The effect of integration of hospitals and post-acute care providers on Medicare payment and patient outcomes

R. Tamara Konetzkaa, Elizabeth A. Stuartb, Rachel M. Wernercc,d*

a Department of Public Health Sciences, University of Chicago
b Department of Biostatistics, Johns Hopkins Bloomberg School of Public Health
c Division of General Internal Medicine, University of Pennsylvania
d Center for Health Equity Research and Promotion, Crescenz VA Medical Center, Philadelphia, PA
*Corresponding author: rwerner@upenn.edu

Acknowledgements
This work was supported by a Health Care Financing and Organization grant from the Robert Wood Johnson Foundation. Rachel Werner was supported in part by grant K24-AG047908 from the NIA.

Abstract
In this paper we examine empirically the effect of integration on Medicare payment and rehospitalization. We use 2005-2013 data on Medicare beneficiaries receiving PAC in the U.S. to examine integration between hospitals and the two most common post-acute care settings: skilled nursing facilities (SNFs) and home health agencies (HHA), using two measures of integration—formal vertical integration and informal integration representing preferential relationships between providers without formal relationships. Our identification strategy is twofold. First, we use longitudinal models with a fixed effect for each hospital-PAC pair in a market to test how changes in integration impact patient outcomes. Second, we use an instrumental variable approach to account for patient selection into integrated providers. We find that vertical integration between hospitals and SNFs increases Medicare payments and reduces rehospitalization rates. However, vertical integration between hospitals and HHAs has little effect, nor does informal integration between hospitals and either PAC setting.

Keywords
Post-acute care; vertical integration; Medicare

JEL Codes
I11, I18
1. Background

Vertical integration has long been of interest to economists, but vertical integration in health care settings remains understudied. The scarcity of evidence has become more apparent as new policies are implemented that directly or indirectly encourage vertical integration in order to increase coordination across settings. These policies are motivated by accumulating evidence from the medical and health services literature suggesting that poorly coordinated care is unsafe for patients and expensive for the health care system (Beers, Sliwkowski et al. 1992, Moore, Wisnivesky et al. 2003, Coleman and Berenson 2004, Van Walraven, Mamdani et al. 2004, Coleman, Mahoney et al. 2005, Coleman, Smith et al. 2005).

Vertical integration was a common approach to attempt to improve coordination in the mid-1990s (Baicker and Levy 2013). With the popularization of managed care, many tertiary-care hospitals acquired closely affiliated services that complement hospital services, such as smaller community-based hospitals, physician practices, and post-acute care providers (Cutler and Scott Morton 2013). By the end of the 1990s there had been significant market consolidation, with the number of acute-care hospitals declining by 15% (Cutler and Scott Morton 2013) and three-quarters of the remaining hospitals having acquired a supplier of post-acute care (Congressional Budget Office 1997).

More recently, attention has again turned to integration in the presence of multiple emerging policies attempting to use financial incentives to improve care coordination. For example, under the Affordable Care Act, Medicare is experimenting with Accountable Care Organizations (ACOs) where payers and providers take on responsibility for managing the health of their members across health care settings and are financially accountable for providing high-quality and low-cost care (Centers for Medicare and Medicaid Services 2013). Other examples of payment reforms that encourage coordination include bundled payments, which combine payments across provider settings for a single episode of care, and financial penalties for hospitals with higher-than-expected readmission rates (Centers for Medicare and Medicaid Services 2013). Although payment bundling is still in the demonstration phase and evidence on ACOs and readmissions penalties is inconclusive, these policies are likely to create new incentives for providers to optimize care across health care settings, potentially through integration.

While integration and market consolidation is expected in response to these emerging policies, the effects of market consolidation may be at odds with the intended policy effects. The policies are designed to encourage coordination of care with the intended effect of improving quality and constraining Medicare spending. At the same time, the achievement of those goals likely depends on the underlying payment policy, the strength of the incentives, and the countervailing anti-competitive effects of consolidation.

Integration may be formal, defined by combined legal ownership, or informal, whereby organizations selectively form strong ties with other organizations through mechanisms such as shared electronic health records, sharing physicians or nurses across settings to promote continuity, or preferentially sharing patients, though remaining legally separate while doing so. The effects of integration may depend on the details of the relationship, but because these mechanisms generally require resources, they typically only make sense in situations when the volume of shared patients is large relative to other potential partners in the market.

There is a large literature on the effects of horizontal integration. While horizontal mergers nearly always reduce competition, the effects of reduced competition on quality and costs are surprisingly mixed. In the hospital setting with regulated prices (i.e. Medicare
payment) reduced competition nearly always reduces quality. With unregulated prices, the effects of reduced competition on quality and costs are uncertain (Gaynor and Town 2012).

The effects of vertical integration on quality and spending are also ambiguous, both theoretically and empirically. Theoretically, vertical integration can serve to achieve efficiencies by facilitating coordination of care, addressing incomplete contracting problems, and otherwise reducing transaction costs (Robinson 1996). On the other hand, vertical integration can enhance or extend market power by limiting rivals’ access to the integrated firm or by raising rivals’ costs by charging higher prices than the internal transfer price of the integrated firm. Vertical integration can also be inefficient without being anticompetitive, simply by reducing choice (Gaynor and Town 2012).

Empirical studies examining the effects of vertical integration in health care are sparse. Two papers examined the effect of vertical integration on competition in the case of hospital-physician practice integration in the 1990s (Ciliberto and Dranove 2006, Cuellar and Gertler 2006). These studies find conflicting results, with one finding that the anticompetitive effects of integration increased prices (Cuellar and Gertler 2006) and the other finding no effect (Ciliberto and Dranove 2006). Research on the effect of vertical integration on efficiency is similarly lacking, with studies on hospital-physician integration in the 1990s finding little relationship between integration and quality and costs (Madison 2004, Burns and Muller 2008). However, these studies use data that is close to two decades old, and most fail to account for the endogenous relationship between a hospital’s decision to integrate and its quality and costs. Two more recent studies have examined the effect of hospital ownership of physician practices on health care prices, finding that vertical integration in the early 2000s was associated with higher prices and spending (Baker, Bundorf et al. 2014, Neprash, Chernew et al. 2015). However, like earlier research, these studies failed to fully account for patient selection into integrated practices and the endogeneity between prices and integration.

One important prior paper has examined the effect of vertical integration on practice patterns in post-acute care using data on integration of hospitals with home health agencies and skilled nursing facilities. David, Rawley, and Polsky (2013) conceptualize vertical integration as a solution to an incomplete contracting problem, whereby integration allows tasks that are substitutable across settings to be more efficiently allocated to the lower-cost setting (the PAC setting). They find that hospitals that are vertically integrated tend to discharge patients to post-acute care quicker and sicker, yet health outcomes are the same or better, suggesting that vertical integration reduces coordination problems (David, Rawley et al. 2013).

We build on the paper by David, Rawley, and Polsky in several key ways. First, their analysis used just one year of data (2006). Thus, they were limited to a cross-sectional analysis using data that was outside the current policy context. In contrast, we use a 2005-2013 panel of data, which enables a longitudinal analysis of organizations that changed integration status over time, and also may be more reflective of the type of integration occurring under current policies. Second, their measure of integration was defined by integration with any provider of a particular type (e.g. a hospital was considered integrated if it was integrated with any SNF, not necessarily the SNF that a particular patient went to). In contrast, we measure integration as a hospital-PAC pair and attribute benefits of integration only to patients who go to the integrated providers. Third, we use instrumental variables rather than matching to account for patient selection. Fourth, we consider informal integration in addition to the more formal vertical integration, an understudied area. Finally, we examine not only hospital readmissions but also Medicare spending, a key outcome in the current policy context.
Our contribution is, therefore, to provide a more complete and updated picture that takes advantage of longitudinal data, better measurement, and a broader array of outcomes and subsamples that are relevant to the current policy context. Specifically, we use Medicare claims data to examine the effects of integration (vertical and informal) between hospitals and PAC providers on Medicare spending and hospital readmissions. We find that hospitals that vertically integrate with SNFs are able to take advantage of the structure of the payment system to increase Medicare payments overall, mostly through increasing the number of SNF days, while reducing hospital readmissions. Little effect of formal vertical integration on either outcome is found for HHAs, likely due to differences in the payment system for this setting. We also find that informal integration has no effect on Medicare payments or readmissions.

2. The Post-Acute Care Context

One setting where the effects of uncoordinated care have received significant attention is care during the post-hospital-discharge period. One-fifth of Medicare beneficiaries are rehospitalized within 30 days of hospital discharge and more than one-third are rehospitalized within 90 days (Jencks, Williams et al. 2009). Some estimate that nearly 90% of these rehospitalizations are unplanned and potentially preventable, translating into a $17 billion expenditure for Medicare, or nearly 20% of Medicare’s acute-care payments (Centers for Medicare and Medicaid Services 2007).

An expanding evidence base suggests that high readmission rates are related to serious deficits in the coordination of care across sites of care. Qualitative studies have demonstrated that when patients are discharged home, they are often unprepared for self-management and unable to reach a health care provider familiar with their care plan when questions arise (vom Eigen, Walker et al. 1999, Harrison and Verhoef 2002). Quantitative studies document high rates of medication errors, incomplete or inaccurate information transfer, and lack of appropriate follow-up care for vulnerable patients during transitions, which compromise quality and patient safety (Beers, Sliwkowski et al. 1992, Van Walraven, Seth et al. 2002, Moore, Wsnivesky et al. 2003, Coleman, Smith et al. 2005). Collectively, these problems in transitions and coordination increase rates of hospital readmission and health care costs.

Medicare pays for the vast majority of PAC, spending $62.1 billion on PAC in 2012 (MedPAC 2013), with over 5 million Medicare beneficiaries using some form of PAC in 2011 (MedPAC 2013). Approximately 38% of all Medicare discharges from hospitals are to PAC. The vast majority of PAC is provided by two key types of organizations: skilled nursing facilities (SNFs) accounting for 49% of discharges to PAC and home health agencies (HHAs) accounting for 43%.

Medicare’s costs of PAC have grown dramatically in recent decades. After Medicare implemented its hospital prospective payment system in the 1980s, hospitals responded by minimizing hospital length of stay, creating an increased demand for PAC and many new PAC providers. As PAC was primarily a fee-for-service sector at the time, the growing use of PAC was accompanied by little incentive for efficient use. Dramatic spending growth led to the implementation of prospective payment systems for PAC following the Balanced Budget Act of 1997. However, even under prospective payment, the use of PAC has continued to grow, in part due to increased concerns over patient safety and the recognized need to provide better transitions between inpatient and outpatient care. Thus, even in the past decade, Medicare spending on PAC has more than doubled, making it the fastest growing major spending category for Medicare, accounting for a large portion of Medicare’s overall spending growth in 1994-2009 (Chandra, Dalton et al. 2013).
In summary, Medicare’s PAC sector is large, expensive, and growing in both spending and policy focus. Examining the effects of vertical integration on patient outcomes and Medicare spending in the setting of hospitals and PAC providers thus provides a unique opportunity to shed light on a fundamental question that is also of current policy importance.

3. Conceptual framework

We assume that both hospitals and PAC providers choose levels of inputs to maximize utility, which may derive from both profits and nonmonetary goals. More specifically, each provider (hospital and PAC) chooses the level of inputs \( I \) of care in order to maximize the utility \( U \) it gets from profits \( \pi \) and patient outcomes \( Q \):

\[
\max_{I_h} U_h[\pi_h (I_h), Q_h (I_h)] \\
\max_{I_{PAC}} U_{PAC}[\pi_{PAC} (I_{PAC}), Q_{PAC} (I_{PAC})]
\]

In the absence of vertical integration, these utility functions remain separate. Optimal inputs are conditional on incentives inherent in the Medicare payment system, where both hospitals and PAC providers are paid under prospective payment systems (PPS). For hospitals under the Inpatient PPS (IPPS), each admission is categorized into a diagnostic-related group (DRG) that has a payment assigned to it based on expected resources use. This has created strong incentives for hospitals to keep patients no longer than medically necessary. Indeed, hospital length of stay has significantly shortened since the introduction of IPPS (Guterman and Dobson 1985, Feder, Hadley et al. 1987, Manton, Woodbury et al. 1993) and hospitals continue to focus on finding ways to decrease length of stay and inpatient costs within the bounds of medically appropriate care.

PAC is also paid prospectively, but the details of the payment systems vary in salient ways by setting. SNF payments are a *per diem* rate set by expected service intensity during the stay. The classification of expected service use is reassessed and potentially adjusted at regular intervals over time as the patient’s condition changes, but the *per diem* payment rate within each interval is predetermined. In contrast, HHA payments are episodic with payments adjusted for illness severity and set for a 60-day episode regardless of number of expected visits. In both cases, limited *ex post* adjustments are made to payments in particular cases, such as lower payments to HHAs for particularly short lengths of stay.

The contrast between per diem payment for SNFs and per episode payments for HHAs translate to contrasting incentives for the intensity of care. Similar to the incentive that hospitals face under the IPPS, HHAs face an incentive to shorten length of stay in PAC and to accept patients with longer length of stay in the hospital. Admitting a patient earlier to these types of PAC erodes margins downstream, as it is costlier to care for patients who are still in intensive stages of recovery. This creates conflicting incentives for hospitals and HHAs, both of which want to shorten length of stay, resulting in an inherent conflict regarding the optimal timing of transition across settings (David, Rawley et al. 2013).

For SNFs, on the other hand, the *per diem* payment system creates no incentive to limit PAC length of stay. Admitting a patient earlier from the hospital may or may not erode SNF margins, as margins depend on the relationship between the per diem rates and the costs of care at different points in the patient’s trajectory of recovery. Admitting a sicker patient may simply entail a longer length of stay in PAC. The inherent incentive to keep patients in SNFs longer may be balanced in part by the requirement to document the
patient's ongoing need for skilled care or the need to have beds available for new patients, potentially to satisfy demand by hospitals as the ongoing source of referrals. In addition, Medicare requires a large co-payment by the patient after the 20th day of SNF care, so patient demand may limit stays past that point. Overall, the contracting problem between hospitals and SNFs in the absence of vertical integration is different from that of HHAs, with less clear incentives with respect to the payment system alone.

Beyond the payment considerations, hospitals and PAC providers have historically had little incentive to coordinate services across settings. Indeed, in some cases, there have been financial incentives for uncoordinated care, such as the case of hospital readmissions, where hospitals got reimbursed for a second stay and PAC providers could have multiple episodes of care.

Vertical Integration

Vertical integration of hospitals and PAC providers joins the utility function across the two providers:

$$\max_{l_{h}+l_{PAC}} U_{l_{h}+l_{PAC}}(l_{h}+l_{PAC})$$

Joint ownership gives financial incentives for hospitals to consider payment and outcomes across the two settings and to allocate general tasks (i.e., tasks that can be performed in either care setting, such as recovery tasks) to their own PAC in a manner that is more efficient (conditional on payment structure), maximizing Medicare payments and patient outcomes.

In the case of vertical integration between hospitals and HHAs, where both the hospital and the HHA are subject to a predetermined episodic payment, little room is left for manipulating Medicare payments. Gains from efficiency must rely on reducing and reallocating inputs, i.e. reducing joint costs.

In the case of vertical integration between hospitals and SNFs, however, any shifting of tasks from the hospital to the SNF creates additional payments in addition to any input-related efficiency gains. Even in the absence of input-related efficiency gains, hospitals that vertically integrate with SNFs may benefit from extending SNF length of stay, as they not only gain payment but can also reduce the risk of readmission. Less pressure to minimize PAC length of stay may enable a stronger focus on using vertical integration to improve patient outcomes that are strategically important to the hospital, such as readmissions.

Increased market power under vertical integration reinforces these incentives. In this setting, vertical integration can enhance market power by ensuring access to PAC beds for the hospital and ensuring a source of referrals for the PAC. Thus, each faces less competition from other providers who may offer patients or PAC beds that would be more aligned with non-integrated, setting-specific incentives.

Informal Vertical Integration

Under informal integration, hospitals and PAC providers conduct a significant number of transactions with each other, sometimes but not always reinforced by agreements or contracts to coordinate care, but remain legally separate entities with separate financial structures. Thus, the utility functions of hospitals and PAC providers remain separate. However, interdependence of the two entities (for patient referrals and PAC beds) implies that utility of one provider is taken into account in the utility function of the other:

Electronic copy available at: https://ssrn.com/abstract=2805172
\[
\max_{I_h} U_h[\pi_h(I_h), Q_h(I_h), U_{PAC}(I_h)]
\]  \hspace{2cm} (4)

\[
\max_{I_{PAC}} U_{PAC}[\pi_{PAC}(I_{PAC}), Q_{PAC}(I_{PAC}), U_h(I_{PAC})]
\]  \hspace{2cm} (5)

Consideration of the other party's utility should lead to more coordination. However, the change in incentives (relative to no integration) faced by hospitals and PAC providers under informal vertical integration are inherently weaker than under formal vertical integration where the utility function is joint. On the margin, more inputs may be invested to increase the profits or quality motives of the other party, but as the benefit from doing so is indirect, incentives for change are small.

In combination, this framework leads to several testable hypotheses, which we address empirically in the next section.

Hypothesis 1: Vertical integration between hospitals and PAC providers leads to increased Medicare payments for hospital-SNF pairs but not for hospital-HHA pairs.

Hypothesis 2: Vertical integration between hospitals and PAC providers leads to reduced hospital readmissions.
   2.A. This effect is likely to be larger for hospital-SNF pairs than for hospital-HHA pairs.

Hypothesis 3: Effects of informal integration will be smaller than of formal vertical integration.

4. Data, Sample, and Empirical Strategy

4.1 Data

Our study relies on patient-level Medicare claims data to observe all Medicare-reimbursed hospitalizations and post-acute care use in the U.S. between 2005 and 2013. We supplement this patient-level data with Medicare provider-level data for hospitals, SNFs, and HHAs, which are used to measure vertical integration between hospitals and PAC providers. These data sources are described more fully below.

Our primary data source is patient-level Medicare claims, including the 100% MedPAR file (including claims for all acute inpatient hospitalizations and SNF stays) and home health claims for all patients discharged from an acute care hospital during our study period. The Medicare claims data are supplemented with the Medicare Beneficiary Summary File, which contains information on beneficiary enrollment in Medicare Part A and Part B, demographics including date of birth, sex, and race, and date of death. Medicare claims are used to measure patient outcomes of interest as well as patient-level covariates. In addition, claims are used to develop a measure of informal integration between hospitals and post-acute care providers (described in detail below).

These patient-level data are supplemented with provider-level data from two annual files. These are the Provider of Service (POS) File, containing information on ownership status (e.g., whether a hospital and PAC provider share ownership); and Medicare Cost Reports, containing the linkages between the specific hospitals and other providers that share ownership.

4.2 Study Sample
We start by including all U.S. acute care hospitals and all Medicare-certified PAC providers. This includes 4,011 hospitals, 16,251 SNFs, and 12,720 HHAs. We pair each hospital in a Hospital Referral Region (HRR) with each SNF and HHA in that HRR. We consider these the potential hospital-PAC relationships that exist within health care markets. This results in 146,387 hospital-SNF pairs and 104,253 hospital-HHA pairs. For each PAC type, we restrict our sample of hospital-PAC pairs to those HRRs that have at least one vertically integrated hospital-PAC pair and one informally integrated hospital-PAC pair for each PAC type.1 This results in a provider-level sample that includes 109,023 hospital-SNF pairs and 74,597 hospital-HHA pairs. The sample includes 78% of HRRs in the SNF sample and 85% in the HHA sample.

We then define our patient sample within the sample of hospital-PAC pairs. The patient-level sample includes all Medicare fee-for-service beneficiaries discharged from an acute care hospital to PAC. We define discharge to PAC as those hospital discharges having a PAC claim within 3 days of hospital discharge. From this sample we exclude all beneficiaries enrolled in Medicare Advantage (MA), as these beneficiaries have incomplete data in the Medicare claims. We exclude beneficiaries if they are enrolled in MA in the one year prior to hospital discharge (to completely measure patient comorbidities) or the 60 days after hospital discharge (to completely measure patient outcomes). We also exclude beneficiaries who are not eligible for Medicare's hospital readmission measure, which is one of our main outcomes. This excludes beneficiaries discharged from the hospital against medical advice, admitted to a PPS-exempt cancer hospital, or with hospital admissions for cancer treatment, primary psychiatric disease, rehabilitation care, or fitting of prostheses and adjustment devices. Finally, because the complete cohort of patients using PAC is very heterogeneous in their primary reasons for hospitalization, we exclude hospitalizations that were not for one of the 25 most common hospital diagnosis related groups (DRGs) for each PAC type. This creates a more homogenous and consistent study population. Approximately 50% of PAC users have a hospitalization for one of the 25 most common DRGs. Our final sample includes 2,651,748 beneficiaries discharged from hospital to SNF and 1,318,577 discharged to HHA.

4.3 Integration

We measure integration between hospitals and PAC providers in two ways. First, we measure formal vertical integration as ownership of a SNF and HHA by an acute care hospital. Vertical integration is measured as a binary variable in each year for every hospital-PAC pair in an HHR. Second, we measure informal integration based on patient flows and the concentration of relationships between hospital and PAC providers. Using Medicare claims data, for each hospital in each HRR we measure the hospital's concentration of discharges to PAC providers in its market using the Herfindahl-Hirschman Index (HHI). To do so, for each PAC type we calculate the share of a hospital's patients going to each PAC provider of that type in its HHR in each year of the study period and then take the sum of squares of those shares, excluding hospitals with fewer than five discharges to a PAC setting. We then identify hospitals with an HHI in the highest quartile (compared to other PACs of the same type across the entire study period). We then pair

---

1 This restriction of having at least one integrated pair for each PAC type is necessary to calculate our instrumental variable, which is based on differential distance between integrated and non-integrated hospitals within HRR (see below for details). We further restrict to HRRs that have both a vertically integrated and an informally integrated PAC pair for each PAC type to keep our sample consistent between analyses of vertical integration and informal integration.
those concentrated hospitals with the PAC provider to which the hospital sends the plurality of its patients, resulting in a binary variable indicating whether a hospital-PAC pair is informally integrated, measured annually. The measure is intended to reflect that the hospital and PAC provider have strong ties and interdependence, which may be accompanied by efforts to coordinate care or smooth transitions.

These two measures of integration are summarized in Figures 1 and 2, showing trends in integration between hospital-PAC pairs over our study period. Rates of both formal and informal integration declined over the study period for SNFs and HHAs. Table 1 shows the overlap between these two measures of integration. The majority of integrated provider pairs are either vertically integrated or informally integrated, but not both. For example, for hospital-SNF pairs, 1.0% of pairs are vertically integrated and 1.2% are informally integrated. Only 0.3% of all hospital-SNF pairs are both vertically and informally integrated while 0.8% are only vertically integrated and 0.9% are only informally integrated.

4.4 Outcome Variables

We measure the impact of integration on three patient-level outcomes. First, we examine Medicare payments over an episode of care encompassing both acute and post-acute care, defining the episode as 60 days from the date of admission to the hospital. We include Medicare payments for the index hospitalization and for the first PAC stay during the 60 day time period in this measure, examining these payments for the entire episode and also separately for acute care and post-acute care.

Second, we examine length of stay. Like Medicare payments, we measure length of stay for the entire 60-day acute/post-acute care episode and also separately for acute care and post-acute care. For both payments and length of stay we account for censoring by death in all regressions by including two covariates: a dummy variable indicating whether the patient died in the first 60-days and the number of days censored due to death.

Our third outcome is readmission to the hospital within 30 days of hospital discharge. We follow Medicare’s definition of hospital readmission from the Hospital Readmission Reduction Program, which includes readmissions to any acute care hospital within 30 days of discharge from an index hospitalization where the readmission was not planned. We use a combined endpoint of readmission or death within 30 days of hospital discharge to account for censoring by death.

Patient outcomes in our study cohort are summarized in Table 2.

4.5 Other Variables

In addition to the instrumental variables approach (described below) used to account for observed and unobserved differences in patient case-mix across hospitals and PAC providers, in all regressions we account for residual heterogeneity by including

2 If the two most commonly used PAC providers have shares that are within 5 percentage points of each other, we consider it a tie and match the hospitals with two PAC providers.

3 Alternative definitions of informal integration based on the importance of the hospital-PAC relationship from the perspective of the PAC provider yielded very similar results.

4 Over the study period, 3.0% of SNFs changed vertical integration status and 10.6% changed informal integration status. For HHAs, 6.0% and 10.8% changed integration, respectively.

5 Planned readmissions include those for bone marrow or solid organ transplant, maintenance chemotherapy, rehabilitation, or a potentially planned procedure not performed to treat an acute condition or a complication of previous care.
measures of age, sex, race, 31 indicators for comorbidities\textsuperscript{6}, and indicators for each of the 25 DRGs included in the study sample.\textsuperscript{7} These covariates are summarized in Table 3.

\textit{4.6 Empirical Strategy}

We estimate empirically the effect of changes in the integration status of hospital and PAC providers on Medicare costs and patient outcomes. We do so using a provider fixed-effects model, leveraging longitudinal data from 2005 to 2013. In these data we observe annual integration status for every hospital-PAC pair in our sample over time, identifying the effect of integration by changes in integration status within hospital-PAC pair. Our basic model specification is:

\[
Y_{ijt} = \beta_1 Integration_{jt} + X_{it} + \mu_j + \varphi_t + \varepsilon_{ijt}
\]

where the dependent variable, \(Y_{ip}\), is one of the patient-level variables defined above (Medicare costs, length of stay, or readmission/death). The independent variable of interest is \(Integration_{ip}\), which is a dummy variable measuring integration either formally (vertical integration) or informally (based on patient flows) at the hospital-PAC pair level in each year. We also include patient-level covariates, hospital-PAC pair fixed effects, and year fixed effects. We estimate this equation separately for formal and informal integration and for SNFs and HHAs.

Estimating the effect of integration on patient outcomes may be biased from at least two potential sources of endogeneity. First, a provider’s choice to integrate may be endogenous to patient outcomes. We rely on provider-pair fixed effects to address this potential source of endogeneity. By including provider-pair fixed effects we difference out any time-invariant environmental factors at a hospital-PAC pair that affect integration decisions and patient outcomes, estimating within-provider effects of changing integration status on patient outcomes.

Second, patient selection of integrated hospitals may be non-random and at least partially based on patient characteristics that are unobservable to the researcher. To account for this potential endogeneity we estimate an instrumental variables model. We use differential distance as our instrument, defining differential distance as the difference in miles between the distance from the centroid of a patient’s home ZIP code to the nearest integrated hospital and the nearest non-integrated hospital in miles, measured separately for vertical integration and informal integration, and for each PAC type. This differential distance encompasses both positive and negative values, depending on whether the beneficiary’s home is closer to an integrated or a non-integrated hospital. A summary of the differential distance to hospitals integrated with SNFs and HHAs in our sample is displayed

\textsuperscript{6} Comorbidities are defined based on CMS Hospital Readmission Reduction Program specifications for risk adjustment of readmission and include: severe infection; other infectious disease pneumonias; metastatic cancer/acute leukemia; severe cancer; other cancers; diabetes mellitus; protein-calorie malnutrition; end-stage liver disease; severe hematological disorders; alcohol abuse; psychiatric comorbidity; hemiplegia, paraplegia, paralysis, functional disability, seizure disorders, CHF, coronary atherosclerosis or angina/CVD; specified arrhythmias; COPD; fibrosis of lung or other chronic lung disorders; dialysis; decubitus ulcer or chronic skin ulcer; sepsis/shock; disorders of fluid, electrolyte, acid-base; iron deficiency or other unspecified anemias; cardiorespiratory failure or shock; acute renal failure; pancreatic disease; rheumatoid arthritis; respiratory dependence/tracheostomy; transplant; coagulation defects/hematologic disorders; hip fracture/dislocation

\textsuperscript{7} See Appendix Table 1 for the list of the top 25 DRGs in each PAC setting.
in Table 4. In all cases, the mean differential distance is positive, indicating the higher prevalence of non-integrated hospitals.

Differential distance is a valid instrument if it is strongly correlated with a patient’s choice of an integrated hospital but not ε, the error term in Equation (6). To test the strength of the correlation we use the standard test of Staiger and Stock (1997), examining whether the $F$-statistics exceed the threshold of 10 (or $t$-statistics exceeding 3.16 for a single instrument). The first-stage estimates in Table 5 show that the $t$-statistics far exceed this threshold.

While we cannot test the second assumption of our instrument having no correlation with the error term directly, we can examine whether our instrument is correlated with observed patient characteristics. To do so, we divide differential distances at the median and examine patient characteristics for those beneficiaries with a differential distance above and below the median (or near versus far from an integrated hospital). These results are displayed in Table 6, showing that in general patient-level characteristics are very similar across these two groups, suggesting that the samples are balanced. One exception to this balance is the differential distance to hospitals that are vertically integrated and informally integrated with SNFs by race, where white beneficiaries tend to have a longer differential distance while blacks and other beneficiaries who are non-white have a shorter differential distance. We include race as well as these other observable characteristics as controls in our models.

We examine Equation (6) using a linear probability model. All standard errors are adjusted for heteroscedasticity using the Huber-White estimator of variance clustered at the provider-pair level.

5. Results

5.1 Primary Findings

Estimates of the effect of integration on Medicare payments are presented in Table 7. Hospital-SNF pairs that are vertically integrated receive higher total Medicare payments for the first 60 days of care than hospital-SNF pairs that are not vertically integrated by $2,424 on a base of $14,291 (or a relative increase of 17.0%). This is driven by higher payments to PACs, with vertically integrated SNFs receiving $2,274 more than non-integrated SNFs, whereas payments to hospitals are similar by integration status. On the other hand, for vertically integrated HHAs, vertical integration is associated with lower total Medicare payments over the first 60 days, though the magnitude of the effect is smaller. Vertically integrated hospital-HHA pairs experience a reduction of $303 in total Medicare payments on a base of $10,352 (for a relative reduction of 2.9%).

The effects of informal integration on total Medicare payments are generally small and not statistically significant. We do observe a statistically significant reduction in hospital payments for hospitals that are informally integrated with a SNF, but of only $326 (or a relative reduction of 2.2% for the average hospital) and with no change in total Medicare payment.

We next examine how length of stay changes in integration to help provide some context for payment changes, presented in Table 8. The total length of stay for the initial hospital and PAC stay increases for hospital-SNF pairs that are vertically integrated by 3.9 days on a base of 30.5 days (or by 12.8%). This change is largely driven by increasing length of the SNF stay with a decline in hospital length of stay. Hospitals that are vertically integrated with HHAs experience a decline in length of stay, which is driven by a decline in the length of HHA episodes.
Among informally integrated pairs the effects of integration on length of stay are generally small and not statistically significant. The one exception to this is for hospital-SNF pairs that are informally integrated where we observe a decline in length of stay that is driven by a shorter SNF stay.

Finally, we test whether integration affects patient outcomes (see Table 9). We estimate that hospitals that are vertically integrated with SNFs have a decline in their rate of 30-day readmission or death by just over 5 percentage points on a base rate of 31.3% (for a relative decline of 17%). For vertically integrated HHAs the effect of integration on readmission or death is close to zero. Estimates of the effect of informal integration between hospitals and PAC providers on readmission or death are small and not statistically significant.

5.2 Robustness Checks

In order to test the robustness of our results to primary model specification and cohort definition, we run a series of specification checks. Robustness checks on our primary outcome of Medicare payment are presented in Table 10. First, because some hospital-PAC pairs are both vertically integrated and informally integrated, we limit our analyses to those hospital-PAC pairs that are either vertically integrated or informally integrated. When we rerun the model after excluding pairs that are both vertically and informally integrated, we find stronger effects of vertical integration on almost all payment variables in all three PAC settings. The effect of informal integration on Medicare payment remains small and statistically insignificant in most cases.

A second potential concern is that the effects of vertical integration may be concentrated in the most competitive markets. Thus, we restrict our sample to the most competitive markets. Using the Hospital Referral Region to approximate market, we calculate market concentration as the Herfindahl–Hirschman Index (HHI) based on each hospital's share of beds in the market. We then estimate the effects of integration on the sample with an HHI of less than 2500. This restriction does not qualitatively change the results.

Third, entry or exit of providers over time may affect the estimation. We re-estimate the model on the balanced subsample of hospital-PAC pairs that are in the sample across all nine years of the study time frame. While this excludes a large number of hospital-PAC pairs, the total number of hospital discharges captured in this smaller sample is 83% of the original sample. This suggests that this restriction primarily excludes hospital-PAC pairs that share relatively few patients and thus are likely to drop out of the sample in periods in which they share no patients. Our results are robust to this sample exclusion, indicating that the results are not driven by a changing sample of providers over the study period.

Finally, we recalculate total Medicare payments include all institutional Medicare payments in the first 60 days after hospital admission. Unlike the dependent variable in the primary specification, this variable includes Medicare payments for rehospitalizations as well as any additional payments for PAC after the index PAC stay. Using this variable as the dependent variable produces similar estimates of the effects of integration.

For the analyses of informal integration, we perform one additional robustness test. We restrict our measure of informal integration to only those hospitals with at least 25 discharges to a PAC setting (rather than limiting it to those hospitals with at least 5 discharges as we did in our primary specification). In our primary measure of informal integration, a high proportion of small hospitals were identified as being highly concentrated in their PAC discharges and thus, in informally integrated relationships with
PAC providers. By limiting the sample to larger hospitals we aim to ensure that our results are not driven by small hospitals. This exclusion does not affect our findings.

Robustness checks are repeated for all analyses using length of stay and readmission measures as the dependent variables. The full results of these specification checks are presented in Appendix Tables 2 and 3. We add one additional specification check on functional form in the length of stay analyses. Because this is a count variable, we re-estimate the main regression using a negative binomial model. While we do find some minor changes in statistical significance with our specification checks, in all cases the results remain qualitatively similar.

6. Conclusion

In this study we present empirical estimates of the effects of hospital-PAC integration on Medicare spending and patient outcomes. These estimates leverage longitudinal data, better measurement than in prior studies, and an instrumental variables approach to provide a more complete picture of the effects of integration in PAC across the full array of PAC settings, and a range of outcomes and patient samples that are relevant to current policy debates.

Our findings are consistent with the hypothesis that the effect of vertical integration depends on the payment mechanism for PAC—whether it is per-diem or episode-based payment—and that informal integration will have little impact on health care delivery or patient outcomes. We find that in vertically integrated SNFs, where the hospital-SNF pairs have incentive to lengthen SNF stays to maximize Medicare payment, SNF length of stay and Medicare payments to SNF increase. This is accompanied by a reduction in rehospitalization rates. In contrast, in vertically integrated HHAs, where HHAs are paid by episode, vertical integration is associated with at most a small reduction in Medicare payment and no change in rehospitalization rates. Under informal integration, where hospital-PAC pairs face weaker incentives for coordination than vertical integration, we find little effect on either Medicare payment or patient outcomes.

The magnitudes of the effects we estimate for changes in SNF payments are meaningful. With vertically integrated hospital-SNF pairs receiving over $2,400 more per beneficiary from Medicare than non-integrated pairs, this 17% relative increase in payment is large but not out of proportion to the estimated increase in SNF length of stay. This increase in spending is accompanied by a significant reduction in rehospitalization rates of over 5 percentage points. Despite this reduction in rehospitalization rates, total spending by Medicare remains higher among beneficiaries receiving care in vertically integrated hospital-SNF pairs. Summing the mean per-beneficiary Medicare payment for index hospitalizations, readmissions, and SNF stays, Medicare appears to be spending 11% more on vertically integrated care compared to non-vertically integrated care.8 The total cost to Medicare of vertical integration depends on how widespread vertical integration between hospitals and SNF is, but based on the over 1.1 million beneficiaries we observe using SNF annually in our data, the Medicare cost could range from $209 million annually if 10% of hospital-SNF pairs were vertically integrated to over $2 billion annually if all SNFs were vertically integrated with hospitals.

8 For a vertically integrated episode of care, Medicare spends approximately $8,042 for a hospitalization, $1,834 for a readmission (or the cost of a hospitalization ($8,042) times the probability of readmission (22.8% excluding deaths)), and $6,249 for a SNF stay. For non-vertically integrated episodes, the Medicare payment for a hospitalization remains the same at $8042, but payments for rehospitalizations go down to $1,399 ($8,042 * 17.4%), and SNF payments go up to $8,522.
In contrast to vertically integrated SNFs, we see little effect of informal integration on Medicare payment or patient outcomes. While this may not be surprising given the weak financial incentives that informal integration provides to coordinate care, informal integration is frequently cited in the trade literature as a way to improve care coordination, decrease spending, and prepare for payment reforms that hold providers accountable for the costs and quality of care. Numerous case studies describe the formation of networks and other forms of informal integration between hospitals and post-acute care providers with the goal of improving patient transitions of care and positioning providers to be competitive under payment reform. As one trade publication advises: “Fee-for-value reimbursement, like bundled payments, and payment penalties relating to hospital readmissions, will require hospitals and post-acute care (“PAC”) providers to be better integrated in order to control costs and maintain positive margins”(Baylor Quality Alliance 2012).

Despite the positive view of integration described in the trade literature, we do not see evidence of an increased trend to informal integration in our data, and we estimate no significant benefit when it does exist. While our data goes through 2013, it is possible that this trend toward integration is more recent and we therefore miss it in our data. Additionally, in the setting of current payment reform, with providers increasingly being held accountable for the costs of care, it is possible that the financial incentives will sufficiently change to provide stronger incentives under informal integration to meaningfully coordinate care. Future research might better tease out the interaction between payment reform and different types of integration.

This study provides new estimates of the effects of vertical integration between hospitals and PAC. From a more fundamental perspective our study emphasizes that providers respond to the financial incentives they face and, thus, the details of payment mechanisms have important impacts on the organization of health care delivery and on provider behavior. In promoting policies to increase coordination of care, policymakers should bear in mind that integration may be inherently anti-competitive and that coordination may be accompanied by higher spending. Thus, designing financial incentives to increase coordination of care and simultaneously control costs are challenging. As we move forward with payment reform aimed at constraining costs and improving quality, designing reforms that anticipate provider responses will be key to their success.
References

Baicker, K. and H. Levy (2013). "Coordination versus competition in health care reform." New England Journal of Medicine 369(9): 789-791.

Baker, L. C., M. K. Bundorf and D. P. Kessler (2014). "Vertical integration: Hospital ownership of physician practices is associated with higher prices and spending." Health Affairs 33(5): 756-763.

Baylor Quality Alliance (2012). INTEGRATING ACUTE AND POST-ACUTE CARE: THE EMERGING MERGING OF THE SECTORS. Strategies for Health Care Leaders. 71.

Beers, M., J. Sliwkowski and J. Brooks (1992). "Compliance with medication orders among the elderly after hospital discharge." Hospital Formulary 27(7): 720-724.

Burns, L. R. and R. W. Muller (2008). "Hospital-physician collaboration: Landscape of economic integration and impact on clinical integration." Milbank Quarterly 86(3): 375-434.

Centers for Medicare and Medicaid Services (2007) "Medicare & Medicaid Statistical Supplement."

Centers for Medicare and Medicaid Services. (2013). "Readmission Reduction Program." Retrieved 9/27/2013, from http://www.cms.gov/Medicare/Medicare-Fee-for-Service-Payment/AcuteInpatientPPS/Readmissions-Reduction-Program.html.

Centers for Medicare and Medicaid Services. (2013). "Shared Savings Program." from http://www.cms.gov/Medicare/Medicare-Fee-for-Service-Payment/sharedsavingsprogram/index.html?redirect=/sharedsavingsprogram/.

Chandra, A., M. A. Dalton and J. Holmes (2013). "Large increases in spending on postacute care in Medicare point to the potential for cost savings in these settings." Health affairs 32(5): 864-872.

Ciliberto, F. and D. Dranove (2006). "The effect of physician–hospital affiliations on hospital prices in California." Journal of Health Economics 25(1): 29-38.

Coleman, E. A. and R. A. Berenson (2004). "Lost in transition: Challenges and opportunities for improving the quality of transitional care." Annals of Internal Medicine 141(7): 533-536.

Coleman, E. A., E. Mahoney and C. Parry (2005). "Assessing the quality of preparation for posthospital care from the patient’s perspective: the care transitions measure." Medical Care 43(3): 246-255.

Coleman, E. A., J. D. Smith, D. Raha and S.-j. Min (2005). "Posthospital medication discrepancies: prevalence and contributing factors." Archives of Internal Medicine 165(16): 1842.

Congressional Budget Office (1997). Medicare spending on post-acute care: A preliminary analysis. Washington, D.C., Congressional Budget Office.
Cuellar, A. and P. Gertler (2006). "Strategic integration of hospitals and physicians." Journal of Health Economics 25(1): 1.

Cutler, D. M. and F. Scott Morton (2013). "Hospitals, market share, and consolidation." JAMA 310(18): 1964-1970.

David, G., E. Rawley and D. Polsky (2013). "Integration and task allocation: Evidence from patient care." Journal of Economics & Management Strategy 22(3): 617-639.

Feder, J., J. Hadley and S. Zuckerman (1987). "How did Medicare's prospective payment system affect hospitals?" The New England Journal of Medicine 317(14): 867.

Gaynor, M. and R. J. Town (2012). Provider competition. Handbook of Health Economics. P. Borras, T. E. McGuire and M. Pauly. Amsterdam, Elsevier. 2: 499-637.

Guterman, S. and A. Dobson (1985). "Impact of the Medicare prospective payment system for hospitals." Health Care Financing Review 7(3): 97-114.

Harrison, A. and M. Verhoef (2002). "Understanding coordination of care from the consumer’s perspective in a regional health system." Health Services Research 37(4): 1031-1054.

Jencks, S. F., M. V. Williams and E. A. Coleman (2009). "Rehospitalizations among patients in the Medicare fee-for-service program." New England Journal of Medicine 360(14): 1418-1428.

Madison, K. (2004). "Hospital–physician affiliations and patient treatments, expenditures, and outcomes." Health Services Research 39(2): 257-278.

Manton, K. G., M. A. Woodbury, J. C. Vertrees and E. Stallard (1993). "Use of Medicare services before and after introduction of the prospective payment system." Health services research 28(3): 269-292.

MedPAC (2013). A Data Book: Health care spending and the Medicare Program (June 2013). Washington, DC, Medicare Payment Advisory Commission.

MedPAC (2013). Report to the Congress: Medicare payment policy (March 2013). Washington, DC, Medicare Payment Advisory Commission.

Moore, C., J. Wisnivesky, S. Williams and T. McGinn (2003). "Medical errors related to discontinuity of care from an inpatient to an outpatient setting." Journal of General Internal Medicine 18(8): 646-651.

Neprash, H. T., M. E. Chernew, A. L. Hicks, T. Gibson and J. M. McWilliams (2015). "Association of financial integration between physicians and hospitals with commercial health care prices." JAMA internal medicine: 1-8.

Robinson, J. C. (1996). "Administered pricing and vertical integration in the hospital industry." Journal of Law and Economics: 357-378.
Staiger, D. and J. H. Stock (1997). "Instrumental Variables Regression with Weak Instruments." *Econometrica: Journal of the Econometric Society*: 557-586.

Van Walraven, C., M. Mamdani, J. Fang and P. C. Austin (2004). "Continuity of care and patient outcomes after hospital discharge." *Journal of General Internal Medicine* **19**(6): 624-631.

Van Walraven, C., R. Seth, P. C. Austin and A. Laupacis (2002). "Effect of discharge summary availability during post - discharge visits on hospital readmission." *Journal of General Internal Medicine* **17**(3): 186-192.

vom Eigen, K. A., J. D. Walker, S. Edgman-Levitan, P. D. Cleary and T. L. Delbanco (1999). "Carepartner experiences with hospital care." *Medical Care* **37**(1): 33-38.
Figure 1. Proportion of hospital-PAC pairs that are vertically integrated over the study period

Figure 2. Proportion of hospital-PAC pairs that are informally integrated over the study period
Table 1. Percentage of hospital-PAC pairs that are vertically integrated, informally integrated, both, or neither.

|                                         | SNF  | HHA  |
|-----------------------------------------|------|------|
| All vertically integrated pairs         | 1.0% | 2.5% |
| All informally integrated pairs         | 1.2% | 2.6% |
| Both VI and informally integrated pairs | 0.3% | 0.9% |
| VI but not informally integrated pairs  | 0.8% | 1.6% |
| Informally integrated but not VI        | 0.9% | 1.5% |
| Neither VI nor informally integrated    | 98.0%| 96.0%|

Table 2. Summary of outcome variables

|                                         | SNF (n=2,651,748) | HHA (n=1,318,577) |
|-----------------------------------------|-------------------|-------------------|
| Medicare payment in first 60 days for   | 14,291 (8,272)    | 10,352 (6,508)    |
| index hospitalization and PAC stay in   |                   |                   |
| $, mean (SD)                            |                   |                   |
| Medicare payment in first 60 days for   | 8,042 (4,908)     | 7,858 (6,252)     |
| index hospitalization in $, mean (SD)   |                   |                   |
| Medicare payment in first 60 days for   | 6,249 (6,252)     | 2,494 (1,385)     |
| index PAC stay in $, mean (SD)          |                   |                   |
| Length of stay in first 60 days for     | 30.5 (17.5)       | 36.0 (17.6)       |
| index hospitalization and PAC stay in   |                   |                   |
| days, mean (SD)                         |                   |                   |
| Length of stay for index hospitalization| 6.5 (4.6)         | 5.0 (3.6)         |
| in days, mean (SD)                      |                   |                   |
| Length of stay in first 60 days for PAC  | 23.9 (17.1)       | 31.0 (17.2)       |
| stay in days, mean (SD)                 |                   |                   |
| 30-day rehospitalization or death, n (%)| 829,506 (31.3)    | 243,688 (18.5)    |

Electronic copy available at: https://ssrn.com/abstract=2805172
Table 3. Summary of post-acute care patients

|                               | SNF               | HHA               |
|-------------------------------|-------------------|-------------------|
|                               | (n=2,651,748)     | (n=1,318,577)     |
| Age, mean (SD)                | 82.6 (8.2)        | 79.27 (8.2)       |
| Female, n (%)                 | 1,771,929 (66.8)  | 821,266 (62.3)    |
| Race, n (%)                   |                   |                   |
| -White                        | 2,298,531 (86.7)  | 1,143,253 (86.7)  |
| -Black                        | 252,261 (9.5)     | 115,029 (8.7)     |
| -Other                        | 21,852 (0.8)      | 14,196 (1.1)      |
| -Asian                        | 32,014 (1.2)      | 15,726 (1.2)      |
| -Hispanic                     | 34,472 (1.3)      | 22,684 (1.7)      |
| -North American Native        | 6,470 (0.2)       | 4,010 (0.3)       |
| -Unknown                      | 6,140 (0.2)       | 3,679 (0.3)       |
| Comorbidities, n(%)           |                   |                   |
| -Severe Infection             | 35,788 (1.3)      | 12,824 (1.0)      |
| -Other Infectious Disease & Pneumonias | 824,257 (31.1) | 268,259 (20.3) |
| -Metastatic Cancer/Acute Leukemia | 64,705 (2.4)   | 31,676 (2.4)     |
| -Severe Cancer                | 107,660 (4.1)     | 56,528 (4.3)      |
| -Other Cancers                | 142,306 (5.4)     | 64,325 (4.9)      |
| -Diabetes Mellitus            | 823,447 (31.1)    | 398,046 (30.2)    |
| -Protein-calorie Malnutrition | 345,726 (13.0)    | 76,884 (5.8)      |
| -End-stage Liver Disease      | 31,035 (1.2)      | 12,268 (0.9)      |
| -Severe Hematological Disorders | 41,528 (1.6)    | 18,770 (1.4)      |
| -Alcohol Abuse                | 66,303 (2.5)      | 13,997 (1.1)      |
| -Psychiatric Comorbidity      | 667,232 (25.2)    | 236,461 (17.9)    |
| -Hemiplegia, paraplegia, paralysis, disability | 162,315 (6.1) | 38,703 (2.9) |
| -Seizure Disorders            | 137,133 (5.2)     | 35,251 (2.7)      |
| -Congestive heart failure     | 698,022 (26.3)    | 274,544 (20.8)    |
| -Coronary atherosclerosis or angina | 1,375,417 (51.9) | 624,115 (47.3) |
| -Specified arrhythmias        | 651,168 (24.6)    | 255,648 (19.4)    |
| -Chronic obstructive pulmonary disease | 796,597 (30.0) | 366,763 (27.8) |
| -Other chronic lung disorders | 99,699 (3.8)      | 52,112 (4.0)      |
| -Dialysis                     | 37,859 (1.4)      | 12,002 (0.9)      |
| -Decubitus Ulcer or Chronic Skin Ulcer | 192,132 (7.2) | 45,613 (3.5) |
| -Septicemia/Shock             | 183,439 (6.9)     | 41,793 (3.2)      |
| -Disorders of fluid, electrolyte, acid-base | 792,087 (29.9) | 257,512 (19.5) |
| -Iron Deficiency or other anemias | 1,183,565 (44.6) | 480,113 (36.4) |
| -Cardiorespiratory Failure or Shock | 282,161 (10.6) | 99,360 (7.5) |
| -Acute Renal Failure          | 566,091 (21.3)    | 194,542 (14.8)    |
| -Pancreatice Disease          | 45,988 (1.7)      | 20,989 (1.6)      |
| -Rheumatoid Arthritis         | 112,500 (4.2)     | 56,776 (4.3)      |
| -Respirator Dependence/Tracheostomy | 7,989 (0.3)    | 2,065 (0.2)       |
| -Transplants                  | 5,268 (0.2)       | 3,747 (0.3)       |
| -Coagulation Defects/Hematologic Disorders | 117,307 (4.4) | 42,132 (3.2) |
| -Hip Fracture/Dislocation     | 123,631 (4.7)     | 20,189 (1.5)      |
| Six most common reasons for hospitalization, n(%) |          |                   |
| -Total knee or hip replacement | 352,519 (13.3)    | 288,402 (21.9)    |
| -Sepsis                       | 213,601 (8.1)     | 59,332 (4.5)      |
| -Congestive heart failure     | 259,897 (9.8)     | 177,957 (13.5)    |
| -Urinary tract infection      | 211,318 (8.0)     | 61,905 (4.7)      |
| -Hip Fracture                 | 226,242 (8.5)     | 0                 |
| -Pneumonia                    | 215,725 (8.1)     | 107,369 (8.1)     |

Electronic copy available at: https://ssrn.com/abstract=2805172
Table 4. Summary of differential distance between closest non-integrated hospital and closest integrated hospital for each PAC type

|                        | SNF      | HHA      |
|------------------------|----------|----------|
| Differential distance to vertically integrated hospital in miles, mean (SD) | 14.6 (30.4) | 11.2 (29.9) |
| Differential distance to informally integrated hospital in miles, mean (SD) | 22.8 (30.0) | 15.4 (32.2) |

Table 5. First stage results, regression of integration status on differential distance

|                        | Based on distance to closest hospital vertically integrated with PAC | Based on distance to closest hospital informally integrated with PAC |
|------------------------|-------------------------------------------------------------------|---------------------------------------------------------------------|
|                        | SNF      | HHA      | SNF      | HHA      |
| Differential distance  | -0.000781*** | -0.00276*** | -0.00170*** | -0.00336*** |
|                        | (-11.25) | (-14.69) | (-20.71) | (-22.54) |
| N of discharges        | 2,651,748 | 1,318,577 | 2,651,748 | 1,318,577 |
| N of provider pairs    | 87,440   | 56,093   | 87,440   | 56,093   |

Electronic copy available at: https://ssrn.com/abstract=2805172
Table 6. Person-level characteristics by differential distance between nearest integrated and nearest non-integrated hospital (for integration with each PAC type)

|                        | Based on differential distance to closest hospital vertically integrated with PAC | Based on differential distance to closest hospital informally integrated with PAC |
|------------------------|---------------------------------------------------------------------------------|-------------------------------------------------------------------------------------|
|                        | SNF          | HHA            | SNF          | HHA          |
| Age                    | < median    | >= median      | < median    | >= median    | < median    | >= median    | < median    | >= median    |
| Age                    | 82.6        | 82.6           | 79.4        | 79.1         | 82.5        | 82.7          | 79.7        | 78.9         |
| Female                 | 66.7%       | 67.0%          | 62.4%       | 62.2%        | 65.2%       | 65.8%         | 62.2%       | 62.4%        |
| Race                   |             |                |             |              |             |                |             |              |
| -White                 | 84.0%       | 89.3%          | 87.0%       | 86.5%        | 84.5%       | 87.8%          | 86.6%       | 86.8%        |
| -Black                 | 11.0%       | 8.0%           | 8.6%        | 8.8%         | 10.4%       | 9.5%           | 8.9%        | 8.6%         |
| -Other                 | 1.1%        | 0.6%           | 1.1%        | 1.0%         | 1.1%        | 0.6%           | 1.2%        | 1.0%         |
| -Asian                 | 1.9%        | 0.5%           | 1.3%        | 1.1%         | 1.7%        | 0.7%           | 1.3%        | 1.1%         |
| -Hispanic              | 1.5%        | 1.1%           | 1.4%        | 2.0%         | 1.8%        | 0.9%           | 1.5%        | 2.0%         |
| -North American Native | 0.2%        | 0.3%           | 0.3%        | 0.3%         | 0.3%        | 0.2%           | 0.2%        | 0.4%         |
| -Unknown               | 0.3%        | 0.2%           | 0.3%        | 0.3%         | 0.2%        | 0.2%           | 0.3%        | 0.3%         |
| Comorbidities, n(%)    |             |                |             |              |             |                |             |              |
| -Severe Infection      | 1.4%        | 1.3%           | 0.9%        | 1.0%         | 1.4%        | 1.3%           | 1.0%        | 1.0%         |
| -Other Infectious Disease & Pneumonias | 30.9%    | 31.3%          | 20.1%       | 20.5%        | 31.4%       | 30.8%          | 20.5%       | 20.1%        |
| -Metastatic Cancer/Acute Leukemia | 2.5% | 2.3%          | 2.4%        | 2.4%         | 2.5%        | 2.4%           | 2.5%        | 2.3%         |
| -Severe Cancer         | 4.1%        | 4.0%           | 4.3%        | 4.3%         | 4.2%        | 4.1%           | 4.4%        | 4.2%         |
| -Other Cancers         | 5.6%        | 5.2%           | 4.9%        | 4.8%         | 5.5%        | 5.3%           | 5.1%        | 4.7%         |
| -Diabetes Mellitus     | 30.9%       | 31.1%          | 30.0%       | 30.3%        | 31.4%       | 30.7%          | 30.2%       | 30.1%        |
| -Protein-calorie Malnutrition | 13.2% | 12.8%          | 5.5%        | 6.1%         | 13.4%       | 12.7%          | 5.6%        | 6.1%         |
| -End-stage Liver Disease | 1.2%    | 1.1%           | 0.9%        | 0.9%         | 1.2%        | 1.1%           | 0.9%        | 0.9%         |
| -Severe Hematological Disorders | 1.5% | 1.6%          | 1.4%        | 1.5%         | 1.5%        | 1.6%           | 1.4%        | 1.4%         |
| -Alcohol Abuse         | 2.5%        | 2.5%           | 1.1%        | 1.0%         | 2.4%        | 2.6%           | 1.1%        | 1.0%         |
| -Psychiatric Comorbidity | 24.3%   | 26.0%          | 17.4%       | 18.5%        | 27.7%       | 25.6%          | 17.8%       | 18.0%        |
| -Hemiplegia, paraplegia, paralysis | 6.3%   | 5.9%          | 2.9%        | 2.9%         | 6.4%        | 5.9%           | 3.0%        | 2.8%         |
| -Seizure Disorders     | 5.3%        | 5.0%           | 2.7%        | 2.7%         | 5.2%        | 5.1%           | 2.7%        | 2.6%         |
| -Congestive heart failure | 26.5%  | 26.2%          | 21.2%       | 20.4%        | 26.4%       | 26.2%          | 21.7%       | 20.0%        |
| -Coronary atherosclerosis or angina | 51.4% | 52.3%        | 47.2%       | 47.4%        | 51.8%       | 51.2%          | 48.3%       | 46.4%        |
| -Specified arrhythmias | 24.6%       | 24.5%          | 19.6%       | 19.2%        | 24.5%       | 24.7%          | 20.4%       | 18.4%        |
| -Chronic obstructive pulmonary disease | 29.9% | 30.2%        | 27.9%       | 27.7%        | 30.0%       | 30.1%          | 28.1%       | 27.6%        |
| -Other chronic lung disorders | 3.8%    | 3.8%          | 3.9%        | 4.0%         | 3.7%        | 3.8%           | 4.1%        | 3.8%         |

Electronic copy available at: https://ssrn.com/abstract=2805172
| Condition                                      | 2014 1 | 2015 1 | 2016 1 | 2017 1 | 2018 1 | 2019 1 | 2020 1 | 2021 1 |
|-----------------------------------------------|--------|--------|--------|--------|--------|--------|--------|--------|
| Dialysis                                      | 1.5%   | 1.3%   | 8.8%   | 0.9%   | 1.5%   | 1.4%   | 0.9%   | 0.9%   |
| Decubitus Ulcer or Chronic Skin Ulcer         | 7.6%   | 6.9%   | 3.5%   | 3.5%   | 7.4%   | 7.1%   | 3.7%   | 3.2%   |
| Septicemia/Shock                              | 7.2%   | 6.6%   | 3.0%   | 3.3%   | 7.2%   | 6.6%   | 3.2%   | 3.2%   |
| Disorders of fluid, electrolytes              | 29.6%  | 30.1%  | 19.1%  | 19.9%  | 30.0%  | 29.7%  | 19.7%  | 19.3%  |
| Iron Deficiency or other anemias              | 44.0%  | 45.3%  | 35.4%  | 37.4%  | 45.1%  | 44.2%  | 36.1%  | 36.7%  |
| Cardiorespiratory Failure or Shock            | 10.4%  | 10.8%  | 7.2%   | 7.9%   | 10.7%  | 10.6%  | 7.4%   | 7.7%   |
| Acute Renal Failure                           | 21.0%  | 21.7%  | 14.4%  | 15.1%  | 21.3%  | 21.4%  | 15.1%  | 14.4%  |
| Pancreatic Disease                            | 1.8%   | 1.7%   | 1.6%   | 1.6%   | 1.7%   | 1.7%   | 1.7%   | 1.5%   |
| Rheumatoid Arthritis                          | 4.1%   | 4.4%   | 4.2%   | 4.4%   | 4.1%   | 4.3%   | 4.3%   | 4.3%   |
| Respirator Dependence/Tracheostomy            | 0.3%   | 0.3%   | 0.2%   | 0.1%   | 0.3%   | 0.3%   | 0.2%   | 0.1%   |
| Transplants                                   | 0.2%   | 0.2%   | 0.3%   | 0.3%   | 0.2%   | 0.2%   | 0.3%   | 0.3%   |
| Coagulation /Hematologic Disorders            | 4.4%   | 4.4%   | 3.1%   | 3.3%   | 4.5%   | 4.4%   | 3.3%   | 3.1%   |
| Hip Fracture/Dislocation                      | 4.6%   | 4.8%   | 1.5%   | 1.5%   | 4.7%   | 4.6%   | 1.5%   | 1.6%   |

Six most common reasons for hospitalization, n(%):

- Total knee or hip replacement: 12.8%, 13.8%, 20.7%, 23.1%, 13.2%, 13.4%, 19.7%, 24.1%
- Sepsis: 8.0%, 8.1%, 4.2%, 4.8%, 8.3%, 7.8%, 4.3%, 4.7%
- Congestive heart failure: 9.8%, 9.8%, 14.0%, 13.0%, 9.7%, 9.9%, 14.3%, 12.7%
- Urinary tract infection: 7.8%, 8.2%, 4.6%, 4.8%, 8.0%, 7.9%, 4.6%, 4.8%
- Hip Fracture: 8.3%, 8.7%, 0%, 0%, 8.5%, 8.5%, 0%, 0%
- Pneumonia: 8.1%, 8.2%, 8.4%, 7.9%, 8.2%, 8.1%, 8.3%, 8.0%
Table 7. Effects of being treated in an integrated hospital-PAC pair vs. a non-integrated pair on Medicare payment in the first 60 days following hospital admission

|                     | SNF                  | HHA                  |
|---------------------|----------------------|----------------------|
|                     | Total payment        | Hospital payment     | PAC payment | Total payment | Hospital payment | PAC payment |
| Vertical integration| 2423.5***            | 149.6                | 2273.9***   | -303.2**      | -261.5**         | -41.67      |
|                     | (4.52)               | (0.57)               | (5.16)      | (-2.35)       | (-2.03)          | (-0.94)     |
| N of discharges     | 2,651,748            | 2,651,748            | 2,651,748   | 1,318,577     | 1,318,577        | 1,318,577   |
| N of provider pairs | 87,440               | 87,440               | 87,440      | 56,093        | 56,093           | 56,093      |
| Informal integration| -204.4               | -326.3***            | 121.8       | 32.4          | 47.1             | -14.71      |
|                     | (-1.23)              | (-3.53)              | (0.86)      | (0.54)        | (0.92)           | (-0.63)     |
| N of discharges     | 2,651,748            | 2,651,748            | 2,651,748   | 1,318,577     | 1,318,577        | 1,318,577   |
| N of provider pairs | 87,440               | 87,440               | 87,440      | 56,093        | 56,093           | 56,093      |

Note: Regression includes all the covariates reported in Table 3, a full set of DRG controls, hospital-PAC-pair fixed effects, and year fixed effects.

Robust t-statistics in parentheses.

* p<0.10  ** p<0.05  ***p<0.01

Electronic copy available at: https://ssrn.com/abstract=2805172
Table 8. Effects of being treated in an integrated hospital-PAC pair vs. a non-integrated pair on length of stay in the first 60 days following hospital admission

|                     | SNF                  | HHA                  |
|---------------------|----------------------|----------------------|
|                     | Total length of stay | Hospital length of stay | PAC length of stay | Total length of stay | Hospital length of stay | PAC length of stay |
| Vertical integration| 3.90***              | -0.74***             | 4.64***             | -1.07*              | -0.10                 | -0.96*              |
|                     | (3.42)               | (-2.70)              | (4.13)              | (-1.95)             | (-1.28)               | (-1.78)             |

N of discharges: 2,651,748  
N of provider pairs: 87,440

|                     | SNF                  | HHA                  |
|---------------------|----------------------|----------------------|
|                     | Total length of stay | Hospital length of stay | PAC length of stay | Total length of stay | Hospital length of stay | PAC length of stay |
| Informal integration| -0.76**              | -0.14                | -0.62*              | -0.41               | -0.02                 | -0.39               |
|                     | (-2.09)              | (-1.48)              | (-1.78)             | (-1.43)             | (-0.48)               | (-1.35)             |

N of discharges: 2,651,748  
N of provider pairs: 87,440

Note: Regression includes all the covariates reported in Table 3, a full set of DRG controls, hospital-PAC-pair fixed effects, and year fixed effects.

Robust t-statistics in parentheses

* p<0.10  ** p<0.05  ***p<0.01
Table 9. Effects of being treated in an integrated hospital-PAC pair vs. a non-integrated pair on rehospitalization or death within 30 days of hospital discharge

|                      | SNF       | HHA       |
|----------------------|-----------|-----------|
| Vertical integration | -0.054**  | -0.004    |
|                      | (-1.96)   | (-0.49)   |
| N of discharges      | 2,651,748 | 1,318,577 |
| N of provider pairs  | 87,440    | 56,093    |

|                      | SNF       | HHA       |
|----------------------|-----------|-----------|
| Informal integration | 0.005     | -0.002    |
|                      | (0.54)    | (-0.47)   |
| N of discharges      | 2,651,748 | 1,318,577 |
| N of provider pairs  | 87,440    | 56,093    |

Note: Regression includes all the covariates reported in Table 3, a full set of DRG controls, hospital-PAC-pair fixed effects, and year fixed effects. Robust t-statistics in parentheses.

* p<0.10  ** p<0.05  ***p<0.01
### Table 10. Robustness checks on Medicare payment outcomes

**Vertical integration**

| Cohort                                      | SNF Total payment | SNF Hospital payment | SNF PAC payment | HHA Total payment | HHA Hospital payment | HHA PAC payment |
|---------------------------------------------|-------------------|----------------------|----------------|-------------------|----------------------|-----------------|
| Primary specification                       |                   |                      |                |                   |                      |                 |
| Vertical integration                        | 2423.5***         | 149.6                | 2273.9***      | -303.2**         | -261.5**             | -41.7           |
|                                             | (4.52)            | (0.57)               | (5.16)         | (-2.35)          | (-2.03)              | (-0.94)         |
| N of discharges                             | 2,651,748         | 2,651,748            | 2,651,748      | 1,318,577        | 1,318,577            | 1,318,577       |
| N of provider pairs                         | 87,440            | 87,440               | 87,440         | 56,093           | 56,093               | 56,093          |
| Vertically integrated but not informally integrated | 3824.3***         | 320.7                | 3503.6***      | -361.6**         | -257.5               | -104.0          |
|                                             | (5.31)            | (0.90)               | (5.86)         | (-2.02)          | (-1.37)              | (-1.44)         |
| N of discharges                             | 2,472,970         | 2,472,970            | 2,472,970      | 10,057,761       | 10,057,762           | 10,057,763      |
| N of provider pairs                         | 86,999            | 86,999               | 86,999         | 55,590           | 55,590               | 55,590          |
| Most competitive markets                    |                   |                      |                |                   |                      |                 |
| Vertical integration                        | 2616.3***         | 186.8                | 2429.5***      | -305.5**         | -266.2*              | -39.3           |
|                                             | (4.56)            | (0.67)               | (5.14)         | (-2.25)          | (-1.95)              | (-0.85)         |
| N of discharges                             | 2,502,313         | 2,502,313            | 2,502,313      | 1,244,192        | 1,244,192            | 1,244,192       |
| N of provider pairs                         | 84,736            | 84,736               | 84,736         | 54,405           | 54,405               | 54,405          |
| Balanced panel of hospital-PAC pairs        |                   |                      |                |                   |                      |                 |
| Vertical integration                        | 2938.3***         | 309.1                | 2629.2***      | -261.2**         | -214.1               | -47.1           |
|                                             | (4.27)            | (0.94)               | (4.63)         | (-2.01)          | (-1.63)              | (-1.06)         |
| N of discharges                             | 2,212,188         | 2,212,188            | 2,212,188      | 1,052,936        | 1,052,936            | 1,052,936       |
| N of provider pairs                         | 28,715            | 28,715               | 28,715         | 11,828           | 11,828               | 11,828          |
| All Medicare payments within 60 days as dependent variable | 2494.6***         |                      | -372.9**       |                   |                      |                 |
|                                             | (4.32)            |                      | (-2.06)        |                   |                      |                 |
| N of discharges                             | 2,651,748         |                      | 1,318,577      |                   |                      |                 |

Electronic copy available at: https://ssrn.com/abstract=2805172
| Cohort                                      | SNF         | HHA         | Total payment | Hospital payment | PAC payment | Total payment | Hospital payment | PAC payment |
|---------------------------------------------|-------------|-------------|---------------|------------------|-------------|---------------|------------------|-------------|
| Primary specification                       | Informally integrated | -204.4     | -326.3***    | 121.8            | 32.4        | 47.1          | -14.71          | (-0.63)     |
|                                             |             | (-1.23)    | (-3.53)     | (0.86)           | (0.54)      | (0.92)        |                 |             |
| N of discharges                             | 2,651,748   | 2,651,748   | 2,651,748     | 1,318,577        | 1,318,577   | 1,318,577     |                 |             |
| N of provider pairs                         | 87,440      | 87,440      | 87,440        | 56,093           | 56,093      | 56,093        |                 |             |
| Vertically integrated but not informally integrated | Informally integrated | -268.2     | -411.2***    | 142.9            | 4.1         | 60.9          | -56.9           | (-1.46)     |
|                                             |             | (-1.22)    | (-3.71)     | (0.75)           | (0.04)      | (0.71)        |                 |             |
| N of discharges                             | 2,387,101   | 2,387,101   | 2,387,101     | 1051948          | 1051948     | 1051948       |                 |             |
| N of provider pairs                         | 86,895      | 86,895      | 86,895        | 55504            | 55504       | 55504         |                 |             |
| Most competitive markets                    | Informally integrated | -315.9*    | -359.2***    | 43.31            | 58.5        | 76.0          | -17.5           | (-0.70)     |
|                                             |             | (-1.78)    | (-3.62)     | (0.29)           | (0.92)      | (1.39)        |                 |             |
| N of discharges                             | 2,502,313   | 2,502,313   | 2,502,313     | 1,244,192        | 1,244,192   | 1,244,192     |                 |             |
| N of provider pairs                         | 84,736      | 84,736      | 84,736        | 54,405           | 54,405      | 54,405        |                 |             |
| Balanced panel of hospital-PAC pairs        | Informally integrated | -363.0*    | -399.8***    | 36.80            | 33.9        | 61.8          | -28.0           | (-1.17)     |
|                                             |             | (-1.92)    | (-3.78)     | (0.23)           | (0.56)      | (1.19)        |                 |             |
| N of discharges                             | 2,212,188   | 2,212,188   | 2,212,188     | 1,052,936        | 1,052,936   | 1,052,936     |                 |             |
| N of provider pairs                         | 28,715      | 28,715      | 28,715        | 11,828           | 11,828      | 11,828        |                 |             |
| Excluding small hospitals                   | Informally integrated | -126.5     | -309.1***    | 182.6            | -123.4*     | -71.6         | -51.8**         | (-1.19)     |

Electronic copy available at: https://ssrn.com/abstract=2805172
|                          | (-0.77) | (-2.71) | (1.39) | (-1.91) | (-1.21) | (-2.06) |
|--------------------------|---------|---------|--------|---------|---------|---------|
| N of discharges          | 2,453,016 | 2,453,016 | 2,453,016 | 952,926 | 952,926 | 952,926 |
| N of provider pairs      | 83,457 | 83,457 | 83,457 | 48,724 | 48,724 | 48,724 |
| All Medicare payments within 60 days as dependent variable | Informally integrated | -182.9 | (-0.91) | 19.8 | (0.20) |
|                          | N of discharges | 2,651,748 | 1,318,577 |
|                          | N of provider pairs | 87,440 | 56,093 |

Note: Regression includes all the covariates reported in Table 3, a full set of DRG controls, hospital-PAC-pair fixed effects, and year fixed effects.

Robust t-statistics in parentheses

* p<0.10  ** p<0.05  ***p<0.01
**Appendix Table 1.** Twenty-five most common DRGs in each PAC setting and percent of patients in each DRG among all patients going to each PAC setting.

| SNF                          | %    |
|------------------------------|------|
| Major joint replacement or reattachment of lower extremity (544) | 7.0  |
| Heart failure & shock (127)  | 5.2  |
| Septicemia w/o mechanical ventilation 96+ hours (567) | 4.2  |
| Intracranial hemorrhage or cerebral infarction (14) | 3.1  |
| Renal failure (316)          | 3.1  |
| Simple pneumonia & pleurisy (89) | 2.9  |
| Chronic obstructive pulmonary disease (88) | 2.3  |
| Kidney & urinary tract infections (320) | 2.3  |
| Hip & femur procedures except major joint (210) | 1.9  |
| Kidney & urinary tract infections (321) | 1.9  |
| Hip & femur procedures except major joint (211) | 1.9  |
| Respiratory infections & inflammations (79) | 1.8  |
| Degenerative nervous system disorders (12) | 1.6  |
| Nutritional & misc metabolic disorders (296) | 1.5  |
| Medical back problems (243)  | 1.4  |
| Simple pneumonia & pleurisy (90) | 1.4  |
| Acute myocardial infarction, discharged alive (121) | 1.3  |
| Nutritional & misc metabolic disorders (297) | 1.2  |
| G.I. hemorrhage (174)        | 1.1  |
| Fractures of hip & pelvis (236) | 1.1  |
| Pulmonary edema & respiratory failure (87) | 1.0  |
| Syncope & collapse (141)     | 1.0  |
| Esophagitis, gastroenteritis & misc digest disorders (182) | 0.9  |
| Cardiac arrhythmia & conduction disorders (138) | 0.9  |
| Septicemia age>17 (416)      | 0.9  |

| HHA                          | %    |
|------------------------------|------|
| Major joint replacement or reattachment of lower extremity (544) | 10.0 |
| Heart failure & shock (127)  | 6.4  |
| Chronic obstructive pulmonary disease (88) | 3.8  |
| Simple pneumonia & pleurisy (89) | 2.5  |
| Septicemia w/o mechanical ventilation 96+ hours (576) | 2.1  |
| Renal failure (316)          | 2.1  |
| Intracranial hemorrhage or cerebral infarction (14) | 2.0  |
| Simple pneumonia & pleurisy (90) | 1.4  |
| Syncope & collapse (141)     | 1.3  |
| Kidney & urinary tract infections (321) | 1.2  |
| Cardiac arrhythmia & conduction disorders (139) | 1.1  |
| Condition                                                                 | Section |
|---------------------------------------------------------------------------|---------|
| Cardiac arrhythmia & conduction disorders (138)                           | 1.1     |
| Acute myocardial infarction, discharged alive (121)                       | 1.1     |
| Kidney & urinary tract infections (320)                                   | 1.1     |
| Cellulitis (278)                                                          | 1.1     |
| Cardiac valve & other major cardiothoracic proc w/o card catheterization (105) | 1.0     |
| Major joint & limb reattachment procedures of lower extremity (209)       | 1.0     |
| Nutritional & misc metabolic disorders (297)                              | 0.9     |
| Pulmonary edema & respiratory failure (87)                                | 0.9     |
| Nutritional & misc metabolic disorders (296)                              | 0.9     |
| Esophagitis, gastroenteritis & misc digest disorders (183)                 | 0.9     |
| Medical back problems (243)                                               | 0.9     |
| G.I. hemorrhage (174)                                                     | 0.9     |
| Transient ischemia (524)                                                   | 0.8     |
| Esophagitis, gastroenteritis & misc digest disorders (182)                 | 0.8     |
### Appendix Table 2. Specification checks on length of stay outcomes

#### Vertical integration

| Cohort                              | SNF                  | HHA                  |                  |                  |                  |                  |                  |
|-------------------------------------|----------------------|----------------------|------------------|------------------|------------------|------------------|------------------|
|                                     | Total LOS            | Hospital LOS         | PAC LOS          | Total LOS        | Hospital LOS     | PAC LOS          |                  |
|                                     | 3.9***               | -0.7***              | 4.6***           | -1.1*            | -0.1             | -1.0*            |                  |
|                                     | (3.42)               | (-2.70)              | (4.13)           | (-1.95)          | (-1.28)          | (-1.78)          |                  |
| N of discharges                     | 2,651,748            | 2,651,748            | 2,651,748        | 1,318,577        | 1,318,577        | 1,318,577        |                  |
| N of provider pairs                 | 87,440               | 87,440               | 87,440           | 56,093           | 56,093           | 56,093           |                  |
|                                     |                      |                      |                  |                  |                  |                  |                  |
| Vertically integrated but not      |                      |                      |                  |                  |                  |                  |                  |
| informally integrated              |                      |                      |                  |                  |                  |                  |                  |
|                                     | 5.2***               | -1.0***              | 6.2***           | -1.3             | -0.03            | -1.3             |                  |
|                                     | (3.38)               | (-2.72)              | (4.11)           | (-1.57)          | (-0.22)          | (-1.57)          |                  |
| N of discharges                     | 2,472,970            | 2,472,970            | 2,472,970        | 1,033,033        | 1,033,033        | 1,033,033        |                  |
| N of provider pairs                 | 86,999               | 86,999               | 86,999           | 55,590           | 55,590           | 55,590           |                  |
|                                     |                      |                      |                  |                  |                  |                  |                  |
| Most competitive markets            |                      |                      |                  |                  |                  |                  |                  |
|                                     |                      |                      |                  |                  |                  |                  |                  |
|                                     | 4.5***               | -0.8***              | 5.4***           | -1.1*            | -0.1             | -0.9*            |                  |
|                                     | (3.73)               | (-2.76)              | (4.45)           | (-1.88)          | (-1.56)          | (-1.67)          |                  |
| N of discharges                     | 2,502,313            | 2,502,313            | 2,502,313        | 1,244,192        | 1,244,192        | 1,244,192        |                  |
| N of provider pairs                 | 84,736               | 84,736               | 84,736           | 54,405           | 54,405           | 54,405           |                  |
|                                     |                      |                      |                  |                  |                  |                  |                  |
| Complete panel of hospital-PAC     |                      |                      |                  |                  |                  |                  |                  |
| pairs                              |                      |                      |                  |                  |                  |                  |                  |
|                                     | 4.6***               | -0.7**               | 5.3***           | -1.3**           | -0.1*            | -1.1**           |                  |
|                                     | (3.10)               | (-2.05)              | (3.64)           | (-2.32)          | (-1.77)          | (-2.08)          |                  |
| N of discharges                     | 2,212,188            | 2,212,188            | 2,212,188        | 1,052,936        | 1,052,936        | 1,052,936        |                  |
| N of provider pairs                 | 28,715               | 28,715               | 28,715           | 11,828           | 11,828           | 11,828           |                  |
|                                     |                      |                      |                  |                  |                  |                  |                  |
| Using negative binomial model       |                      |                      |                  |                  |                  |                  |                  |
|                                     |                      |                      |                  |                  |                  |                  |                  |
|                                     | 0.4***               | -0.3***              | 0.4***           | -0.04***         | -0.02*           | -0.04***         |                  |
|                                     | (16.46)              | (-8.98)              | (14.55)          | (-4.79)          | (-1.87)          | (-4.26)          |                  |
| N of discharges                     | 2,626,214            | 2,626,214            | 2,626,214        | 1,299,442        | 1,299,442        | 1,299,442        |                  |

Electronic copy available at: https://ssrn.com/abstract=2805172
**Informal integration**

|            | SNF | HHA |
|------------|-----|-----|
| Cohort     | Total LOS | Hospital LOS | PAC LOS | Total LOS | Hospital LOS | PAC LOS |
| Primary specification | -0.8** | -0.1 | -0.6* | -0.4 | -0.02 | -0.4 |
| N of discharges | 2,651,748 | 2,651,748 | 2,651,748 | 1,318,577 | 1,318,577 | 1,318,577 |
| N of provider pairs | 87,440 | 87,440 | 87,440 | 56,093 | 56,093 | 56,093 |
| Vertically integrated but not informally integrated | -0.9* | -0.2 | -0.7 | -1.4** | -0.03 | -1.3*** |
| N of discharges | 2,387,101 | 2,387,101 | 2,387,101 | 1,051,948 | 1,051,948 | 1,051,948 |
| N of provider pairs | 86,895 | 86,895 | 86,895 | 55,504 | 55,504 | 55,504 |
| Most competitive markets | -0.6 | -0.1 | -0.5 | -0.03 | -0.02 | -0.4 |
| N of discharges | 2502313 | 2502313 | 2502313 | 1,244,192 | 1,244,192 | 1,244,192 |
| N of provider pairs | 84736 | 84736 | 84736 | 54,405 | 54,405 | 54,405 |
| Complete panel of hospital-PAC pairs | -0.9** | -0.1 | -0.8* | -0.3 | -0.02 | -0.3 |
| N of discharges | 2212188 | 2212188 | 2212188 | 1,052,936 | 1,052,936 | 1,052,936 |
| N of provider pairs | 28715 | 28715 | 28715 | 11,828 | 11,828 | 11,828 |
| Excluding small hospitals | -0.7** | -0.01 | -0.7** | -0.7** | 0.02 | -0.7** |
| N of discharges | 2453016 | 2453016 | 2453016 | 952,926 | 952,926 | 952,926 |

*Electronic copy available at: https://ssrn.com/abstract=2805172*
| Using negative binomial model | Informally integrated | 83457 | 83457 | 83457 | 48,724 | 48,724 | 48,724 |
|-------------------------------|-----------------------|-------|-------|-------|--------|--------|--------|
| N of discharges               | 2,626,214             | 2,626,214 | 2,626,214 | 1,299,442 | 1,299,442 | 1,299,442 |
| N of provider pairs           |                      |       |       |       |        |        |        |
| Robust t-statistics in parentheses |                    | (-2.10) | (-0.87) | (-1.77) | (-13.37) | (-1.60) | (-15.63) |
| Note: Regression includes all the covariates reported in Table 3, a full set of DRG controls, hospital-PAC-pair fixed effects, and year fixed effects. |
| * p<0.10  ** p<0.05  ***p<0.01 |
### Appendix Table 3. Specification checks on rehospitalization or death outcomes

#### Vertical integration

| Cohort                                      | SNF     | HHA     |
|---------------------------------------------|---------|---------|
| **Primary specification**                   |         |         |
| Vertical integration                        | -0.054**| -0.004  |
|                                             | (-1.96) | (-0.49) |
| N of discharges                             | 2,651,748 | 1,318,577 |
| N of provider pairs                         | 87,440  | 56,093  |
| **Vertically integrated but not informally integrated** |         |         |
| Vertical integration                        | -0.063* | -0.012  |
|                                             | (-1.65) | (-0.94) |
| N of discharges                             | 24,729,70 | 1,033,033 |
| N of provider pairs                         | 86999   | 55590   |
| **Most competitive markets**                |         |         |
| Vertical integration                        | -0.070**| -0.006  |
|                                             | (-2.37) | (-0.76) |
| N of discharges                             | 2,502,313 | 1,244,192 |
| N of provider pairs                         | 84,736  | 54,405  |
| **Complete panel of hospital-PAC pairs**    |         |         |
| Vertical integration                        | -0.062* | -0.005  |
|                                             | (-1.75) | (-0.59) |
| N of discharges                             | 2,212,188 | 1,052,936 |
| N of provider pairs                         | 28,715  | 11,828  |

#### Informal integration

| Cohort                                      | SNF     | HHA     |
|---------------------------------------------|---------|---------|
| **Primary specification**                   |         |         |
| Informal integration                        | 0.005   | -0.002  |
|                                             | (0.54)  | (-0.47) |
| N of discharges                             | 2,651,748 | 1,318,577 |
| N of provider pairs                         | 87,440  | 56,093  |
| **Vertically integrated but not informally integrated** |         |         |
| Informal integration                        | 0.0001  | -0.007  |
|                                             | (0.01)  | (-0.84) |
| N of discharges                             | 2,387,101 | 1,051,948 |
| N of provider pairs                         | 86,895  | 55,504  |
| **Six most common DRGs**                    |         |         |
| Informal integration                        | 0.006   | -0.001  |
|                                             | (0.47)  | (-0.20) |
| N of discharges                             | 1,282,965 | 757,073  |
| N of provider pairs                         | 67,936  | 44,349  |

Electronic copy available at: https://ssrn.com/abstract=2805172
|                      | Informal integration |       |       |
|----------------------|----------------------|-------|-------|
|                      |                      | 0.004 | -0.001|
|                      |                      | (0.45)| (-0.26)|
| N of discharges      | 2,502,313            | 1,244,192|
| N of provider pairs  | 84,736               | 54,405|

|                      | Informal integration |       |       |
|----------------------|----------------------|-------|-------|
|                      |                      | 0.004 | -0.001|
|                      |                      | (0.38)| (-0.11)|
| N of discharges      | 2,212,188            | 1,052,936|
| N of provider pairs  | 28,715               | 11,828|

|                      | Informal integration |       |       |
|----------------------|----------------------|-------|-------|
|                      |                      | -0.001| -0.000|
|                      |                      | (-0.11)| (-0.09)|
| N of discharges      | 2,453,016            | 1,201,838|
| N of provider pairs  | 83,457               | 49,325|

Note: Regression includes all the covariates reported in Table 3, a full set of DRG controls, hospital-PAC-pair fixed effects, and year fixed effects.
Robust t-statistics in parentheses
* p<0.10 ** p<0.05 ***p<0.01