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OWNING THE AGENT:
HOSPITAL INFLUENCE ON PHYSICIAN BEHAVIORS

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ABSTRACT

The organizational structure of U.S. health care has changed dramatically in recent years, with nearly half of physicians now employed by hospitals. This trend toward increasing vertical alignment between physicians and hospitals may alter physician behavior relative to physicians remaining in independent or group practices. We examine the effects of such vertical alignment using an instrumental variable strategy and a clinical context facilitating well-defined episodes of care. We find relatively modest positive effects (point estimates of 7% or lower) on total Medicare payments per episode, characterized by an increase in billable activity among other integrated physicians alongside a large decrease in activity among non-integrated providers. Acquiring hospitals ultimately capture more revenue following a physician practice acquisition; yet, the smaller overall bundle of care generates no net savings to Medicare due to location-based payment rules favorable to hospitals.

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A data appendix is available at http://www.nber.org/data-appendix/w28859
A GitHub Replication Files is available at https://github.com/imccart/physician-hospital-VI

1 Introduction

Hospital and physician services constitute the two largest components of U.S. health expenditures and jointly accounted for nearly $2.1 trillion in U.S. health spending in 2019 (55% of total health expenditures). With such money at stake, hospitals as downstream firms have clear incentives to influence physician behavior where possible to improve profitability (Gaynor & Town, 2012; Gaynor *et al.*, 2015; Post *et al.*, 2018). Moreover, the opportunity to influence treatment patterns for financial gain exists so long as patients remain at an informational disadvantage and insurer monitoring of physician decisions is incomplete.[1] However, traditional physician-hospital relationships rely heavily on informal arrangements and often incomplete incentive alignment, thereby limiting a hospital's direct control over its revenue streams. This paper aims to quantify hospitals' influence on physician behaviors, where we consider hospital acquisitions of physician practices as movement toward greater monitoring and control by hospitals and possibly improved incentive alignment between hospitals and physicians.

Hospital acquisitions of physician practices have the potential to influence physician behaviors in at least two general ways. First, following integration, hospitals become the residual claimant for malleable income streams that are strongly shaped by physician decision-making, including physicians' directly provided services, complementary services (e.g., diagnostic tests), and referrals to other providers owned by the hospital (Kocher & Sahni, 2011). The ability of the hospital to profitably influence these separate but interdependent sources of revenue will depend on the amount of control that can be exercised over the newly acquired practice. Second, organizational structure is known to influence physician effort and revenue generation. Economists have long recognized the inherent trade-off between risk-spreading and incentivizing individual physician output when forming groups (Gaynor & Gertler, 1995). In the context of practice acquisitions, vertical integration could disincentivize physician effort (i.e., billable activity) by joining the affected physician with a larger group of other hospital-employed physicians and diminishing the financial incentives tied to ownership of a practice.[2] It is therefore an open empirical question as

[1]There is now a substantial literature showing that a large share of spending is not driven by patient preferences. See, for example, Wennberg & Gittelsohn (1973), Skinner & Fisher (1997), Wennberg *et al.* (2003), Baicker & Chandra (2004), and Gottlieb *et al.* (2010), among others. More recently, Finkelstein *et al.* (2016) exploits patient migration to estimate that 50-60% of geographic variation in spending is due to supply-side factors. Molitor (2018) likewise uses cardiologists' migration patterns to show that 60-80% of the variation in treatment styles can be explained by characteristics of the local physician practice.

[2]In our context, practice ownership prior to being vertically integrated could be a sole proprietorship or a partnership share in a given practice or (horizontally integrated) physician group.

to how these different and potentially countervailing forces within vertical structures ultimately shape the overall intensity and spending belonging to a given episode of care.

Our analysis allows us to decompose the effects of vertical integration on physician behaviors into these various dimensions. We accomplish this in-part by adopting more comprehensive measures of spending and utilization than what are found in the most closely related literature. Specifically, we are primarily interested in measures that capture usage across all facilities and providers within a given time horizon (i.e., an "episode of care"). We therefore simultaneously incorporate mechanical increases in spending due to location-based billing advantages for hospitals but also potential physician behavior changes related to referral decisions and care quantities once physicians transition from being practice owners to hospital employees. Moreover, since we examine all spending and claims within an episode, we can also distinguish between services provided in outpatient versus physician office settings as well as services provided by integrated versus non-integrated physicians.[3]

Our theoretical framework is one in which an episode of care is initiated by a physician/hospital pair, in consultation with the patient. Once an elective inpatient stay is initiated, we assume that the physician and hospital can maintain some influence on treatment patterns throughout the episode (e.g., follow-up visits, testing, or related consultations), even if care is not delivered at the same hospital or by the same physician. For example, the operating physician, as the focal provider in such a clinical context, would typically dictate the post-operative discharge plan and guide the patient on necessary follow-up care in order to facilitate a full recovery, and importantly, increase the probability of achieving the targeted post-surgical health outcomes (e.g., better patient mobility and reduced pain following a joint replacement). The operating physician is also likely to advise the patient on the timing and frequency of follow-up care, either delivered by the operating physician herself or other providers.

Our analysis is based on a 20% random sample of Medicare fee-for-service (FFS) beneficiaries from 2008 to 2015. The novelty of our data is that it captures all the medical encounters for a beneficiary, which allows us to calculate a comprehensive measure of utilization and spending. Specifically, we observe all inpatient, outpatient, skilled nursing facility (SNF), home health, and professional services claims over our time period. We aggregate the claims-level data into distinct episodes, where each episode is initiated by a planned and elective inpatient procedure and en-

[3]We also consider measures of total yearly services provided at the physician level, in order to gauge effects of integration on physician effort at both the intensive and extensive margins.

compasses all claims up to 90 days after the inpatient stay. On average, our episode-level spending accounts for over 75% of total spending per year per beneficiary. We supplement the claims data with information on hospital characteristics and county demographics from a variety of sources. As discussed in more detail in Section 3, our final analytic dataset consists of 1,526,971 episodes, covering 71,271 unique physicians and 4,501 unique hospitals.

Data on hospital ownership of physician practices comes from the SK&A physician survey database. These data offer several advantages compared to other common measures of alignment, such as a hospital's self-reported classification within the American Hospital Association (AHA) annual surveys (Cuellar & Gertler, 2006; Ciliberto & Dranove, 2006; Baker *et al.*, 2014). For example, measures of integration at the hospital level cannot identify variation across physicians operating at the same hospital. Our unique combination of data can overcome this challenge and is therefore a clear improvement in this regard. The SK&A data also contain detailed information on each physician practice, including practice size, group affiliation (i.e., horizontal integration), and single or multi-specialty status.

For each episode, our outcomes include all physician and hospital charges, Medicare spending, and number of claims, as well as quality measures including mortality, readmissions, and complications.[4] Our regression specifications include physician-hospital fixed effects as well as a rich set of patient, physician, hospital, and market characteristics. The key variable of interest in all cases is an indicator for whether the operating physician is part of a practice owned by the hospital system.

Due to the two-sided matching process by which physicians and hospitals become vertically integrated as well as empirical evidence comparing integrated versus non-integrated pairs over time, we propose an instrumental variables (IV) estimate for vertical integration using a 2010 Medicare payment shock as our instrument. Dranove & Ody (2019) examine this payment shock in detail, showing that the shock had a significant and meaningful effect on hospital acquisitions of physician practices. The purpose of the payment shock, as discussed in more detail in Section 4, was to update physician payments using new survey information. The update differentially affected services provided in an office setting versus a facility setting, thereby increasing the incentive for hospitals to acquire certain physician practices. We formulate our instrument in two steps: 1) we

[4] We focus on the relationship between vertical integration and spending/utilization; however, effects on quality are clearly important when interpreting any effects on spending. We therefore present results for quality in the supplemental appendix. In general, we find null effects of vertical integration on quality, consistent with findings in Carlin *et al.* (2015a) and Koch *et al.* (2018), among others.

calculate the total additional revenue gained per physician (due to the payment updates) if the visits were conducted in a facility setting (or billed as such) compared to a physician's office; and 2) we incorporate this differential revenue as an independent variable in a first-stage prediction of hospital ownership of physician practices.

From our IV analysis, we estimate a relatively small but economically meaningful increase in Medicare payments following vertical integration, alongside a relatively large reduction in the intensity of services per episode. Specifically, our point estimates suggest no more than a 7% increase in Medicare payments per episode among vertically integrated physician-hospital pairs, with around 17 fewer claims per episode (a 23% reduction on a base of 74 total claims per episode).[5] When we decompose each episode into spending for inpatient, outpatient (facility), SNF, home health, and professional services, we find large relative increases in outpatient and home health spending, coupled with large reductions in the quantity of office-based professional services, consistent with a net increase in episode spending overall. Our results for outpatient spending, specifically, are also in-line with Koch *et al.* (2017); however, our findings suggest that the bulk of this increase tied to elective surgical care is ultimately offset by a reduction in total number of professional claims when the surgeon is vertically integrated. More specifically, we find that the reduction in professional services claims derives entirely from a reduction in visits to non-integrated providers. Billable activity during the episode among other physicians employed by the same hospital actually increases more than 10-fold in our data, from less than one visit to other integrated physicians prior to acquisition to over four visits to other integrated physicians after acquisition. This translates to nearly $2,000 in additional Medicare revenues flowing to the integrated entity. Hospitals appear able to keep more care within the system when owning the focal physician agent, which reveals an indirect channel for financial benefits from a given practice acquisition. Indeed, our results are consistent with newly integrated physicians conforming to the referral patterns of their peers that were previously integrated with the same hospital.

Given the potential for integration to disincentivize effort, we also examine the effects of vertical integration on physician effort, measured both on the intensive margin (number of visits per episode) and overall (total visits and claims in the year). Here, we find little evidence that physicians actively reduce the amount of care per patient in the absence of direct financial incentives,

[5]We focus much of our discussion on the IV estimates, with OLS estimates presented in the supplemental appendix. Our OLS estimates align with the IV results, albeit with smaller effect sizes. Specifically, our OLS estimates suggest little to no effect of integration on total payments and a slight reduction in the number of claims per episode.

conditional on an elective procedure taking place. Conversely, we find that physicians significantly decrease their total number of claims in a year, with a net decrease of nearly 50 claims on a base of around 280 per year. As has been well-documented, physicians also bill a large number of office visits through the outpatient setting after integration, such that the net effect on physician-level annual spending is small and statistically insignificant.

Our findings contribute to two related literatures. Our first contribution is to the broader literature on physician agency. In documenting physician agency problems, authors typically examine changes in physician treatment choices due to relative differences in financial incentives across services. For example, Clemens & Gottlieb (2014) study physician responses to changes in Medicare reimbursement rates, finding that physicians increase the amount of care and shift toward more profitable treatments after a relative reduction in Medicare payments. Afendulis & Kessler (2007) similarly show that patients receive significantly more care, with no discernable quality improvement, when physicians have the authority to both diagnose *and* operate relative to physicians restricted to diagnostic competencies. Relatedly, Gruber & Owings (1996) demonstrate a movement toward more profitable services (in their case, an increase in cesarean section deliveries) following a reduction in demand for labor and delivery services, and Iizuka (2012) finds that physicians in Japan are more likely to prescribe drugs for which they share some portion of the markup. The presence of physician agency problems is also implicit in studies of unexplained geographic variation in health care utilization (e.g., Finkelstein *et al.* (2016) and Molitor (2018), among many others). Our analysis identifies physician-to-physician referrals as another important dimension of physician agency, whereby hospitals appear to use vertical integration to limit referrals to non-integrated physicians. In this way, our work highlights the physician's relationship with the hospital as a potential mediating factor in understanding effects of physician agency on patient care, which also aligns with several recent studies focused on diagnostic testing quantities and referral choices when physicians are hospital-owned (Chernew *et al.*, 2021; Whaley *et al.*, 2021; Young *et al.*, 2021).

In addition, our work directly connects to the broader and growing literature on the effects of vertical integration throughout the health care sector, which span a variety of empirical settings and associated outcomes. For example, Baker *et al.* (2016) studies physician-level admitting patterns among practices owned by hospitals, and Baker *et al.* (2014) examined changes in market-level spending due to hospital ownership of physician practices (as reported in AHA survey data).

Capps *et al.* (2018) similarly considers the effects of vertical integration on an overall physician price index, which is composed of inpatient and outpatient claims activity. Carlin *et al.* (2015b) and Carlin *et al.* (2015a) study the effects of physician-hospital integration on referral patterns and quality of care for a specific health care system, and Walden (2016) examines hospital acquisitions of primary care practices and its effects on inpatient referrals. Richards *et al.* (2020) likewise explore how physicians' treatment setting choices for outpatient procedures respond to hospital ownership. Finally, Koch *et al.* (2017) examine the effect of vertical integration on physician-level behavior in the clinic and outpatient setting, focusing specifically on acquisitions of 27 large physician practices, and Koch *et al.* (2018) similarly study the effect of vertical integration on health outcomes. Our central contribution to the vertical integration literature is to leverage a unique clinical context (i.e., elective inpatient procedures) that is both common among Medicare beneficiaries and tractable for demarcating episodes of care within an extensive combination of data. We are then able to examine the net effects of vertical integration with an aggregate measure of per-patient spending for a large, national sample of patients, hospitals, and physicians that allows for offsetting behaviors, such as adjustments to quantities of care as well as increases in payments due to reallocating treatments across care settings.

From a policy perspective, the impact of hospital-physician integration on treatment intensity and excessive Medicare spending appears to be context-specific and can meaningfully diverge when looking at isolated services versus net spending over an entire episode of care. Specifically, our results using the full episode of care suggest smaller effects of vertical integration on spending that would be estimated when focusing specifically on the role of facility fees or on spending at the acquiring hospital. That said, our results still reveal higher Medicare spending, albeit for a substantively smaller bundle of care within the average episode. Under a site-neutral payment regime, Medicare would have experienced savings through lower total episode payments overall. Beyond the public insurance program, vertical integration is known to have undesirable implications for provider-insurer contracting, such as increases in physician prices documented by Capps *et al.* (2018) and hospital prices documented by Baker *et al.* (2014) and Lin *et al.* (2021), which may be of greater policy concern than the effects of integration on Medicare spending.

2 Motivation

We motivate our empirical analysis with a simple model of physician behavior (Ellis & McGuire, 1996; Finkelstein & McGarry, 2006). We assume physician j and hospital k initiate an episode of care for patient i, the goal of which is to maximize the perceived utility of patient i as well as the profits of the physician (or the physician's practice) or the hospital. The total amount of care delivered in this episode is denoted y_{ijk}.[6] Note that the initiating physician-hospital pair is *not* assumed to *directly* provide all care in the episode — they need only maintain some influence on treatment patterns throughout the episode.

Given the inherent differences in revenue generation for a physician-owned versus hospital-owned practice, we split this optimization problem between physicians that are vertically integrated with a hospital (VI) and those that are non-integrated (NI).[7] Denote profits to a non-integrated physician by $\pi_{j,NI} = R_j\left(y_{ijk}\right) - c_{j,NI}\left(y_{ijk}\right)$, where R_j captures the net revenue to the physician (reimbursement net direct costs of patient care) and $c_{j,NI}$ denotes other indirect costs not reimbursed by insurers. Denote profits to the hospital by $\pi_k = R_k\left(y_{ijk}\right) - c_k\left(y_{ijk}\right)$ and perceived patient utility by $\tilde{u}(y_{ijk})$. Omitting subscripts on the revenue and cost functions, we assume that $R'\left(y_{ijk}\right) > 0$ and $R''\left(y_{ijk}\right) \leq 0$; $c'\left(y_{ijk}\right) > 0$ and $c''\left(y_{ijk}\right) > 0$; and $u'(y_{ijk}) > 0$ and $u''(y_{ijk}) \leq 0$. Assuming that the physician's objective is additively separable in perceived patient preferences and profits, the non-integrated physician's objective function is

$$y_{ijk}^{NI} = \arg\max_{y} \left\{ \theta_u \tilde{u}\left(y; \Gamma_k, \Gamma_j, \kappa_i\right) + \theta_\pi^j \pi_{j,NI}\left(y; \Gamma_k, \Gamma_j, \kappa_i\right) \right\},$$

where Γ_k, Γ_j, and κ_i reflect hospital, physician, and patient characteristics, respectively, and θ_u and θ_π^j capture different weights that the physician places on perceived patient preferences and own-profits. The solution to the non-integrated physician's optimization problem therefore satisfies the following,

$$\theta_u \tilde{u}'\left(y_{ijk}^{NI}\right) = \theta_\pi^j \left(c'_{j,NI}(y_{ijk}^{NI}) - R'_j(y_{ijk}^{NI})\right). \tag{1}$$

[6]To simplify notation, we let the subscript j denote physician j within a given practice. Our empirical analysis ultimately restricts the sample to physicians that operate in a single practice, so that we can uniquely assign practice characteristics (including ownership by a hospital system) to the physician.

[7]The type of integration in this paper, that of a hospital purchasing a physician practice, differs from some recent studies in the literature. Starc & Town (2019), for example, examines the effects of integration in the design of Medicare Advantage benefits, while Cuesta *et al.* (2019) considers the effects of vertical integration between hospitals and insurers.

Similarly, denote the profits to a vertically integrated physician by $\pi_{j,VI} = \bar{R} - c_{j,VI}(y_{ijk})$, where $\bar{R}$ denotes a fixed salary received from the acquiring hospital. The vertically integrated physician's objective function is

$$y_{ijk}^{VI} = \arg\max_{y} \left\{ \theta_u \tilde{u}\left(y; \Gamma_k, \Gamma_j, \kappa_i\right) + \theta_\pi^j \pi_{j,VI}\left(y; \Gamma_k, \Gamma_j, \kappa_i\right) + \theta_\pi^k \pi_k\left(y; \Gamma_k, \Gamma_j, \kappa_i\right) \right\},$$

reflecting the fact that a vertically integrated physician may incorporate hospital profits into their objective function. The weight assigned to the hospital's profit function in the physician's optimization problem is captured by θ_π^k. The optimal amount of care for an integrated physician is then reflected by

$$\theta_u \tilde{u}'\left(y_{ijk}^{VI}\right) = \theta_\pi^j c'_{j,VI}(y_{ijk}^{VI}) + \theta_\pi^k \left(c'_k(y_{ijk}^{VI}) - R'_k(y_{ijk}^{VI})\right). \qquad (2)$$

Comparing Equations 1 and 2, and assuming that perceived patient preferences remain unchanged, we see that the optimal amount of care for a vertically integrated versus non-integrated physician depends largely on two factors. First, as an employee, an integrated physician's marginal revenue for own-profits drops to zero. All else equal, this would tend to reduce the amount of care in an episode. This is a classic agency mechanism in which salaried arrangements disincentivize effort relative to being self-employed. In our empirical context, we consider physician effort both on the intensive margin (i.e., conditional on an elective procedure taking place) and overall (i.e., total physician claims and spending per year). Our context is also somewhat unique in that the acquired physician in our case is a surgeon rather than a primary care physician. Even still, the operating physician accounts for around 20% of all physician office visits in an average episode, suggesting an opportunity for economically meaningful reductions in physician's own-effort within an episode. Nonetheless, we suspect that effects of integration on physician's own-effort within an episode are likely not a major factor given the relatively larger numbers of other types of claims (e.g., labs and imaging). Our empirical analysis therefore also considers a more aggregate measures of physician effort (i.e., billable activity) using total physician-level spending and claims in a year.

Second, for a vertically integrated physician, the hospital's profit function is now part of their optimization problem. The extent to which this affects treatment decisions depends on the relative size of θ_π^k versus θ_π^j. If θ_π^k is sufficiently large, then we would expect an adjustment to treatment patterns that is more financially favorable to hospitals.[8]

We refer to such a response as "hospital influence," and there are at least three ways in which hospital influence may affect treatment decisions. First, all else equal, the hospital financially benefits as the amount of care increases. Researchers also posit that vertical integration may facilitate some form of product bundling wherein hospitals group many services together (Madison, 2004; Afendulis & Kessler, 2007). This dimension of hospital influence would tend to increase the amount of care.

Second, hospital influence may determine which providers a patient visits throughout the episode. Specifically, hospitals may prefer that patients only visit other physicians within the same hospital system, otherwise restricting visits to non-integrated physicians. Imposing these forms of restrictions may confer additional bargaining power to the hospital (Gowrisankaran *et al.*, 2015; Ho & Lee, 2017). For example, in the extreme case in which patients can visit any physician in their area, the insurer is less affected if they exclude the hospital from their network. Conversely, if patients are restricted only to visit other physicians in the same system, then the insurer stands to lose more if the hospital is not in their network. This dimension of hospital influence will tend to decrease the amount of care to non-integrated physicians but may have little to no effect on visits to other integrated physicians since such visits contribute directly to the hospital's revenue.

Third, hospitals may influence where care is delivered. For example, a physician can choose to operate in the acquiring hospital, k, as opposed to some other hospital for which the physician also has admitting privileges. Assuming the quality of treatment is the same at either hospital, the patient may be indifferent to either location. Vertical integration is then a mechanism by which the hospital increases the probability of the physician operating in their hospital relative to that of a competitor hospital (Baker *et al.*, 2016). Similarly, integrated physicians may bill for the same visit as an outpatient service instead of a standard office visit, even though the nature of the visit itself is identical. Koch *et al.* (2017) find strong empirical evidence of such behavior, with integrated physician practices much more likely to bill for services in an outpatient setting rather than an office setting. This dimension of hospital influence will tend to increase spending but may not effect the quantity of care.

[8] It is reasonable to assume that the physician's marginal costs do not meaningfully change after integration with a hospital; however, integration may reduce practice costs by lowering the administrative burden of seeing patients, or integration may increase the costs of communicating with non-integrated physicians (e.g., due to barriers in sharing information via electronic medical records). Such costs are notoriously difficult to measure, and we have no such measures available in our data.

Ultimately, this discussion suggests that vertical integration creates both upward and downward pressure on the total amount of care, with potentially separate effects on spending. Downward pressure derives from the loss of marginal revenue from the physician's profit function, and potentially from a reduction in care delivered by other, non-integrated physicians, while upward pressure derives from the standard financial incentive to provide more care, all else equal. Fully examining the effects of vertical integration on the amount of care therefore requires a more aggregate measure of treatment, as reflected in our episode-based outcomes.

Empirically, we assume $\tilde{u}$, π_j, and π_k are additively separable in i and (j, k, t). A reduced-form analog to Equations 1 and 2 then follows:

$$y_{ijkt} = x_{it}\beta + z_{jkt}\lambda + \gamma_{jk} + \omega_t + \epsilon_{ijkt}, \tag{3}$$

where x_{it} denotes a vector of patient characteristics, some of which may be time-invariant; z_{jkt} denotes observed physician and hospital characteristics, including an indicator for physician-hospital integration; γ_{jk} denotes time-invariant physician-hospital fixed effects; ω_t denotes time fixed effects; and ϵ_{ijkt} is an error term. The net effect of integration on the total amount of care is captured empirically within the vector of coefficients on physician-hospital characteristics, λ. The key variable of interest is an indicator for whether the physician practice is owned by the hospital. We consider this net effect in Section 5. We then attempt to decompose this net effect into two areas. First, we examine changes due to reallocation of care, which we argue is a reflection of heterogeneities in treatment effects within an episode. This is the subject of Section 6. Second, we consider effects of vertical integration on visits to different types of physicians. This analysis is in Section 7. As part of this analysis, we also consider the effects of vertical integration on visits to the same physician, which we take as a proxy for the effect of vertical integration on the physician's own-effort on the intensive margin (measured in billable visits per episode). We then extend this analysis to a measure of total physician-level spending and claims per year.

3 Data

3.1 Dataset Construction

Our analysis aims to quantify the net effects of vertical integration by examining costs and utilization over an extended period rather than a single visit. We refer to this extended period as an "episode of care," adopting the language from CMS regarding bundled payments. We define an episode as all care observed during a 90-day period after a planned inpatient stay as well as all professional services (i.e., "carrier" claims) incurred 30 days prior.[9] We define a planned admission as an elective admission type that is initiated by a physician or clinic, as captured in the admission source variable in the Medicare claims data. This excludes, for example, transfers from other hospitals or inpatient stays initiated through the emergency department, urgent care center, or trauma center. Our analysis is based on Parts A and B claims for a 20% sample of Medicare beneficiaries from 2008 through 2015.

The purpose of focusing on elective procedures is threefold: 1) conditional on diagnosis and procedure codes, we anticipate less unobserved variation in Medicare expenditures and utilization among planned procedures relative to inpatient stays initiated through an emergency department or transferred from another hospital; 2) treatment for elective procedures is subject to more discretion by the physician and hospital, offering a better opportunity to study changes in physician behavior due to integration; and 3) planned inpatient procedures are also more likely to have a predictable discharge plan that can be influenced by both the physician and the hospital. Our sample construction is therefore similar in spirit to Card *et al.* (2009) in that we limit our sample according to the reason for admission rather than a specific underlying diagnosis or procedure.[10] As a sensitivity analysis, we also limit our sample only to major orthopedic procedures, with similar overall findings. Those results are included as part of our specification curves discussed in Section 5.

[9]This definition and construction of an episode follows recent guidance from CMS in calculating bundled payments for joint replacement (Mechanic, 2015). Ellimoottil *et al.* (2017) also finds that this broad construction of an episode highly correlates with a more clinically narrow definition, such as the episodes constructed in the *hospital compare* data and the RAND health insurance experiment (Aron-Dine *et al.*, 2013).

[10]For example, Card *et al.* (2009) focuses on unplanned admissions through the ED for "non-deferrable" conditions. The sample construction in Card *et al.* (2009) helps in the validity of their regression discontinuity research design by focusing on patients who must be admitted to the hospital regardless of timing or insurance status. Similarly, our sample construction helps to focus on patients for which the physician is more likely to have some influence over the treatment decisions, or at least focus on patients that are likely to have consulted a physician before pursuing the operation.

We construct a dataset of all 90-day episodes from 2008 through 2015, where each episode is initiated by a planned and elective inpatient stay. All episodes in our final data are non-overlapping, so that any elective inpatient stay observed within an existing episode is treated as an inpatient stay in that episode rather than as initiating a new episode. The operating physician associated with the initial inpatient stay is assigned as the physician to that episode. Similarly, the admitting hospital for the initial inpatient stay is assigned as the hospital for the episode. We restrict the sample to individuals aged 65 and above, and we drop episodes in which Medicare payments or charges fall in the highest or lowest one-percent of all observed amounts in a given year.

Our final dataset consists of 1,526,971 total episodes. Consistent with the general reduction in inpatient care, we see a reduction in the number of episodes per year from over 227,000 in 2008 down to 173,000 in 2014.[11] We observe 107,327 unique physician/hospital pairs in these data, based on 4,501 unique hospital NPIs and 71,271 unique physician NPIs.

We incorporate additional hospital-level data from the provider of service (POS) files and the AHA annual surveys, which we merge to the episode data using the Medicare provider number. These data include the number of staffed hospital beds and indicators for hospital teaching status, membership in a larger hospital system, and for-profit/not-for-profit ownership. We then incorporate hospital financial information and data on total discharges from the Healthcare Cost Report Information System (HCRIS), again merged based on the Medicare provider number. Finally, we incorporate local demographic and other county-level variables from the American Community Survey (ACS), merged based on county FIPS codes observed in the AHA data.

We then merge data on hospital ownership of *office-based* physician practices from SK&A, a commercial research firm that regularly surveys the ambulatory physician practice landscape. The SK&A database approximates a near-universe of U.S. office-based physician practices and provides detailed information regarding practice ownership affiliations (including the health system name for those vertically integrated), practice specialty, practice size, and practice location.[12] The SK&A data also includes each physician's NPI, which we use to merge to the claims data.

Note that our SK&A data are bi-annual so that we only observe ownership affiliations for odd-numbered years — 2009, 2011, 2013, and 2015. We therefore do not know the precise timing of some acquisitions. As an example, consider a practice that is observed to be owned by a hospital

[11]We restrict our 2015 data to January-September in order to ensure that we observe all claims for 90 days after the inpatient stay.

[12]Since SK&A focuses on the office-based physician practice landscape, our analysis does not consider hospitalists or other forms of hospital-based physician employment.

system in 2011 but not in 2009. This practice could have been acquired in 2010 or 2011. In our analysis, we assign treatment status based on data from the prior year, which means that the vertical integration indicator in this example is set to 1 beginning in 2011 and 0 in 2010.[13] This ensures that any purchase of a practice is accurately indicated as such in the data (i.e., no false positives).

3.2 Dependent Variables

Our unit of observation is a 90-day episode beginning with a planned and elective inpatient stay, and our main outcomes are episode charges, Medicare payments, and number of claims per episode. These totals include all Parts A and B claims except for durable medical equipment (DME) and hospice care. Our outcomes therefore capture the overwhelming majority of all health care utilization within each episode and over 75% of annual spending per patient. We also consider several measures of quality, including 90-day mortality, 90-day readmissions, and other complications. We measure complications based on the incidence of sepsis and surgical site infections (SSI) within the 90-day episode. All quality measures are therefore constructed based on the same 90-day time frame as our spending measures. We define "any" complication as whether the patient is diagnosed with sepsis or a surgical site infection (SSI) over the episode. Lists of ICD-9 diagnosis codes used to identify sepsis and SSI are included in the supplemental appendix. Since quality is of secondary interest in this analysis, we present our results on vertical integration and quality in the supplemental appendix. Across all specifications and estimators, we find no evidence that vertical integration meaningfully improves quality.

3.3 Independent Variables

Our primary independent variable of interest is an indicator for whether physician practice j is owned by hospital k (or the system to which hospital k is a member), which is captured within z_{jkt} in Equation 3. Our "treatment" is therefore defined at the physician-hospital level, with the operating physician and admitting hospital serving as the treated pair, consistent with the expositional framework in Section 2. This is not to suggest that the operating physician or admitting hospital has full control over all episode payments, only that they can influence treatment patterns before

[13] We can only assign treatment status based on data from the prior year if the practice is observed in both years. If instead the practice in our example is observed in 2010 but not in 2009, then we assign treatment status based on 2011 data.

and after discharge. Intuitively, we consider vertical integration as one way in which hospitals can gain further control over pre- and post-discharge treatment patterns, and we assume that any such control is exercised in concert with the operating physician.

We also include in z_{jkt} the following physician, hospital, and market characteristics: 1) physician practice characteristics, such as practice size, an indicator for an independent versus group practice, an indicator for whether the practice is single or multi-specialty, an indicator for whether the practice owns their own surgery center, the average experience among physicians in the practice, and the percentage of female physicians in the practice; 2) hospital characteristics, including the number of full-time equivalent (FTE) nurses, the number of FTE physicians,[14] the number of FTE residents, the number of FTE other medical staff, the number of FTE non-medical staff, and indicators for whether the hospital is part of a larger system, for-profit versus not-for-profit ownership, and designation as a major teaching hospital; and 3) county characteristics, including a set of variables that capture the county's distribution of age, income, gender, education, and race, as well as indicators for whether the county hospital market is a monopoly, duopoly, or triopoly.

Since the same patient will not (on average) have several episodes for a given physician-hospital pair, we do not include patient-specific fixed effects. We instead include in x_{it} a set of variables intended to capture the total health care utilization for patient i in years prior to time t. Specifically, we sum all claims and Medicare payments for each patient in all years before t, calculate (separately) the quartiles for each of these two variables, and form six indicator variables for whether the patient falls in the 2nd, 3rd, or 4th quartile of each variable.[15] We also include in x_{it} a set of dummy variables for the DRG code and the first three ICD-9 diagnosis codes, all based on the initiating inpatient stay for each episode. There are over 10,000 possible ICD-9 diagnosis codes. We therefore collapse these codes into 18 different disease categories (e.g., ICD-9 codes in the range of 390-459 reflect diseases of the circulatory system) plus an additional dummy for missing codes.[16]

[14]We include the number of FTE physicians as an independent variable under the assumption that most of these physicians are part of hospital-based physician practices rather than office-based physician practices as reflected in the SK&A data.

[15]In calculating total Medicare payments or claims, we make no restrictions on the type of procedures and include all observed claims for each patient. This reflects substantially more observations per patient because the observations are not restricted to be planned and elective procedures.

[16]Details of the disease categories are presented in the supplemental appendix.

3.4 Descriptive Statistics

Descriptive statistics for the episode-level data are provided in Table 1, as well as histogram of the 10 most frequently occurring DRGs in Figure 1. We see from Table 1 that an average 90-day episode incurs around \$100,000 in hospital and professional charges, around \$24,700 in Medicare payments, and over 70 separate claims. We also present summary statistics for our selected quality measures. On average, mortality rates per episode are 3.83%, with readmission rates of 17.6% and complication rates (defined as "any" complication) of 3.6%. Finally, Table 1 shows that 14% of episodes are initiated by an integrated physician-hospital pair in 2008 compared to nearly 34% in 2015.

Tables 2–3 present descriptive statistics for individual physicians and hospitals, respectively. From Table 2, our final data consist of around 5 episodes per physician.[17] Also from Table 2, we see that around 15% of physicians in our data were integrated with a hospital or hospital system in 2008 compared to nearly 37% in 2015. Recall that integration is defined at the hospital system and practice level, so that physicians can operate at multiple hospitals within the same system that owns their practice. Physicians may also (and do) operate at hospitals outside of the system that owns their practice, such that the percentage of episodes initiated by an integrated physician-hospital pair in Table 1 should be slightly lower than the percentage of integrated physicians in Table 2.

Table 3 describes the average hospital in our data. From Table 3, there are about 55 episodes per year in a given hospital, and the initiating hospitals have an average of 205 staffed beds.[18] The percentage of hospitals that are designated as for-profit increased slightly from 18.5% in 2008 to 21.3% in 2015, as did the percentage of hospitals reporting membership in a larger hospital system (from 58.5% in 2008 to 69.5% in 2015). Similarly, the percentage of hospitals that are identified as owning at least one physician practice (or hospitals affiliated with a larger system that owns a practice) increased from 35% in 2008 to 58% in 2015.

[17] In our specification curves in Figure 6, we include estimates when limiting the sample to physician-hospital pairs with more episodes, with little change in the results.

[18] Adjusting for our 20% sample, our data reflect just over 250 episodes per hospital per year. This count of episodes is broadly consistent with other studies in the literature. For example, Dummit *et al.* (2016) report around 200 "lower extremity joint replacement admissions" per year in their study of the hospital bundled payment program. We include a broader set of conditions but with the restriction to planned and elective inpatient stays as per the admission source codes.

4 Estimation Strategy

Our initial goal is to estimate the net effect of vertical integration on total episode charges, Medicare spending, and number of claims using the specification in Equation 3. Our baseline specification adjusts for observable patient, hospital, physician, and county characteristics, as well as time (year and month) and joint physician-hospital fixed effects. Our primary independent variable of interest is an indicator for whether physician j's practice is owned by hospital k or the larger system to which hospital k is a member.

Ordinary least squares (OLS) estimates are presented in the supplemental appendix; however, there are at least three barriers to assigning a causal interpretation to such an analysis. First, patients may prefer vertically integrated physician-hospital pairs over non-integrated pairs for unobserved reasons that are correlated with health care utilization. Second, hospitals may actively pursue the purchase of physician practices for unobserved reasons that are also related to physician treatment patterns. And third, physicians may actively pursue being acquired by certain types of hospitals, again for unobserved reasons that are correlated with treatment patterns. While it is plausible that patient preferences are unaffected by physician-hospital integration, it is less plausible that physician or hospital preferences are exogenous with respect to vertical integration.

To empirically investigate the presence of endogeneity within our clinical context, we consider an event study in which the treated group is defined as any physician-hospital pair that becomes vertically integrated in a given year, and our control group consists of all physician-hospital pairs that are not vertically integrated at any point over our time period. We also consider separate event studies for the 2011 and 2013 treatment group in order to avoid concerns due to differential treatment timing (Goodman-Bacon, 2018; Callaway & Sant'Anna, 2020). In all cases, we form an indicator variable for treated practices and interact this indicator variable with year dummies. We exclude the 2010 interaction term (or the 2012 interaction term for the 2013 treatment group) so that all estimates are interpreted relative to the year prior to integration. The results are presented in Figure 2.

The top panel in Figure 2 presents event study results for log charges, the middle panel presents results for log payments, and the bottom panel presents results for the number of claims. Column 1 (panels a, c, and e) presents results for the 2011 treatment group, with all estimates interpreted relative to 2010, and column 2 (panels b, d, and f) presents results for the 2013 treatment group, with estimates relative to 2012. For charges and payments, the event study graphs suggest a differential trend among physician-hospital pairs that become vertically integrated. Specifically, we estimate between 5% and 10% lower charges per episode and between 2% and 4% lower payments per episode among physician-hospital pairs that are ultimately integrated, with this difference increasing toward 0 closer to the treatment date. Alternatively, we find relatively little evidence of differential trends in the number of claims.

In light of this empirical evidence and the prior discussion, we pursue an instrumental variables (IV) estimator that exploits a plausibly exogenous update to the physician fee schedule in 2010 as an instrument. Dranove & Ody (2019) study this price shock in detail and present strong empirical evidence that the payment change affected physician-hospital vertical integration; however, since our analysis focuses on a different set of physicians in a different empirical context, we revisit some of their analysis here before presenting the IV results.

4.1 Institutional Background

To better understand the update to the physician fee schedule, recall that CMS pays physicians an administratively set fee based on the relative value units (RVUs) of each service. There are three RVUs for any given procedure or service: 1) a work RVU, which is an estimate of the cost of the physician's work for each service; 2) a malpractice RVU, which is an estimate of the malpractice costs for each service; and 3) a practice expense RVU, which is an estimate of the practice expenses for each service and may differ depending on the location of the service (e.g., a physician's office versus outpatient facility). The practice expense RVU is further split into direct and indirect expenses, where the indirect expenses are calculated as some percentage of direct expenses. CMS then takes the sum of these three RVUs and multiplies by an RVU-to-dollar conversion factor in order to find the final dollar figure for each service.

Prior to 2010, CMS relied in-part on the American Medical Association's (AMA's) Socioeconomic Monitoring System survey to calculate the indirect/direct cost ratios in the practice expense RVUs. This information was eventually perceived as outdated, and in 2007-2008, CMS deployed a new survey to update their indirect/direct cost estimates. This new survey was the Physician Practice Information Survey (PPIS). As highlighted in Dranove & Ody (2019), the PPIS acts as a shock to the payment differential between services provided in an office versus facility setting. Acquiring physician practices, and thus exploiting the payment differentials between office and facility settings, became more or less attractive to hospitals due to the PPIS.

4.2 Calculation of PPIS Price Changes

Following Dranove & Ody (2019), we measure the price changes due to PPIS in two steps. First, we construct the price change relative to the baseline 2009 price, separately for facility and non-facility (e.g., office-based) payments and separately for each HCPCS code, c. We denote these price changes by $\Delta p^c_{f,t} = p^c_{f,t} - p^c_{f,2009}$ for facility payments and $\Delta p^c_{nf,t} = p^c_{nf,t} - p^c_{nf,2009}$ for non-facility payments.[19] Second, we construct the relative price differential, $\Delta p^c_{r,t} = \Delta p^c_{f,t} - \Delta p^c_{nf,t}$, as the difference in price changes between facility and non-facility payments. This reflects the additional distortion in facility versus non-facility payments introduced by the PPIS.

We then aggregate $\Delta p^c_{r,t}$ up to the physician level based on the physician's count of office-based claims for HCPCS code c. We use 2008 claims for physician j in order to avoid additional endogeneity of claim counts due to the price changes, denoted by $q_{j(c),2008}$, and we weight this measure by 2008 non-facility prices. Finally, we normalize this total revenue change by the non-facility revenue in 2008. The resulting physician-level measure is:

$$\Delta \text{Revenue}_{j,t} = \frac{\sum_c \Delta p^c_{r,t} \times q_{j(c),2008} \times p^c_{nf,2008}}{\sum_c q_{j(c),2008} \times p^c_{nf,2008}}. \tag{4}$$

In constructing the quantities, $q_{j(c)}$, we exclude all HCPCS codes that appear to be "exclusive" to a non-facility setting, which we define as occurring over 90% of the time in a non-facility setting versus a facility setting. For consistency with Dranove & Ody (2019), we also calculate an analogous measure of the relative revenue increase due to a different change to the physician fee schedule phased in from 2007 to 2010. We refer to the revenue change from the 2007 price shock as $\Delta \text{Revenue}^{2007}_{j,t}$ and from the 2010 price shock as $\Delta \text{Revenue}^{2010}_{j,t}$, noting that the revenue change from the 2007 price shock is calculated relative to a 2006 baseline price while the 2010 price shock is calculated relative to a 2009 baseline price.[20]

4.3 Evaluating the PPIS as an Instrument

Figure 3 presents the mean $\Delta \text{Revenue}^{2010}_{j,t}$ from 2008 through 2015, separately for physicians that are vertically integrated at some point over our panel versus physicians that are never integrated.

[19] The PPIS price shock was introduced gradually from 2010 to 2013, with 1/4th of the full price differential introduced in 2010, 1/2 of the differential in 2011, 3/4ths of the differential in 2012, and the full payment differential in 2013.

[20] The 2007 price change offers very little identifying power in our analysis since we do not observe "new" vertically integrated physician-hospital pairs until 2011.

We see from the figure a clear diversion in the relative revenue gained from PPIS among vertically integrated and non-integrated physicians, which suggests that hospitals focused their acquisitions on physician practices with higher potential for revenue gains due to location-based payment differentials.

To examine this incentive more formally, we again follow Dranove & Ody (2019) and estimate a linear probability model of vertical integration for physician j as a function of $\Delta\text{Revenue}_{j,t}^{2010}$ and $\Delta\text{Revenue}_{j,t}^{2007}$, interacted with year dummies. In Figure 4, we present the point estimates and 95% confidence intervals for the coefficients on $\Delta\text{Revenue}_{j,t}^{2010}$ and year interactions. The results show an economically large and statistically significant increase in the probability of integration from the PPIS price shock.

Collectively, Figures 3 and 4 reveal a strong relationship between the PPIS and physician-hospital integration; however, the analysis thus far is at the physician level and largely ignores the hospital. To comport with our empirical analysis, we need an instrument at the physician-hospital level. We adapt the analysis for our setting in two steps.

First, we form the set of all possible physician-hospital pairs. We define this set, separately for each physician, as all hospitals to which a physician is observed to have operated throughout our panel. This set is time-invariant and therefore is not a source of endogeneity in our episode-level data with physician-hospital fixed effects. Second, we form the predicted probability of acquisition based on a logistic regression of the equation:

$$\begin{aligned} I_{jkt} = {} & \lambda_1 z_{jkt} + \lambda_2 \Delta\text{Revenue}_{j,t}^{2010} + \lambda_3 \Delta\text{Revenue}_{j,t}^{2007} \\ & + \lambda_4 z_{jkt} \Delta\text{Revenue}_{j,t}^{2010} + \lambda_5 z_{jkt} \Delta\text{Revenue}_{j,t}^{2007} + \omega_{jkt}, \end{aligned} \quad (5)$$

where I_{jkt} denotes an indicator for whether physician j is vertically integrated with hospital k at time t; and z_{jkt} denotes a vector of practice and hospital characteristics, including practice size, average experience among physicians in the practice, an indicator for multi-specialty practice, number of staffed hospital beds, for-profit ownership of the hospital, teaching status, and hospital system membership. We also include the physician-level differential revenues from the 2007 and 2010 price shocks, and we interact these price shocks with all physician and hospital characteristics. We estimate this equation separately in each year t.

With estimates of λ, we denote the predicted probability of physician j being vertically integrated with hospital k as $\hat{I}_{jkt}$. We then employ $\hat{I}_{jkt}$ as a generated instrument for the vertical integration indicator in Equation 3. We summarize the results of this procedure in Figure 5, which presents the differential predicted probability of vertical integration for a given physician-hospital pair from 2008 to 2015. Specifically, we present $\frac{1}{N_{jk}} \sum_{jk} \left(\hat{I}_{jkt} - \hat{I}_{jk,2008} \right)$, separately between integrated and non-integrated physician-hospital pairs. As is clear from the graph, our predicted probability of vertical integration is much higher for those pairs that are actually observed to be integrated, and the differential probability of integration only deviates between the two groups once the PPIS begins to be phased in starting in 2010.

Finally, note that our empirical application examines the effects of vertical integration on episode spending for elective inpatient stays. Such inpatient stays are not directly affected by our instrument since the set of procedures in our data generally cannot be provided in an office setting. This feature, combined with the previous discussion and results in Figures 3–5, offer compelling support for the use of the 2010 PPIS price shock as a plausibly exogenous source of variation in physician-hospital vertical integration.

5 Net Effect of Vertical Integration on Amount of Care

We employ the predicted probability of integration as an instrument for observed integration, which yields a first-stage F-stat of over 350. We present the IV estimates in Table 4, with results for log charges in column 1, log payments in column 2, and number of claims in column 3. We estimate an increase in spending of nearly 7% among vertically integrated physician-hospital pairs; however, as discussed below, this point estimate is on the higher end of estimates across various alternative specifications and samples. We also estimate a large reduction of nearly 17 claims per episode following vertical integration. This estimate reflects a 23% reduction in claims given an average of 74 claims per episode. Collectively, these baseline results suggest an increase in spending per episode alongside a large reduction in the number of claims per episode. This pattern of results is consistent with an increase in spending per claim (due to a movement from office-based physician visits to outpatient facilities) which is offset by a reduction the total number of claims. We investigate this pattern in more detail in Section 6.

The magnitudes of our estimates are also reasonable given the known payment differentials between office-based visits versus outpatient settings. For example, Medicare pays more than double for a routine office visit performed in an outpatient setting versus an office-based setting. The payment differential is even larger for other services, such as MRI or endoscopy.

We also present a specification curve in Figure 6 that shows the results of several alternative specifications. First, note that our main specification underlying Table 4 includes an indicator for integration of the physician-hospital pair as well as an indicator for whether the hospital owns *any* physician practice. We include the latter term because non-integrated physicians continue to operate at hospitals that have acquired other practices, and similarly, physicians integrated with a given hospital may still operate in other hospitals in the same time period. The hospital-level measure of integration is nonetheless highly correlated with integration specifically for a given physician-hospital pair. We therefore re-estimate results when excluding the hospital-level vertical integration measure, with estimates reflected in the specification labeled as "Base" in Figure 6.

Second, we consider the role of hospital quality by including quality measures as additional covariates—the intuition being that vertical integration may be correlated with quality, which is also correlated with our utilization measures. One concern with this specification is that quality itself may be an outcome of vertical integration, so it is not clear that such quality measures should be included as covariates. Nonetheless, for completeness, we re-estimate our main specification when including quality measures as covariates, as reflected in the specification labeled as "Quality" in Figure 6.

Third, we consider several alternative sample restrictions. Our concern is that, while we restrict the analysis to episodes initiated by a planned, elective inpatient stay, there remains a wide variety of different procedures and thus physician types in our final dataset. In our alternative samples, we consider restrictions on the number of episodes per physician-hospital pair, thereby focusing on relatively more "familiar" physician-hospital pairs (i.e., excluding physician-hospital pairs with very few interactions over time). We also consider explicit restrictions on the types of surgeries, where we focus only on orthopedic conditions (spinal fusion and joint replacements) with DRGs 460, 461, 462, 469, and 470. The DRG restrictions are reflected in the specification curve with the "DRGs" label. Finally, as an additional form or risk adjustment, we restrict the sample to only patients that are discharged to home in the initial inpatient stay, as reflected by the label "Home" in the specification curve.

We estimate effects separately across all combinations of specifications and sample restrictions. The top panel of Figure 6 presents our specification curve for episode payments, and the bottom panel presents the specification curve for number of claims in the episode. In both cases, the highlighted dot denotes our estimates from the main specification in Table 4. The figure offers some reassurance that the findings from our preferred specification are robust to a range of specification/sample restriction combinations. In terms of spending, our estimates in Table 4 are on the higher end of the range of estimates, suggesting smaller increases in spending among more frequently-occurring physician-hospital pairs. The theme from both figures nonetheless remains—we find some evidence of an increase in Medicare payments and consistent evidence of a sizeable reduction in number of claims per episode following vertical integration.

6 Reallocation of Care across Treatment Settings

Our estimated effects of vertical integration on Medicare payments in Table 4 and Figure 6 are small relative to other studies. For example, Koch *et al.* (2017) estimate an increase in outpatient expenditures of at least 18% among vertically integrated physicians, with some estimates as high as 50%. As highlighted in Section 2, one potential explanation for this difference is that surgeon-hospital integration in our clinical context leads to a reallocation of treatment to the acquiring hospital and a substitution of office visits with outpatient centers, but an overall reduction in total claims. The first two effects will tend to increase spending to a specific hospital or physician, but when combined with the third effect, changes in episode spending could be smaller or even negative.

Empirically, these different responses would tend to manifest as heterogeneous effects of vertical integration both within and across episodes. Within an episode, there may be increases in outpatient spending but decreases in other professional services. Across episodes, we anticipate the greatest opportunity for offsetting behavior is among otherwise high-utilization episodes. We consider each of these dimensions of heterogeneity throughout the remainder of this section.

6.1 Heterogeneity within Episodes

We split our episodes into five components: 1) inpatient claims (after the initial procedure); 2) facility-based outpatient claims; 3) professional services claims, including labs and imaging; 4) SNF claims; and 5) home health care claims. For each component, we re-estimate Equation 3 using IV as explained in Section 4. Results are summarized in Table 5, where we present results both for log payments and the count of claims.

Note that, while our spending outcomes are measured in logs, the levels of spending differ substantially across categories. For example, total Medicare spending per episode averages $22,600. The bulk of this amount is for the initial inpatient stay. Average inpatient spending after the initial inpatient stay is $2,273; average outpatient spending in the episode is $1,800; average spending on professional services is $5,055; and average spending on SNFs is about $1,000, similarly for home health. A very small fraction of episodes (4.6%) incur $0 additional spending in office-based professional services and facility-based outpatient care beyond the initial inpatient stay.

Consistent with Koch *et al.* (2017), we estimate relatively large and statistically significant increases in outpatient spending following vertical integration. Specifically, our estimate on log spending suggests an increase of nearly 26% in outpatient spending among vertically integrated physician-hospital pairs, but we estimate a similarly large *reduction* of 37% in spending on professional services. Our results for number of claims mirror those for spending. We also estimate a large increase of nearly 60% on home health care.

We stress, however, that our IV estimator reflects local treatment effects among potentially different sets of physician-hospital pairs across the different components of an episode (Heckman *et al.*, 2006). In context, the marginal physician-hospital pair for whom integration affects outpatient spending may be different than the marginal physician-hospital pair for whom integration affects spending on professional services. It is therefore difficult to directly compare the IV estimates across the components of an episode, particularly since our instrument is based specifically on the gain to facility-based services (reflected in our outpatient component) due to the 2010 CMS price shock. That said, we suspect that the physician-hospital pairs most affected in terms of outpatient spending are similar to the set of physician-hospital pairs most affected in their spending on office-based professional services. As such, we conclude from Table 5 that the increase in facility-based outpatient payments is largely offset by a decrease in spending on office-based professional services.

Given the estimated reduction in professional services, we also investigate heterogeneities in the timing of professional services (i.e., before the admit, during the initial inpatient stay, or post-discharge) and the type of service claim (i.e., evaluation and management, lab, imaging, etc.). Results are summarized in Table 6. We estimate the largest reduction in claims coming after discharge, where we find nearly 9 fewer claims on average among integrated physician-hospital pairs. We also estimate a reduction of around 6 claims within the initial inpatient stay, and a reduction of 3 claims in the 30 days prior to the operation.

In the bottom panel of Table 6, we categorize each observed claim as either "evaluation and management" (E&M), imaging, labs, or other, and we then estimate Equation 3 with IV using the count of each category of claims within an episode. We estimate about 4.5 fewer E&M claims, 3 fewer laboratory claims, 3 fewer imaging claims, and about 7.5 fewer "other" claims. On a base of 22 E&M claims per episode, 14 lab claims, 10 imaging claims, and 22 other claims, our estimates for imaging and labs reflect much larger relative reductions compared to all other claim types.

6.2 Heterogeneity across Episodes

In this section, we examine potential heterogeneities in estimated effects along the distribution of our outcomes of interest.[21] Specifically, we estimate unconditional quantile regressions using the same empirical specification as in Equation 3 (Firpo *et al.*, 2009; Borgen, 2016). We present results in Figure 7, with results for Medicare spending in the top panel and claims in the bottom panel. Each panel in Figure 7 shows the point estimate and 95% confidence interval of physician-hospital integration on the outcome of interest at the relevant quantile.

The top panel of Figure 7 shows little variation in estimated effects on Medicare spending. Conversely, the bottom panel shows that the largest effects on number of claims arise for episodes in the highest claim quantiles. This pattern of results is again consistent with offsetting behaviors within an episode, where the largest opportunity for reduction in claims would come from otherwise high-utilization episodes.

7 Hospital Influence on Physician Referrals

Our results in Sections 5 and 6 reveal two important findings. First, vertical integration leads to a net increase in Medicare spending for the episode. Second, the increase in spending derives in large part from an increase in claims in the outpatient setting which, due to Medicare reimbursement

[21]Since the time frame of our analysis slightly overlaps with the adoption of Medicare bundled payments, and since the bundled payment program largely affects orthopedic procedures, hospital participation in bundled payments is a natural source of heterogeneity across hospitals in our application. Using indications in the claims data regarding bundled payment eligibility, our IV estimates suggest that episodes initiated as part of the bundled payment program were associated with about 18 fewer claims per episode, compared to a reduction of 14 claims among episodes not part of the bundled payment program. These results do not suggest that bundled payments play a meaningful role in our overall estimates.

policies, are reimbursed at a higher rate than identical services in a physician's office; however, this increase is largely offset by a sizeable reduction in claims for professional services. The remaining increases in spending derive from increases in home health care services.

While these are important findings from a policy-perspective, the results do not yet identify the underlying mechanism of the decrease in professional services claims. In the context of our theoretical framework in Section 2, the question is whether the reduction in services comes from a reduction in the physician's marginal revenue or from a change in the incentives associated with visits to other integrated versus non-integrated physicians. The former will be associated with a reduction in visits to the operating physician, while the latter will be associated with a reduction in visits to other non-integrated physicians outside of the hospital system. To address this question, we begin by identifying all providers visited within each episode and examining the relative frequency in which those providers are associated with the same hospital system. Specifically, we form an indicator set to 1 if the physician NPI in any given claim is part of a practice that is also owned by the same hospital system, and we count all such claims in the episode. We do this separately by outpatient and office settings, and separately by whether the claim is associated with the same physician as the operating physician or with some other vertically integrated physician.

We present results in Table 7, where we find that the overall reduction in professional services claims comes almost entirely from non-integrated providers. Specifically, we estimate that vertical integration leads to a very modest decrease of 0.3 claims going to the same operating physician, an increase of nearly 3 claims to other vertically integrated providers, and a large decrease of nearly 20 claims associated with other non-integrated providers. To aid the interpretation of these results, we also present estimates of the effects on payments (in dollars). These results show that the increase in claims to vertically integrated physicians generates nearly $2,000 in additional revenue for the acquiring hospital (assuming the hospital is the residual claimant on all such claims), which is offset by a reduction of nearly the same amount in spending to non-integrated providers.

These results show that patients are much more likely to stay "in the system" throughout the episode of care when the episode is initiated by a vertically integrated physician-hospital pair. This adjustment to referral patterns significantly increases the revenue for the vertically integrated system while similarly decreasing revenue to other non-integrated providers. Moreover, since the number of claims and spending associated with the initiating physician remains largely unchanged, we conclude from this analysis that vertical integration does little to affect the average physician's own billable activity effort *within an episode* (i.e., on the intensive margin). In the context of our framework in Section 2, the replacement of $R_j(y_{ijk})$ with $\bar{R}$ in the physician's optimization problem does not appear to have a major effect on patient treatment patterns conditional on a given surgery. Instead, changes to care within the episode derive almost entirely from reductions in visits to non-integrated providers. Combined with our reallocation results in Section 6, we conclude that vertical integration is a strong mechanism by which hospitals appear to gain influence over health care delivery within an episode.

As an additional analysis, we focus specifically on professional services claims in order to investigate the similarity between a recently acquired physician and their previously-acquired peers at the same hospital. The purpose of this analysis is to further assess the extent to which hospitals appear to influence physician behavior. While gauging such "similarity" is difficult with claims data, we measure similarity by comparing observed episodes of physicians at time t to average episodes (for the same hospital) of integrated physicians in year $t-1$. To construct our outcome measure, we take the square difference between the count of professional services claims for a given episode and the mean count among all episodes for physicians integrated with the same hospital in the prior year. The log of this difference is the outcome of interest. The key independent variable is again an indicator for whether the physician is integrated with hospital k, but in this case, we limit the analysis to physicians that were not integrated at time $t-1$. Therefore, at each time t, the sample consists either of physicians that are not integrated with hospital k or of physicians that are newly integrated with hospital k in that year. We estimate a 95% confidence interval of $[-0.515, -0.046]$ for the effect of vertical integration on this measure of "similarity." In other words, newly-acquired physician practices become between 5% and 52% more similar (with regard to the count of professional services claims) to previously-acquired physicians compared to non-integrated physicians.

Finally, in Table 8, we broaden our measure of physician effort and estimate the effects of integration on total physician-level spending and number of claims. Similar to our prior results, we estimate a large reduction in office-based claims. About 38% of this drop in office-based claims is substituted with claims in an outpatient setting, again reflecting the extra reimbursements due to hospitals from such billing practices; however, the bulk of the reduction in office-based claims is not offset, suggesting that surgeons' billable activity indeed decreases after integration. On a base of nearly 280 total claims per year per physician, we estimate a reduction in effort of around 15%, coming almost entirely from a reduction in office visits. Nonetheless, because outpatient visits are reimbursed at a higher rate, this reduction in visits does not translate to a reduction in Medicare payments for care provided directly by the acquired physician.

8 Discussion

By vertically integrating with physician practices, hospitals and physicians become more financially integrated and to some degree share in the combined profits from hospital care and physician services—though not necessarily in a well-defined and easily contracted way. Compared to an independent or group practice not otherwise owned by a hospital system, vertical integration introduces potential pressure from the hospital system for a physician to change their treatment patterns to better align with the preferences and financial interests of the hospital. Some of these pressures may be purely cost reducing, such as adopting a standard medical device across physicians for a given procedure (Craig *et al.*, 2018); however, other pressures may increase treatment intensity or reallocate care to different and higher reimbursing settings. Any such influences are also taking place against a backdrop of the newly formed employer-employee relationship, which can change physician incentives for billable activity effort, irrespective of hospital motivations or actions. The net effect of these different and sometimes opposing forces is consequently an empirical question.

In this paper, we use Medicare FFS claims from a 20% sample of Medicare beneficiaries to construct measures of spending and utilization for 90-day episodes of care. We focus our analysis on the effects of vertical integration between physicians and hospitals on episode-level spending and utilization. Our preferred results are those from an instrumental variables analysis in which we exploit a plausibly exogenous price shock to physician fee schedules in 2010 as an instrument for downstream physician-hospital vertical integration. Using our IV estimates, we estimate net increases in Medicare spending within an episode alongside large reductions in total number of professional claims, which indicate less intensive treatment bundles, on average, after hospital-physician integration.

We consider our results in the context of the existing literature by first splitting our episodes into their inpatient, outpatient, SNF, home health, and professional services components. With this analysis, we find large increases in outpatient spending, consistent with the reallocation of patients across care settings documented in Koch *et al.* (2017), as well as large relative increases in spending on home health—though this is from a low base. We also estimate large decreases in spending on professional services, the net effect of which is to offset most of the mechanical increases in outpatient spending due to favorable site-of-care differentials tied to Medicare payment rules. The largest reduction in professional services comes from post-discharge care, where we estimate a reduction of nearly 9 claims on average.

Turning specifically to the issue of hospital influence following the acquisition of their practice, we investigate changes in referral patterns for vertically integrated physicians. Here, we find strong evidence that vertical integration shapes referral patterns within an episode, wherein patients are much more likely to visit another integrated physician practice under common hospital ownership when the episode is initiated by a vertically integrated physician-hospital pair. This is consistent with hospitals exercising more influence over treatment patterns for additional financial gain—approximately $2,000 on average in our analyses. The focal surgeons do not strongly increase or decrease their own billable activity per episode following hospital ownership, but instead, our evidence reveals that the reduction in professional service activity estimated in our main results entirely localizes to other, non-integrated physicians. These declines are evident before, during, and after the index hospitalization for surgical treatment, and the lower levels of utilization span all domains of care (e.g., physician visits, laboratory tests, and imaging). Our estimates therefore do not suggest that hospital-owned physicians systematically limit a certain type of care nor do they indicate that intertemporal substitution of services (e.g., due to provider "congestion" within vertical structures) can easily explain our collection of results. Instead, our findings are more consistent with newly-integrated physicians conforming to the practice patterns of their already-integrated and less-intensive peers. The resulting reduction in episode treatment intensity consequently shields Medicare from the full spending increases that its payment policies would otherwise predict. That said, Medicare is simultaneously paying more over the 90-day window for beneficiaries to receive substantively less care, which implies a foregone savings opportunity for the public insurance program and taxpayers if a site-neutral payment regime were implemented. In other words, even if the services now absent from the episode post-integration were uniformly inefficient ("low-value") care, Medicare has effectively failed to capture any of the savings. At the same time, hospitals' inability to preserve the overall episode treatment intensity and redirect those additional services to its employed providers and owned assets (e.g., imaging and other diagnostic technology) means that these firms either choose not to or are unable to fully align physician behavior with a hospital revenue maximization objective.

Finally, we find no evidence of an effect of vertical integration on quality, measured using readmission rates, mortality rates, or incidence of complications following our clinical episodes of interest. Our key contribution is therefore to show the net effect of favorable Medicare financial incentives from formal hospital-physician integration when treatment episodes can be well-defined and hence allow for the combination of reimbursement changes as well as changes in care quantities. Hospitals successfully capture new revenue streams by becoming the residual claimant on care provided by the newly owned physician and shifting some of their referrals toward other providers within the overarching firm. This is consistent with strategic behavior, rather than improved care delivery motivations, as the key driver of hospitals' acquisitions of physician practices. Our findings, coupled with other known effects of vertical integration (e.g., increased bargaining power and higher prices), encourage greater attention by regulators and antitrust authorities.

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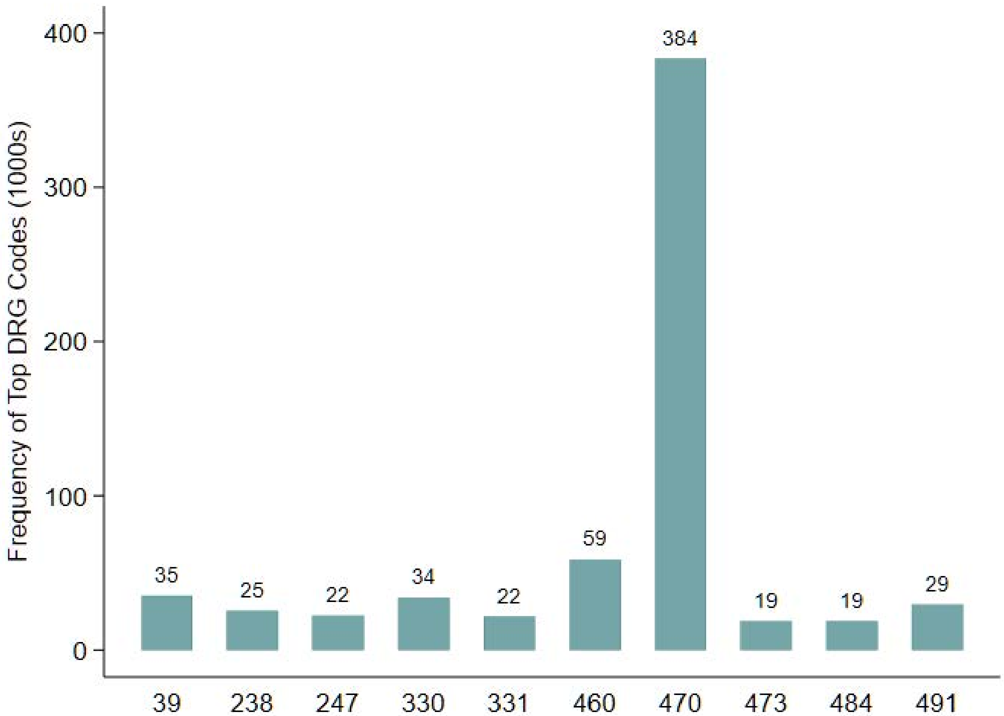
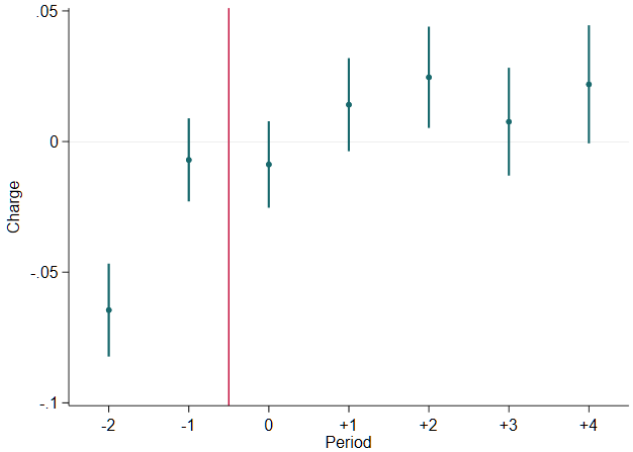
Tables and Figures

Figure 1: Top 10 DRGs

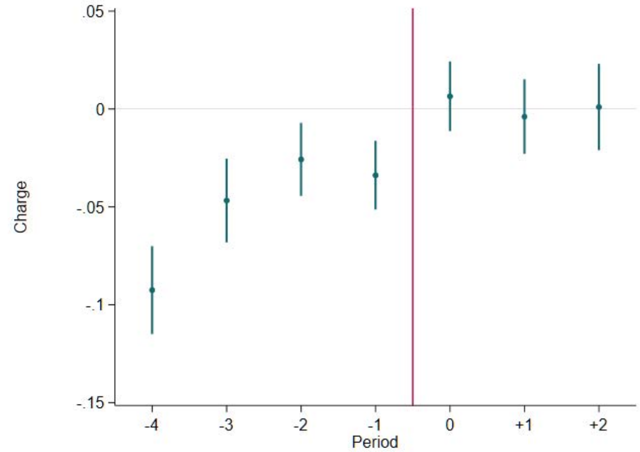


Note: Frequency of most common DRGs associated with the initial inpatient stay of an episode. For a comprehensive list of DRGs and descriptions, see http://data.nber.org/drg/drgdesc11.pdf.

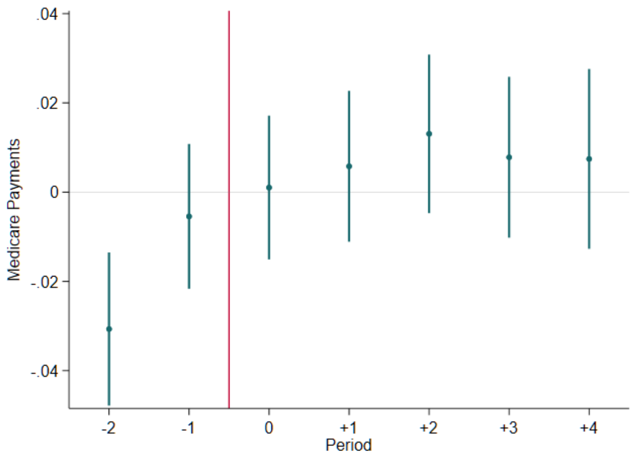
Figure 2: Event Studies



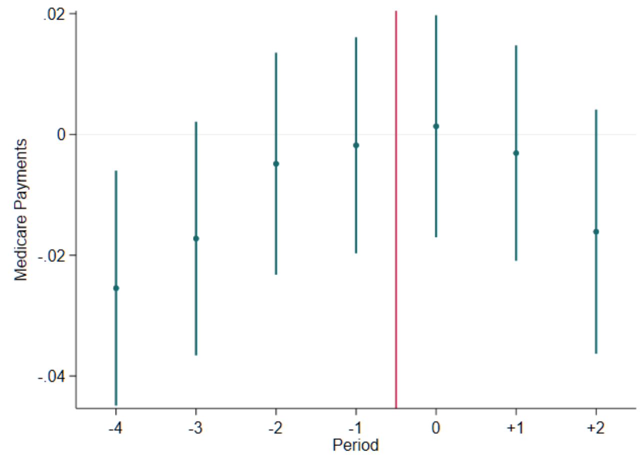
a. Charges, 2011 treatment



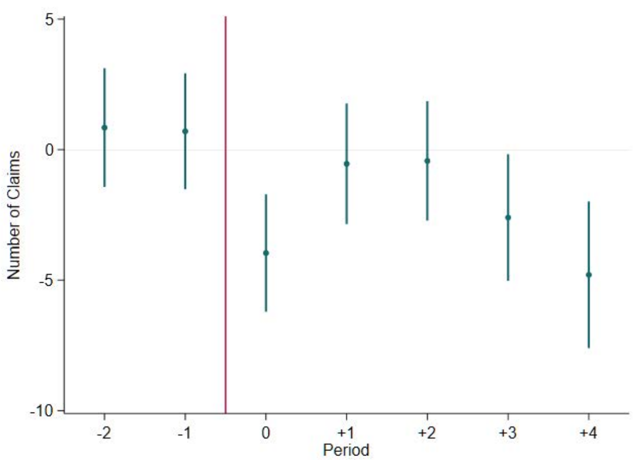
b. Charges, 2013 treatment



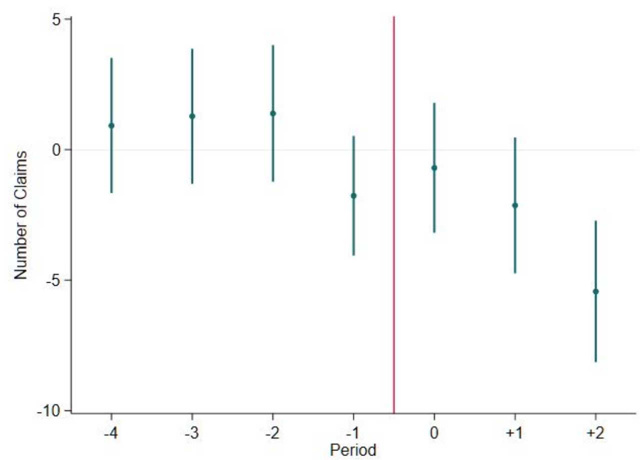
c. Medicare payments, 2011 treatment



d. Medicare payments, 2013 treatment



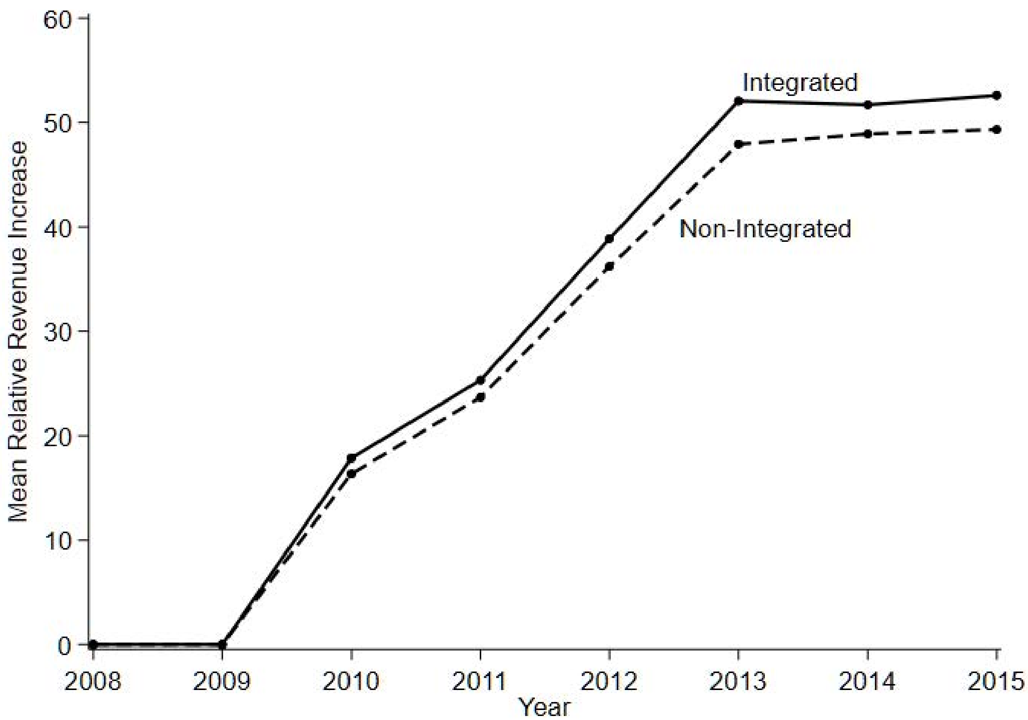
e. Number of claims, 2011 treatment



f. Number of claims, 2013 treatment

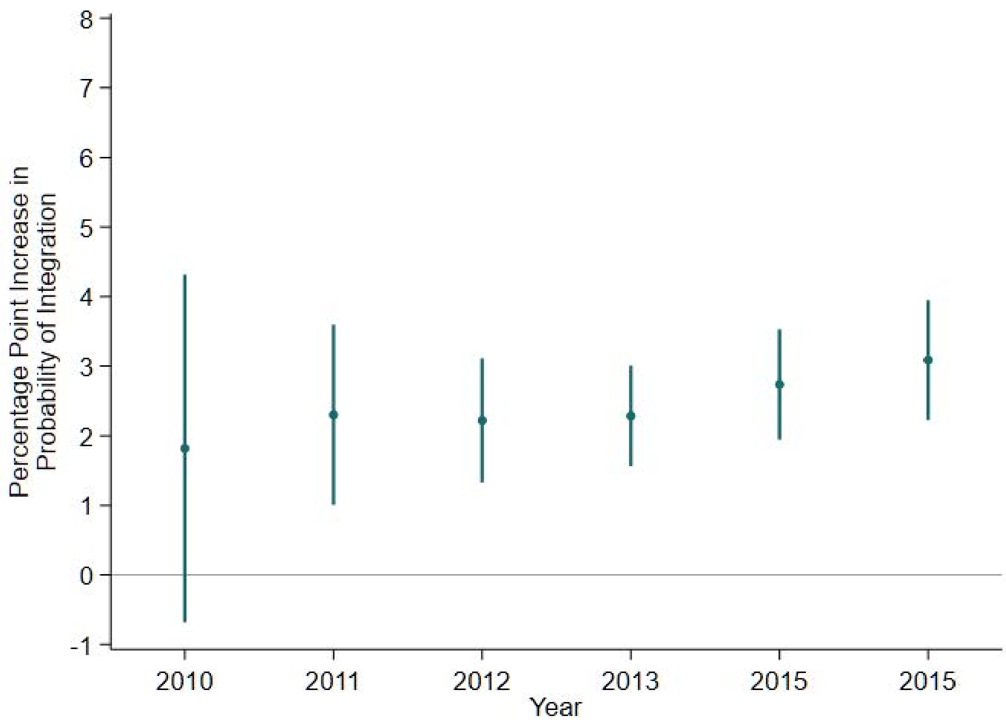
Note: Figures present the results of an event study based on Equation 3 and adding interactions between year dummies and integration status. The excluded year in panels (a), (c), and (e) is 2010, and the excluded year in panels (b), (d), and (f) is 2012.

Figure 3: Physician-level PPIS Relative Revenue Change



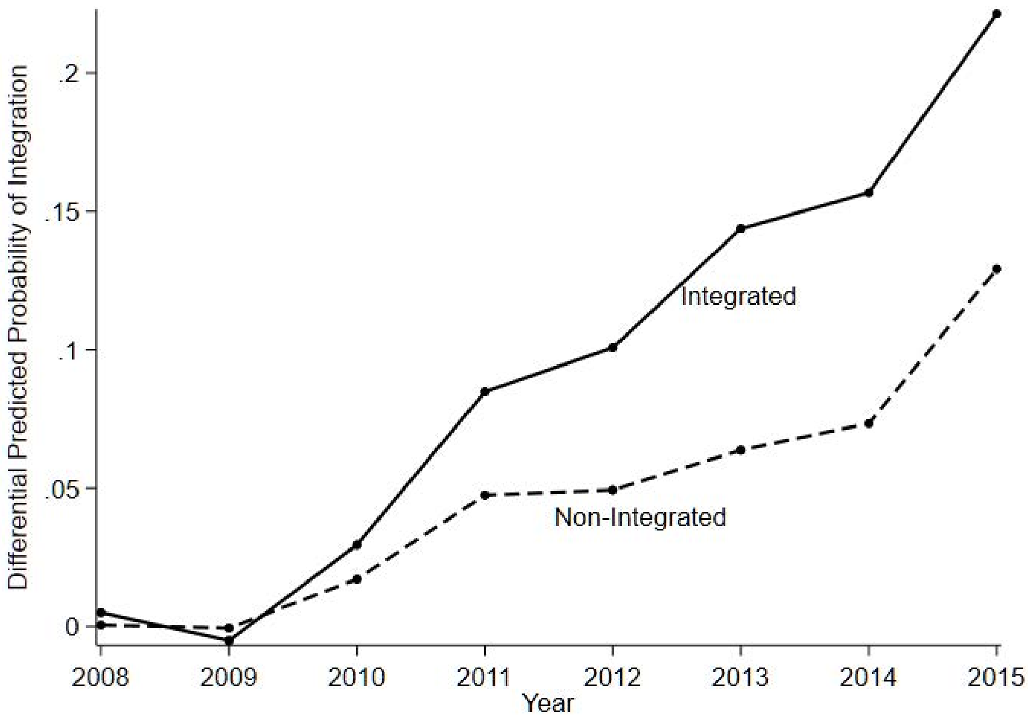
Note: Mean revenue change calculated from Equation 4 in the text. "Integrated" denotes physicians that are vertically integrated at some point over our panel, and "non-integrated" denotes physicians that are never integrated in our data.

Figure 4: Estimates from LPM of Vertical Integration



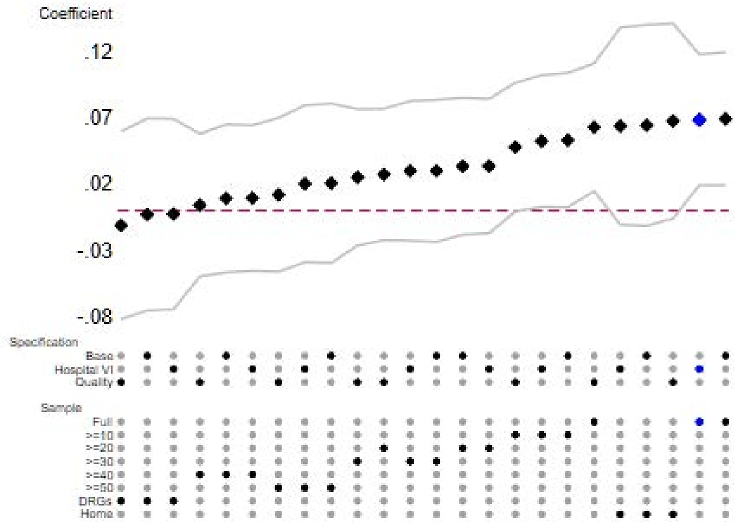
Note: Point estimates and 95% confidence intervals for the coefficients on $\Delta\text{Revenue}_{j,t}^{2010} \times 1(t)$ based on a linear regression of physician integration on $\Delta\text{Revenue}_{j,t}^{2007}$, $\Delta\text{Revenue}_{j,t}^{2010}$, year dummies, and interactions of year dummies on the revenue change variables, $\Delta\text{Revenue}_{j,t}^{2007} \times 1(t)$ and $\Delta\text{Revenue}_{j,t}^{2010} \times 1(t)$. The revenue change variables are defined explicitly in Equation 4.

Figure 5: PPIS as an IV for Physician-Hospital Integration

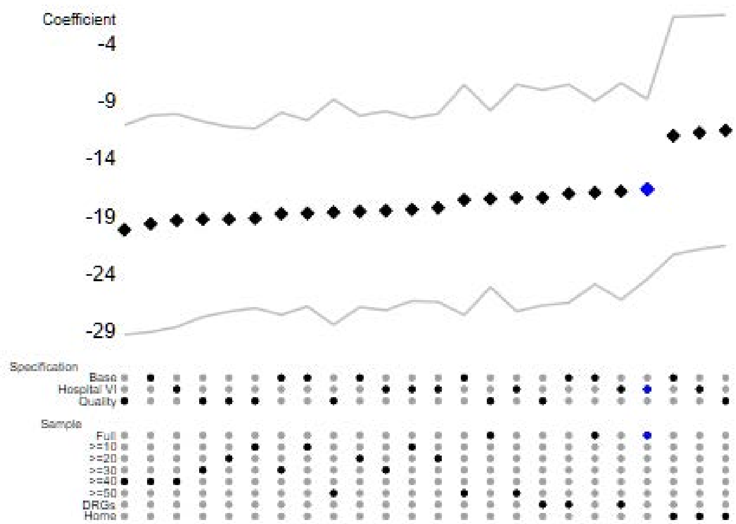


Note: Predicted probability of integration (less the baseline prediction in 2008) from a logistic regression of physician-hospital integration on the revenue change variables and other covariates discussed in Equation 5. "Integrated" denotes physician-hospital pairs that are vertically integrated at some point over our panel, and "non-integrated" denotes physician-hospital pairs that are never integrated in our data.

Figure 6: Specification Curves for IV Estimates



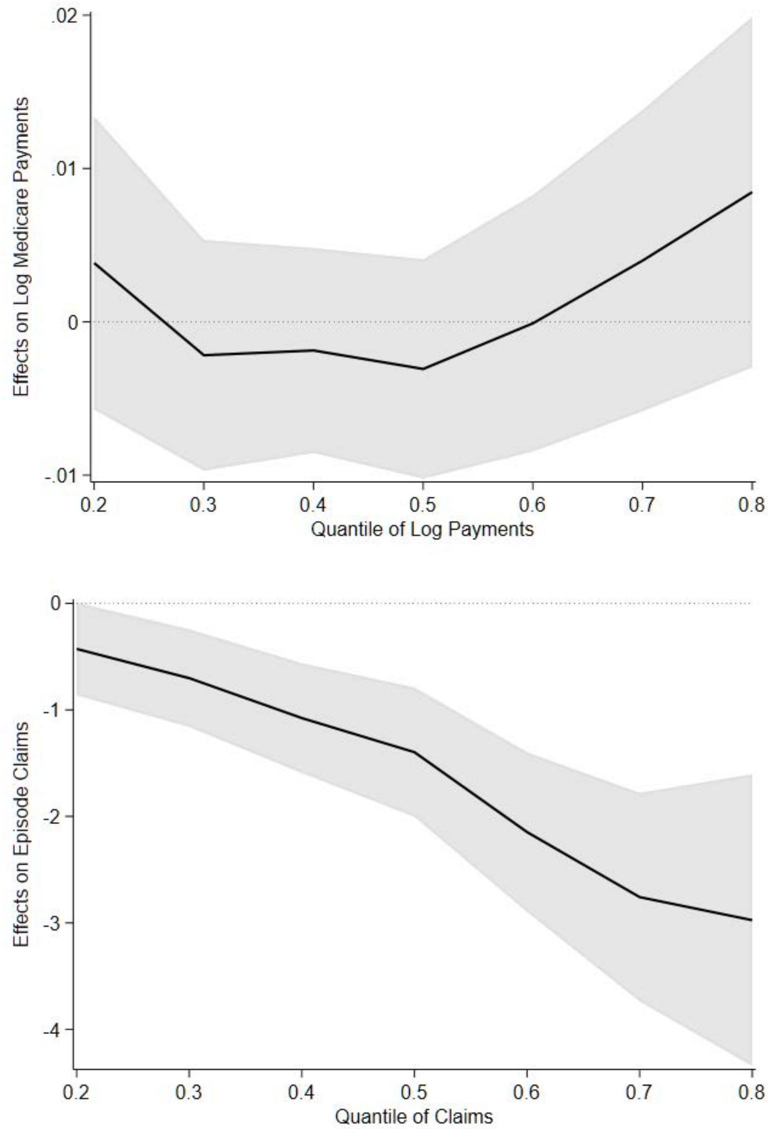
a. Episode payments



b. Number of claims

Note: Point estimates and 95% confidence intervals for the coefficient on physician-hospital vertical integration estimated using IV. "Base" denotes a specification without adjusting for hospital-level vertical integration or quality of care in an episode; "Hospital VI" denotes a specification that includes an indicator for hospital-level vertical integration (the preferred specification presented in the text); and "Quality" denotes a specification that includes an indicator for within-episode mortality as an additional control variable. "Full" denotes the full sample, which is the sample underlying the results in the main text; ">= 10" through ">= 50" denote restrictions on the minimum number of episodes per physician-hospital pair in the estimation sample; "DRGs" denotes the sample that is restricted to orthopedic procedures only; and "Home" denotes a sample that is restricted to patients discharged to home. The code for our specification curves was adapted from Hans S. Sievertson, who kindly made his code available at github.com/hhsievertsen/speccurve.

Figure 7: Quantile Regression Results for Total Payments and Claims



Note: Estimates and 95% confidence intervals for the coefficient on vertical integration from unconditional quantile regressions of log Medicare payments and number of claims (Firpo *et al.*, 2009; Borgen, 2016).

Table 1: **Descriptive Statistics per Episode**[a]

	2008	2009	2010	2011	2012	2013	2014	2015	Total
Charges	82,680	89,734	95,219	100,714	108,284	115,000	121,684	125,683	102,931
	(67,388)	(73,218)	(77,918)	(81,715)	(87,210)	(92,553)	(98,267)	(100,556)	(85,232)
Medicare Payments	22,256	23,363	24,094	24,636	25,362	25,975	26,798	27,037	24,734
	(15,913)	(17,076)	(17,513)	(17,797)	(18,169)	(18,114)	(18,137)	(18,208)	(17,624)
Log Charges	11.06	11.15	11.21	11.26	11.34	11.41	11.47	11.50	11.28
	(0.712)	(0.709)	(0.706)	(0.704)	(0.690)	(0.680)	(0.676)	(0.673)	(0.711)
Log Payments	9.785	9.823	9.850	9.874	9.902	9.942	9.998	10.01	9.888
	(0.689)	(0.709)	(0.723)	(0.724)	(0.734)	(0.707)	(0.646)	(0.639)	(0.704)
Claims	71.54	72.79	73.48	71.48	75.74	77.33	78.50	75.16	74.30
	(88.30)	(87.12)	(88.35)	(89.14)	(87.81)	(85.74)	(85.06)	(79.88)	(86.89)
% Mortality	4.15%	3.88%	3.96%	3.86%	3.97%	3.68%	3.48%	3.34%	3.83%
% Readmission	19.2%	18.7%	18.4%	17.9%	17.3%	16.4%	15.9%	15.6%	17.6%
% Sepsis	2.04%	2.04%	2.13%	2.16%	2.23%	2.24%	2.38%	2.09%	2.16%
% SSI	1.69%	1.67%	1.69%	1.70%	1.67%	1.67%	1.67%	1.40%	1.66%
% Any Complication	3.49%	3.45%	3.58%	3.59%	3.66%	3.63%	3.76%	3.24%	3.56%
% Integration	14.1%	14.8%	15.2%	20.0%	21.3%	24.5%	26.6%	33.7%	20.3%
N	227,313	208,538	206,888	203,188	196,455	185,778	173,257	125,554	1,526,971

[a]Mean values by year calculated across all episodes, with standard deviations in parenthesis. In order to allow for a full 90-day episode, we exclude all episodes initiated after September 2015.

Table 2: **Descriptive Statistics per Physician**[a]

	2008	2009	2010	2011	2012	2013	2014	2015	Total
Episodes	5.256	4.923	4.860	4.923	4.929	5.003	5.002	4.149	4.904
	(5.990)	(5.736)	(5.758)	(5.890)	(5.958)	(6.194)	(6.263)	(5.026)	(5.883)
Practice Size	11.66	12.02	12.49	13.22	14.48	14.43	14.74	14.45	13.33
	(26.01)	(24.67)	(23.62)	(23.50)	(25.12)	(23.36)	(22.69)	(21.33)	(23.98)
Experience	22.58	22.46	22.31	23.36	23.03	23.96	23.72	24.79	23.18
	(6.447)	(6.387)	(6.432)	(6.710)	(6.646)	(6.863)	(6.831)	(6.846)	(6.674)
% Female	0.108	0.105	0.111	0.112	0.113	0.113	0.110	0.111	0.110
	(0.201)	(0.197)	(0.204)	(0.204)	(0.202)	(0.199)	(0.192)	(0.191)	(0.199)
% with PCP	3.52%	3.27%	3.41%	3.63%	3.18%	2.72%	2.46%	2.13%	3.10%
% Multi-specialty	25.3%	25.6%	26.4%	23.5%	24.8%	26.6%	28.4%	35.0%	26.6%
% Surgery Center	47.5%	48.9%	48.4%	52.5%	52.7%	53.3%	53.3%	48.2%	50.5%
% Independent	47.7%	47.6%	47.1%	46.1%	44.8%	43.5%	40.8%	32.9%	44.4%
% Integrated	15.1%	15.7%	16.6%	21.6%	23.2%	26.4%	28.8%	36.6%	22.3%
N	43,248	42,361	42,571	41,276	39,856	37,134	34,641	30,263	311,350

[a]Mean values by year calculated across unique physicians, with standard deviations in parenthesis. In order to allow for a full 90-day episode, we exclude all episodes initiated after September 2015.

Table 3: **Descriptive Statistics per Hospital**[a]

	2008	2009	2010	2011	2012	2013	2014	2015	Total
Episodes	63.42	59.21	58.31	58.00	55.81	53.29	50.75	38.31	54.82
	(90.82)	(84.86)	(83.14)	(82.35)	(79.90)	(75.71)	(73.42)	(55.26)	(79.35)
Physician FTE	24.65	25.67	27.34	28.91	29.32	32.55	32.80	34.46	29.40
	(100.3)	(106.4)	(107.9)	(110.0)	(111.5)	(123.9)	(122.7)	(122.3)	(113.3)
Resident FTE	26.30	26.90	27.57	29.10	29.55	30.60	32.30	33.23	29.40
	(109.3)	(112.7)	(115.7)	(118.5)	(122.8)	(124.2)	(130.2)	(133.2)	(120.9)
Nurse FTE	351.1	360.8	365.5	374.1	379.3	385.2	401.6	426.5	380.0
	(449.0)	(461.3)	(467.5)	(482.7)	(493.0)	(499.7)	(528.8)	(566.3)	(494.5)
Other FTE	771.4	771.7	770.3	790.6	789.4	794.6	808.0	851.8	792.9
	(982.8)	(980.4)	(978.2)	(1,028)	(1,046)	(1,094)	(1,124)	(1,193)	(1,054)
Beds (100s)	2.033	2.040	2.033	2.059	2.038	2.040	2.062	2.113	2.052
	(2.158)	(2.144)	(2.146)	(2.151)	(2.162)	(2.149)	(2.206)	(2.289)	(2.175)
% For-profit	18.5%	19.7%	20.2%	20.6%	21.0%	21.2%	21.3%	21.3%	20.5%
% System	58.5%	60.0%	60.7%	62.3%	63.8%	65.4%	67.5%	69.5%	63.4%
% Major Teaching	7.70%	7.92%	7.78%	8.16%	7.36%	7.46%	7.12%	7.72%	7.65%
% Integrated	35.4%	35.2%	37.7%	42.0%	43.2%	45.6%	51.0%	58.2%	43.4%
N	3,584	3,522	3,548	3,503	3,520	3,486	3,414	3,277	27,854

[a]Mean values by year calculated across unique hospitals, with standard deviations in parenthesis. In order to allow for a full 90-day episode, we exclude all episodes initiated after September 2015.

Table 4: **Instrumental Variables Estimates**[a]

	Log Charges	Log Payments	Number of claims
Integrated with Hospital k	0.123***	0.069***	-16.659***
	(0.030)	(0.025)	(3.979)
Any Hospital Integration	-0.010***	-0.002	0.681*
	(0.003)	(0.003)	(0.356)
Practice Characteristics			
Practice Size	0.000	0.000	0.088***
	(0.000)	(0.000)	(0.020)
Average Experience	0.000	-0.000	-0.109**
	(0.000)	(0.000)	(0.051)
% Female	0.001	-0.013	-1.701
	(0.017)	(0.014)	(1.902)
Adult PCP	0.015	0.017	4.562
	(0.032)	(0.029)	(5.371)
Multi-specialty	-0.005	-0.002	-2.184
	(0.009)	(0.010)	(1.375)
Surgery Center	-0.013	-0.006	-1.990
	(0.010)	(0.010)	(1.377)
Independent	0.052***	0.030**	-7.390***
	(0.014)	(0.012)	(1.844)
Hospital Characteristics			
Physician FTE	-0.000*	0.000*	-0.002
	(0.000)	(0.000)	(0.002)
Resident FTE	-0.000	-0.000	0.002
	(0.000)	(0.000)	(0.002)
Nurse FTE	0.000	-0.000*	-0.004***
	(0.000)	(0.000)	(0.001)
Other FTE	0.000	0.000	-0.000
	(0.000)	(0.000)	(0.000)
Beds	0.004**	0.000	0.432*
	(0.002)	(0.002)	(0.250)
N	1.005 MM	990,589	1.023 MM

[a]Results from instrumental variables with hospital-physician, year, and month fixed effects. Standard errors are in parenthesis, clustered by physician. We instrument for the vertical integration indicator as discussed in Section 4 in the main text. All regressions include county demographic variables (total population, age distribution, income distribution, and education) as well as dummies for whether the county hospital market is a monopoly, duopoly, or triopoly. We also include hospital bed size and indicators for whether the hospital is for-profit, part of a larger system, or a major teaching hospital. * p-value <0.1, ** p-value <0.05, *** p-value <0.01

Table 5: **Effects on Components of an Episode**[a]

	Log Payments	Claims
Episode	0.069***	-16.659***
	(0.025)	(3.979)
Inpatient[b]	0.148	0.010
	(0.152)	(0.024)
Outpatient	0.258**	1.022***
	(0.133)	(0.384)
Professional	-0.373***	-17.809***
	(0.106)	(3.839)
SNF	0.145	0.022
	(0.122)	(0.027)
Home Health	0.587***	0.095***
	(0.168)	(0.025)

[a]IV results based on separate regressions of Medicare payments for each component of the full episode, split by inpatient, outpatient, and professional services. We also include results for the full episode for completeness. Since many episodes incur $0 spending after the initial inpatient stay, we add 1 to all spending measures and present results using the log of Medicare payments (+ 1) as our outcome. We instrument for the vertical integration indicator as discussed in Section 4 in the main text. Included covariates and fixed effects follow from Table 4. Standard errors in parentheses, clustered by physician. * p-value <0.1, ** p-value <0.05, *** p-value <0.01

[b]Only includes claims in the inpatient setting incurred after the initial inpatient stay.

Table 6: **Effects on Components of Professional Services**[a]

	Log Payments	Claims
Timing within Episode		
Before inpatient stay	-0.820***	-3.017***
	(0.116)	(0.974)
During inpatient stay	-0.406***	-6.201***
	(0.111)	(1.281)
After inpatient stay	-0.269**	-8.590***
	(0.113)	(2.676)
Type of Service		
Evaluation & Management		-4.461***
		(1.644)
Labratory		-2.889**
		(1.130)
Imaging		-2.912***
		(0.687)
Other		-7.521***
		(1.548)

[a]IV results for the coefficient on hospital-physician vertical integration, based on separate regressions of Medicare payments and claims for professional services. Panel 1 splits services by before the initiating inpatient stay (30 days prior), during the inpatient stay, and after (90 days). Panel 2 splits services by type of service. We instrument for the vertical integration indicator as discussed in Section 4 in the main text. Included covariates and fixed effects follow from Table 4. Standard errors in parentheses, clustered by physician. * p-value <0.1, ** p-value <0.05, *** p-value <0.01

Table 7: **Effects on Referral Patterns**[a]

	Payments	Claims
Same Physician	-5.269	-0.309*
	(83.034)	(0.182)
Other VI Physicians	1,960***	2.739***
	(87.686)	(0.240)
Other Non-VI Physicians	-1,951***	-19.107***
	(274.816)	(3.882)

[a]IV results for the coefficient on hospital-physician vertical integration. We instrument for the vertical integration indicator as discussed in Section 4 in the main text. Outcomes derive from all professional services claims within an episode. Standard errors in parentheses, clustered by physician. Included covariates and fixed effects follow from Table 4. * p-value <0.1, ** p-value <0.05, *** p-value <0.01

Table 8: **Effects on Physician Effort**[a]

	Log Payments	Claims
Total	0.038	-47.072**
	(0.051)	(20.541)
Professional Services	-0.146**	-68.591***
	(0.067)	(17.882)
Inpatient Claims	0.067	-4.436***
	(0.061)	(1.976)
Outpatient Claims	0.527***	26.750***
	(0.109)	(6.283)

[a]IV results for the coefficient on physician-level vertical integration. We instrument for the vertical integration indicator as discussed in Section 4 in the main text, aggregated to the physician level by taking the expected probability across all hospitals in which the physician operated in a given year. Outcomes consist of all claims on which the operating physician is listed as the billing physician. Covariates include all physician and market level variables described in 4, as well as physician fixed effects, with standard errors clustered by physician. * p-value <0.1, ** p-value <0.05, *** p-value <0.01