables used in the analysis. We first present the mean and standard deviation for the whole sample (columns. 1-2), then divide observations into two groups—for facilities that are not private equity owned (columns 4-5) and for those that are (columns 6-7). We observe clear differences between private equity owned facilities and those not owned (all statistically significant at the 1% level except where noted). Private equity targets are slightly larger, have fewer staff hours per resident, and a lower Overall Five Star rating. There have been secular increases for the whole sector in both ratings and staffing over time. For staffing, this reflects more stringent standards from regulators

[13] These files were organized and made available for research by the Long Term Care Focus research center at Brown University. See www.ltcfocus.org for more details.

[14] For more details on how the ratings are produced, see Rating Guide.

over time. Average staff hours per patient day increased from 3.5 in 2000 to 3.7 in 2017. Similarly, overall average Five Star ratings increased from 2.9 in 2009 to 3.25 in 2017. As the private equity deals occurred primarily later in the sample, it is therefore remarkable that they have lower measures of quality on average. The secular trends underscore the need for analysis that controls for time trends to establish causal effects.

3.2 Patient Data

Our second data source consists of patient-level billing claims and assessment data for Medicare fee-for-service beneficiaries from 2004 to 2016. We observe the universe of billing data for hospital care (inpatient and outpatient) and nursing homes for these beneficiaries, as well as detailed patient assessments recorded in the Minimum Data Set (MDS).[15] We use these files to track beneficiaries' demographics, spending, and health outcomes such as mortality. The MDS helps observe clinical assessments such as mobility and the use of anti-psychotic drugs.

The unit of observation is a nursing home stay for a Medicare beneficiary that begins during our sample period, which we begin in 2005 in order to have at least one look-back year. Our main sample restriction is to identify index nursing home stays for patients, defined as stays that begin at least a year after discharge from a previous nursing home stay. This helps avoid mis-attributing adverse effects to the wrong nursing home. To further avoid attribution error, we consider only the patient's first index stay in our entire sample period. Hence, each patient appears only once in our sample. Using this approach, we settle on a sample of more than seven million patients over 12 years. For each of these patients, we also observe clinical assessments from the MDS, which we successfully match to the claims files.[16]

[15]Specifically, we use 100% samples of the following: Medicare Beneficiary Summary File (MBSF), Hospital inpatient and outpatient, and Skilled Nursing Facility claims files. These are obtained through a reuse DUA with CMS and accessed through the NBER.

[16]Following prior studies (Grabowski et al., 2013), we use some other restrictions to arrive at our sample. We restrict to patients over 65 years of age who are enrolled in Medicare parts A and B for at least 12 months before the start of the nursing home stay. This restriction ensures that we observe prior medical care history and pre-existing conditions. We also restrict to stays associated with a hospital visit in the previous month, so that all patients are admitted after a hospital-based procedure and are relatively homogeneous. We drop patients who went to a nursing home in a state other than their state of residence as recorded in the Medicare

Table 1 Panel B presents summary statistics on the final patient-level sample. We are most interested in the effect on mortality, which is an unambiguously bad outcome, has little measurement error, and is difficult to "game" on the part of a facility or a government agency. For these and other reasons, short-term mortality has become the gold-standard measure of provider quality in the health economics and policy literature (McClellan and Staiger, 1999). We use an indicator for death within 90 days following discharge (including during the stay), based on death dates recorded in the Medicare master beneficiary summary file. The high level of short-term mortality—one in six patients die within three months of discharge—indicates the general morbidity of this patient cohort.

We use two measures of spending. The first is the total amount that the nursing home bills to Medicare and the patient for the index stay in 2016 dollars. Medicare covers the entire cost until the 21st day of stay, at which point the patient begins paying a coinsurance, which has risen somewhat over time and is now $170.5 per day.[17] Therefore, the vast majority of total payments are from the government, and are unrelated to the quality of care once the patient "case mix" (i.e., severity) is established, and conditional on the nursing home maintaining its accreditation status. Private equity-owned facilities charge about 10% more than other facilities. The second measure is the total amount paid for the stay and the 90 days following discharge. This captures any subsequent hospital inpatient or outpatient care, and it provides a more holistic picture of spending from Medicare's perspective.

Demographic measures associated with risk are quite similar across the types of facilities, including patient age, the share of patients who are black and married, and the Charlson Comorbidity Index, a standard measure of patient mortality risk based on co-morbidities (Charlson et al., 1994).[18] We create a high-risk indicator that is one if the previous-year Charlson score is greater than two. According to this definition, about 40%

master beneficiary summary file. This drops a small fraction of patients (less than 5%) and is meant to exclude patients who may be traveling when admitted to a nursing home. We match the index nursing home stays to the MDS sample on beneficiary ID, facility ID, and admission date. We achieve a match rate of 93% and drop unmatched patients.

[17] See https://www.resdac.org/cms-data/files/ip-ffs/data-documentation and https://www.medicare.gov/Pubs/pdf/10153-Medicare-Skilled-Nursing-Facility-Care.pdf.

[18] The "Charlson score" assigns a point score to each of 17 disease categories recorded during the 12 months before the index stay and sums them to create an overall disease burden score.

of patients are high-risk. The difference between facility types is not significant.

Finally, we examine five measures of patient well-being, the first four of which comprise inputs to the quality portion of CMS' Five Star ratings. The first is an indicator for the patient starting anti-psychotic medication during the stay. Anti-psychotic use in the elderly is known to increase mortality, and non-pharmaceutical interventions such as music and breathing exercises have been shown to be more effective (Taragano et al. (1997); Kuehn (2005); Sink et al. (2005); Schneider et al. (2005); Banerjee et al. (2011); Press and Alexander (2013)). The second is an indicator for the patient's self-reported mobility score declining during the stay. The third is an indicator for developing a pressure ulcer. The fourth is an indicator for the patient's self-reported pain intensity score increasing during the stay. The last measure is the length of stay. All else equal, a shorter length of stay implies lower coinsurance payments, reduced risk of infection from being in a congregate healthcare setting, and enables faster return to life at home.

3.3 Private Equity Deal Data

Our primary source of data on private equity transactions is a proprietary list of deals in the "Elder and disabled care" sector compiled by Pitchbook Inc., a leading market intelligence firm in this space. The deals span 2004 to 2015. We match the target names to individual nursing facilities using name (facility or corporate owner) and address as recorded in CMS data.[19] Target names in these deals typically refer to holding companies, which often do not reflect the names of individual facilities. The matching process required manual Internet searches to confirm chain affiliations. We supplement the Pitchbook data in two ways. First, we conduct additional Internet searches that yielded a small number of private equity deals not reported by Pitchbook. Second, we obtain a list of merger and acquisition deals from 2005 to 2016 from Levin Associates, a market intelligence firm that tracks the healthcare sector. This helps us to identify facilities that did not experience a new private equity deal,

[19] We obtain data on nursing home attributes (name, address, city, owner name and type, number of beds) and quality measures (deficiencies) from Nursing Home Compare. See https://data.medicare.gov/data/nursing-home-compare for more details.

but were acquired by an existing private equity-owned chain.[20]

This process yields 118 deals, which correspond to a change in ownership to private equity for 1,674 facilities. The deals are spread over time (no particular year or part of the business cycle dominates) and across private equity firms. Figure B.1 shows the number of deals in each year. In total, our data contain 120 unique private equity firms that acquired nursing homes. Most deals are syndicated and involve multiple private equity firms. Table B.4 presents the top 10 deals by number of facilities acquired. Deal sizes are skewed, with the top 10 deals accounting for about 80% of all facilities acquired. On average, we observe private equity-owned facilities for eight years post-acquisition. Hence the results should be interpreted as medium to long-term effects of private equity ownership.[21]

It is difficult to ascertain whether we comprehensively capture private equity activity in this sector. While there is no 'official' tally of private equity-owned nursing homes to benchmark against, our sample size compares favorably against an estimate of 1,876 nursing homes reportedly acquired by private equity firms over a similar duration, 1998–2008 (GAO, 2010). Nonetheless, our analysis likely underestimates the extent of private equity activity in nursing homes, as matching between Pitchbook deals and individual facilities is very challenging.

Figure 1 Panel A shows how private equity investment in healthcare has increased over time based on the total amount of private equity deal activity in the Healthcare sector as captured by the Pitchbook data platform. Panel B focuses on the Elder and Disabled Care sub-sector, which includes the nursing homes that we study as well as assisted living and other types of care. To allow for adequate post-buyout observations, we use deals only through 2015. The shaded areas in the graphs correspond to years after our sample ends, showing a continuous increase in the number of deals each year. Hence, the role of private equity has continued to grow since then. The bottom two panels use our data from Medicare

[20] We matched approximately 290 additional facilities using information from the Levin files to the CMS data. Of these, about 40 were private equity-owned.

[21] A likely source of measurement error is not capturing private equity disinvestment from facility ownership. For the top 10 deals (80% of facilities) we verified PE exit via manual internet searches and incorporated it in the analysis. The main results are robust to dropping observations of facilities that have been owned by PEs for 10 years or more. As expected, the coefficients modestly increase in magnitude when we do so.

on skilled nursing facilities. In each graph, the solid line represents the number (Panel C) and share (Panel D) of facilities that are private equity owned. The dashed line represents the same statistics at the patient level. As of the end of our deals data in 2015, private equity-owned facilities represented 8% of all nursing facilities in the Medicare data, corresponding to an annual flow of about 100,000 patients. Note that the large spike in the mid-2000s across all the graphs reflects an economy-wide private equity boom during this period, and is not specific to healthcare. Similarly, the flat lining in Panels C and D starting in 2009 reflects the lull in deal activity in the late 2000s and early 2010s. Given the patterns in Panel B, the share of facilities that are private equity-owned is likely substantially higher today.

To understand whether deals are concentrated in particular regions, we plot the location of private equity-owned facilities across the US in Figure B.2. Private equity firms appear to be more active in large metropolitan markets, and in certain states such as Florida, Texas, New York, Pennsylvania and Massachusetts. However, there is no obvious concentration, and we do not find systematic variation with local measures of income, age, elder population, or share of patients eligible for Medicare Advantage.

3.4 Targeting

This paper does not address why nursing homes may or may not be profitable acquisition targets, and does not assess returns from investing. However, exploring what types of facilities are targeted can help us to interpret the effects of buyouts on patient welfare and is also useful for identifying the most relevant control variables for our empirical analysis. We describe which characteristics are robustly associated with buyouts in Table 2, which presents estimates of Equation 1:

$$PE_{jt} = \alpha_s + \alpha_t + \beta \mathbf{X}_{jt} + \varepsilon_{jt} \tag{1}$$

Here, PE_{jt} is 100 if the facility j is acquired in a private equity deal in year t (we drop all years post-deal, and multiply by 100 for ease of reading). PE_{jt} is zero for never-PE and private equity-owned facilities before the deal. We include state and year fixed effects.

We report models including variables known to be central to nursing home quality of care and economics or that are potentially important and robustly predict buyouts. In column 1, find that facilities in more urban counties are more likely to be targeted.[22] Urban nursing homes tend to be closer to hospitals and likely enjoy thicker labor markets. Facilities in a state with a higher ratio of elderly people are also more likely to be targeted. County-level income, race, and home ownership do not predict buyouts.

In column 2, we turn to facility characteristics. Chains are more likely to be acquired than independent facilities, likely reflecting substantial fixed costs in deal-making. Hospital-owned facilities are less likely to be targeted. Private equity firms also tend to target larger and higher-occupancy facilities. We consider patient-level characteristics in column 3: the share of the nursing home's population on Medicaid, the share on private insurance, and the share who are Black. The first two are strongly negatively associated with buyouts, meaning that a higher share of Medicare patients (the omitted group) is positively associated with being targeted. In column 4, we assess two facility-level quality measures we employ in the analysis: Five Star overall rating and staff hours per patient day. Both are negatively associated with buyouts, but once we control for rating, staffing is not significant. These results indicate that private equity firms target relatively low-performing nursing homes.

Finally, in column 5 we include all of variables from the previous models that had predictive power. Some, such as admits per bed and hospital ownership, become small and insignificant after controlling for the other variables. Notably, the Five Star rating and the state elder ratio retain their magnitudes and precision.

4 Empirical Strategy

This section first explains the instrumental variables strategy that we use for patient-level outcomes (Section 4.1), and then the differences-in-differences design that we use for facility-level outcomes (Section 4.2).

[22] We define urban as being in the top 2 out of 9 county groups classified as urban based on a Department of Housing and Urban Development 2003 rural-urban classification.

4.1 Estimation at the Patient Level

If customer composition changes after the private equity buyout, there may be unobservable differences in patient risk that confound analysis. This problem is not limited to healthcare; endogenous changes in customer selection could affect outcomes for any stakeholder that matches with the target firm. Differential customer selection could reflect a number of channels, including a change in advertising or reactions to a change in quality. We use patient-level data to develop an instrument for the match between patients and nursing homes. We first explain how the instrument is built and estimated (Section 4.1.1), and then describe the identification assumptions and validity tests (Section 4.1.2).

4.1.1 Instrument

There are two primary concerns related to measuring the causal effects of PE on outcomes. First, PE buyouts may targeted different facilities. Second, PE buyouts may change the composition of patients. We deal with the first concern by including facility fixed effects, and examining pre-trends. To control for changes in the selection of patints, we use a differential distance instrument (McClellan et al., 1994). The instruments exploits the fact that patients are most likely to choose providers located close to them. There is evidence that this is especially true for nursing homes; for example, Hackmann (2019) finds that the median distance between a senior's former residence and her nursing home is under 7km, and the mean is 11km. As a result, this instrument is commonly used in the nursing home setting to control for patient selection (Grabowski et al. (2013); Huang and Bowblis (2019)).

We compute the difference (in miles) between two distances: from a patient's residence to the closest private equity owned nursing home; and from the patient's residence to the nearest alternative facility. As the differential distance decreases in value, the nearest private equity-owned facility is closer to the patient. We compute the difference between the patient's home zip code and the nearest facility's zip code. Following convention in the literature, we drop patients with outlier differential distance values.[23]

[23] Specifically, we drop patients with a differential distance value beyond 70 miles, which is approximately

The first stage is estimated using Equation 2, and the second stage is estimated using Equation 3. The endogenous regressor of interest $PE_{i,j,r,t}$ is an indicator set to one if patient i in region r attends facility j is private equity-owned in year t. We instrument with linear and squared differential distance between i's home and the nearest private equity owned facility, $D_{i,r}$.

$$PE_{i,j,r,t} = \alpha_j + \alpha_{r,t} + \zeta_1 D_{i,r,} + \zeta_2 D_{i,r}^2 + \Xi \mathbf{X}_{iz} + \nu_{i,j,r,t} \tag{2}$$

$$y_{i,j,r,t} = \alpha_j + \alpha_{r,t} + \phi PE_{i,j,r,t} + \Gamma \mathbf{X}_{iz} + \varepsilon_{i,j,r,t} \tag{3}$$

Our preferred model controls for facility α_j and patient hospital referral region (HRR) by year fixed effects ($\alpha_{r,t}$), as well as controls X_{iz} for patient risk and zipcode-level time-varying characteristics. Risk controls include indicators for age, gender, marital status, dual eligible, and the 17 disease categories that are used to compute the Charlson score described above.[24] Standard errors are clustered by facility.

The instrument controls for the selection of patients under two assumptions. First, there is the inclusion restrictions that the instrument affects whether individuals attend PE-owned nursing home. This assumption is testable, and the first stage results are reported in Table 3. The instrument robustly predicts going to a private equity-owned nursing home. In particular, a one standard deviation increase in differential distance (15.4 miles) reduces the probability of going to a private equity-owned nursing home by 7 percentage points, 78% of the mean. The F-statistic is 226, well above conventional rule-of-thumb thresholds for weak instruments.[25]

the 95th%ile (i.e., the nearest private equity facility is 70 miles further than the nearest non-PE facility). The concern here is that these patients are plausibly located in markets which private equity facilities do not operate in, and hence could differ in some unobserved ways correlated with health or spending outcomes. To be symmetric, we also drop (the very few, <15) patients who have a differential distance value below -70.

[24]To construct these indicators, we use diagnoses codes recorded in claims billed over the one year prior to the index nursing home stay (hospital stays, ED visits, and outpatient visits). Therefore we do not use codes recorded by the nursing home itself, avoiding the possibility of bias due to up-coding by the private equity nursing home.

[25]The relationship between individuals attending a particular nursing home and distance is quite similar for PE and non-PE owned facilities. The relationship between distance and nursing homes is also stable over time, and does not change following PE acquisitions. These results are show in appendix figure B.3.

The second assumption is the exclusion restriction, that patient distance from the nearest PE-owned nursing home is uncorrelated with other determinants of outcomes, conditional on observables. In other words, whether an individual lives closer to a PE-owned nursing home is not related to outcomes such as patient spending or mortality, other than through the effect of the PE-owned nursing home. This assumption is not directly testable, but we can provide support for the assumption through placebo tests, which are shown in section 5.

As in any IV analysis, individuals who comply with the instrument by going to the nearest nursing home type may not be representative of the average patient. This does not invalidate the IV, but means that causal effects on health outcomes may be different in the non-complier population. To characterize compliers with the instrument, we compare them to the average patient at a private equity-owned nursing home. Specifically, we estimate the first stage regression but use an indicator for differential distance being above median as the independent variable of interest. We do this within various sub-groups of patients as well as in the overall population. The ratio sheds light on the relative likelihood of a person in this group being a complier, relative to the average in the population.

The estimation results and ratios are in Table B.5. Compliers are extremely similar to the average patient for three age bins, gender, and marital status. The probability of complying is somewhat lower among individuals with above median income, non-white race, and urban zip code. It is very similar to the overall probability for individuals with below median income or white race, and higher for individuals in rural zip codes. For example, the largest difference across all the characteristics we considered is rural vs. urban: people in rural areas are 20% more likely to be compliers than the average patient. In sum, we can conclude that our compliers are representative on age, gender, marital status, lower income, and white race, but are underrepresented if above-median income and overrepresented in rural areas.

4.1.2 Instrument Assumptions and Validation Tests

IV estimation differs from the gold standard in healthcare research, randomized trials, because randomization of patients to treatment is indirect rather than deliberate. As in all such analyses, we must rely on two untestable identification assumptions. The first is

random assignment (i.e. the exclusion restriction), which requires that unobserved characteristics correlated with health outcomes are not correlated with the differential distance measure. The instrument should affect outcomes only through its effect on the probability of going to a private equity-owned facility. The second assumption is monotonicity, which requires that individuals who went to a private equity-owned nursing home that is closer would have gone to another type of facility if instead it had been closer. This is true on average, but the assumption is at the patient level which is untestable because we do not observe the counterfactual of where the patient would have gone were the facility they matched to in a different location. Monotonicity is necessary to interpret the estimates as a well-defined local average treatment effect (LATE).

An important test for randomization examines whether differential distance is correlated with observed patient risk. Figure 2 Panel A shows how the instrument is related to high risk (see Section 3.2). We project the high risk indicator on the controls we use in our main regression, and collapse the residuals into 20 bins. Similarly, we run a regression of differential distance on the controls and collapse the residuals into twenty bins. We plot the means of each bin, with the high-risk indicator on the Y-axis and differential distance on the X-axis. The figure also presents a fitted line and the slope coefficient. Overall, the figure suggests a negligible correlation of risk and differential distance. This fact, alongside the extensive time-varying geographic and patient-level controls we can include in the estimation, make the instrument unlikely to be correlated with unobserved patient risk.

Additional evidence for random assignment is that patient characteristics are similar for high and low differential distance. We document this in Table 4, where we summarize 21 patient characteristics for above- and below-median differential distance nursing homes. The top two rows of the table show that consistent with a strong instrument, below-median differential distance averages 2.76 miles, while the above-median average is 24.9 miles. The associated probability of going to a private equity-owned facility declines from 17% to 2%. The patient characteristics in the subsequent rows are extremely similar across the two groups. For example, 64% of each group are women, and 29% of each group have diabetes. While differential distance is highly predictive of going to a private equity-owned facility,

it appears to randomize patients with respect to observed risk and demographics. The final evidence for randomization is robustness to including controls. To perform this test, we show results with and without patient risk controls.

There might be concern that private equity-owned nursing homes tend to locate in places with higher risk patients, for example that are socioeconomically disadvantaged. We account for any cross-sectional differences with facility fixed effects. To our knowledge, this is a contribution to the literature as no study has previously combined the differential distance estimator with facility fixed effects to address bias in selection of acquisition targets. However, it is possible that private equity firms choose areas that are on track to become more disadvantaged. To assess whether this is a problem, we include time-varying zip code level demographic controls from the U.S. Census Bureau's American Community Survey, specifically annual median household income and the shares of the population that are white, that are renters rather than home-owners, and that are below the Federal poverty line.

A related concern may be that HRRs are too large and do not sufficiently control for unobserved heterogeneity in patient risk across facilities. Hence we also test robustness to using the more granular market definition of Health Service Areas (HSA).[26] There are nearly 800 HSAs while there are only about 300 HRRs. Table 3 column 3 presents results using this finer market definition, with similar estimates.

We provide evidence consistent with the monotonicity assumption in Figure 2 Panel B, which contains a binscatter plot of the first stage, showing that the likelihood of going to a private equity-owned facility increases nearly linearly with differential distance. It is estimated in the same way as Panel A described above, except that the outcome is an indicator for the facility being private equity-owned. The monotonicity assumption also implies that the first-stage should be negative for various sub-samples of patients with different characteristics. Table B.5 shows that when we estimate the relationship between

[26]These were developed by the National Center for Health Statistics of the Centers for Disease Control in the mid 1990s. They are designed to identify a single county or contiguous sets of counties where Medicare patients seek hospital care within the area. We use a slightly modified version developed by the SEER program of the National Cancer Institute, available for download at https://seer.cancer.gov/seerstat/variables/countyattribs/hsa.html.

below-median differential distance and private equity (essentially a simplified first stage), we observe coefficients that are very similar to the full-sample result and all significant at the .01 level for a variety of sample splits by age, gender, income, race, and location status. This is also consistent with the monotonicity assumption.

4.2 Differences-in-Differences Estimation at the Nursing Home Level

For outcomes at the nursing home level, the best available method is a differences-in-differences model. Since we use it to assess operational changes after controlling for patient cohort risk, the patient composition problem is somewhat less important than for patient welfare outcomes. We use variants of the following specification:

$$Y_{jt} = \alpha_j + \alpha_t + \beta PE_{jt} + \gamma_1 \mathbf{P}_{jt} + \gamma_2 \mathbf{M}_{jt} + \varepsilon_{jt} \tag{4}$$

PE_{jt} takes a value of one if facility j is private equity-owned in year t. The coefficient of interest is β, which captures the relationship between private equity ownership and the outcome Y_{jt}. To control for all factors invariant within the facility and year, we include facility fixed effects (α_j) and year fixed effects (α_t).

We show the results with and without two sets of controls. The vector $\mathbf{P}_{jt}$ includes three controls for patient cohort mean risk. First, Case Mix Index (CMI) is a composite measure of patient risk based on medical history of diagnosis or treatment for a large number of conditions. Second, Acuity index is a measure of patient risk computed using the patient's assessed Activities of Daily Living (ADL) scores.[27] The third control is the share the facility's patients who are Black. One reason we present results excluding these controls is that they may be affected by the private equity buyout, in which case they would be "bad controls" that could bias results. The vector $\mathbf{M}_{jt}$ includes five county-level controls that address possible differential trends in local market structure: nursing home Herfindahl Hirschman Index (HHI), number of for-profits, number of chain-owned, number of hospital-based, and number of overall facilities. To avoid spurious correlation with the

[27] In both cases, a greater value indicates a riskier patient cohort for the nursing home. We winsorize both the CMI and Acuity Index at the 1% and 99% level in each year.

facility's own attributes, we use a leave-one-out procedure.

The identifying assumption is that private equity targets and control facilities would continue on parallel trends in the absence of the buyout. To test whether this appears to be true, we focus on whether there are differential pre-trends across the two groups, and whether any effects appear associated with discontinuous changes shortly after the buyout. To do this, we present event studies plotting the coefficients β_s from estimating Equation 5.

$$Y_{jt} = \alpha_j + \alpha_t + \sum_{s \neq 0} \beta_s \text{Deal Year}_{\text{js}} + \varepsilon_{jt} \tag{5}$$

$\text{Deal Year}_{\text{js}}$ is an indicator that is one in year s relative to the buyout year for facility j, and zero otherwise. The remaining terms are as defined above for Equation 4.

5 Effects of Private Equity Ownership

The primary goal of this paper is to assess whether private equity ownership improves the quality of care and reduces the cost of care for taxpayers. The causal effects on the best measures of these outcomes – mortality and spending per patient – are presented in Section 5.1. We then explore in Section 5.2 three channels for the effect on mortality: patient-level measures of health and well-being, and facility-level compliance with care standards and nurse staffing per patient.

5.1 Main Effects on Mortality and Spending

We estimate Equation 3 in Table 5 Panel A. In these main models, we include 22 patient-level controls, four zip-year socioeconomic controls, facility fixed effects, and patient HRR-by-year fixed effects (described in Section 4.1.1). Our most important result is that going to a private equity-owned nursing home increases the probability of mortality by 1.82 percentage points, about 10% of the mean (column 1). In the context of the health economics literature, this is a very large effect.

We calculate the implied cost in statistical value of life-years in Table B.6 Panel A. As

life expectancy varies substantially across men and women, we estimate the effect separately by gender. We translate the IV coefficients into lives and life-years lost based on the number of index stays by patients of private equity-owned nursing homes during our sample period. This leads to an estimate of 20,821 additional deaths due to private equity ownership of nursing homes over our ten-year sample period. To estimate life-years lost, we rely on observed survival rates for patients at nursing homes that are not private equity-owned. This leads to an estimate of 205,065 lost life-years. Applying a standard estimate of statistical value of a life-year of $100,000 Cutler and McClellan (2001) inflated to 2016 dollars, this implies a mortality cost of $26.6 billion.

The next two columns of Table 5 Panel A consider spending per patient, which is overwhelmingly billed to Medicare. The amount charged per nursing home stay increases by 19% (column 2; note it is necessary to exponentiate coefficients larger than .1 when the outcome is logged). As Table 1 shows, on average private equity-owned nursing homes bill $14,800 per stay, while all other nursing homes bill $13,500. This does not seem to reflect additional preventive care that is compensated for by lower subsequent needs, because we also observe that the total amount billed for both the stay and the 90 days following the stay increases by 11.3%. The OLS results, in Appendix Table B.7, are smaller, consistent with less risky patients selecting into private equity-owned nursing homes. This could reflect either differential screening on the part of the facility, or a change in demand, perhaps because of a new advertising strategy or information about quality.

5.1.1 Robustness

To test that the ownership change intervention explains the results rather than spurious trends, we implement a placebo analysis using claims data from 2002–07, a period with little private equity ownership of nursing homes and little overlap with our main sample. We randomly set the PE dummy to turn on in 2004 or 2005 for facilities that eventually got acquired by private equity firms. Further, we discard data for any facility starting in the year it actually got acquired. We compute differential distances under these 'placebo' assignments and implement the IV analysis. Table 5 Panel B repeats the models from Panel

A with the placebo PE, and reassuringly finds small and insignificant effects, consistent with acquired facilities being on differential trends prior to the deal.

In a different type of robustness test, we estimate the IV in a reduced form way by projecting outcomes directly on the instrument. If differential distance predicts going to a private equity nursing home with sufficient power, it should predict the outcomes we observe in the IV estimate. That is, mortality and spending should decline as differential distance grows larger (i.e., relative to the nearest alternative, a private equity facility is farther away). We observe this to be true in Figure 3, which plots coefficients from regressing each outcome on quintiles of differential distance, with the furthest quintile as the reference group, and as above include facility and patient HRR x year fixed effects, with standard errors clustered by facility. We see that our effects are generally reflected in this reduced form approach, with the largest effects in the bottom two quintiles. We also plot placebo coefficients, using the same placebo construction as above. These exhibit no negative relationship with quintiles of differential distance. Together, these results help to confirm the main results.

The central aim of this paper is to assess whether private equity as an ownership type is relevant to outcomes. It could alternatively be the case that private equity ownership leads to rising economies of scale or consolidation that explain our results, along the lines of the mechanism proposed for effects of dialysis mergers in Eliason et al. (2020). To test this hypothesis, we conduct three tests in Table 6, shown in the two rows beneath the repeated main model for comparison. The first includes a control for being a chain vs. an independent facility. If our effects are explained by the “rolling-up" of independent facilities into more efficient chains, the estimates should attenuate. Instead, they are essentially unchanged. The second test excludes the top two deals, which correspond to joining the very large Genesis Healthcare and Golden Living chains. The effect is actually larger without these two deals, indicating that the effect is not driven by the very largest firms. Perhaps the most important test, however, is the third one, in which we keep only the top five deals. For these deals, the chain was already at more than 100 facilities and stayed the same size over the sample period. Therefore, we are holding chain size constant and evaluating the effect of a change in ownership. Again, we find a larger effect than the main result. In sum, it does not seem

that chain corporate structures or synergies in large firms explain our results.

The remaining rows of Table 6 report robustness tests that vary the controls. If the instrument does not randomly assign patient risk, we expect patient controls to substantially affect the results. Instead, the results are overall robust to alternative controls, consistent with random assignment. The first row of this group reports includes the zip-year socioeconomic controls. The coefficients decline only slightly, to 1.6 percentage points for mortality, and 16.9% for spending. The next two rows substitute HSA-year and county-year fixed effects, respectively, for HRR-year fixed effects to define patient markets. The final row omits all controls. The results are generally quite stable.

5.1.2 Heterogeneity in mortality effects

To assess whether particular types of patients are responsible for the striking effects of going to a private equity-owned nursing home on mortality, we split the sample on characteristics of interest in Table 7. Panel A considers patient characteristics. We first divide the sample into four groups based on patient risk and age. We expect that high patient age is associated with a greater need for attentive but not necessarily high-skill or medicalized care, for example helping patients to use the toilet and minimizing infection risk. Higher risk – a measure constructed from disease burdens – should be associated with more need for high-skill, medicalized RN care. Older, high risk patients require the most intensive and high-skill care. Therefore, we split the sample into four groups around the median age of 80 and around the high-risk indicator (Charlson score above two). The results document a striking pattern: The effect on mortality is driven by patients who are low risk, with the most robust result among patients who are low risk but high age. The high risk, high age group has a large, positive coefficient, but it is noisier. This suggests that private equity-owned nursing homes are able to take just as good care of the sicker patients, especially when they are on the younger side, but in the process, the lower risk and older patients may not receive adequate attention.

The second sample split is on gender. We find positive effects in both groups, but the effect is larger and much more robust among female patients. They represent 65% of the

sample and are on average older. Next, we consider race/ethnicity. We divide the sample into white patients and those of all other backgrounds. Our result is driven by white patients, with a coefficient of 2.2 percentage points significant at the .01 level, compared to a noisy negative coefficient for other types of patients. The third split is on rural vs. urban zipcodes. Our result is driven by facilities in urban areas. Notably, Table 2 shows that private equity firms are generally more likely to target facilities in more urban areas. Finally, the last set of results divide the sample into three previous health diagnosis categories; the two largest of cardio-vascular disease and injuries, and then all other. The coefficients are all positive and relatively close to the main estimate, but the effect is larger and more robust among patients with cardio-vascular disease.

In Panel B, we shift to market and facility level characteristics. As there is evidence that for-profit incentives generally and private equity ownership specifically are associated with lower quality of care in more concentrated markets (Gandhi et al., 2020), we examine whether our effects vary with the Herfindahl-Hirschman Index (HHI) of the hospital referral region (HRR). We find that the coefficient is larger among nursing homes in below-median HHI areas, but the coefficient is more precise among nursing homes in above-median HHI areas. As both coefficients are relatively close to our main estimate, concentration does not appear to be a main driver of our result. The last sample split divides facilities into those in which the percent of patients who are private payers (i.e. not on Medicare or Medicaid) is above vs. below 10%. The coefficient is much larger among facilities with fewer private paying patients, which would be consistent with incentives to reduce quality of care being higher when payment is from the government and largely divorced from both the patient's personal finances and her outcomes. However, this is a noisy effect. The coefficient is 1.48 percentage points and more precise among nursing homes with higher shares of private paying patients.

5.2 Exploring Channels: Patient Well-being and Quality of Care

In this section we consider three channels that may help to explain the adverse effect on mortality documented above. All the results are presented in Table 8. The first channel of patient well-being comprises five patient-level measures (described in detail in Section 3.2) which are evaluated using the IV in Panel A. The first is whether a patient starts taking anti-psychotic medications. As discussed above, antipsychotics are increasingly discouraged in the elderly due to their association with mortality and the greater efficacy of behavioral interventions. We find that going to a private equity-owned nursing home increases the chances of starting anti-psychotics by 3 percentage points, or 50% of the mean.

We also find a positive effect on experiencing worsening mobility, which increases by 4.1 percentage points, or 7% of the mean (column 2). We do not find a significant effect on the third measure – developing ulcers – though the coefficient is positive (column 3). Fourth, there is a positive effect on increasing pain intensity of almost 3 percentage points, which is 11% of the mean. Last, we find that going to a private equity-owned nursing home increases the length of stay by 23%. This effect may be related to the spending result because the fixed per diem payment structure makes extending stays a well-known mechanism for increasing revenue. The OLS results for all five outcomes are in Appendix Table B.7. Again, they are smaller, consistent with selection leading to downward bias in OLS.

The second channel is compliance with care protocols. Our outcome of interest is the facility-level Five Star rating, which varies from one (worst) to five (best), as explained in Section 3.1. Here and for the further facility-level analysis below, we use the difference-in-differences model described in Section 4.2. For each outcome, the top row of coefficients are from specifications with only facility and year fixed effects as controls, while the bottom row reports coefficients from specifications with patient risk and time-varying market controls. We also show dynamic event studies to address the main concern with this model; that targeted facilities were on track to experience the outcomes regardless of the buyout. If the event studies indicate no pre-trends and discontinuous changes that are consistent with the regression results, it is unlikely that the facility would have otherwise experienced the

changes.

To assess compliance with clinical care standards, we focus on the Deficiency rating, which reflects whether the facility is satisfying routine care protocols such as storing and labeling drugs properly, disinfecting surfaces, as well as other aspects of care such as ensuring resident rights, avoiding patient abuse, and administrative efficiency. Severe deficiencies are defined as placing resident health or safety in immediate jeopardy. In Panel B column 1, we find that this rating declines by 0.077 percentage points, which is 2.7% of the mean and 6.2% of a standard deviation (the most relevant measure given how this variable is constructed). The Overall rating also declines by a similar amount (column 2). Figure 4 presents event studies for each outcome. There are no pre-trends, consistent with the identifying assumption, and the negative effects appear immediately after the change in ownership and persist for at least five years.

The Overall rating has three components: the Deficiency rating, a Quality rating derived from the four patient assessment outcomes in Panel A columns 1-4, and a Staffing rating, which is based on the staffing measures evaluated in Panel C. Since we evaluate these in a granular way, we do not focus on the other ratings, but we also find negative, significant effects of equal or larger magnitudes. The apparent disconnect between demand and quality of care may reflect information frictions in nursing home quality transparency. Two studies have found no demand effects of information about nursing home care quality, in particular CMS' Five Star ratings (Grabowski and Town (2011); Werner et al. (2012))

As discussed above, nursing staff per patient is a well-established input to nursing home quality. In Panel C, we estimate effects on staff per patient-day, which is is the most relevant measure because absolute staffing levels do not account for changes in patient volume. In column 1, we show that staff hours decline by .05, or 1.4% of the mean. This is driven by reductions in the 'front line' caregivers – Certified Nursing Assistants (CNAs) and Licensed Practical Nurses (LPNs), shown in in columns 2 and 3. For example, CNAs decline by 0.066, which is 2.9% of the mean. In contrast, there is an increase in use of Registered Nurses (RNs), whose hours increase by about 7.4%. The event studies in Figure 4 again reveal no pre-trends and indicate immediate declines after the buyout in front-line staffing,

while the increase in RN staffing appears only starting in the third year after the buyout. We describe and present robustness tests for this facility-level analysis in Appendix A.

The substantial increase in RN staff hours does not compensate for the decline in CNA/LPN staff hours because RNs account for only 12.5% of all staff hours. Medicare cost reports indicate that CNAs and LPNs receive an hourly wage that is about 40% and 70% respectively of the wage paid to RNs, which is around $35 per hour. Unfortunately, we cannot observe actual staffing costs, which would be informative about whether facilities are taking cost reduction steps such as using more part-time labor and reducing individual shifts.

The existing literature helps to connect the effects on staffing with the health outcomes in Section 5.1. Tong (2011) and Ruffini (2020) find that additional low-skill nursing staff reduce mortality in nursing home patients. In a similar vein, Grabowski et al. (2011) notes that antipsychotics are believed to substitute for direct care and shows that when nursing homes increase wages, inappropriate use of anti-psychotics decreases. Therefore, it is intuitive that lower overall staffing – in particular lower-skill staffing – would be associated with increases in adverse conditions related to lack of attention, such as more use of anti-psychotics and lower mobility.

The increase in RN availability is consistent with our finding that the negative effects on mortality are driven by older rather than sicker patients. RN care is most relevant for the more medicalized aspects of nursing home care, while front line nurses are most relevant for daily living activities such as preventing infections and turning patients in bed. One possibility is that managers may have looked for ways to cut overall labor costs while changing the mix of nursing staff capability to maintain quality and patient experience, as RNs are crucial to nursing home quality (Zhang and Grabowski (2004); Lin (2014)). An alternative explanation is the regulatory focus on RNs. For example, CMS uses the availability of RNs to determine eligibility for Medicare reimbursement.[28] Given the tight

[28]Specifically, such facilities are defined by having "an RN for 8 consecutive hours a day, 7 days a week (more than 40 hours a week), and that there be an RN designated as Director of Nursing on a full time basis." See https://www.cms.gov/Regulations-and-Guidance/Guidance/Manuals/Downloads/som107c07pdf.pdf.

regulatory scrutiny of RN availability, it would be difficult to reduce staffing levels in this category.

To explore whether the decline in staff availability causes the observed decline in quality, we examine whether the private equity-owned nursing homes that experienced particularly large staff declines are also those that saw their Five Star Ratings decline the most. That is, we correlate changes in staff availability and Five Star ratings within facilities before and after they were acquired by private equity firms. This analysis recovers correlations and does not imply causality. Hence, we present the raw data rather than results from regression models. Appendix Figure B.4 presents bin-scatter plots of the change in Five Star rating over the three years around private equity acquisition on the Y-axis versus the change in aggregate staff hours per patient day during the same period. We limit the sample to a period of three years around the acquisition to mitigate the effects of secular trends. Each plot also presents the slope coefficient of the fitted line. The plots show a striking upward slope. Facilities that experienced larger declines in staff availability also experienced greater decline in ratings. Overall the patterns are consistent across rating types and suggest that cuts to nursing staff maybe an important channel to explain the quality declines.

The final type of outcome we explore is volume and efficiency. While less related to taxpayer cost and patient welfare, these are interesting outcomes from the perspective of understanding how private equity ownership creates value. Appendix Table B.8 Panel A reports estimates for two variables. First, in column 1 we find no measurable change in the number of available beds, implying no capacity expansion, which may reflect state regulations restricting new nursing home beds. The event study in Appendix Figure B.5 Panel A is consistent with no effect on facility size. Any changes in patient volume therefore directly affect utilization rates.

Column 2 of Appendix Table B.8 Panel A suggests that following a private equity buyout, log admissions increase by 2.4%, or about five patients per year for the average facility. The figure for admissions (Panel B) indicates that facilities targeted by private equity tend to be on track to higher admissions in the years preceding the buyout. We therefore cannot be confident that the result from Table B.8 represents a causal effect. If

there is any increase, it does not seem to have a meaningful impact on market-level admissions, consistent with any effect reflecting business-stealing rather than providing care for individuals who would not otherwise have gone to a nursing home. This is because at the HRR level, we observe no effect of initial private equity entry on admissions, as shown in Appendix Table B.8 Panel B and Appendix Figure B.5 Panel C.

6 Conclusion

This paper studies private equity buyouts in healthcare, an important sector where private equity activity has increased dramatically and generated policy debate, in part because intensive government subsidy and other market frictions make high-powered for-profit incentives potentially misaligned with the goal of providing quality care at a reasonable cost. Nursing homes are a useful setting because they have particularly high levels of for-profit ownership and subsidy, as well as substantial information frictions.

In an instrumental variables design incorporating facility fixed effects, we address both the selection and targeting challenges to identification. We find that going to a private equity-owned nursing home increases the chances of mortality by about 10%, and also has adverse effects on other health outcomes such as mobility and pain intensity. Furthermore, at the facility level, we document declines in nursing hours per patient and in measures of compliance with Medicare's standards of care.

We might expect quality declines to be accompanied by reduced demand. These two forces may be disjointed because of information frictions in healthcare markets (Arrow (1963)). Over the last two decades, federal and state governments have implemented several tools to reduce these frictions, such as publicly available report cards aggregating information on providers. However, the evidence on whether consumer demand responds to these initiatives is mixed, including for nursing homes (Dafny and Dranove (2008); Bundorf et al. (2009); Epstein (2006); Grabowski and Town (2011); Werner et al. (2012); Kolstad (2013)). The fact that the source of revenue is not the patient – unlike many markets where the consumer pays for his own goods – may create incentives to reduce

costs in ways that negatively affect the quality of care. These misaligned incentives appear to become higher powered under private equity ownership.

There are many channels for future work. For example, there has been significant private equity investment in sectors such as education, defense and infrastructure, which like healthcare rely on high levels of government subsidy but are characterized by opaque product quality. Study is needed to determine how government programs can be redesigned to align the interests of private equity-owned firms with those of taxpayers and consumers.

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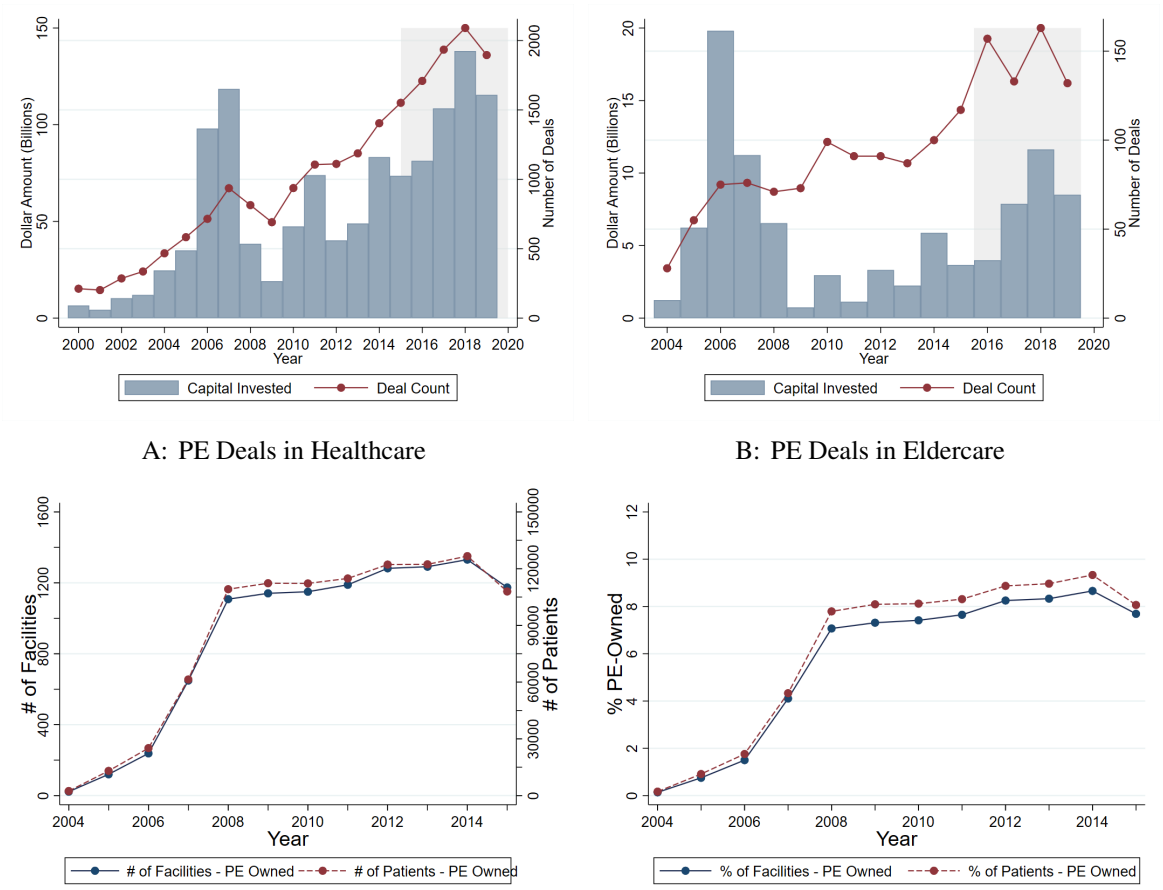
Figures and Tables



A: PE Deals in Healthcare

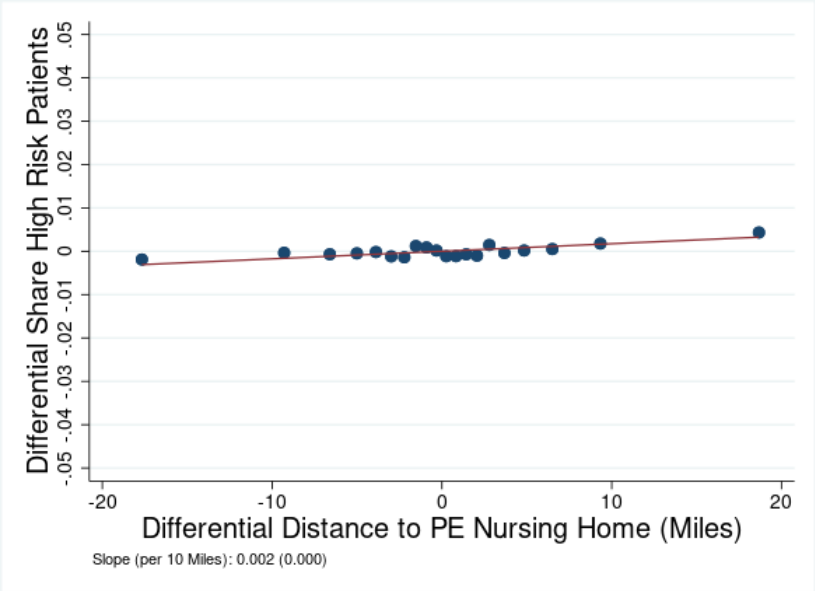
B: PE Deals in Eldercare

C: Number of Nursing Home Facilities and Patients Acquired by PE

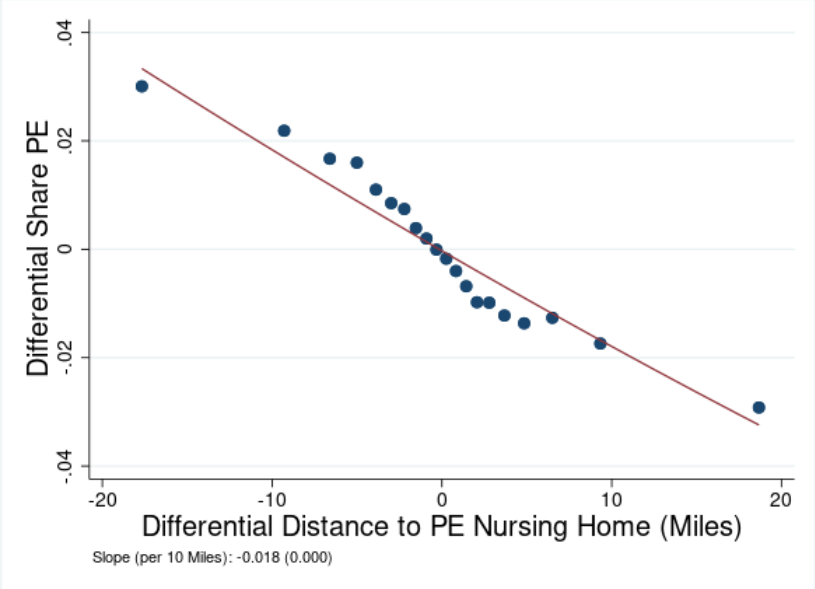
D: Percentage of Nursing Home Facilities and Patients Acquired by PE

Figure 1: **Private Equity Ownership in Healthcare**

Note: This figure shows PE deals in health care over 2004–2015. Panel A and B present the total capital invested (left axis) and number of transactions (right axis) by PE firms in healthcare and eldercare, by year. Panels C and D focus on the number of active nursing homes owned by PE firms in each year. Panel B presents the number of PE-owned facilities (left axis) and patients admitted at these facilities (right axis). Note that the total number of facilities ever bought by PE firms is larger (1,674) than what is plotted here since some of these facilities closed/ went back to non PE ownership over time. Panel D presents these trends as a percentage of total number of facilities and patients admitted respectively.



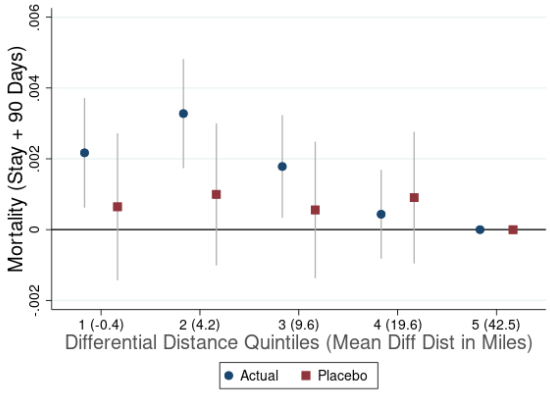
A: High Risk Patients



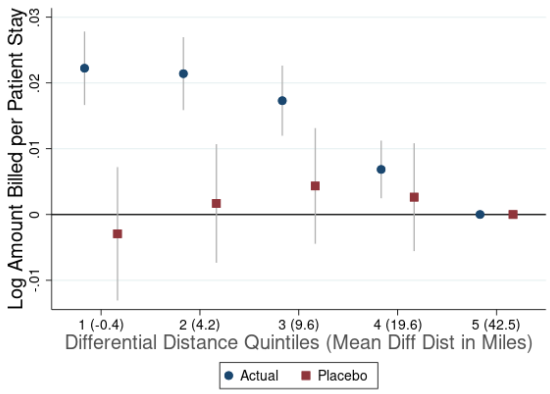
B: Stay at PE Nursing Home

Figure 2: **Patient Characteristics with Differential Distance**

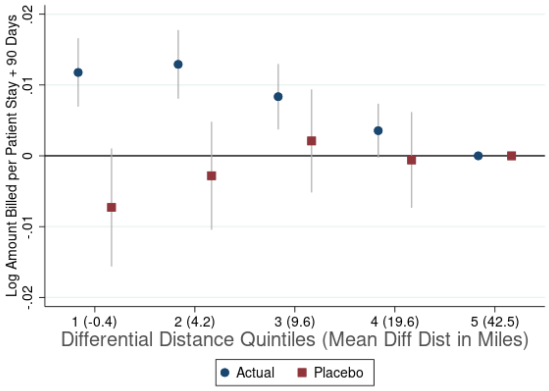
Note: This figure presents scatter plots of patient characteristics with differential distance to the nearest PE facility. The independent variable is the difference in distance (in miles) of the nearest PE nursing home to the nearest non-PE nursing home for the patient. The dependent variable in Panel A is an indicator for the patient to have a Charlson Co-morbidity Index (based on diagnoses recorded in hospital inpatient and outpatient claims over the 12 months before admission to nursing home) greater than 2, and in Panel B is an indicator for the nursing home being PE owned. The data was collapsed into 20 equal sized bins and we plot the means of residuals in each bin that were obtained from models including facility and patient HRR x Year fixed effects, and patient demographics: age, race, gender, maritial status, and an indicator if patients are dual eligible. The figures also present quadratic fitted lines for these plots. Each plot also presents the slope coefficient (per 10 miles of differential distance) with the corresponding standard error. Standard errors are clustered by facility.



A: Mortality (Stay + 90 Days)



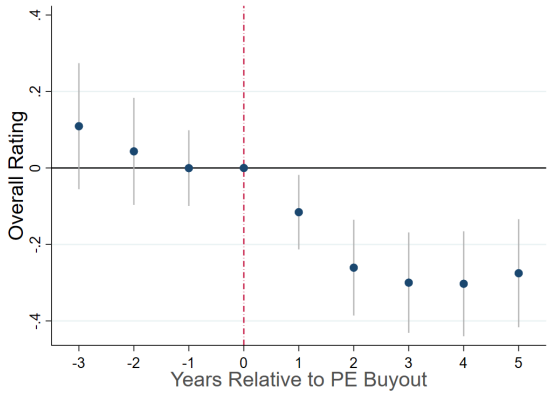
B: Log Amount Billed per Patient Stay



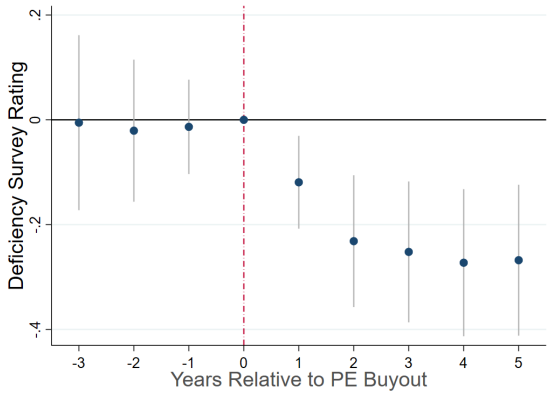
C: Log Amount Billed per Patient Stay + 90 Days

Figure 3: **Patient Outcomes and Differential Distance**

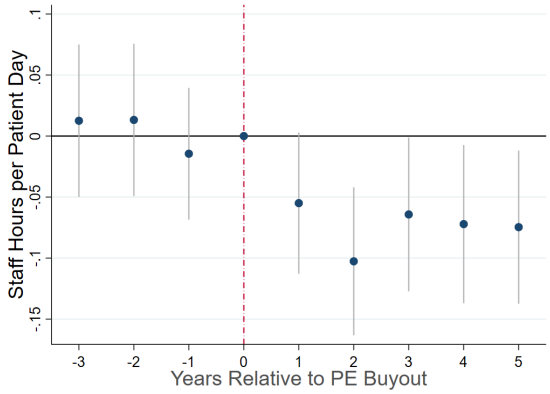
Note: This figure presents results from reduced form regressions for patient-level outcomes on the instrument, differential distance. Each blue point (actual) in the figure represents a coefficient β_s, obtained by estimating the equation $Y_i = \alpha_{m,t} + \alpha_j + \sum_{s=2}^{5} \beta_s \, 1(Q_{DD} = s)_i + \gamma_1 \, X_i + \gamma_2 \, M_{izt} + \epsilon_i$, where $1(Q_{DD} = s)_i$ is an indicator for the q^{th} quintile of differential distance. For each red point (placebo), we assign placebo PE acquisition to year 2004 (if actual deal year before 2008) and 2005 (if actual deal year 2008 or after) and accordingly recompute differential distance. The highest quintile group, i.e., individuals relatively furthest away from a PE facility, is the reference group. Log total payment in Panel B refers to the total payment for the index nursing home stay. Standard errors are clustered by facility.



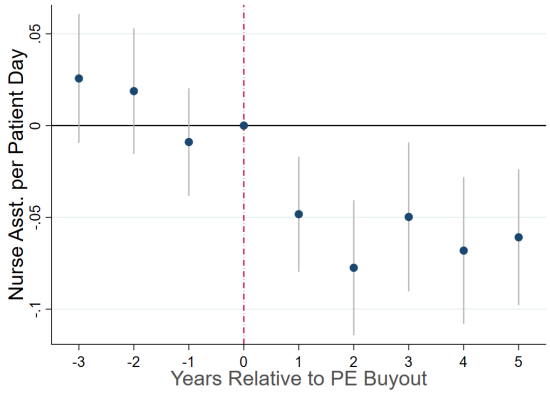
A: Overall Rating



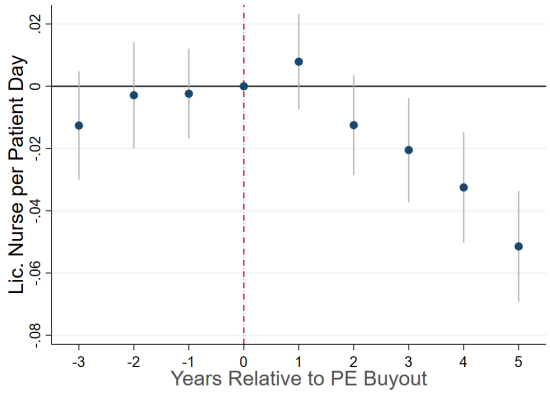
B: Deficiency Survey Rating



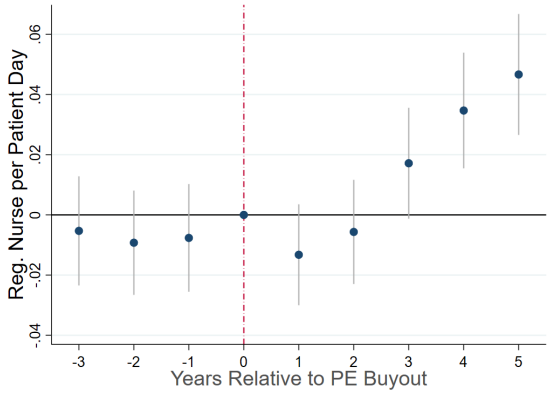
C: Staff Hour per Patient Day



D: Nurse Asst. per Patient Day



E: Lic. Nurse per Patient Day



F: Registered Nurse per Patient Day

Figure 4: **Aggregate Quality and Staffing Outcomes**

Note: This figure presents event studies on Quality of care measures (Five Star ratings) and Staffing around the time a nursing home experiences a PE buyout. Each point in the figures represents the coefficient β_s obtained by estimating Equation 5 as discussed in Section 4. Year = 0 is the omitted point. In Panels A and B, we present effects on the Five-star ratings awarded by CMS - overall rating and deficiencies identified by independent contractors in audits, respectively. A negative effect on ratings implies a decline in quality. Panels C to F present results on nurse staffing per-patient for all staff, nurse assistants, licensed nurses, and registered nurses respectively. All models include facility and year fixed effects. All dependent variables are winsorized at 1 and 99% level. Standard errors are clustered by facility.

Table 1: **Descriptive Statistics**

	All			Not PE Owned		PE Owned	
	Mean	SD	Count	Mean	Count	Mean	Count
A. Facility Level Attributes							
Overall Five-Star Rating	3.17	1.30	138,204	3.20	127,441	2.83	10,763
Deficiency Five-Star Rating	2.84	1.25	138,204	2.86	127,441	2.62	10,763
Staff Hours per Pat. Day	3.59	1.49	284,108	3.60	271,118	3.38	12,990
Nurse Assistant Hours per Pat. Day	2.28	0.79	284,108	2.29	271,118	2.06	12,990
Licensed Nurse Hours per Pat. Day	0.82	0.46	284,108	0.82	271,118	0.82	12,990
Registered Nurse Hours per Pat. Day	0.46	0.57	284,108	0.46	271,118	0.49	12,990
Number of Beds	104.48	56.60	284,108	104.11	271,118	112.34	12,990
Admissions	184.16	166.97	284,108	180.40	271,118	262.47	12,990
Admissions per Bed	2.20	3.30	284,108	2.18	271,118	2.55	12,990
Ratio Medicaid	0.60	0.24	284,104	0.60	271,114	0.60	12,990
Ratio Medicare	0.15	0.17	284,104	0.15	271,114	0.18	12,990
Ratio Private	0.25	0.19	284,104	0.25	271,114	0.22	12,990
B. Medicare Patient Attributes							
Age	81.39	8.11	7,441,205	81.43	6,743,750	80.91	697,455
Female	0.64	0.48	7,441,205	0.64	6,743,750	0.62	697,455
Black	0.08	0.27	7,441,205	0.08	6,743,750	0.09	697,455
White	0.88	0.32	7,441,205	0.88	6,743,750	0.88	697,455
Married	0.34	0.47	7,441,205	0.34	6,743,750	0.35	697,455
Urban	0.70	0.46	7,441,205	0.70	6,743,750	0.73	697,455
Charlson Score (Previous) > 2	0.39	0.49	7,441,205	0.39	6,743,750	0.41	697,455
Cardio-Vascular Disease	0.18	0.39	7,441,205	0.18	6,743,750	0.18	697,455
Injury	0.19	0.39	7,441,205	0.19	6,743,750	0.19	697,455
Other	0.63	0.48	7,441,205	0.63	6,743,750	0.63	697,455
Dual Eligible	0.18	0.38	7,441,205	0.18	6,743,750	0.17	697,455
Differential Distance (Miles)	15.10	16.88	7,441,205	16.44	6,743,750	2.11	697,455
Mortality (Stay + 90 Days)	0.17	0.38	7,441,205	0.17	6,743,750	0.18	697,455
Starts Anti-Pyschotics	0.06	0.23	7,441,205	0.06	6,743,750	0.06	697,455
Mobility Reduces	0.53	0.50	7,441,205	0.52	6,743,750	0.62	697,455
Develops Ulcers	0.09	0.28	7,441,205	0.09	6,743,750	0.09	697,455
Pain Intensity Increases	0.27	0.44	7,441,205	0.27	6,743,750	0.30	697,455
Length of Stay (Days)	59.22	96.64	7,441,205	58.98	6,743,750	61.61	697,455
Log Amount Billed per Patient Stay (2016$)	13,600	12,200	7,441,205	13,500	6,743,750	14,800	697,455
Log Amount Billed per Patient Stay + 90 Days (2016$)	21,100	20,100	7,441,205	21,000	6,743,750	22,700	697,455

Note: This table presents descriptive statistics for key variables used in the analysis. Panel A presents descriptives on facility-level data for all nursing homes over the years 2000–17 while Panel B presents patient-level data for Medicare patients with index stays over the years 2007–2016. A unit of observation is facility-year in Panel A and unique patient in Panel B. Columns 1,2 and 3 present means, standard deviations and number of observations for the full sample. We categorize facilities into two groups. Columns 4 and 5 present means and number of observations at facilities that never experienced a PE acquisition or before PE acquisition during our sample period. Columns 6 and 7 present corresponding values for facilities in the post-buyout period. For most variables, about 10% of the observations pertain to facilities that experienced a PE acquisition. Sample sizes differ across variables in Panel A since they were sourced from multiple sources or in some cases were reported only for more recent years. In Panel A, all continuously varying variables were winsorized at the 1 and 99% levels. We compute the Charlson Co-morbidity Index using co-morbidities diagnosed in hospital inpatient and outpatient claims (first 10 dx codes) over the 12 months prior to, but not including, the index stay. Length of stay and spending values in Panel B are winsorized at the 99% level. Spending values are deflated to be in 2016$. 'Total' billing includes hospital inpatient, outpatient including emergency department, and nursing home stay spending over the 90 days following discharge from the index stay and includes the index stay. The following patient-level variables were sourced from the Minimum Data Set (MDS): marriage, anti-psychotics, mobility, and pressure ulcers. Medicare patients that could not be merged into the MDS (94% match rate) were dropped from the sample. If any of the MDS variables was missing, then we set the respective indicator to zero.

Table 2: **Targeting**

	Mean	(1)	(2)	(3)	(4)	(5)
Urban Indicator	0.56	0.193***				0.107***
		(0.037)				(0.041)
State Elder Ratio	0.24	4.309***				19.142***
		(1.328)				(3.906)
1(Chain)	0.53		0.836***			0.368***
			(0.033)			(0.029)
Hospital-Owned	0.07		-0.212***			0.021
			(0.054)			(0.071)
Log(Beds)	4.5		0.286***			0.084***
			(0.030)			(0.032)
Admits Per Bed	2.08		0.051***			0.006
			(0.007)			(0.015)
Ratio Medicaid	0.60			-0.884***		-0.479**
				(0.117)		(0.232)
Ratio Private	0.25			-1.442***		-0.459*
				(0.144)		(0.238)
Ratio Black	0.10			0.005		
				(0.099)		
Overall Rating	3.15				-0.074***	-0.066***
					(0.015)	(0.015)
Staff Hr per Patient Day	3.55				-0.021	
					(0.018)	
Observations		235,684	218,605	218,605	103,832	103,832
Y-Mean		0.6	0.6	0.6	0.6	0.6

Note: This table shows estimates of the relationship between pre-existing nursing home characteristics and whether a nursing home is a target of a private equity buyout. Independent variables include indicator for urban, and share of state population which is elderly for Col 1, indicator for being member of a chain, indicator for the nursing home being hospital-based, the log number of beds, and admits oer bed for Col 2, share of patients covered by Medicaid, share of patients who pay privately, and the share of patients who are black indicator in Col 3, and Five-star ratings awarded by CMS, and staff hours per patient day for Col 4. We re-run regression on all variables which appear significant in Col 1 to 4 in Col 5. The dependent variable is 100 if the nursing home was acquired by private equity in that year and 0 otherwise. We remove all observations of private equity-owned facilities in years following the take-over by PE. We control for state and year FEs. Standard errors are clustered by facility.

Table 3: **Patient-Level Analysis: First Stage**

	(1) 1(PE)	(2) 1(PE)	(3) 1(PE)	(4) 1(PE)	(5) 1(PE)
Differential Distance	-0.0468***	-0.0468***	-0.0444***	-0.0410***	-0.0468***
(In 10 Miles)	(0.002)	(0.002)	(0.002)	(0.002)	(0.002)
(Differential Distance)^2	0.0061***	0.0060***	0.0058***	0.0054***	0.0061***
(In 10 Miles)	(0.000)	(0.000)	(0.000)	(0.000)	(0.000)
Market Controls		Y			
Patient Controls	Y	Y	Y	Y	
Facility FEs	Y	Y	Y	Y	Y
Patient FEs Level	HRR x Year	HRR x Year	HSA x Year	County x Year	HRR x Year
Observations	7,441,125	7,433,191	7,440,986	7,440,653	7,441,125
Y-Mean	0.09	0.09	0.09	0.09	0.09
F-Stat	226	225	222	205	226

Note: This table presents estimates of the relationship between private equity ownership of the nursing home and the patient's differential distance. Each cell presents the coefficient β obtained by estimating Equation 2. The independent variable is the difference in distance (both linear and quadratic, in 10 miles) to the nearest PE nursing home and the nearest non-PE nursing home for the patient. This is calculated based on distances between the respective zip code centroids. The outcome variable is an indicator for whether the nursing home serving the patient is private equity-owned (=1 if private equity-owned, 0 otherwise). Column 1 (our preferred specification) controls for facility and patient market (Hospital Referral Region) x Year fixed effects, and patient risk controls (indicators for 17 pre-existing conditions used to define the Charlson Co-morbidity Index inferred from claims over the one year prior to admission, and sex, age, race, marital status, and an indicator if patients are dual eligible). Column 2 adds controls for patient zip-year characteristics: median household income, the shares of the population that are white, that are renters rather than home-owners, that are below the Federal poverty line, and that are enrolled in medicare advantage program. Column 3 uses the same controls as in col. 1 but defines patient market using a narrower market definition: Health Service Area (HSA) instead of HRR. Column 4 uses the same controls as in col. 1 but defines patient market using a narrower market definition: county instead of HRR. Column 5 is similar to col. 1 except it does not include the patient level controls. Throughout, we exclude patients with a differential distance of greater than 75 miles, approximately the 95^{th} percentile value. These patients have no realistic PE nursing home option. To maintain symmetry, we also exclude (the very few) patients with a differential distance of less than -75 miles. Standard errors are clustered by facility.

Table 4: **Balance of Patient Characteristics**

Patient Attribute	(1) DD < Median	(2) DD > Median
Differential Distance	2.76	27.45
PE Owned Nursing Home	0.17	0.02
Age	81.37	81.40
Female	0.64	0.64
Black	0.09	0.07
Married	0.35	0.34
Dual Eligible	0.16	0.19
AMI	0.12	0.12
Congestive Heart Failure	0.27	0.29
PVD	0.10	0.10
CEVD	0.19	0.20
Dementia	0.05	0.06
COPD	0.27	0.28
Rheumatoid Arthritis	0.04	0.04
Peptic Ulcer	0.03	0.03
Mild Liver Disease	0.01	0.01
Diabetes	0.29	0.29
Diabetes + Complication	0.06	0.06
Paraplegia	0.04	0.04
Renal Disease	0.18	0.17
Cancer	0.14	0.13
Severe Liver Disease	0.01	0.01
Metastatic Cancer	0.05	0.04
AIDS	0.00	0.00
Number Of Patients	3,720,933	3,720,272

Note: This table presents the balance in patient attributes with respect to the instrument: differential distance. We divide patients into two groups based on whether their differential distance is below or above the median value (8.9 miles). Recall that differential distance (DD) is the difference between distance to the nearest PE nursing home and the nearest non-PE nursing home for the patient. Column 1 presents the means of patient characteristics for patients with DD below the median value, while Column 2 presents the means for patients with DD greater than the median. Characteristics include four demographics and 17 pre-existing co-morbidity indicators used to compute the Charlson Co-morbidity Index. Paraplegia includes both partial and complete paralysis. We generated indicators for the 17 disease groups using the 'charlson' command in Stata, available at http://fmwww.bc.edu/RePEc/bocode/c/charlson.html. We considered diagnosis codes on hospital inpatient and outpatient claims over the 12 months prior to, but not including, the index nursing home stay.

Table 5: **Patient-Level Analysis: IV Results**

	A: Main Results		
	(1) Mortality (Stay + 90 Days)	(2) Log Amount Billed Per Patient Stay	(3) Log Amount Billed Per Patient Stay + 90 Days
1(PE)	0.0182**	0.1735***	0.1070***
	(0.007)	(0.028)	(0.024)
Observations	7,441,125	7,441,125	7,441,125
Y-Mean	0.17	9.07	9.56
F-Stat	226	226	226
	B: Placebo Analysis		
	(1) Mortality (Stay + 90 Days)	(2) Log Amount Billed Per Patient Stay	(3) Log Amount Billed Per Patient Stay + 90 Days
1(PE)	0.005	0.0014	-0.0319
	(0.008)	(0.042)	(0.035)
Observations	7,335,775	7,335,775	7,335,775
Y-Mean	0.18	9.01	9.52
F-Stat	245	245	245

Note: This table presents estimates of the relationship between PE ownership and patient health and spending. In Panel A, each cell presents the coefficient β obtained by estimating the OLS counterpart of Equation 3. The independent variable is an indicator for the patient being admitted to a PE nursing home, instrumented by differences in distance to the nearest PE and non-PE facility. Panel B presents results from a placebo analysis of the relationship between private equity ownership and patient health and spending. For this analysis, we use data over 2002–07, a period with very little actual PE ownership and which has little overlap with the main analysis sample. We assign placebo PE acquisition in 2004 to facilities that were eventually acquired before 2008 and 2005 to facilities acquired in and post 2008 by PE firms. Accordingly we re-compute differential distance values taking into account these placebo acquisitions. We present effects for claims-based patient quality outcomes - patient death within 90 days of discharge from the index stay, and total amount billed (2016$). All regressions include facility and patient HRR x Year fixed effects, and patient risk controls. Patient risk controls include age, race, gender, marital status, indicators for 17 pre-existing conditions used to compute the Charlson Index, and an indicator if patients are dual eligible. Standard errors are clustered by facility.

Table 6: **Patient-Level Analysis: Robustness**

	(1) Mortality (Stay + 90 Days)	(2) Log Amount Billed Per Patient Stay	(3) Log Amount Billed Per Patient Stay + 90 Days
Base Specification			
1(PE)	0.0182**	0.1735***	0.1070***
	(0.007)	(0.028)	(0.024)
Chain Controls			
1(PE)	0.0182**	0.1734***	0.1070***
	(0.007)	(0.028)	(0.024)
Top 5 Deals Only			
1(PE)	0.0380***	0.2417***	0.1516***
	(0.013)	(0.047)	(0.040)
W/O Top 2 Deals			
1(PE)	0.0347***	0.2231***	0.1475***
	(0.012)	(0.044)	(0.037)
Zip-Year Controls			
1(PE)	0.0160**	0.1692***	0.1031***
	(0.007)	(0.028)	(0.024)
HSA-Year FEs			
1(PE)	0.0221***	0.1736***	0.1118***
	(0.008)	(0.030)	(0.025)
County-Year FEs			
1(PE)	0.0216***	0.1375***	0.0855***
	(0.010)	(0.034)	(0.029)
No Controls			
1(PE)	0.0310***	0.2377***	0.1139***
	(0.008)	(0.031)	(0.024)
Observations	7,441,125	7,441,125	7,441,125
Y-Mean	0.17	9.07	9.56

Note: This table presents results from specification checks on the relationship between PE ownership and patient health and spending. Each cell presents the coefficient β obtained by estimating Equation 3 by 2SLS. The independent variable is an indicator for the patient being admitted to a PE nursing home, instrumented by differences in distance to the nearest PE and non-PE facility. We present effects for claims-based patient quality outcomes - patient death within 90 days of discharge from the index stay, and total amount billed (2016$). All models include facility fixed effects. The first five rows include HRR x Year fixed effects, the sixth row uses Health Service Areas (HSA), and the seventh row uses county to define patient market instead of HRR. The second row includes patient zip controls: median household income, the shares of the population that are white, that are renters rather than home-owners, that are below the federal poverty level, and that are enrolled in medicare advantage program. The third row controls for facility being part of a chain. The fourth row limits to only the 5 largest PE deals while calculating effects for PE acquisition. The fifth row calculates the results removing the 2 largest PE deals. All rows includes patient risk controls: age, race, gender, marital status, indicators for 17 pre-existing conditions used to compute the Charlson score, and an indicator if patients are dual eligible. Standard errors are clustered by facility.

Table 7: **Heterogeneity in Patient Mortality**

	(1) Observations	(2) Mean	(3) Coefficient	(4) (Std. Errors)
A: Patient Level				
1. Age & Risk				
Low Risk, 65-80	1,689,655	0.07	0.0203*	(0.012)
High Risk, 65-80	1,278,719	0.21	-0.016	(0.017)
Low Risk, 80+	2,851,748	0.16	0.0365***	(0.012)
High Risk, 80+	1,620,021	0.27	0.020	(0.016)
2. Gender				
Male	2,668,772	0.21	0.0129	(0.013)
Female	4,772,145	0.15	0.0218***	(0.008)
3. Race				
White	6,551,479	0.17	0.0222***	(0.008)
Other	888,573	0.17	-0.0202	(0.023)
4. Urban - Rural				
Urban Zipcode	5,235,412	0.16	0.0368***	(0.010)
Rural Zipcode	2,204,103	0.18	0.0084	(0.012)
5. Previous Health Diagnosis				
Cardio-Vascular	1,351,900	0.21	0.0310*	(0.016)
Injury	1,417,824	0.12	0.0214	(0.014)
Other	4,670,725	0.18	0.0129	(0.009)
B: Market/Facility Level				
1. Hirfindahl Hirschman Index				
Hhi < Median	3,720,840	0.16	0.0269	(0.020)
Hhi > Median	3,720,207	0.18	0.0152*	(0.008)
2. % Private				
% Private < 10%	1,175,235	0.18	0.0374	(0.023)
% Private > 10%	6,265,819	0.17	0.0148*	(0.008)

Note: This table presents heterogeneity in the effects of private equity ownership on patient mortality. Col 1 gives the total number of observations, Col2 the mean, and Col 3 and 4 present the coefficient β and its standard error obtained by estimating Equation 3 by 2SLS. The independent variable is the indicator for a patient being admitted to a PE nursing home, instrumented by differences in distance to the nearest non-PE and PE nursing home. The outcome variable is an indicator for patient death within 90 days of discharge from the index stay. Panel A explores heterogeneity on patient level factors - by dividing patients into 4 groups based on severity of pre-existing co-morbidities (high risk = Charlson Index greater than 2) and age (greater than 80) in 1, gender in 2, race in 3, urban and rural in 4 and previous health diagnosis in 5. Panel B explores heterogeneity based on market/ facility factors - dividing markets below and above the median Hirfindahl Hirschman Index (HHI) computed HHI using market shares in terms of beds as observed in 2003-04, where the HRR in which the nursing home is located is considered its market, and basis percentage of private patients in the nursing home observed in 2003-04. All models include facility and patient HRR x Year fixed effects. We additionally control for the usual patient risk controls as in the main regression. Standard errors are clustered by facility.

Table 8: **Potential Channels**

	A: Patient Level Outcomes			
	(1) 1(Starts Anti-Psychotics)	(2) 1(Mobility Decreases)	(3) 1(Develops Ulcers)	(4) 1(Pain Intensity Increases)
1(PE)	0.0299***	0.0403***	0.0051	0.0289*
	(0.006)	(0.011)	(0.008)	(0.016)
Observations	7,441,125	7,441,125	7,441,125	7,441,125
Y-Mean	0.06	0.52	0.09	0.27
	B: Facility Level - 5 Star Rating			
	(1) Deficiency Rating	(2) Overall Rating		
1(PE) (No Control)	-0.075**	-0.079**		
	(0.037)	(0.036)		
1(PE) (With Control)	-0.077**	-0.082**		
	(0.037)	(0.036)		
Observations	138,051	138,051		
Y-Mean	2.9	3.2		
	C: Facility Level - Staffing			
	(1) Staff Hour per Pat. Day	(2) Nurse Asst. Hour per Pat. Day	(3) Lic. Nurse Hour per Pat. Day	(4) Reg. Nurse Hour per Pat. Day
1(PE) (No Control)	-0.050***	-0.068***	-0.019***	0.037***
	(0.017)	(0.010)	(0.006)	(0.005)
1(PE) (With Control)	-0.048***	-0.066***	-0.019***	0.037***
	(0.016)	(0.010)	(0.006)	(0.005)
Observations	283,767	283,767	283,767	283,767
Y-Mean	3.6	2.3	0.8	0.5

Note: This table presents estimates of the relationship between PE ownership and patient health assesments and nursing home outcomes. In Panel A, each cell in the first row presents the coefficient β obtained by estimating Equation 3. The independent variable is an indicator for the patient being admitted to a PE nursing home, instrumented by differences in distance to the nearest PE and non-PE facility. Outcome variables are indicators for patient health assesments. All models include facility and patient HRR x Year fixed effects. We additionally control for the usual patient risk controls as in the main regression. In Panel B and C, each cell presents the coefficient β obtained by estimating equation 4 with a different outcome. The independent variable is an indicator for whether a nursing home is private equity-owned (=1 if private equity-owned, 0 otherwise) starting in the next year from the deal announcement date. Panel A presents results for patient level outcomes - an indicator for patient starting anti- pyschotics, decrease in patient mobility, developing/worsening pressure ulcers, and increase in pain intensity. Panel B presents results for quality outcomes as measured by Five-star rating awarded by CMS - overall rating and deficiencies identified by independent contractors in audits, respectively. A negative effect on ratings implies a decline in quality. Panel C presents results on per patient staffing availability for all nurses, nurse assistants, licensed nurses, and registered nurses. The top row presents results with no controls. The bottom row presents the results including controls, which consist of market-level and patient controls, as described in Section 4. All models include facility and year fixed effects. All variables are winsorized at 1 and 99% levels. Standard errors are clustered by facility.

Appendix: For Online Publication

A Robustness Tests of Facility-Level Analysis (For Online Publication)

We use a number of strategies to test the robustness of these nursing home-level results. First, the best available test for whether changes in patient composition may explain the results is to compare the effects with and without our rich array of patient risk controls. The patient risk and market controls included in the second row for each variable in Table 8 and Appendix Table B.8 do not attenuate the point estimates or their statistical significance. Stability in the presence of controls is encouraging and implies that differences in patient risk or location are not driving the effects, particularly for staffing. Second, it would be worrying if the results reflected particular private equity deals or firms. However, the results are robust to including either lead investing firm or deal fixed effects.

Third, we may be concerned that including the minority of nonprofit nursing homes in the control group somehow skews the estimates, despite facility fixed effects. As an alternative estimation strategy, we make the sample of for-profit nursing homes more homogeneous by estimating effects on a matched subset of comparison facilities. This helps produce a sample with more balance between non-targeted and targeted facilities on market environment, size, patient volume and demographics. The full analysis sample has about 18,000 and 1,670 non-targeted and targeted facilities respectively. Table 1 shows that targeted facilities were larger and attracted more patients even before private equity acquisition. This may raise concerns about differences on unobserved attributes that may interact with the decision to acquire these facilities and bias our coefficients. The matching estimator addresses this concern.

Specifically, we use Coarsened Exact Matching Iacus, King and Porro (2012) to identify a subset of targeted and non-targeted facilities with similar attributes pertaining to the market environment (concentration of nursing homes – Herfindahl-Hirschman Index, leave-one-out fraction of for-profit and chain nursing homes in the county), facility attributes (number of beds and whether the facility is in an urban location), patient demographics (percent female), and risk (Case Mix Index and Acuity Index). We match facilities which were acquired by private equity firms to those not acquired during our sample period based on the values of the targeted facilities 2 years prior to the year of acquisition. This helps avoid incorporating anticipation effects, if there are any. We then retain any non-targeted facility that was ever matched to a targeted facility.

This process results in a sample of 1,320/1,674 facilities bought by PEs, and 4,132/16,818 comparison facilities in the matched sample. Evidently, a number of targeted facilities could not be matched by the algorithm. We used the 'cem' command in Stata to identify the matched sample. Table A.1 presents descriptive statistics on the matched sample and shows that the targeted and non-targeted facilities are indeed more similar on size, patient volume and demographics. We estimate Equation 4 as with the full sample and present the results in Table A.2. The effects are similar to the estimates in our main sample. For example, the effect on the Overall rating is -.13, which is larger than the main effect of -.082. The effect on total staff hours per patient day declines slightly, from -.05 to -.04, but the mean in this sample is lower.

Further robustness tests are in Appendix Table A.3. These show similar or larger results

with controls for facilities being part of a chain, and without the top two deals.[29] These demonstrate that the results here are also not driven by corporatization or large scale. A final concern is that we do not observe when private equity firms exit their investment by selling the nursing home. This could lead to misclassification of some nursing homes as private equity-owned when they are no longer so. We tested the importance of this misclassification bias by dropping observations of private equity-owned facilities at ten years or more of ownership. These cases are most likely to be misclassified since private equity firms typically exit investments within this time horizon. The coefficients remain largely unaffected, and in some cases become larger. These results are not reported, but are available on request. Note that particularly in recent years, private equity exits are often to other private equity firms in secondary transactions, so in practice the time under private equity ownership is typically longer than the average investment period.

[29] We do not present results limiting to Top 5 deals as 5 Star ratings only available post 2009, and 4 out of 5 Top 5 deals take place before 2009.

Table A.1: **Matched Sample - Descriptive Statistics**

	All			Not PE Owned		PE Owned	
	Mean	SD	Count	Mean	Count	Mean	Count
Overall Five-Star Rating	2.92	1.26	45,432	2.95	36,711	2.77	8,721
Deficiency Five-Star Rating	2.90	1.15	45,381	2.97	36,668	2.64	8,713
Staff Hours per Pat. Day	3.32	1.02	90,933	3.33	80,366	3.29	10,567
Nurse Assistant Hours per Pat. Day	2.15	0.64	90,933	2.17	80,366	2.03	10,567
Licensed Nurse Hours per Pat. Day	0.79	0.34	90,933	0.79	80,366	0.80	10,567
Registered Nurse Hours per Pat. Day	0.36	0.30	90,933	0.35	80,366	0.45	10,567
Number of Beds	110.76	37.53	90,933	110.37	80,366	113.76	10,567
Admissions	214.10	159.31	90,933	207.43	80,366	264.83	10,567
Admissions per Bed	1.96	1.52	90,933	1.91	80,366	2.36	10,567

Note: This table presents descriptive statistics for the matched sample used in robustness checks. The sample contains 1,349/1,674 facilities bought by PEs, and 4,067/16,818 comparison facilities that were not bought by PEs during our sample period. We used Coarsened Exact Matching (CEM) to obtain this sample. Private equity-owned facilities were matched two years prior to buyout in order to avoid anticipation effects. The facilities were matched on market attributes such as whether urban, HHI, nature of other nursing homes, and number of facilities; facility attributes such as number of beds, and patient characteristics such as Case Mix Index (CMI), Acuity Index, and% female patients.

Table A.2: **Effects using matched comparison group**

	A: 5 Star Rating	
	(1) Overall rating	(2) Deficiency rating
1(PE)	-0.128***	-0.109***
	(0.041)	(0.042)
Observations	45,392	45,392
Y-Mean	3.0	2.7

	B: Staffing			
	(1) Staff hour per pat. day	(2) Nurse Asst. hour per pat. day	(3) Lic. Nurse hour per pat. day	(4) Reg. Nurse hour per pat. day
1(PE)	-0.037**	-0.049***	-0.026***	0.033***
	(0.018)	(0.011)	(0.006)	(0.005)
Observations	90,908	90,908	90,908	90,908
Y-Mean	3.3	2.2	0.8	0.4

Note: This table presents estimates of the relationship between private equity buyouts and outcomes using a matched comparison group of facilities, without including controls. We used Coarsened Exact Matching (CEM) to match facilities on a number of facility attributes, patient risks, and market characteristics. When considering the targeted facility, we used their data two years prior to private equity buyout to mitigate the role of anticipation effects. Table A.1 presents descriptive statistics for this sample. The sample also drops all non-profit nursing homes. Corresponding results on the full sample are presented in facility level outcomes for Table 8. Each cell presents the coefficient β obtained by estimating Equation 4 with a different outcome. The independent variable is an indicator for whether a nursing home is private equity-owned (=1 if private equity-owned, 0 otherwise) starting in the next year from the deal announcement date. All models include facility and year fixed effects. All variables are winsorized at 1 and 99% levels. Standard errors are clustered by nursing home.

Table A.3: **Robustness: Facility Level Results**

	A: 5 Star Rating	
	(1) Deficiency Rating	(2) Overall Rating
1(PE)	-0.109***	-0.128***
	(0.042)	(0.041)
Observations	45,392	45,392
Y-Mean	2.7	3.0

	B: Staffing			
	(1) Staff Hour per Pat. Day	(2) Nurse Asst. Hour per Pat. Day	(3) Lic. Nurse Hour per Pat. Day	(4) Reg. Nurse Hour per Pat. Day
1(PE)	-0.037**	-0.049***	-0.026***	0.033***
	(0.018)	(0.011)	(0.006)	(0.005)
Observations	90,908	90,908	90,908	90,908
Y-Mean	3.3	2.2	0.8	0.4

Note: This table presents estimates of the relationship between private equity buyouts and outcomes. Corresponding results are presented in facility level outcomes for Table 8. Each cell presents the coefficient β obtained by estimating Equation 4 with a different outcome. The independent variable is an indicator for whether a nursing home is private equity-owned (=1 if private equity-owned, 0 otherwise) starting in the next year from the deal announcement date. We control for a chain indicator in the first row, and remove the top 2 deals by size in the second row. We do not present results limiting to Top 5 deals as 5 Star ratings only available post 2009, and 4 out of 5 Top 5 deals take place before 2009. All models include facility and year fixed effects. All variables are winsorized at 1 and 99% levels. Standard errors are clustered by nursing home.

B Supplementary Figures and Tables (For Online Publication)

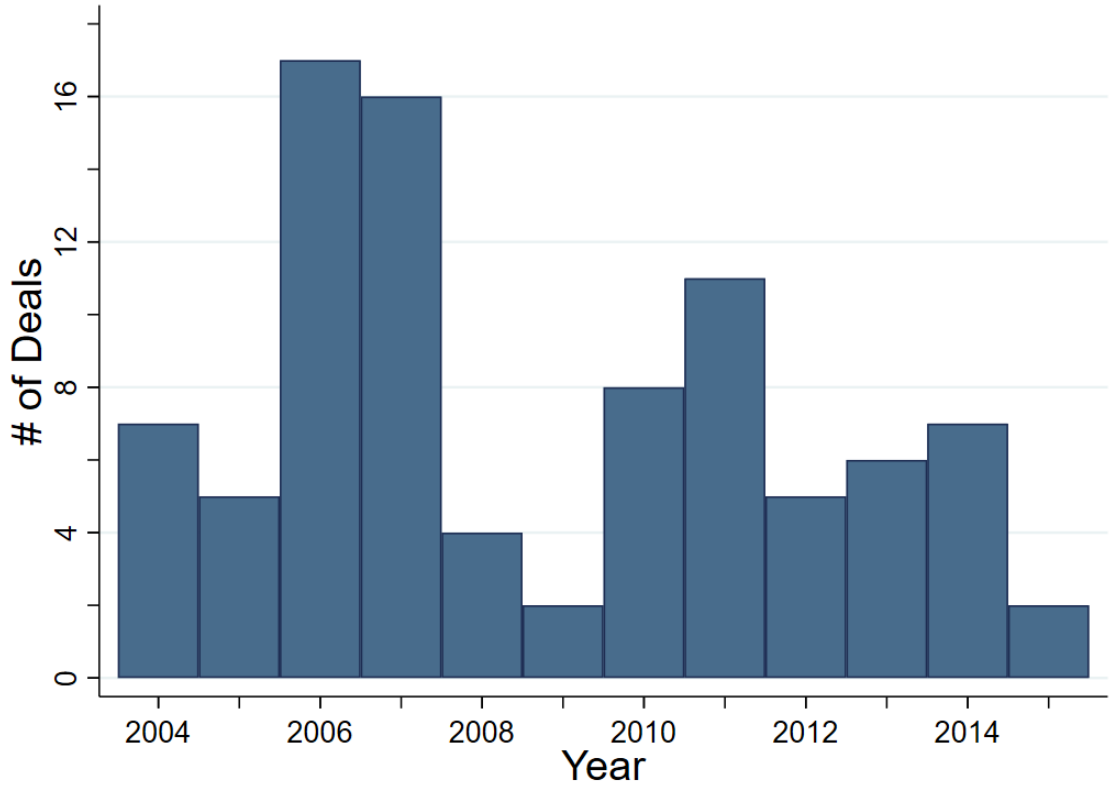


Figure B.1: **PE deals for Nursing Homes by Year**

Note: This figure shows the number of unique deals deals for active nursing homes by private equity firms for each year over the period 2004–2015.

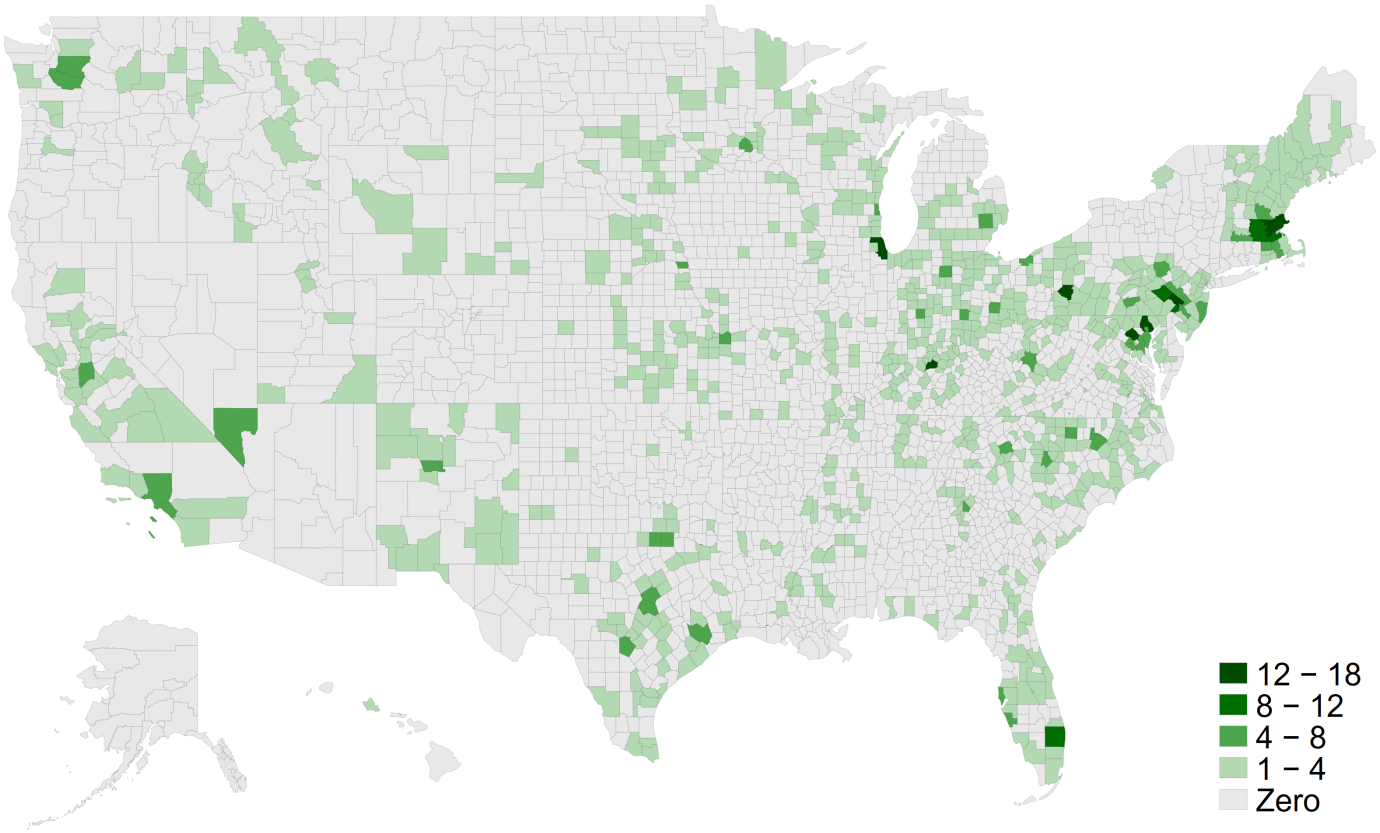
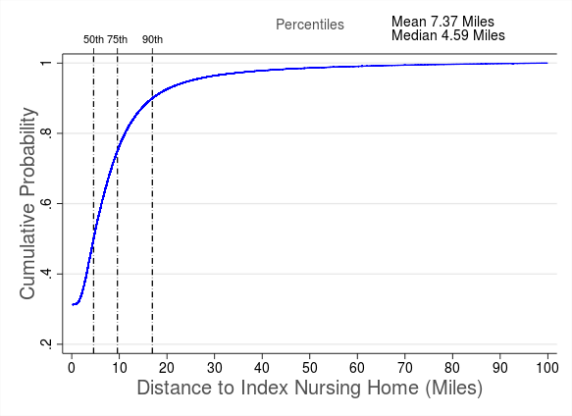
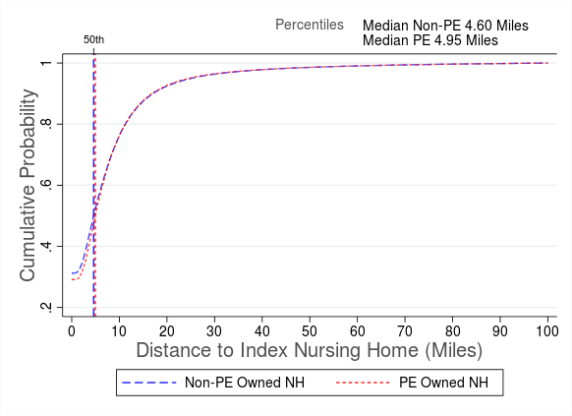


Figure B.2: **Location of Private Equity Targets**

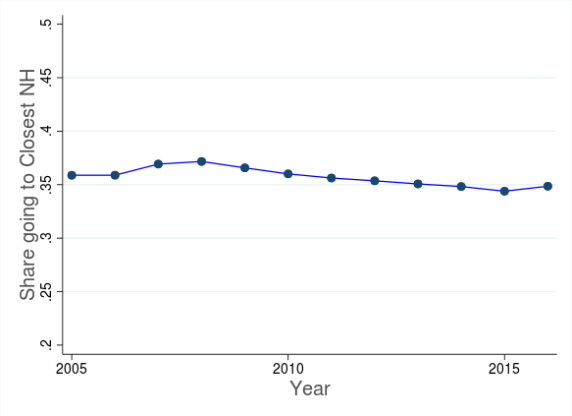
Note: This figure presents the number of facilities bought by private equity firms in each county over the period 2004–2015. We identified 1,674 such facilities.



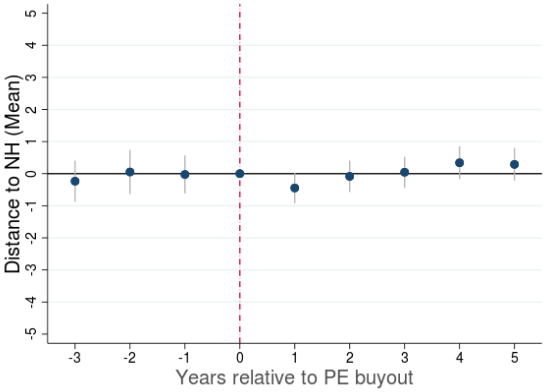
A: CDF: All Patients



B: CDF: PE vs. Non-PE Patients



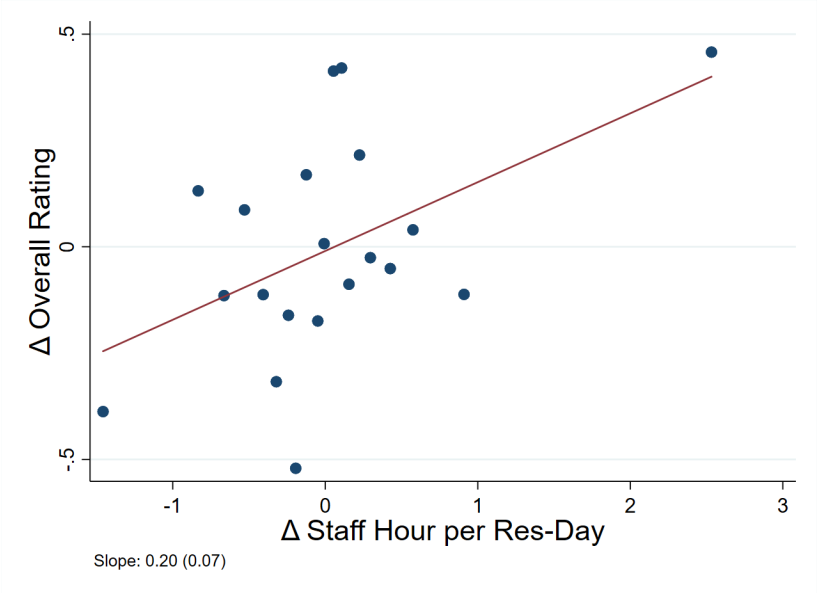
C: Trendline: Share going to Closest Nursing Home



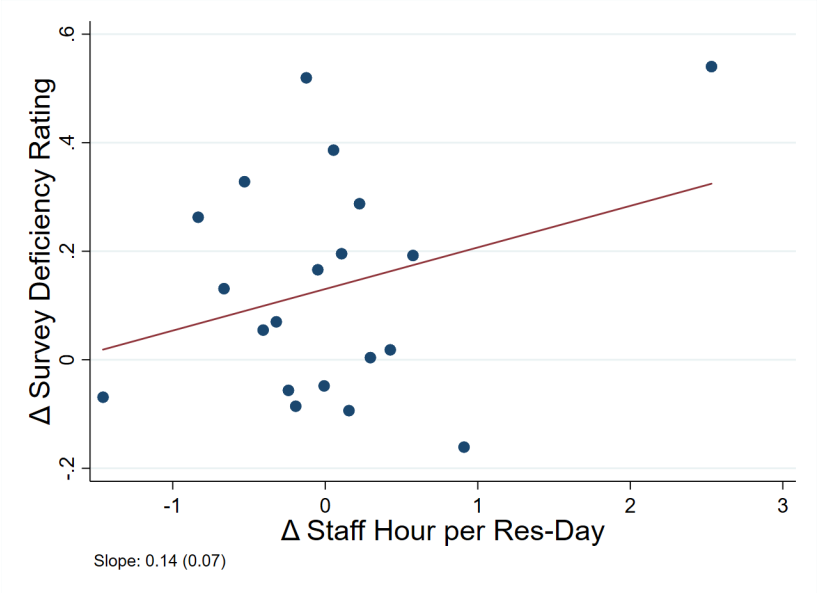
D: Event Study: PE Acquisition

Figure B.3: **Distance to Nursing Home**

Note: This figure relates to distance from patient zip code to index nursing home zip code. Panels A and B present CDFs of distance from patient zip code to index nursing home zip code. Panel A presents the CDF pooling PE and non-PE patients together. It also identifies the median, 75th and 90th percentile distances. Panel B presents the CDFs separately for PE and non-PE patients, and their respective median distances. Panel C presents the annual trendline for share of patients going to their closest nursing home. Panel D presents event study on mean distance from patient zip code to index nursing home. Each point in the figures represents the coefficient β_s obtained by estimating Equation 5 as discussed in Section 4. Year = 0 is the omitted point. All models include facility and HRR X Year fixed effects. Standard errors are clustered by facility



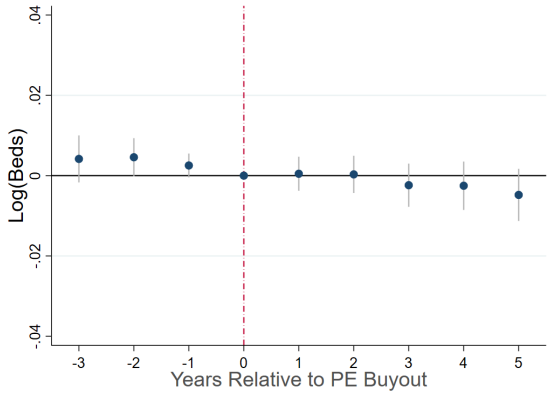
A: Overall Rating



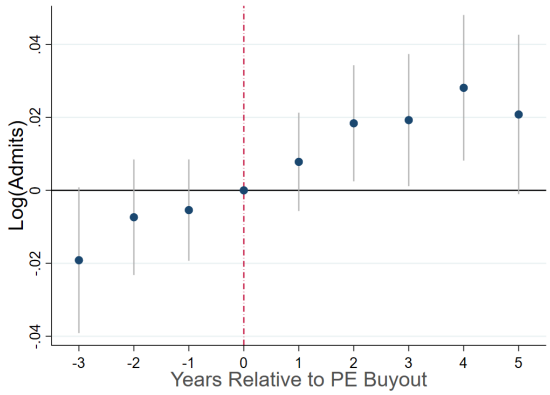
B: Deficiency Rating

Figure B.4: **Staff Availability and Five Star Ratings**

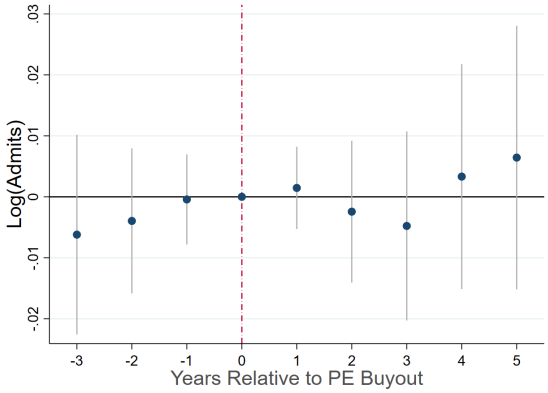
Note: This figure presents scatter plots of changes in total staff hours available per patient day in the three years post-PE buyout versus three years pre-buyout on the X-axis, against changes in CMS Five-star rating over the same period on the Y-axis. Panel A presents overall rating, and Panel B presents survey based deficiency rating. The data was collapsed into 20 equal sized bins and we plot the means in each bin. The figures also present fitted lines for these plots obtained using linear regressions on the underlying data. Each plot also presents the slope coefficient with standard error.



A: Log(Beds)



B: Log(Admits)



C: Market size change

Figure B.5: **Aggregate Volume Outcomes**

Note: This figure presents event studies on volume of admissions around the time a nursing home experiences a PE buyout. Each point in the figures represents the coefficient β_s obtained by estimating Equation 5 as discussed in Section 4. The unit of measurement is nursing home for Panel A and B and HRR in which nursing home is located in Panel C. Year = 0 is the omitted point. All dependent variables are winsorized at 1 and 99% level. All models include facility and year fixed effects in Panels A and B, and facility HRR and year fixed effects in Panel C. We control for state year trends for all models. Standard errors are clustered by facility for Panels A and B and by HRR in which nursing home is located in Panel C.

Table B.4: **Top 10 Private Equity Deals**

Sr. No.	Target Name	Private Equity Firm(s)	Deal Year	Number of Facilities
1	Genesis Healthcare	Formation Capital, JER Partners	2007–14	327
2	Golden Living	Fillmore Capital Partners	2006	321
3	Kindred Healthcare	Signature Healthcare, Hillview Capital	2014	150
4	HCR Manorcare	Stockwell Capital, The Carlyle Group	2007–18	145
5	Mariner Healthcare	Fillmore Capital Partners	2004	95
6	Skilled Healthcare Group	Onex, Heritage Partners	2005–07	76
7	Trilogy Investors	Lydian Capital Partners	2007–15	65
8	Lavie Care Centers	Formation Capital, Senior Care Development	2011	61
9	Laurel Health Care Company	Formation Capital, Longwing Real Estate Ventures	2006–16	41
10	Harden Healthcare	NXT Capital, Oaktree Speciality Lending	2013	35

Note: This table presents some details on the top 10 private equity deals in our sample, ordered by the number of unique nursing home facilities involved in the deal. This represents the number of facilities we were able to identify and match in our administrative data, the actual number of facilities in the deal may have been different. We set the PE indicator to turn on in the year following the deal year. If a closing year is mentioned, it implies the PE investors exited or went public in that year. Accordingly, we turn off the PE indicator in the year following the closing year.

Table B.5: **Complier Characteristics**

	Observations	Coefficient	(Std. Errors)	Ratio
Full Sample	7,441,125	- 0.0438***	(0.003)	
A. Age				
Age < 74	1,690,155	- 0.0408***	(0.002)	0.93
74 < Age < 84	2,906,165	- 0.0439***	(0.003)	1.00
Age > 84	2,844,249	- 0.0455***	(0.003)	1.04
B. Gender				
Male	2,668,772	- 0.0448***	(0.003)	1.02
Female	4,772,145	- 0.0432***	(0.003)	0.99
C. Marital Status				
Unmarried	4,901,532	- 0.0439***	(0.003)	1.00
Married	2,539,310	- 0.0431***	(0.003)	0.98
D. Beneficiary Zip Income				
Income < Median	3,716,638	- 0.0512***	(0.004)	1.17
Income > Median	3,724,346	- 0.0295***	(0.003)	0.67
E. Race				
White	6,551,479	- 0.0443***	(0.003)	1.01
Other	888,573	- 0.0380***	(0.003)	0.87
F. Urban - Rural				
Urban Zipcode	5,240,446	- 0.0342***	(0.003)	0.78
Rural Zipcode	2,199,050	- 0.0643***	(0.004)	1.47

Note: This table presents estimates compliers by various groups. We present the coefficient β, obtained by estimating the equation $PE_i = \alpha_j + \alpha_{m,t} + \beta\, 1(DD_i > Median) + \epsilon_i$. $1(DD_i > Median)$ is an indicator for patient i's differential distance to the nearest PE owned facility being greater than the median value. The model includes facility j and patient HRR x year fixed effects $\alpha_{m,t}$, but no other controls. We divide the sample by age, gender, marital status, income in patient zip code, race and facility urban status. Urban status is determined following federal data available at https://www.ers.usda.gov/data-products/rural-urban-continuum-codes.aspx. Beneficiaries located in zipcodes with continuum values of 1 or 2 are assigned to be urban. We also present the ratio of the coefficient obtained for each sub-group to that for the full sample. Standard errors are clustered by facilities.

Table B.6: **Mortality Costs**

	(1) Male	(2) Female
A: IV estimates		
1(PE)	0.0129	0.0218***
	(0.013)	(0.008)
Observations	2,668,772	4,772,145
Y-Mean	0.21	0.15
F-Stat	223	223
B: Placebo		
1(PE)	-0.0001	0.0086
	(0.023)	(0.013)
Observations	810,479	2,151,970
Y-Mean	0.22	0.15
F-Stat	223	244
C: Calculations		
Number of Patients in PE Facilities	483,627	665,871
Additional Deaths	6,239	14,516
Total Lives Lost	20,755	
Mean Life Expectancy	8.6	10.4
Additional Loss in Person Years	53,616	150,757
Total Person Years Lost	204,373	
Value of Life Year (2016 $)	130,000	
Total Cost (2016 $)	26.57 Billion	

Note: This table presents estimates of additional deaths, life-years lost, and total cost due to private equity ownership of nursing homes. Panel A presents the coefficient β obtained by estimating Equation 3 by 2SLS. The independent variable is the indicator for a patient being admitted to a PE nursing home, instrumented by differences in distance to the nearest non-PE and PE nursing home. The outcome variable is an indicator for patient death within 90 days of discharge from the index stay. Panel B presents a placebo analysis for this patient subsample using the same approach as for the whole sample, as presented in Table 5. All models include facility and patient HRR x year fixed effects and the usual patient risk controls as in the main specification. Standard errors are clustered by facility. Panel C presents calculations to estimate lives, life-years lost and total cost based on Panel A coefficients.

Table B.7: **Patient-Level Analysis: OLS Results**

	A: Main Outcomes			
	(1) Mortality (Stay + 90 Days)	(2) Log Amount Billed Per Patient Stay	(3) Log Amount Billed Per Patient Stay + 90 Days	
1(PE)	0.0035***	-0.0226***	-0.0141***	
	(0.001)	(0.006)	(0.005)	
Observations	7,441,125	7,441,125	7,441,125	
Y-Mean	0.17	9.07	9.56	
F-Stat	226	226	226	
	B: Assesment Based Outcomes			
	(1) 1(Starts Anti-Psychotics)	(2) 1(Mobility Decreases)	(3) 1(Develops Ulcers)	(4) 1(Pain Intensity Increases)
1(PE)	0.0114***	0.0359***	0.0097***	0.0276***
	(0.001)	(0.003)	(0.003)	(0.005)
Observations	7,441,125	7,441,125	7,441,125	7,441,125
Y-Mean	0.06	0.52	0.09	0.27
F-Stat	226	226	226	226

Note: This table presents estimates of the relationship between PE ownership and patient health and spending. Each cell presents the coefficient β obtained by estimating the OLS counterpart of Equation 3. The independent variable is an indicator for the patient being admitted to a PE nursing home. In Panel A, we present effects for claims-based patient quality outcomes - patient death within 90 days of discharge from the index stay, and total amount billed (2016$). Panel B presents results for MDS assesment based outcomes - an indicator for patient starting anti- pyschotics, decrease in patient mobility, developing/worsening pressure ulcers, and increase in pain intensity. All regressions include facility and patient HRR x Year fixed effects, and patient risk controls. Patient risk controls include age, race, gender, marital status, indicators for 17 pre-existing conditions used to compute the Charlson Index, and an indicator if patients are dual eligible. Standard errors are clustered by facility.

Table B.8: **Patient Volume**

	A: Patient Spending	
	(1) Beds (Log)	(2) Admissions (Log)
1(PE)	-0.003	0.024***
(No Control)	(0.003)	(0.009)
1(PE)	-0.003	0.024***
(With Control)	(0.003)	(0.009)
Observations	283,767	283,767
Y-Mean	4.5	4.8
	B: Market Volume	
	(1) Admissions (Log)	
1(PE)	0.01	
(No Control)	(0.010)	
1(PE)	0.006	
(With Control)	(0.008)	
Observations	5,490	
Y-Mean	12.7	

Note: This table presents estimates of the relationship between private equity acquisitions with patient volume. Each cell presents the coefficient β obtained by estimating equation 4 with a different outcome. Panel A presents results for log beds, and log admissions. Panel B presents effects on log volume in the HRR. In Panel A, the independent variable is an indicator for whether a nursing home is private equity-owned (=1 if private equity-owned, 0 otherwise) starting in the next year from the deal announcement date. In Panel B, we set the indicator to turn on when a PE firm first acquires a facility located in the market (HRR). The unit of measurement is nursing home for Panel A and HRR in which nursing home is located in Panel B. The top row presents results with no controls. The bottom row presents the results including controls, which consist of market-level and patient controls, as described in Section 4. All models include facility and year fixed effects in Panels A, and facility HRR and year fixed effects in Panel B. We control for state year trends for all models. All variables are winsorized at 1 and 99% levels. Standard errors are clustered by facility (market) in Panel A (B).

Table B.9: **Robustness: Channels in levels**

	A: Patient Level Outcomes				
	(1) 1(Takes Anti-Psychotics)	(2) 1(Reduced Mobility)	(3) 1(Has Ulcers)	(4) 1(Moderate to High Pain)	(5) Length of Stay (Log)
1(PE)	0.0418***	0.0831***	0.0268***	0.0115	0.2095***
	(0.007)	(0.017)	(0.010)	(0.018)	0.0310
Observations	7,441,125	7,441,125	7,441,125	7,441,125	7,441,125
Y-Mean	0.10	0.63	0.17	0.35	3.41
	B: Facility Level - Absolute Staffing				
	(1) Staff Hour (Log)	(2) Nurse Asst. Hour (Log)	(3) Lic. Nurse Hour (Log)	(4) Reg. Nurse Hour (Log)	
1(PE)	-0.010**	-0.012	-0.043***	0.067***	
(No Control)	(0.005)	(0.007)	(0.008)	(0.015)	
1(PE)	-0.010**	-0.011	-0.043***	0.067***	
(With Control)	(0.005)	(0.007)	(0.008)	(0.015)	
Observations	220,941	220,941	220,941	220,941	
Y-Mean	11.6	11.1	10.0	9.0	

Note: This table presents estimates of the relationship between PE ownership and patient health assesments and nursing home outcomes. In Panel A, each cell in the first row presents the coefficient β obtained by estimating Equation 3. The independent variable is an indicator for the patient being admitted to a PE nursing home, instrumented by differences in distance to the nearest PE and non-PE facility. Outcome variables are indicators for patient health assesments. All models include facility and patient HRR x Year fixed effects. We additionally control for the usual patient risk controls as in the main regression. In Panel B, each cell presents the coefficient β obtained by estimating equation 4 with a different outcome. The independent variable is an indicator for whether a nursing home is private equity-owned (=1 if private equity-owned, 0 otherwise) starting in the next year from the deal announcement date. Panel A presents results for patient level outcomes - an indicator for patient being on anti- pyschotics, low patient mobility, presence of pressure ulcers, moderate to high pain intensity, and length of stay during the index nursing home stay. Panel B presents results on the logarithm staffing availability for all nurses, nurse assistants, licensed nurses, and registered nurses. The top row presents results with no controls. The bottom row presents the results including controls, which consist of market-level and patient controls, as described in Section 4. All models include facility and year fixed effects. All variables are winsorized at 1 and 99% levels. Standard errors are clustered by facility.