NBER WORKING PAPER SERIES

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Working Paper 29564
http://www.nber.org/papers/w29564

NATIONAL BUREAU OF ECONOMIC RESEARCH
1050 Massachusetts Avenue
Cambridge, MA 02138
December 2021, Revised September 20222

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors. Lu Jinks's work on this project was completed while in graduate school. The opinions and conclusions expressed are solely those of the authors and do not represent the views of the affiliated organizations. The views expressed herein are those of the authors and do not necessarily reflect the views of the National Bureau of Economic Research.

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NBER Working Paper No. 29564
December 2021, Revised September 20222
JEL No. H75,I11,J22

ABSTRACT

Policies to reduce health care payments can lead to health care access issues if providers reduce their supply in response to reimbursement rate reductions. We examine the impact of a policy that reduced reimbursement rates by 30% in a workers' compensation insurance system that provided generous reimbursement rates relative to other payers even after the rate reduction. The results suggest that providers' supply is inelastic at the part of the reimbursement distribution that we study. Our estimates indicate that the policy reduced annual workers' compensation medical costs by over $400 million without affecting injured workers' health care utilization or health.

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1 Introduction

The United States spends more on health care than any other country, and many experts argue that lowering high health care reimbursement rates is key for slowing or reversing the growth in health care spending (Anderson et al. 2003; Anderson et al. 2019; Papanicolas et al. 2018). A concern with reducing reimbursement rates in fee-for-service systems is that provider supply reductions to lower reimbursements have the potential to reduce access to care and to lead to worse health outcomes for patients. To some observers, though, the potential for reductions in unnecessary care is an added benefit of reimbursement rate reductions (Arrow et al. 2009; Ginsburg 2011; Hackbarth et al. 2008).

Understanding the impact of reimbursement rates on providers' treatment decisions is important for forming policies to reduce health care costs that maintain or improve the efficiency of health care allocations. A major challenge in studying supply responses to reimbursement rates is that reimbursement rates and provider supply are typically endogenously determined. Another challenge in studying the impact of reimbursement rates is that the reimbursement rates paid to providers can also typically affect the amounts patients pay for care, meaning changes in health care quantities from reimbursement rate changes may reflect combined supply and demand responses.

Most research into provider responses to financial incentives has examined the impact of a payer changing relative reimbursements for a limited number of services or for select providers and has regularly found that even small changes in reimbursement rates can elicit large changes in providers' treatment decisions, both in the immediate and long terms.[1] For example, Clemens and Gottlieb (2014) study across-the-board changes in Medicare reimbursement rates within certain geographies and find that a 1% increase in reimbursement rates leads to a 1.5% increase in the amount of health care provided to patients. Other research has also found evidence of an elastic supply response to reimbursement rates in Medicare (Gross et al. 2021; Hackmann and Pohl 2018).

In this paper, we examine provider responses to a large, legislatively induced change to re-

[1]Most of this literature focuses on changes to financial incentives in Medicaid and Medicare. For a review, refer to Chandra et al. (2011), who summarize the literature as follows: "The literature is clear that providers respond to payments, and that the response can be very large." Recent studies of providers' responses to financial incentives include Alexander (2020), Alexander and Schnell (2019), Cabral et al. (2021), Einav et al. (2018), Eliason et al. (2018), Fung et al. (2021), Gross et al. (2021), Gupta (2021), Hackmann and Pohl (2018), Mulcahy et al. (2018), and Mulcahy et al. (2020).

imbursement rates in the Illinois workers' compensation system. As with most state workers' compensation systems, the Illinois system reimburses providers using a fee schedule that sets reimbursement rates that insurers must pay for specific services absent a contractual agreement for alternate rates. Ever since Illinois established its fee schedule in 2005, its stipulated reimbursement rates have been high relative to reimbursements from other payers, especially relative to reimbursements paid by major government insurers. In 2010, for example, the reimbursement rates in the Illinois workers' compensation fee schedule for many procedures common in workers' compensation insurance were more than five times Medicare's rates (including the payments from Medicare and cost sharing from patients).

In an effort to reduce medical costs, Illinois policymakers cut scheduled reimbursement rates in the Illinois workers' compensation system by 30% across all medical services in 2011. As shown in Appendix Figure A.1, which plots state-level means of workers' compensation medical costs in the first 90 days after injuries occurring in 2009-2010, a 30% decrease in medical costs in the Illinois workers' compensation insurance system is big enough to move Illinois 8 positions in the ranking of workers' compensation medical costs, but because Illinois medical costs were second highest in the nation prior to the rate cut, Illinois still has above-average workers' compensation medical costs even after the large decrease in reimbursement rates. Both before and after the fee reduction, scheduled payments in the Illinois workers' compensation system were also high relative to the means of payments typically found in studies of private health insurance. For example, Clemens and Gottlieb (2017) find that private payments for surgeries are 60% higher than Medicare's payments on average.[2] In providing variation in reimbursement rates that is large but that still maintains above-average reimbursement rates, this setting allows for understanding providers' supply response to reimbursement changes at an extreme part of the supply curve that accounts for a disproportionately large share of health care spending.

[2]Note, however, that private insurance payments can vary dramatically. While the Illinois workers' compensation insurance reimbursements are higher than a majority of private payments available to providers, studies of private insurance typically find that there are enough other similarly large payments that this part of the reimbursement distribution is still relevant. For example, using data from the Health Care Cost Institute, Cooper et al. (2019) find that while hospitals are paid 85% more from private health insurers than from Medicare for knee replacements on average, average private reimbursement rates for knee replacements at the one-third of hospitals with the highest private reimbursement rates are roughly 3 times Medicare's rates. The pre-policy reimbursement rate for knee replacements in the Illinois workers' compensation system of approximately 4.5 times Medicare's rate became approximately 3 times Medicare's rate after the 30% reduction.

To study the impact of this policy, we draw on a unique administrative data source from a third-party administrator that processes workers' compensation insurance claims for approximately 1,000 large, self-insured employers. These data contain information on over 1.5 million workers' compensation claims from 2009 to 2013 and, unlike most sources of workers' compensation administrative data, allow for cross-state analysis. Workers' compensation insurance is an especially conducive setting for studying the impact of providers' financial incentives on providers' decisions because injured workers have no out-of-pocket costs for treatment, meaning that a change in reimbursement rates has large financial implications for providers but does not affect patients' cost for care.

We estimate the impact of the policy using a difference-in-differences research design that compares how differences in outcomes between claimants in Illinois and claimants in other states changed after Illinois reduced scheduled reimbursement rates. Our estimates indicate that the 2011 policy led to a roughly 30% decrease in reimbursement rates paid for medical services by workers' compensation insurers in Illinois relative to other states, which indicates the scheduled reimbursement rates are binding. Yet despite this large decrease to reimbursement rates, we find no evidence that the policy affected the average amount of medical care that claimants received. Even with a conservative approach to inference, the large magnitude of the change in reimbursement rates results in 95% confidence intervals that can easily rule out the elastic responses documented in other settings. The largest upper bound of the 95% confidence intervals we estimate for our baseline utilization measure rules out a supply elasticity above 0.31.

These results are consistent with a mixed-economy model (Sloan et al. 1978) in which providers first exhaust the highest-reimbursing demand before making decisions about providing care at lower reimbursement rates.[3] In these models, a fixed-rate payer changing its reimbursement rate will only affect the care the payer's enrollees receive if the payer's enrollees are a provider's marginal patients. Thus, changes to high reimbursement rates, like those paid in the Illinois workers' compensation system, have the potential to affect health care spending without changing health care utilization. Combining the results from this study with the results from studies of other parts of the reimbursement distribution that find elastic supply responses helps understand when and why reimbursement rates affect treatment decisions and indicates that decreases in reimbursement rates

[3] Refer to Appendix B for a fuller discussion of the mixed-economy model and how it applies in our setting.

do not necessarily lead to supply reductions. Instead, these results suggest that supply responses differ at different parts of the payment distribution and point to reducing reimbursement rates in the right tail of the rate distribution as a potential avenue for reducing health care costs without leading to major changes in care. Our estimates imply that lowering scheduled reimbursement rates in the Illinois workers' compensation system reduced annual workers' compensation costs by over $400 million (in 2020 dollars) with no detectable effect on the amount of care injured workers receive.

2 Background

Workers' compensation insurance is mandatory, state-regulated insurance against workplace injuries that provides medical care and cash benefits to people injured at work. As of 2018, workers' compensation insurance covered approximately 97.5% of U.S. workers covered by unemployment insurance. In 2018, workers' compensation costs totaled approximately $100 billion, which is roughly three times the 2018 cost of unemployment insurance (calculated as benefits plus administrative costs). Roughly half of workers' compensation insurance benefits are paid for injured workers' medical care, and half are paid as cash to replace lost earnings that occur as a result of injuries. Employers either purchase workers' compensation policies from insurers or self-insure. Self-insured employers assume the financial risks for workers' compensation insurance and typically contract with a third-party administrator to manage claims. Self-insured employers account for about one quarter of all workers' compensation benefits paid in Illinois and in the nation as a whole.

In Illinois, as in most states, workers' compensation claimants can choose their own providers, and absent a contractual agreement for rates different than those in the fee schedule, insurers must reimburse providers' fee-for-service charges up to a maximum rate that varies across services. The original fee schedule was established as part of a 2005 workers' compensation reform that had the stated aim of reducing Illinois workers' compensation costs. Health care provider organizations initially expressed concerns when lawmakers announced their intention to establish a fee schedule, arguing that setting low reimbursement rates would endanger claimants' access to care (Silverman 2004). However, these provider organizations expressed satisfaction with the language in the final bill, which specified that scheduled reimbursement rates would be set at 90% of the 80th percentile of charges from a database with a minimum of 12,000,000 Illinois line items.[4] The fee schedule went into effect in 2006.

Basing scheduled rates on *charges* had major implications for the fee schedule because charges are often far above reimbursements that providers actually receive from most payers (Bai and Anderson 2015, Bai and Anderson 2016, Batty and Ippolito 2017a, Batty and Ippolito 2017b). According to one study's data (Bai and Anderson 2016), providers' charges were as high as 28.5 times Medicare's reimbursement rates. As would be expected based on the Illinois pricing scheme and the distribution of charges, the resulting Illinois workers' compensation insurance fee schedule established high reimbursement rates. For example, in 2010 the professional portion of arthroscopic knee surgery (CPT code of 29882) was reimbursed at roughly $670 in Medicare (including the payment from Medicare and coinsurance from Medicare patients) and at nearly $4,000 by Illinois workers' compensation insurance.

Despite the stated goal of the 2005 reform being to reduce employers' workers' compensation costs, Illinois workers' compensation insurance premiums rose by over 17% from 2006 to 2010. During this same period, most states experienced double-digit decreases in workers' compensation premiums. In the year before the 2005 reform was passed, Illinois had the 20th most expensive workers' compensation premiums out of all states (State of Illinois 2019). By 2010, Illinois had the third most expensive workers' compensation premiums in the nation. In response to the rise in workers' compensation premiums that accompanied the high reimbursement rates, the Illinois legislature passed a new workers' compensation bill in June of 2011. The main change instituted by the new law was the 30% reduction in scheduled reimbursements for all medical services occurring on or after September 1, 2011, that we examine in this study. Refer to Travelers (2011) for a full summary of Public Act 97-18.

[4]The Ingenix database was the only database that met these requirements (IWCC 2010). The 2005 reform was a priority of then-governor Rod Blagojevich, who was later removed from office for corruption and convicted of several crimes, including for trying to trade increased Medicaid reimbursement rates from the State for campaign donations from the chairman of the board of the Illinois Hospital Association. Even if policymakers intended to provide high reimbursement rates, the reimbursement rates later being decreased suggests policymakers might not have understood how high reimbursement rates based on charges would be or how the high reimbursement rates would affect workers' compensation insurance premiums.

3 Data and Methods

The data used in this study contain information on workers' compensation claims occurring from 2009 to 2013 across all 50 states at 984 large firms that self-insure their workers' compensation benefits. The data contain detailed information on all medical care and cash benefits paid to or on behalf of injured workers through workers' compensation insurance, as well as rich information on injuries, injured workers, and firms. Refer to Appendix C for additional information on the data, including details on the construction of each variable used in the analysis and means and standard deviations of variables.

The sample contains information on 1,516,713 claims, 75,168 of which are from Illinois. Columns 1 and 2 of Table 1 show average age, share male, and industrial composition of claims separately for Illinois and the rest of the nation and indicate that Illinois claimants in the administrative data are similar to claimants in the rest of the nation in terms of industrial composition and basic demographics. Columns 3 through 6 of Table 1 show characteristics of claimants who received workers' compensation cash benefits in the previous year from the 2009 to 2019 Annual Social and Economic Supplement (ASEC) of the March Current Population Survey (CPS). As can be seen from columns 3 and 4, which include all cash benefit recipients, the administrative data used in this analysis overrepresent trade and transportation and underrepresent mining, utilities, and construction relative to workers' compensation claims more generally. These differences likely arise in part from the combination of firm size being positively associated with self-insurance and trade and transportation firms being larger on average than construction firms. Columns 5 and 6 of Table 1 show characteristics of CPS claimants at firms with at least 1,000 employees. As expected, the industrial composition of claims at large firms more closely resembles the industrial composition of claims in the administrative data. Table 1 underscores an important point: While we have no reason to expect that the effects of reimbursement rate changes would differ for self-insured and fully insured firms, our analysis draws on data from self-insured firms and thus does not provide direct evidence on the impact of reimbursement rates on fully insured firms.

We first examine the impact of the policy on reimbursement rates paid to providers using a service-level data set with information on over 25 million medical services provided to injured workers within one year of injuries from 2009 to 2013.[5] With this service-level data set, we estimate models of the following form:

$$paid_{icfst} = \nu_c + \delta_f + \lambda_s + \gamma_t + X_i\alpha + \beta policy_{st} + \varepsilon_{icfst}, \tag{1}$$

where i denotes the injured worker, c denotes the service's Current Procedural Terminology (CPT) code, f denotes the injured worker's firm, t denotes the year-month the service occurred, and *paid* is the log of the reimbursement paid for a service. All specifications of Equation (1) control for the following fixed effects: CPT code (ν_c), firm (δ_f), state (λ_s), and year-month (γ_t). In addition to these controls, we also evaluate the robustness of the baseline results to progressively supplementing Equation (1) with additional controls (X_i) for workers' demographic, employment, and injury characteristics. The demographic controls are age, number of dependents, a male indicator variable, and marital status indicator variables. The employment controls are years of tenure at the firm and indicator variables for the worker's employment status when filing the claim. The injury controls are fixed effects for body part injured and for the cause of the injury. The *policy* variable is an indicator variable equal to one for services in Illinois occurring September 1, 2011, or later. The coefficient on this variable is the estimated effect of the 2011 policy on paid reimbursement rates in percent terms.

After documenting the effect of the policy on paid reimbursement rates, we then analyze the policy's effect on claim-level outcomes by estimating the following equation:

$$y_{ifst} = \delta_f + \lambda_s + \gamma_t + X_i\alpha + \beta policy_{st} + \varepsilon_{ifst}, \tag{2}$$

where y represents various claim-level outcomes, *policy* is an indicator variable equal to one for workers injured in Illinois on September 1, 2011, or later, and all other variables are defined as before. We construct confidence intervals using a permutation-based approach in the spirit of Conley and Taber (2011) by estimating placebo regressions that set the *policy* variable equal to one for

[5]The data contain information on approximately 28 million medical services from 2009 to 2013. Because we control for CPT code fixed effects when estimating the impact of the policy on reimbursement rates, we exclude roughly 2.6 million observations with missing CPT codes for the service-level analysis. For the claim-level analysis, we create health care outcomes using information on all payments to providers, including payments for services missing CPT codes.

each of the control states for the actual policy date and for 3, 6, and 12 months before and after the policy. Appendix Figure A.2 plots the distributions of these 350 permutation coefficients for our baseline outcomes. We estimate 95% confidence intervals as the 2.5th and 97.5th percentiles of the distributions of permutation estimates re-centered around the estimated effect for Illinois.

The baseline analysis focuses on two measures of health care quantity. The first is the log of the number of medical services received within 90 days of an injury, which accounts for the majority of all first-year medical care. Because reimbursement rates are based on dates of service rather than on injury dates, this measure could include care reimbursed under either schedule for workers injured in the 90 days before the policy was implemented. To prevent partially treated claims from biasing the estimates of the effect of the policy, we exclude injuries that occurred in the 90 days immediately prior to the new fee schedule being implemented. We also exclude medical care for these injuries in the service-level regression for consistency. In addition to estimating the impact of the policy on medical care within 90 days of an injury, we also examine the impact of the policy on the number of medical services received within one year of injuries. As the vast majority of workers return to work within a year of injury (Bureau of Labor Statistics 2020), treatment within a year of injury provides a meaningful summary of care received. Though the estimates of the effect of the policy on first-year medical care have the potential to be biased if reduced reimbursement rates affect medical care, the exclusion of injuries occurring 90 days before the policy implementation mitigates this concern since the majority of first-year medical care (58% in our data) occurs within 90 days of injuries.

4 The Effect of Reducing Scheduled Reimbursement Rates

The black line in Figure 1 plots event study coefficients of the effect of the policy on logged reimbursement rates paid from a single regression of Equation (1) using service-level data. The coefficients indicate that reimbursement rates were trending similarly in Illinois and the rest of the nation prior to the 2011 policy. Immediately after the policy went into effect, however, reimbursement rates fell by 30% in Illinois.

Panel A of Table 2 reports estimates of the average effect of the reimbursement policy on logged reimbursement amounts paid. Column 1 presents the coefficient from a specification that includes the baseline fixed effects with no additional controls for worker or injury characteristics.

Columns 2 through 4 progressively add controls to evaluate the robustness of the estimated effect of the policy to controlling for demographic, employment, and injury characteristics. Column 5 includes the controls in column 4 but defines the firm fixed effects as combinations of firm and state, which allows firms' baseline reimbursement rates to differ across states. Column 6 includes a control for state-specific linear time trends. Across all specifications, the estimates indicate that the policy reduced reimbursement rates by roughly 30% on average, which suggests that scheduled reimbursement rates were binding, both before and after the policy change.

The blue series in Figure 1 plots estimates of the effect of the reimbursement policy on the logged number of health care services claimants receive within 90 days of injuries. An elastic supply response would mean post-policy coefficients for health care quantities would be larger in magnitude than the corresponding coefficients for the reimbursement rates. Figure 1, however, provides no evidence that injured workers received less care because of the reduced reimbursement rates.

Panel B of Table 2 reports estimates of the impact of the policy on the logged number of health care services received by injured workers in the first 90 days after injuries from Equation (2). Column 1 displays the estimated effect from a specification that includes state fixed effects, firm fixed effects, and year-month fixed effects. The point estimate is 0.052 with a 95% confidence interval of -0.088 to 0.206 and corresponds to a 95% confidence interval for the supply elasticity with respect to scheduled reimbursement rates of -0.69 to 0.29.[6] Columns 2 through 6 progressively supplement the regression with additional controls as in Panel A. Across all specifications, the point estimates of the effect of the policy are positive and statistically indistinguishable from zero. The magnitude of the changes in reimbursement rates means this analysis can easily rule out an elastic supply response. The largest upper bound of the 95% confidence intervals for the supply elasticity with respect to the scheduled reimbursement rates from the estimates in Panel B is 0.31. Panel C of Table 2 replicates the analysis from Panel B for services received within the first year of an injury and finds results that are similar to those in Panel B.

These results are consistent with the mixed economy model's prediction that changes to reim-

[6]We calculate the implied elasticities and their confidence intervals by dividing the estimates and confidence intervals from Panels B and C of Table 2 by -0.3—the decrease in scheduled reimbursement rates set by the 2011 policy. Refer to Appendix A for a discussion of using the scheduled reimbursement rates rather than the paid reimbursement rates and to Appendix Table A.1 for elasticity estimates for all specifications.

bursements rates that are high relative to providers' marginal rates will not impact supply. We next discuss and assess possible alternative explanations for the patterns documented in Table 2.

While the results in Table 2 are consistent with an inelastic supply response, they do not assess the possibility that providers respond to reduced reimbursement rates by billing for different services rather than by changing the number of services they provide, which could occur from upcoding or from true changes in the intensity of care provided and would be supply responses that would not be captured by our baseline measures. To assess this possibility, Figure 2 plots estimated effects of the policy on different measures of utilization from the specification in column 5 of Table 2. Coefficient 1 and 2 in Figure 2 are the baseline estimates from Panels B and C of Table 2. Coefficients 3-6 in Figure 2 are estimates of the effect of the policy on 90-day and one-year utilization measures that weight services to reflect their relative intensity. Coefficients 3 and 4 are from specifications that set the dependent variables to be the log of utilization weighted by the national mean amounts paid for each service in 2009. Coefficients 5 and 6 are from specifications that set the dependent variables to be the log of the number of relative value units (RVUs) of care received. We find no evidence that the policy affects these alternative measures.

A related possibility is that combining all care could mask heterogeneous responses across different types of services. The last 8 estimates in Figure 2 are of the effects of the policy on measures of 90-day and first-year utilization of the following different types of services: diagnostic services, inpatient surgical care services, non-diagnostic outpatient services, and emergency care RVUs. Because these utilization measures have a non-trivial number of zeros, we estimate the effects in levels and then plot the percent effects relative to the means. Across all measures, we find no evidence that the policy affected utilization.

The conclusion that the study's findings indicate that health care supply is inelastic at the part of the reimbursement rate distribution we study assumes that providers alter their supply in response to reimbursement rate changes if doing so is optimal for them. A competing explanation for the inelastic response is that providers could be inattentive to financial incentives in workers' compensation insurance more generally. Inattention to workers' compensation reimbursements could arise since revenue from treating injured workers constitutes a small share of total health care revenue. Using data on office visits from the 2009 National Ambulatory Medical Care Survey, we assess how the amount of care provided to injured workers varies across specialties. While the share of office visits paid by workers' compensation insurance across all doctors is small at 2%, the volume varies considerably across specialty. Pediatricians and gynecologists, for example, do not have any office visits paid for by workers' compensation insurance, while workers' compensation patients are roughly 10% of orthopedists' volume on average. Given that workers' compensation insurance payments are much higher than most government insurance payments, a 30% decrease in reimbursement rates would likely be salient for providers specializing in orthopedic issues. Moreover, other studies find evidence that providers' treatment decisions respond to changes in workers' compensation insurance incentives. For example, Powell and Seabury (2018) and Mulcahy et al. (2020) find that providers' treatment of injured workers was influenced by reforms to the California workers' compensation insurance system that altered providers' financial incentives, which suggests the scope for supply adjustments for care provided to injured workers.[7]

The supply elasticities we estimate differ from supply elasticities typically found in other settings. The most comparable research focuses on changes in reimbursement rates in Medicare and Medicaid. In Medicare, studies often find evidence of elastic responses to reimbursement rate changes (e.g., Clemens and Gottlieb 2014; Gross et al. 2021; Hackmann and Pohl 2018). Recent studies examining the impact of increased Medicaid reimbursement rates from the Affordable Care Act on utilization obtain conflicting findings. Fung et al. (2021) and Mulcahy et al. (2018) do not find evidence that the increased Medicaid reimbursements affected provider supply, while Alexander and Schnell (2019) and Cabral et al. (2021) do. Alexander and Schnell and Cabral et al. argue the reasons they find effects is that they use more comprehensive data, exploit variation in the size of reimbursement rate changes across states, and focus specifically on eligible Medicaid enrollees and care. Alexander and Schnell estimate an elasticity of physician willingness to accept adult Medicaid patients with respect to reimbursement rates of 0.83. The baseline supply elasticity estimated in Cabral et al. is 1.2. The findings from these studies are consistent with there being a meaningful amount of health care with marginal costs near both Medicare and Medicaid reimbursement rates, though we again note conflicting evidence on supply responses to Medicaid

[7] According to our data, California's mean 90-day medical cost is in the bottom quintile of state workers' compensation insurance systems. California's reimbursements being in a different part of the reimbursement distribution could factor into why these reforms affected health care utilization. However, the reforms differentially impacted reimbursements of different services and include other potential pathways that the studies argue might also influence utilization. Likely in part for these reasons, these studies do not estimate elasticities, and it is difficult to compare the magnitude of our elasticity estimates to the magnitude of the parameters they estimate.

reimbursement rates.

Combining the findings from the literature and from the current study suggest that the elasticity of supply varies at different parts of the reimbursement rate distribution, which indicates that the impact of policies that change reimbursement rates on health care supply depend on both the size of the reimbursement change and the generosity of initial reimbursement rates. Appendix Figure A.3 illustrates this relationship for several of the recent studies that quantify the magnitude of the variation they study and estimate supply elasticities.

The potential for health reductions from provider responses to reduced reimbursement rates is a concern with implementing policies aimed at lowering health care costs. Arguably, the most plausible channel through which reimbursement rate reductions could affect health is through reductions in care, since decreased reimbursement rates will decrease health if they lead to patients receiving less care and if the marginal care is productive. The lack of a supply response documented in Table 2 and Figure 2 suggests that health reductions arising from the 2011 Illinois policy may be unlikely. However, if providers respond to lower prices with quality reductions or care delays, the policy studied in this paper could still have resulted in reduced health for injured workers without changing the amount of care claimants receive. Table 3 displays estimates of the effect of the policy on measures of injured workers' disability and recovery and on the number of days from the injury date until the injured worker's first treatment. None of the estimates indicate that the reimbursement reduction led to injured workers having decreased health or delayed access to care.

The elasticity of supply with respect to reimbursement rates is relevant for understanding the impact of reimbursement rates on overall medical costs since supply responses to reimbursement rate changes will either enhance or counteract the direct impact on costs holding quantity fixed. The effect of changing reimbursement rates on insurers' medical costs can be calculated directly using the elasticity of medical care with respect to the reimbursement rate $\varepsilon_{Q,R}$ since total medical cost $C(R)$ is a product of the reimbursement rate R and the quantity of care $Q(R)$ provided at the reimbursement rate. Differentiating the health care cost function, $C(R) = R * Q(R)$, with respect to R yields the following formula for the elasticity of medical costs with respect to the reimbursement rate:

$$\varepsilon_{C,R} = 1 + \varepsilon_{Q,R}. \tag{3}$$

The policy having no impact on utilization would indicate that the elasticity of medical costs with respect to reimbursement rates is 1.0 and would mean that the policy reduced workers' compensation medical costs by 30%. Calculating the effect of the policy on medical costs using the point estimates from column 5 of Panels B and C of Table 2 and Equation (3) yields estimated cost changes from the policy that range from -26% to -24%.[8] Columns 5 and 6 of Table 3 display estimates of the effect of the policy on medical costs obtained from estimating Equation (2) with the log of total medical costs as dependent variables. As with the results more broadly, the spending results in Table 3 are consistent with the policy having little impact on utilization. A 26.9% decrease in first-year medical costs (as in column 6) translates to an annual cost savings of approximately $423 million in 2020 dollars in first-year medical costs, assuming the estimated effect from this study holds for all Illinois workers' compensation claims.[9,10]

A social planner seeking to set optimal reimbursement rates in workers' compensation insurance would balance the welfare losses from higher reimbursement rates increasing workers' compensation insurance costs with the welfare gains from higher reimbursement rates increasing health care utilization and health. Refer to Appendix A for a discussion of a simple framework that yields a formula that describes how the expected utility of workers with workplace injury risk covered by workers' compensation insurance varies with the reimbursement rates paid to providers. By reducing workers' compensation costs without influencing health care utilization or health, the 2011 policy increased welfare by an amount equal to uninjured workers' value of the additional take-home pay from reduced workers' compensation costs, assuming workers bear the costs of workers' compensation insurance premiums through reduced wages.

Before concluding, we highlight several nuances of the setting and analysis. First, the estimates presented in this paper are of the effects of reductions in reimbursement rates within a few years

[8] Refer to Appendix A for these calculations for all specifications in Table 2.

[9] This calculation assumes 225,000 workers' compensation claims are filed each year in Illinois, which is the midpoint of the State of Illinois estimate of the number of claims in 2012 of 200,000 to 250,000 (State of Illinois 2013).

[10] In Appendix A, we assess the credibility of our estimated cost savings and of the analysis more generally using an alternative data source with information on aggregate workers' compensation insurance costs. We show that our baseline approach and results are supported by the aggregate data in two key ways. First, we show that we obtain an estimate of total cost savings that is similar to our baseline estimate by applying our estimated percent effect on medical costs to aggregate 2010 Illinois medical costs from the alternative data source. Second, we show that trends in workers' compensation medical costs in the aggregate data match our findings. Specifically, we show that aggregate workers' compensation medical costs in Illinois fell by 27.5% from 2010 to 2012 relative to aggregate medical costs in the rest of the nation, which is in line with our estimated decreases of 26.9% and 28.0%.

of rates being reduced. To the extent that providers slowly change business practices or that fewer people seek training to become health care providers in response to reduced reimbursement rates, long-run effects of changes to reimbursement rates could differ from short-run effects. Relatedly, while workers' compensation insurance's annual cost of $100 billion in 2018 makes it one of the larger U.S. social insurance programs, broader changes to reimbursement rates could have general equilibrium effects that do not occur in this setting. Finally, the results in this paper do not speak to the efficiency of relative reimbursement rates, nor do they indicate that injured workers receive the optimal amount of health care. Thus, the analysis does not imply that policies that affect the amount of health care injured workers receive would not affect injured workers' health.

5 Conclusion

The United States spends trillions of dollars on health care each year. High-cost care in the right tail of the cost distribution accounts for a disproportionate share of this spending, which has led to calls to lower high reimbursement rates. Decreasing reimbursement rates has the potential to decrease spending, with elastic supply responses potentially magnifying the direct impacts of price decreases. However, as elastic supply responses also have the potential to reduce access to valuable health care services, understanding provider responses to changes in reimbursement rates is important for setting reimbursement policy. In this paper, we examined the impact of a policy that decreased scheduled reimbursement rates by 30% in a large insurance system with fixed reimbursement rates that are high relative to other payers' reimbursement rates. Despite finding that the policy reduced reimbursement rates paid by approximately 30%, we find no evidence that the reduced reimbursement rates led to decreases in the total amount of care injured workers received. The lack of a supply response in this setting differs markedly from the elastic supply responses documented elsewhere. Our findings, along with findings of elastic responses elsewhere in the literature, suggest that a reimbursement rate's rank in the distribution of providers' available reimbursement rates is relevant in determining supply responses and indicate that supply elasticities can vary greatly at different parts of the supply curve.

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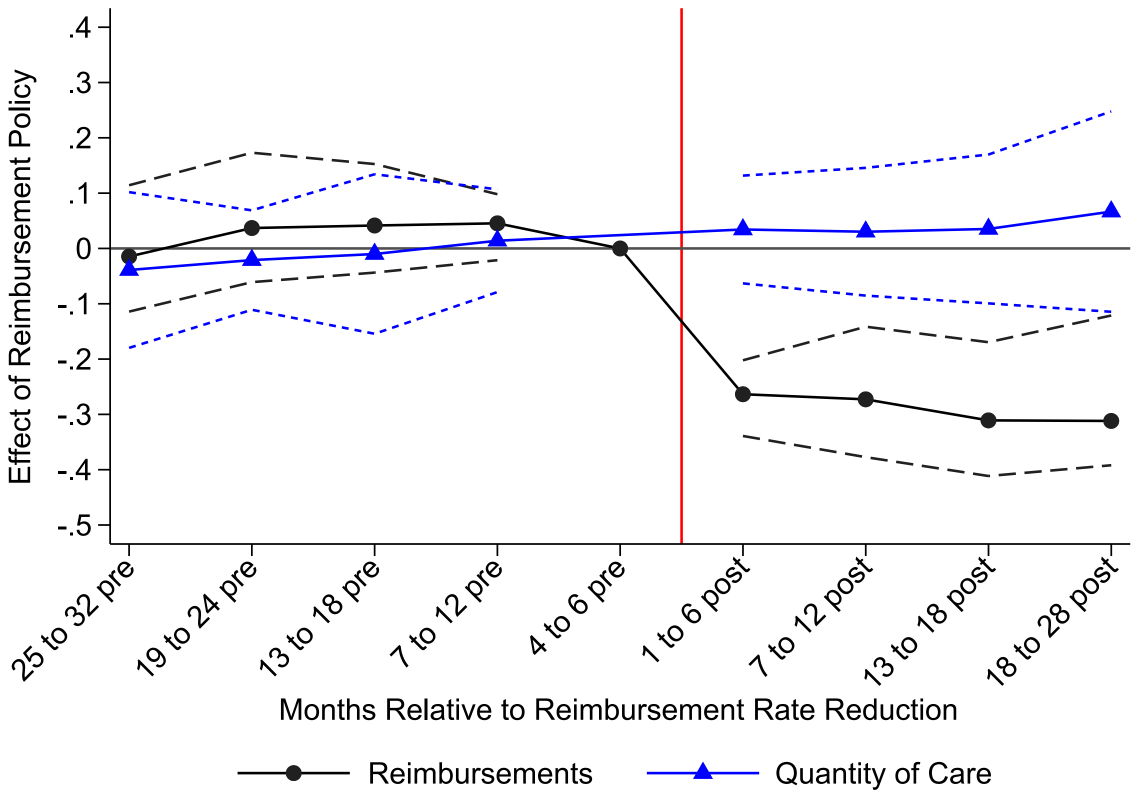
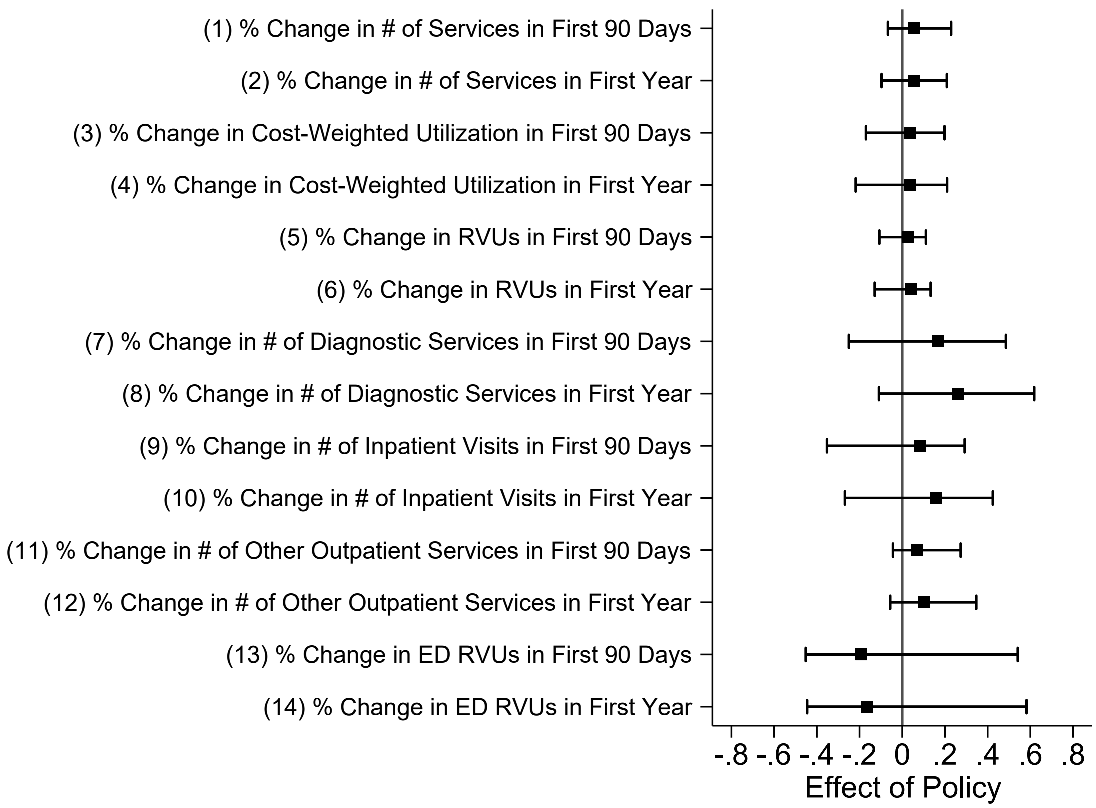
Figure 1: Event Study Coefficients of the Effect of the Reimbursement Policy



Notes: Each marker is a coefficient on an indicator variable for Illinois observations interacted with the number of months from the implementation of the reimbursement rate reduction. The x-axis indicates the number of months from implementation. The y-axis indicates the coefficient estimate. The omitted category is months four through six before the policy's implementation. Observations for injuries from the 90 days immediately prior to the policy's implementation are excluded from the sample. The black circles are from a single service-level regression with the log of reimbursement amounts paid as the dependent variable. The sample for this regression contains 25,186,927 services occurring from 2009 to 2013. The blue triangles are from a single injury-level regression with the log of the number of services received within 90 days of injuries as the dependent variable. The sample for this regression contains 1,481,013 workers' compensation claims occurring from 2009 to 2013. Both regressions include firm-by-state fixed effects, year-month fixed effects, claimants' age, claimants' number of dependents, indicator variables for claimants' sex, marital status, and employment status, claimants' years of tenure at the firm, fixed effects for the body part injured, and fixed effects for the cause of the injury. The service-level regression also includes CPT fixed effects. The dashed lines indicate 95% confidence intervals calculated using the permutation procedure described in the text.

Figure 2: Estimates of the Effect of the Reimbursement Policy on Different Measures of Utilization



Notes: Each marker is an estimate of the effect of the reimbursement policy on the indicated outcome from separate regressions of Equation (2). The first six estimates are from a specification with the log of the measure as the dependent variable. The next eight estimates are percent effects relative to the mean from a specification with the level of the measure as the dependent variable. The sample includes workers' compensation claims occurring from 2009 to 2013 at firms that self-insure their workers' compensation benefits. All specifications include firm-by-state fixed effects, year-month fixed effects, claimants' age, claimants' number of dependents, indicator variables for claimants' sex, marital status, and employment status when filing the claim, claimants' years of tenure at the firm, fixed effects for the body part injured, and fixed effects for the cause of the injury. 95% confidence intervals calculated using the permutation procedure described in the text are shown with the estimates.

Table 1: Characteristics of Workers' Compensation Claimants

	(1)	(2)	(3)	(4)	(5)	(6)
	Administrative Data		ASEC CPS, All Firm Sizes		ASEC CPS, Firms≥1,000 Workers	
	Illinois	Rest of U.S.	Illinois	Rest of U.S.	Illinois	Rest of U.S.
Male (%)	53.7	54.5	58.8	59.6	59.7	51.4
Mean Age	41.7	40.4	45.9	45.5	46.6	46.4
Industry (%)						
Natural Resources and Mining	0.2	0.4	1.0	3.4	0.8	1.8
Construction	0.6	0.9	4.9	10.7	0.0	3.9
Manufacturing	10.1	12.0	17.8	16.0	16.3	14.5
Trade, Transportation, and Utilities	49.2	44.6	39.4	32.4	45.9	42.9
Information, Financial Activities, and Professional Services	12.3	11.4	9.2	8.6	11.9	6.6
Educational and Health Services	20.1	16.7	18.7	22.7	13.2	25.3
Leisure and Hospitality	2.8	5.5	7.7	4.0	11.1	3.8
Other	4.6	8.5	1.5	2.1	0.8	1.3
Medical Costs in First 90 Days	2,838	1,863				
Medical Costs in First Year	5,393	3,045				
Number of Services in First 90 Days	19.1	16.6				
Number of Services in First Year	32.8	26.0				
RVUs in First 90 Days	13.8	11.0				
RVUs in First Year	23.3	16.9				
N	75,168	1,441,545	136	4,688	73	2,082

Notes: The data for columns 1 and 2 come from workers' compensation claims occurring from 2009 to 2013 at firms that self-insure their workers' compensation insurance. The data for columns 3 through 6 come from workers who received cash benefits from workers' compensation insurance in the previous calendar year from the 2009 to 2019 ASEC CPS. The statistics in columns 3 through 6 are calculated using IPUMS weights.

Table 2: Estimates of the Effect of the Reimbursement Policy on Reimbursement Amounts Paid and on Number of Services

	(1)	(2)	(3)	(4)	(5)	(6)
Panel A. Dependent Variable: Log(Reimbursement Amount Paid)						
Effect of Policy	-0.308	-0.308	-0.308	-0.307	-0.311	-0.329
	[-0.435, -0.173]	[-0.435, -0.173]	[-0.435, -0.172]	[-0.435, -0.172]	[-0.442, -0.176]	[-0.389, -0.257]
Mean of Dep. Var. in Levels in 2010 in IL	130	130	130	130	130	130
N	25,186,927	25,186,927	25,186,927	25,186,927	25,186,927	25,186,927
Panel B. Dependent Variable: Log(Number of Services in First 90 Days)						
Effect of Policy	0.052	0.053	0.051	0.048	0.056	0.006
	[-0.088, 0.206]	[-0.086, 0.208]	[-0.086, 0.205]	[-0.094, 0.221]	[-0.067, 0.229]	[-0.046, 0.050]
Mean of Dep. Var. in Levels in 2010 in IL	18.1	18.1	18.1	18.1	18.1	18.1
N	1,481,013	1,481,013	1,481,013	1,481,013	1,481,013	1,481,013
Panel C. Dependent Variable: Log(Number of Services in First Year)						
Effect of Policy	0.048	0.050	0.048	0.044	0.056	-0.026
	[-0.113, 0.192]	[-0.108, 0.206]	[-0.108, 0.204]	[-0.147, 0.194]	[-0.097, 0.209]	[-0.070, 0.028]
Mean of Dep. Var. in Levels in 2010 in IL	31.0	31.0	31.0	31.0	31.0	31.0
N	1,516,713	1,516,713	1,516,713	1,516,713	1,516,713	1,516,713
Baseline Controls	x	x	x	x	x	x
Individual Controls		x	x	x	x	x
Employment Controls			x	x	x	x
Injury Controls				x	x	x
Firm-by-State Fixed Effects					x	x
State-Specific Time Trend						x

Notes: Each column displays an estimate of the effect of the reimbursement policy on the indicated dependent variable from separate regressions. The sample for Panel A includes health care services provided to workers' compensation claimants from 2009 to 2013 at firms that self-insure their workers' compensation benefits. The sample for Panels B and C includes workers' compensation claims occurring from 2009 to 2013 at firms that self-insure their workers' compensation benefits. All specifications include firm fixed effects, state fixed effects, and year-month fixed effects. The service-level regressions in Panel A also include CPT fixed effects. The individual controls include claimants' age, claimants' number of dependents, and indicator variables for claimants' sex and marital status. The employment controls include claimants' years of tenure at the firm and indicator variables for claimants' employment status when filing the claim. The injury controls include fixed effects for the body part injured and the cause of the injury. 95% confidence intervals calculated using the permutation procedure described in the text are shown in brackets.

Table 3: Estimates of the Effect of the Reimbursement Policy on Health-Related Outcomes and Medical Costs

	(1) Received Cash Benefits	(2) Days of Lost Work Benefits	(3) Subsequent Claim within 1 Year	(4) Days from Injury to Treatment	(5) Log of Total Medical Costs in First 90 Days	(6) Log of Total Medical Costs in First Year
Effect of Policy	-0.006 [-0.053, 0.024]	-0.562 [-13.534, 9.556]	-0.007 [-0.026, 0.014]	-0.299 [-6.135, 2.193]	-0.280 [-0.461, -0.151]	-0.269 [-0.484, -0.096]
Mean of Dep. Var. in Levels in 2010 in IL	0.38	44.87	0.087	10.53	3,169	5,892
N	1,516,713	1,516,713	1,434,500	1,516,713	1,481,013	1,516,713

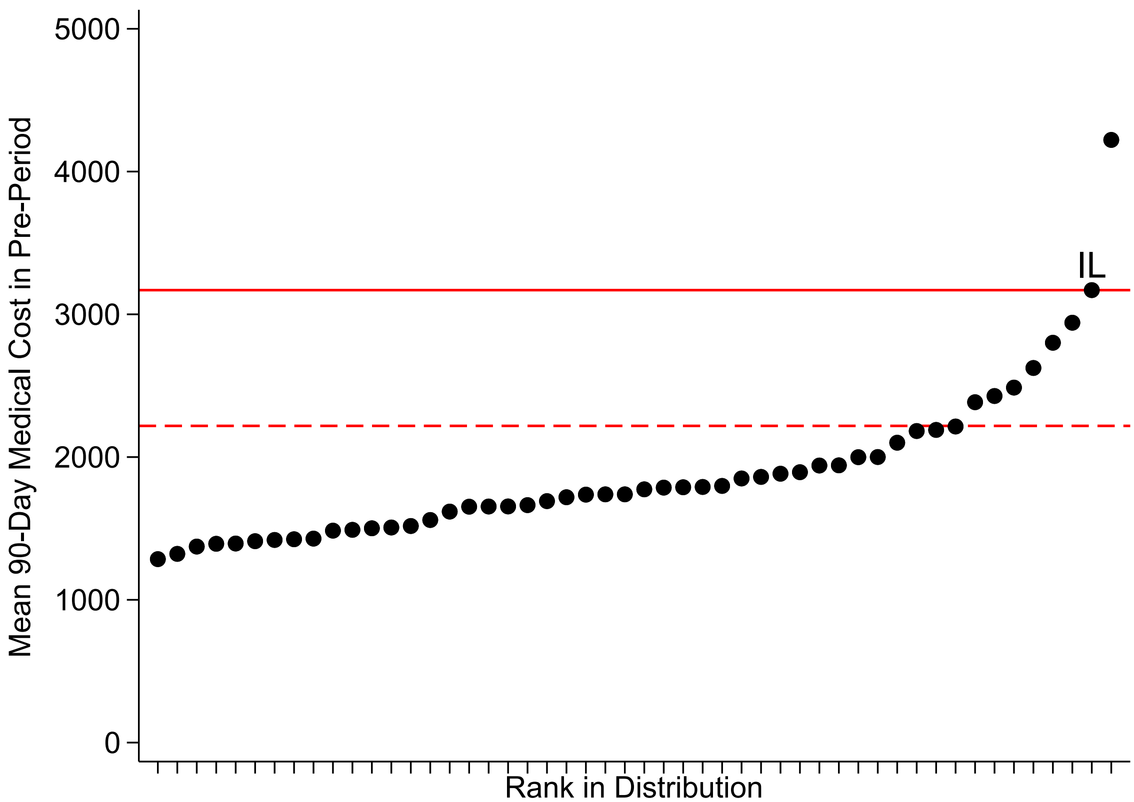
Notes: Each column displays an estimate of the effect of the reimbursement policy on the indicated outcome from separate regressions of Equation (2). The sample includes workers' compensation claims occurring from 2009 to 2013 at firms that self-insure their workers' compensation benefits. All specifications include firm-by-state fixed effects, year-month fixed effects, claimants' age, claimants' number of dependents, indicator variables for claimants' sex, marital status, and employment status when filing the claim, claimants' years of tenure at the firm, fixed effects for the body part injured, and fixed effects for the cause of the injury. 95% confidence intervals calculated using the permutation procedure described in the text are shown in brackets.

APPENDIX

A Supplemental Analysis

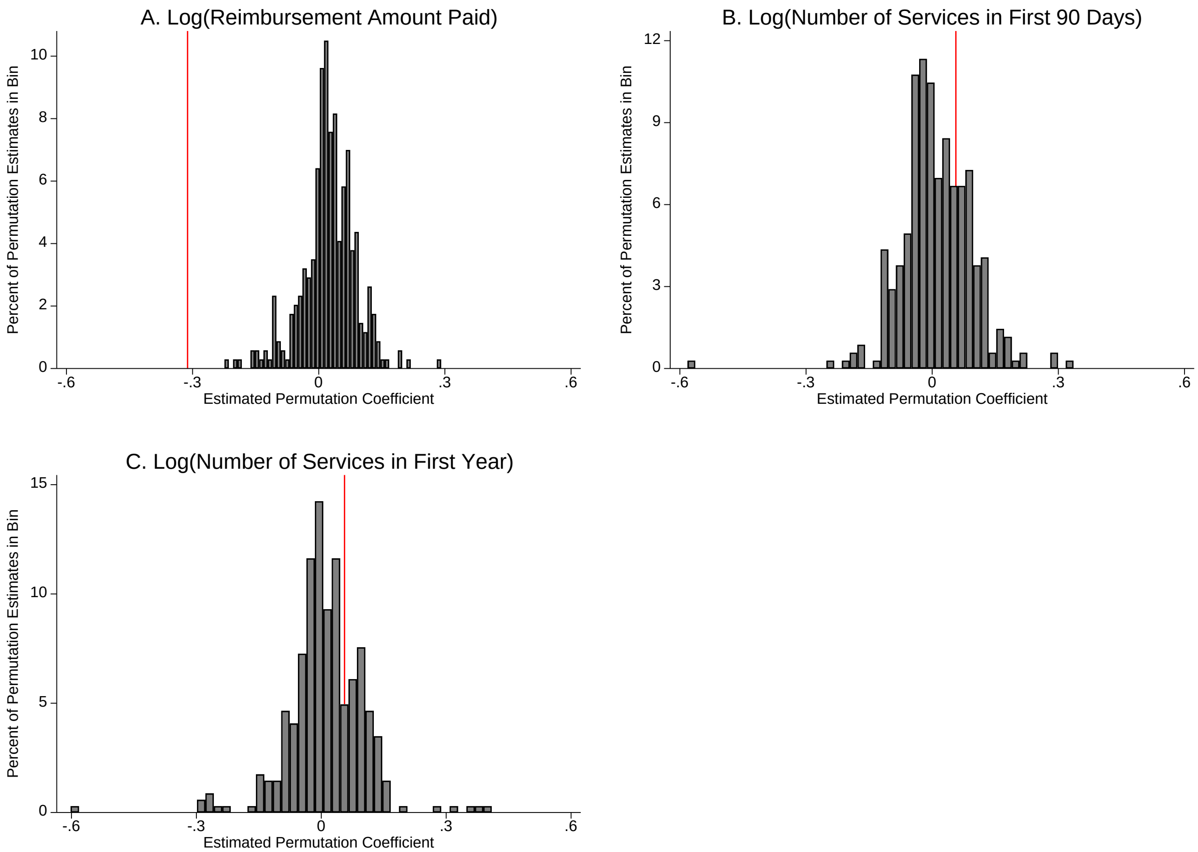
Appendix Figures

Figure A.1: Mean 90-Day Medical Costs by State



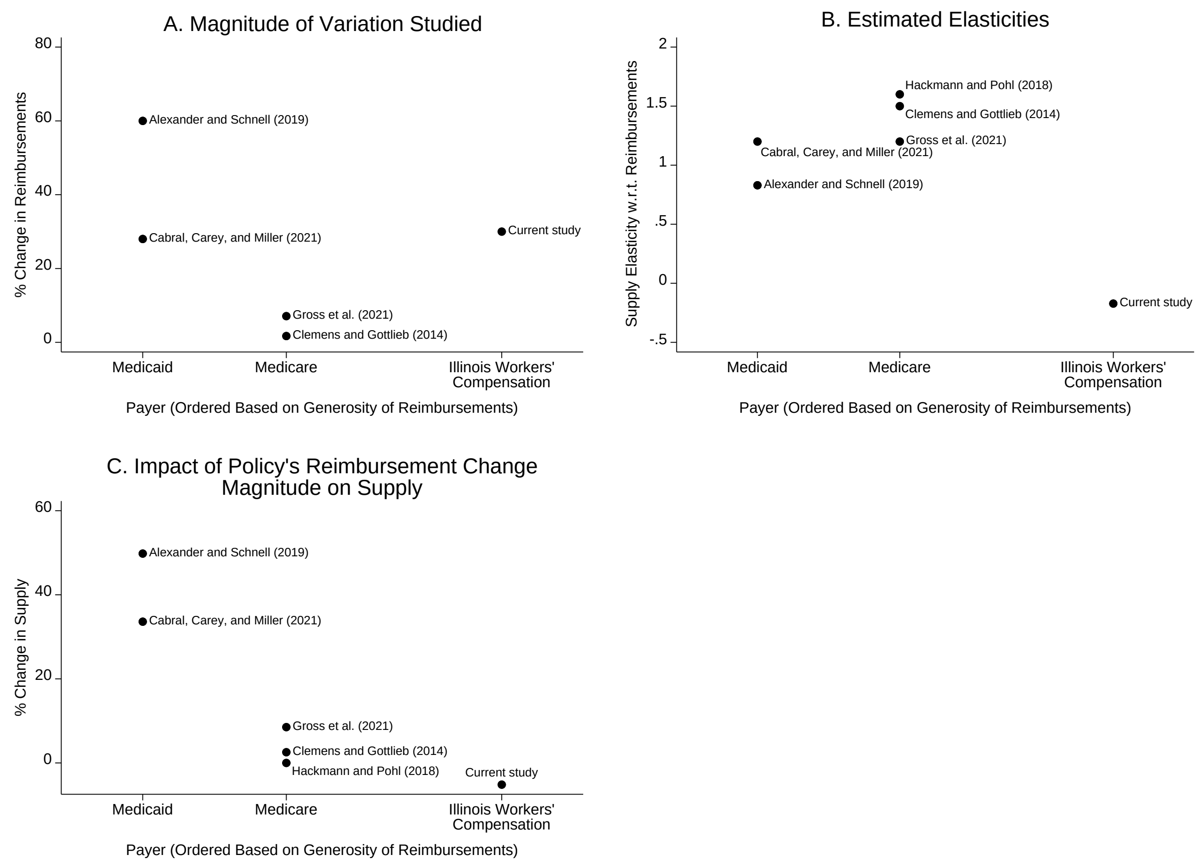
Notes: The graph plots means of 90-day medical costs in the pre-policy period by state. The solid red line indicates the pre-policy mean for Illinois. The dashed red line indicates a 30% reduction in Illinois costs.

Figure A.2: Permutation Coefficients



Notes: The graph plots the distributions of the permutation coefficients obtained by estimating placebo regressions that set the policy variable equal to one for each of the control states for the actual policy date and for 3, 6, and 12 months before and after the policy. The red lines indicate the Illinois estimates.

Figure A.3: Summarizing Variation and Findings Relative to Related Papers



Notes: The graphs plot reimbursement rate variation, supply elasticities, and policy impacts from recent studies examining supply responses to reimbursement rates. The x-axis indicates the setting and is ordered by payment generosity.

Calculations Using the Estimated Effect of the Policy on the Number of Medical Services Provided

The main text referenced and summarized various calculations that used the estimates of the effect of the policy on the quantity of health care services from Table 2. Table A.1 presents the specific calculations for each Table 2 estimate. The first rows of Panels A and B of Table A.1 reproduce the estimated coefficients from Table 2. The second rows display the health care supply elasticities with respect to reimbursement rates implied by those estimates. We calculate these elasticity estimates by dividing the estimates of the effect of the policy on health care quantities in Table 2 by -0.3—the decrease in scheduled reimbursement rates set by the 2011 policy. The third rows of Panels A and B of Table A.1 display implied cost elasticities with respect to reimbursement rates, which we calculate as one plus the supply elasticity as indicated in Equation (3). The fourth rows of each panel of Table A.1 display predictions of the impact of the policy on total medical costs, which we obtain by multiplying the cost elasticities by -0.3.

An alternative to using the 30% reduction in reimbursement rates as set by the policy for these calculations is to use our estimates of the effect of the policy on reimbursement rates paid. We have chosen to instead use the 30% decrease set by the policy for these calculations for the following reasons. First, in practice, policymakers can typically set scheduled reimbursement rates rather than paid reimbursement rates, which makes the change in scheduled reimbursement rates natural to use when interpreting the difference-in-difference estimates. Second, an advantage to using the change specified by the policy is that the "first stage" effect of the policy on scheduled reimbursement rates is known with certainty and does not vary across specifications. Since the estimates in Table 2 are consistent with the scheduled reimbursement rates binding, the choice between using the change in scheduled reimbursement rates set by the policy or using our estimate of the effect of the policy on reimbursement rates paid matters little in practice for the calculated elasticities. For example, the estimated effect of the policy on health care services in column 1 of Table 2 Panel B of 0.052 corresponds to an elasticity of -0.172 if we use the legislatively set decrease to scheduled reimbursement rates and to an elasticity of -0.168 if we instead used the corresponding estimate of the effect of the policy on paid reimbursements from column 1 of Table 2 Panel A of -0.308.

Table A.1: Calculations Using Estimated Effects on Number of Medical Services

	(1)	(2)	(3)	(4)	(5)	(6)
Panel A. Medical Care in First 90 Days						
Effect of Policy on Log(Number of Services)	0.052	0.053	0.051	0.048	0.056	0.006
	[-0.088, 0.206]	[-0.086, 0.208]	[-0.086, 0.205]	[-0.094, 0.221]	[-0.067, 0.229]	[-0.046, 0.050]
Elasticity of Medical Supply with Respect to Scheduled Reimbursement Rates	-0.172	-0.178	-0.170	-0.161	-0.188	-0.020
	[-0.687, 0.293]	[-0.693, 0.287]	[-0.683, 0.287]	[-0.737, 0.313]	[-0.763, 0.223]	[-0.167, 0.153]
Elasticity of Medical Costs with Respect to Scheduled Reimbursement Rates	0.828	0.822	0.830	0.839	0.812	0.980
	[0.313, 1.293]	[0.307, 1.287]	[0.317, 1.287]	[0.263, 1.313]	[0.237, 1.223]	[0.833, 1.153]
Predicted % Effect of Policy on Medical Costs	-0.248	-0.247	-0.249	-0.252	-0.244	-0.294
	[-0.388, -0.094]	[-0.386, -0.092]	[-0.386, -0.095]	[-0.394, -0.079]	[-0.367, -0.071]	[-0.346, -0.250]
Panel B. Medical Care in First Year						
Effect of Policy on Log(Number of Services)	0.048	0.050	0.048	0.044	0.056	-0.026
	[-0.113, 0.192]	[-0.108, 0.206]	[-0.108, 0.204]	[-0.147, 0.194]	[-0.097, 0.209]	[-0.070, 0.028]
Elasticity of Medical Supply with Respect to Scheduled Reimbursement Rates	-0.159	-0.167	-0.159	-0.147	-0.186	0.085
	[-0.640, 0.377]	[-0.687, 0.360]	[-0.680, 0.360]	[-0.647, 0.490]	[-0.697, 0.323]	[-0.093, 0.233]
Elasticity of Medical Costs with Respect to Scheduled Reimbursement Rates	0.841	0.833	0.841	0.853	0.814	1.085
	[0.360, 1.377]	[0.313, 1.360]	[0.320, 1.360]	[0.353, 1.490]	[0.303, 1.323]	[0.907, 1.233]
Predicted % Effect of Policy on Medical Costs	-0.252	-0.250	-0.252	-0.256	-0.244	-0.326
	[-0.413, -0.108]	[-0.408, -0.094]	[-0.408, -0.096]	[-0.447, -0.106]	[-0.397, -0.091]	[-0.370, -0.272]
Baseline Controls	x	x	x	x	x	x
Individual Controls		x	x	x	x	x
Employment Controls			x	x	x	x
Injury Controls				x	x	x
Firm-by-State Fixed Effects					x	x
State-Specific Linear Time Trend						x

Notes: Each cell in the first row of each panel displays an estimate of the effect of the reimbursement policy on the indicated outcome from separate regressions of Equation (2). These estimates are reproduced from Table 2. The sample includes workers' compensation claims occurring from 2009 to 2013 at firms that self-insure their workers' compensation benefits. All specifications include firm fixed effects, state fixed effects, and year-month fixed effects. The individual controls include claimants' age, claimants' number of dependents, and indicator variables for claimants' sex and marital status. The employment controls include claimants' years of tenure at the firm and indicator variables for claimants' employment status when filing the claim. The injury controls include fixed effects for the body part injured and the cause of the injury. 95% confidence intervals are shown in brackets below the estimates. The next rows display the calculations of the implied supply and cost elasticities with respect to reimbursement rates and the implied effect of the policy on medical costs based on the estimated coefficients for the effect of the reimbursement policy on care received.

Corroborating Evidence from Aggregate Data

We now present analysis that uses aggregate data on workers' compensation insurance costs from the National Academy of Social Insurance (NASI) to evaluate the credibility of our estimated impact of the policy on medical costs. NASI produces its estimates of aggregate state-level workers' compensation costs using data from multiple sources, including state surveys, A.M. Best, and the National Council on Compensation Insurance. NASI's cost estimates incorporate medical costs for fully insured and self-insured employers and are used by a variety of policymakers, including by the Centers for Medicare & Medicaid Services and the National Institute for Occupational Safety and Health. The specific NASI numbers we use for the calculations we present in this section can be found in Table 9 of Sengupta et al. (2012) and Table 10 of McLaren et al. (2018). NASI rounds its cost estimates to the nearest thousand. We inflation adjust all dollar amounts in this section to 2020 dollars.

Our baseline estimate of the total medical cost savings in the first year after injuries from the 2011 policy is the product of three numbers: 1) our estimate of the effect of the policy on first-year medical costs in percent terms (0.269), 2) Illinois's 2010 mean first-year medical costs in the administrative data ($6,992), and 3) the midpoint of the State of Illinois's estimated range of the number of workers' compensation claims occurring in Illinois in 2012 (225,000):

$$\begin{aligned}\text{Annual Cost Savings} &= 0.269 * \$6,992 * 225,000 \\ &= \$423 \text{ million.}\end{aligned}$$

The accuracy of this estimate relies on 1) the external validity of our estimated percent effect on average medical costs, 2) self-insured medical costs being representative of workers' compensation medical costs more generally, and 3) the accuracy of the State of Illinois's estimate of the number of workers' compensation claims in Illinois. We use NASI's aggregate data to cross-check our bottom-line cost savings estimate by multiplying NASI's estimate of aggregate 2010 medical costs in the Illinois workers' compensation system ($1,644 million) by our estimated percent effect of the policy on average medical costs. Finding a drastically different number when using NASI's 2010 medical costs as our baseline would raise concerns about the validity of our estimate. Performing this calculation provides an estimate of

$$\begin{aligned}\text{Annual Cost Savings} &= 0.269 * \$1,644 \text{ million}\\ &= \$442 \text{ million.}\end{aligned}$$

which is larger than our baseline estimate, presumably in part because NASI's cost measure includes medical spending beyond the first year after injuries, but it is reassuring that the two numbers are not dramatically different from each other.

Cost savings of this magnitude would likely be reflected in aggregate data. To examine if the cost savings we estimate is corroborated by changes in Illinois's aggregate workers' compensation costs, we use NASI's estimates of 2010 and 2012 medical costs to compute the simple difference-in-differences estimate of the effect of the policy as follows:

$$\begin{aligned}\beta_{agg} =& \log(\text{ILcost}_{2012}) - \log(\text{ILcost}_{2010})\\ &- [\log(\text{nonILcost}_{2012}) - \log(\text{nonILcost}_{2010})]\\ =& \log(\$1,325 \text{ million}) - \log(\$1,644 \text{ million})\\ &- [\log(\$33,991 \text{ million}) - \log(\$32,037 \text{ million})]\\ =& -0.275,\end{aligned}$$

where ILcost_t is aggregate medical costs in Illinois in year t and nonILcost_t is aggregate medical costs in all states other than Illinois in year t. The 27.5% decrease obtained from this approach is in line with our baseline estimates and translates to a cost savings of

$$\begin{aligned}\text{Annual Cost Savings} &= 0.275 * \$1,644 \text{ million}\\ &= \$452 \text{ million.}\end{aligned}$$

To summarize the analysis presented in this section, we use an additional data source with information on aggregate costs to assess the validity of our main estimates of the policy's impact on total medical costs. While total medical cost is only one of the outcomes we study in the main analysis, it is a useful one to validate because it reflects both reimbursement rates and the quantity of health care. We show that the aggregate data on workers' compensation insurance medical costs support our main findings and analysis.

Welfare Framework

To assess the welfare implications of the reductions in reimbursement rates, we consider a simple framework that allows for describing how the expected utility of workers with workplace injury risk covered by workers' compensation insurance varies with the reimbursement rates paid to providers. Consider a labor market with a large number of workers who earn wage w if uninjured. Workers are injured at work with exogenous probability α that is constant across workers. If injured, workers are unable to earn the wage and instead receive a cash payout b from workers' compensation insurance as well as an amount of health care $Q(R)$ that is a function of the reimbursement rate R paid to providers. Injured workers have health $H(Q(R))$ that is a function of the amount of health care they receive and is valued equivalently to consumption. Workers' compensation insurance is financed by premiums paid by uninjured workers. The premium amount each uninjured worker pays is the worker's share of benefits paid to and on behalf of injured workers: $\frac{\alpha}{1-\alpha}(R * Q(R)+b)$. Each worker's expected utility W before injury outcomes are realized can be expressed as a function of reimbursement rates as follows:

$$W(R) = \alpha \underbrace{U[b+H(Q(R))]}_{1} + (1-\alpha) \underbrace{U[w - \frac{\alpha}{1-\alpha}(R * Q(R)+b)]}_{2} \tag{4}$$

Terms 1 and 2 in Equation (4) denote the worker's utility when injured and when uninjured. The derivative of Equation (4) with respect to the reimbursement rate describes how average utility varies with the reimbursement rate. For uninjured workers, a higher reimbursement rate decreases utility by increasing the amount of their wages paid to finance workers' compensation insurance. For injured workers, a higher reimbursement rate increases utility if $Q(R)$ and $H(Q(R))$ are both increasing in R.

If health care utilization increases with reimbursement rates, then determining the sign of $W'(R)$ requires understanding how health increases with medical care and how much injured workers value additional health. If the amount of medical care an injured worker receives is unresponsive to reimbursement rates—as the empirical analysis presented in this paper indicates was the case for the decrease in reimbursement rates studied in this paper—then the impact of higher reimbursement rates on expected utility simplifies to an expression that is always negative and consists only of the welfare cost to uninjured workers from the higher costs to finance workers' compensation insurance:

$$W'(R) = -\alpha Q(R)U[C_N]U'[C_N], \tag{5}$$

where $C_N = w - \frac{\alpha}{1-\alpha}(R * Q(R) + b)$ is the worker's consumption when uninjured. This expression indicates that the 2011 policy increased welfare by an amount equal to uninjured workers' value of the additional take-home pay from reduced workers' compensation costs.

B Mixed Economy Model of Provider Supply

The mixed-economy model of Sloan et al. (1978) studies provider decision-making when providers face varying reimbursement rates and can be applied to workers' compensation insurance to generate predictions about the impact of changes to workers' compensation reimbursement rates on health care provided to injured workers. In our application of the model, providers can treat private patients as well as injured workers whose care is paid for by workers' compensation insurance. Providers face a downward sloping demand curve for treating private patients and receive a fixed price for treating injured workers through workers' compensation insurance.[1] Providers prefer to treat private patients until the marginal revenue from private patients equals the workers' compensation reimbursement rate, at which point, they prefer to treat injured workers. If providers treat all the injured workers seeking their services, they will then resume treating private patients. Appendix Figure B.1 provides graphical representations of the model. Graph A shows a case where the workers' compensation rate is lower than most rates in the private market. The solid line represents the original demand curve providers face.

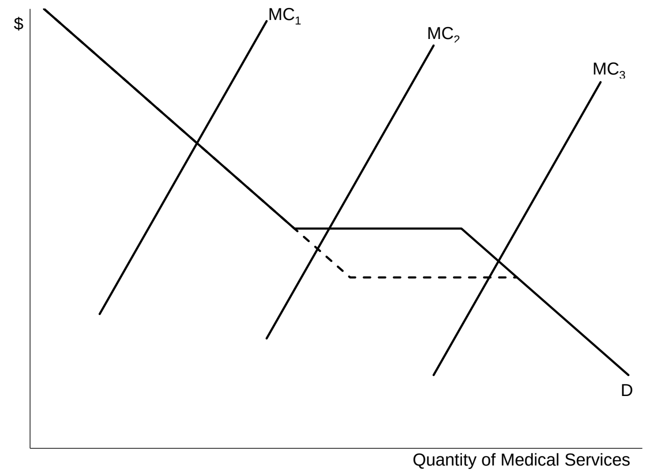
Providers' marginal cost of providing health care increases with the amount of care supplied. Providers produce the quantity of health care such that the marginal cost of providing additional care equals the marginal revenue generated from that care. Thus, a provider's mix of private patients and workers' compensation patients depends on the provider's marginal cost curve. In Graph A, provider 1 treats only private patients. Providers 2 and 3 both see a mix of private patients and injured workers, but provider 3's marginal patient is a private patient while provider 2's marginal patient is an injured worker. The dashed line depicts the effect of a workers' compensation insurance rate cut on providers' marginal revenue. In Graph A, the rate cut does not affect provider 1 but leads to provider 2 no longer treating injured workers and to provider 3 treating some but not all injured workers seeking care. Thus, the model predicts that a reduction in workers' compensation reimbursement rates leads to injured workers receiving less care on average if the reimbursement rate cut affects marginal revenue at providers' initial quantity supplied.

The original mixed-economy model and many of its subsequent applications focus on understanding how Medicaid expansions and reimbursement levels affect Medicaid patients' access to

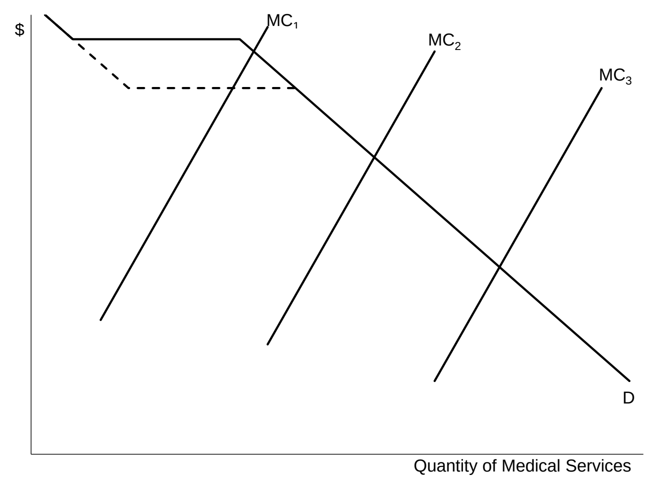
[1]Note that these reimbursement rates can be interpreted as reimbursements net of hassle costs, which may be higher with workers' compensation insurance than with health insurance.

care, and they thus focus on a fixed-rate insurer with reimbursement rates that are low relative to the rate that most private payers offer (Buchmueller et al. 2016, Carey et al. 2020, Garthwaite 2012, and McInerney et al. 2017). For Medicaid, providers with low marginal costs are likely marginal to reimbursement changes. However, the mixed economy model can also provide predictions about the effect of rate changes for a fixed-rate payer with rates that are high relative to most other payers' rates. This scenario is shown in Graph B of Appendix Figure B.1. In this case, providers with high marginal costs would be marginal to the reimbursement cut. In graph B, the cut to the reimbursement rate affects provider 1's amount of care supplied to injured workers. If no providers have sufficiently high marginal cost (i.e., if provider 1 is not in the market), the cut to the reimbursement rate would not affect equilibrium care supplied to injured workers.

Figure B.1: Provider Response to a Workers' Compensation Reimbursement Rate Cut



A. Low Fixed Reimbursement Rate



B. High Fixed Reimbursement Rate

Notes: The graphs illustrate providers' supply response to a workers' compensation reimbursement rate as indicated by the mixed-economy model of Sloan et al. (1978). Graph A shows a case where workers' compensation reimbursement rates are lower than most other reimbursement rates, while Graph B shows a case where workers' compensation reimbursement rates are higher than most other reimbursement rates.

C Data and Variable Construction

As described in the main text, the data used in this study come from a third-party administrator with claims that span all 50 states and Washington, DC. Per the agreement for accessing the data, we are unable to share the name of the third-party administrator. Illinois's total number of workers' compensation claims and the number of claims in the administrative data together indicate that the company administered benefits for roughly 7% of all Illinois workers' compensation insurance claims during the study period. In this appendix, we provide additional information on the construction of the study variables.

The analysis of services in Table 2 and in Figure 1 includes medical services occurring from 2009 to 2013 with non-missing CPT codes. CPT codes are produced by the American Medical Association and describe medical services provided to patients. The claim-level analysis in Tables 2 and 3 and in Figures 1 and 2 includes claims occurring from 2009 to 2013. Since the utilization measures include information from up to one year after the injury date, service-level data from 2009 to 2014 are used to construct these measures. Claims for injuries occurring in the 90 days before the 2011 policy went into effect are excluded from the analysis. We also exclude medical care for these injuries in the service-level regression for consistency.

As described in the main text, we progressively supplement the estimation with controls for the claimant's demographic, employment, and injury characteristics. Table C.1 displays means and standard deviations of claim-level variables used in the study. The demographic variables are as follows: claimant's age, number of dependents, an indicator for the claimant being male, an indicator variable for the claimant being single, and an indicator variable for the claimant being married. The omitted marital status category is people with unknown marital status. The employment variables are as follows: years of tenure at the firm, an indicator for the claimant being employed full-time, and an indicator for the claimant being employed part-time. Years of tenure at the firm is calculated as the number of years from the worker's start date to the injury date. Approximately 97% of workers are classified as full-time or part-time when they filed their claim. The remaining classifications, which are the omitted category in the regressions, include unemployed, retired, and seasonal. The injury variables are based on National Council on Compensation Insurance codes and include indicators for the body part injured and for the cause of the injury. The body part categories are as follows: head; neck; upper extremity; trunk; lower extremity; multiple; miscellaneous. The causes of injury are as follows: include burn or scald-heat or cold exposure (*Burn* in Table C.1); caught in or between; cut, punctured, scrape (*Laceration* in Table C.1); fall or slip injury; motor vehicle; strain; striking against or stepping on (*Striking/Stepping* in Table C.1); struck; miscellaneous.

The variable for having received cash benefits used in Table 3 equals one if the claimant received any benefits paid as cash. Cash benefits include temporary disability benefits, permanent disability benefits, and much rarer benefits like death and burial benefits. The number of days of lost work benefits is the number of days of income-replacement benefits paid to workers by the third-party administrator. The number of days of work a person needs to miss to be eligible for these benefits varies from three to seven depending on the state. Injured workers in Illinois are eligible for these benefits after missing at least three days of work. Because we are focusing on medical care received at most one year after injuries, we cap this measure at 365. Days from first treatment is the number of days from the reported date of the injury to the date of the first treatment for the injury.

Column 6 of Table 2 displays an estimate of the effect of the policy from a specification that includes a control for a state-specific linear time trend. To create this control, we first estimate the state-specific time trend using pre-policy data. We then use the trend estimates to predict logged quantities after the policy and use this predicted quantity measure as a control in Equations (1) and (2).

Receiving inadequate medical care for an injury has the potential to result in subsequent health problems if incomplete healing from one injury increases the likelihood of subsequent injuries. To test for evidence that the reimbursement policy increases the likelihood that people have subsequent claims, we create an indicator variable that equals one if a claimant has a subsequent claim within one year of the original injury. To create this measure, we take advantage of the fact that, while the data do not contain a unique identifier for each worker, they contain enough information to identify individual workers with a high degree of probability. We first construct an individual identifier based on the following information: the claimant's employer, sex, birth year, and exact date of hire. We then create an indicator variable that equals one if an identifier has a subsequent claim within one year of the original injury. Note that subsequent claims could include new injuries as well as the aggravation of prior injuries. Approximately 5% of claims are missing the date of hire, which precludes us from identifying subsequent claims for these observations. While this variable is a useful measure of subsequent health problems, it is important to note that it will not capture all cases of incomplete recovery. In addition to the possibility that a person may suffer from incomplete healing without filing a subsequent workers' compensation claim, this approach will not capture subsequent workers' compensation claims for people who change employers.[2]

Figure 2 analyzed the impact of the policy on measures of total cost-weighted medical care that injured workers receive in the first 90 days after an injury and in the first year after an injury. To create these measures, we use a variable in the administrative data that classifies all services as being physician office visit, physical therapy, diagnostic services, surgeries, emergency care, inpatient care, or outpatient care not elsewhere classified. We first calculate the national mean of amounts paid for each category of service using the workers' compensation administrative data from the whole country in 2009. Next, we apply the 2009 mean cost of each category to all services in that category in all years of the data. Finally, we sum the cost-weighted medical care that claimants receive in the first 90 days after an injury and in the first year after an injury. These cost-weighted utilization measures allow surgeries to contribute more to utilization than office visits do, but because we use a fixed sample to construct the weights, any variation in these measures comes from differences in care provided rather than from differences in reimbursement rates across state or time.

[2]Note, however, that medical benefits do not need to end if injured workers return to work or if they change jobs. While we will not be able to identify subsequent claims for the same worker for workers who change jobs, we will be able to identify subsequent care for the claim.

Table C.1: Descriptive Statistics for Key Variables

A. Demographic Characteristics		**B. Employment Characteristics**		**C. Injury Characteristics**		**D. Claim Characteristics**	
Age	40.4	Years of Service	6.4	Body Part		Number of Services	16.7
	(13.2)		(8.3)	Injured Indicators:		in First 90 Days	(24.9)
				Head	0.18		
Male Indicator	0.54	Employment		Neck	0.02	Number of Services	26.3
		Status Indicators:		Upper Extremities	0.34	in First Year	(51.8)
Number of Dependents	0.24	Regular	0.84	Trunk	0.18		
	(0.88)	Part-Time	0.13	Lower Extremities	0.19	Medical Spending	1,911
		Other	0.04	Multiple	0.08	in First 90 Days	(7,721)
Marital Status				Miscellaneous	0.01		
Indicators:						Medical Spending	3,161
Single	0.39			Cause of		in First Year	(11,565)
Married	0.33			Injury Indicators:			
Unknown	0.28			Burn	0.14	Days Between Injury	8.6
				Caught In or Between	0.07	and First Treatment	(30.9)
				Laceration	0.08		
				Fall or Slip	0.15	Received Cash	
				Motor Vehicle	0.02	Benefits Indicator	0.27
				Strain	0.29		
				Striking/Stepping	0.06	Days of Lost	32.0
				Struck	0.13	Work Benefits	(84.7)
				Miscellaneous	0.07		
						Subsequent Claim	
						within 1 Year Indicator	0.09

Notes: The table displays means of key variables for the sample. For non-binary variables, standard deviations for the variable are shown in parentheses below the means. The variables are described in Appendix C. The sample includes workers' compensation claims occurring from 2009 to 2013 at firms that self-insure their workers' compensation benefits. The sample contains 1,516,713 claims. The utilization measures within the first 90 days are non-missing for 1,481,013 claims. The subsequent claim measure is non-missing for 1,434,501 claims.