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Worker earnings, service quality, and firm profitability: Evidence from nursing homes and minimum wage reforms

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Worker earnings, service quality, and firm profitability: Evidence from nursing homes and minimum wage reforms

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Abstract

This paper examines whether higher wages paid to low-income workers affects the quality of services they provide to consumers. To answer this question, I combine wage variation for direct care staff in long-term residential care settings, driven by minimum wage reforms, with objective measures of patient health. I find that a ten percent increase in the minimum wage raises low-skilled nursing home workers' earnings one to two percent, reduces separations, and increases stable hires. These earnings gains and increases in firm-specific human capital translate into marked improvements in patient health and safety. A ten percent increase in the minimum wage would prevent at least 15,000 deaths, lower the number of inspection violations by one to two percent, and reduce the cost of preventable care. Firms are able to fully offset higher labor costs by attracting patients with a greater ability to pay and increasing prices for these residents, resulting in no significant change in profitability. Considering costs elsewhere in the health system, savings from pressure ulcer treatment alone offsets up to half of the increased wage bill, and if the social value of increased longevity for nursing home residents is at least $21,000 – well below existing estimates – higher wages in this sector are fully offset by improvements in care.

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1 Introduction

While the quality of goods and services affects consumer well-being, in many settings employers and customers cannot discern quality at the time of production or purchase. In these situations, front-line workers may have weak performance incentives, and paying employees higher wages can improve output quality (Shapiro and Stiglitz, 1984; Akerlof, 1982; Lazear and Moore, 1984). Beyond standard efficiency wage considerations, increasing pay for low-wage workers increases households' financial resources and may reduce stress driven by budget pressures (Mani et al., 2013). Finally, employee turnover is high in many low-skilled industries, and if higher wages reduce the arrival rate of better-paying jobs, increases in tenure and job-specific expertise can improve production efficiency.

Although the efficiency wage and firm-specific human capital theories are well developed, the existing empirical work is largely limited to workers in production industries, where quality is often readily observable. In contrast, there is little evidence whether higher worker compensation affects consumer outcomes in low-wage service industries where employee effort is particularly difficult to monitor and quality is subjective or not easily quantified. Moreover, whether wage increases induced by government *policy* can improve worker performance remains an unanswered question.

This paper broadens our understanding of how employee compensation translates into consumer well-being by examining the relationship between direct-care workers' wages and patient health and safety in long-term residential care settings. I measure consumer outcomes using objective measures of patient health and safety for the near-universe of nursing homes, and leverage 25 years of wage increases for healthcare support staff driven by minimum wage reforms. Importantly, wage variation due to statutory minimum wages differs from wage increases that are determined by profit maximization decisions. While both mandatory and voluntary wage increases could improve service quality by attracting more productive workers and incentivizing greater effort, mandated wage increases may also prompt firms to reduce staff, leading to worsened quality of care. Therefore, if both the number of workers and their effort affect output, whether higher minimum wages affect service quality is *a priori* uncertain.

In order to test whether legislated wage increases affect service quality, I adapt the contigu-

ous county-pair differences-in-differences framework, pioneered by Card and Krueger (1994) and generalized by Dube et al. (2010) and Dube et al. (2016). I build upon this approach by including city- and establishment-level reforms, in addition to state and county changes. The rich temporal and spatial variation in minimum wages permits comparisons of patient well-being in the same facility due to exogenous changes in labor costs, and relative to neighboring firms, while flexibly accounting for demographic and economic changes at a very local level.

I first establish higher minimum wages increase earnings among low-skilled healthcare workers, with a ten percent minimum wage increase raising nursing assistant earnings 1.2 to 2.0 percent while not significantly reducing low-skilled employment. Although nursing homes are relatively unexplored in the U.S. minimum wage literature, the earnings and employment responses are comparable to those found for affected workers in other low-wage industries (Dube et al., 2010, 2016; Reich et al., 2017; Jardim et al., 2017; Cengiz et al., 2019).[1] I also find suggestive evidence higher minimum wages increase tenure by reducing separations and increasing the share of hires who remain with their employer for at least three months, again consistent with existing work in other sectors (Dube et al., 2016; Jardim et al., 2018; Portugal and Cardoso, 2006; Brochu and Green, 2013).

Second, I provide some of the first empirical evidence how employee wages affect consumer well-being. Here, I find higher wages improve patient safety and health, with a ten percent minimum wage increase reducing the number of health inspection violations by one to two percent (0.1 violation each period for the typical facility), the fraction of residents with moderate-to-severe pressure ulcers by 1.7 percent (0.14 percentage points), and the annual number of deaths occurring in nursing homes by 3.1 to 3.3 percent (15,000-16,000 deaths a year). Event study analyses illustrate that resident health does not systematically diverge prior to minimum wage increases, supporting the basic differences-in-differences framework, and that reductions in the most costly health outcomes – pressure ulcers and mortality – persist after the initial wage shock.

Third, I examine how employers offset higher labor costs. I find that the mechanical increase in costs from the baseline low-skilled labor share fully accounts for the reported cost changes.

[1] Examining early minimum wage reforms, the 1966 FLSA expanded increased wages among newly-covered workers, including nursing home employees (Bailey et al., 2020; Derenoncourt and Montialoux, 2018).

Facilities do not substitute towards higher-skilled labor or other factors of production, but increase the revenue they receive from consumers in two ways. First, firms charge private payors more (about 75 percent of the increase in per-resident revenue), and second, firms shift the resident mix towards higher-revenue patients by serving more private payors and fewer Medicaid recipients.

My findings are consistent with minimum wages improving patient health through increasing firm-specific human capital and improving worker performance. Importantly, the underlying motivation for efficiency wages – namely that higher compensation improves worker productivity when effort is *imperfectly observable* to employers and consumers – makes disentangling potential mechanisms particularly difficult in this setting. In the absence of a direct measure of worker productivity, several extensions can rule out competing explanations. First, although I find nursing home residents become more positively selected following minimum wage increases, changes in observable patient characteristics cannot account for most of the observed health improvements. Second, I do not find higher minimum wages increase firm closures or mergers, suggesting the findings are not driven by low-performing firms exiting the market. Third, while higher wages could improve quality by altering incentives of current workers, attracting better workers, or leading firms to substitute towards higher-skilled staff, there are no significant changes in worker demographic characteristics or increased employment among credentialed nursing staff. Together, these patterns are consistent with higher minimum wages inducing better performance among current workers and improving production efficiency through greater retention.

These findings provide empirical evidence on how higher wages can improve service quality in low-wage settings. Although a single industry, the nursing home sector is an important setting to explore the relationship between worker economic security and consumer outcomes. First, long-term care is a large and rapidly growing sector of the economy, accounting for about 10 percent of Medicaid and Medicare expenditures. More than half of individuals reaching age 65 will require long-term care at some point in their lives, much of which is provided in residential settings (Favreault and Dey, 2015). Patients have imperfect information about the quality of care at the time of admission, as health conditions develop over time and require expertise to diagnose. The traditional fee-for-service reimbursement model, combined with a large role

of government financing through Medicaid and Medicare, results in relatively inelastic consumer demand for most consumers that reduces incentives for providers to offer cost-efficient treatments. As the population ages, demand for long-term care will increase, placing greater pressure on government finances and increasing demand for health service workers. In addition, medical experts, policymakers, families, and patients have expressed concerns about the quality of long-term care for at least sixty years (Castle and Ferguson, 2010; Institute of Medicine, 1986). In an effort to monitor service provision, the federal government has implemented a series of inspection and reporting requirements. I build a novel dataset from this information that includes administrative measures of staffing, health inspection violations, and patient health for the near-universe of nursing homes spanning the 1991 through 2017 period.

This paper contributes to three distinct literatures in economics and public health. First, an extensive literature finds that higher statutory minimum wages increase earnings, with an earnings elasticity among affected groups centered around 0.2 (CBO, 2019, Wascher and Neumark (2007), and Schmitt (2013) overview of the recent literature).[2] Employment effects center around zero (Belman and Wolfson, 2014; Doucouliagos and Stanley, 2009), but vary across specifications, especially whether substate geographic controls are used (Card and Krueger, 1994, 2000; Dube et al., 2010, 2016; Allegretto et al., 2011, 2017; Totty, 2017; Neumark and Wascher, 1992; Deere et al., 1995; Neumark et al., 2014) and the time period examined (Cengiz et al., 2019).[3] This existing research, however, is largely limited to two sectors, the retail and food services industries, and my results indicate that relatively recent minimum wage reforms increase earnings among low-wage workers by a comparable amount, but in a different setting (low-wage healthcare support), and without significantly reducing employment.

Second, a smaller literature examines the effects of minimum wages on consumer well-being, documenting that higher minimum wages increase consumer prices (Draca et al., 2011; Harasz-

[2]Higher minimum wages also stimulate income mobility, improve long-term earnings growth, and reduce inequality at the bottom of the income distribution (Rinz and Voorheis, 2018; DiNardo et al., 1996; Lee, 1999; Lemieux, 2008; Autor et al., 2016).

[3]Employment responses may differ across worker types. While some work finds disemployment effects concentrated among less-experienced workers, or in poor economic conditions (Jardim et al., 2018; Meer and West, 2016; Sabia et al., 2012; Addison et al., 2013; Clemens and Wither, 2019; Gittings and Schmutte, 2016), other work finds higher minimum wages decrease overall employment, but increase the share of teenage workers in relatively high-wage labor markets (Giuliano, 2013; Lang and Kahn, 1998).

tosi and Lindner, 2015; Aaronson et al., 2008; Allegretto and Reich, 2018). Other outcomes are relatively unexplored, and this paper provides some of the first empirical evidence of how higher minimum wages can affect consumer well-being on non-financial dimensions. One notable exception is Giupponi and Machin (2018), who examine a single, national minimum wage reform in the UK and find higher minimum wages increase the number of nursing home inspection violations. One important difference between these settings is that British nursing homes have limited ability to increase prices, whereas I document that firms respond to higher labor costs by charging consumers higher prices and shifting toward relatively high-revenue payors. More generally, my findings are consistent with a series of papers finding that higher wages for public-sector employees, such as hospital employees and teachers, improve service quality, measured by hospital deaths (Propper and Van Reenen, 2010) and student test scores (Britton and Propper, 2016).

Third, this paper relates to personnel policies in the long-term care sector. The previous work in this area finds that increased staffing due to changes in regulations and macroeconomic conditions reduces mortality and the number of inspection violations (Chen and Grabowski, 2015; Matsudaira, 2014a; Park and Stearns, 2009; Antwi and Bowblis, 2018; Stevens et al., 2015), but has mixed effects on other measures of patient health (Matsudaira, 2014a; Chen and Grabowski, 2015; Bowblis, 2011; Park and Stearns, 2009). Other work finds unionization decreases staffing levels but does not worsen patient outcomes, suggesting labor market policies can alter worker productivity in this sector (Sojourner et al., 2015). This paper complements the existing literature by examining a policy – minimum wages – that has not been fully explored in previous work. One notable exception is Cawley et al. (2006), who find that higher minimum wages reduce the use of physical restraints and increase use of psychotropic medications. Compared to Cawley et al. (2006), my analyses cover a more recent period and leverage variation in the minimum wage that occurs within a narrow geographic area. More broadly, I find that higher wages improve patient outcomes by at least as much as comparably-priced staffing requirements and have benefits net of existing regulations and economic conditions. In particular, all of the main results account for business cycles and state anti-poverty programs, and I find similar improvements regardless of whether facilities are located in a state with a minimum direct care staffing requirement.

The remainder of this paper proceeds as follows. Section 2 describes the nursing home industry. Section 3 outlines how legislated wage increases may affect worker, consumer, and employer outcomes. Section 4 describes the cross-county border pair empirical approach. Section 5 presents results, and Section 6 concludes. Supplemental appendices provide additional results, robustness checks, and a comprehensive data description.

2 Institutional setting: Nursing homes

There are approximately 15,600 nursing homes (also called nursing facilities) in the United States that provide 24-hour health, personal care, supportive, and rehabilitative services to about 1.4 million residents.[4] Most nursing home residents are elderly and require assistance with activities of daily living (ADL), such as eating, bathing, dressing, mobility, and toileting (HHS, 2015). Demand tends to be high relative to supply, and most nursing homes operate near capacity.[5]

2.1 Nursing home employment

Nursing homes are labor-intensive enterprises and a large employer of low-wage workers. These facilities employ about 1.6 million workers, approximately 40 percent of whom work in healthcare support roles as nursing assistants.

The duties of nursing staff, particularly nursing assistants, directly affect patient health and longevity. Nursing assistants record vital signs, monitor health outcomes, report conditions to certified nurses, and provide medical and personal care to residents. This care includes "emotional labor," or conversing and building relationships with patients (Hochschild, 2012), as well as administering medical treatments and helping residents with transportation, feeding, bathing, and mobility (ONET, 2018).

The typical healthcare support worker in the long-term care industry receives about $13 an hour, comparable to wages in other low-pay sectors (BLS, 2019).[6] Turnover is also high in this

[4] Approximately 92 percent of certified nursing home facilities are dually certified as skilled nursing facilities (SNF) (HHS, 2015). SNFs provide services that can only be provided under the supervision of a registered nurse or doctor. Medicare fully covers the first 20 days of SNF care after hospital discharge, and provides co-insurance for the next 80 days. Medicare does not coves nursing home care, but dually certified facilities can receive both Medicaid and Medicare reimbursement.

[5] In 2016, the median occupancy rate was 85 percent, and 15 percent of facilities had an occupancy rate greater than 95 percent.

[6] This estimate is based on dividing annual earnings by 2,080 (40 hours a week times 52 weeks a year). Overtime

industry: 62 to 86 percent of nursing assistants change employers each year (Berridge et al., 2018), with most of these transitions occurring among nursing homes.

To situate nursing homes in the broader minimum wage literature, Table 1 compares wages and demographic characteristics of nursing staff to workers in other ow-wage industries – food service and retail. Table 1 shows that nursing assistant wages are slightly higher than restaurant workers, but comparable to retail workers.[7] In contrast, licensed nursing staff receive wages higher than typical private sector workers. These statistics indicate that while many nursing assistants are likely affected by minimum wage reforms, LPNs and RNs are not. Examining wage responses among these higher-skilled occupations provide a placebo test, as null earnings effects for licensed nurses suggests that the empirical design is not simply capturing economy-wide wage increases.

2.2 Quality of care and patient health outcomes

Nursing homes are subject to extensive federal reporting and inspection requirements. Federal care standards date to 1961, and were strengthened under the 1987 Nursing Home Reform Act (NHRA), which requires annual independent health inspections; nursing credentialing; minimum RN staffing levels; and routine, comprehensive patient assessments (Castle and Ferguson, 2010; Institute of Medicine, 1986). Nursing homes report this information to the federal government in order to qualify for Medicaid and Medicare reimbursement, and I leverage these data in order to provide a comprehensive analysis of consumer well-being.

2.3 Firm payment sources and revenue

Nursing homes operate in a market with limited scope for free entry: the number of beds is largely fixed at both the facility and aggregate level as most states have a certificate-of-need (CON) law which restricts construction and limits the number of beds each facility can provide (NCSL, 2019; HHS, 2015). Demand for nursing home care is likely relatively price inelastic for

is common among nursing assistants: approximately 20 percent report being subject to mandatory overtime, and about half report being able to work overtime hours (CDC, 2004). As overtime pay is most frequently paid at 1.5 times the normal hourly wage, this figure likely overstates hourly wages.

[7] Following Dube et al. (2019), workers affected by a 10 percent minimum wage increase is calculated as the fraction of workers earnings below 110 percent of the current minimum ("directly affected") and those earnings between 110 percent of the current minimum and 115 percent of the new minimum ("indirectly affected"). Consistent with this estimate, Cengiz et al. (2019) document that workers earning $3 above the minimum wage may be affected by spillovers and indirectly affected workers account for 40 percent of the increased labor costs.

most prospective consumers, as there are few close substitutes for intensive nursing services and most residents do not incur the full cost of the services. Only about one-quarter of residents pay for care from their own funds or private insurance, the remainder are covered by either Medicare (14 percent) or Medicaid (62 percent) (Kaiser Family Foundation, 2016). Both Medicare and Medicaid reimbursement rates are set by expected patient costs, with Medicare rates determined by each resident's service needs and a local cost-of-living adjustment (AARP, 2018; CMS, 2019; Federal Registry, 2018) and Medicaid rates set by payment structures that vary across states.[8] Private rates are set based on actual costs at market rates, averaging $263 a day, or 30 percent more than average Medicaid rates (Appendix Table B1). While private payors' demand is expected to respond to both price and quality, those covered by public insurance are likely less responsive to changes in either prices or quality (Gertler, 1989).

3 Conceptual framework

Higher wages can affect the actions of workers, firms, and consumers. This section provides an intuition for each actor's possible responses in the context of the nursing home industry, and Appendix D describes these incentives in greater detail.

3.1 Workers

All else equal, higher wages increase the opportunity cost of unemployment, and therefore, workers are expected to increase effort in order to maintain employment. In addition to a pure effort channel, higher wages could reduce household financial concerns and improve performance by alleviating stress and reducing cognitive loads (Mani et al., 2013). Finally, higher wages reduce the arrival rate of higher wage offers from competing firms, leading workers to remain with an employer for a longer tenure. All of these factors – greater effort, reduced cognitive burdens, and increased firm-specific human capital – are predicted to improve performance and the quality of care provided to consumers.

[8] Medicare reimbursement is based on an intake assessment, and residents who are expected to require help with many ADLs, or who require extensive rehabilitation or therapeutic services are assigned a relatively high reimbursement rate. In 2019, the base per-diem rate ranged from $209 to $832, adjusted by a local cost index.

3.2 Consumers

If higher quality increases consumer demand, prices will change in the same direction as quality as long as supply is not perfectly elastic. In the nursing home setting, the predictions are more nuanced as firms serve two general types of residents: those who pay from their own resources, and those with insurance coverage through Medicaid or Medicare. As insured individuals are not financially responsible for the care they receive, their demand is relatively price inelastic, while private payors' demand is expected to increase when quality improves. As discussed in Section 2, these consumers provide different levels of revenue, with Medicaid recipients yielding lower revenue than private payors.

3.3 Firms

Higher minimum wages increase the cost of employing each low-skilled worker, and profit-maximizing firms will substitute away from low-wage labor to other factors of production, such as higher-skilled labor and capital. All else equal, staffing reductions are expected to worsen the quality of care a firm offers. However, although per-worker costs increase, each low-skilled worker's performance is expected to improve. Therefore, with limited factor substitution or minor disemployment effects, overall firm quality could improve.

Another possible margin of adjustment is the number of residents served or beds offered. However, in the nursing home sector, facilities cannot adjust supply in the short-term due to CON laws and regulations that prohibit discharging current residents. As the number of individuals who could benefit from care exceeds the number of available beds (Gertler, 1989), firms take Medicaid rates multiplied by the number of beds as a revenue floor and select the employment mix (and therefore quality) that yields the level of private demand to maximize net revenue.[9]

The nursing home industry structure and each actor's incentives suggest higher wages should result in the following patterns:

1. **If staffing levels fall and average tenure does not increase, quality is expected to worsen**; conversely, if staffing levels and tenure both weakly increase, quality is expected to

[9]It is illegal for firms to discriminate in admissions or care based on payment type; however, facilities are able to turn away consumers if they are unable to provide services that address a prospective resident's care needs. If firms are unable to adjust their resident and employee composition, higher minimum wages may reduce profits.

improve. If staffing levels fall and tenure increases, the effect on quality is ambiguous.

2. **Improved quality is expected to increase consumer prices**.
3. **Quality improvements are expected increase the share of residents paying out of pocket** since private payors generate more revenue than Medicaid recipients.

These responses are not necessarily limited to mandated wage increases, raising the question why firms do not unilaterally raise wages in order to attract private payors and generate higher per-resident revenue. This question is particularly relevant given that less than 2 percent of firms exclusively serve either Medicaid beneficiaries or private payors and firms report difficulty in finding and retaining qualified workers.[10] With imperfect information in either the labor or the product (nursing home service) market, however, it may be rational for firms to pay low wages and offer relatively low quality of care. In the labor market, asymmetric information on wage offers and earnings potential may arise due to search costs or a perception that the nursing home industry offers relatively low wages. A higher guaranteed wage could induce workers to enter the nursing home labor market, and with a large enough supply response, this channel could reduce the firm's fixed hiring costs, even though hourly wage rates increase.In the product market, even if wages perfectly reflect quality, it is unclear prospective residents know or are able to act on this information. Most nursing homes operate near capacity or maintain waitlists and therefore residents may be unable to change facilities once they realize a firm's quality, resulting in a muted demand response for any unilateral wage increase. In contrast, if all firms in an area increase wages, consumers may expect quality at *any* facility will be better after the wage increase than before even if they cannot discern a particular firm's quality. Therefore, economy-wide wage reforms may be necessary to trigger a consumer demand response that allows firms to operate without lowering profitability.

4 Empirical framework

I extend the cross-border differences-in-differences approach pioneered by Card and Krueger (1994) and generalized by Dube et al. (2010) and Dube et al. (2016) by comparing changes

[10] On media reports describing difficulties finding workers, see https://www.nytimes.com/2018/07/27/health/medicare-nursing-homes.html and https://www.wgbh.org/news/local-news/2019/10/10/cape-cod-nursing-homes-suffer-from-a-shortage-of-nursing-assistants.

in patient outcomes within a nursing home following an increase in the statutory minimum wage to changes among facilities in neighboring counties that did not experience such wage changes. This "county pairs" sample includes establishments in counties where the neighboring county faced a different minimum wage at any point over the analysis period, including facilities that straddle a state border (such as Illinois and Indiana) or a county border within a state (such as Cook County (Chicago) and DuPage County), as well as facilities in cities bordering a county with a different minimum (such as Seattle and adjacent Snohomish County). Robustness checks broaden the sample to include all facilities across the country using coarser geographic controls and provide largely similar results (Appendix C).

The prevailing minimum wage is the highest federal, state, county, or city minimum applicable to a facility the date the outcome of interest was measured, adjusted for inflation using the CPI-U-RS.[11] Importantly, minimum wages vary within narrow geographic areas, and this spatial variation has increased over time. Figure 1 shows that a large fraction of nursing home residents live in a jurisdiction with a minimum wage change due to federal, state, or local policy action each year. Figure 2 maps the geographic variation in minimum wages from 2002 through 2017, with darker shades corresponding to larger cross-border gaps. In the late 1990s and early 2000s, minimum wage variation was concentrated in the Mid-Atlantic, New England, and Western states; by the 2010s, approximately one-third of nursing home patients lived in a jurisdiction where an adjacent county had a different minimum wage, including some residents in the midwest and south. In total, the main county pairs sample consists of approximately 7,700 facilities in 1,136 counties which experienced an average of seven minimum wage reforms between 1990 and 2017.[12]

With this sample, I compare changes within a facility following a minimum wage increase, relative to changes in neighboring facilities using a generalized differences-in-differences model. The mortality and QWI-based employment measures are aggregated at the county level (c), other

[11] In addition to the geographic variation in minimum wages, facilities receiving federal contracts and subcontracts are subject to a $10.10 minimum wage (in 2015 dollars) as of 2015 (Executive Order 13658). I identify federal contractors by matching facility street addresses to contractor information from the Federal Procurement - Next Generation Data System (USASpending.gov, 2018) and estimate the contractor minimum wage affects approximately four percent of nursing facilities. Results are nearly identical when excluding federal contractors.

[12] Appendix Table B2 presents descriptive statistics for this sample compared to facilities in all counties, and indicates the county pair sample is similar to the full universe of nursing homes in staffing levels per resident, resident demographic characteristics, number and severity of inspection violations, and patient outcomes.

measures are estimated at the facility level (f). For each outcome $y_{c(f)pt}$ in county c or facility f, in county border pair p at time t, I estimate:

$$y_{c(f)pt} = \beta log(MW)_{c(f)pt} + X'_{c(f)pt}\phi + \gamma_{c(f)} + \gamma_{pt} + \varepsilon_{c(f)st} \quad (1)$$

where $log(MW)_{c(f)pt}$ is the prevailing real minimum wage in county c or facility f.[13] $X'_{c(f)pt}$ is a vector of county and facility controls, including the overall county unemployment rate; state income assistance and tax policy controls; race and gender characteristics of nursing home residents; payment sources of nursing home residents; and the population age structure. Facility characteristics are included primarily for precision, and labor market controls account for factors that may affect policymakers' decisions to change minimum wages, elderly health, or nursing home staffing.[14] $\gamma_{c(f)}$ is a county (facility) fixed effect that absorbs all time-invariant county (facility) characteristics, and γ_{pt} is a county-pair-by-time fixed effect that accounts for local features that evolve over time, including labor market conditions and changes in the share of residents requiring long-term care.[15] β provides the causal effect of a 100 log point increase in the minimum wage under the assumption that within a county pair and conditional on observable economic, demographic, and policy changes, minimum wage increases are uncorrelated with changes in potential health of nursing home residents. Importantly, facilities on either side of a policy discontinuity operate in the same labor market and are therefore likely to experience similar business cycle fluctuations and serve similar resident populations.

Table 2 examines whether facilities that face higher minimum wages systematically differ from competing firms in lower-wage counties within each county pair by regressing a series of characteristics on an indicator for whether a facility is located in the highest minimum wage jurisdiction within a county-pair-year. While the average within-pair minimum wage difference is approximately 57 cents (in 2017 dollars), county unemployment, population, and facility size do not significantly differ between low and high- minimum wage counties. In addition, while nursing

[13] For county-level analyses where a subset of jurisdictions have city-level minimum wages, I define the minimum wage as the highest minimum within the county. For example, in January 2017, the minimum wage in Berkeley was $12.53 and the rest of Alameda County was $10.50. The QWI and mortality results assign the Berkeley minimum to the entire Alameda County. Less than four percent of the county-pairs sample includes city-level minimums, and results are robust to using the average minimum wage within these counties.

[14] Results are robust to omitting all demographic and policy covariates.

[15] Since a county can enter the sample multiple times, all standard errors are clustered at the county level. In general, this approach provides more conservative inference than clustering at the border segment level and does not systematically result in larger or smaller standard errors than two-way clustering by county and year.

homes subject to higher wages have fewer female residents and a slightly younger population, the point estimates in column (2) are small relative to the average values in column (1). In light of these small differences, my preferred specifications control for time-varying resident demographics and include facility fixed effects (absorbing time-invariant county characteristics). Furthermore, I demonstrate that changes in resident demographics that coincide with minimum wage reforms only account for a small fraction of the observed improvements in patient health and safety.

The county pair design flexibly captures local business cycle and health outcomes with time fixed effects that vary by county pair, γ_{pt}. This approach may lack external validity, however, as γ_{pt} is only identified for counties with minimum wages that differ from their neighbors. To allay concerns that facilities in border counties systematically differ from those in interior counties, Appendix C presents results using a state-by-year differences-in-differences framework with all facilities and counties and controlling for regional conditions with Census division-by-period fixed effects (γ_{dt}) and state linear time trends ($\gamma_s * year$), following Allegretto et al. (2017):

$$y_{fcdst} = \beta log(MW)_{fcdst} + X'_{fcdst}\phi + \gamma_f + \gamma_{dt} + \gamma_s * year + \varepsilon_{fcdst} \quad (2)$$

Results are largely robust to this approach, indicating the findings are not due to the unique experiences of border counties and suggesting that cross-border spillovers within narrow geographic areas are not driving the main results.[16]

5 Results

5.1 Workers

5.1.1 Workers' earnings and employment

Although nursing homes are a large employer of low-skilled labor, the previous literature has not fully examined how minimum wages affect this labor market in the US context.[17] Therefore, in order to establish whether minimum wages are binding for low-skilled workers in this setting, I assemble staffing and wage data from several sources. First, the Quarterly Workforce Indicators (QWI) provides quarterly county-level administrative data on employment, earnings, and turnover

[16] An alternative approach, comparing outcomes among facilities within a Hospital Referral Region (HRR) is shown in Appendix Table C3, C5, and C7. Again, patterns are qualitatively similar for this sample.

[17] A large literature documents the role of minimum wages in the UK nursing home market, see for example, Giupponi and Machin (2018), Draca et al. (2011), Machin and Wilson (2004), and Machin et al. (2003).

(hires plus separations) for nursing care facilities, disaggregated by predicted worker gender and educational attainment. Table 1 shows that in the CPS, approximately 90 percent of nursing staff are women, about half of nursing assistants have a high school diploma or less, two-thirds of LPNs have some college, and two-thirds of RNs have a four-year college education. As the QWI does not include occupational information, I proxy for minimum-wage nursing staff by focusing on female employment and classifying workers in three education bins: those with no more than a high school education, those with some college, and those with a four-year degree.[18]

I supplement the QWI earnings analyses with facility-occupation-level wage and salary data derived from payroll records for California facilities and reported to the Office of Statewide Health-care Planning and Development (OSHPD). As payroll-based wage data are only available for a single state, these estimates are only estimated on California's county and city reforms. In addition, to provide a benchmark to the existing literature, I examine earnings responses using the Current Population Survey Outgoing Rotation Group (CPS-ORG), and American Community Survey (ACS). Since respondents' county of residence or work is not always available in the CPS or ACS, the county-pair differences-in-difference approach is not feasible with these data; therefore, I estimate a state-by-year differences-in-differences model with Census division-by-year and either state (CPS) or PUMA (ACS) fixed effects, as in Equation 2. For employment, staffing by occupation in full-time-equivalents and hours per resident per day is available for all facilities through CMS's Online Survey Certification and Reporting and Certification and Survey Provider Enhanced Reporting (OSCAR/CASPER) systems (Centers for Medicare and Medicaid, 2018c).

Table 3 examines the relationship between minimum wages and low-skilled nursing home employees earnings. Column (1) reports an earnings elasticity with respect to the minimum wage among female nursing home staff with no more than a high school education of approximately 0.12. This estimate is similar to the estimated elasticity among California nursing assistants (column (2)), as well as hourly wages and weekly earnings among CPS nursing assistant respondents (columns (3) and (4)). Annual earnings are less precisely estimated and larger in magnitude,

[18]More than 80 percent of nursing home employees are women, and all results are robust to including workers of both genders. The lowest-education group is defined as the residual from total wages and employment minus counts allocated to workers with at least some college. Given the occupational structure of nursing home staff, the "high school" groups likely include food service and maintenance workers; while the "college" results likely include executives and physicians.

but again show nursing assistant pay rises following minimum wage increases (column (5)). Appendix Table B3 examines earning responses among higher-skilled staff and shows some earnings reductions among workers with some college education, but these results are sensitive to the dataset and importantly, any reductions at earnings at the top of the skill distribution suggest the empirical approach is not simply capturing economy-wide wage increases.

Table 4 reports corresponding employment elasticities for low-skilled staff. Both the QWI analysis in column (1) and OSCAR/CASPER results in columns (2-5) suggest minimum wage increases do not significantly reduce the number of nursing assistants or the time spent with residents, while the number of full-time equivalent workers slightly increases. These results are consistent with dynamic monopsony models with search and matching friction where higher wages enable employers to find workers and fill vacancies (Manning, 2003; Flinn, 2006). Columns (6) and (7) additionally show the slight increase in FTE nursing assistants is driven by increases in part-time staff, which may reflect employers being able to recruit more workers or lowering labor costs by reducing overtime hours. In addition, there is no significant change in vocational nurse staffing, while the amount of patient time provided by RNs slightly falls: a 10 percent minimum wage increase reduces RN patient time by about 17 seconds a day (Appendix Table B4).

To place these results in context with the existing minimum wage literature, Figure 3 scales the earnings (panel (a)) and employment (panel (b)) elasticities by the fraction of nursing assistants earning close to the minimum wage in Table 1 and plots the results (in orange) with analogous estimates from the existing literature in a funnel plot where more precise estimates are further from the x-axis.[19] Panel (a) shows my earnings estimates are similar in magnitude to those found in the previous literature, and panel (b) illustrates that while there is less of a consensus of the effects of minimum wages on employment, both the QWI and OSCAR/CASPER employment responses are within the range documented in earlier work.[20]

The combination of higher earnings and no systematic reduction in staffing levels for low-

[19] The data appendix provides a complete list of studies included.

[20] Much of the disagreement in the existing literature stems from differences in empirical approaches and time period considered (Allegretto et al., 2017; Neumark et al., 2014; Cengiz et al., 2019). Appendix Table C2 shows that minimum wages do not significantly reduce the number of nursing assistants or the hours worked in state-by-year fixed effects models, at least since the mid-1990s. These results are consistent with employment losses found in early work driven by state-level employment trajectories during the 1980s (Cengiz et al., 2019).

skilled staff at first appears at odds with limited monopsony power in the nursing assistant labor market found in Matsudaira (2014b); however, several possibilities could reconcile these findings. First, employers may respond to both policy changes by altering non-wage compensation or workplace amenities; data limitations preclude a comprehensive evaluation of this channel. Related, if staff-to-patient ratios measure a job's demands, minimum staffing requirements effectively increase compensation by lowering job demands (Currie et al., 2005). Finally, worker quality could change under either policy, with staffing requirements lowering average worker quality and higher minimum wages improving average worker quality. Findings from the previous literature are somewhat mixed on this point. While Matsudaira (2014a) finds patient outcomes do not improve, Tong (2011) finds higher staffing levels reduce mortality.[21]

5.1.2 Employee retention and turnover

Although the stock of nursing home workers does not significantly respond to higher wages, worker flows may change. In job ladder models, higher wages decrease turnover as the arrival rate of better-paying jobs falls, while in frameworks with endogenous separations, separations increase as fewer employee-employer matches are profitable (Dube et al., 2016; Bontemps et al., 1999; Mortensen and Pissarides, 1994; Pissarides, 2000; Brochu and Green, 2013). On the hiring side, with search frictions or employer bargaining power, higher minimum wages can increase the hiring rate (Flinn, 2006; Manning, 2003; Card and Krueger, 2015); on the other hand, hiring may fall if the cost of posting vacancies increases (Dube et al., 2016).

Following Dube et al. (2016), Table 5 examines how low-skilled worker flows change in response to higher minimum wages, and Appendix Table B5 provides analogous results for higher-educated groups. Column (1) shows low-skilled worker turnover does not significantly change, but disaggregating the turnover rate shows responses consistent with dynamic monopsony models in which higher wages enable firms to fill vacancies and retain workers. Column (2) indicates that "stable" hires, defined as new hires who remain with the same employer for at least three months, increases, while column (3) indicates separations fall by a magnitude similar to that found for teenagers and restaurant workers (Dube et al., 2016; Portugal and Cardoso, 2006; Brochu

[21] Another possibility is that California nursing assistant labor markets in the late 1990s are not representative of other labor markets over the full 1990-2017 period. However, I do not find larger employment increases in any staffing measure when dropping the state of California and/or the first years of the sample period.

and Green, 2013). To the extent that firm-specific human capital increases with tenure, greater retention is expected to improve worker performance and lower training and hiring costs.

5.1.3 Worker types

Efficiency wage models predict that higher earnings can enhance productivity by increasing effort among workers or prompting new workers to enter the labor market (Shapiro and Stiglitz, 1984). As minimum wage critics point to potential disemployment effects, particularly for young and inexperienced workers (Congressional Budget Office, 2019; Wascher and Neumark, 2007; Jardim et al., 2018), it is important to understand whether any changes in consumer well-being are driven by changes in workforce composition.

Table 6 examines whether higher wages change the demographic characteristics of nursing home nursing assistants with data from the CPS and ACS. Neither dataset shows an economically or statistically significant change in nativity, racial/ethnic group, gender, educational attainment, or household characteristics. Combined with the insignificant changes in overall turnover and increases in tenure in Table 5, these results suggest that any changes in patient outcomes are likely due to increases in firm-specific human capital and improved worker performance, rather than changes in the types of workers employed in healthcare support occupations.

5.1.4 Employee effort and absenteeism

Higher wage levels could change staffing patterns by affecting absenteeism or workplace injury. *A priori*, the relationship between higher wages and workplace safety is ambiguous. On one hand, longer tenures could increase workers' aptitude and expertise, or higher pay might reduce cognitive pressures and improve decision-making among low-wage workers (Mani et al., 2013). In addition, efficiency wage frameworks predict that higher wages could improve worker caution by increasing the opportunity cost of time away from work. On the other hand, if employers require greater work intensity, injury levels may increase.

Nursing homes have high rates of workplace injury relative to other industries: about 11 percent of workers incur a workplace injury or illness each year, compared to about 4 percent of all private sector employees (Bureau of Labor Statistics, 2017). Consistent with higher wages increasing worker effort and skill, rather than exclusively increasing job demands, Appendix Table

B6 shows a 10 percent increase in the minimum wage reducing total workplace injuries and illnesses by about 2.5 percent (2.7 percentage points), with a statistically insignificant and smaller reduction in more severe injuries that require time away from work or a modification of duties.[22]

5.2 Consumers

Given that higher minimum wages increase earnings, reduce separations, and do not significantly reduce employment or change observable characteristics of low-skilled nursing home employees, patient outcomes are expected to improve. To empirically test this prediction, I apply the facility-level county-pairs differences-in-differences design in Equation 1 to several objective measures of health and safety.

5.2.1 Patient safety

Nursing homes receive unannounced health inspections every 9-15 months, conducted by independent state surveyors who observe the facility and interview staff, patients, and family members about the quality and frequency of care (Abt Associates, 2013; Centers for Medicare and Medicaid, 2018a).[23] The type, number, severity, and scope of each violation a facility has received, as well as the date the inspection occurred is reported in the OSCAR/CASPER data. Many types of violations are associated with patient safety measures, such as avoiding accident hazards and providing sanitary food preparation, and others are correlated with measures of worker productivity, such as routinely assessing resident, communicating patient conditions to family members, changing bed linens, and providing residents with prescribed services. The data appendix provides excerpts from several narrative reports in order to illustrate the nature of the inspection process and the types of penalties facilities may receive.

I match every violation a facility has received since 1998 to the prevailing minimum wage at the date of inspection and construct several measures of patient safety: the total number of violations, the number of severe violations that present immediate harm or danger to residents,

[22] Improved worker attendance could provide positive externalities to coworkers whose leave use does not change by reducing the need for overtime or lowering patient-staff ratios. Although data on overtime use is not systematically collected, the common use of overtime in this sector suggests lower absenteeism could improve workplace climate and help firms retain employees.

[23] The time between inspections is uncorrelated with minimum wages, and in models that include past number of violations, violation scores, presence of a severe violation, facility characteristics, local labor market controls, and facility and time fixed effects observable characteristics explain approximately 40 percent of the variation between inspection periods, suggesting that inspection timing is largely random.

and an index incorporating the number of violations and the severity and prevalence of each infraction in a standardized score following Kling et al. (2007) and Anderson (2008).[24] For each measure, I consider all violations, as well as a "quality of care" measure using the subset of violations that are most closely associated with nursing responsibilities (Chen and Grabowski, 2015; Harrington et al., 2000, 2001; Matsudaira, 2014a; Antwi and Bowblis, 2018).[25]

Inspection violations are common in nursing homes: each inspection approximately 96 percent of facilities have at least one violation, and the typical facility has five. About a quarter of all citations are due to five infractions, all of which relate to direct care staff's performance: improper infection control and prevention, not maintaining accurate medication records, unsafe or unsanitary food preparation and storage, not taking measures to avoid preventable accidents, and not providing basic care.[26]

Table 7 panel (a) shows that while higher minimum wages do not significantly affect the likelihood that a facility has any violation (column (1)), a 10 percent increase in the real minimum wage reduces the number of violations by approximately 0.06 (column (2)). The final row in each panel of Table 7 (ϵ_{mw}) presents the implied elasticity of violations with respect to the minimum wage and shows a 10 percent increase in the minimum wage reduces the number of violations by about 1 percent. Although one might be particularly concerned with the most egregious violations, column (3) shows an increase in the probability of receiving at least one severe citation, while column (4) shows no significant change in the number of such violations. Finally, incorporating both the prevalence and severity in a standardized score, a 10 percent increase in the minimum wage improves patient safety by approximately 0.01 standard deviations (column (5)).

Table 7 panel (b) presents analogous results for the subset of "quality of care" violations that

[24] Using the date of each inspection allows me to include instances where a facility received multiple inspections during the calendar year. The index for facility f in year y is calculated as the raw score from adding the scope/severity points assigned to each violation v_{fy} in severity category, sev, and scope category sc: $v_{fy} = \sum_{sc \in SC} \sum_{sev \in SEV} v_{sc,sev,f,y}$ and standardized as $z_{fy} = \frac{v_{fy} - \overline{v}}{\sigma_{\overline{v}}}$ where $\overline{v}$ is the grand mean among all nursing homes and $\sigma_{\overline{v}}$ is the corresponding standard deviation. The data appendix provides additional details.

[25] "Quality of care" violations include assessment, quality of care, nursing, dietary, physician, rehabilitative services, dental, and pharmacy regulation infractions (Harrington et al., 2000). I obtain similar results when measuring care violations as the subset of violations that are likely due to one of 33 job tasks or 25 job activities using ONET. Results and a list of violations under this alternative definition are available upon request.

[26] Although inspection violations indicate an environment that jeopardizes patient safety, more than 90 percent of infractions put residents at risk for harm, but are not causing harm or immediate danger at the time of the inspection. This pattern suggests that although infractions indicate a risky environment, violations may not immediately translate into patient well-being.

are most closely associated with nursing care. Higher wages lead to larger reductions in quality of care violations, with a 10 percent minimum wage increase reducing the likelihood a facility has any quality of care violation by 0.5 percentage points (0.6 percent) and the number of such violations by about 0.07 (2 percent). However, there is no significant change in severe violations, measured by having any severe violation, the number of such violations, or a standardized score.[27]

These findings provide some of the first empirical evidence on how higher minimum wages affect consumer well-being and service provision. The existing evidence on this relationship examines a single, national minimum wage reform in the UK, where higher minimum wages increased inspection violations (Giupponi and Machin, 2018). There are important differences between these settings: although both British and American nursing homes are labor-intensive firms that employ staff at low wages and have high occupancy rates, UK local governments regulate reimbursement rates and do not adjust rates for changes in staffing costs, in contrast, as I document below, American firms are able to charge consumers higher prices and incur no significant change in profitability.[28]

Previous work in public health and economics has examined the relationship between patient safety and other policy-induced staffing changes. This work documents higher levels of firm-specific human capital and greater facility funding reduce the number of violations. On the other hand, the relationship between minimum staffing levels and violations is less robust (Matsudaira, 2014a). The results in Table 7 suggest higher wages are at least as cost-efficient as reforms that increase staffing without changing remuneration. For example, previous work estimates an additional hour of nursing assistant care per patient day (a 44 percent staffing increase for the average facility) is associated with 0.7-1.2 fewer violations (Bowblis and Roberts, 2018; Harrington et al., 2000). Other work examining the effect of unionization finds no large reduction in patient safety, despite reductions in staffing numbers (Sojourner et al., 2015). Beyond staffing levels,

[27] For all measures, these findings are robust to alternative weighting schemes and sample definitions, shown in Appendix Table C3, as well as limiting the sample to substate reforms (thereby accounting for any coincident change in state inspection policy or stringency). In addition, falsification exercises show a slight *increase* in fire code violations unrelated to nursing care and no change in violations for admission practices, suggesting that the results in Table 7 are not capturing an overall improvement in facility environments.

[28] There are other possible explanations for these different findings. For example, the nature of inspections may differ between the countries. In addition, Giupponi and Machin (2018) evaluate changes over a one-year period where less than 40 percent of firms have an observation both before and after the reform, which precludes fully accounting for changes in inspection routines or the long-term care sector that affected firms at the same time. In contrast, my analysis covers 20 years of inspections with wage reforms that affected facilities at different times.

employment flows may affect patient safety. To this point, Antwi and Bowblis (2018) estimate a 1 percentage point reduction in turnover in all nursing (RN, LPN, and assistant) staff due to poor economic conditions leads to 0.07 fewer quality of care violations, approximately equivalent to the estimated effect of a 10 percent minimum wage increase.[29] Finally, these estimates imply a 10 percent increase in the minimum wage is similar to improvements in patient safety following a four percentage point increase in the unemployment rate (Huang and Bowblis, 2018), or about one-third of the improvements in safety following increased Medicare reimbursement rates in the early 2000s (Konetzka et al., 2004).[30]

5.2.2 Resident health outcomes

Table 7 suggests minimum wages improve patient safety on some dimensions, but the lack of a robust relationship between minimum wages and the most harmful violations leaves open the question whether higher wages translate into health outcomes. To make further traction on this point, I examine several measures of resident health that facilities submit to CMS each quarter. These "Quality Measures" (QM) are conditions that are indicative of the service quality provided by direct care staff, including pressure ulcers (pressure sores or bed sores), urinary tract infections (UTIs), physical restraints, and psychotropic medications (Brandeis et al., 1994; Dorr et al., 2005; Phillips et al., 1996; Cawley et al., 2006; Hughes et al., 2000; Grabowski et al., 2011).

For example, pressure ulcers are a preventable, but relatively common, adverse health condition among nursing home residents affecting more than eight percent of residents. Greater nursing assistant attention is expected to reduce the formation and severity of ulcers as nursing assistants help residents with mobility and transportation and monitor health conditions. Consistent with higher wages improving the quality of care, Table 8, column (1) shows that raising the minimum wage 10 percent reduces the fraction of residents with moderate-to-severe pressure ulcers by 0.14 percentage points, or about 1,900 fewer cases each period. This result is robust to including time-varying resident demographic characteristics, suggesting that the reduction is not driven by facilities admitting more low-risk patients (column (2)).

Second, UTIs are the most common bacterial-related cause of hospitalization among long-

[29] Estimates of annual nursing assistant turnover range from 62 percent to 86 percent (Berridge et al., 2018).
[30] In the early 2000s, reimbursement rates increased up to 20 percent.

term care residents and affect about seven percent of residents. Indwelling catheters, administered and monitored by nursing assistants and support staff, are a common cause of UTIs and prompt removal or reduced catheter use reduces the risk of infection (Genao and Buhr, 2012; Saint, 2000; Matsumoto, 2001; CDC, 2009; ONET, 2018). Although point estimates in columns (3) and (4) suggest higher minimum wage slightly reduce the share of residents with infections, this relationship is not statistically significant.

Third, nursing homes may adjust the use of physical restraints in response to higher wages, but the direction of this relationship is ambiguous. If restraints require intense staff attention or assembly, higher wages may increase the use of such devices (Grabowski et al., 2011), but as physical restraints restrict movement, greater nursing resources and attention should reduce the use of these devices (Cawley et al., 2006). Columns (5) and (6) shows a weak negative relationship between minimum wages and physical restraints, consistent with other work finding more nursing resources in the form of additional staff reduce restraint use (Cawley et al., 2006; Phillips et al., 1996; Grabowski et al., 2011).

Fourth, psychotropic medications are sedating drugs that affect mental processes and behavior; accordingly, higher quality care is expected to reduce the fraction of residents receiving these medications.[31] While previous work has found additional licensed nurses are associated with lower anti-psychotic use (Hughes et al., 2000; Grabowski et al., 2011), columns (7) and (8) indicate that higher minimum wages do not reduce the use of psychotropic medications, with point estimates suggesting a meaningful increase.

Finally, columns (9) and (10) combine results for pressure ulcers, UTIs, and physical restraints into a standardized "poor health outcome" index, where a value of one indicates composite patient outcomes worsen by one standard deviation (Kling et al., 2007; Anderson, 2008). In line with the point estimates in columns (1) through (6), a 10 percent minimum wage increase improves patient outcomes by 0.02 standard deviations.

These results indicate that modest minimum wage increases yield meaningful improvements in consumer health for conditions that result from patterns of care. The estimated improvements for

[31] Psychotropics, including anti-psychotics, antidepressents, anxiolytics, and hypnotics, were added as a QM in 2011, somewhat restricting this analysis.

pressure ulcers are somewhat larger than similar-costly policies that are often suggested as ways to improve nursing home care. For example, minimum staffing requirements and unionization have no robust effect on pressure sores prevalence (Matsudaira, 2014a; Sojourner et al., 2015), and a 10 percent minimum wage increase reduces ulcers by a rate similar to a near-doubling of RN care (Konetzka et al., 2008; Dorr et al., 2005). The reductions in pressure ulcers from higher wages are also sizable relative to improvements in resident health stemming from business cycle fluctuations. For example, a 10 percent increase in the minimum wage is approximately equivalent to a 1.2 percentage point increase in the local unemployment rate (Huang and Bowblis, 2018) or a 2.6 percentage point (3-4 percent) reduction in worker turnover (Antwi and Bowblis, 2018).

5.2.3 Mortality

Tables 7 and 8 suggest minimum wages improve patient safety and health; however, each of these outcomes is subject to measurement error concerns. For example, about half of UTIs are asymptomatic, inspections are prone to inspector oversight, and health conditions reported by facility employees.[32] Death, although an extreme outcome, is well-measured and not subject to these concerns. While mortality rates are relatively low in the general population, rates are relatively high among nursing home residents: about one-third die within a year of nursing home admittance, about three times the rate for the general population ages 85 and older (Flacker and Kiely, 2003; National Vital Statistics Reports, 2018).

I calculate the age-adjusted death rate, m_{cy}, by county and place of death from Vital Statistics microdata, with the age adjustment based on each county's age distribution in the year 2000:[33]

$$m_{cy} = \sum_{a=65}^{85+} \frac{deaths_{cay}}{pop_{cay}} * \frac{pop_{a,2000}}{\sum_{k=65}^{85+} pop_{k,2000}} \tag{3}$$

Where $deaths_{cay}$ is the number of deaths in nursing homes in county c among individuals aged a in year y, and pop_{cay} is the number of individuals aged a each county-year.[34] The second

[32] If higher wages induce greater effort or reduce cognitive pressures, assessments become more accurate following minimum wage increases. With such "ascertainment bias," higher minimum wages would increase the reported prevalence of each condition, and Table 8 would understate health improvements (Arling et al., 2005).

[33] This analysis focuses on deaths in "nursing homes" for 1990-2003 and "nursing home/long term care" settings in 2004-2013. Following Stevens et al. (2015), I confirm this slight definition change does not coincide with a series break in the share of deaths occurring in nursing homes. Appendix Figure A1 compares the age-adjusted and raw mortality rate over the study period, illustrating the population has become more aged over this period.

[34] Approximately 20 percent of nursing home residents die after being transferred to a hospital (Temkin-Greener et al., 2013). This undercount complicates a causal interpretation of the results only if minimum wage increases coincide with changes in facility discharge or hospital admittance policies. At odds with this hypothesis I do not find minimum wages affect hospitalization rates or the elderly mortality in hospitals.

term is the national fraction of elderly individuals age *a* in year 2000.[35]

Table 9 shows a 10 percent increase in the minimum wage reduces the overall age-adjusted elderly mortality rate by 0.7 percent (column (1)), or 0.5 percent accounting for demographic changes in nursing home residents. This overall increase in longevity is driven by lower mortality in nursing home settings. A 10 percent increase in the minimum wage reduces deaths in the nursing homes by 3.3 percent, or 3.1 percent controlling for changes in resident demographics (columns (3) and (4)). Applying these estimates to the number of nursing home deaths in 2013 suggests an across-the-board 10 percent increase in each county's minimum wage that year would have saved approximately 15,200 to 16,200 lives.[36] In contrast, there is no significant relationship between minimum wages and elderly mortality rates in non-nursing home settings (columns (5) and (6)), including deaths occurring in hospitals (columns (7) and (8)).[37]

These mortality reductions are somewhat larger than the estimated effects of other labor market changes affecting nursing homes, particularly given the modest costs of minimum wage increases. For example, Stevens et al. (2015) estimate a one percentage point increase in the unemployment rate reduces nursing home mortality rates by 4.7 percent. By this metric, a ten percent increase in the minimum wage is equivalent to a 0.66 percentage point increase in the unemployment rate. Put another way, the 2007-2009 increase in the federal minimum wage had approximately half the effect on elderly mortality as the change in unemployment during the Great Recession. Another labor market change, California's minimum staffing requirement policy, suggests increasing staffing levels by ten percent reduces mortality in 4.7 percent (Tong, 2011). As a ten percent minimum wage increase raises nursing assistant pay by about 1-2 percent, increasing wages may be more cost-efficient than increasing staffing levels.

[35] County population data are top-coded at age 85 and approximately 40 percent of nursing home deaths occur among those older than 85, I cannot determine extensions in life expectancy or quality-adjusted life years.

[36] Additional results suggest nursing home mortality reductions are concentrated among deaths due to respiratory conditions, degenerative brain diseases, and kidney-related conditions. For deaths outside nursing homes, only kidney conditions is significantly correlated with minimum wage.

[37] Results are qualitatively robust to alternative measures of mortality, including the number and log number of deaths, the mortality rate expressed in levels, and the inverse hyperbolic sine transformation.

5.3 Patient safety and health: Robustness and alternative explanations

5.3.1 Alternative empirical approaches

The main county-pair differences-in-differences design leverages wage differences between neighboring counties and controls for county unemployment rates in order to isolate wage variation that is orthogonal to local labor market conditions. Appendix Tables C4 and C6, and columns (1) and (2) of Appendix Table C7 present results for nursing homes in all counties, including those in states' interiors, with state and Census division-by-time fixed effects models that include state-specific linear trends (Equation 2) in order to allay concerns that the previous results are sensitive to the county-pair design or sample. Despite stronger identifying assumptions, results are largely robust to this modification.[38]

Appendix Tables C3 and C5 show the main patient safety and health outcomes are qualitatively unchanged with other sample modifications: including extreme values, unweighted specifications, and omitting facilities that are located within hospitals. Finally, panel (d) of Appendix Tables C3 and C5 and column (3) of Appendix Table C7 replaces the county-pair sample with observations that are located in a Hospital Referral Region (HRR) where the statutory minimum wage differs across jurisdictions. The HRR sample includes more rural and midwestern counties than the county-pair sample (Appendix Figure A2), but improvements in patient health are similar to the main findings. Finally, in results available upon request, results are not driven by the early or later years of the analysis period, and are qualitatively similar when limiting the sample to within-state minimum wage changes, thereby accounting for all unobserved changes in state-level policies and suggesting that cross-border spillovers are minor in this setting.

5.3.2 Dynamic responses to minimum wage reforms

The differences-in-differences analyses show the contemporaneous effect of minimum wage increases. If safety measures take time to implement or patient health results from longer-standing patterns of care, the medium-term effect of higher wages will be larger than the immediate ef-

[38] While the point estimate on nursing home mortality is slightly positive in the all county sample when state trends are included (Appendix Table C7), there is an active debate on the appropriate use of geographic controls; moreover, it is unclear whether the rationale for including trends when measuring labor market variables pertains to other outcomes. Models excluding state linear trends produce results nearly identical to those in Table 9, column (4).

fect, and the differences-in-differences estimate is smaller than the full dynamic treatment effect (Goodman-Bacon, 2018). On the other hand, firms may adjust wage schedules before the reform becomes effective. More generally, a causal interpretation of the differences-in-differences results requires that within a pair of neighboring counties and conditional on covariates, minimum wage timing is uncorrelated with factors affecting elderly health.

Figure 4 presents event study plots showing how outcomes (solid circles) evolve following changes in minimum wages (hollow circles) using the approach in Equation 4. I focus on the number of quality of care violations (panel (a)); the prevalence of pressure ulcers (panel (b)) and UTIs (panel (c)); and nursing home mortality (panel (d)), and track outcomes over a 13 quarter (panels (a) through (c)) or ten year (panel (d)) period. Results illustrating employment patterns and resident demographics are provided in Appendix Figures A4 and A5, respectively.

Since minimum wage changes are frequent events and can occur in either county within each pair, I limit the event study sample to reforms that increased the inflation-adjusted minimum wage gap between the two counties by at least five log points, and exclude events for which another reform changed the log gap by more than 0.5 log points in the previous six quarters (panels (a) through (c)) or four years (panel (d)). Appendix Figure A3 shows the years in which these events occurred.[39] Although a relatively small fraction of all reforms, this subsample includes the starkest changes. I then scale each event by the change in the log wage gap, following an approach similar to that in Dow et al. (2019) and Finkelstein et al. (2016), and stack all events.[40] Specifically,for outcome y_{fcpyq} in facility f in county c in year y in quarter q, I estimate:

$$y_{fcpyq} = \sum_{i=m}^{n} \kappa_i 1\{\gamma_{yq} = i\} * 1\{\Delta log(MW)_{cpi=0} > \Delta log(MW)_{(-c)pi=0}\} * \\ \left(\Delta log(MW)_{cpi=0} - \Delta log(MW)_{(-c)pi=0}\right) + X_{cpyq}^{'}\phi + \gamma_{py} + \gamma_f + \gamma_{i=0} + \varepsilon_{fcpyq} \tag{4}$$

where $1\{\gamma_{yq} = i\}$ is an indicator function for each quarter in event time i, interacted with an indicator for facilities on the "treatment" side of the border $\{\Delta log(MW)_{cpi=0} > \Delta log(MW)_{(-c)pi=0}\}$ that experienced a larger change in the minimum wage than their neighbors, scaled by change in the log wage gap $\left(\Delta log(MW)_{cpi=0} - \Delta log(MW)_{(-c)pi=0}\right)$. As in the differences-in-differences specifications, $X_{cpyq}^{'}$ includes county unemployment rates and facility and population character-

[39] Given different reporting windows, the sample of minimum wage reforms slightly varies across outcomes.
[40] A distributed lag specification yields qualitatively similar, albeit less precise, results.

istics, as well as quarter fixed effects γ_q for the results in panels (a) through (c). γ_{py}, and γ_f are county-pair-year and facility fixed effects, respectively. The mortality specifications replace facility fixed effects with county fixed effects and define event time in years, rather than quarters.

Crucially, Figure 4 does not show economically or statistically significant pre-trends for any outcome, indicating that the differences-in-differences estimates are not simply picking up correlations between longer-term improvements in elderly health and prevailing wages. Following a minimum wage increase, however, the number of violations and prevalence of pressure ulcers and UTIs falls over the subsequent six quarters (panels (a)-(c)). In addition, panel (d) shows mortality rates fall by approximately 20 to 30 log points following a 100 log point change in the minimum wage gap, similar to the results in Table 9.[41]

The timing of patient health changes are consistent with how each outcome develops over time: inspection citations occur immediately but may reflect longer-standing environmental features, UTIs can develop within several days, whereas pressure sores result from persistent lack of movement over several weeks or months, and mortality results from cumulative health inputs. Appendix Figure A4 explores whether these dynamics track employment patterns and shows no significant change in the number of nursing assistants four years before through five years after a wage increase, while RN care falls about three years after higher minimum wages became fully effective. Together, these patterns suggest that the health improvements observed in Figure 4 are not driven by greater direct care staff time or substitution towards licensed nursing staff.

5.3.3 Patient composition

The main results control for resident demographic characteristics in order to avoid confounding changes in patient outcomes with underlying risk factors, and results are similar when excluding these controls. However, changes in the type of individuals with access to long-term care services has social welfare implications, particularly if establishments offset higher labor costs by increasing prices or targeting relatively wealthy, private-paying residents.[42] While facilities cannot legally

[41] Although each event study plot suggests larger (albeit noisier) health improvements than the differences-in-differences results, the event studies only leverage the largest and most temporally isolated minimum wage increases – reforms expected to generate the largest changes in patient outcomes. Additional results, available upon request, suggest that marginal improvements diminish with respect to the minimum wage change.

[42] Average Medicaid reimbursement rates are approximately 26 percent lower than rates received by private payors, and about half that of average Medicare reimbursement (Appendix Table B1).

discriminate against providing care based on payment source, a nursing home can turn away a patient if it is unable to meet his or her care needs.[43] These protocols suggest that profit-maximizing firms may target Medicare and private payors when labor prices increase in order to increase revenue and avoid reducing staffing levels.

Consistent with this hypothesis, Table 10 shows a ten percent minimum wage increase reduces the the share of residents covered by Medicaid by 0.5 percent (0.26 percentage points, column (1)), increases the share of residents paying out-of-pocket or covered by private insurance by a similar amount (0.25 percentage points, or one percent, column (2)), and does not change the fraction of residents covered by Medicare (column (3)).

Facilities may also increase revenue by determining residents require more intensive services in order to receive higher payments from Medicare and private patients. Evidence on this margin is somewhat mixed: across all residents, average care needs increase about 0.02 standard deviations following a 10 percent minimum wage increase (Table 10 columns (4) and (5)).[44] However, the observed shifts are not driven by Medicare recipients, as there is no economically or statistically significant change in average Medicare reimbursement rates (columns (6) and (7)).[45]

Higher wages may also change facilities' discharge or admission practices; for example, firms may discharge relatively low-revenue Medicaid patients, leverage economies of scale by increasing occupancy rates, or increase hospital transfers in order to receive Medicare rates when patients are readmitted to the facility (Mor et al., 2010). Columns (8) and (10) show no economically or statistically significant change in discharge or occupancy rates, respectively. Consistent with improved resident care and inconsistent with facilities "churning" patients to maximize revenue, column (9) shows a ten percent minimum wage increase decreases hospital admissions by 0.13 percentage points (0.8 percent).

[43] The number of Medicaid and Medicare residents is capped at the number of beds that are certified by CMS, but a certified bed can also be occupied by a private payor. In practice, all beds are open to Medicaid recipients in more than 94 percent of facilities.

[44] These standardized indices are computed from scales summarizing the average number of ADLs residents require assistance with (column (1)) and the number of ADLs plus therapeutic and rehabilitative services (column (2)). See data appendix for details.

[45] If the Medicaid formula for each need group is accurate and each patient accurately categorized, however, higher reimbursement rates also correspond to additional staffing time and resources that offset any additional revenue. Analyses for Medicare recipients are further complicated by periodic changes in the reimbursement schedule, the most substantial of which occurred in 2011.

Table 11 examines other changes in resident characteristics. Columns (1-6) report characteristics that are not sensitive to subjective admissions decisions; columns (7-11) show results for care needs that may be altered by assessor judgment. Results are mixed across both dimensions. For some characteristics, higher minimum wages lead to advantageous selection – with fewer residents experiencing obesity, hypertension, needing help walking, or bladder incontinence. On other dimensions – residents admitted from the hospital, schizophrenia, and bowel incontinence – higher minimum wages increase the care need mix consistent with Table 10 columns (4-5).

One simple approach to bound the extent to which resident composition changes drive the main findings is provided by the change in overall elderly mortality (Table 9, column (1)), which suggests a 10 percent increase in the minimum wage reduces the overall elderly mortality rate by 0.7 percent, about 22 percent of the change in nursing home mortality.

For a complementary bounding exercise that is also feasible for health inspection violations and pressure ulcers, I estimate Equation 1 on predicted changes in patient health that are exclusively due to changes in demographic and payment composition, where predicted outcomes $\widehat{y_{c(f)t}}$ are defined from interacting all two-way combinations of patient characteristics. Appendix Table B7 shows predicted changes due to objective resident characteristics (Table 11 columns (1-6)) in odd-numbered columns. Even-numbered columns show predicted changes based on all resident characteristics in Table 11 and average ADL needs from Table 10. The last row of Appendix Table B7 indicates changes in objective patient demographics account for 13 percent of the observed reduction in health inspection violations (column (1)), 3 percent of pressure ulcer prevalence (column (3)), and would predict increased mortality rates (column (5)). Incorporating all patient care needs suggests observed characteristics account for no more than 13, 42, or 22 percent of the improvement in violations, pressure ulcers, and mortality, respectively.[46]

Although resident compositional changes do not fully explain the main results, these shifts raise distributional considerations. While comparable health data is not available for individuals outside of residential settings, Table 9 does not show elderly mortality occurring outside of nursing homes significantly rises (columns (3) and (4)). Therefore, at least measured by mortality, these

[46]In additional results, I do not observe significant changes in resident segregation by payment source or demographic characteristics within the same county.

shifts do not worsen outcomes for those losing access to care.

5.3.4 Heterogeneity

How higher wages affect workers and patients may vary with the local market structure. Appendix Table B8 explores whether average effects mask heterogeneous responses by interacting the minimums wage with whether a establishment has a higher-than-average Medicaid share, is privately owned, part of a multi-establishment chain, in a competitive industry, or in a state with a minimum staffing requirement. Across outcomes, health improvements do not systematically vary with provider type, suggesting that changes in patient health are not limited to a particular type of facility or service area. Appendix Table B9 examines worker outcomes, and generally shows no significant differences in employment and earnings along these characteristics, except earnings gains are smaller in counties with a large share of multi-establishment chains.

5.4 Firm costs, revenue, and profitability

If consumer demand is price inelastic, firms can charge consumers higher prices, receive greater revenue, and increase worker earnings without substantially lowering employment or profits. Even if firms cannot adjust prices, they may be able to offset higher labor costs elsewhere in their balance sheet by selling assets, lowering investments, or increasing their liabilities.

Table 12 examines how higher labor wages affect firm revenue and costs using annual financial data for the subset of facilities serving Medicare patients.[47] Column (1) shows costs per resident increase by slightly less than half the estimated wage increase in Table 3 – about 70 to 90 percent of nursing assistants' share of the total labor bill or 97-98 percent of the total low-skilled share of the labor bill.[48] Column (2) indicates that prices charged to residents increase by more than the additional costs, although this estimate is imprecise and the amount charged does not always reflect the payment a facility receives, particularly for individuals with insurance coverage. Column (3) indicates a 10 percent minimum wage increase generates a 0.7 percent increase revenue per resident, slightly more than the estimated costs in column (1) and suggesting that firms are able to fully offset higher labor costs by increasing revenue. Accordingly, profitability, measured by net

[47] These data are only available for Medicare-certified SNFs, and facilities that serve few Medicare patients may submit an abbreviated form that does not include all information.

[48] "Low-skilled" is defined as nursing assistants, maintenance workers, and food preparation staff.

income does not significantly change (column (4)).[49]

Changes in per-resident revenue combines any changes in patient composition and changes in revenue from each payor type. Table 10, column (3) showed that a 10 percent minimum wage hike increases the fraction of residents not covered by Medicaid or Medicare by about 0.25 percentage points (1 percent). Among residents who are covered by government sources, there is no significant change in per-resident revenue (Table 10, columns (6) and (7) for Medicare recipients (firm level) and Table 12, column (5) Medicaid per diem (state average)).[50] Decomposing the increase in per-resident revenue indicates that approximately 75 percent is due to changes in the prices paid by private payors and 25 percent is due to facilities serving fewer Medicaid recipients.[51]

Another potential confounding factor is that higher labor costs may cause low-performing firms to exit the market. As outcomes are not available for closed facilities, high exit rates would overstate the aggregate benefits from higher minimum wages. To explore this issue, I create a balanced panel of facilities that appear at any point in my sample, defining the outcome of interest an indicator for whether the facility appears in the sample in a given year, and extend the event study analysis from Equation 4. Appendix Figure A9 shows there is no significant pre-reform patterns in industry growth and no change in firm exits or entry up to four years after a minimum wage increase, indicating that higher minimum wages do not change market composition. These patterns are consistent with barriers to entry and high demand for services in this sector, and contrast with higher turnover among fast-food restaurants (Aaronson et al., 2018).

As discussed in Section 3, the ability to re-coup higher labor costs through greater revenue raises the question why firms do not unilaterally increase wages in order to improve services. However, with labor market search frictions, labor supply responses are small with any firm's independent action, and if consumers lack information about employee wages or service quality, the demand response to higher wages is muted. In contrast, if all firms must increase wages, even if consumers cannot discern a particular firm's quality or employees do not know a specific firm's

[49] Net income is total revenue – including ancillary, outpatient, and clinical services – minus total costs.

[50] Facility-level Medicaid payments are not systematically collected across states over time. The results in column (5) provide average state payments, collected by Brown School of Public Health (2019) from a survey of state Medicaid officials for the 2000 through 2009 period.

[51] Charges, costs, and revenues by payor type are not available for most facilities. The decomposition applies the point estimates in Table 12 column (4) and Table 10 columns (1-3) and prices paid by each payor type approximated as the mark-up implied by Appendix Table B1, to the average daily cost in Table 12 column (4).

wage schedule, they may expect quality at *any* facility in an area will be better and wages weakly higher after the minimum wage increase than before. Therefore, economy-wide wage mandates may be necessary to trigger a meaningful increase in labor supply or consumer demand that allows firms maintain profitability. Beyond these considerations, I emphasize that Table 12 shows no significant change in profitability following modest minimum wage increases – while firms are not strictly worse off paying higher wages, nor are they better off.

6 Conclusion

This paper finds that higher wages among low-skilled health workers translate into improved patient safety, better health, and reduced mortality for nursing home residents. These benefits are both statistically significant and economically meaningful. To quantify the magnitude of these changes, I apply the expected costs of pressure sore treatment from the previous literature (Dorner et al., 2009; Meddings et al., 2015; Agency for Healthcare Research and Quality, 2016; Brem et al., 2010) to the point estimates in Table 8 columns (1-2) and the estimated increase in nursing assistant wages in Table 3. This simple back-of-the-envelope calculation suggests that cost savings from pressure sore treatment alone offset between approximately 20 and 50 percent of the increase in staff costs.[52] Although there is wide variation in valuations of life at older ages, wage increases in this sector fully pay for themselves if the value of increased longevity for nursing home residents is at least $21,000.[53]

While accounting for improved service quality enhances the desirability of minimum wages relative to a framework that does not account for this margin, it is less obvious whether minimum wages are socially beneficial. Appendix E outlines the social welfare considerations and demonstrates that higher minimum wages are more desirable the greater the welfare weights assigned to elderly individuals and low-income workers, the higher the dependency ratio of the Medicaid population to current taxpayers, and the responsiveness of nursing home quality to higher wages.

The results documented in this paper show that higher minimum wages can improve consumer

[52] As I do not find significant changes in employment or consistent changes in earnings for other skill categories, this estimate assumes a null employment response and no changes in earnings among higher-skilled nursing staff.

[53] This estimate is well below reasonable parameter estimates in Murphy and Topel (2006) and Hall and Jones (2007), as well as willingness to pay, as measured by annual costs of residential care (Appendix Table B1).

well-being. While these findings are consistent with recent work documenting higher minimum wages increase retail worker productivity without lowering profits (Coviello et al., 2018), when extrapolating to the broader economy several points are critical. First, restrictions on the supply of nursing home services and operating regulations create entry costs that stifle competition in both the labor and product markets. Second, there are few close substitutes for nursing home care, and consumer demand is likely relatively inelastic among insured individuals. Therefore, while I do not find significant reductions in profits or employment, these results may not apply to industries facing greater competitive pressures or more elastic consumer demand. With these caveats in mind, the results are of policy interest in their own right. Across the world, governments are major actors in health care provision and financing. In the United States, Medicaid and Medicare account for nearly 18 percent of GDP, ten percent of which is spent on long-term care (Centers for Medicare and Medicaid, 2018b). These costs will increase as population ages, and the potential to increase longevity and reduce expenditures on preventable medical care through policies that benefit workers in this industry has important social welfare and fiscal implications.

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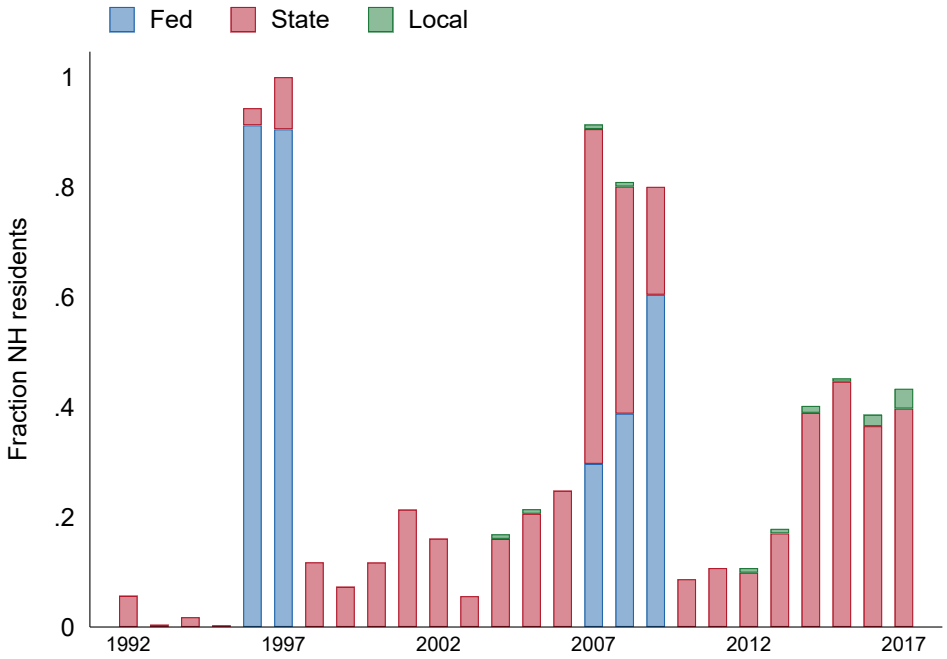
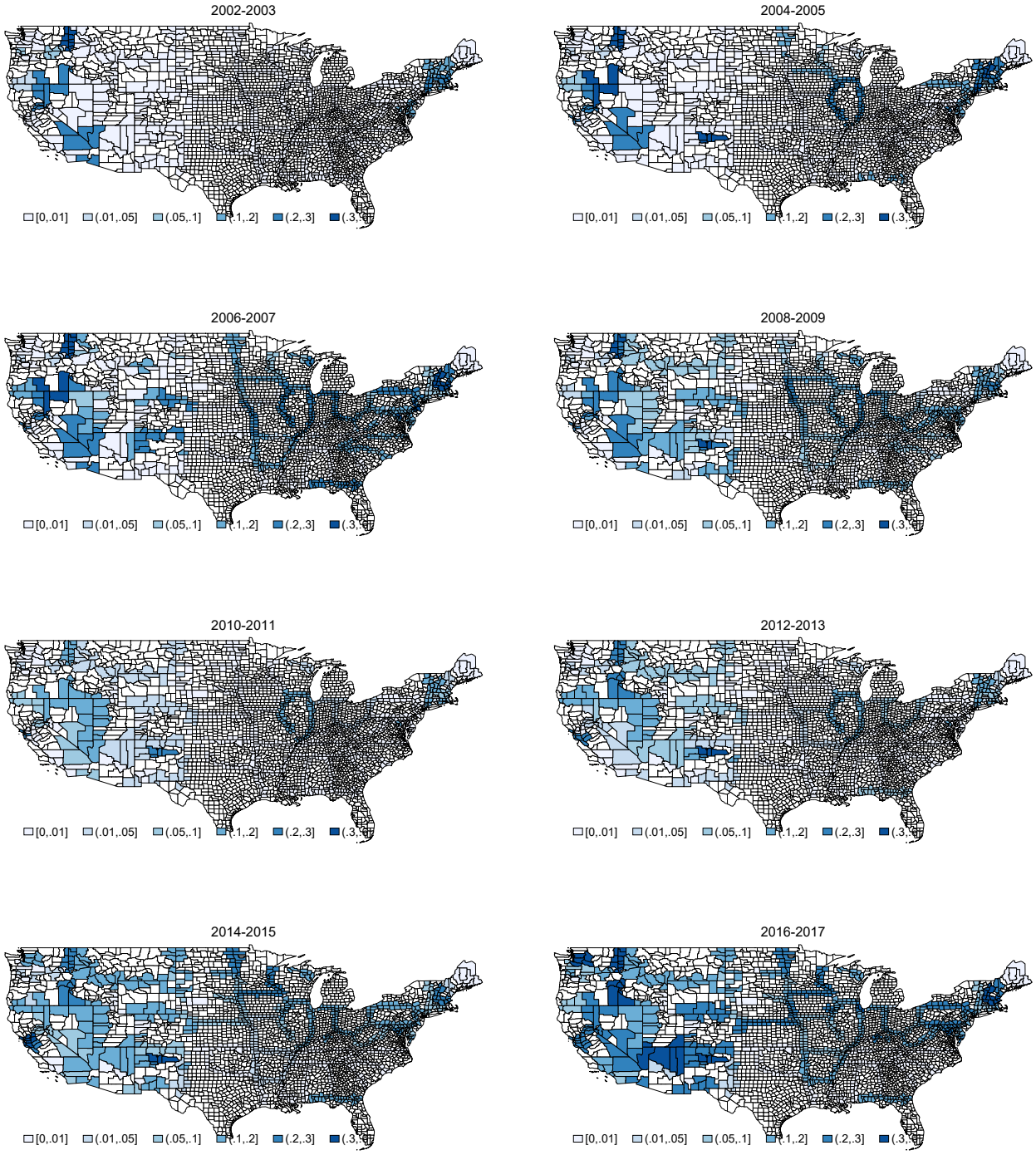
Figure 1: Number of Nursing Home Residents in Jurisdiction with Minimum Wage Increase, County Pairs Sample



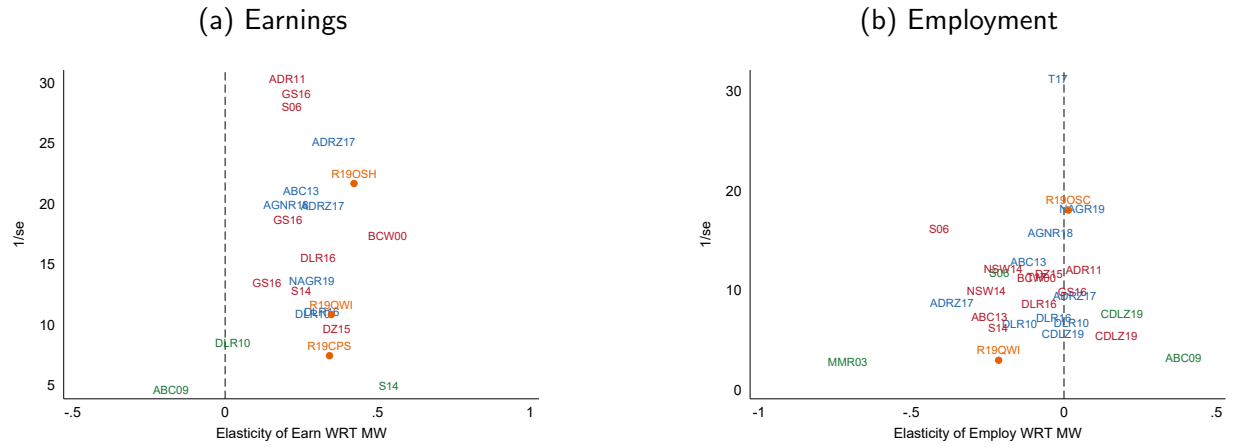
Notes: Figure shows the share of the nursing home residents in the county pairs sample living in a jurisdiction that experienced a minimum wage reform in relative to the previous year by the level at which the reform occurred (federal, state, or substate). Population data from SEER, minimum wage reforms from Vaghul and Zipperer (2016), Labor Center (2018), and Bureau of Labor Statistics (2018).

Figure 2: County Pair Log Minimum Wage Differential, by Year



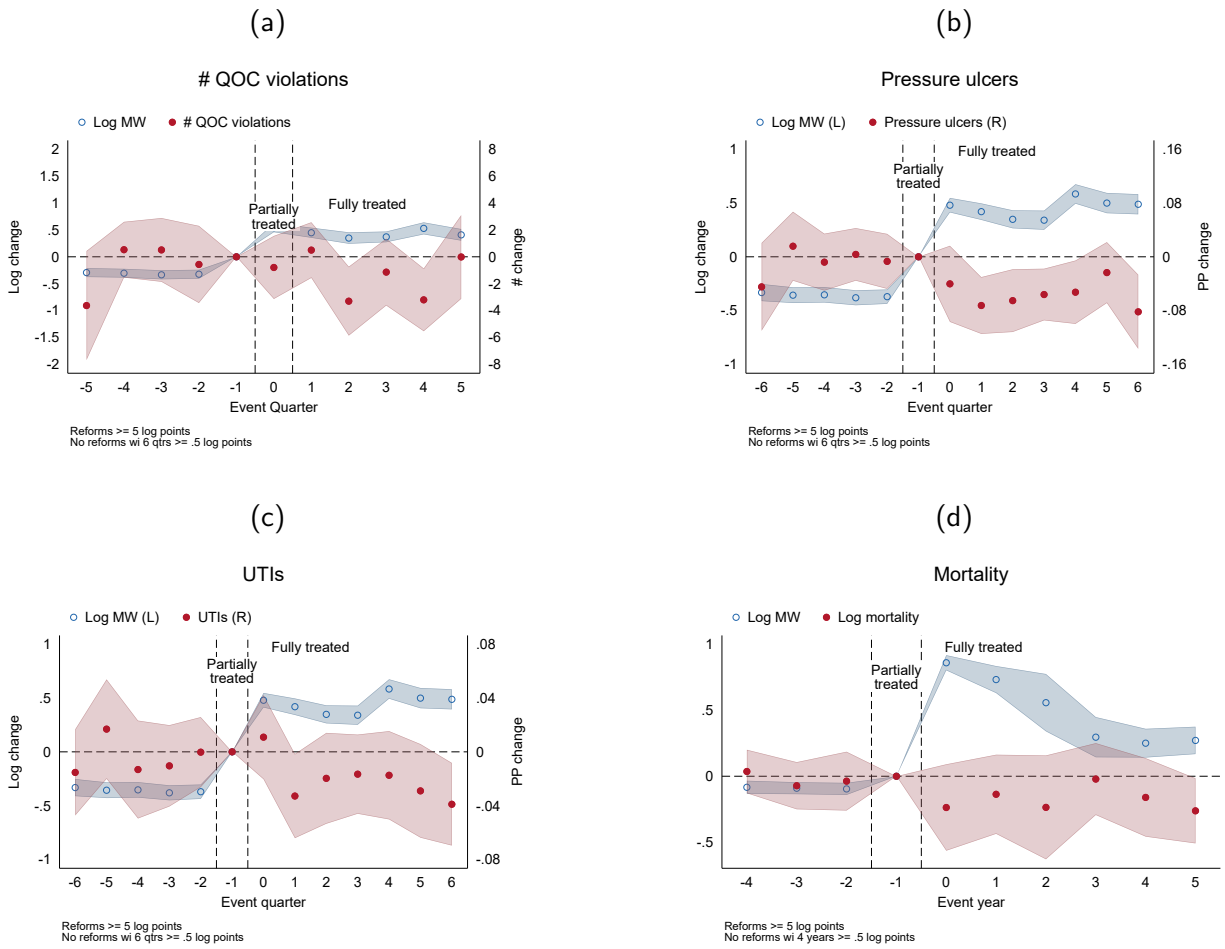
Notes: Figure shows the maximum difference in (inflation-adjusted) log minimum wages between adjacent counties for each two year period in which there is at least one nursing facility in each county. See text for details. Minimum wage data from Vaghul and Zipperer (2016), Labor Center (2018), and Bureau of Labor Statistics (2018), nursing home presence from OSCAR/CASPER.

Figure 3: Employment and Earnings Responses, Nursing Home Workers and Previous Literature



Notes: Figure shows a funnel plot estimates of the elasticity of earnings (panel (a)) and employment (panel (b)) with respect to the minimum wage, scaled by the fraction of low-wage workers. The fraction of low-wage workers is estimated as the share of workers of each demographic group or occupation earning within 127 percent (110 percent times 115 percent) of the current minimum wage from the 2014-2018 CPS-ORG. Labels denote author initials and year; see data appendix for full citations. Blue labels show estimates for restaurant workers, maroon for teenagers, orange for US nursing home workers, and green for all other groups.

Figure 4: Event studies, Patient Outcomes and Minimum Wages



Notes: Figure shows event studies from Equation 4. Blue line indicates the change in the minimum wage; red line shows the change in patient outcomes: the number of quality of care violations (panel (a)) pressure ulcers (panel (b)), UTIs (panel (c)), and log mortality (panel (d)). Sample is limited to reforms that changed the within-county-pair log gap by at least 5 log points and for which there were no changes greater than 0.5 log points in the preceeding six quarters (panels (a) through (c)) or four years (panel (d)). All specifications include controls for county employment rates and the elderly population share; state EITC parameters, the share of the elderly population receiving Supplemental Security Income, and AFDC/TANF caseloads and benefit levels; and county-pair-year and reform year fixed effects. Panels (a) through (c) additionally include facility and quarter fixed effects; panel (d) includes county fixed effects. Shaded areas indicate 95 percent confidence intervals with robust standard errors clustered at the county level. P-value of test all pre-reform coefficients for patient outcomes equal zero is: 0.942 (panel (a)); 0.870 (panel (b)); 0.667 (panel (c)); and 0.936 (panel (d)). Data from OSCAR/CASPER 1998-2017 (panel (a)) 2012-2017 (panels (b) and (c)) and Vital Statistics 1990-2013. See text and data appendix for details.

Table 1: Earnings and Demographic Characteristics of Nursing Home and Low-wage Workers

	(1)	(2)	(3)	(4)	(5)	(6)
	Nursing home workers			*Other low-wage sectors*		*All*
	Nursing assistants	LPNs	RNs	Food services	Retail	Private sector
	Minimum wage exposure					
Workers (1000s) (OES)	604.4	210.9	153.1	12856.1	14452.6	122999.2
Median wage (OES)	13.33	$22.91	$30.98	$11.05	$13.54	$18.58
% affected by MW increase (CPS)	0.336	0.103	0.031	0.653	0.433	0.262
Demographics (CPS)						
% ages 25-54	0.632	0.686	0.720	0.500	0.548	0.647
% HS education or less	0.482	0.229	0.014	0.571	0.427	0.355
% some college, $<$ 4yr degree	0.416	0.674	0.331	0.314	0.348	0.286
% black	0.348	0.273	0.119	0.123	0.133	0.110
% Hispanic	0.157	0.117	0.067	0.256	0.175	0.169
% white	0.419	0.537	0.707	0.521	0.606	0.639
% female	0.887	0.895	0.895	0.514	0.584	0.463
% HH w/ children	0.507	0.553	0.523	0.315	0.347	0.437
% married	0.377	0.483	0.625	0.288	0.413	0.543

Notes: Table shows average wages and demographic characteristics for nursing home workers by occupation (columns 1-3); workers in other low-wage sectors (columns 4-5); and all workers (column 6). The number of workers and median wages is provided from 2018 Occupational Employment Statistics data; the remaining rows are author's calculations using the 2014-2018 CPS-ORG. See data appendix for details.

Table 2: Nursing Home and Area Characteristics, Differences between County Pairs

	(1)	(2)
	Average, highest MW county	County pair difference
Min wage (2017 $)	8.297	0.565***
		(0.085)
Cty unemployment (x100)	6.772	0.128
		(0.114)
Share popn > 65 (x100)	13.93	0.039
		(0.165)
State EITC rate (x100)	7.76	-0.005
		(0.014)
Any state EITC	40.6	-0.024
		(0.036)
TANF/AFDC maximum	560.2	-5.964
		(15.99)
Avg facility size	106.3	-1.038
		(1.444)
CZ HHI (X.0001)	59.66	0.008**
		(-0.004)
% NH residents female (x100)	68.85	-1.155***
		(0.404)
% NH residents black (x 100)	17.57	1.893
		(1.357)
% NH residents Medicaid (x 100)	59.66	0.733
		(0.725)
Avg NH resident age	80.17	-0.766***
		(0.209)
Observations		841958

Notes: Table shows the average characteristics of the county in each county-pair with the highest minimum wage (column (1)) and difference in average characteristics between the highest-minimum wage jurisdiction and lowest-minimum wage jurisdiction within a county-pair year from a regression including a series of year fixed effects and an indicator for whether the facility faced the pairwise-highest minimum wage (column (2)). Sample is limited to county-pair-years with within-pair minimum wage variation. Robust standard errors clustered by county in parentheses. Minimum wage data from minimum wage reforms from Vaghul and Zipperer (2016), Labor Center (2018), and Bureau of Labor Statistics (2018); population from SEER; state policy controls from University of Kentucky (2019); and resident demographics from LTC Focus. See text and data appendix for details.

Table 3: Minimum Wages and Low-skilled Employee Earnings

	(1)	(2)	(3)	(4)	(5)
	QWI	OSHPD	Current Population Survey		American Community Survey
	Log(quarterly earnings)	Log(annual earnings)	Log(hourly earnings)	Log(wkly earnings)	Log(annual earnings)
log(MW)	0.117***	0.142***	0.115**	0.199**	0.339**
	(0.031)	(0.016)	(0.045)	(0.077)	(0.139)
N	23214	45324	23556	23556	51234
DV mean (level)	2622.8	29361.99	12.05	448.90	20117.60
Geo FE	County	Facility	State	State	PUMA
Geo X year FE	Cty pair	Cty pair	Division	Division	Division
Area business cycle controls	X	X	X	X	X
Demographic controls	X	X	X		X
State linear trends			X	X	X

Notes: Table shows earnings elasticity with respect to the minimum wages for low-skilled nursing home workers. Column (1) reports results for female employees with no more than a high school education employed in NAICS sector 6231 at the end of the quarter from the Quarterly Workforce Indicators data, covering years 2000-2017. Workers with $\leq$ HS are defined as all employees minus those with at least some college education. Columns (2)-(5) report earnings for nursing assistants working in nursing homes from the California Office of Statewide Health Planning and Development (OSHPD) (column (2), years 2003-2017), the Current Population Survey Outgoing Rotation Groups (columns (3-4), years 1991-2017), and decennial Census and American Community Survey (column (5), years 2000-2017). $log(MW)$ is the natural log of the highest minimum wage in county c (column (1)), the local or state minimum wage (column (2)), county (for those living in identifiable urban areas) or state minimum (columns (3-4)) or maximum minimum wage in a PUMA (column (5)) at time t, adjusted for inflation using the CPI-U-RS. All specifications controls for county employment rates and the elderly population share; and state EITC parameters, the share of the elderly population receiving Supplemental Security Income, and AFDC/TANF caseloads and benefit levels. Column (1) additionally includes county fixed effects; column (2) includes facility fixed effects; columns (3-4) include state fixed effects; column (5) includes Public-Use Microdata Area (PUMA) fixed effects. Column (1) is weighted by county population, column (2) by the number of beds in a facility, and columns (3-5) use person weights for the respective survey. Robust standard errors clustered by county (columns (1-2)), state (columns (3-4)) or PUMA (column (5)). See text and data appendix for details. *** $= p < 0.01$, ** $= p < 0.05$, * $= p < 0.10$.

Table 4: Minimum Wages and Low-skilled Employment

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Log ($\leq$ HS employment)	Log(nursing asst hrs per resident day)		Log(FTE nursing asst)		Log(FT nursing asst)	Log(PT nursing asst)
log(MW)	-0.072	0.005	0.005	0.063***	0.064***	0.070***	0.194***
	(0.113)	(0.018)	(0.018)	(0.024)	(0.024)	(0.025)	(0.055)
N	25594	269059	269059	404777	404777	402697	313592
DV mean (level)	1072.4	2.271	2.271	38.079	38.079	32.080	7.458
Geo FE	County	Facility	Facility	Facility	Facility	Facility	Facility
Geo X year FE	Cty pair	Cty pair	Cty pair	Cty pair	Cty pair	Cty pair	Cty pair
Area business cycle controls	X	X	X	X	X	X	X
Demographic controls	X		X		X	X	X
Data	QWI	OSCAR/CASPER		OSCAR/CASPER		OSCAR/CASPER	OSCAR/CASPER

Notes: Table shows employment elasticity with respect to the minimum wages for low-skilled nursing home workers. Column (1) reports results for female employees with no more than a high school education employed in NAICS sector 6231 at the end of the quarter from the Quarterly Workforce Indicators data, covering years 2000-2017. Workers with $\leq$ HS are defined as all employees minus those with at least some college education. Columns (2)-(7) report results from the OSCAR/CASPER staffing reports reported by facilities to CMS, covering years 2000-2016 (columns (2-3)) and 1992-2017 (columns (4-7)). Sample includes facilities in counties that straddle a minimum wage discontinuity. $log(MW)$ is defined as the natural log of the county minimum wage in year-quarter t in 2017 dollars, adjusted for inflation using the CPI-U-RS. Log hours per resident day (columns (2-3)) is defined as the number of nursing assistant staffing hours, divided by the number of patients times 24 (including direct care and administrative time). FTE employees (columns (3-4)) is defined as sum of FT and PT nursing assistants, in full-time equivalent units. FT employees defined as the number of nursing assistants typically working at least 35 hours a week; PT employees defined as those typically working fewer than 35 hours a week. All specifications include county-pair-time and controls for county employment rates and the elderly population share; and state EITC parameters, the share of the elderly population receiving Supplemental Security Income, and AFDC/TANF caseloads and benefit levels. Column (1) additionally includes county fixed effects; columns (2-7) include facility fixed effects. "Demographic controls" include average resident age, and the share of residents female, white, black, and covered by Medicaid. Robust standard errors clustered by county. Column (1) is weighted by county population, columns (2-7) by the number of beds in a facility. See text and data appendix for details. *** $= p < 0.01$, ** $= p < 0.05$, * $= p < 0.10$.

Table 5: Minimum Wages and Low-Skilled Worker Flows: Quarterly Workforce Indicators

	(1)	(2)	(3)
	Log (turnover)	Log(hires, employed 1+ qtr)	Log (separations)
log(MW)	-0.053	0.359**	-0.238*
	(0.100)	(0.174)	(0.140)
N	10164	9208	14380
DV mean (rate)	0.199	0.111	0.196

Notes: Table shows results for workers with a high school education or less from the Quarterly Workforce Indicators data, covering years 2000-2017. Nursing staff in nursing homes are identified as women without any college education employed in NAICS sector 6231 working in counties that straddle a minimum wage discontinuity. $log(MW)$ is defined as the natural log of the highest minimum wage in county c at time t in 2017 dollars, adjusted for inflation using the CPI-U-RS. $log(turnover)$ is the log sum of all hires and all separations, divided by two; $log(hires, employed1 + qtr)$ is the natural log of the hires who remained employed for at least three months; and $log(separations)$ is the natural log of the the number of workers who separated from their employer in a county-quarter-education cell. All specifications include county-pair-quarter and county fixed effects and controls for county employment rates and the elderly population share; and state EITC parameters, the share of the elderly population receiving Supplemental Security Income, and AFDC/TANF caseloads and benefit levels. All cells are weighted by county population. Robust standard errors clustered by county. See text and data appendix for details. *** $= p < 0.01$, ** $= p < 0.05$, * $= p < 0.10$.

Table 6: Minimum Wages and Worker Characteristics

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Citizen	White	Female	$\leq$ HS	Prime age	Married	Parent
Panel a: Current Population Survey							
log(MW)	-0.0522	-0.0448	-0.0340	0.0002	0.0827	0.0093	-0.0439
	(0.0468)	(0.0777)	(0.0753)	(0.0947)	(0.0819)	(0.0904)	(0.0834)
N	24883	24883	24883	24883	24883	24883	24883
DV mean	0.803	0.505	0.915	0.638	0.691	0.410	0.564
ϵ_{mw}	-0.0650	-0.0887	-0.0372	0.0003	0.1197	0.0227	-0.0778
Geo FE	State	State	State	State	State	State	State
Panel b: American Community Survey							
log(MW)	0.0136	-0.002	0.0171	-0.112	0.006	0.0610	-0.0662
	(0.0340)	(0.0739)	(0.0559)	(0.101)	(0.100)	(0.0991)	(0.102)
N	52590	52590	52590	52590	52590	52590	52590
DV mean	0.979	0.693	0.927	0.684	0.643	0.385	0.528
ϵ_{mw}	0.0139	-0.0023	0.0184	-0.1637	0.0086	0.1584	-0.1254
Geo FE	PUMA	PUMA	PUMA	PUMA	PUMA	PUMA	PUMA
Area business cycle controls	X	X	X	X	X	X	X
State linear trends	X	X	X	X	X	X	X
Division X year FE	X	X	X	X	X	X	X

Notes: Table shows average demographic characteristics for nursing assistants employed in nursing home settings from the Current Population Survey Outgoing Rotation Groups (panel (a), covering years 1991 through 2017), and decennial Census and American Community Survey (panel (b), covering years 2000 through 2017). $log(MW)$ is defined as the natural log of the local or state minimum wage (panel (a)), county (for those living in identifiable urban areas) or state minimum (columns (2) and (3)) or maximum minimum wage in a PUMA (panel (b)) at time t in 2017 dollars, adjusted for inflation using the CPI-U-RS. All specifications include state linear trends; Census division-by-year fixed effects; and controls for local county employment rates and the elderly population share, state EITC parameters, the share of the state elderly population receiving Supplemental Security Income, and state AFDC/TANF caseloads and benefit levels. Panel (a) additionally includes state fixed effects and panel (b) includes Public-Use Microdata Area (PUMA) fixed effects. Standard errors clustered by state (panel (a)) or PUMA (panel (b)). See text and data appendix for details. *** $= p < 0.01$, ** $= p < 0.05$, * $= p < 0.10$.

Table 7: Minimum Wages and Health Inspection Violations

	(1)	(2)	(3)	(4)	(5)
Panel a: All health violations					
	Any	Number	Any severe	Number severe	Standardized score
log(MW)	-0.0004	-0.6149*	0.0711***	0.0911	-0.1164*
	(0.0097)	(0.3437)	(0.0246)	(0.0610)	(0.0651)
N	345102	345102	345102	345102	345102
DV mean	0.958	6.428	0.1664	0.3309	0.0328
Demographic controls	X	X	X	X	X
ϵ_{mw}	0.000	-0.096	0.427	0.275	
Panel b: Quality of care (QOC) violations					
	Any	Number	Any severe	Number severe	Standardized score
log(MW)	-0.0540**	-0.7408***	0.0336	0.0562	-0.0750
	(0.0243)	(0.1985)	(0.0222)	(0.0367)	(0.0535)
N	345102	345102	345102	345102	345102
DV mean	0.8677	3.5282	0.1360	0.1869	-0.0146
Demographic controls	X	X	X	X	X
ϵ_{mw}	-0.062	-0.210	0.247	0.301	

Notes: Table shows results from the state health inspection reports reported to CMS, covering years 1998-2017. Sample includes facilities in counties that straddle a minimum wage discontinuity. $log(MW)$ is defined as the natural log of the minimum wage faced by facility f at time t in 2017 dollars, adjusted for inflation using the CPI-U-RS. "Severe" violations are those presenting actual harm or immediate jeopardy to residents (CMS categories G-L). "Quality of care" violations follow the definition in Harrington et al. (2001) to include violations in the quality of care, assessment, nursing, dietary, physician, rehabilitative services, dental, and pharmacy regulation categories, see the data appendix for a complete list. "Standardized score" allocates violation points to each violation based on the CMS scoring criteria and normalizes the score distribution across facilities as in Kling et al. (2007) and Anderson (2008) (Centers for Medicare and Medicaid Services, 2011). All specifications include county-pair-time and facility fixed effects and controls for county employment rates and the elderly population share; and state EITC parameters, the share of the elderly population receiving Supplemental Security Income, and AFDC/TANF caseloads and benefit levels; and facility average resident age, market concentration, and the share of residents female, white, black, and covered by Medicaid. Robust standard errors clustered by county. All regressions weighted by facility size. "ϵ_{mw}" summarizes the elasticity of the outcome measure with respect to the minimum wage. See text and data appendix for details. *** $= p < 0.01$, ** $= p < 0.05$, * $= p < 0.10$.

Table 8: Minimum Wages and Patient Health

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	Pressure ulcers (share)		UTI (share)		Restraint (share)		Psychotropic (share)		Health index	
log(MW)	-0.0140***	-0.0139***	-0.0065	-0.0075	-0.0079	-0.0081*	0.0318	0.0347	-0.1976***	-0.2063***
	(0.0051)	(0.0050)	(0.0051)	(0.0050)	(0.0048)	(0.0048)	(0.0284)	(0.0283)	(0.0727)	(0.0717)
N	289855	289855	329915	329915	330077	330077	179169	179169	286092	286092
DV mean	0.083	0.083	0.073	0.073	0.025	0.025	0.190	0.190	-0.104	-0.104
Demographic controls		X		X		X		X		X
Δ # residents (1000s), 10% increase	-1.89	-1.87	-0.88	-1.01	-1.06	-1.09	4.29	4.68		
ϵ_{mw}	-0.1681	-0.1669	-0.0895	-0.1033	-0.3173	-0.3253	0.1674	0.1826		

Notes: Table shows patient outcomes results from long-term resident assessment reports reported by facilities to CMS, covering years 2005-2017. Sample includes facilities in counties that straddle a minimum wage discontinuity. $log(MW)$ is defined as the natural log of the minimum wage faced by facility f at time t in 2017 dollars, adjusted for inflation using the CPI-U-RS. All variables are winsorized at the 99th percentile to exclude extreme values. All specifications include county-pair-time and facility fixed effects and controls for county employment rates and the elderly population share; and state EITC parameters, the share of the elderly population receiving Supplemental Security Income, and AFDC/TANF caseloads and benefit levels. Even-numbered columns also include controls for average resident age, facility market concentration, and the share of residents female, white, black, and covered by Medicaid. Robust standard errors clustered by county. All regressions weighted by facility size. "ϵ_{mw}" summarizes the elasticity of the outcome measure with respect to the minimum wage. "Δ # residents (1000s), 10% increase" summarizes the estimated change in the number of residents for a 10 percent increase in the minimum wage. See text and data appendix for details. *** $= p < 0.01$, ** $= p < 0.05$, * $= p < 0.10$.

Table 9: Minimum Wages and Log Elderly Mortality Rates, by Place of Death

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
	All		Nursing homes		Non-nursing homes		Hospitals	
log(MW)	-0.0722**	-0.0509*	-0.333***	-0.311***	-0.0068	0.0145	0.0327	0.0574
	(0.0330)	(0.0289)	(0.118)	(0.114)	(0.0424)	(0.0397)	(0.0839)	(0.0824)
N	55306	55306	50680	50680	55258	55258	40038	40038
DV mean (level)	0.0516	0.0516	0.0158	0.0158	0.0365	0.0365	0.0228	0.0228
Δ # residents (1000s), 10% increase	n/a	n/a	-16.238	-15.165	n/a	n/a	n/a	n/a
County controls	X	X	X	X	X	X	X	X
Demographic controls		X		X		X		X

Notes: Table shows county-level age-adjusted log mortality rates covering years 1990-2013 for the population ages 65 and older by place of death from Vital Statistics. The age adjustment, defined in Equation 3, holds the age composition of the population fixed at its 2000 distribution; see Stevens et al. (2015) and the data appendix for technical details. Sample includes counties that straddle a minimum wage discontinuity. $log(MW)$ is defined as the natural log of the highest minimum wage in county c at time t in 2017 dollars, adjusted for inflation using the CPI-U-RS. All specifications include county-pair-year and county fixed effects and controls for county employment rates and the elderly population share; and state EITC parameters, the share of the elderly population receiving Supplemental Security Income, and AFDC/TANF caseloads and benefit levels. Demographic controls include CZ-level market concentration and county-average resident age, and the share of residents female, white, black, and covered by Medicaid. Robust standard errors clustered by county. All regressions weighted by county elderly population. "Δ # residents (1000s), 10% increase" summarizes the estimated change in the number of residents for a 10 percent increase in the minimum wage. See text and data appendix for details. *** $= p < 0.01$, ** $= p < 0.05$, * $= p < 0.10$.

Table 10: Minimum Wages, Payment Methods, and Care Needs

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
	Resident share			Average resident care needs		Log avg Medicare rate		Discharge	Hospital	Occupancy
	Medicaid	Other	Medicare	ADL index	Care index	1996-2010	2011-2017	rate	admit rate	rate
log(MW)	-0.0264**	0.0249**	0.0082	0.1811***	0.2138***	-0.0079	-0.0199	-0.0129	-0.0134**	0.0076
	(0.0129)	(0.0119)	(0.0060)	(0.0382)	(0.0335)	(0.0166)	(0.0154)	(0.0101)	(0.0053)	(0.0064)
N	729778	729623	729986	714858	722459	144915	96552	287251	328676	729510
DV mean	0.5927	0.2362	0.1517	0.0086	0.0033	333.8	458.0	0.6202	0.1785	0.8439
ϵ_{mw}	-0.0445	0.1054	0.0541					-0.0208	-0.0751	0.0090

Notes: Table the share of nursing home residents by payment source (columns (1) through (3)); average standardized care needs (columns (4) and (5)); and discharge, transfer, and occupancy rate (columns (8) through (10)) derived from resident assessment reports reported by facilities to CMS covering years 2000 through 2016, as well as the average reimbursement rate for among residents covered by Medicare based on RUG classification (columns (6) and (7)) from Medicare cost reports (HCRIS) reported to CMS, covering years 1996-2017. Sample includes facilities in counties that straddle a minimum wage discontinuity. $log(MW)$ is defined as the natural log of the minimum wage faced by facility f at time t in 2017 dollars, adjusted for inflation using the CPI-U-RS. All specifications include county-pair-year and facility fixed effects and controls for county employment rates and the elderly population share; and state EITC parameters, the share of the elderly population receiving Supplemental Security Income, and AFDC/TANF caseloads and benefit levels. Columns (6) and (7) additionally limit the sample to facilities with a reporting period that starts and ends after February of the ending year and includes controls the starting and ending months of the cost reporting period; the number of beds in the facility; the days in the reporting period; and whether a reporting period was less than 11 or more than 13 months. Robust standard errors clustered by county. All regressions weighted by facility size. "ϵ_{mw}" summarizes the elasticity of the outcome measure with respect to the minimum wage. See text and data appendix for details. *** $= p < 0.01$, ** $= p < 0.05$, * $= p < 0.10$.

Table 11: Minimum Wages and Patient Demographic Characteristics

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)
	Patient demographics						Patient care needs				
	Avg age	% female	% black	% white	% obese	% hosp admit	% hyper-tension	% help walking	% schiz-ophrenic	% incontinence (bowel)	% incontinence (bladder)
log(MW)	-0.247	-0.022***	-0.009	0.004	-0.010**	0.011*	-0.022***	-0.022**	0.016**	0.031***	-0.013**
	(0.185)	(0.004)	(0.007)	(0.006)	(0.004)	(0.006)	(0.008)	(0.011)	(0.007)	(0.759)	(0.550)
N	700443	687142	405164	680773	504728	696518	681590	364937	240810	685442	464768
DV mean	80.09	0.686	0.169	0.797	0.2457	0.8264	0.683	0.130	0.151	0.707	0.219
ϵ_mw	-0.003	-0.032	-0.052	0.005	-0.041	0.013	-0.032	-0.169	0.106	0.044	-0.059

Notes: Table shows patient characteristics derived from resident assessment reports reported by facilities to CMS, covering years 2000-2016, summarized in LTC Focus. Sample includes facilities in counties that straddle a minimum wage discontinuity. $log(MW)$ is defined as the natural log of the minimum wage faced by facility f at time t in 2017 dollars, adjusted for inflation using the CPI-U-RS. All specifications include county-pair-time and facility fixed effects and controls for county employment rates and the elderly population share; and state EITC parameters, the share of the elderly population receiving Supplemental Security Income, and AFDC/TANF caseloads and benefit levels. Robust standard errors clustered by county. All regressions weighted by facility size. "ϵ_{mw}" summarizes the elasticity of the outcome measure with respect to the minimum wage. See text and data appendix for details. *** $= p < 0.01$, ** $= p < 0.05$, * $= p < 0.10$.

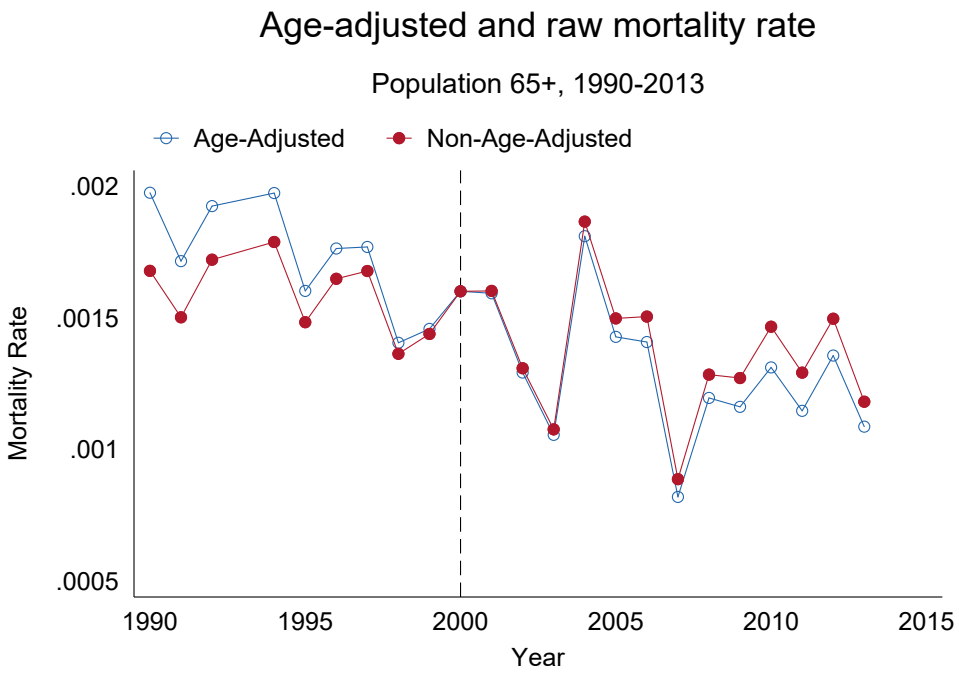
Table 12: Minimum Wages and Facility Revenue and Costs

	(1)	(2)	(3)	(4)	(5)
	Costs/ resident	Charge/ resident	Revenue/ resident	Net income	Avg Mcaid per diem (state)
log(MW)	0.0434*	0.0874	0.0687*	-1.4430	-0.0269
	(0.0244)	(0.1020)	(0.0352)	(1.1480)	(0.0853)
N	286988	279082	273940	287723	480
DV mean (level)	75108.4	16997.0	91717.2	1440.5	184.57
County controls	X	X	X	X	X
# days	X	X	X	X	
Log(beds)	X	X	X	X	
DV transformation	Log	Log	Log	IHS	Log

Notes: Table shows facility revenues and cost metrics from Medicare cost reports (HCRIS) reported to CMS, covering years 1996-2017 (columns (1-4)) and average state Medicaid reimursement rates from Brown School of Public Health (2019) (column 5). Sample in columns (1-4) includes facilities in counties that straddle a minimum wage discontinuity, with a reporting period that starts and ends in January or February of the ending year. $log(MW)$ is defined as the natural log of the minimum wage faced by facility f at time t in 2017 dollars, adjusted for inflation using the CPI-U-RS. All specifications include county-pair-year and facility fixed effects and controls for county employment rates and the elderly population share; state EITC parameters, the share of the elderly population receiving Supplemental Security Income, and AFDC/TANF caseloads and benefit levels; the starting and ending months of the cost reporting period; the number of beds in the facility; the days in the reporting period; and whether a reporting period was less than 11 or more than 13 months. Dependent variable is the log of the cost, charge, or revenues per resident (columns (1-3), respectively), or the inverse hyperbolic sine of net income (column (4)). Robust standard errors clustered by county. All regressions weighted by facility size. Column (5) estimates the two-way state and year fixed effect model in Equation 2 with division-by-year fixed effects and state linear trends at the state level (standard errors clustered by state). See text and data appendix for details. *** $= p < 0.01$, ** $= p < 0.05$, * $= p < 0.10$.

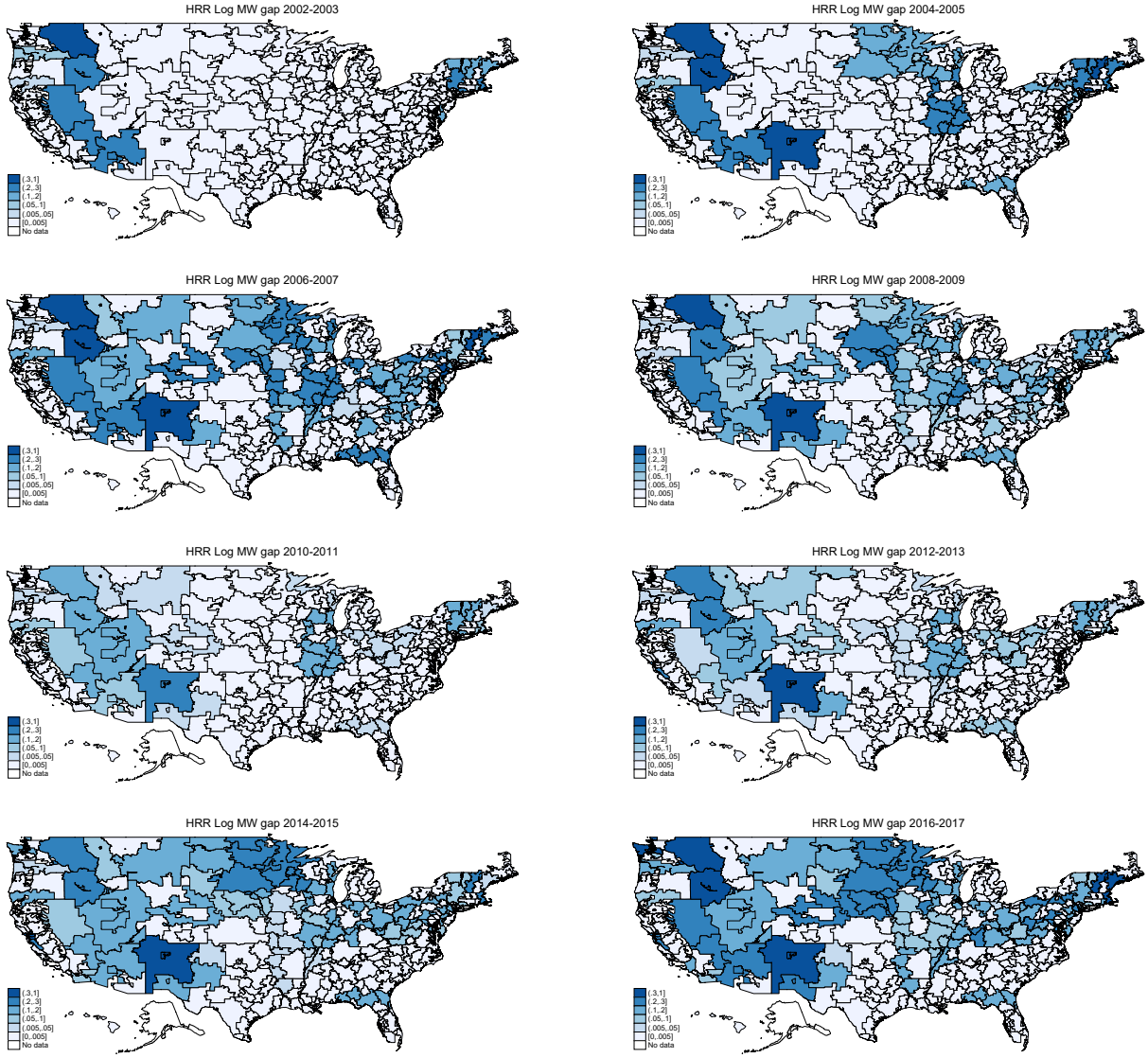
A Additional figures

Appendix Figure A1: Age Adjusted and Raw Mortality Rate



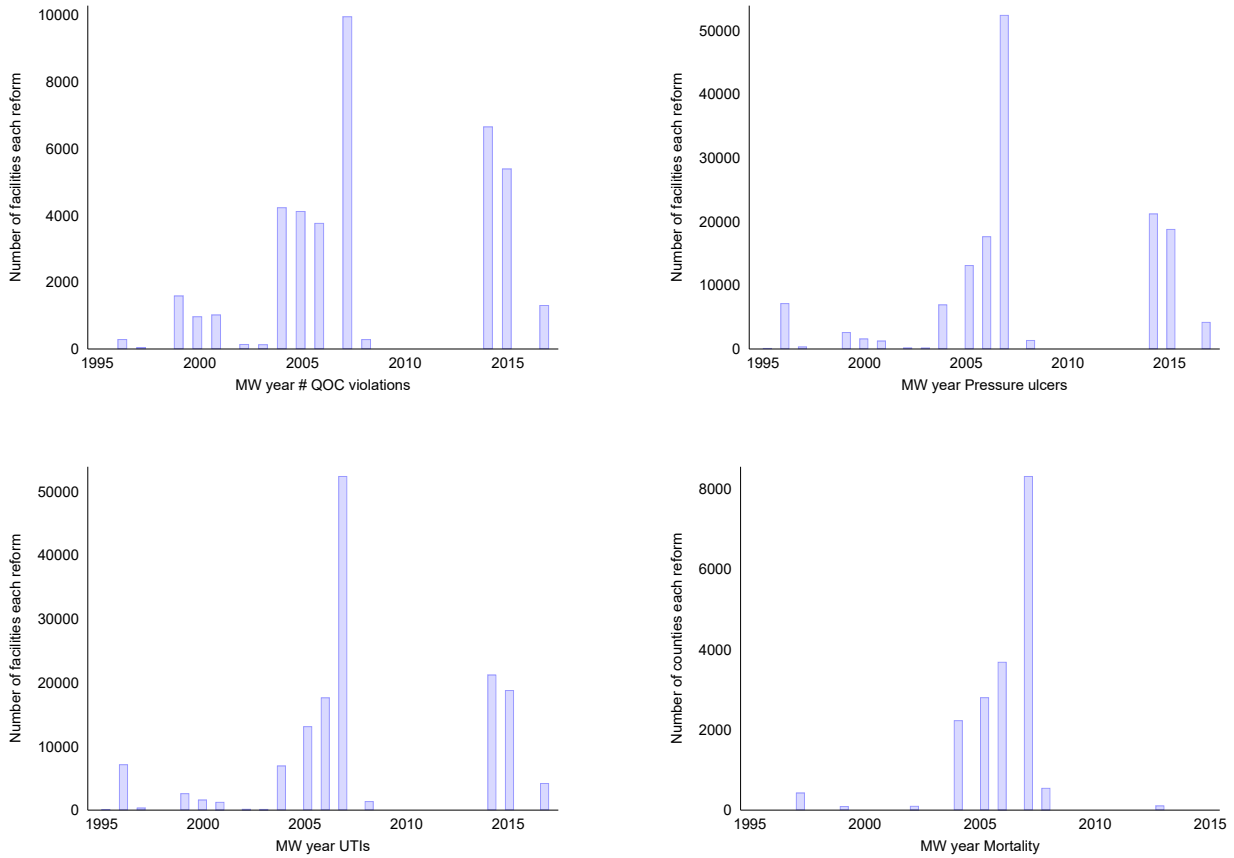
Notes: Figure shows the county-level age-adjusted (blue, open circle) and raw (red, closed circle) elderly mortality rate for 1990 through 2013. The age-adjusted series holds the age distribution of the elderly population fixed at year 2000 values. Age is topcoded at 85 years.

Appendix Figure A2: Hospital Referral Region Log Minimum Wage Differential, by Year



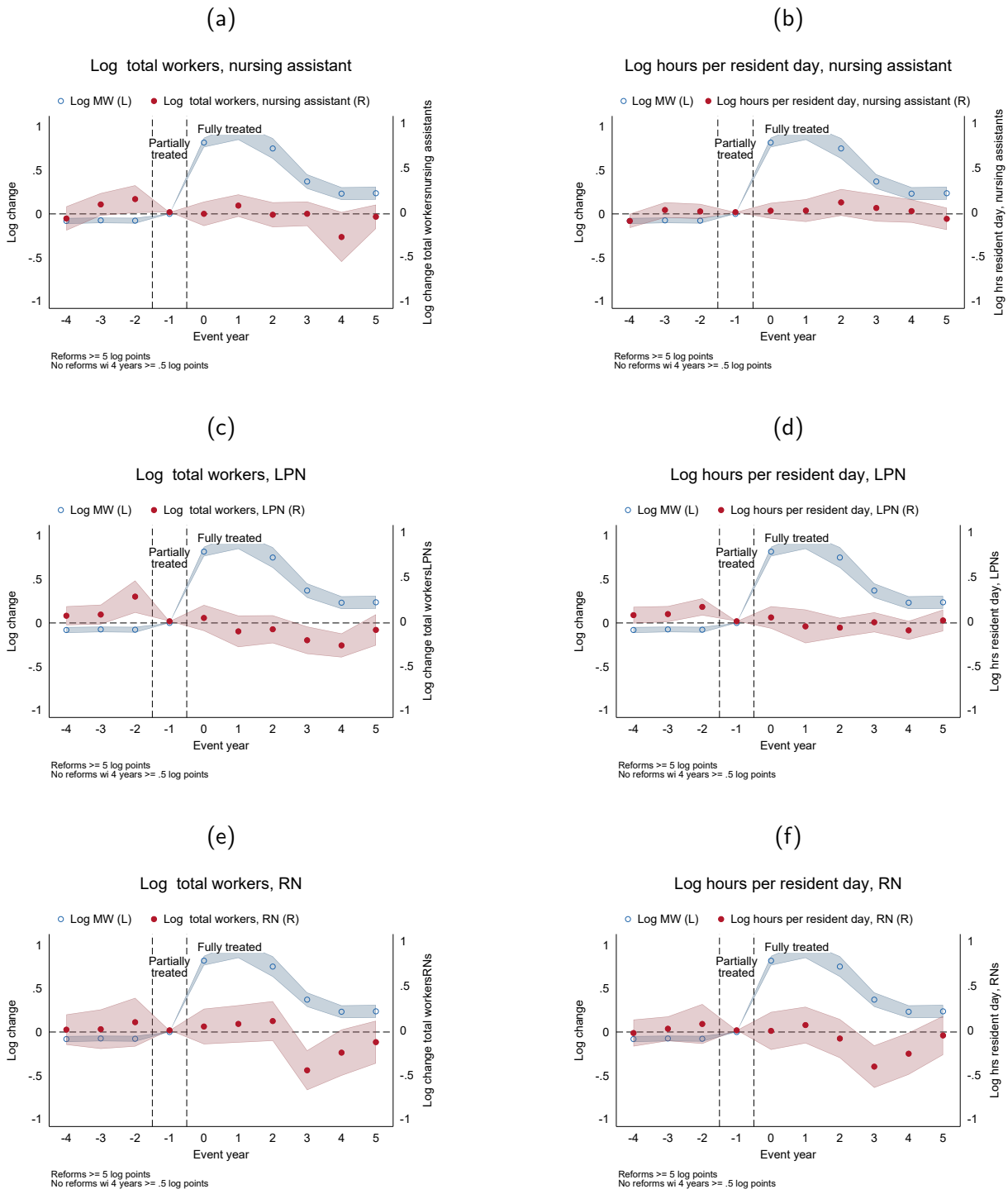
Notes: Figure shows the difference in (inflation-adjusted) log minimum wages between the jurisdiction with the highest statutory minimum and lowest statutory minimum within a Hospital Referral Region (HRR) for each two year period. See data appendix for details.

Appendix Figure A3: Reform Years: Event Study



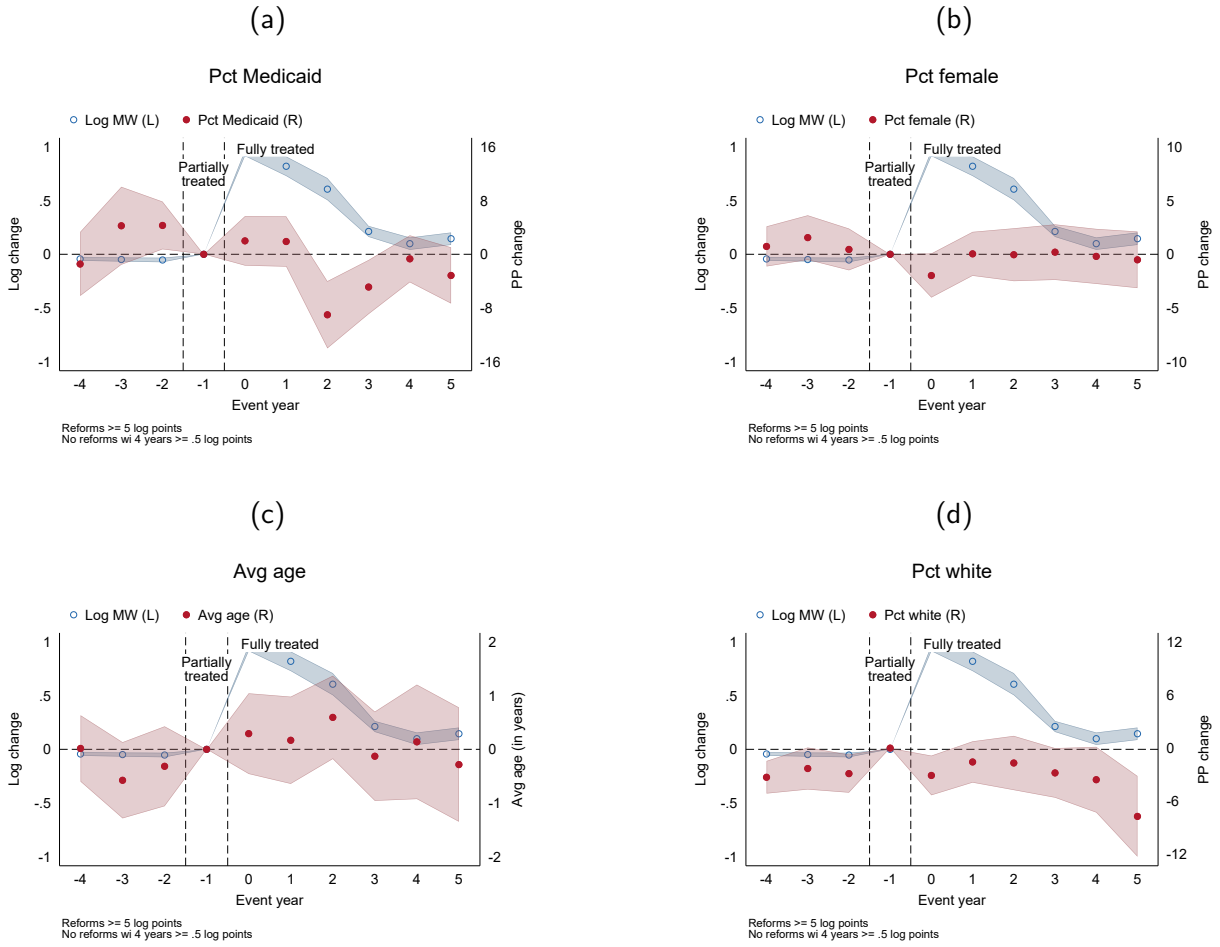
Notes: Figure shows the subsample of minimum wage reforms that are included in the event study analysis in Figure 4. This subsample of reforms only includes changes that altered the within-county-pair log gap by at least 5 log points and for which there were no changes greater than 0.5 log points in the preceeding six quarters (panels (a) through (c)) or four years (panel (d)). See text and data appendix for details.

Appendix Figure A4: Event Studies, NH Employment and Minimum Wages



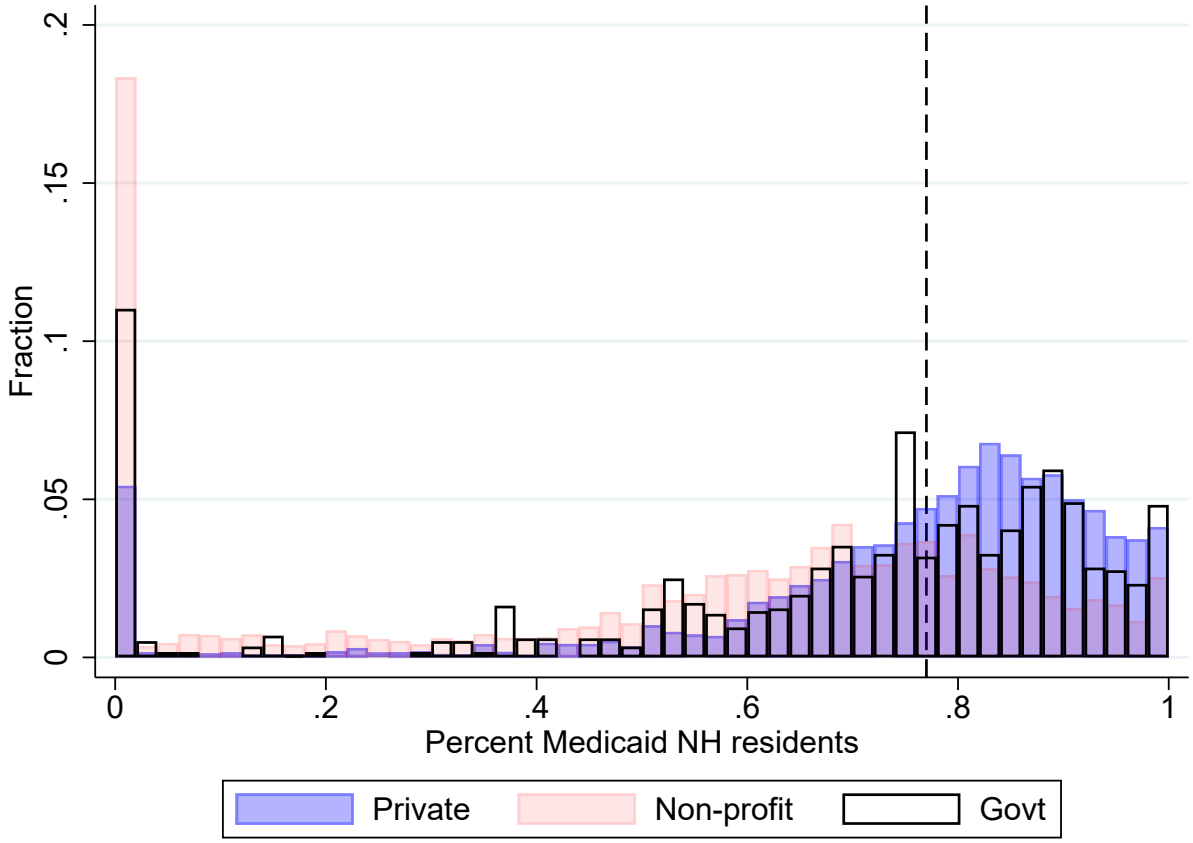
Notes: Figure shows event studies from Equation 4. Blue line indicates the change in the minimum wage; red line shows the change in employment for nursing assistants (top), LPNs (middle), and RNs (bottom) by FTE workers (left panel) or hours per pair wage gap by at least 5 log points and for which there were no changes greater than 0.5 log points in the preceeding four years, covering 1992-2017 (left panel) and 2000-2016 (right panel). Log hours per resident day is staffing hours for each occupation divided by the number of patients times 24. Log number total employees is the (natural log) of full-time equivalent workers for each occupation. All specifications include controls for county employment rates and the elderly population share; state EITC parameters, the share of the elderly population receiving SSI, and AFDC/TANF caseloads and benefit levels; and facility, county-pair-year, and reform year fixed effects. Shaded areas indicate 95 percent confidence intervals with robust standard errors clustered at the county level. See text and data appendix for details.

Appendix Figure A5: Event Studies: Patient Characteristics and Minimum Wages



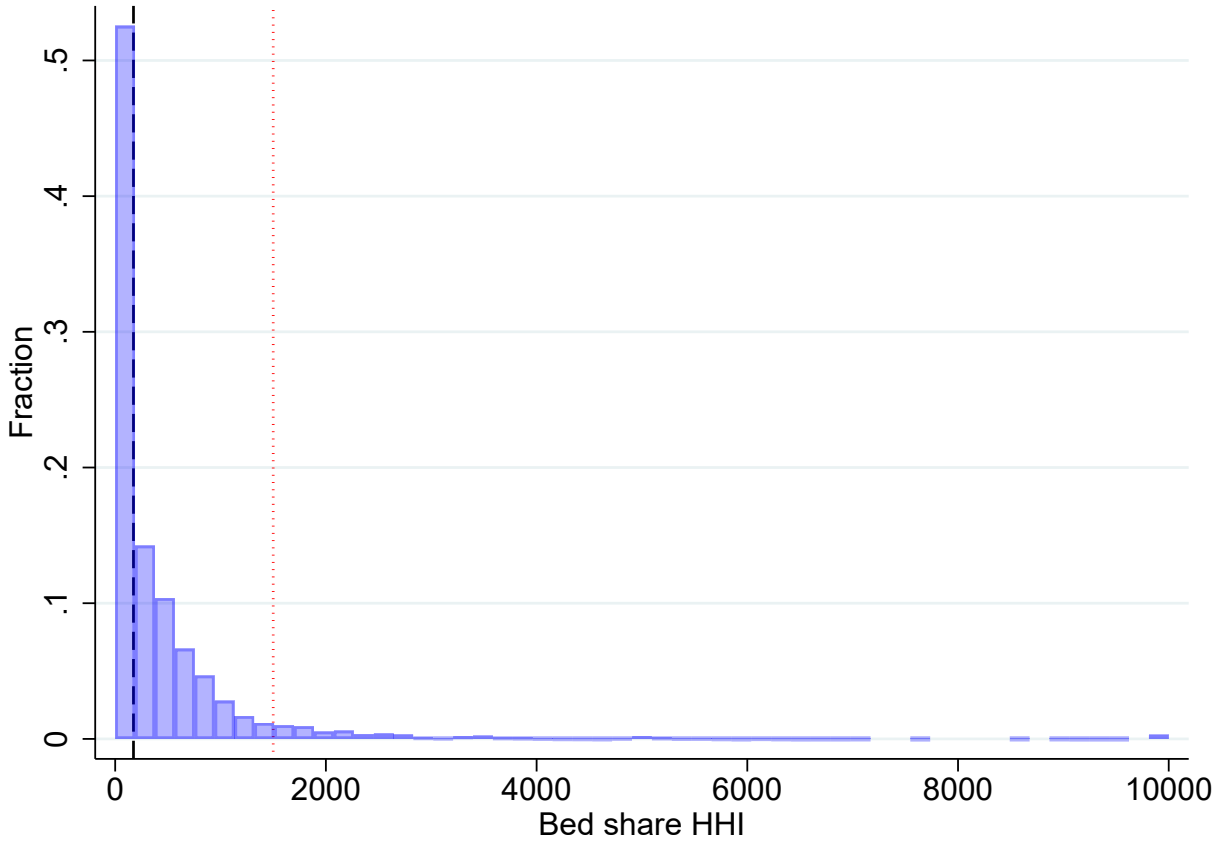
Notes: Figure shows event studies from Equation 4. Blue line indicates the change in the minimum wage; red line shows the change in patient characteristics based on annual patient assessment information from LTC Focus spanning 2000 through 2016. Sample is limited to reforms that changed the within-county-pair log gap by at least 5 log points and for which there were no changes greater than 0.5 log points in the preceeding four years. All specifications include controls for county employment rates and the elderly population share; state EITC parameters, the share of the elderly population receiving Supplemental Security Income, and AFDC/TANF caseloads and benefit levels; and facility, county-pair-year and reform year fixed effects. Shaded areas indicate 95 percent confidence intervals with robust standard errors clustered at the county level. See text and data appendix for details.

Appendix Figure A6: Share of Residents Covered by Medicaid, by Ownership



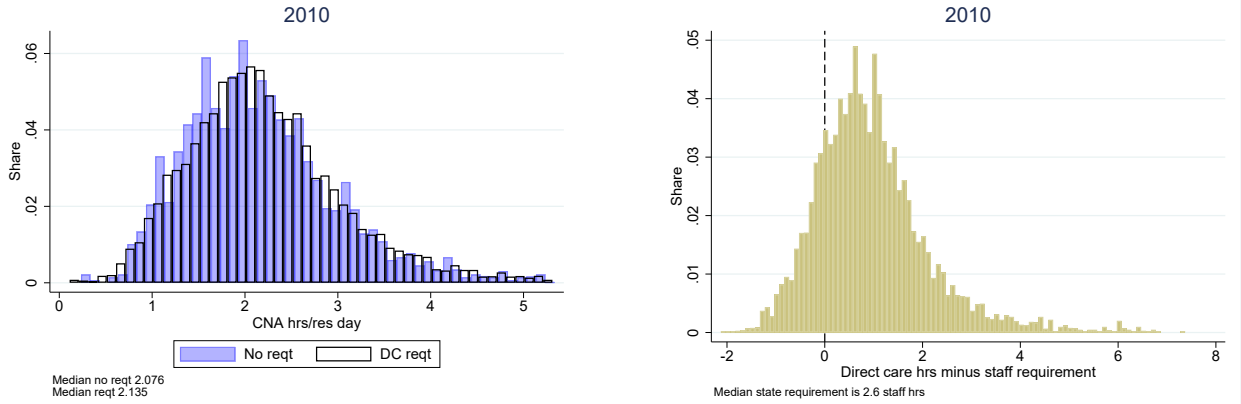
Notes:This figure plots the distribution of maximum Medicaid share for the 2000-2016 period among facilities that straddle a minimum wage discontinuity. The vertical dashed line is the sample median (77 percent).

Appendix Figure A7: Nursing Home Market Concentration



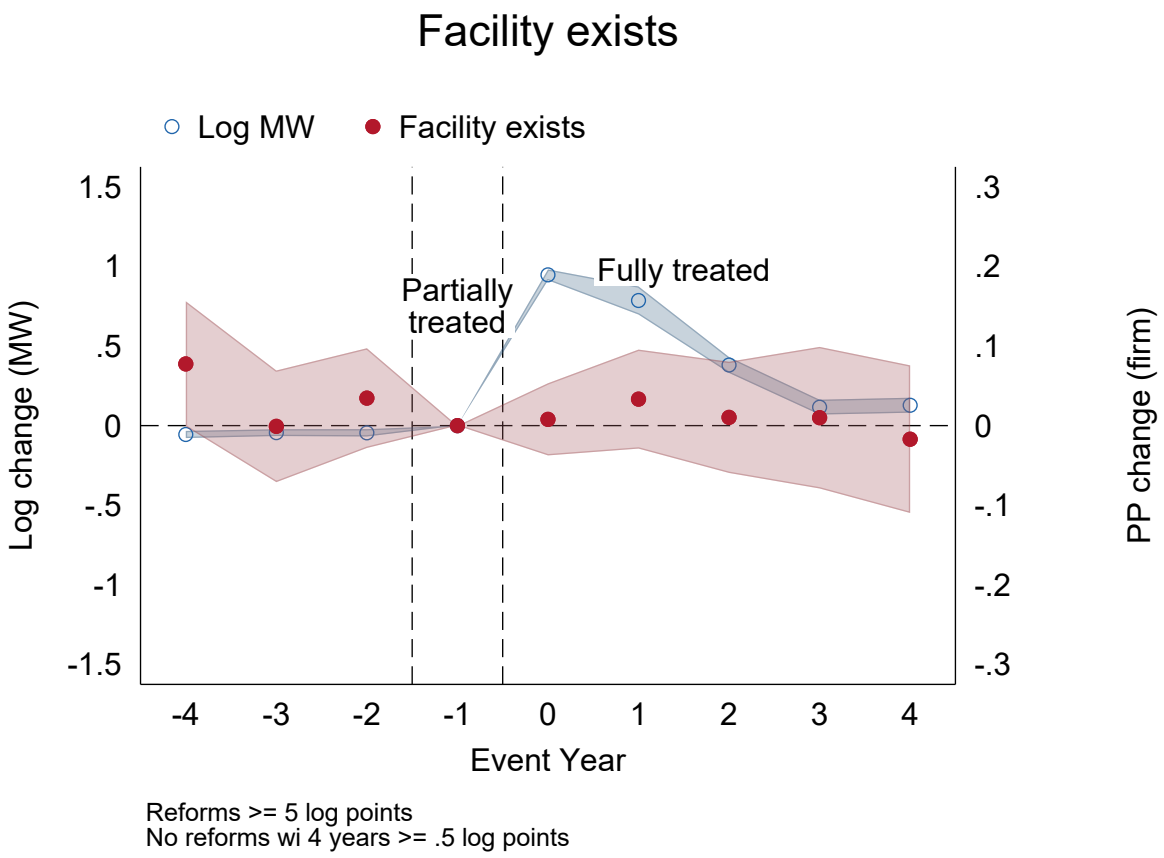
Notes: This figure plots the bed share HHI distribution for the 2000-2016 period among facilities that straddle a minimum wage discontinuity. The HHI ranges from 0 (perfect competition) to 10,000 (monopoly). The black vertical dashed line is the median over this period (278); the red dotted line denotes the threshold for a "highly competitive" market (1,500).

Appendix Figure A8: Nursing Assistant Hours Per Resident Day, by Direct Care Staffing Requirement



Notes: Figure on left plots the distribution of nursing assistant hours per resident per day by whether a facility is located in a state requiring a minimum number of NA hours or employees. Right figure shows the difference in reported direct care hours and the state's minimum requirement for states with a staffing floor defined in staff hours per resident day as of 2010 (25). All calculations based on 2010 staffing requirements summarized in (Harrington, 2010).

Appendix Figure A9: Firm Churn: Entry and Exits



Notes: Figure shows event studies from Equation 4 on a balanced panel of facilities where the dependent variable equals one if the facility operated in year y. Blue line indicates the change in the minimum wage; red line shows the change in the likelihood (percentage points) a firm operates in a given year. Sample is limited to reforms that changed the within-county-pair log gap by at least 5 log points and for which there were no changes greater than 0.5 log points in the preceeding four years. Specifications includes county-pair-year, county, and reform year fixed effects, as well as controls for county employment rates and the elderly population share; and state EITC parameters, the share of the elderly population receiving Supplemental Security Income, and AFDC/TANF caseloads and benefit levels. Shaded areas indicate 95 percent confidence intervals with robust standard errors clustered at the county level. P-value of the joint hypothesis that all pre-reform coefficients equal zero is 0.225.

B Appendix: Additional Results

Appendix Table B1: Average Nursing Home Prices, by Payment Source (2016)

	Private payor	Medicare	Medicaid
Alabama	200	343	196
Alaska	800	427	148
Arizona	210	457	66
Arkansas	170	348	236
California	267	565	115
Colorado	252	438	134
Connecticut	412	506	338
Delaware	350	433	275
DC	325	428	369
Florida	260	407	175
Georgia	205	368	129
Hawaii	376	504	207
Idaho	243	377	132
Illinois	187	430	99
Indiana	220	390	349
Iowa	189	360	217
Kansas	183	360	146
Kentucky	221	359	217
Louisiana	170	321	213
Maine	301	401	231
Maryland	300	426	199
Massachusetts	385	493	253
Michigan	262	404	176
Minnesota	269	427	165
Mississippi	214	333	254
Missouri	162	358	184
Montana	237	365	160
Nebraska	208	368	180
Nevada	240	484	79
New Hampshire	318	421	258
New Jersey	330	516	188
New Mexico	209	398	131
New York	364	509	409
North Carolina	225	379	138
North Dakota	350	278	318
Ohio	224	396	244
Oklahoma	147	344	142
Oregon	289	495	101
Pennsylvania	305	406	318
Rhode Island	279	440	345
South Carolina	211	365	122
South Dakota	207	325	166
Tennessee	201	355	138
Texas	150	394	109
Utah	185	439	64
Vermont	288	411	197
Virginia	235	392	115
Washington	282	488	87
West Virginia	319	337	348
Wisconsin	260	406	167
Wyoming	233	374	194
US average (unweighted)	263	407	195

Notes: Table shows average per-day cost of nursing home care, by payment source. Private and Medicaid rates from AARP (2018); Medicare rates author's calculations from Centers for Medicare and Medicaid Services (2018).

Appendix Table B2: Descriptive Statistics, All Facilities and County Pair Sample

	(1)	(2)
	All counties	County pair
Panel a: County staffing		
Min wage (2017$)	7.532	7.600
	(0.789)	(0.856)
$\leq$ HS female employment	385.7	519.3
	(675.7)	(1064.1)
$\leq$ HS female earnings	1861.5	1946.3
	(345.2)	(372.8)
$\leq$ HS female turnover	0.236	0.224
	(0.173)	(0.254)
Observations	205735	170578
Panel b: Facility staffing		
Min wage (2017$)	7.948	8.280
	(0.875)	(1.087)
NA hrs per resident day	2.268	2.308
	(0.671)	(0.670)
LPN hrs per resident day	0.810	0.799
	(0.351)	(0.379)
RN hrs per resident day	0.449	0.504
	(0.419)	(0.446)
FTE aides	36.74	37.88
	(24.11)	(25.75)
FTE LPNs	12.90	12.92
	(8.993)	(9.799)
FTE RNs	6.420	7.454
	(5.679)	(6.779)
Observations	907550	991486
Panel c: Inspection violations		
Min wage (2017$)	7.818	8.190
	(0.925)	(1.124)
Any violation	0.931	0.933
	(0.254)	(0.250)
# violations	5.795	6.254
	(4.895)	(5.282)
Any severe violation	0.175	0.167
	(0.380)	(0.373)
# severe violations	0.298	0.282
	(0.859)	(0.836)
Standardized score	0.000	0.000
	(1.000)	(1.000)
Any care violation	0.841	0.846
	(0.366)	(0.361)
# care violations	3.284	3.430
	(3.075)	(3.046)
Any severe care violation	0.143	0.138
	(0.350)	(0.345)
# severe care violations	0.183	0.176
	(0.501)	(0.497)
Standardized care score	0.000	0.005
	(1.000)	(0.992)
Observations	316244	360591

Appendix Table B2: (continued)

Panel d: Patient health		
Min wage (2017$)	7.940	8.283
	(0.899)	(1.118)
% pressure ulcers	0.089	0.095
	(0.059)	(0.061)
% UTI	0.076	0.076
	(0.050)	(0.050)
% restraints	0.030	0.033
	(0.045)	(0.049)
% psychotropic medication	0.195	0.191
	(0.097)	(0.096)
Observations	997909	1092186
Panel e: Mortality		
Age-adjusted mortality (all)	0.052	0.052
	(0.020)	(0.018)
Age-adjusted mortality (nursing home)	0.037	0.037
	(0.019)	(0.017)
Age-adjusted mortality (non-nursing home)	0.016	0.015
	(0.009)	(0.008)
Age-adjusted mortality (hospital)	0.019	0.020
	(0.018)	(0.016)
Observations	71319	58182

Appendix Table B2: (continued)

	(1)	(2)
	All counties	County pair
Panel f: Controls (patient health sample)		
County unemployment (x100)	6.284	6.490
	(2.651)	(2.618)
% population $>$ 65	15.000	14.200
	(3.990)	(3.340)
State EITC rate (x100)	0.072	0.087
	(0.133)	(0.168)
Any state EITC	0.435	0.437
	(0.496)	(0.496)
TANF/AFDC maximum	486.0	552.9
	(196.9)	(210.3)
Avg facility size	106.2	107.0
	(62.89)	(65.59)
CZ HHI	588.9	460.0
	(990.2)	(871.4)
% NH residents female	69.49	68.72
	(11.59)	(12.08)
% NH residents black	15.00	17.40
	(22.09)	(23.71)
% NH residents Medicaid	59.68	59.25
	(23.44)	(24.64)
Avg NH resident age	80.57	80.27
	(5.892)	(6.298)
Observations	997909	1092186

Notes: Table shows average characteristics (standard deviations in parentheses) for all facilities (column (1)) and facilities in the county-pairs sample (column (2)) for QWI county-level employment (a), OSCAR/CASPER facility-level staffing measures (b), inspection violations (c), patient health outcomes (d), mortality (e), and area economic and policy, as well as facility demographic controls (f). "County" pairs sample consists of facilities located in a county that border another county with a different minimum wage at any point over the 1991 through 2017 period. See text and data appendix for details.

Appendix Table B3: Minimum Wages and Higher-skilled Employee Earnings

	(1)	(2)	(3)	(4)	(5)
	QWI	OSHPD	Current Population Survey		American Community Survey
	Log(quarterly earnings)	Log(annual earnings)	Log(hourly earnings)	Log(wkly earnings)	Log(annual earnings)
			Panel b: LPN/LVNs		
log(MW)	0.040	-0.061	-0.151*	-0.319**	0.270
	(0.032	0.078)	(0.086)	(0.139)	(0.193)
N	23214	45303	4969	4969	17675
DV mean	2838.0	59356.87	19.74	747.90	35244.80
			Panel b: RNs		
log(MW)	0.052	0.082	-0.146	-0.130	-0.270
	(0.037)	(0.123)	(0.142)	(0.137)	(0.201)
N	23214	44782	6122	6122	15712
DV mean	3422.7	78147.42	25.43	962.00	48211.40
Geo FE	County	Facility	State	State	PUMA
Geo X year FE	Cty pair	Cty pair	Division	Division	Division
Area business cycle controls	X	X	X	X	X
Demographic controls	X	X	X		X
State linear trends			X	X	X

Notes: Table shows earnings elasticity with respect to the minimum wages for higher-skilled nursing home workers. Column (1) reports results for female employees with some college (panel (a)) or a four-year degree (panel (b)) employed in NAICS sector 6231 at the end of the quarter from the QWI (2000-2017). Columns (2)-(5) report earnings for LPNs (panel (a)) or RNs (panel (b)) working in nursing homes from the CA OSHPD (column (2), 2003-2017), the CPS-ORG (columns (3-4), 1991-2017), and decennial Census and ACS (column (5), 2000-2017). $log(MW)$ is the natural log of the highest minimum wage in county c (column (1)), the local or state minimum wage (column (2)), county (those living in identifiable urban areas) or state minimum (columns (3-4)) or maximum minimum wage in a PUMA (column (5)) at time t, adjusted for inflation using the CPI-U-RS. All specifications controls for county employment rates and the elderly population share; and state EITC parameters, the share of the elderly population receiving SSI, and AFDC/TANF caseloads and benefit levels. Column (1) includes county fixed effects; column (2) includes facility fixed effects; columns (3-4) include state fixed effects; column (5) includes PUMA fixed effects. Column (1) is weighted by county population, column (2) by the number of beds in a facility, and columns (3-5) use person weights for the respective survey. Robust standard errors clustered by county (columns (1-2), state (columns (3-4)) or PUMA (column (5)). See text and data appendix for details. *** $= p < 0.01$, ** $= p < 0.05$, * $= p < 0.10$.

Appendix Table B4: Minimum Wages and Higher-skilled Employment

	(1)	(2)	(3)	(4)	(5)	(6)	(7)
	Log (employment)	Log(hrs per resident day)		Log(FTE)		Log(FT)	Log(PT)
Panel a: Vocational nurse (LPN/LPV)							
log(MW)	-0.091	0.0292	0.024	0.026	0.025	0.009	0.009
	(0.110)	(0.024)	(0.024)	(0.027)	(0.028)	(0.032)	(0.065)
N	25594	266653	266653	403367	403367	395721	295538
DV mean (level)	758.6	0.786	0.786	12.815	12.815	10.830	2.785
Panel b: Registered nurse (RN)							
log(MW)	-0.018	0.005	0.026	-0.029	-0.039	-0.0719*	0.1842***
	(0.117)	(0.019)	(0.027)	(0.034)	(0.035)	(0.040)	(0.053)
N	25594	269059	403367	408058	408058	383506	290793
DV mean (level)	586.5	2.271	12.815	7.458	7.458	6.212	2.105
Geo FE	County	Facility	Facility	Facility	Facility	Facility	Facility
Geo X year FE	Cty pair	Cty pair	Cty pair	Cty pair	Cty pair	Cty pair	Cty pair
Area business cycle controls	X	X	X	X	X	X	X
Demographic controls	X		X		X	X	X
Data	QWI	OSCAR/CASPER		OSCAR/CASPER		OSCAR/CASPER	OSCAR/CASPER

Notes: Table shows employment elasticity with respect to the minimum wages for higher-skilled nursing home workers. Column (1) reports results for female employees with some college (panel (a)) or a four-year degree (panel (b)) employed in NAICS sector 6231 at the end of the quarter from the QWI, covering years 2000-2017. Columns (2-7) report results from OSCAR/CASPER staffing reports, covering 2000-2016 (columns (2-3)) and 1992-2017 (columns (4-7)) for LPNs (panel (a)) and RNs (panel (b)). Sample includes facilities in counties that straddle a minimum wage discontinuity. $log(MW)$ is defined as the natural log of the county minimum wage in year-quarter t, adjusted for inflation using the CPI-U-RS. Log hours per resident day (columns (2-3)) is defined as the number of nursing assistant staffing hours, divided by the number of patients times 24 (including direct care and administrative time). FTE employees (columns (3-4)) is the sum of FT and PT nursing assistants, in full-time equivalent units. FT employees defined as the number of nursing assistants typically working at least 35 hours a week; PT employees defined as those typically working fewer than 35 hours. All specifications include county-pair-time and controls for county employment rates and the elderly population share; and state EITC parameters, the share of the elderly population receiving SSI, and AFDC/TANF caseloads and benefit levels. Column (1) additionally includes county fixed effects; columns (2-7) include facility fixed effects. "Demographic controls" include average resident age, and the share of residents female, white, black, and covered by Medicaid. Robust standard errors clustered by county. Column (1) is weighted by county population, columns (2-7) by the number of beds in a facility. See text and data appendix for details. *** $= p < 0.01$, ** $= p < 0.05$, * $= p < 0.10$.

Appendix Table B5: Minimum Wages and High-Skilled Worker Flows: Quarterly Workforce Indicators

	(1)	(2)	(3)
	Log (turnover)	Log(hires, employed 1+ qtr)	Log (separations)
Panel a: Some college			
log(MW)	-0.044	-0.304**	-0.044
	(0.108)	(0.130)	(0.108)
N	10164	14380	10164
DV mean (rate)	0.150	0.153	0.150
Panel b: College degree			
	Log (turnover)	Log(hires, employed 1\+ qtr)	Log (separations
log(MW)	-0.096	0.193	-0.096
	(0.116)	(0.203)	(0.116)
N	10164	9208	10164
DV mean (rate)	0.145	0.0841	0.145

Notes: Table shows results from the Quarterly Workforce Indicators data, covering years 2000-2017. Nursing staff in nursing homes are identified by women employed in NAICS sector 6231 working in counties that straddle a minimum wage discontinuity. Panel (a) includes workers with some college education (education category 3); Panel (b) includes those with at least a four-year degree (education category 4). $log(MW)$ is defined as the natural log of the highest minimum wage in county c at time t in 2017 dollars, adjusted for inflation using the CPI-U-RS. $log(turnover)$ is the log sum of all hires and all separations, divided by two; $log(hires, employed1 + qtr)$ is the natural log of the hires who remained employed for at least three months; and $log(separations)$ is the natural log of the the number of workers who separated from their employer in a county-quarter-education cell. All specifications include county-pair-quarter and county fixed effects and controls for county employment rates and the elderly population share; and state EITC parameters, the share of the elderly population receiving Supplemental Security Income, and AFDC/TANF caseloads and benefit levels. All cells are weighted by county population. Robust standard errors clustered by county. See text and data appendix for details. *** $= p < 0.01$, ** $= p < 0.05$, * $= p < 0.10$.

Appendix Table B6: Worker Illness and Injury

	(1)	(2)	(3)
	TCR	DART	DAFWII
log(MW)	-2.747***	-0.802	-0.089
	(0.916)	(0.584)	(0.376)
Observations	76218	76218	76218
DV mean	10.959	7.041	3.555
ϵ_{mw}	-0.251	-0.114	-0.025
Cty controls	X	X	X
Division X time FE	X	X	X
State linear trends	X	X	X

Notes: Table shows staffing results from estimating Equation 2 on establishment specific injury and illness data from the Department of Labor's Occupational Safety and Health Administration (OSHA) for years 2002 through 2011. Sample includes all surveyed nursing home facilities, identified as those with NAICS code 6231 or SIC codes 8052, 8059, 8062, 8082, or 8361 in order to maximize comparability across years. $log(MW)$ is defined as the natural log of the minimum wage faced by facility f at time t in 2017 dollars, adjusted for inflation using the CPI-U-RS. Column (1) shows the Total Case Rate (TCR), defined as (Number of OSHA Recordable injuries and illnesses X 200,000) / Employee total hours worked. Column (2) show the Days Away Restricted Transfer (DART) rate, defined as Days away, restricted, transferred*200,000)/employee hours worked. Column (3) shows the Days Away With Illness or Injury (DAFWII) rate, defined as (Days away with illness or injury*200,000)/employee hours worked. All specifications include Census Division-time and county fixed effects, state linear trends, and controls for county employment rates and the elderly population share; state EITC parameters, the share of the elderly population receiving Supplemental Security Income, and AFDC/TANF caseloads and benefit levels. Robust standard errors clustered by county. See text and data appendix for details. *** $= p < 0.01$, ** $= p < 0.05$, * $= p < 0.10$.

Appendix Table B7: Predicted Changes in Patient Safety and Health

	(1)	(2)	(3)	(4)	(5)	(6)
	$\widehat{QOCviolations}$		$\widehat{Pressureulcers}$		$\widehat{NHMortality}$	
log(MW)	-0.097	-0.100	0.000	-0.006*	0.015	-0.067
	(0.086)	(0.090)	(0.001)	(0.003)	(0.039)	(0.064)
N	348755	348755	666604	666604	30676	30676
Patient demographics, bivariate interactions	X	X	X	X	X	X
Care needs, bivariate interactions		X		X		X
County controls	X	X	X	X	X	X
% main effect from	0.131	0.135	0.027	0.420	-0.048	0.215

Notes: Table shows the expected number of quality of care violations (columns (1-2)), fraction of residents with pressure ulcers (columns (3-4)), and log nursing home mortality rate (columns (5-6)) based on changes in resident characteristics. The dependent variable $\widehat{y_{c(f)t}}$ in odd-numbered columns is estimated from a regression with twoway interactions for the share of female, black, white, and Medicaid recipients, as well as the fraction of admissions from the hospital and an indicator whether each of these variables is missing. The even-numbered columns follow the same approach, but add the share of residents with hypertension, schizophrenia, incontinence (bowel and bladder), the fraction of residents who need help walking, and the overall ADL index. Sample includes facilities in counties that straddle a minimum wage discontinuity. $log(MW)$ is defined as the natural log of the minimum wage faced by facility f at time t in 2017 dollars, adjusted for inflation using the CPI-U-RS. All specifications include county-pair-time and facility fixed effects and controls for county employment rates and the elderly population share; and state EITC parameters, the share of the elderly population receiving Supplemental Security Income, and AFDC/TANF caseloads and benefit levels. Robust standard errors clustered by county. All regressions weighted by facility size. See text and data appendix for details. *** $= p < 0.01$, ** $= p < 0.05$, * $= p < 0.10$.

Appendix Table B8: Patient Safety and Health by Provider Characteristics

	(1)	(2)	(3)	(4)	(5)
	High Medicaid share	Private ownership	Multi-establishment chain	Competitive industry	Direct care staff req't
	Panel a: Number of QOC violations				
log(MW)	-0.751**	-0.834**	-0.776**	-0.904**	-0.751**
	(0.341)	(0.341)	(0.343)	(0.362)	(0.344)
log(MW) X char	-0.009	0.094**	0.019	0.160	-0.004
	(0.029)	(0.038)	(0.027)	(0.107)	(0.045)
N	114722	114722	114030	114722	114722
DV mean | char = 0	3.535	3.211	3.517	3.718	3.452
DV mean | char = 1	3.719	3.796	3.748	3.628	3.710
E(char) = 1	0.535	0.723	0.539	0.941	0.704
	Panel b: Share with pressure ulcers				
log(MW)	-0.018**	-0.018***	-0.018***	-0.022***	-0.016***
	(0.0080)	(0.006)	(0.006)	(0.006)	(0.006)
log(MW) X char	0.001	0.000	-0.001	0.004**	-0.004**
	(0.011)	(0.001)	(0.001)	(0.002)	(0.002)
N	262024	262024	261277	262024	262024
DV mean | char = 0	0.085	0.081	0.092	0.076	0.090
DV mean | char = 1	0.095	0.094	0.089	0.091	0.091
E(char) = 1	0.565	0.713	0.511	0.953	0.760
	Panel c: Nursing home log mortality rate				
log(MW)	-0.157	-0.122	-0.099	-0.112	-0.103
	(0.111)	(0.108)	(0.107)	(0.109)	(0.110)
log(MW) X char	0.114	0.000	-0.027***	-0.011	-0.018
	(0.142)	(0.014)	(0.011)	(0.015)	(0.012)
N	31320	31328	31294	31328	31328
DV mean | char $<$ 0.5	0.013	0.014	0.012	0.013	0.015
DV mean | char $\geq$ 0.5	0.012	0.013	0.014	0.013	0.012
E(char) = 1	0.172	0.736	0.554	0.969	0.688

Notes: Table shows patient outcomes results disaggregated by provider characteristics from OSCAR/CASPER health inspections (1998-2017, panel (a)), patient assessment reports (2012-2017, panel (b)), and Vital Statistics mortality files (1990-2013, panel (c)). Sample includes facilities in counties (panels (a) and (b)) and counties (panel (c)) that straddle a minimum wage discontinuity. $log(MW)$ is defined as the natural log of the minimum wage faced at time t in 2017 dollars, adjusted for inflation using the CPI-U-RS. *char* is an indicator equal to one for facilities satisfying each characteristic in the column header (high Medicaid share, private ownership, chain, located in a competitive industry, or in a state with a minimum staffing requirement for direct care staff) in panels (a) and (b), and the share of nursing home beds satisfying each characteristic in panel (c). All specifications include county-pair-time fixed effects and controls for county employment rates and the elderly population share; state EITC parameters, the share of the elderly population receiving Supplemental Security Income, and AFDC/TANF caseloads and benefit levels; and facility average resident age, facility market concentration, and the share of residents female, white, black, and covered by Medicaid. Panels (a) and (b) additionally include facility fixed effects; panel (c) includes county fixed effects. Robust standard errors clustered by county. Regressions weighted by facility size (panels (a) and (b)) or size of the elderly population (panel (c)). See text and data appendix for details. *** $= p < 0.01$, ** $= p < 0.05$, * $= p < 0.10$.

Appendix Table B9: Staffing Changes by County Characteristics

	(1)	(2)	(3)	(4)	(5)
	High Medicaid	Private	Chain	Competitive	Direct care staff reqt
Panel a: Log (employment)					
log(MW)	-0.080	-0.114	-0.097	-0.123	-0.075
	(0.109)	(0.105)	(0.106)	(0.111)	(0.106)
log(MW) X char	-0.027*	0.027	0.010	0.025	-0.023
	(0.015)	(0.022)	(0.013)	(0.023)	(0.018)
N	25974	25974	25966	25974	25974
DV mean (level) | char $< p_{50}$	99.39	107.2	165.6	21.59	132.4
DV mean (level) | char $\geq p_{50}$	174.2	167.9	101.3	137.4	135.7
$\overline{char}$	0.469	0.712	0.560	0.977	0.720
Panel b: Log (earnings)					
log(MW)	0.114***	0.121***	0.118***	0.111***	0.122***
	(0.031)	(0.032)	(0.031)	(0.033)	(0.033)
log(MW) X char	0.004	-0.008	-0.009**	0.005	-0.007
	(0.004)	(0.007)	(0.004)	(0.007)	(0.007)
N	23044	23044	23036	23044	23044
DV mean (level) | char $< p_{50}$	2063.4	2129.6	2113.9	1802.1	1961.5
DV mean (level) | char $\geq p_{50}$	2117.3	2042.4	2063.2	2096.0	2138.7
E(char) = 1	0.475	0.717	0.562	0.978	0.722

Notes: Table shows earnings and employment for workers with a high school education or less from the QWI. Sample includes counties that straddle a minimum wage discontinuity. $log(MW)$ is defined as the natural log of the minimum wage faced by facility f at time t in 2017 dollars, adjusted for inflation using the CPI-U-RS. *char* interacts the (bed-weighted) share of facilities in a county satisfying each characteristic in the column header (high Medicaid share, private ownership, chain, located in a competitive industry, or in a state with a direct staffing requirement). All specifications include county-pair-time and county fixed effects and controls for county employment rates and the elderly population share; and state EITC parameters, the share of the elderly population receiving Supplemental Security Income, and AFDC/TANF caseloads and benefit levels. All regressions weighted by county population. Robust standard errors clustered by county. See text and data appendix for details. *** $= p < 0.01$, ** $= p < 0.05$, * $= p < 0.10$.

C Appendix: Robustness Tables

Appendix Table C1: Alternative Samples: Nursing Home Employment

	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
	Nursing assistants			LPN/LVNs			RNs		
Panel a: Log hours per resident day									
log(MW)	-0.0167	0.0109	-0.0065	0.0218	0.0036	0.0002	-0.1169***	-0.0883**	-0.1205***
	(0.0193)	(0.0180)	(0.0187)	(0.0246)	(0.0223)	(0.0234)	(0.0412)	(0.0367)	(0.0420)
Observations	272691	269059	254694	270214	266653	253413	271357	267922	254291
DV mean (level)	2.3613	2.2705	2.2513	0.8489	0.7857	0.7695	0.5536	0.4842	0.4447
Panel b: Log number total employees									
log(MW)	0.0157	0.0045	0.0852***	-0.0248	-0.0259	0.0425	-0.0890**	-0.1113***	-0.0304
	(0.0320)	(0.0216)	(0.0240)	(0.0409)	(0.0244)	(0.0278)	(0.0441)	(0.0292)	(0.0356)
Observations	410344	412547	384252	409080	412700	383180	414051	417620	387011
DV mean (level)	38.5537	37.9312	38.7209	12.8065	12.7178	12.8955	7.4487	7.4252	7.3739
Outliers	X			X			X		
Hospitals	X	X		X	X		X	X	
Weight	# residents	Unweighted	# residents	# residents	Unweighted	# residents	# residents	Unweighted	# residents

Notes: Table shows staffing results from the OSCAR/CASPER staffing reports reported by facilities to CMS, covering years 2000-2016 (panel a) and 1992-2017 (panel b). Sample includes facilities in counties that straddle a minimum wage discontinuity. "Outlier" specifications (columns (1), (4), and (7)) include facilities with reported employment above the 99th percentile; columns (2), (5), and (8) replace resident weights with unweighted specifications; columns (3), (6), and (9) exclude facilities located in a hospital. $log(MW)$ is defined as the natural log of the county minimum wage at time t in 2017 dollars, adjusted for inflation using the CPI-U-RS. Log hours per resident day is defined as the number of staffing hours for each occupation divided by the number of residents. Log number total employees is defined as the (natural log) of full-time equivalent workers for each occupation group. All specifications include county-pair-time and facility fixed effects and controls for county employment rates and the elderly population share; state EITC parameters, the share of the elderly population receiving Supplemental Security Income, and AFDC/TANF caseloads and benefit levels; and facility market concentration, average resident age, and the share of residents female, white, black, and covered by Medicaid. Robust standard errors clustered by county. See text and data appendix for details. *** $= p < 0.01$, ** $= p < 0.05$, * $= p < 0.10$.

Appendix Table C2: Full County Sample: Nursing Assistant Employment

	(1)	(2)	(3)	(4)
	Nursing assistants			
Panel a: Log hours per resident day				
log(MW)	0.091***	0.082***	0.081***	0.081***
	(0.019)	(0.018)	(0.018)	(0.020)
Observations	256112	256112	256112	256112
DV mean (level)	2.130	2.130	2.130	2.130
Panel b: Log number total employees				
log(MW)	0.157***	0.036*	0.058**	0.064***
	(0.028)	(0.021)	(0.025)	(0.021)
Observations	362047	362047	362047	362047
DV mean (level)	28.905	28.905	28.905	28.905
Division X year FE		X		X
State trends			X	X

Notes: Table shows staffing results from estimating Equation 2 on the OSCAR/CASPER staffing reports reported by facilities to CMS, covering years 2000-2016 (panel a) and 1992-2017 (panel b). Sample includes all nursing home facilities. $log(MW)$ is defined as the natural log of the minimum wage faced by facility f at time t in 2017 dollars, adjusted for inflation using the CPI-U-RS. All specifications include facility fixed effects and controls for county employment rates and the elderly population share; state EITC parameters, the share of the elderly population receiving Supplemental Security Income, and AFDC/TANF caseloads and benefit levels; and facility average resident age, market concentration, and the share of residents female, white, black, and covered by Medicaid. Columns (2) through (4) also include division-by-year and/or state linear trends. Robust standard errors clustered by county. All regressions weighted by facility size. See text and data appendix for details. *** $= p < 0.01$, ** $= p < 0.05$, * $= p < 0.10$.

Appendix Table C3: Alternative Samples: Health Inspection Violations and Patient Safety

	(1)	(2)	(3)	(4)	(5)	(6)
	All violations			Quality of care violations		
	#	# severe	Std score	#	# severe	Std score
	Panel a: Including outliers					
log(MW)	-1.0015**	0.0602	-0.1896**	-0.7612***	0.0368	-0.0560
	(0.4590)	(0.0753)	(0.0869)	(0.2247)	(0.0465)	(0.0661)
N	348731	348731	348731	348731	348731	348731
DV mean	6.6877	0.3628	0.0820	3.6514	0.2027	0.0239
ϵ_{mw}	-0.1498	0.1659		-0.2085	0.1815	
	Panel b: Unweighted					
log(MW)	-0.4048	0.0907*	-0.0766	-0.6339***	0.0445	-0.0592
	(0.2944)	(0.0492)	(0.0557)	(0.1726)	(0.0279)	(0.0468)
N	354960	354960	354960	354960	354960	354960
DV mean	6.2587	0.3224	0.0008	3.4357	0.1820	-0.0330
ϵ_{mw}	-0.0647	0.2813		-0.1845	0.2445	
	Panel c: Excluding facilities in hospitals					
log(MW)	-0.4581	0.0882	-0.0867	-0.6945***	0.0685*	-0.0682
	(0.3389)	(0.0608)	(0.0642)	(0.1941)	(0.0360)	(0.0534)
N	328703	328703	328703	328703	328703	328703
DV mean	6.4589	0.3353	0.0387	3.5391	0.1895	-0.0112
ϵ_{mw}	-0.0709	0.2630		-0.1962	0.3615	
	Panel d: Hospital Referral Region					
log(MW)	-0.363	-0.0103	0.0823	-0.382*	-0.0001	0.0261
	(0.363)	(0.0834)	(0.0703)	(0.223)	(0.0435)	(0.0712)
N	223933	223933	223933	223933	223933	223933
DV mean	6.0270	0.3440	-0.0342	3.3250	0.1920	-0.0077
ϵ_{mw}	-0.0602	-0.0299		-0.1149	-0.0005	

Notes: Table shows staffing results from facility health inspections for 1998-2017. Sample includes facilities in counties that straddle a minimum wage discontinuity. Panel (a) include facilities with violations above the 99th percentile; panel (b) replaces resident weights with unweighted specifications; panel (c) excludes facilities located in a hospital; and panel (d) replaces the county-pair sample with facilities where the minimum wage differs within a Hospital Referral Regions (HRR). $log(MW)$ is defined as the natural log of the minimum wage faced by facility f at time t in 2017 dollars, adjusted for inflation using the CPI-U-RS. "Severe" violations present actual harm or immediate jeopardy to residents (CMS categories G-L). "Quality of care" violations follow the definition in Harrington et al. (2001). "Standardized score" is a normalized measure of the CMS-issued score (Centers for Medicare and Medicaid Services, 2011). All specifications include facility fixed effects and controls for county employment rates and the elderly population share; state EITC parameters, the share of the elderly population receiving Supplemental Security Income, and AFDC/TANF caseloads and benefit levels; and the facility share of residents female, white, black, and covered by Medicaid. Panels (a) through (c) include county-pair-year fixed effects; panel (d) includes HRR-year fixed effects. Robust standard errors clustered by county. See text and data appendix for details. *** $= p < 0.01$, ** $= p < 0.05$, * $= p < 0.10$.

Appendix Table C4: Full County Sample: Health Inspection Violations and Patient Safety

	(1)	(2)	(3)	(4)	(5)	(6)
	#		# severe		Standardized score	
	Panel a: All inspection violations					
log(MW)	-1.676***	-1.351***	-1.420***	-0.036	-0.342***	-0.275***
	(0.528)	(0.504)	(0.075)	(0.078)	(0.108)	(0.103)
N	307025	307025	307025	307025	307025	307025
DV mean	6.162	6.162	0.374	0.374	0.0748	0.0748
ϵ_{mw}	-0.272	-0.219	-3.797	-0.097		
	Panel b: Quality of care violations					
log(MW)	-1.057***	-0.692***	-0.0346	-0.0066	-0.179**	-0.061
	(0.271)	(0.248)	(0.0424)	(0.0448)	(0.073)	(0.071)
N	307025	307025	307025	307025	307025	307025
DV mean	3.367	3.367	0.206	0.206	0.0177	0.0177
ϵ_{mw}	-0.314	-0.206	-0.168	-0.032		
Division X year FE	X	X	X	X	X	X
State linear trends		X		X		X

Notes: Table shows staffing results from estimating Equation 2 on the state health inspection reports reported to CMS, covering years 1998-2017. Sample includes all nursing home facilities. $log(MW)$ is defined as the natural log of the minimum wage faced by facility f at time t in 2017 dollars, adjusted for inflation using the CPI-U-RS. "Severe" violations are those presenting actual harm or immediate jeopardy to residents (CMS categories G-L). "Quality of care" violations follow the definition in Harrington et al. (2001) to include violations in the quality of care, assessment, nursing, dietary, physician, rehabilitative services, dental, and pharmacy regulation categories. "Standardized score" allocates violation points to each violation based on the CMS scoring criteria and normalizes the score distribution across facilities (Centers for Medicare and Medicaid Services, 2011). All specifications include Census Division-time and facility fixed effects and controls for county employment rates and the elderly population share; state EITC parameters, the share of the elderly population receiving Supplemental Security Income, and AFDC/TANF caseloads and benefit levels; and facility average resident age, market concentration, and the share of residents female, white, black, and covered by Medicaid. Columns (2), (4), and (6) also include state linear trends. Robust standard errors clustered by county. All regressions weighted by facility size. See text and data appendix for details. *** $= p < 0.01$, ** $= p < 0.05$, * $= p < 0.10$.

Appendix Table C5: Alternative Samples: Patient Health

	(1)	(2)	(3)	(4)	(5)
	Share sores	Share UTI	Share restraint	Share psychotropic	Health index
Panel a: With outlier observations					
log(MW)	-0.0165***	-0.0074	-0.0131	0.0346	-0.2397**
	(0.0057)	(0.0051)	(0.0112)	(0.0292)	(0.1000)
N	292587	332334	332800	180639	292555
DV mean	0.0858	0.0741	0.0273	0.1939	-0.0922
Δ # residents (1000s), 10% increase	-2.224	-0.997	-1.765	4.663	
ϵ_{mw}	-0.1923	-0.0999	-0.4799	0.1784	
Panel b: Unweighted					
log(MW)	-0.0127***	-0.0086*	-0.0061	0.0281	-0.2062***
	(0.0046)	(0.0045)	(0.0039)	(0.0275)	(0.0597)
N	289855	329915	330077	179169	286092
DV mean	0.0833	0.0726	0.0249	0.1901	-0.1035
Δ # residents (1000s), 10% increase	-1.711	-1.159	-0.822	3.787	
ϵ_{mw}	-0.1525	-0.1185	-0.2450	0.1478	
Panel c: Excluding facilities in hospitals					
log(MW)	-0.0141***	-0.0071	-0.0076	0.0338	-0.2021***
	(0.0052)	(0.0051)	(0.0050)	(0.0295)	(0.0738)
N	280797	319169	319088	172449	277100
DV mean	0.0834	0.0726	0.0252	0.1910	-0.1004
Δ # residents (1000s), 10% increase	-1.900	-0.957	-1.024	4.555	
ϵ_{mw}	-0.1691	-0.0978	-0.3016	0.1770	
Panel d: Hospital Referral Region					
log(MW)	-0.0117***	-0.0097*	-0.0068*	-0.0033	-0.1766***
	(0.0045)	(0.0053)	(0.0039)	(0.0148)	(0.0594)
N	150144	170080	170711	100609	148762
DV mean	0.0757	0.0715	0.0209	0.1890	-0.1858
Δ # residents (1000s), 10% increase	-1.577	-1.307	-0.916	-0.445	
ϵ_{mw}	-0.1546	-0.1357	-0.3254	-0.0175	

Notes: Table shows patient outcomes results from long-term resident assessment reports reported by facilities to CMS, covering years 2005-2017. Sample includes facilities in counties that straddle a minimum wage discontinuity. Panel (a) includes facilities with reported employment above the 99th percentile; panel (b) replaces resident weights with unweighted specifications. Panel (c) excludes facilities located within hospitals. Panel (d) replaces the county-pair sample with facilities where the minimum wage differs within a Hospital Referral Regions (HRR). $log(MW)$ is defined as the natural log of the minimum wage faced by facility f at time t in 2017 dollars, adjusted for inflation using the CPI-U-RS. All specifications include facility fixed effects and controls for county employment rates and the elderly population share; state EITC parameters, the share of the elderly population receiving Supplemental Security Income, and AFDC/TANF caseloads and benefit levels; and facility average resident age, market concentration, and the share of residents female, white, black, and covered by Medicaid. Panels (a) through (c) include county-pair-year fixed effects; panel (d) includes HRR-year fixed effects. Robust standard errors clustered by county. See text and data appendix for details. *** $= p < 0.01$, ** $= p < 0.05$, * $= p < 0.10$.

Appendix Table C6: Full County Sample: Patient Health

	(1)	(2)	(3)	(4)	(5)
	Share sores	Share UTI	Share restraint	Share psychotropic	Health index
Panel a: Division X year FE					
log(MW)	-0.0122***	-0.0114***	-0.0050*	0.0133	-0.1953***
	(0.0033)	(0.0035)	(0.0027)	(0.0104)	(0.0428)
N	299209	336236	337556	199272	296266
DV mean	0.0794	0.0709	0.0219	0.1933	-0.1640
Δ # residents (1000s), 10% increase	-1.64	-1.54	-0.67	1.79	
ϵ_{mw}	-0.1537	-0.1608	-0.2283	0.0688	
Panel b: Divison X year FE and state linear trends					
log(MW)	-0.0131***	-0.0114***	-0.0084***	0.0008	-0.2284***
	(0.0029)	(0.0034)	(0.0024)	(0.0113)	(0.0364)
N	299209	336236	337556	199272	296266
DV mean	0.0794	0.0709	0.0219	0.1933	-0.1640
Δ # residents (1000s), 10% increase	-1.21	-1.23	-0.23	1.87	
ϵ_{mw}	-0.11	-0.13	-0.08	0.07	

Notes: Table shows patient outcomes results from estimating Equation 2 on long-term resident assessment reports reported by facilities to CMS, covering years 2005-2017. Sample includes all facilities. $log(MW)$ is defined as the natural log of the minimum wage faced by facility f at time t in 2017 dollars, adjusted for inflation using the CPI-U-RS. All specifications include Census Division-time and facility fixed effects and controls for county employment rates and the elderly population share; state EITC parameters, the share of the elderly population receiving Supplemental Security Income, and AFDC/TANF caseloads and benefit levels; and facility average resident age, facility market concentration, and the share of residents female, white, black, and covered by Medicaid. Panel (b) also includes state linear time trends. Robust standard errors clustered by county. All regressions weighted by facility size. See text and data appendix for details. *** $= p < 0.01$, ** $= p < 0.05$, * $= p < 0.10$.

Appendix Table C7: Full County Sample: Mortality

	(1)	(2)	(3)
	Panel a: All deaths		
log(MW)	-0.0297	-0.0113	-0.0189
	(0.0215)	(0.0128)	(0.0287)
N	71052	71052	58351
DV mean (level)	0.052	0.052	0.051
	Panel b: Nursing home deaths		
log(MW)	-0.218***	0.189*	-0.286*
	(0.0448)	(0.110)	(0.157)
N	66895	66895	55382
DV mean (level)	0.017	0.017	0.017
Δ # residents (1000s), 10% increase	-10.630	9.216	-13.946
	Panel c: Non-nursing home deaths		
log(MW)	0.0768***	-0.0350	0.0397
	(0.0208)	(0.0325)	(0.0747)
N	71012	71012	58313
DV mean (level)	0.037	0.037	0.035
County controls	X	X	X
Division X year FE	X	X	
State linear trends		X	
HRR X year FE			X

Notes: Table shows changes in county-level age-adjusted mortality rates from estimating Equation 2 on county-level mortality counts by age and place of death covering years 1990-2013 for the population ages 65 and older. The age adjustment, defined in Equation 3, holds the age composition of the population fixed at its 2000 distribution; see (Stevens et al., 2015) and the data appendix for technical details. Sample includes all counties. $log(MW)$ is defined as the natural log of the highest minimum wage in county c at time t in 2017 dollars, adjusted for inflation using the CPI-U-RS. All specifications include controls for county employment rates and the elderly population share as well as state EITC parameters, the share of the elderly population receiving Supplemental Security Income, and AFDC/TANF caseloads and benefit levels. Specifications in columns (1) and (2) include Census Division x year and fixed effects; column (3) includes counties where the minimum wage differs within the Hospital Referral Region (HRR) and includes HRR-by-year fixed effects. Robust standard errors clustered by county. All regressions weighted by county elderly population. Columns (2), (4), and (6) also include state linear trends. See text and data appendix for details. *** $= p < 0.01$, ** $= p < 0.05$, * $= p < 0.10$.

D Appendix: Actions of workers, consumers, and firms with minimum wages

Higher wages may affect the cost, quality, and quantity of nursing home services. This appendix illustrates how workers, firms, and clients respond to mandated wage increases, with a simplified framework based on Feldstein (1977). This stylized set-up shows that *a priori*, higher minimum wages could improve or worsen the quality of nursing home care.

There are three types of agents: nursing home employees, firms, and consumers. Workers supply labor to maximize utility; firms choose staffing levels and resident composition to maximize profits; and potential consumers choose the quantity of nursing home care they receive to maximize utility.

Worker utility maximization

Nursing home workers are of two types $i \in \{p = low-skilled, r = high-skilled\}$. Low-skilled labor, denoted by subscript p, can be conceptualized as nursing assistants; high-skilled labor, r, are primarily RNs and physicians.

Generalizing the baseline Shapiro and Stiglitz (1984) model, individuals derive utility each period from consumption and effort, $U_i(w, e) = u(w_i) - b_i(e_i)$, increasing and concave in after-tax wages w_i and decreasing and convex in effort e_i. The worker's effort function $b_i(.)$ varies across individuals and potentially over time. That is, the cost of effort may depend on innate characteristics, such as a worker's comparative advantage, but also on factors that may evolve over time, such as her tenure with a particular employer or experience in the industry.[54]

Employers cannot perfectly monitor worker effort, but instead observe a noisy signal of effort $\widehat{e_i} = e_i + \mu_i$ where $\mathbb{E}(\mu_i) = 0$. Workers without employment have $\overline{w}$ available for consumption through either unemployment insurance or income assistance benefits. The unemployed do not incur effort costs, and receive utility $U(\overline{w})$.

Each period, employed workers become unemployed with exogeneous probability q and are fired due to inadequate performance with probability $D(\widehat{e_i})$, a weakly decreasing function of observed effort $D^{'}(\widehat{e_i}) \leq 0$.[55] Unemployed workers find employment with exogeneous probability s. If unemployed, a worker receives $\overline{w}$ as income from unemployment insurance or income assistance programs.

Flow utility for individuals with discount rate r is then given by:

$$V^i = \begin{cases} V^{w_i} = \frac{(1+r)(u(w_i)-b(e_i))+(q+D(\widehat{e_i}))V_u}{r+q+D(\widehat{e_i})} & \text{if employed} \\ V^u = \frac{(1+r)u(\overline{w})+sV^{w_i}}{r+s} & \text{if unemployed} \end{cases} \tag{5}$$

Taking wages w_i as given, workers choose an effort level to equate the expected present value

[54] Increases in occupation- or firm-specific human capital shift the effort function, resulting in the observationally-similar pattern as a worker putting forth greater effort holding b constant. More generally, higher wages could affect both the b and the e terms.

[55] This general framework is consistent with settings where worker effort is imperfectly observable and firms face monitoring costs increasing in the size of the workforce (Rebitzer and Taylor, 1995).

of utility while unemployed to that while employed.

$$V^{w_i} = V^u \tag{6}$$

$$b_i(e_i) = u(w_i) - \frac{r}{1+r} V^{w_i} \tag{7}$$

$$e_i = b_i^{-1}\left((u(w_i) - u(\overline{w})) \frac{D(\widehat{e}_i)(1-q)}{D(\widehat{e}_i)(1-q) + (r+s+q)} \right) \tag{8}$$

Effort is increasing in wages, but rises less than in proportion to wage increases with diminishing marginal utility of consumption ($e^{'}(w) > 0$ and $e^{''}(w) < 0$, shown in panel (a) of Figure D1). Intuitively, higher wages increase the value of employment relative to non-employment, prompting workers to exert greater effort in order to reduce the likelihood of non-employment as in Shapiro and Stiglitz (1984).[56]

In more dynamic settings, effort may also change as a worker gains expertise in her role or familiarity with her workplace and colleagues, shifting the $b(.)$ function so that providing a given effort is less "costly" to the worker (panel (b) of Figure D1).

Consumer demand Prospective nursing home clients have demand for nursing home beds given by $X = X(P_c, Q, I, Z)$ where P_c is the price nursing homes charge residents, which can differ than the amount actually paid after insurance; Q is perceived quality, which is (potentially imperfectly) correlated with actual quality Q_N; I is insurance coverage that offsets market prices; and Z is a vector of individual characteristics. Demand is decreasing in net price (therefore increasing in insurance coverage) and increasing in quality $\frac{\partial X}{\partial P} < 0$, $\frac{\partial X}{\partial I} > 0$, and $\frac{\partial X}{\partial Q} > 0$.

As discussed in Section 2, nursing homes serve three types of patients – those who pay out of pocket, and those with insurance coverage through Medicaid or Medicare. For simplification, this section pools Medicaid and Medicare recipients as the weighted average of these two groups.[57] At one extreme, private payors, denoted by subscript p have no insurance coverage, $I_p = 0$ and pay the rates nursing homes charge $P_p = P_c$. When prices increase, these consumers demand fewer services. Holding prices constant, increased quality increases demand.

At the other extreme, Medicaid and Medicare beneficiaries, denoted by subscript g, have full insurance coverage $P_c - I_g = P_g = 0$. These clients are unresponsive to price changes and fill any remaining beds after firms meet private demand. Medicaid patients are less attractive from the firm's perspective Aa Medicaid reimburses facilities at a rate lower than the charged amount, $P_g < P_c$ (Gertler, 1989). P, the relevant revenue for setting prices and quality from the firm's perspective, is the weighted average of the resident groups.

Firm profit maximization Firms have some market power in the product market and produce consumer health of quality Q_N with labor, $L = L_p + L_r$, and non-labor, K. Importantly, Q_N can depend on both the quantity of inputs, L and K, and workers' effort levels. Greater worker effort e leads to higher quality of services provided. As worker effort is monotonically increasing in wages, the healthcare production function can be written as $Q_N = Q_N(L, w, K)$, where $\frac{\partial Q_N}{\partial L} > 0$, $\frac{\partial Q_N}{\partial K} > 0$, $\frac{\partial Q_N}{\partial e}\frac{\partial e}{\partial w} > 0$. All else equal, higher wages improve quality.

[56] As minimum wages increase wages for all employers, employee effort is unlikely to respond via a "gift" mechanism as in other efficiency wage models (e.g.: Akerlof (1982)).

[57] The implications are identical, but notationally more cumbersome, when disaggregating these groups.

Firms incur average costs per resident day of $C = w_p L_p + w_r L_r + rK$, and receive average per-resident revenue P. Firms' profits are then $D = P - C$, where $D < 0$ denotes operating losses.

The quantity of health produced is constrained by the firm's supply of nursing home beds, X, which is governed by state regulation, such as CON laws. Subject to the resource constraint X, firms maximize profit by choosing the cost-minimizing combination of inputs and quality, assuming workers will choose the optimal effort level for a given wage.[58] The profit-maximizing wage level is set such that the marginal value of additional effort equals the additional productivity of an additional factor (Figure D1) (Solow, 1979):

$$max_{L,w,K}\pi = PX(Q, P, I, Z) - C \text{ subject to } P - C \geq D \tag{9}$$

Market equilibrium, no minimum wages Figure D2 displays equilibrium prices, quality, and costs in the absence of minimum wages. In equilibrium, demand for nursing home beds equals supply, shown by line DS_0 in Figure D2, Quadrant I. Holding price constant, higher quality increases demand for nursing home services; therefore, when quality improves, firms will raise prices in order to satisfy the bed constraint.

Higher quality care requires additional inputs and therefore greater costs ($\frac{\partial Q}{\partial L} > 0$, $\frac{\partial Q}{\partial K} > 0$, $\frac{\partial Q}{\partial e}\frac{\partial e}{\partial w} > 0$, and $r, w > 0$). With diminishing marginal factor products, each additional worker or equipment provides a smaller quality improvement than the previous input, resulting in a strictly increasing, concave cost-quality relationship, depicted as line CQ_0 in Figure D2 Quadrant III.

Finally, Figure D2 Quadrant IV graphs the budget constraint $P - C = D$ showing the price-costs combinations that yield a given profit level.

Connecting the set of cost-quality combinationsthat are feasible with the available technology in Quadrant III and the firm's the budget constraint in Quadrant IV provides line FC_0 in Quadrant I of Figure D2. Market equilibrium is the price-quality combination that is both technologically feasible and equates supply and demand – the intersection of DS_0 andFC_0. In the absence of minimum wages, quality, prices, and costs given by $Q_N = Q_0$, $P = P_0$, and $C = C_0$, respectively.

Market equilibrium, minimum wages A minimum wage increase changes prices and quality by altering firms' costs and the production technology. If firms select inputs (and therefore quality) and prices to maximize profits before a minimum wage increase, higher minimum wages shift the production function away from the profit-maximizing (cost-minimizing) combination (from (e_0, w_0) to (e_1, w_1) in Figure D1). Accordingly, costs increase for any quality level, shown in panel (a) of Figure D3. Given that higher wages increase the "effective" number of workers by making each employee more productive, employment among low-skilled labor, and potentially other factors, will decrease. In the new equilibrium, quality falls to Q_1 and prices decrease to P_1 in order to satisfy the bed constraint.

Alternatively, minimum wages may change firms' budget constraint such that profits fall (panel (b) of Figure D3). Such a scenario can arise in settings where firms face an upward-sloping labor supply curve (due to efficiency wages, monitoring costs, search frictions, or bargaining power, see

[58] If the labor market is imperfectly competitive, the wage level is also a choice variable. If the labor market is perfectly competitive, all firms take wages as given, and equilibrium the (sole) prevailing wage will be that which satisfies $e'(w)^{-1} = w$ (Solow, 1979).

Manning (2003), Card and Krueger (2015), and Rebitzer and Taylor (1995) for examples). In this case, any higher costs are borne by the firm, and both prices and quality may increase.

Another possibility is that quality may improve without reducing firm profits. This scenario arises with increasing marginal product of worker effort (a convex relationship between costs and quality in Quadrant III), but in more realistic settings, such a pattern could appear if higher wages change production technology – for example, by increasing worker retention or reducing other costs associated with low effort, such as human resource staff needing to monitor workers' effort, job training services, or fees paid for violations. Another possibility is that facilities may have imperfect information about their production function, in which case legislated wage increases can shift firms towards the production frontier (similar to mechanisms in Flinn (2006)). This setting is the converse of that in Figure D3, panel (a). In equilibrium, minimum wages increase both prices and quality, without necessarily reducing profits.

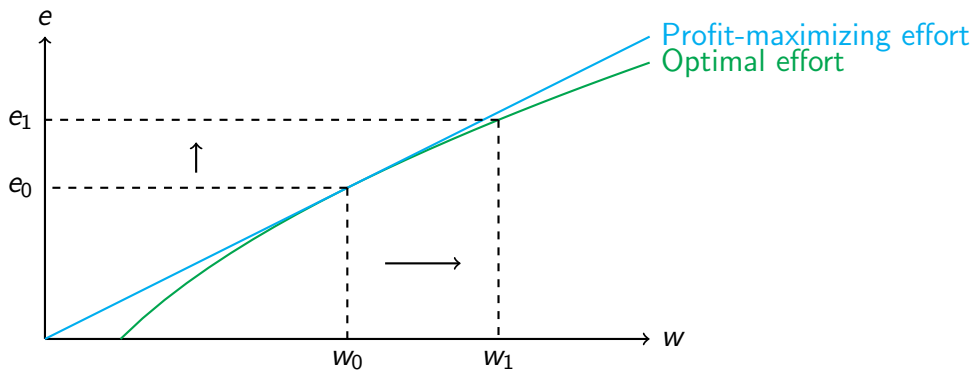
These predicted responses suggest three empirically-observable patterns:

1. **If staffing levels fall and average tenure does not increase, quality is expected to worsen**; conversely, if staffing levels and tenure weakly increases, quality is expected to improve. If staffing levels fall and tenure increases, the effect on quality is ambiguous.
2. **Improved quality is expected to increase consumer prices**. Higher quality may also lower firm profits.
3. **Quality improvements are expected to shift services away from Medicaid recipients towards private payors** since Medicaid residents generate less revenue than those paying out of pocket.

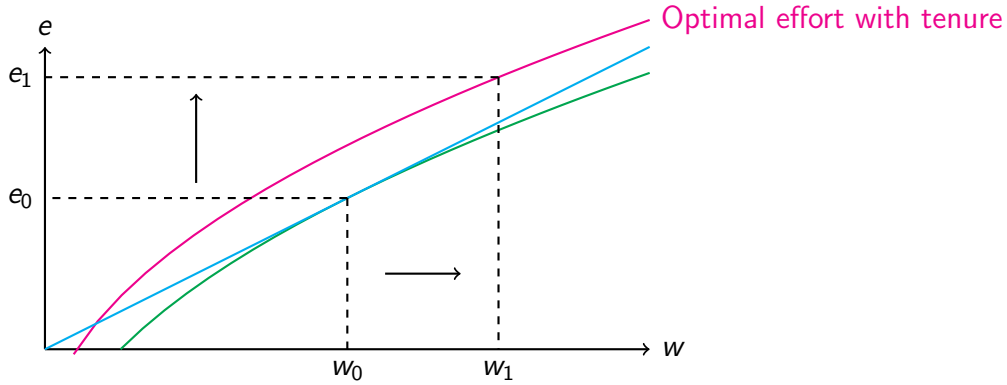
This simplified setting also illustrates that the costs and benefits of higher wages are not evenly distributed. From a social welfare perspective, the desirability of minimum wages depends on the social welfare weights attached to low-wage workers, firm owners, taxpayers, and customers; changes in access to health services; and the relationships among worker earnings, consumer health, and resident prices. Appendix E describes these tradeoffs in greater detail.

Appendix Figure D1: Worker Effort Incentives

(a) No change in tenure

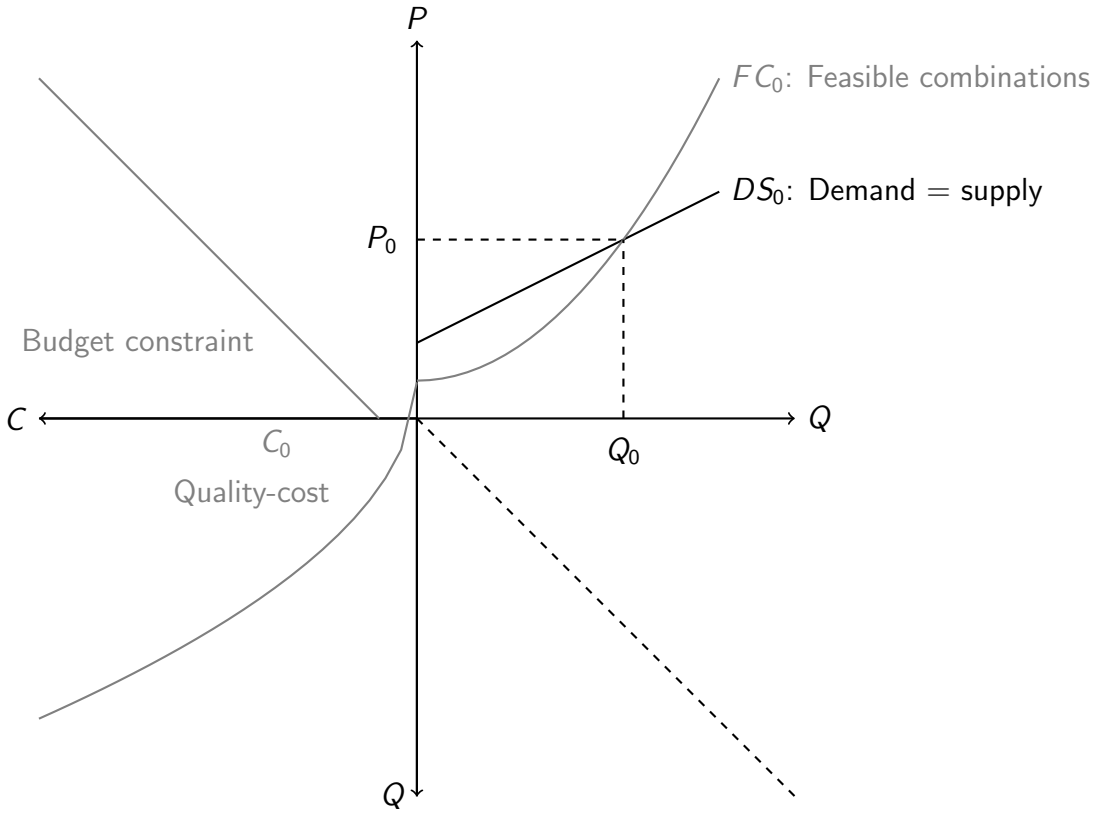


(b) Increase in tenure



Notes: Figure shows a possible relationship between wages w and the effort level e that maximizes utility (green). See Section 3 for a heuristic description. The linear blue line shows the cost-minimizing level of effort for the firm. Each actor assumes the other will act rationally and equilibrium is given by (w_0, e_0). Panel (a) shows that if human capital does not change, a binding minimum wages moves actors away from this equilibrium to (w_1, e_1) – effort levels increase, but less than the proportional increase in firm costs. Panel (b) shows that if minimum wages lead to greater worker retention, workers obtain greater human capital, reducing the costs associated with any effort level. Increased tenure amplifies any efficiency wage channel and leads to even higher service quality.

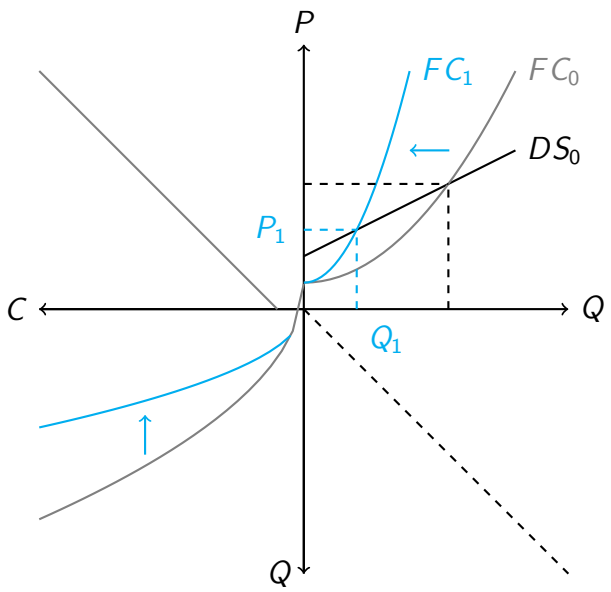
Appendix Figure D2: Market Equilibrium, No Minimum Wages



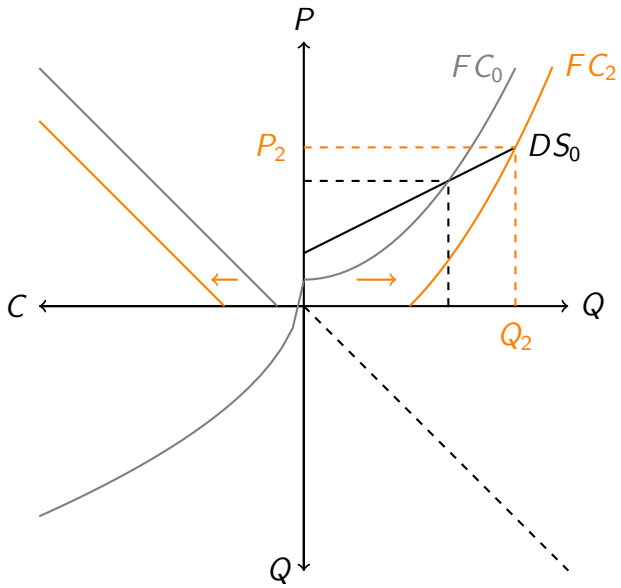
Notes: Figure shows a possible market equilibrium based on price, quality, and cost decisions. DS maps all the price-quality combinations that equate nursing home supply with demand, and FC indicates all price-quality combinations that are feasible with the production technology in Quadrant III and satisfy the firm's revenue constrain in Quadrant IV.

Appendix Figure D3: Market Equilibrium, Minimum Wage Adjustments

(a) Minimum wages reduce production efficiency



(b) Minimum wages lower firm profits



Notes: Figure shows two possible changes in market equilibrium following a statutory increase in the minimum wage. DS maps all the price-quality combinations that equate nursing home supply with demand, and FC indicates all price-quality combinations that are feasible with the production technology in Quadrant III and satisfy the firm's revenue constrain in Quadrant IV. Panel (a) presents the hypothetical situation where higher minimum wages increase firm costs and lead to an inefficient factor mix, reducing quality and price. Panel (b) presents the hypothetical situation where higher minimum wages reduce firm profits, potentially increasing prices and quality.

E Appendix: Nursing home wages, care, and social welfare

This appendix builds on the discussion in Appendix D to describe the social welfare implications of higher minimum wages.

Workers are of two subtypes $i \in \{l = low-skilled, r = high-skilled\}$ $(w^l < w^r)$. These workers are employed by firm owners f, and provide care to two types of nursing home customers: private payors p and those covered by government programs g. g is modeled as a weighted average of Medicaid or Medicare. Each subpopulation's share of the overall population is given by θ^i, with welfare weights ζ^i, and $\overline{\zeta} = 1$. For ease of notation, define each subpopulation's welfare-weighted share of the total population as $\rho^i = \theta^i \zeta^i$.

E.1 Set-up

Workers As described in Appendix D, workers who are employed derive utility from consumption w^i and disutility for effort e^i, while those without work consume out of unemployment insurance or means-tested benefits $\overline{w}$ and do not incur effort.

Contemporaneous individual utility is therefore:

$$U^i = \begin{cases} u(w^i) - b_i(e^i) & \text{if employed} \\ u(\overline{w}) & \text{if unemployed} \end{cases} \tag{10}$$

The fraction of working-age individuals in each group with employment is L^i, and those without work $(1 - L^i)$.

Firm owners: Firm owners receive utility in the form of profits, where $U^f = \pi$ and $\pi = PX(Q, P, I, Z) - wL - rK$.

Nursing home residents: Potential nursing home consumers are elderly individuals who derive utility from health care quality Q obtained by accessing nursing home services X as in Appendix D, and bequests m left to decedents: $V^i(Q, m) = \nu(Q) + z(m)$, where $\nu^{'}, z^{'} > 0$ and $\nu^{''}, z^{''} < 0$. The amount of nursing home services and bequests is determined by the wealth constraint $PX(Q, P, I, Z) + m \leq W$.

Government payors have wealth $W^g = 0$ and insurance $I^g = P^g$, and therefore have no out-of-pocket costs. Since $P^g = 0$ and $\frac{\partial V}{\partial Q} > 0$, these clients have perfectly inelastic demand for nursing home care. In particular, nursing homes are able to fill any beds not occupied by private payors with Medicaid recipients.

Private payors have accumulated wealth $W^p > 0$, incomplete insurance coverage $(I^p < P^p)$, and demand for nursing services increasing in quality and decreasing in price $(\frac{\partial X}{\partial Q} > 0, \frac{\partial X}{\partial P} < 0)$.

As in Gertler (1989), the number of nursing home beds is less than the elderly population $\theta^g + \theta^p < X$, the fraction of Medicaid recipients with access to care is $\Theta = \frac{X - X^p}{\theta^g + \theta^p}$.

Balanced budget requirement: Policymakers must finance Medicaid recipients' nursing home stay out of tax revenue. Government per-diem rates are given by $P_g < P$, with total cost $P_g \theta_g \Theta = T$.[59] Linear taxes at rate τ are levied on high-income workers' wages and firms' net

[59] Appendix Table B1 shows Medicaid reimbursement rates tend to be lower than average private rates.

profits to cover this care such that:

$$T = \Theta\theta_g P_g \tag{11}$$
$$T = \tau\left(w_r L_r \theta_r + \theta_f \pi\right) \tag{12}$$
$$\tau = \frac{\Theta\theta_g P_g}{\left(w_r L_r \theta_r + \theta_f \pi\right)} \tag{13}$$

Therefore, if quality improves, prices paid by private payors increase and firms serve additional private payors (see Section 3). Since the number of beds is fixed, fewer government beneficiaries obtain nursing services and government costs may fall. On the other hand, if Medicaid reimbursement rates are not fixed at P_g, but are a function of private rates ($P_g = \alpha P$, with $\alpha < 1$), the reduction in costs to taxpayers are partially offset by higher per-resident bed rates among those who continue to receive care. Therefore, even if firm profits and higher-income individuals are not directly affected changes in labor costs, they may be indirectly affected through changes in the financing requirements.

E.2 No minimum wages:

In the absence of minimum wages at time $t = 0$, social welfare is:

$$SW_0 = \rho^l\left(L_0^p(u(w_0^p) - b(e_0^p)) + (1 - L_0^p(u(\overline{w}))\right. \tag{14}$$
$$+ \rho^r\left(L_0^r(u(w_0^r) - b(e_0^r)) + (1 - L_0^r(u(\overline{w})) + \rho^f \pi_0\right. \tag{15}$$
$$+ \rho^g \Theta_0 \nu(Q) + \rho^p\left(\nu(Q) + z(m)\right) \tag{16}$$

E.3 Minimum wages:

The introduction of a binding minimum wage at time $t = 1$ has several effects on the nursing home market (Appendix D). First, low-skilled worker wages increase. Second, employment composition may change. Third, given higher costs of production for a given quality level, firm profits may fall, prices may increase, and service will change. The net effect is then:

$$\Delta SW = SW_1 - SW_0 = \rho^l\left(\underbrace{L_1^l(\Delta(u(w^l) - b(e^l)))}_{\text{Employed low-skilled workers' earnings}} + \underbrace{(L_0^l - L_1^l)\left(u(\overline{w}) - (u(w_0^l) - b(e_0^l))\right)}_{\text{Change in low-skilled employt}}\right) \tag{17}$$

$$+ \rho^r\left(\underbrace{L_1^r(\Delta(u(w^r) - b(e^r)))}_{\text{Employed high-skilled workers' earnings}} + \underbrace{(L_0^r - L_1^r)\left(u(\overline{w}) - (u(w_0^r) - b(e_0^r))\right)}_{\text{Change in high-skilled employt}}\right) \tag{18}$$

$$+ \rho^f \Delta\pi + \underbrace{\rho^p\left(\Delta(\nu(Q) + z(m))\right)}_{\text{Private payor health net of price}} + \rho^g\left(\Theta_1 \underbrace{\Delta(\nu(Q))}_{\text{Govt health}} + \underbrace{\Delta\Theta\nu(Q_0)}_{\text{Access change}}\right) \tag{19}$$

Without accounting for quality, the ν terms drop out. While ΔQ could theoretically be positive

or negative, this paper documents that minimum wages improve quality in the nursing home sector. Therefore, accounting for quality improvements increases the desirability of minimum wages from a social welfare perspective.

A broader question, however, is whether increases in the minimum wage are socially desirable. This will depend on normative welfare weights attached to each population, aggregate employment and income changes, the strength of the relationship between higher wages and service quality, and the price elasticity of private demand for nursing home services. For policymakers with redistributional preferences, where $\zeta^f < \zeta^r < \zeta^p$ and $\zeta^w < \zeta^g$, minimum wages are most likely to be welfare-improving when the private demand with respect to quality, $\frac{\partial X_p}{\partial Q}$ is relatively inelastic, but higher wages are an effective tool for inducing improved performance ($\frac{\partial Q}{\partial W_p} > 0$ is large). From a political economy lens, policymakers will favor minimum wages if the median voter benefits. Given relatively high voter turnout among elderly and higher-income individuals, wage increases are most likely to be legislated when higher wages yield quality improvements (and particularly when turnout is increasing in both income and age).

Applying the empirical results from Section 5, this paper finds:

$$\Delta(u(w^l) - b(e^l)) \geq 0 \tag{20}$$

$$(L_0^l - L_1^l)\left(u(\overline{w}) - (u(w_0^l) - b(e_0^l))\right) \approx 0 \tag{21}$$

$$(L_0^r - L_1^r)\left(u(\overline{w}) - (u(w_0^r) - b(e_0^r))\right), \Delta(u(w^r) - b(e^r)) \approx 0 \tag{22}$$

$$\Delta\pi \approx 0 \tag{23}$$

$$(\Delta(\nu(Q) + z(m))) \geq 0 \tag{24}$$

$$\Delta(\nu(Q)) > 0 \tag{25}$$

$$\Delta\Theta < 0 \tag{26}$$

Therefore, modest increases in the minimum wage are welfare-improving if and only if:

$$\rho^l\left(L_1^l(\Delta(u(w^l) - b(e^l)))\right) + \rho^p\left(\Delta(\nu(Q) + z(m))\right) + \rho^g\Theta_1\nu(Q_1) > \rho^g\Theta_0\nu(Q_0) \tag{27}$$