Three Enquiries Concerning Hospital-Physician Vertical Integration

by

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DEDICATION

I dedicate this dissertation to my brother Keaton, my sisters Zoe and Carlie, and my parents Junior and Londa. I began my education in a Michigan kindergarten. It is a special privilege to complete it with a doctorate, surrounded by family, in my home state. And to Olaf: I would have loved celebrating this milestone with you as Dr. Millert and Dr. Post.

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ABSTRACT

Hospitals and physicians in the United States increasingly work together under common ownership. Over the past decade, physicians have gravitated toward employment at hospital-owned facilities and hospitals have acquired large numbers of physician practices; collectively, these changes have become known as "vertical integration" among these providers. The rapid growth in vertical integration raises questions about the causes and effects of this fundamental realignment in the American health care delivery system. In this dissertation, I explore three economic issues connected to the causes and consequences of this realignment.

In the first chapter of this dissertation, I investigate vertical integration from a health care payment policy lens. I explore whether Medicare reimbursement policy created incentives that have driven vertical integration. I measure the size of the differences in Medicare reimbursement at integrated and non-integrated sites for a nationally representative sample of physicians. I then evaluate whether these reimbursement differences stimulated vertical integration activity. I find that despite large financial incentives, these payment differentials exerted little influence on vertical integration, implying only a small role for Medicare payment policy in accelerating or decelerating vertical integration.

In the second chapter, I examine vertical integration from a labor economics lens. Since changes in productivity incentives often accompany changes in employment setting, I examine the clinical output of primary care physicians who join hospital systems, i.e., the productivity of physicians who become vertically integrated. I find that when physicians move from a non-

integrated practice to an integrated practice, they reduce their clinical output by 10 to 20 percent. They see fewer patients, bill fewer services, and generate less professional revenue. These sizable effects imply that vertical integration could reduce physician workloads, but with fewer primary care appointments available, integration may also threaten patient access to essential care.

In the third chapter, I explore vertical integration with an eye toward clinical documentation and alternative payment models. Hospitals and physicians might integrate to prepare for, or to perform better in, alternative payment models that use patients' documented clinical severity as the cornerstone of risk-adjusted payment. These models create large incentives for provider systems to document patient illness as thoroughly as possible. Hospitals may extend their documentation resources to their integrated physician practices. To test whether vertical integration affects documented patient illness, I examine a sample of several million patients with varying exposure to vertically integrated physicians. Using several statistical approaches, I estimate that patient exposure to vertically integrated physicians is associated with annual increases in reported patient illness of 10-24 percent. These large effects imply that the increasing prevalence of vertically integrated systems may raise costs to Medicare, Medicaid, and commercial health insurers.

The continued rise in health care spending constitutes one of the most pressing public policy problems in the United States. Understanding the complex role of vertical integration in this problem is one step toward greater affordability. This dissertation adds three specific insights to increase that understanding.

CHAPTERS

Chapter 1. Site-Based Payments and Hospital-Physician Vertical Integration

Chapter 1 Abstract

Importance: Vertical integration of hospitals and physicians has accelerated in the last decade, causing increases in prices and spending. One commonly cited reason for this acceleration is Medicare's site-based payment policy that pays providers more for the same services if performed in a hospital-owned office.

Objective: To determine the relationship between Medicare's site-based outpatient billing policy and hospital-physician integration.

Design: Retrospective, longitudinal study of physicians from all 50 U.S. States who served Medicare patients between 2010-2015 (n=1,737,678 physician-year observations). For each physician-year, we calculated the disparity between Medicare reimbursement under hospital ownership and under physician ownership. Using regression analysis, we estimated the relationship between these payment differences and hospital-physician integration, adjusting for region, market concentration, and physician fixed effects.

Setting: The study included physicians who billed Medicare between January 1, 2010 and December 31, 2015 (n=1,737,678 physician-year observations).

Participants: Integrated and non-integrated physicians were selected. Eligible medical specialties included primary care, diagnostic radiology, obstetrics and gynecology, cardiology, surgery, psychiatry, gastroenterology, neurology, dermatology, urology, and otolaryngology. Data were analyzed from November 1, 2018 through February 28, 2020.

Exposure: Difference in Medicare reimbursement between hospital-owned and physician-owned settings, measured using each physician's claims and comparing service-level reimbursements in the Medicare Physician Fee Schedule and the Medicare Outpatient Prospective Payment System.

Main Outcomes and Measures: Physician integration with a hospital, measured as integrated if a physician billed outpatient services under a hospital outpatient place of service, or if a physician's employer name corresponded to a hospital system.

Results: 50,278 physicians were integrated in 2010 (17.9 percent), while 61,054 physicians were integrated in 2015 (20.5 percent). Medicare reimbursement for physician services would have been an average of 85 percent higher, or approximately $77,000 higher per year, if a physician integrated instead of remaining independent. There was considerable variation across specialties: cardiologists faced a 59 percent reimbursement increase under integration, primary care physicians 72 percent, and urologists 244 percent. Yet there was a relatively weak relationship between outpatient payment differentials and integration. An increase in this outpatient payment differential equivalent to moving from the 25th to 75th percentile was associated with only a 0.17 percentage point increase in the probability of integrating with a hospital (95% CI: 0.07 to 0.28, $p < .01$). The marginal effect of the payment differential was larger among primary care physicians, where a 25th to 75th percentile increase was associated with a 0.45 percentage point increase in the probability of integrating (95% CI: 0.35 to 0.55, $p < .001$). By contrast, the relationship between the payment differential and integration was negative among cardiologists, with a 1.55 percentage point decrease in the probability of integrating (95% CI: -1.82 to -1.28, $p < .001$). Across all specialties, the marginal effect of the payment differential was larger at higher levels of the differential, most notably among primary care physicians. Higher hospital market concentration and being in a rural area were also associated with greater likelihood of integration.

Conclusions and Relevance: While Medicare's site-based outpatient payment policy may play a smaller role in the increase of hospital-physician vertical integration than previously thought, it may influence hospital-physician integration decisions on the margin among physicians who face especially high payment differentials, particularly in primary care.

Introduction

Over the last decade, hospitals continued to acquire physician practices in large numbers.[1–3] As of 2018, hospitals owned 31.2 percent of physician practices, up from 13.6 percent in 2012.[2] Site-based reimbursement, in which outpatient care can be billed at a higher rate if the place of service is owned by a hospital, is one potential driver of hospital-physician vertical integration (hereafter, "integration").[4,5] In 2011, an office visit with a new patient could be billed for $198 in a doctor's office. The same visit could be billed for $331 if the office were designated a hospital outpatient department (HOPD), thereby generating a facility fee in addition to the physician fee.[6] The Medicare Payment Advisory Commission (MedPAC) noted that the HOPD-office payment difference "creates a financial incentive for hospitals to purchase freestanding physicians' offices and convert them to [outpatient departments] without changing their location or patient mix."[7] These observations, and concern about unnecessary increases in spending, have led to calls for "site-neutral payments," or equal payment for certain outpatient procedures, regardless of practice site. The Centers for Medicare and Medicaid Services (CMS) introduced site-neutral rulemaking that took effect on January 1, 2019, decreasing off-campus HOPD reimbursement to office levels for certain patient visits. Although litigation against the rule is ongoing, CMS has pursued its site-neutral policies in 2020.[8]

Despite this move towards site-neutral payments, little is known about the extent to which site-based payment influences integration. While hospitals can increase reimbursement from physician services through integration, site-based payment may not be a major factor in integration decisions. Instead, hospitals may be driven more by the desire to gain leverage in price negotiations with commercial payers[9] and influence physician referral behavior and hospital choice.[10,11] Integration could also be driven by a shared desire across hospitals and physicians to enhance care coordination, facilitate health information exchange, or adapt to new payment models.[4]

In this paper, we examined the relationship between site-based Medicare payment differences and integration. Using 2010-2015 Medicare data, we calculated the reimbursement value of each physician's services if performed in an HOPD and compared it to the value if performed in an office. We then assessed whether hospital outpatient payment differentials were associated with greater likelihood of integration, hypothesizing that larger payment differentials would lead to greater integration.

Methods

We used Medicare 20 percent sample files of Part B claims; Medicare Provider Analysis and Review files (MEDPAR); Medicare Outpatient Prospective Payment System (OPPS) files; Medicare Physician Fee Schedule (PFS) files; Medicare Data on Provider Practice and Specialty (MD-PPAS); and the American Medical Association (AMA) Physician Masterfile. All datasets included years 2010-2015. MEDPAR contains patient claims for inpatient encounters. The Medicare Part B claims contain the claims history for a 20% sample of Medicare beneficiaries, described in detail elsewhere.[12] The Medicare OPPS and PFS files contain information required to calculate prices for services in the office and HOPD settings. MD-PPAS contains tax identifiers and legal names for each physician's primary place of practice. The AMA Masterfile is a comprehensive database of nearly all U.S. physicians and lists demographic and professional characteristics associated with each physician.

The claims files allowed us to characterize several aspects of a physician's practice: whether a physician was integrated with a hospital; the market concentration of hospitals and physicians;

and the number of procedures performed and the associated Medicare revenue. We used the Part B claims with the Medicare OPPS and PFS files to calculate the value of each physician's services if billed from an office and if billed from an HOPD.

Our study population included physicians in the United States who billed Medicare between 2010 and 2015. We limited our analysis to physicians with specialty codes of primary care, diagnostic radiology, OB/GYN, cardiology, surgery, psychiatry, gastroenterology, neurology, dermatology, urology, and otolaryngology. We excluded oncology because of the unique role of the 340B drug program in hospital-physician relations in this specialty.[13–15] We also required each physician to have over 10 recorded line items in Medicare claims and have a matching record from the AMA Masterfile. We excluded a small number of physicians with invalid National Provider Identifiers. The resulting file was an unbalanced panel of physicians (n=1,737,678 physician-years) who met these criteria in all six years of the study period (see Appendix 1.1 for sample flow diagram).

Our outcome was physician integration with a hospital. We defined integration using a strategy developed by Neprash and colleagues which uses place of service codes found in Medicare claims.[4] We supplemented this definition by identifying physicians whose legal names in MD-PPAS data were likely to correspond to hospital employment (Appendix 1.8).

Our key exposure variable was a measure of the financial incentive to bill under an HOPD place of service, which we call the "HOPD ratio." To calculate the magnitude of this financial incentive, we examined the full bundle of services for which a physician billed Medicare each year, using the Healthcare Common Procedure Coding System (HCPCS) codes found on each claim. Medicare specifies reimbursement levels for each HCPCS code and each place of service. We compared the dollar amount of revenue if a physician performed all their services under an office code to the revenue if performed under an HOPD code. For every physician in each year, we measured the HOPD ratio as the revenue available if they billed their bundle of services from an HOPD divided by the revenue available if they billed from an office. Each physician thus had their own HOPD ratio, with variation in this ratio across physicians driven by differences in the bundle of services that each physician delivered to their patients. This measure exhibits variation across specialty (since physicians of different specialties perform different procedures, each of which is associated with different HOPD-office payment disparities) as well as within specialty (since each physician within a specialty performs a slightly different bundle of procedures depending on their patients' needs). More detail about our approach can be found in Appendix 1.8.

We were interested in understanding the relationship between the HOPD ratio and integration among physicians. We hypothesized that physicians with large potential gains from billing as an HOPD instead of an office, i.e., those with large HOPD ratios, would be more likely to be acquired by the end of the study period. To test this, we estimated linear probability models with physician fixed effects. We also calculated and controlled for market competitiveness of hospitals and physicians, since the degree of market competition influences the incentive to integrate.[9] We clustered standard errors at the physician level. In our preferred specification, we include the ratio, its squared term, and its cubic term to account for non-linearity in the effect. We report the marginal effects of the ratio on the probability to integrate. We also performed stratified analysis, estimating this model within samples of primary care physicians, surgeons, cardiologists, and other specialties.

We conducted several sensitivity analyses to examine the robustness of our results to alternative specifications (Appendix 1.3 and Appendix 1.4). We tested a sample that included oncologists.

We tested Logit models and linear probability models (with and without physician fixed effects). We implemented our independent variable with squares and cubic terms, with lags, and expressed in dollars. These analyses did not change our conclusions.

Our study has several limitations. First, since we use Medicare prices in our analysis, we can only make inferences on the effect of Medicare reimbursement rates on integration. While commercial rates are also important to physicians, many commercial payers negotiate their prices using Medicare rates as a benchmark.[16] This suggests that although commercial rates may be higher, the HOPD ratio is likely to remain comparable. Second, we use a claims-based measure of integration supplemented by a keyword search of physicians' employer names. If acquired practices do not promptly update their place of service in their Medicare claims, then a claims-based approach may introduce measurement error into our dependent variable and bias our findings toward a null result. The advantage of a claims-based measure is that it is easily understood, can be reliably reproduced using a commonly available data source, and allows us to generate a large, nationally representative physician sample. Moreover, it is the best fit with our research question, which centers on the ability of providers to receive larger payments using a different place of service on Medicare claims. If providers do not update their place of service after integration, we would not measure their integration status correctly – however, neither would the provider be able to receive higher reimbursement, implying that taking advantage of the payment differential was not the primary incentive. The levels and trends of integration that we calculate are also broadly consistent – overall and across specialties – with research using alternative measures (see Appendix 1.2). We also believe our keyword search supplement helps to mitigate measurement error. Third, we focus on only a subset of physician specialties and select years. While our findings may not generalize to every specialty, our subset contains the most common physician types and allows for a parsimonious analysis. Further, our analysis captures a key time period, as the years between 2010 and 2015 reportedly exhibited the sharpest increase in integration.[17] Fourth, a potential critique of this analysis is that the payment changes are not sufficiently exogenous, i.e., that the service-level payment updates are correlated to the underlying costs of performing those services, thereby leaving profitability (and the incentive to integrate) unchanged, biasing our results toward the null. We propose, however, that costs and reimbursement updates are weakly correlated. Medicare reimbursement updates derive from numerous factors, of which provider costs are only one; other factors include beneficiary access to care, quality of care, providers' access to capital, and Medicare payments (p. 31).[7] During our study timeframe, MedPAC further stated "Medicare payment policy should not be designed simply to accommodate whatever level of cost growth a sector demonstrates… The Commission does not start with any presumption that an update is needed or that any increase in costs should be automatically offset by the update" (p. 37).[7] Given the array of budgetary factors taken into account for payment updates, we think that reimbursement updates are likely to be weakly correlated to underlying costs.

Results

We identified a total of 1,737,678 physician-years who met inclusion criteria between 2010 and 2015 (Table 1.1). Primary care physicians comprised about 46 percent of our sample. Integration increased between 2010 and 2015 from 17.9 percent of the sample to 20.5 percent. The average HOPD ratio in 2010 was 1.85. This indicates that for the average physician, the revenue they would have generated for their bundle of services if performed in an HOPD would have been 185 percent the size of revenue they would have generated for the same services if performed in an office. Given that average office revenue in 2010 was approximately $91,000, this implies that integrating with a hospital would have increased total reimbursement by approximately $77,000. The HOPD ratio increased to an average of 1.92 in 2015. The average hospital referral region (HRR) Herfindahl-Hirschman index (HHI) for hospitals was over 1,700 and for physician specialties was over 300.

The levels of integration differed markedly by specialty, with diagnostic radiologists having the highest rates of integration (59 percent), dermatologists the lowest (6 percent), and primary care physicians in the middle (22 percent) (Figure 1.1). For urology, surgical specialties, and gastroenterology, the 2011 HOPD ratio exceeded 2.00. There was little evidence of a cross-sectional relationship between the HOPD ratio and integration. Physicians in all specialties faced an incentive to integrate, with about a quarter of physicians having a ratio of 2.00 or more, indicating that reimbursement for their services would have been double in a hospital-owned outpatient department compared to equivalent services delivered in an office (Appendix 1.5). Diagnostic radiologists were the most integrated specialty in our sample (59 percent). These physicians provide a service to other doctors or hospitals and do not take care of patients directly. Most radiology tests occur in the hospital inpatient or outpatient setting as opposed to the office, corresponding to the high levels of hospital employment we observed in our data.

Estimates from the adjusted models showed that the HOPD ratio was significantly associated with integration, though the magnitude of the effect was generally small and varied by specialty (Figure 1.2). In the full sample, the average effect of a 1-unit increase in the HOPD ratio (approximately equal to moving from the 5th percentile to the 90th percentile of the HOPD ratio) was associated with a 0.47 percentage point increase in the probability of integrating with a hospital.

Our estimates showed heterogeneous effects of the HOPD ratio over the size of the ratio. At the lowest decile of the HOPD ratio, the effect in the full sample was negative: marginal increases in the ratio decreased the probability of integration with a hospital (marginal effect [ME] = -0.02). The effect grew steadily more positive as the size of the ratio increased: by the 50th percentile, we observed a small positive relationship between the ratio and integration (ME = 0.005). At the 80th and 90th percentiles, the effect of an increase in the HOPD ratio was about 3 percentage points (ME=0.03) (Figure 1.2).

The effect of the HOPD ratio varied substantially by specialty. We observed, however, a similar pattern across all specialties we examined, in that the effect was smallest at low levels of the ratio, and largest at high levels of the ratio. In primary care, this curve was sharp: while the ratio had a small negative effect among those in the lowest decile, the marginal effect among the second decile was a positive 1 percentage point, and at the 90th percentile, the effect was nearly 10 percentage points. In cardiology, the marginal effects grew from the lowest decile to the highest, but at all levels, the marginal effects were negative, until the 80th and 90th percentiles, at which point the effect was not statistically different from zero. Among surgeons, the marginal effects were, between the 10th and 40th percentiles, close to zero, and positive but relatively small from the 50th through 90th percentiles (between 1 and 3 percentage points). Among the remaining physician specialties, the effects in the lower half of the HOPD ratio distribution were slightly negative or non-significant, and in the upper half of the distribution, slightly positive or non-significant.

We also found that high levels of hospital market concentration as well as rural geography was associated with a higher probability of a physician being integrated (Appendix 1.3, column 2). To identify these effects, we estimated a linear probability model in which we dropped physician fixed effects, but included physician age, medical specialty, region, rural status, and market concentration of hospitals and physicians. A 10 percent increase in the HRR-level hospital HHI was associated with a 2.2 percentage point increase in the probability of integrating with a hospital. Physician market concentration was associated with a lower probability of integrating. Rural status was associated with an 8 percentage point greater probability of integrating with a hospital. Sensitivity analyses confirmed the robustness of our results to alternative specifications (Appendix 1.3 and Appendix 1.4).

Discussion

In this national study of the relationship between Medicare's outpatient payment differentials and hospital-physician integration, we report three main findings. First, HOPD ratios were high and varied considerably across specialties. Second, HOPD ratios were associated with greater integration among physicians facing the largest site-based payment disparities. Third, there was considerable heterogeneity in the association between HOPD ratios and integration across specialties, with primary care physicians exhibiting much more responsiveness than other specialties.

A number of recent studies have shown an increase in integration in the past decade.[2,18] Nikpay and colleagues also demonstrated differences in integration trends by specialty, finding that oncology and cardiology accelerated faster than other specialties.[17] A recent investigation examined the roles of Medicare's chemotherapy drug payment policy and 340B drug discount program in driving hospital-physician integration among oncology practices. The investigators found little evidence that these policies caused vertical integration.[14]

Our results add nuance to two published studies that explore site-based payments and integration. Song and colleagues found that after payment changes in 2010 that favored the HOPD setting, growth in the share of services performed in the HOPD setting grew by 2.7-5.9 percentage points for the three cardiology imaging services they selected.[19] In our study, we add to this approach by allowing thousands of possible outpatient physician services, using payment updates across a six-year period, and controlling for physician-specific effects. In contrast with Song and colleagues, among cardiologists, we find that, on average, moving from the 25^{th} percentile of the HOPD ratio to the 75^{th} percentile decreases the probability of a cardiologist integrating with a hospital by about 1.5 percentage points (Appendix A7). Practices with high imaging volumes, of the sort studied by Song and colleagues, may have particularly high payment differentials. Hospitals might disproportionately prefer to integrate with practices with high imaging volumes, which would help explain these findings. Consistent with this possibility, our effect becomes less negative among cardiologists at higher levels of the ratio, even becoming slightly positive at the 90^{th} percentile.

Second, Dranove and Ody examine a broader swathe of the physician population and determine that changes to Medicare prices in 2010 accounted for 20 percent of the increase in hospital employment.[5] Our study differs in several key ways. Notably, our exposure is different. We use annual payment updates from 2010-2015 instead of a single-year payment shock. We also rely on Medicare claims data while Dranove and Ody proxy for exposure to Medicare price changes using private claims data. They also exclude the most common procedures in calculating relative prices (which would include, for example, office visits), although the authors indicate that this exclusion did not substantively affect their results. Their analyses, which find a positive relationship, are restricted to metro areas; our results include rural areas, in which we find that the average effect of the HOPD ratio is weaker. Lastly, their measure of integration relies on private claims data, ours on Medicare data. Our samples may include slightly different sets of physicians. While we would expect high correspondence between integration measures from their data and ours, the degree of correspondence is unknown. Further work to compare the correlation between different ways of measuring integration is essential in this topic.

The present study broadens our understanding of payment policy and vertical integration in several key ways. It is the first to describe the size of the financial incentive to integrate by quantifying the magnitude of the HOPD-office payment differential for each physician's actual bundle of Medicare services each year, eschewing guesswork about composition of services, and we find that the financial incentive is enormous – over $77,000 per year for the average physician. We also add to the literature with detailed estimates of specialty-specific differences in integration patterns, as well as specialty-specific differences in the relationship between integration and Medicare's site-based billing policies; we find that it is difficult to characterize the relationship for physicians as a uniform group, since specialty appears to exert a strong influence on this relationship. Finally, we show that outpatient reimbursement policy may be less responsible for driving hospital-physician vertical integration than previously thought. Previous studies of this topic have alluded to a potential role for relative outpatient prices in integration.[1,20] Our evidence suggests this role is relatively small. The effect of the HOPD ratio may have been more important among primary care physicians (exhibiting a positive relationship) and cardiologists (exhibiting a negative relationship) than other specialties during our study period. Concentrated hospital markets also appear to increase the likelihood that a physician integrates with a hospital. We also observed that rural providers were more likely to integrate than their urban counterparts. Incentives to integrate could differ across rural and urban areas for several reasons: physician labor markets are less competitive in rural areas than urban; rural critical access hospitals (CAHs) are exempt from certain value-based reforms like Medicare's Hospital Readmissions Reduction Program (HRRP); and rural hospitals are subject to different quality improvement programs and looser staffing restrictions.[21] In the present study we were unable to test which factors drive the observed urban-rural difference, though we think this is an important area of further research.

The regulation of site-based payments has seen changes in recent years. In 2015, Congress passed the Bipartisan Budget Act, which grandfathered in HOPD payment rates to existing offices that billed as off-campus HOPDs on or before November 1, 2015. The 21st Century Cures Act of 2016 extended these exceptions to offices that were mid-transition at that time. However, recent rulemaking activity from CMS has begun to impose certain site-neutral payments on off-campus HOPDs – even among grandfathered HOPDs – beginning with clinic visits. The legality of this payment rule is subject to a lawsuit by the American Hospital Association, but as of January 1, 2019, clinic visits began being paid the same reimbursement as an office. CMS projected that these changes would save the Medicare program $380 million in 2019 and $760 million in 2020.[22]

Facility fees appear to distort incentives and cause care to be delivered in unnecessarily expensive settings.[23] MedPAC has pointed out that facility fees are "an inefficient way to reward hospitals for improving care (such as reducing readmissions) because it does not distinguish between hospitals that improve care and reduce spending and those that do not."[24] Site-neutral payments will likely reduce costs for beneficiaries receiving outpatient care. The long-term effects of expanding site-neutral payments are less clear. Facility payments exist, in principle, to ensure the sustainability of facilities, like HOPDs, that carry higher overhead costs.[24] In the extreme case, canceling all facility payments and instead reimbursing all outpatient settings under PFS rates (in other words, implementing total site-neutral payments) might cause some facilities to close their doors or reduce their services. This would, as a byproduct, also reduce competition, which would be counterproductive to cost containment and would create barriers to patient care. Further, HOPDs might add value to care delivery in their communities, such as efforts to improve care coordination, in which case facility payments might promote these activities.[24]

Site-specific payments, however useful they may be on their own merits, seem to exert only a modest influence on decisions about hospital acquisitions of physician practices. Disparities in payment rates between HOPDs and offices existed for many years without an acceleration in integration, which highlights the inadequacy of site-specific reimbursement as the main explanation for the recent increase in integration.

The bargaining hypothesis, i.e., that providers vertically integrate to gain a leg up in negotiations with commercial payers, is another hypothesis that may underlie the trend toward vertical integration. Many recent studies have confirmed that vertical integration is associated with rising commercial prices.[4,25,26] Alternatively, physicians today may find independent practices less commercially viable than in the past due to the costs of regulatory compliance, alternative payment models, or electronic health records.[27,28] Physician work preferences could be another important factor; some have suggested that generational differences in preference for economic security or work life balance may push more physicians to work for hospitals, and evidence from staff surveys suggests that burnout is lower among physicians working for hospitals.[18,29]

Given that integration appears to threaten the affordability of care with minimal gains in quality[10,30–36], it is worth further evaluating what the underlying causes of integration are and what can be done to address them. Antitrust policy is unlikely to be a reliable remedy: many office acquisitions are not large enough to trigger antitrust scrutiny, and physicians who are directly hired to work at a hospital facility are not part of acquisitions at all.[37,38] Many provider markets are already well beyond the "highly concentrated" thresholds set by antitrust agencies.[39] Further work should explore not only the implications of vertical integration for cost and access, but also the underlying strategic motivations of providers and whether these motivations are amenable to policy intervention. Site-neutral payments can help to reduce the costly effects of the movement toward vertical integration, but, over our study period, would have likely done little to slow it down.

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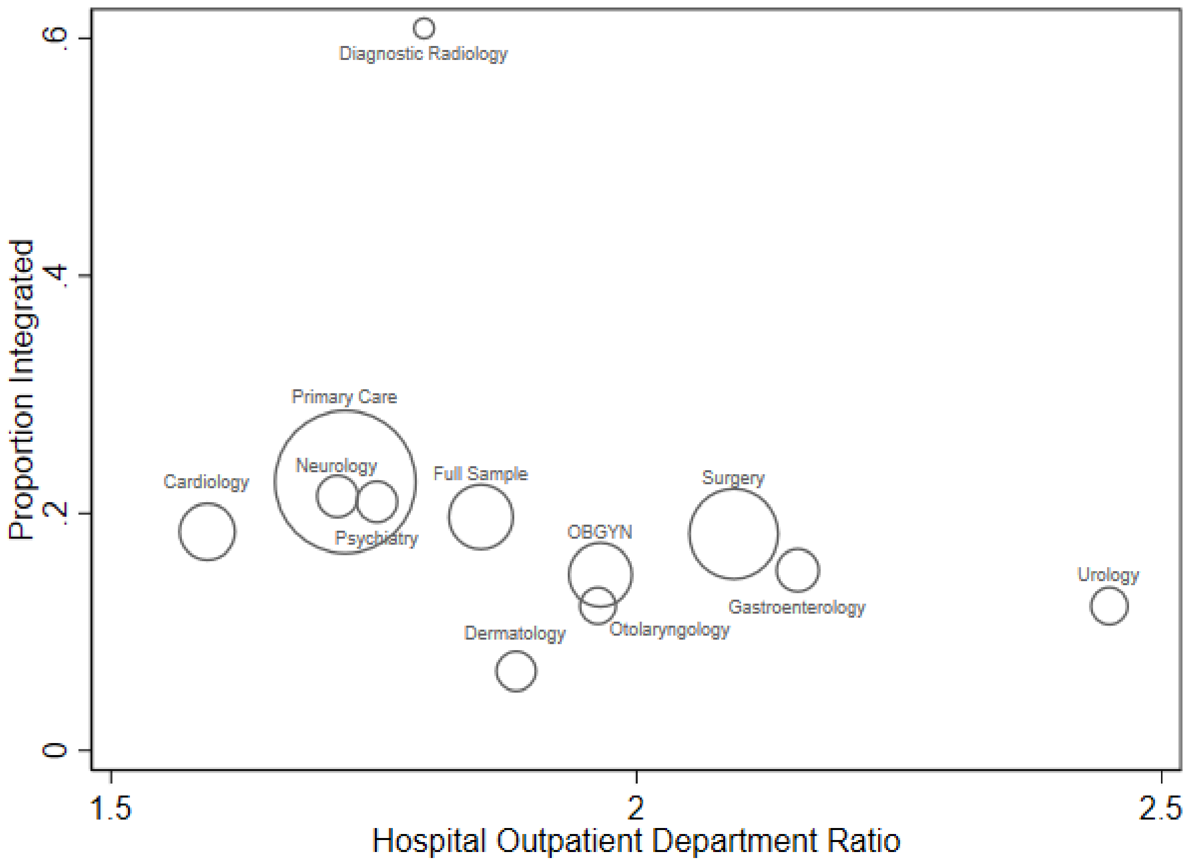
Chapter 1 Exhibits

Table 1.1. Characteristics of physicians in the study sample

	2010	2015
N		
Total	280,703	297,472
Primary Care	135,069 (48.1%)	132,634 (44.6%)
Non- Primary Care	145,634 (51.9%)	164,838 (55.4%)
Physician Demographics		
Integrated N %		
Yes	50,278 (17.9%)	61,054 (20.5%)
No	230,425 (82.1%)	236,418 (79.5%)
HOPD Ratio mean (SD)	1.85 (0.36)	1.92 (0.42)
Office revenue mean (SD)	90,929 (165,493)	92,413 (183,795)
Age mean (SD)	50 (10)	52 (11)
Female	71,772 (25.6%)	86,921 (29.2%)
Census Region		
Midwest	23%	23%
Northeast	22%	22%
South	34%	34%
West	21%	21%
Market characteristics		
Average hospital HHI (HRR level)	1,756	1,852
Average physician HHI (HRR level)	326	336

Note: Average hospital and physician HHIs are weighted by the number of physicians in the sample practicing in each of the relevant geographies.

Figure 1.1. Variation in integration and the hospital outpatient department ratio by specialty

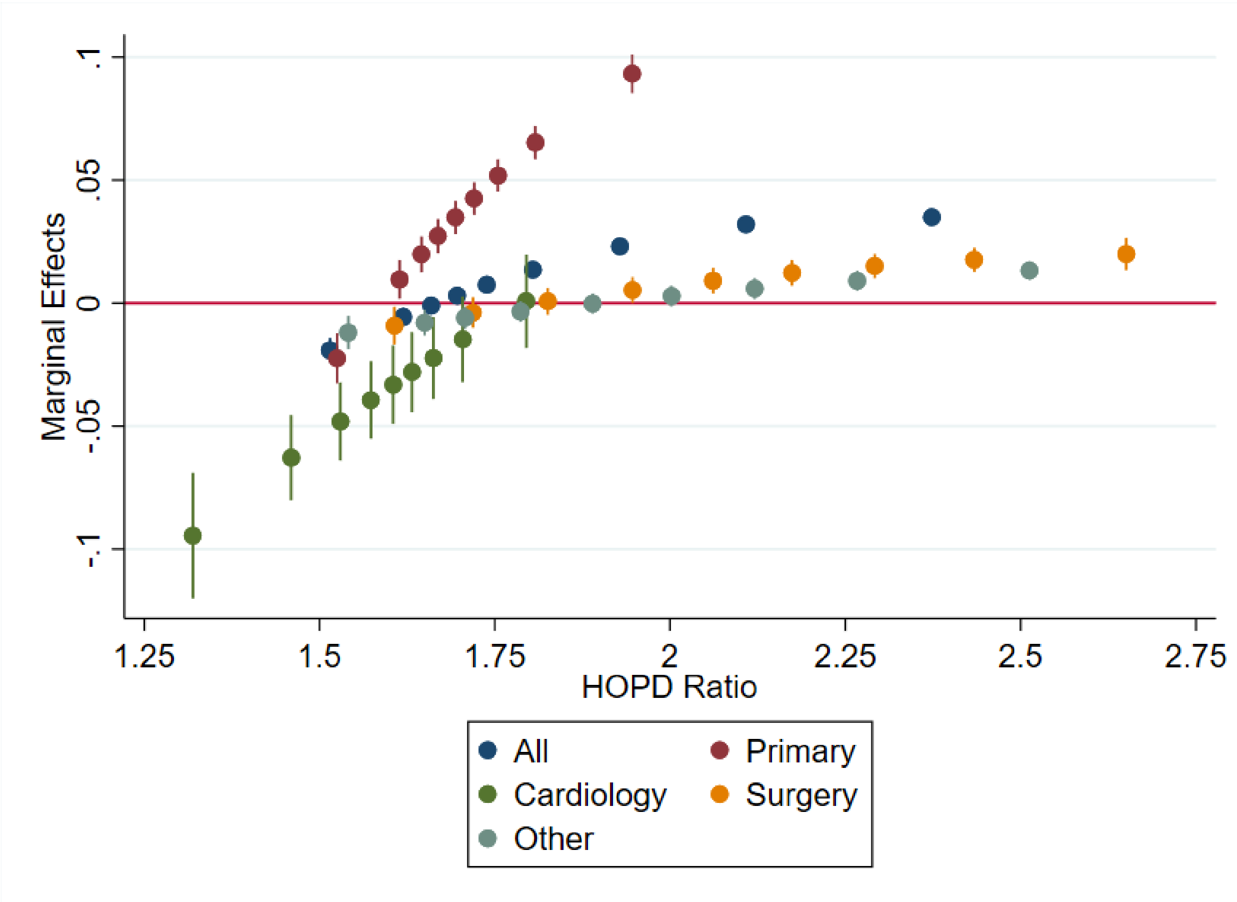


Note: Exhibit includes data from 1,539,358 physician-years between 2010 and 2015.

Note: OBGYN – Obstetrics and Gynecology

Note: Larger circles denote a greater number of physicians.

Figure 1.2. Marginal Effects of HOPD Ratio on the Probability of Integrating with a Hospital



Note: HOPD – Hospital Outpatient Department

Marginal effects and 95% confidence interval bars shown for a model with physician fixed effects and controls for hospital and physician Herfindal-Hirschman Indices. Points are the deciles of the HOPD ratio within each specialty. Sample sizes for each of the models above were: 1,737,678 (full sample), 798,414 (primary care), 312,228 (surgery), 118,409 (cardiology), and 508,627 (other specialties). Other specialties include dermatology, diagnostic radiology, gastroenterology, neurology, obstetrics and gynecology, psychiatry, and urology.

Chapter 1 Appendix

Appendix 1.1. Sample Flow Diagram

	Starting sample size
Provider NPI-years 2010-2015	3,973,934
Inclusion criteria	Resulting N
NPI appears in both Medicare and AMA files	3,021,343
NPI valid length and format	3,021,337
Specialties of interest	2,346,034
Exclude oncology	2,255,267
Exclude those with 10 or fewer line items	2,207,055
Nonmissing key variables (HOPD ratio, HHI)	1,814,906
Keep physicians aged 21-84	1,809,608
Geographic information nonmissing	1,737,678
Final sample size	1,737,678

Note: AMA – American Medical Association; HHI – Herfindal-Hirschman Index; HOPD – Hospital Outpatient Department; NPI – National Provider Identifier

Appendix 1.2. Comparing Integration Estimates

	2008, Neprash	2010, Post	2011, Nikpay	2012, Neprash	2015, Nikpay	2015, Post
Primary care	18	22	13-20	24	22-37	23
Hematology-Oncology or Oncology	24		25	32	50	
Diagnostic radiology	45	57		45		60
Neurology	18	17	16	22	30	24
Cardiology	27	12	15	28	40	22
Orthopedic surgery	8		10	10	30	
Gastroenterology	11	12	10	14	25	17
Otolaryngology	8	9	7	11	18	14
Urology	9	9	10	12	22	14
Ophthalmology	8		4	9	5	
Dermatology	7	6	5	8	7	7
Pediatric			11-40		18-55	
General surgery		15	15		40	20
Pulmonology			15		38	
Psychiatry		25	7		12	19
Rheumatology			14		28	
Colorectal surgery			9		33	
Women's Health		12	13		25	16

Sources: [4,17]

Appendix 1.3. Comparing linear probability models with and without fixed effects and logit

	(1)	(2)	(3)
VARIABLES	LPM FE (Preferred)	LPM	Logit
Integrated			
HOPD Ratio	-0.257***	-0.754***	0.0247***
	(0)	(0)	(0)
HOPD Ratio squared	0.123***	0.368***	
	(0)	(0)	
HOPD Ratio cubed	-0.0180***	-0.0540***	
	(0)	(0)	
year = 2011	0.00586***	0.000174	0.000576
	(0)	(0.722)	(0.232)
year = 2012	0.0135***	0.0139***	0.0137***
	(0)	(0)	(0)
year = 2013	0.0208***	0.0220***	0.0213***
	(0)	(0)	(0)
year = 2014	0.0245***	0.0215***	0.0215***
	(0)	(0)	(0)
year = 2015	0.0286***	0.0257***	0.0257***
	(0)	(0)	(0)
Hospital HHI (ln)	0.0186***	0.0219***	0.0206***
	(0)	(0)	(0)
Specialty HHI (ln)	-0.00190*	-0.00575***	-0.00482***
	(0.0649)	(0)	(0)
Number of claims (ln)	-0.0282***	-0.0779***	-0.0668***
	(0)	(0)	(0)

Number of elective claims (ln)	0.00572***	0.00680***	0.00364***
	(0)	(0)	(3.94e-10)
Number of nonelective (ln)	-0.000472	0.00365***	0.00166*
	(0.417)	(5.39e-07)	(0.0586)
Age	-		
Rural	0.0921***	0.0795***	0.0703***
	(0)	(0)	(0)
Northeast	-0.0507***	-0.0613***	-0.0518***
	(2.01e-05)	(0)	(0)
South	-0.105***	-0.0879***	-0.0846***
	(0)	(0)	(0)
West	-0.0569***	-0.101***	-0.0924***
	(2.83e-07)	(0)	(0)
Cardiology	-0.0407***	0.0430***	0.0426***
	(2.61e-07)	(0)	(0)
Dermatology	-0.0455*	-0.104***	-0.137***
	(0.0911)	(0)	(0)
Diagnostic Radiology	0.0154	0.396***	0.277***
	(0.710)	(0)	(0)
Gastroenterology	-0.0528***	-0.110***	-0.0856***
	(1.47e-06)	(0)	(0)
Neurology	-0.0180	-0.0236***	-0.0162***
	(0.377)	(0)	(2.47e-07)
OBGYN	-0.00604	-0.190***	-0.166***
	(0.802)	(0)	(0)
Otolaryngology	0.0357	-0.0949***	-0.0881***
	(0.227)	(0)	(0)
Psychiatry	0.00757	-0.0941***	-0.0786***

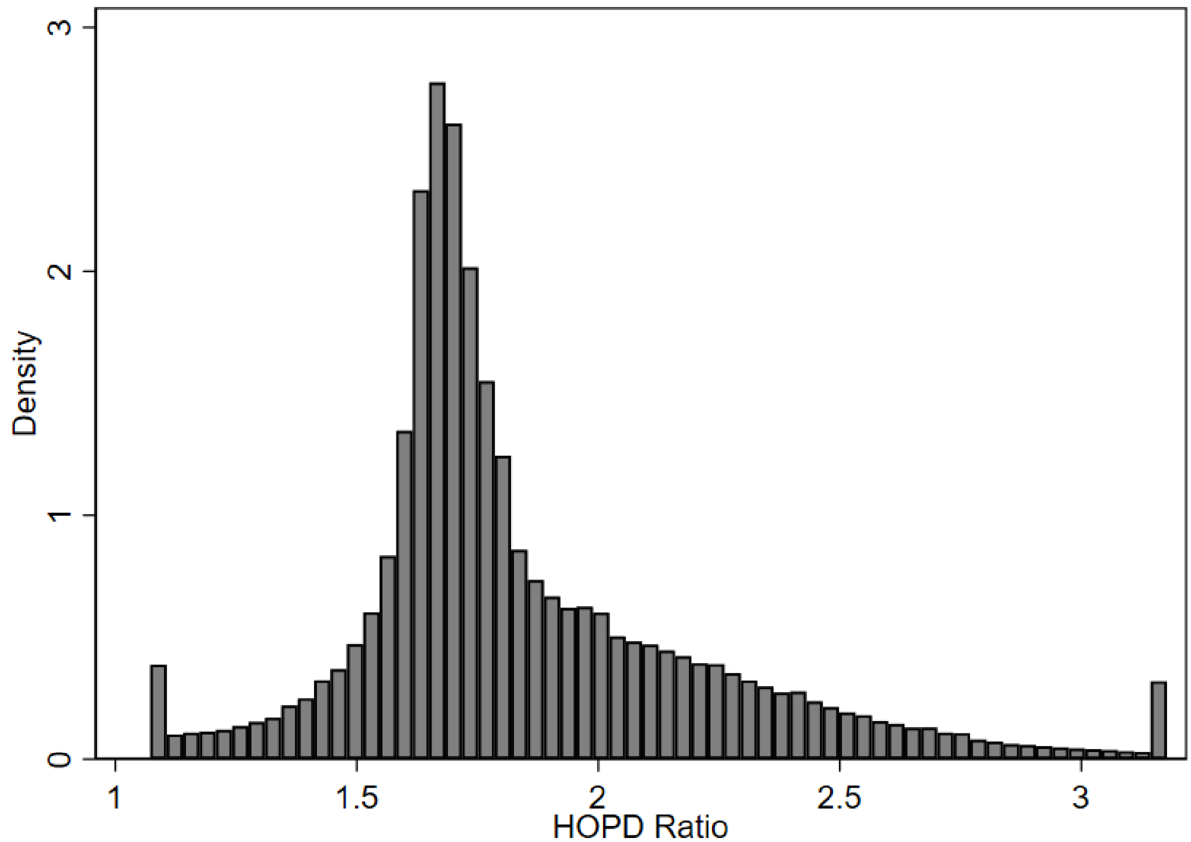
	(0.811)	(0)	(0)
Surgery	-0.0170	-0.103***	-0.0824***
	(0.129)	(0)	(0)
Urology	-0.0283	-0.0695***	-0.0644***
	(0.384)	(0)	(0)
Age		-0.00231***	-0.00224***
		(0)	(0)
Constant	0.397***	1.103***	
	(0)	(0)	
Observations	1,737,678	1,737,678	1,737,678
R-squared	0.851	0.125	

Notes: Estimates for Logit are marginal effects. The reported estimates for the linear probability models (LPMs) with and without fixed effects (FEs) are coefficients. P-values are listed below each estimate. Marginal effects for various specifications can be found in Appendix eTable 4.

Appendix 1.4. Average Marginal Effects of HOPD Ratio in Different Specifications

Specification	Marginal Effect	95% CI Lower Limit	95% CI Upper Limit
Ratio, ratio squared, ratio cubed (preferred)	0.0047	0.0019	0.0075
Ratio, ratio squared	0.0051	0.0023	0.0079
Ratio	0.0097	0.0076	0.0118
HOPD-Office differential measured in thousands of dollars	0.0002	0.0001	0.0003
1-year lagged ratio	0.0000	-0.0009	0.0009
1-year lagged ratio, ratio, ratio squared, ratio cubed	-0.0023	-0.0054	0.0007
Ratio, ratio squared, ratio cubed with oncologists	0.0033	0.0005	0.0061
Ratio, ratio squared, ratio cubed, oncologists only	-0.1009	-0.1284	-0.0734

Appendix 1.5. Histogram of HOPD Ratio



Note: HOPD Ratio indicates the relative reimbursement value of physician services performed in the hospital outpatient department (HOPD) compared to equivalent services in a physician office. A ratio of 2 indicates that the reimbursement was twice as large in the HOPD as compared to the office. We Winsorized the ratio at the 1st and 99th percentiles. This figure displays data for all physician years from 2010-2015 (n=1,737,678). The 25th percentile is 1.64 and the 75th percentile is 2.01.

Appendix 1.6. Average HOPD Ratios and Percentiles by Specialty

		Percentile				
Medical Specialty	Average HOPD Ratio	10th	25th	50th	75th	90th
Full Sample	1.85	1.52	1.64	1.74	2.01	2.37
Cardiology	1.59	1.32	1.50	1.61	1.68	1.79
Dermatology	1.88	1.58	1.73	1.85	2.01	2.19
Diagnostic Radiology	1.79	1.16	1.44	1.74	2.09	2.44
Gastroenterology	2.15	1.94	2.04	2.14	2.26	2.38
Neurology	1.72	1.51	1.62	1.68	1.76	1.93
OBGYN	1.96	1.43	1.66	1.83	2.21	2.74
Otolaryngology	1.96	1.62	1.74	1.90	2.13	2.39
Primary Care	1.72	1.53	1.63	1.69	1.78	1.95
Psychiatry	1.75	1.48	1.61	1.70	1.89	2.01
Surgery	2.09	1.61	1.77	2.06	2.36	2.65
Urology	2.44	2.05	2.23	2.42	2.64	2.89

Appendix 1.7. Average Effects of a 25th-to-75th percentile change in HOPD Ratio

Medical Specialty	Average Marginal Effect of 1-Unit Change	25th-to-75th Unit Change	Marginal Effect of 25th-to-75th	95% CI Lower Limit	95% CI Upper Limit
Full Sample	0.0047	0.3699	0.0017	0.0007	0.0028
Cardiology	-0.085	0.182	-0.015	-0.018	-0.013
Dermatology	0.002	0.284	0.001	-0.004	0.005
Diagnostic Radiology	-0.018	0.652	-0.012	-0.027	0.003
Gastroenterology	0.019	0.218	0.004	-0.001	0.009
Neurology	0.002	0.135	0.000	-0.004	0.004
OBGYN	0.005	0.550	0.003	0.001	0.005
Otolaryngology	0.013	0.387	0.005	0.001	0.009
Primary Care	0.031	0.144	0.004	0.003	0.006
Psychiatry	-0.002	0.280	-0.001	-0.007	0.006
Surgery	-0.007	0.589	-0.004	-0.006	-0.002
Urology	0.005	0.411	0.002	-0.003	0.007

Appendix 1.8. Measuring Vertical Integration and the HOPD Ratio

Measuring Vertical Integration

We defined integration using a strategy developed by Neprash and colleagues. They utilize the place of service codes found in Medicare claims. During our study period, when a hospital acquired a physician, the physician became eligible to bill under the Hospital Outpatient Department (HOPD) place of service code. The incentives to make this billing change were strong, since reimbursement under an HOPD designation was often higher than under an office designation. We created an indicator for each physician in each year to indicate integration status by counting the number of line items billed in the Medicare Carrier (physician/supplier) claims under an office code and under an HOPD code. When 75 percent or more of these line items were billed under an HOPD code, we classified the physician as integrated. In addition to the Carrier claims, Neprash and colleagues also used the Outpatient claims to reclassify some Carrier claims that were likely miscategorized as having taken place in the office setting. We do not take this additional step because the number of reclassified claims was small (2-3%). Their eMethods (2015) contains a clear explanation of the details in their approach. In addition, we use MD-PPAS data to supplement the claims-based approach. If a physician's tax identifier legal name contains the keywords "medical center," "hospital," "system," "health science center," "health sciences center," or "med ctr," we identify them as integrated.

Measuring the HOPD Ratio

We did not include all HCPCS codes in our measurement of the HOPD ratio, because some procedures can only be performed in certain settings; for example, open heart surgery cannot be performed or reimbursed in an office. For our research question, we were interested in the set of services that could be performed in either an office or in an HOPD. Rather than making clinical judgments about the appropriateness of place of service for each of the 10,000+ procedures in the HCPCS system, we took an empirical approach: we used only those HCPCS codes which, nationally, were performed at least 5 percent of the time under both office and HOPD place of service codes. Many procedures fall into these groups: they are nearly always (or, very rarely) performed in one place or the other. We infer that such procedures are not suitably transferable between settings, and therefore exclude them. In addition, since we must compare revenue potential, we only used HCPCS codes for which Medicare lists prices in both the office and HOPD settings. We identified 1,436 HCPCS codes that met our criteria in 2010 and similar numbers for years 2011-2015. We Winsorized the HOPD ratio at the 1st and 99th percentiles.

Chapter 1 Appendix References

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Chapter 2. Clinical Output of Hospital-Integrated Physicians

Chapter 2 Abstract

Over 40 percent of physicians are employed by hospital systems. Hospital-physician vertical integration has raised concerns about spiraling health care prices, stagnant quality of care, and a changing landscape for the future of the health care workforce. This changing landscape is particularly important for primary care physicians, who serve as the front line for both patient care and efforts to reform the delivery system. In this research, we examined an understudied aspect of vertical integration: the clinical output of primary care physicians after integration with a hospital. We used detailed longitudinal data from Medicare claims and merged it with the American Medical Association Masterfile to assess several measures of physician output among 74,975 primary care physicians from 2010-2016. We used a difference-in-differences analysis to compare physician-generated claims, professional revenue, work relative value units (RVUs), and number of patients served between physicians who integrated with hospital systems and those who did not. Among 4,733 integrating physicians, integration reduced the volume of physician claims by 17% ($p < .001$) and RVUs by 10% ($p < .001$). These reductions were especially pronounced in the first year of integration (-21% and -13%) and persisted in smaller magnitudes through the entire study period (-13% and -5% by the seventh year post-integration). Integration reduced professional fee revenue by an average of $32,495 per primary care physician per year (22%, $p < .001$), and reduced the number of Medicare patients treated by primary care physicians by an average of 22 (6%, $p < .001$) compared to non-integrating physicians. We also compared the declines in clinical output across small and large practices as well as rural and non-rural practices. Our results imply that vertical integration may reduce the incentives for physicians to deliver higher volumes of care. Further, vertical integration may make it more difficult for Medicare patients to access primary care. Finally, these findings

inform future work on the profitability and sustainability of vertically integrated hospital-physician organizations.

Introduction

Over the last decade, American hospitals have acquired physician practices in large numbers and have become major employers of physicians.[1–3] As of 2018, hospitals owned 31.2 percent of physician practices, up from 13.6 percent in 2012.[2] Observers have offered numerous rationales that could explain this large shift in the provider landscape toward "vertical integration" of hospitals and doctors: younger physicians prefer a greater work-life balance; coordinating health services across inpatient and outpatient settings has become more important with the proliferation of alternative payment models; integrated provider systems may confer a bargaining advantage in negotiations with commercial insurers; and payment for services delivered in hospital-owned practices is higher than payment for services in physician-owned practices.

Recent research suggests that vertical integration has increased prices and not improved quality.[4–10] However, the effect of integration on physician clinical output remains understudied. This is critical for two reasons: first, physician clinical output is one of the key ways that hospitals may recoup their investments in physician practices. Most of the value of a physician practice comes from the work that physicians do. Integration could streamline administrative processes to give physicians more time to spend treating patients, thus increasing clinical output. Second, increased physician clinical output under integration, particularly in primary care, could mean expanded access to valuable care among Medicare beneficiaries.

In this paper, we seek to fill this gap. We examine the effects of integration on a large, nationally representative sample of primary care physicians. Primary care physicians work in a unique clinical environment: they are the main point of contact in the health care system for most patients, and they serve as the gateway to specialty care. From a policy point of view, this makes them an essential part of any effort to reform the delivery system. From a hospital management point of view, primary care physicians generate referrals to lucrative tertiary services, making them attractive as investments. We make use of a unique dataset by linking multiple physician characteristics files to seven years of Medicare claims data over a period that exhibited significant integration activity (2010-2016). The resulting dataset is a fully balanced panel of about one-third of all U.S. primary care physicians. We find that integration reduces professional fees by 22%, the volume of physician claims by 17%, RVUs by 10%, and unique Medicare patients by 6%. These reductions were especially pronounced in the first year of integration.

This analysis makes several contributions to the existing literature. First, it is the first study to examine the effect of vertical integration on the clinical output of primary care physicians. Second, it uses Medicare claims to generate a seven-year physician-level panel dataset. This offers several advantages; we can control for unobservable heterogeneity to a greater degree than other similar studies through physician fixed effects; the long study period allows us to more rigorously examine the parallel trends assumption of our difference-in-differences model; and inferences from this large sample of physicians have national implications. Third, we use multiple measures of clinical output – number of claims, professional revenue, relative value units, and number of unique patients treated – to address the concept of clinical output from multiple stakeholder perspectives. Because complete claims are required for payment, and our measures are claims-based, our clinical output measures are also likely to be valid.

This study also has several important implications. First, because integration leads to declines in physician clinical output among Medicare patients, hospitals could be losing money on practice acquisitions. If hospitals are recouping their investments, they are most likely doing so through the avenues of higher negotiated commercial reimbursement, facility fees, or referral capture. Second, integration could reduce access to care among Medicare beneficiaries. Third, because the declines in clinical output are heterogeneous across small and rural practices, integration may exacerbate existing disparities in geographic health care access.

Defining Clinical Output

Our operational definition of clinical output includes measures of the number of Medicare claims generated, the size of professional fees, the work "relative value units" of billed care as defined by the American Medical Association, and the number of unique patients treated. These measures are critically important, as they directly affect access to care and health care spending and are often used in compensation contracts. While the production of health, or quality, is central to patient welfare, it is not the focus of our investigation.

Primary Care and Vertical Integration

Primary care physicians play a key role in the delivery of health services. They also play an important role in hospital strategies for clinical excellence and business performance. In previous decades, hospitals acquired primary care practices to "capture lives," or to increase the likelihood that primary care physicians would refer their patients to hospital-owned facilities and specialists. [11] This rationale persists today, with the additional impetus that integrating with primary care practices might equip delivery systems for participation in new payment models such as accountable care organizations.[12] These reasons make primary care physicians essential from both a clinical and policy point of view.

Institutional Context: Medicare Payment Policy and Vertical Integration

Medicare's fee-for-service outpatient payment policy reimburses physicians using the Physician Fee Schedule (PFS), a roster of procedure codes tied to specific physician services delivered to patients. The value of each procedure code in the PFS includes a designated amount for the physician's labor (the work RVUs), the overhead costs associated with a physician's office, malpractice insurance costs, and a geographic adjuster. When in a physician-owned practice, Medicare pays physicians for each of these components exclusively through the PFS. When, however, a hospital acquires a physician practice, the reimbursement comes in two forms: the PFS, and the Medicare Outpatient Prospective Payment System (OPPS). Integrated physicians continue to bill Medicare for their labor per the PFS, but without the reimbursement for overhead costs or malpractice insurance costs. To cover these costs, Medicare pays a procedure-specific facility fee to the hospital as specified in the OPPS. The facility fee is generally agreed to be larger than the foregone components of the PFS; some have suggested hospitals and physicians integrate explicitly to take advantage of this payment system.[13] As a result, reimbursement revenue from professional fees declines after integration while total reimbursement revenue increases.

Theory of The Relationship Between Vertical Integration and Clinical output

Hospital Perspective

We conceptualize the hospital acquisition of a physician practice as having both a financial aspect and a strategic component. In the first instance, hospitals behave as profit-maximizers; even non-profit hospitals are unlikely to pursue business strategies that causes persistent financial losses. Correspondingly, it is reasonable to assume that hospitals expect a financial return on their investments in physician practices. Given that the financial value of a practice derives largely from the amount of care its physicians deliver, physician clinical output constitutes one of the key sources for hospital return on investment. Through integration, hospitals may seek to increase the total volume of care that physicians deliver. In fact, agency-based economic theory about vertical integration would predict such behavior. Under this theory, two independent firms may experience misaligned incentives or a "principal-agent" problem, but under common ownership, this problem is resolved. Here, hospitals benefit from facility revenues whenever physicians perform services in their facilities. However, when operating as separate organizations, physicians do not share in those revenues, leading to (from the hospital's point of view) an undersupply of services. Under integration, hospitals and physicians both seek to maximize the benefits and minimize the costs to their shared organization; integration has been shown, for example, to increase the probability that employed physicians refer their patients to their employer hospital.[14] Physician clinical output should, under this framework, increase with hospital integration. There is also a strategic component to integration that goes beyond narrow financial considerations. Economic theory also posits that vertical integration may serve to block competitors from access to key inputs; here, the key inputs are physicians, without which hospitals can produce very few health services. This strategy is known as "vertical foreclosure," and some empirical work in hospital-physician vertical integration is consistent with hospitals behaving in this way, though it is difficult to test directly.[15] Vertical foreclosure causes declines in market competitiveness, and in this context, would mean increases in prices that hospitals negotiate from commercial insurers. Modifying physician clinical output would not be the primary goal of hospital acquisitions; predictions about output from this framework are ambiguous. An additional strategic consideration that is important in clinical settings is grounded in dynamic capabilities theory. In this theory, firms use integration as a strategy to develop capabilities that confer a competitive advantage in rapidly changing environments.[16] Thus, hospitals may seek to integrate with physicians in order to produce higher quality care; better coordinate between the inpatient and post-acute care settings; or standardize treatment protocols for patients in their system. The predictions from dynamic capabilities strategy are ambiguous with respect to physician clinical output. Capabilities in the integrated firm may promote efficiency and reduce duplicative care, driving down measures of clinical output; or they may allow the integrated firm to more easily coordinate lucrative imaging and elective procedures. A final strategic consideration is that delivery systems may integrate to increase their bargaining power with commercial insurers. Among integrating delivery systems, improved bargaining power with commercial insurers could drive prices higher, which would raise the value of a commercial patient relative to a Medicare patient. This change in relative value could induce integrated delivery systems may seek to shift care away from Medicare patients and toward commercial patients. Rural communities serve a larger proportion of Medicare and Medicaid patients than their non-rural counterparts. In rural areas, we hypothesize that the relative scarcity of commercial patients makes this "payer-shifting" strategy less viable. If so, rural physicians who integrate should exhibit a smaller decline in Medicare activity compared to their non-rural counterparts.

Physician Perspective

We conceptualize integrating physicians as individuals offering their services under different employment scenarios. From a contractual perspective, integration could replace strong incentives to produce clinical output with weaker ones. Many physicians in independent practices have strong productivity incentives that encourage seeing many patients: compensation in most physician-owned practices depends in part (in about a quarter of practices, exclusively) on fee-for-service productivity.[17,18] Under hospital integration, the marginal incentive to provide additional care may be weaker, with productivity-based compensation replaced by a salary model that reduces the personal return to billing more services.[11,17] If these incentives prevail, then physician clinical output is likely to fall after a hospital acquisition.

Physicians in solo practices have the sharpest incentives for clinical output: they are the residual claimant to the profits made by the practice. By contrast, the incentives among physicians in larger groups are less sharp, since compensation derives from both salary and productivity components.[19] For this reason, we anticipate larger declines in clinical output among physicians in small practices who join hospital systems compared to the declines in clinical output among physicians in large practices who join hospital systems. This result would be consistent with the hypothesis that hospital-employed physicians respond to the weaker volume incentives under salaried hospital arrangements.

Review of Related Literature

This study is informed by previous work on hospital-physician vertical integration as well as the broader literature on physician responses to financial incentives. Studies have explored the relationship between integration and prices, spending, and quality. Most have found that prices and spending are higher among hospital-owned physicians, although the magnitudes vary considerably.[5,9] Some research found that integration increased spending by several percentage points[6,7] while others estimated that among Medicare beneficiaries, spending increased by as much as 18 percent per patient.[20] A related study found that integrated cardiologists increased the intensity of treatments for their patients.[8] Moreover, most of the studies of vertical integration and quality have found small or insignificant effects of integration on improvements in patient screening, outcomes, or mortality.[15] Together, these results imply that integration may have a causal effect on prices, utilization, and spending while doing little to improve quality.

Vertical integration with hospitals also involves changes in physician financial incentives. The relationship between physicians' financial incentives and their behavior has long received attention in health economics. Emanuel and Fuchs argue that the fee-for-service payment system creates physician incentives to do more even when there is "a slim clinical rationale for an intervention."[21] Clemens and Gottlieb find that physician financial incentives are an important determinant of the volume and composition of care delivered, especially among procedures over which physicians have more discretion.[22] Coey observed a large response by physicians to the size of the payments for heart attack treatments, leading to overly aggressive treatment styles.[23] Yet only one study has explicitly explored how physician clinical output responds to the incentives of vertical integration. Using survey data from a cardiologist association, Chunn and colleagues found that hospital integration was associated with considerably higher compensation ($129,263, or about 25 percent) and roughly four percent lower work RVUs compared to independent practices. The authors suggest that hospitals may engage in "bidding wars" for desirable practices, driving up wages for integrated cardiologists.[24] This result may help to explain the finding that hospitals usually suffer losses in the first several years following a physician practice acquisition.[1]

While the above theory and empirical work provide a foundation for the present study, important limitations remain. The lone study that examines clinical output has a relatively small sample size (n=13,642 physician-years); is limited to cardiologists, a specialty which may lack generalizability to other physicians; and due to survey non-response, its authors are unable to create a balanced panel to fully control for potentially endogenous physician characteristics. Moreover, the clinical output effects of integration within the Medicare population are unknown; this is particularly important because higher commercial prices achieved through integration provide incentives to substitute Medicare patients for commercial patients. Finally, little is known about the implications of integration among primary care physicians. As the cornerstone and gatekeepers of the health system for most patients, primary care practices serve a key role in patient access to care.

Methods

Data

We created a robust analytical sample by linking the following seven data sources: Medicare Carrier line items from 2010-2016, Medicare Data on Provider Practice and Specialty (MD-PPAS), the American Medical Association Physician Masterfile, Medicare Provider Analysis and Review (MedPAR) data, Medicare Physician Fee Schedules, Medicare Outpatient Prospective Payment System files, and the U.S. Department of Agriculture commuting zone files. The procedure we used to create the analytical file is described in Appendix 2.1.

Our resulting file contained over 3 million physician-year observations. We applied a series of exclusion and inclusion criteria (Appendix 2.2). Of the 1,856,627 physician-year observations that remained after these criteria, 671,966 were primary care physicians as categorized by MD-PPAS. Since this study is concerned with identifying the effect of integration on those who leave office settings to join hospital systems, we used only physicians who were unintegrated in the base year (2010), remained in the sample through 2016, and did not dis-integrate at any time. The resulting analytical file included 4,733 integrating primary care physician-years (the treatment group) and 70,242 primary care physician-years who remained unintegrated throughout the study period (the control group). The sample characteristics are presented in Table 2.1.

Model

We evaluated the effect of integration using a difference-in-differences (DD) methodology. A classic DD involves a common start date. In our application, no such common start date exists: some physicians integrated with hospitals as early as 2010, while others remained unintegrated until 2016. We centered each physician's integration start dates around $t = 0$, where $t = 1$ indicated the first full year of integration. The control group, similarly, lacked a start date. We assigned the control group to artificial start dates by randomizing each control physician to a starting year, then created a corresponding t variable. The probability of assigning a physician in the control group to a starting calendar year was based on the proportion of physicians who integrated in each calendar year. This allowed us to compare the treatment group to the control group along a common time scale.

We used physician fixed effects to address unobserved time-invariant physician characteristics that may have been correlated with integration and clinical output. The identifying assumptions for causal inference in DD models are parallel trends and common shocks. The parallel trends assumption requires that the control group serve as a good counterfactual to the treatment group: in the absence of treatment, the treated group would have continued along the same trend as the control group. This assumption, though untestable, is given more credence by demonstrating that the two groups followed parallel trends in the pre-period, suggesting that they could have plausibly continued in the same manner without treatment. Under the common shocks assumption, any shocks that might alter the outcomes for either the treated group and control are common to both – that is, there is no shock (such as legislation, policy, or economic disruptions) that differentially affects the outcomes of the treated group.

We verified that the pre-period trends were parallel. Figure 2.1 contains a visual depiction of the two groups set along the time-to-integration axis. For completeness, we also examined these results by annual integrating cohort: those who integrated in 2010, in 2011, through 2016 (Appendix 2.3). With minimal exceptions across study outcomes and treated cohorts, parallel trends appeared to be consistently present. In our analysis, we also made the common shocks assumption: that any shock to the study subjects in the post-period was experienced by both the treatment and control groups. The analysis was focused on primary care physicians, so there was no risk of specialty-specific shocks that would differentially affect one group comprised of, for example, a disproportionate number of specialists. Further, the observable characteristics suggested that treated and control groups in the pre-period had similar distributions of sex, age, and practice size.

Our model specification allowed us to estimate heterogeneous effects by time period (i.e., leads and lags). We controlled for the calendar year of the observation as well as the competitiveness of the hospital market and the physician market. The parameters of interest were the fully-interacted time variable and treatment variable.

We estimated the leads and lags effects model for physician *i* in integration year *t*:

$$(1)\ Productivity_{it} = \sum_{j=-6}^{7} \beta_j (Int_i * Time_{it}) + \tau_j Time_{it} + \gamma X_{it} + \delta Year_t + \pi\mu_i + \varepsilon_{it}$$

$Productivity_{it}$ was any of the four dependent variables. Int_i took the value of 1 if the physician was in the integration group and 0 otherwise, while $Time_{it}$ took the value of 1 if the observation occurred in time to integration *t* for physician *i*. The treatment effects were contained in the vector β_j where $j > 0$. β_1 was the effect of integration on output in the first full year of integration (contemporaneous treatment), while β_2 through β_7 gave the effects for the subsequent periods (i.e., the lagged effects). The overall treatment effect was estimated by taking an observation-weighted average of the lagged effects. Our model also provided estimates for possible leading effects in each pre-period, i.e., changes in current output associated with anticipation of future treatment. These estimates were given by the vector β_j where $j \leq 0$. This aided our examination of our identification strategy: if the coefficients of leading effects were significantly different from zero, it would have suggested a violation of parallel trends between the treated and untreated groups in the pre-period. X_{it} includes hospital and physician Hirschman-Herfindahl Indices. We included calendar year ($\delta Year_t$), time to integration ($\tau_j Time_{it}$) and physician ($\pi\mu_i$) fixed effects to identify the treatment effect using within-physician variation over time. ε_{it} is a physician-year level error term.

We estimated the heterogeneous effects of integration by practice size using Equation (1) for two groups (physicians in the first and fourth quartiles of practice size) and comparing their β_j parameter estimates. We also estimated the heterogeneous effects of integration on rural and non-rural practices using Equation (1) and comparing their β_j parameter estimates.

In all specifications, we estimated linear models with standard errors robust to physician-level clustering.

Results

We identified 524,825 physician-year observations (74,975 unique primary care physicians) that met our criteria between January 1, 2010 and December 31, 2016. Table 2.1 displays unadjusted descriptive statistics of our study sample for the pre-period and post-period among the integrating (n=4,733) and comparison (n=70,242) groups. Integrating physicians were slightly younger (an average of 50 years old compared to 51 years old). They were more likely to be female (34 percent versus 30 percent), from the Midwest (44 percent versus 21 percent), and much more likely to practice in a rural area (36 percent of integrating physicians were in rural areas, compared to 18 percent of control physicians). The pre-period number of Medicare claims and revenue is somewhat lower among integrating physicians (1,426 compared to 1586, and $121,201 compared to $147,185). Similarly, the number of RVUs billed by integrating physicians was slightly lower (1,178 compared to 1,434). However, integrating physicians treated about 6 percent more unique patients than non-integrating physicians (368 compared to 348). At the time of integration, the median practice size was 3 physicians, with a 25th percentile of 1 and a 75th percentile of 21 (Appendix 2.4).

In our DD analysis, we detected large negative effects of integration on clinical output (Figure 2.1). This was true across all measures. Medicare claims volume declined among comparison physicians, but decreased by much more among integrating physicians (DD estimate: -261, 95% CI: -291 to -230). This implies a 17 percent decline in claims volume (Table 2.2). We also observed a large decline in Medicare revenue from professional fees, where the decline among integrating physicians' revenue contrasted with an increase in professional fees among the comparison physicians for an adjusted DD estimate of -32,495 (95% CI: -36,194 to -28,796), implying a 22 percent reduction. After integration, physicians also billed fewer work relative value units compared to the comparison group (-145, 95% CI: -170 to -119) for a decline of 10 percent. Similarly, physicians saw about 6 percent fewer patients after integration (-22, 95% CI: -28 to -15).

We found treatment effect heterogeneity by time period (Figure 2.1; see also Appendix 2.5). The first full year of integration exhibited the largest declines, with subsequent years showing less extreme treatment effects. This pattern was true for the outcomes of claims volume (e.g., first year: -324, 95% CI: -192 to -147; sixth year: -270, 95% CI: -322 to -218), RVUs, and patients treated. This could have occurred if integrating physicians took time to adjust to a new practice environment, slowly ramping up their billing and patient visits over time. However, even five and six years after integration, the level of output remained below that of control physicians. For professional revenue, the gap between control physicians and integrating physicians was approximately constant over time (first year: -37,784, 95% CI: -41,761 to -33,806; sixth year: -37,831, 95% CI: -43,437 to -32,224).

We also found heterogeneity by physician characteristics (results for claims volume shown in Figure 2.2; see Appendix 2.6 for other dependent variables). As expected, pre-period levels of output were higher among small practice physicians (annual claims volume=1,692) than large practice physicians (annual claims volume=1,245). In percentage terms, the declines in claims between small and large practices were similar (-19 percent and -22 percent), although integrating physicians from small practices, given their higher baseline levels of output, exhibited larger total declines than integrating physicians from large practices (-321 and -268) (Table 2.2). Professional revenue fell by a larger magnitude among small practices, although the percentage change was smaller (-26 percent among small practices and -32 percent among large practices). RVUs declined among small practices and large practices (-15 percent and -9 percent). The number of treated patients declined in both small and large groups (-5 percent and -10 percent). These results imply output declines among solo practitioners that, while comparable to or smaller than physicians from large practices in percentage terms, were often larger in magnitude (the RVU decline was about 2.5 times larger).

Integrating rural physicians exhibited declines in clinical output across all four measures. Claims fell by 337 (-17 percent), revenue by $43,224 (-28 percent), RVUs by 198 (-13 percent) and patients by 25 (-6 percent). Clinical output also fell among non-rural physicians. Comparing these two groups showed that rural physicians' clinical output fell by larger amounts both in percentage terms and in absolute terms compared to their non-rural counterparts.

Discussion

In this study, we found evidence that hospital-physician vertical integration reduced primary care physician clinical output among Medicare patients. Integration was associated with fewer Medicare claims and large declines in physicians' professional revenue. Integration also reduced physician RVUs. Finally, integration led to a decline in the number of patients treated. Together, these findings imply that hospital-physician vertical integration reduces physician clinical output and potentially reduces Medicare patient access by statistically and economically significant amounts.

At least two mechanisms could underlie these findings. First, these results could imply a straightforward explanation about contractual incentives under different organizational types. In this explanation, hospital employment contract incentives result in an aggregate decline in the clinical productivity of physicians in integrated settings relative to non-integrated settings. While we do not directly observe employment contract details, hospital employers tend to compensate physicians through salary to a greater degree than private practice, which tends to emphasize volume in compensation. Salaried physicians face weaker marginal incentives to treat additional patients or perform additional services. Among physicians who had an ownership stake in the practice, hospital acquisition also removes their status as the residual claimant to the business profits. Together, these effects would lead one to expect a decline in clinical output under hospital employment, which we observe here.

Second, these findings could imply a nuanced change in clinical output that intersects with strategic organizational goals of delivery systems. The observed decline in care offered to Medicare beneficiaries could be offset by additional care offered to commercially-insured patients. This analysis of Medicare data cannot answer that question directly, but existing literature suggests a rationale: researchers have concluded that hospital-physician vertical integration causes increases in commercially-insured prices. Integration may therefore raise the value of commercially-insured patients relative to Medicare patients. If so, delivery systems might seek to substitute between payers. This payer-shifting explanation hinges on the ability of delivery systems to influence the patients that physicians treat. Delivery systems may well possess that ability: following integration, many non-clinical components of the practice become centralized at the delivery system level; in fact, physicians cite fatigue with billing, scheduling, and other administrative tasks as reasons to work for a hospital rather than practice independently. If the delivery system becomes responsible for scheduling appointments, they may make more appointments available for commercial patients and limit availability for Medicare patients. Our results, however, do not support the payer-shifting hypothesis. Rural areas tend to have more Medicare patients and fewer commercial patients, implying less ability to payer-shift, which should result in smaller declines relative to their non-rural counterparts. We find the opposite: integrating rural physicians reduce their clinical output by larger amounts. Our rural analysis indicates that primary care physicians in rural areas serve a large number of patients every year – an average of 422 patients per physician per year, compared to 328 among non-rural physicians. However, given the sizable integration-related declines that we observe in claims, professional revenue, RVUs, and patients treated, integration appears to exert a large contractionary effect on the supply of health care in rural communities.

The results also have implications for hospitals and delivery systems. Hospitals do not appear to be recouping their investment through increases in the professional services of acquired physicians. This suggests that if acquisitions are profitable, there are compensating effects from (1) commercial price or volume increases, (2) referrals, or (3) facility fees. Each of these could be enough to make up for the loss in professional revenue, but this is unknown. Estimating the magnitude of these is a subject worthy of further research. The analysis in the present study does not rule out the possibility that hospitals are losing money on their investments. The total financial value of physician activity could decline under integration. If all care – referrals, tests, care for non-Medicare patients – were to decline by the same magnitude as the observed 10 percent RVU decline, hospitals could be losing considerable sums per physician per year. While acquisition negotiations are strictly confidential, it is possible that hospitals also pay a purchase price for the practice itself, which they would need to pay off in addition to new salary expenses and annual losses of output. In short, one possibility is that for hospitals, vertical integration might be driven by strategic considerations, such as vertical foreclosure or dynamic capabilities, as much as short-term financial considerations. Another possibility is that primary care physicians may practice differently in integrated environments. It may be easier to refer patients to other procedures, including lucrative elective surgeries, when such resources are located within the same organizational body. A shift toward more specialty care and/or surgery is consistent with reports in the literature that patient-level spending rises after integration.[8,10,20,25]

These findings do not unconditionally cast in a bad light the role of vertical integration in patient care. Although integrating physicians reduce the care they deliver, they may be reducing wasteful or low-value care, which would be a welcome development in a health system known for its inefficiency.[26,27] Further, we are unable with this data to observe how physicians allocate their time in private practice and in hospital employment. It is possible that integrated physicians spend more time with patients, which could improve patient satisfaction or care quality. However, these results do suggest that integration makes it more difficult for Medicare patients to access care.

The study has several important limitations. Most notably, it relies on Medicare fee-for-service claims data. Our analysis does not include Medicare Advantage, commercial insurance, or Medicaid claims. It is possible that while integrated physicians perform less care among Medicare fee-for-service patients, total physician clinical output remains constant by shifting to patients from other payers. Because our analysis does not include data from these other payers, we are unable to test whether integration causes payer-shifting. Future research should examine the degree to which integration is associated with compositional changes in the payer mix within a physician's panel; some evidence suggests an association between integrated practices and the likelihood of accepting Medicaid patients.[28] There are also advantages of Medicare data: it does not suffer from the problems associated with survey data; it yields a large, nationally representative sample; and because accurate completion of claims is required for physicians and hospitals to be paid, the measures of clinical output we use are likely to be valid. An additional limitation is that patient welfare is not present in this analysis. We do not measure quality of care, patient satisfaction, or patient costs. A full assessment of vertical integration would consider these factors.

Future work can evaluate the explanatory power of vertical foreclosure theory by testing the extent to which rival hospitals experience declines in admissions, tests, or referrals following integration. Policymakers should discourage vertical integration to the extent that it causes foreclosure, as foreclosure reduces both competition and patient choice.[29] Researchers may also seek to evaluate dynamic capabilities theory by exploring whether organizational processes, financial metrics, or other hospital system performance indicators respond to integration. Testing the other mechanisms by which hospitals may recoup their investments, evaluating the payer-shifting hypothesis (ideally with an all-payer claims database), and incorporating physician wage data are important next steps in this literature. Moreover, this paper suggests that the role of urban-rural differences and practice size in the causes and effects of integration has been overlooked. Finally, researchers interested in whether integration improves patient care should examine how the composition of services changes when physicians integrate.

Chapter 2 References

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Chapter 2 Exhibits

Table 2.1. Sample Characteristics

	Pre-integration		Post-integration	
	Control	Integrating	Control	Integrating
N				
Physician-year observations	168982	11506	322712	21625
Unique physicians	56423	3844	70242	4733
Integrated with hospital	0	0	0	100
Age(mean)	51	50	54	52
Female(percent)	30	34	30	36
Size of practice (number of physicians)	21	19	19	35
Region				
Midwest	21	44	21	47
Northeast	23	14	22	13
South	35	28	35	24
West	21	13	22	16
Rural (percent)	18	36	18	33
Medicare Claims Volume (mean)	1586	1426	1516	1009
Medicare Professional Revenue (mean)	147185	121201	148486	84161
Medicare Relative Value Units (mean)	1434	1178	1402	942
Medicare Unique Patients (mean)	348	368	342	319
HHI Hospital	1757	2142	1808	2136
HHI Specialty	162	190	165	170

Note:
HHI - Hirschman-Herfindahl Index of hospital referral region; HOPD - Hospital Outpatient Department
Sample comprised of physicians who begin the study period unintegrated.

Figure 2.1. Physician Productivity Before and After Vertical Integration

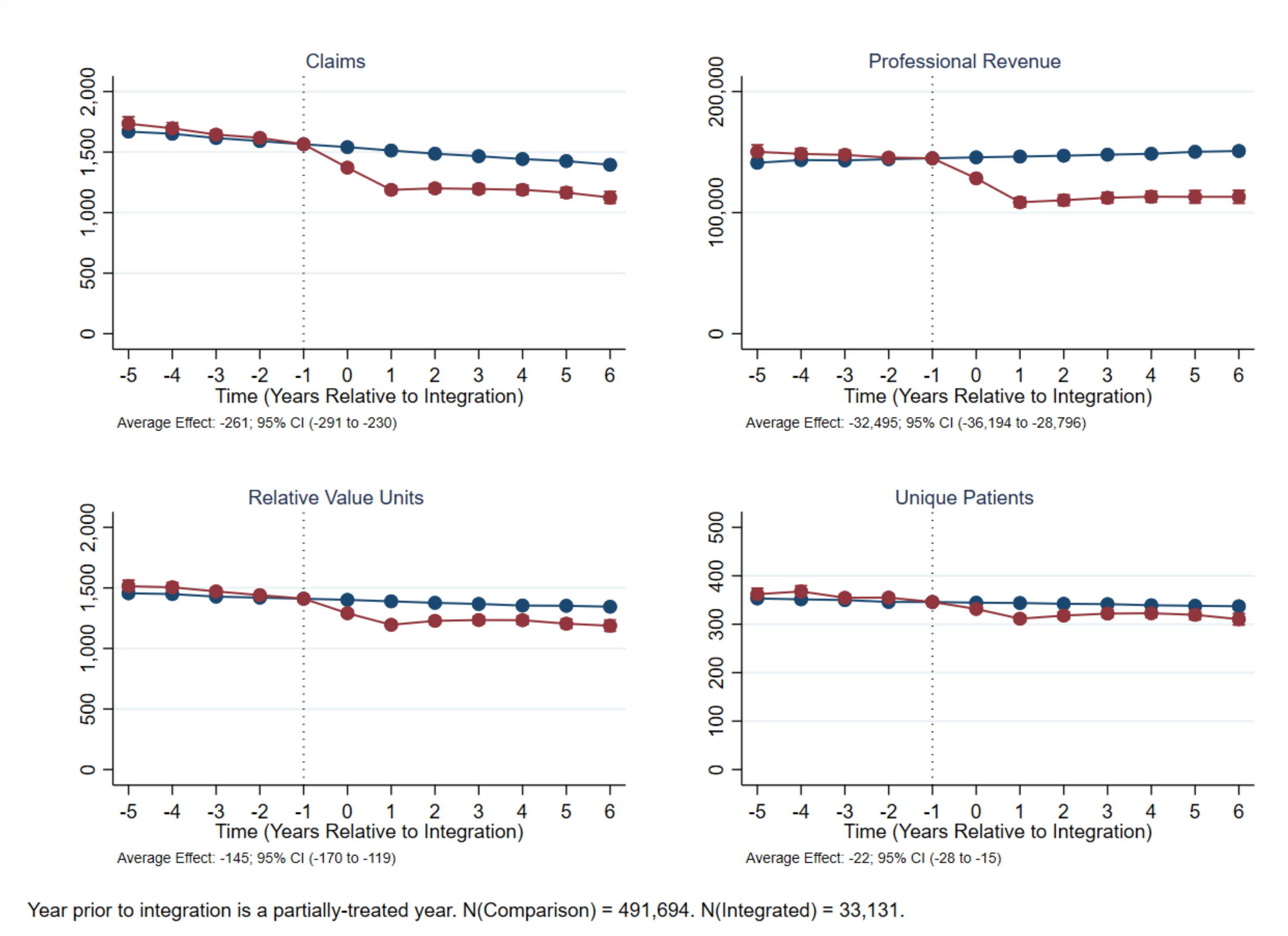
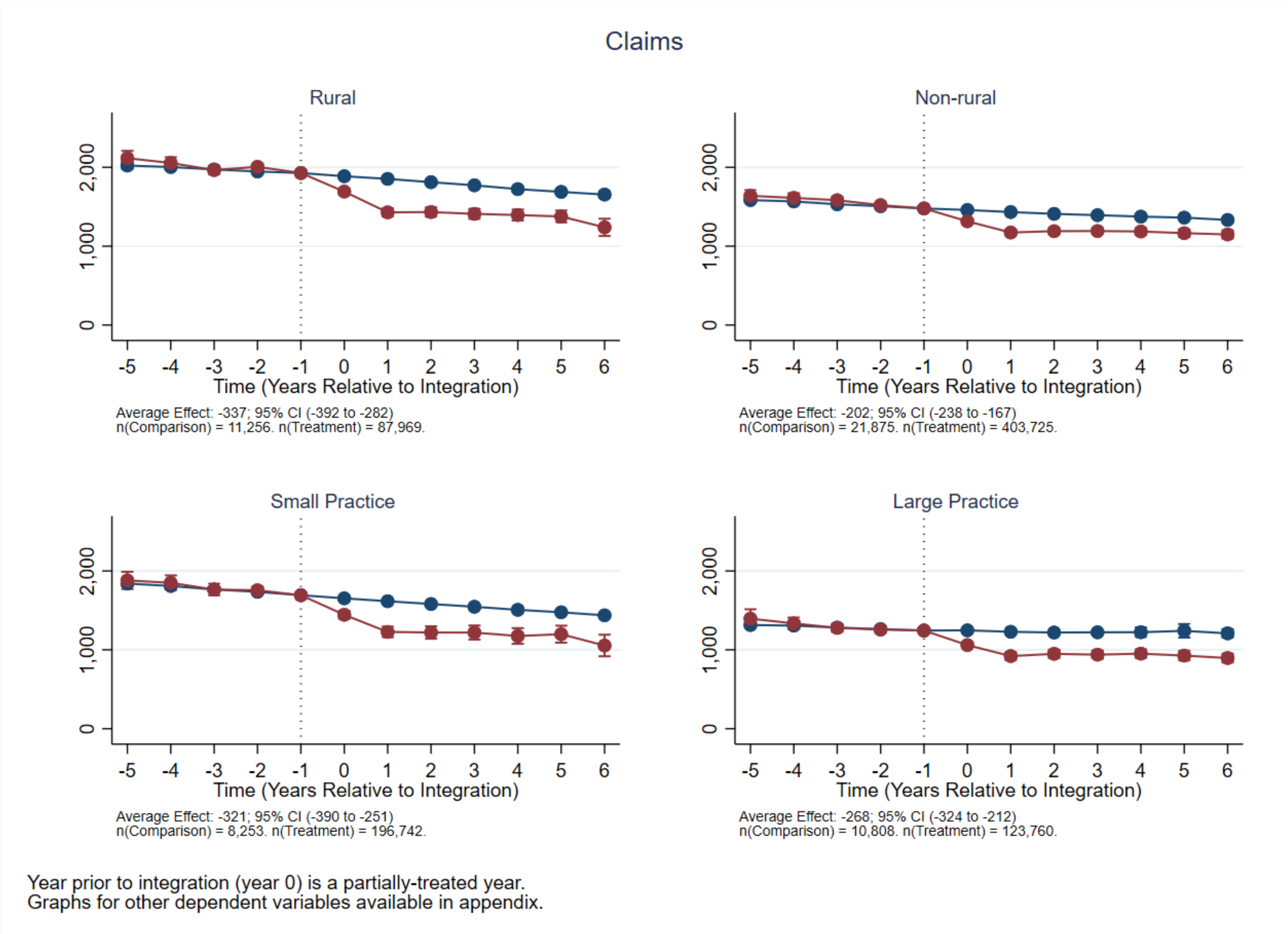


Table 2.2. Effects of Integration on Productivity Across Practice Types

Measure	Subgroup	Pre-period level among integrating physicians	Average effect of integration in post-period (magnitude)	Average effect of integration in post-period (percentage)
Annual number of claims	Overall	1564	-261 (-291, -230)	-17%
	Small	1692	-321 (-390, -251)	-19%
	Large	1245	-268 (-324, -212)	-22%
	Rural	1928	-337 (-392, -282)	-17%
	Non-rural	1479	-202 (-238, -167)	-14%
Annual professional revenue	Overall	144890	-32495 (-36194, -28796)	-22%
	Small	175606	-45225 (-57461, -32989)	-26%
	Large	97220	-30929 (-34418, -27441)	-32%
	Rural	157170	-43224 (-51091, -35357)	-28%
	Non-rural	142018	-26339 (-30102, -22575)	-19%
Annual relative value units	Overall	1411	-145 (-170, -119)	-10%
	Small	1693	-247 (-312, -182)	-15%
	Large	1010	-90 (-121, -58)	-9%
	Rural	1571	-198 (-243, -152)	-13%
	Non-rural	1373	-116 (-147, -85)	-8%
Annual unique patients	Overall	346	-22 (-28, -15)	-6%
	Small	342	-17 (-32, -2)	-5%
	Large	302	-31 (-41, -21)	-10%
	Rural	422	-25 (-37, -12)	-6%
	Non-rural	328	-17 (-24, -10)	-5%
Notes: Pre-period level calculated as the adjusted value of the final pre-period (t = -1).				
Average effect calculated as observation-weighted adjusted estimates where t >= 0.				

Figure 2.2. Effects of Integration on Claims Volume, by Physician Characteristic



Chapter 2 Appendix

Appendix 2.1. Construction of Analytical File and Measuring Vertical Integration

Construction of Analytical File

We began with a 20% sample of Medicare Carrier line items from 2009-2016. These files contain information on Medicare beneficiaries' physician visits (Part B). Each year of these files includes approximately 300 million observations, containing information such as the procedure code for each service delivered, the place of service, and, importantly, the performing physician's National Provider Identifier (NPI). From these files we constructed summary characteristics of each NPI in each year, including: the percentage of their services billed from an office and from a hospital outpatient department; the total amount of Medicare revenue billed and the sites of service from which it was billed; the specialty codes associated with the NPI; and geographic variables. We linked these annual NPI summary files to the American Medical Association Physician Masterfile, a proprietary dataset that indexes virtually all physicians in the United States. We kept the Carrier file claims that matched to a record in the Masterfile to include only physicians in the dataset. We merged the resulting files to Medicare Data on Provider Practice and Specialty (MD-PPAS). MD-PPAS is an annual data resource produced by CMS that contains provider specialty designations and several measures calculated from the 100% Medicare claims files, including the number of unique patients a provider treats and the total volume of Medicare revenue. We linked the 2010-2016 annual MD-PPAS data to our merged Carrier-Masterfile summary files. We used Medicare Provider Analysis and Review (MedPAR) files from 2009-2016 to create measures of hospital market competitiveness. We used Medicare PFS and OPPS files to calculate the number of RVUs associated with each physician’s procedures as found in the claims data, and summed them for each physician in each year. Using the numbers obtained from the 20% claims files, we multiplied the summed number of claims, amount of professional revenue, and RVUs by five in order to approximate the total annual values for these variables. We used the “number of unique patients” field in MD-PPAS for each physician in each year for the outcome of number of patients. We merged data from the U.S. Department of Agriculture by zip code to retrieve the commuting zone corresponding to each physician’s zip code. We classified each commuting zone along an urban-rural continuum: we took the average of the Rural-Urban Commuting Area codes, which range from 1 (highly urban) to 10 (highly rural) for each Census Tract within each county of the commuting zone.[30,31] we assigned commuting zones with an average RUCA score of 4 or greater to “rural” status, and all other commuting zones to non-rural status. We calculated each physician’s practice size at the time of integration using MD-PPAS tax identifier number information (TIN). For each TIN in each year, we calculated the number of unique NPIs. For each physician, practice size corresponded to the number of unique NPIs in that physician’s primary TIN for the year.

Measuring Vertical Integration

We defined integration using a strategy developed by Neprash and colleagues. They utilize the place of service codes found in Medicare claims. During our study period, when a hospital acquired a physician, the physician became eligible to bill under the Hospital Outpatient Department (HOPD) place of service code. The incentives to make this billing change were strong, since reimbursement under an HOPD designation was often higher than under an office designation. We created an indicator for each physician in each year to indicate integration status by counting the number of line items billed in the Medicare Carrier (physician/supplier) claims under an office code and under an HOPD code. When 75 percent or more of these line items were billed under an HOPD code, we classified the physician as integrated. In addition to the Carrier claims, Neprash and colleagues also used the Outpatient claims to reclassify some Carrier claims that were likely miscategorized as having taken place in the office setting. We do not take this additional step because the number of reclassified claims was small (2-3%). Their eMethods (2015) contains a clear explanation of the details in their approach. In addition, we use MD-PPAS data to supplement the claims-based approach. If a physician's tax identifier legal name contains the keywords "medical center," "hospital," "system," "health science center," "health sciences center," or "med ctr," we identify them as integrated.

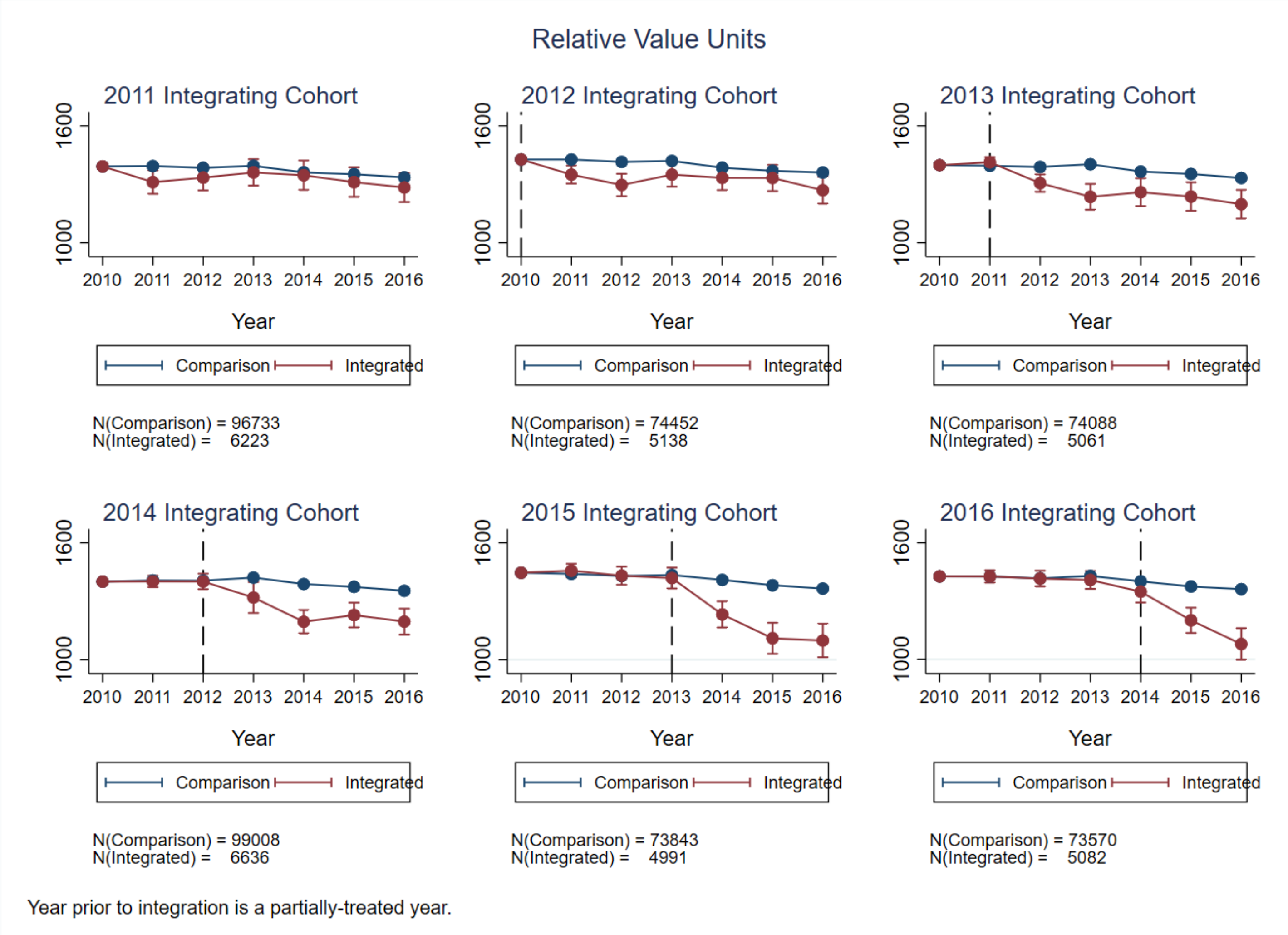
Appendix 2.2. Sample Flow Diagram

Inclusion criteria	Resulting Sample Size (Physician-Year observations)
Provider NPI-years 2010-2016	4708481
Appears in Medicare claims	4708481
Appears in AMA Masterfile	3550511
NPI valid length and format	3550504
Exclude those with 10 or fewer line items	3462819
Provider State Code in 50 U.S. States	3433121
Exclude physicians with reported age range outside 20-85	3423989
Keep physicians with populated specialty information	3064986
Key variables populated (market concentration, rural, dependent variables, region)	2795181
Appear in all 7 years	1946049
MD-PPAS specialty is Primary Care	665214
Keep physicians who never integrate and those who become permanently integrated	539386
Appear in all 7 years after exclusions	524825
Final sample size	524825

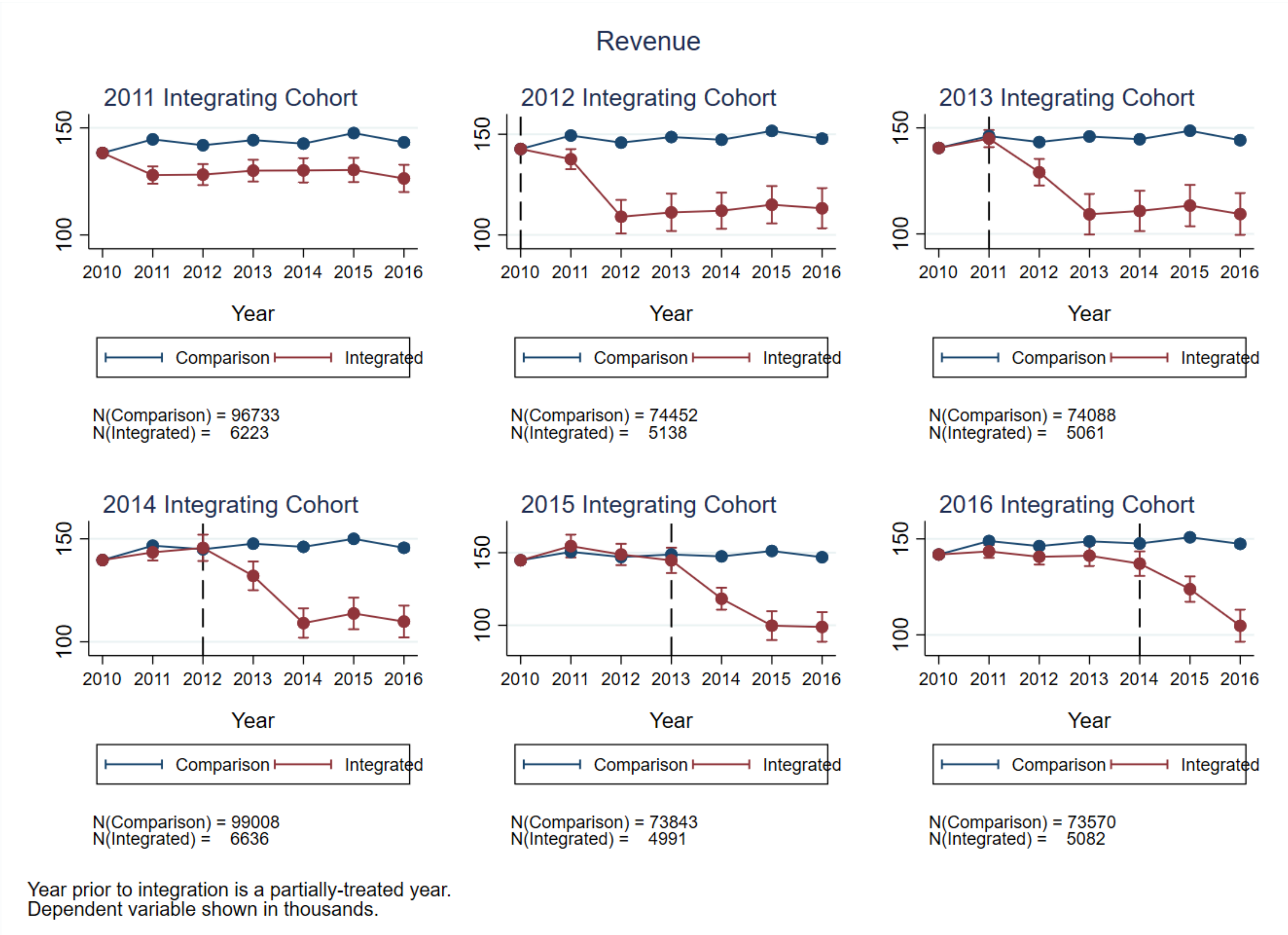
Note: AMA – American Medical Association; MD-PPAS – Medicare Data on Provider Practice and Specialty; NPI – National Provider Identifier

Appendix 2.3. Dependent Variables Before and After Integration, by cohort year

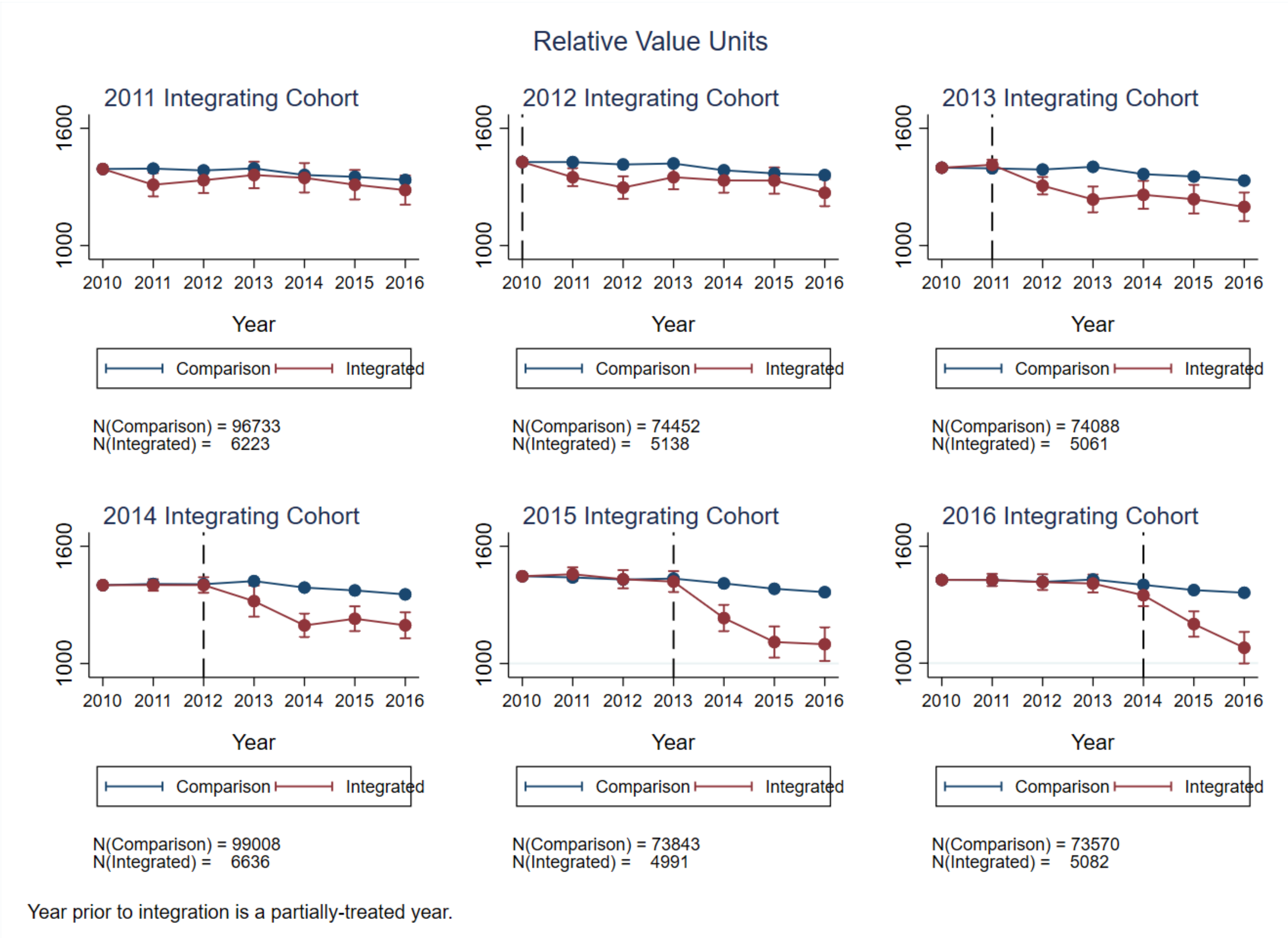
Panel A. Claims before and after integration, by cohort year



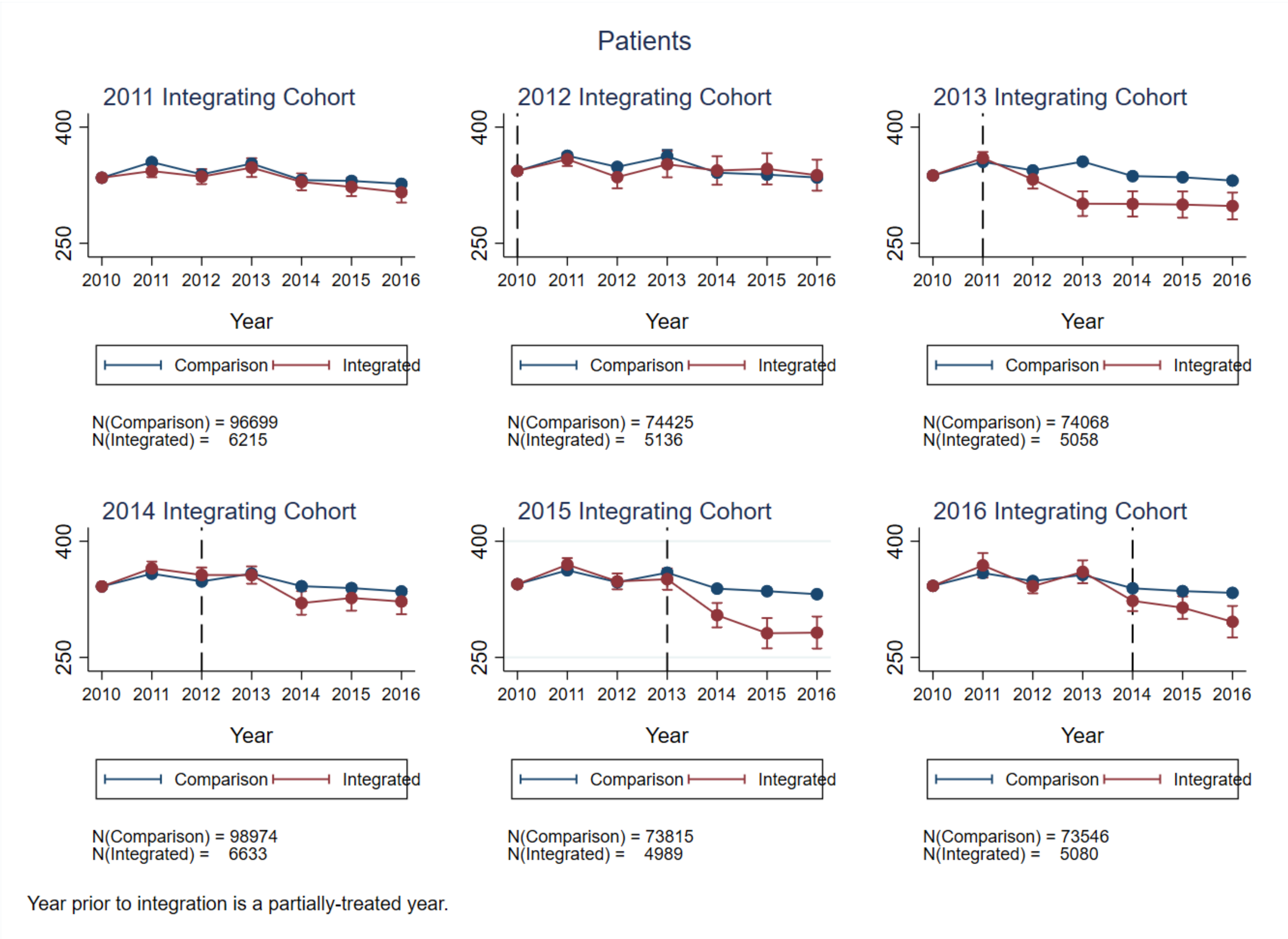
Panel B. Professional Revenue before and after integration, by cohort year



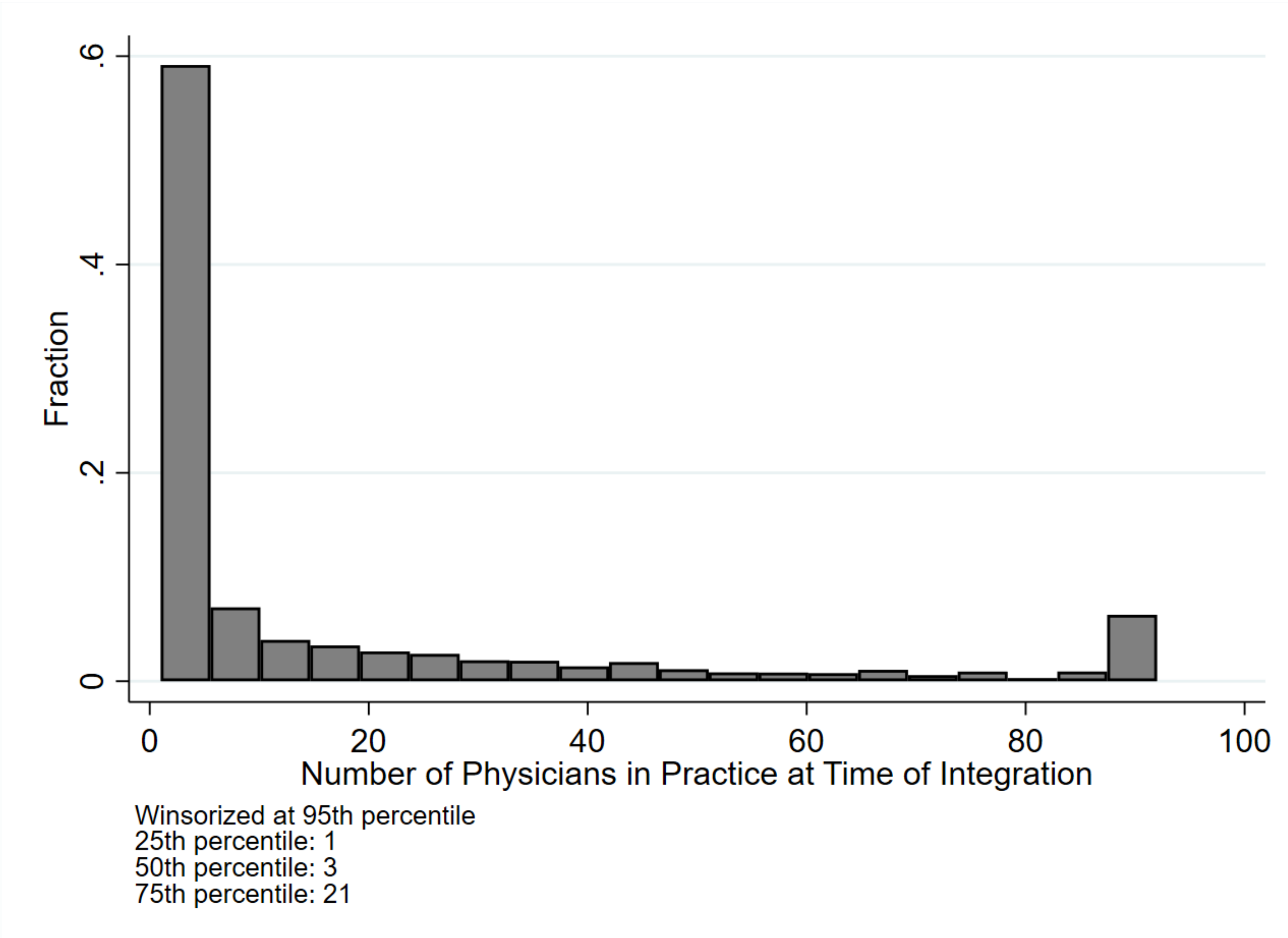
Panel C. Relative Value Units before and after integration, by cohort year



Panel D. Unique patients before and after integration, by cohort year



Appendix 2.4. Size of Practice at Time of Integration



Appendix 2.5. Physician Fixed-Effects Regression in Full Sample, all dependent variables

VARIABLES	(1) Claims	(2) Revenue	(3) RVUs	(4) Patients
Time = -5	104.9***	-3,744***	44.98***	7.215***
	(85.25 - 124.6)	(-5,979 - -1,510)	(28.54 - 61.43)	(4.091 - 10.34)
Time = -4	86.87***	-1,492**	38.13***	5.417***
	(73.42 - 100.3)	(-2,883 - -101.2)	(26.93 - 49.33)	(2.895 - 7.940)
Time = -3	51.72***	-1,747***	16.93***	3.913***
	(41.91 - 61.53)	(-2,717 - -776.8)	(9.252 - 24.62)	(2.357 - 5.468)
Time = -2	26.86***	-800.8**	8.596***	0.0406
	(19.31 - 34.40)	(-1,485 - -116.8)	(3.519 - 13.67)	(-1.327 - 1.408)
Time = -1 (base)				
Time = 0	-23.35***	744.5**	-9.845***	-1.503**
	(-29.69 - -17.01)	(138.4 - 1,351)	(-14.54 - -5.147)	(-2.730 - -0.276)
Time = 1	-51.42***	1,418***	-21.68***	-2.132***
	(-58.96 - -43.89)	(668.9 - 2,167)	(-27.56 - -15.80)	(-3.581 - -0.683)
Time = 2	-77.80***	2,090***	-34.19***	-3.799***
	(-88.51 - -67.08)	(1,145 - 3,034)	(-41.23 - -27.16)	(-6.091 - -1.507)
Time = 3	-98.22***	2,978***	-43.69***	-4.441***
	(-113.7 - -82.70)	(1,840 - 4,117)	(-51.98 - -35.40)	(-6.272 - -2.611)
Time = 4	-122.0***	3,689***	-56.63***	-6.830***
	(-145.3 - -98.68)	(2,382 - 4,997)	(-66.45 - -46.82)	(-8.795 - -4.865)
Time = 5	-138.6***	5,311***	-58.52***	-7.896***
	(-168.1 - -109.2)	(3,685 - 6,936)	(-70.79 - -46.24)	(-10.31 - -5.479)
Time = 6	-169.3***	5,977***	-65.96***	-8.827***
	(-193.0 - -145.7)	(4,077 - 7,876)	(-81.16 - -50.76)	(-12.09 - -5.561)
Leading Effects				
Treated group # time -5	64.90**	9,063***	58.04**	8.827
	(6.344 - 123.5)	(3,065 - 15,060)	(7.273 - 108.8)	(-3.458 - 21.11)
Treated group # time -4	44.84*	5,082**	56.15***	16.29***

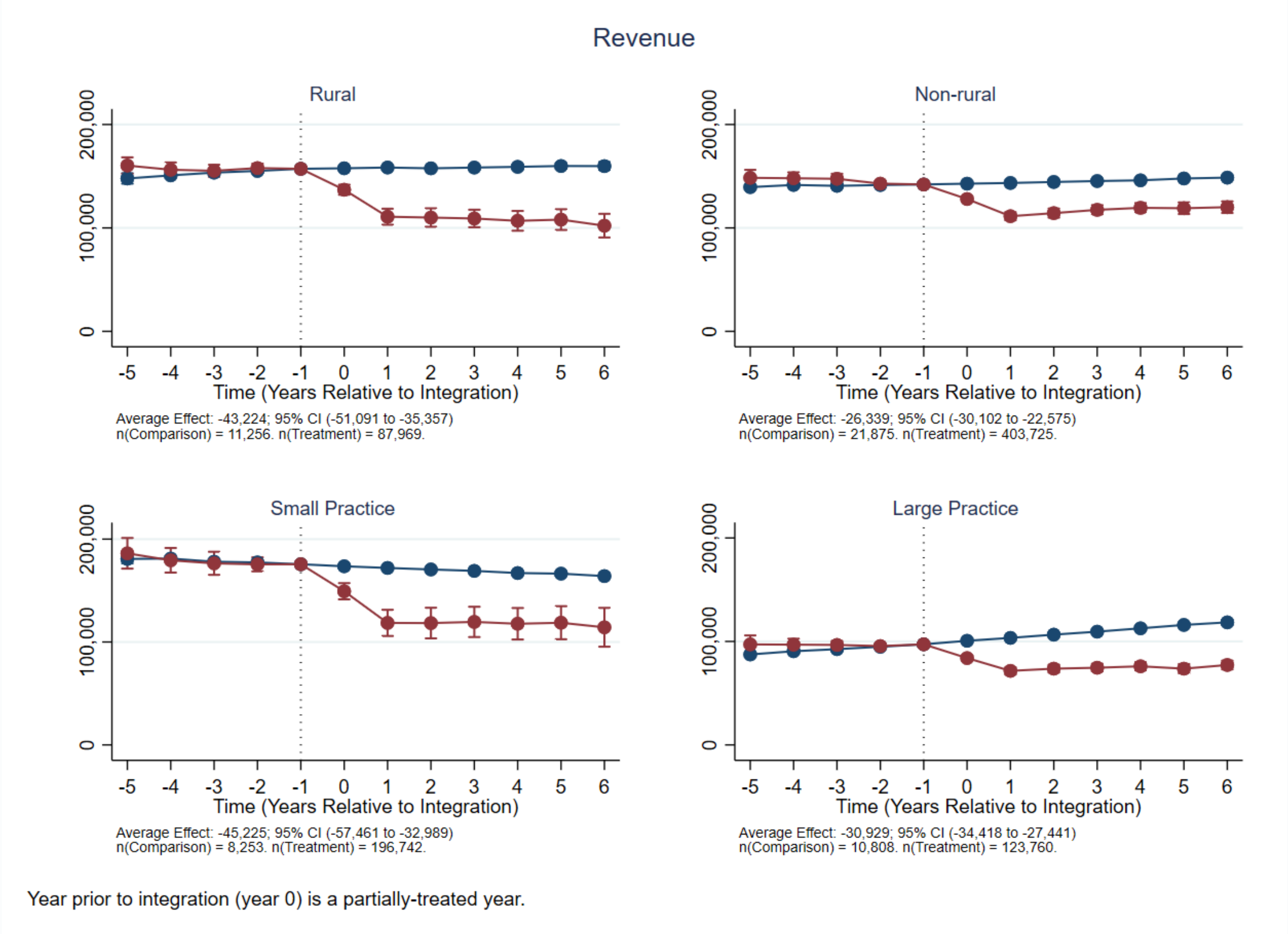
	(-2.247 - 91.93)	(496.1 - 9,667)	(17.05 - 95.25)	(4.581 - 27.99)
Treated group # time -3	28.41	4,547**	43.36***	4.665
	(-6.663 - 63.47)	(702.9 - 8,392)	(13.50 - 73.22)	(-2.329 - 11.66)
Treated group # time -2	26.61**	1,378	20.84**	8.989***
	(0.717 - 52.50)	(-1,031 - 3,787)	(1.814 - 39.87)	(3.608 - 14.37)
Treated group # time -1	0	0	0	0
Lagged Effects				
Treated group # time 0	-169.6***	-17,329***	-110.0***	-12.97***
	(-192.0 - -147.2)	(-19,958 - -14,700)	(-134.2 - -85.71)	(-17.48 - -8.461)
Treated group # time 1	-324.6***	-37,784***	-193.7***	-32.40***
	(-355.4 - -293.8)	(-41,761 - -33,806)	(-220.8 - -166.5)	(-39.29 - -25.51)
Treated group # time 2	-286.0***	-36,709***	-148.6***	-24.33***
	(-321.3 - -250.7)	(-41,249 - -32,169)	(-179.4 - -117.9)	(-32.11 - -16.55)
Treated group # time 3	-270.8***	-35,592***	-132.7***	-19.53***
	(-309.0 - -232.6)	(-40,092 - -31,092)	(-164.8 - -100.6)	(-27.80 - -11.27)
Treated group # time 4	-253.9***	-35,420***	-121.0***	-16.52***
	(-298.2 - -209.5)	(-40,221 - -30,618)	(-156.9 - -85.21)	(-25.70 - -7.343)
Treated group # time 5	-260.1***	-37,160***	-147.7***	-18.59***
	(-309.6 - -210.7)	(-42,616 - -31,704)	(-187.6 - -107.9)	(-29.11 - -8.070)
Treated group # time 6	-270.1***	-37,831***	-157.2***	-26.74***
	(-322.4 - -217.9)	(-43,437 - -32,224)	(-205.4 - -109.1)	(-39.00 - -14.47)
2011.year	34.04***	5,705***	12.29***	20.28***
	(29.20 - 38.88)	(5,173 - 6,237)	(8.136 - 16.44)	(19.09 - 21.47)
2012.year	39.66***	2,412***	17.10***	8.973***
	(32.85 - 46.47)	(1,731 - 3,093)	(11.75 - 22.46)	(7.982 - 9.965)
2013.year	53.33***	4,011***	38.09***	21.68***
	(45.99 - 60.67)	(3,280 - 4,742)	(32.41 - 43.77)	(19.67 - 23.68)
2014.year	22.02***	1,819***	16.55***	3.589***
	(15.25 - 28.79)	(1,150 - 2,488)	(11.25 - 21.86)	(2.588 - 4.590)
2015.year	17.71***	4,888***	8.607***	2.608***
	(12.69 - 22.72)	(4,365 - 5,412)	(4.505 - 12.71)	(1.844 - 3.371)

2016o.year	-	-	-	-
HHI hospital (ln)	22.84	-924.2	14.52	8.522***
	(-5.337 - 51.02)	(-3,419 - 1,571)	(-2.829 - 31.87)	(4.378 - 12.67)
HHI physician (ln)	6.562	3,027***	6.015	0.624
	(-5.307 - 18.43)	(1,537 - 4,517)	(-1.999 - 14.03)	(-1.041 - 2.288)
Constant	1,348***	135,957***	1,267***	273.7***
	(1,168 - 1,528)	(120,013 - 151,902)	(1,148 - 1,387)	(244.7 - 302.7)
Observations	524,825	524,825	524,825	524,638
R-squared	0.816	0.874	0.882	0.839

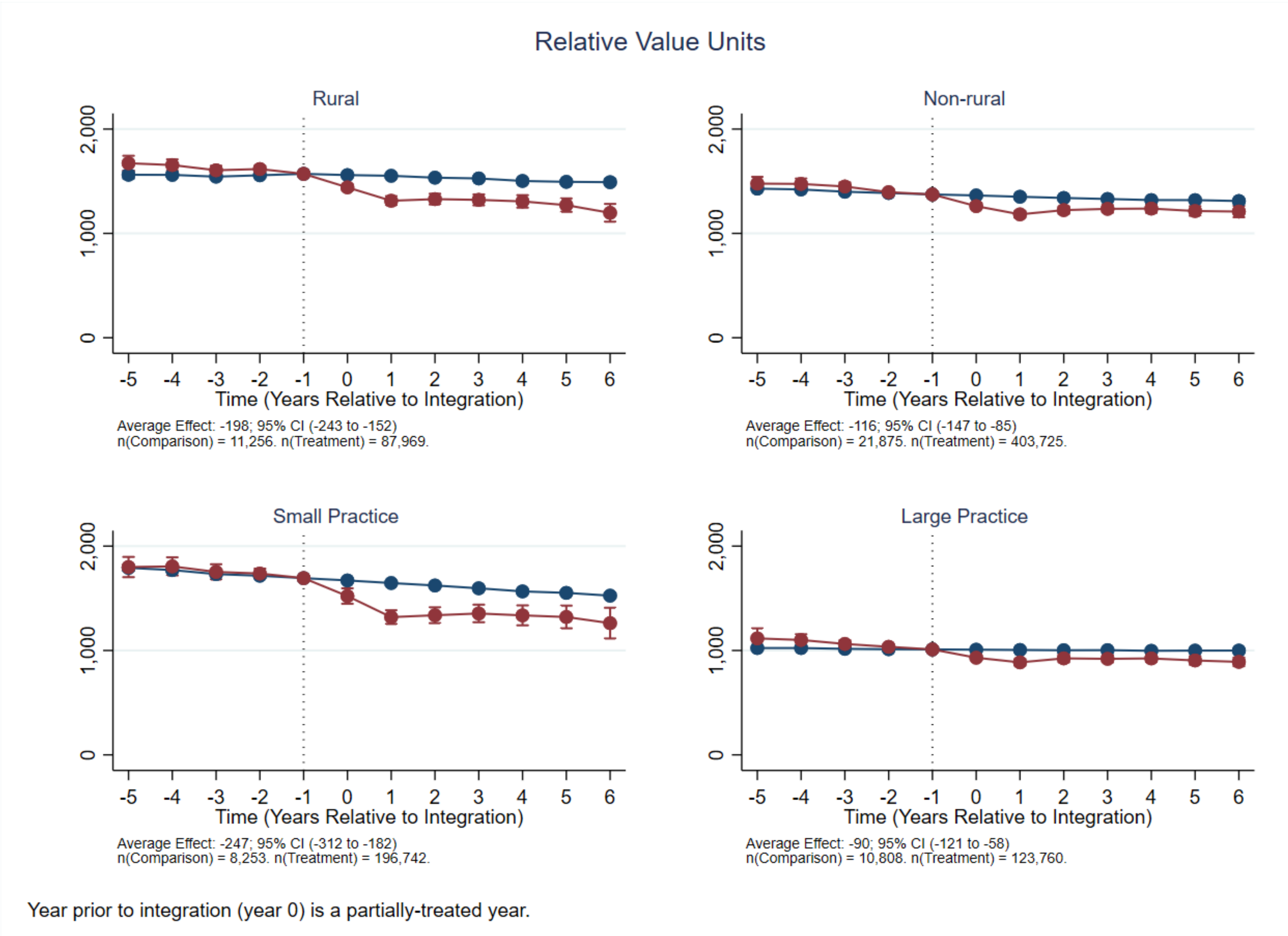
Robust ci in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Appendix 2.6. Effects of Integration on Dependent Variables, by Physician Characteristic

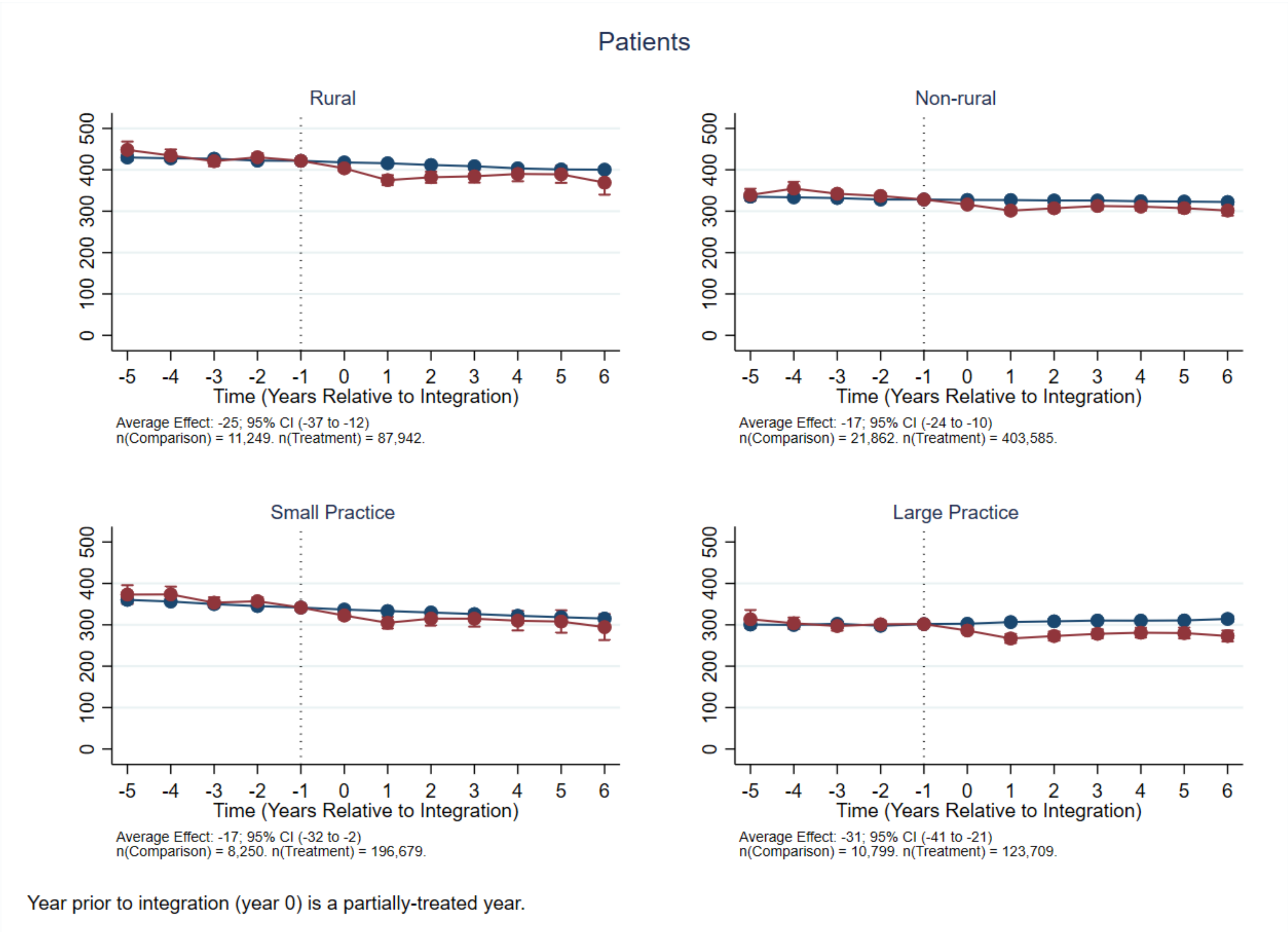
Panel A. Revenue



Panel B. Relative Value Units



Panel C. Unique Patients



Chapter 3. Association of Coded Patient Severity with Hospital-Physician Vertical Integration

Chapter 3 Abstract

Importance: Hospitals have rapidly acquired physician practices, but the effects of these vertically integrated provider systems on the coding of patient illness remain unclear.

Methods: We used Medicare patient claims from 2010-2015 to evaluate whether patients treated by vertically integrated physicians exhibited differences in the levels and growth in patient clinical severity scores. We calculated patient-year hierarchical clinical condition (HCC) scores and used linear regression to evaluate the relationship between growth in HCC scores and vertical integration, adjusting for year, patient-level fixed effects, area and market characteristics, and physician age, gender, and practice size.

Results: Using 25,266,973 patient-year observations, we found that patients with more exposure to vertically integrated physicians exhibited significantly larger increases in coded severity ($p < 0.001$). With each additional year of vertical integration, patient severity increased by 20.4 percent (95% CI: 18.3 to 22.4, $p < .001$). These effects were non-linear: the longer that an integrated physician treated a patient, the larger the increase in coded severity. Instrumental variables analysis showed a significant effect as well (10.4 percent, 95% CI: 8.9 to 11.9, $p < .001$).

Conclusion: Vertical integration facilitates higher coding intensity. The benefits of vertically integrated delivery systems should be weighed against the increased costs associated with higher reported patient severity.

Introduction

Hospital ownership of physician practices and hospital employment of physicians has increased rapidly in the last decade.[1–5] While the increased prevalence of these provider arrangements (often called vertical integration) likely has multiple causes, some have noted that delivery systems might bring together inpatient and outpatient services under common ownership in part to prepare for and better perform in alternative payment models.[6–8] These models, such as accountable care organizations (ACO) and episode-based payment initiatives, carry incentives for systems to reduce costs while improving quality. The payments from these models are adjusted for the risk of the patient population. The Centers for Medicare and Medicaid Services (CMS), for example, uses patient demographic information and the diagnosis codes found in Medicare administrative claims data to calculate a patient risk score that they use in establishing benchmarks for the Medicare Shared Savings Program ACO. Correspondingly, hospitals and physicians have an incentive to maximize the coded severity of the patients in their care as documented in diagnoses. Moreover, these alternative payment incentives overlay an existing incentive structure that rewards providers for maximizing the reported severity of their patients. Payment rates for Medicare Severity Diagnosis Related Groups (MS-DRGs) increase with patient severity. In 2017, Medicare reimbursed a coronary bypass without major complication and comorbidity (MCC) at an average rate of $23,406; if the procedure was coded with MCC, the rate rose to $34,825.[9] Vertical integration could help hospitals and physicians more comprehensively code the severity of their patients. Hospital systems may have full-time professional medical coders, software tools, consultants, and other services that they can share with acquired physician practices to assist in documenting all available conditions. Hospitals have much at stake: 60-80 percent of payment for inpatient surgery episodes accrues to the hospital.[10] Hospitals depend on the cooperation of physicians to document patient severity, and integration may help increase that cooperation.

Despite these incentives and the increasing prevalence of hospital-physician vertical integration, the effects of integration on coded patient severity are unknown. In this study, we used national Medicare claims data over a six-year window to evaluate whether patients treated by vertically integrated physicians exhibited larger increases in their coded severity. We attributed patients to physicians and measured whether their physicians were vertically integrated with a hospital. We compared changes in coded severity among patients affiliated with integrated physicians to those that were not, using both a difference-in-differences model with patient-level fixed effects and instrumental variables analysis to estimate the effects. Our findings provide policymakers with insights about the role of vertical integration in coded severity and the rising cost of care.

Methods

Data and Sample

We created our sample using national claims from 2010-2015. We linked several data sources: Medicare fee-for-service Carrier line items from 2010-2015, Medicare Data on Provider Practice and Specialty (MD-PPAS), the Medicare Master Beneficiary Summary file, the American Community Survey, and the Area Health Resources File.

We applied several inclusion criteria to arrive at our analytical sample (see Appendix 1). We selected patients with Medicare Part A and Part B coverage who were not enrolled in Medicare Advantage, were alive through the duration of the study period, and had our outcomes and covariates populated in the data sources. We excluded patients whom we could not attribute to a primary care physician or for whom attributed physician covariates were missing. Lastly, we selected patients who were enrolled in Medicare fee-for-service for at least two years of our six-year window to ensure that our findings applied to a reasonably representative sample of patients (i.e., requiring a full six years of continuous enrollment – or conversely, only one year – could introduce sample bias toward the sickest or healthiest patients).

Key Variables

With the information available in the data sources above, we measured each patient's age, sex and race. We attributed each patient to the primary care physician from whom he or she received the plurality of his or her care that year. We also measured area and market characteristics for each beneficiary. Following the covariate approach in related work by Markovitz and colleagues, we measured the county-level rates of high school completion, four-year college completion, and the market penetration of Medicare Advantage plans.[11] In addition, we measured the hospital referral region Herfindahl-Hirschman Index, a measure of market competition, for hospitals and for primary care physicians. Finally, we measured several physician-level characteristics, including physician age, sex, and whether they resided in a rural area. We calculated the size of the practice in which each physician operated by counting the number of unique NPIs that billed under each TIN.

We calculated whether a physician was vertically integrated with a hospital each year using a claims-based method established in the literature.[12] For each physician, we measured the percentage of claims that they billed under Medicare's office place of service codes and hospital outpatient department (HOPD) place of service. When at least 75 percent of these claims were billed under the HOPD code, we classified the physician as integrated; we varied this threshold and our results did not substantially change. To capture additional integrated physicians that the claims-based measure may have missed, we supplemented our measure by classifying physicians as integrated if their primary employer was likely a hospital system using a variety of keywords, including "hospital," "medical center," and "health system" (see Appendix 2 for details).

We calculated our exposure variable in several ways. First, we calculated for each patient the cumulative number of years in which they were attributed to a vertically integrated physician. For example, a patient whose attributed physician was not integrated in 2010 or 2011, but whose attributed physician in 2012-2015 was integrated, would have exposure scores for years 2010 through 2015 of 0,0,1,2,3,4, respectively. With this cumulative measure, we accounted for the fact that physicians entered into vertically integrated arrangements at different times throughout our study period; we also accounted for possible effects of being treated within a vertically integrated system over long periods of time. Estimation using this definition appears in Figure 3.2 (Models 1 and 2). We also calculated exposure with dummy variables for patients who had one year, two years, and three or more years of being attributed to a vertically integrated physician. Lastly, we also use the simple measure of whether a patient's attributed physician in each year was vertically integrated. In all specifications, we control for calendar year.

Our outcome was the HCC score of each patient in each year. This score, which we calculated in accordance with CMS specifications, measures the spending risk of the patient, reflecting clinical diagnoses and socioeconomic health predictors, with a population mean set to 1.00. Patients with higher risk scores have higher predicted spending.

Analysis

We estimated the effect of integration on coded severity using three approaches.

First, we used a flexible linear regression model with patient-level fixed effects, controls for area characteristics, and controls for physician characteristics. We applied the model to the full analytical sample. We first used cumulative years of exposure to integration as the outcome variable (Model 1 of Figure 3.2); we also estimated a model in which we added a squared term of this variable (Model 2 of Figure 3.2). We also estimated the effect using the dummy variables described above (Model 3 of Figure 3.2). These measures allowed for a possible non-linear relationship between years of integration and changes in coded patient severity. Our identification relies on within-patient variation in integration status and changes in coded patient severity. Our strategy assumes that after including patient fixed effects and time-varying controls, there are no remaining time-variant omitted variables that affect both integration and changes in coded severity.

Second, we conducted a difference-in-differences (DD) analysis in which we tested several different constructions of the comparison group. In our preferred specification, we used inverse probability weighting (IPW) to construct the comparison group from all available patients. IPW can reduce the bias in estimated treatment effects by weighting observations according to the inverse of the probability of receiving their actual treatment.[13,14] In this analysis, the treated group is the set of patients who began unintegrated and permanently switched to integrated. We tested several other comparison groups by grouping patients into five different types of exposure – those whose attributed physicians were never integrated (Never), always integrated (Always), began unintegrated and permanently switched to integrated (Integrater), began integrated and permanently switched to unintegrated (Disintegrater), and those who switched back and forth (Switcher). One disadvantage of this approach is that it required some simplifying categorizations to create our exposure type subgroups; for example, any patient who switched back and forth between integration and non-integration was a “Switcher,” though there were different levels of exposure to integration within this group. The advantage of this grouped analysis, however, was that it allowed us to track consistent groups of patients before and after integration or de-integration in a DD framework. In addition to our inverse probability weighting approach, we also estimated our model using the Never group and the Always group as comparisons; results for these can be found in Appendix 5. In our setting, no common start date exists: patients might receive treatment from an integrated physician in only 2010, only 2015, or no years at all. Therefore, we centered each patient's start dates around t=0, where t=1 indicated the first year they were treated by an integrated physician. Among the groups with no start dates – the Never and Always groups – we assigned artificial start dates by randomizing each patient to a starting year. The probability of a patient being assigned to a starting year was based on the proportion of Integrater patients who began seeing treated physicians in each year. This approach allowed us to evaluate different groups of patients along a common time scale. Our identifying assumptions in this model are those of a difference-in-difference analysis. In the absence of treatment, we assumed the difference between treated and control groups would have remained constant from the pre-period through the post-period. We further assumed that the outcome trend did not influence selection into or out of integration, and that there were no shocks, other than the treatment, that differentially affected the treatment or control groups.

Third, we developed an instrumental variables approach. We defined our instrument as the percentage of all local physicians who were integrated with hospitals in each year (using the geography of core-based statistical areas [CBSA]). Geographic instruments have been used in related applications to identify treatment effects: Sheetz and colleagues rely on regional utilization of laparoscopy as an instrument to evaluate the safety of laparaoscopic and open colectomy procedures in the presence of differences in skill among surgeons; Xian and colleagues use a differential distance measure to evaluate the mortality associated with stroke centers; and Gaynor uses area-level instruments to account for the endogenous supply of physicians in an area.[15–17] We found that our instrument exhibits considerable variation (Appendix 9). This variation effectively assigns nearby patients to higher or lower probabilities of being treated by an integrated physician.

This approach is essential because patients in Medicare fee-for-service can select their own physicians. This freedom of choice raises the potential for self-selection bias in our context. The study designs of the foregoing approaches will control for any time-stable patient characteristics as well as many time-varying covariates. However, if patients self-select into treatment by integrated physicians due to unobserved time-varying changes in health trajectory – a reasonably likely possibility for some patients – then the estimates from the first two approaches may be upwardly biased. We would mistake the effect of a patient's worsening health condition on coded severity for the effect of vertical integration on coded severity. Our instrumental variables analysis solves this problem by "randomizing" patients into the care of vertically integrated physicians via the proportion of local physicians that are integrated. Provided that patients do not move to localities because of a locality's level of integrated physicians – which, based on Current Population Survey data below, we propose is a reasonable proviso – the estimates we recover from our instrumental variables analysis will be unbiased.

We conducted a two-stage least squares regression. In the first stage, we estimated the strength of the relationship between our instrument (percent of CBSA physicians vertically integrated) and our endogenous variable (whether the patient was attributed to a vertically integrated physician that year). We generated predicted values for whether the patient was attributed to an integrated physician. In our second stage, we regressed our outcome variable (coded patient severity) on these predicted values. In both specifications, we included our covariates, including patient fixed effects. We clustered our standard errors at the patient level. The effect that we identified using this instrument was a local average treatment effect (LATE) among the compliers – i.e., the effect among the patients whose attributed integration status ("treatment") was determined by the instrument.

Our instrumental variables analysis has two key assumptions: instrument relevance and the exclusion restriction. Our instrument must be a significant predictor of the endogenous variable to avoid the biases associated with weak instruments.[18] This is testable. We show in our results that there is a correlation between the percent of physicians who are integrated and the probability of a patient being attributed to a vertically integrated physician. Weak instruments can cause instrumental variables estimates to be asymptotically biased.[18] However, in our case, we do not anticipate that this is an issue: we found a very strong relationship between our instrument and the endogenous variable. Moreover, weak instrument bias can be mitigated if the instrument passes the second assumption, that is, the exclusion restriction: the instrument does not exert any effect on the outcome variable except through its relationship with the endogenous variable. While this is not testable, we argue that this instrument passes the exclusion restriction. We do not think that the percentage of local physicians that are integrated with a hospital system has an independent effect on patient's coded severity. The most plausible violation would be if patients self-select into CBSAs that have higher or lower proportions of integrated physicians due to their expected changes in health status. Our approach controls for any time-stable health status with our patient fixed effects, however, if older adults move to CBSAs due to changes in health status, this would threaten the validity of the exclusion restriction.

To measure this potential threat, we examined moving data from the Current Population Survey of the U.S. Census Bureau for the age group that most closely reflected our sample.[19] We found that adults in this age group were highly stationary. If they did move, they usually stayed within the same county. In 2019, there were approximately 23.4 million Americans between ages 70 and 79. Among these, there were 868,000 moves (3.7 percent of the 70-79 population). Fewer than 1 in 6 of these moves were health-related, and 58 percent of moves were same-county changes in residence. Given these figures, we estimate that, on the high end, only about 0.3 percent of the population moves counties due to health reasons. Fewer still are likely to move CBSAs (which are larger than counties). Finally, it is likely that many of these health-related moves reflect adults moving into long-term care facilities, in which case they do not bias our results, because our sample includes only community-based individuals. For these reasons, we think our instrument passes the exclusion restriction.

Results

Descriptive Results

After applying our inclusion criteria, we generated an analytical sample of 25,266,973 patient-years, representing 5,979,862 distinct patients (Table 3.1). Seventy-three percent of the patients in our sample received the plurality of their primary care from a non-integrated physician during the study period, while 27 percent received their care from an integrated physician in at least one year. Among those with at least one year of treatment from a vertically integrated physician, the average number of years exposed to vertically integrated physicians was 2.6 of 4.7 years.

The patients treated by integrated physicians closely resembled the patients treated by non-integrated physicians in demographics: patients were approximately 72 years of age in both groups; about 59 percent of the sample was female; and the racial distribution was very similar. They also appeared similar in area characteristics, such as the poverty rate, the percentage of the population that graduated from high school and college, and the Medicare Advantage penetration in the county. Hospital markets were slightly more concentrated among patients treated by integrated physicians (HHI of 2100 compared to 1923), a pattern also shown in the market for primary care physicians (188 compared to 162).

The non-integrated physician population was slightly older (53.4 years to 50.9 years), had fewer females (24 percent compared to 28 percent), and was less rural (23 percent compared to 33 percent) than the integrated physician population. As expected, the size of the practices differed considerably. Non-integrated physicians had a median practice size of 6 providers, while integrated physicians had a median size of 48.

Patients differed in their clinical profiles across integration exposure. Those treated by non-integrated physicians were coded as having an average of 1.96 chronic conditions, while patients treated by integrated physicians had an average of 2.48 chronic conditions. Similarly, the HCC coded severity score was 1.11 among non-integrated physicians and 1.35 among those treated by integrated physicians. For both integrated and non-integrated patients, coded severity increased from 2010 to 2015, consistent with patients aging during this window. However, patients of integrated physicians exhibited a larger increase in coded severity: from 2010 to 2015, these patients showed an increase of 53 percent while the increase among non-integrated physicians increased 38 percent. The changes in integration severity were very similar between those who were always treated by integrated physicians and never treated by integrated physicians (Figure 3.1).

Statistical Results

As described in our methods, we conducted our statistical analyses with three approaches.

We first specified a flexible linear model with patient-level fixed effects, controls for area characteristics, and controls for physician characteristics. The outcome variable was the HCC coded severity score. We began with the simple value of the exposure variable (cumulative years of exposure to vertically integrated physicians); then, to allow for a non-linear relationship between exposure to vertical integration and coded severity, we tested models with a quadratic term and dummy variables for 1, 2, and 3 or more years of attribution to a vertically integrated physician.

In the first model, the marginal effect of one year of vertical integration was 3.24 percent (95% CI: 3.08 to 3.40), implying that for each additional year of treatment under a vertically integrated physician, patient clinical severity scores rose by 3.24 percent. By extension, over the course of six years, this implies that severity scores under an integrated physician would rise by approximately 21 percent (1.0324^6=1.21). In the next model, we included the cumulative years of vertical integration as well as its squared term. In this model, the marginal effect of another year of treatment under a vertically integrated physician more than tripled to 12.59 percent (95% CI: 11.27 to 13.91). This larger marginal effect suggests that coding changes accumulate over time, and that with a longer duration of treatment from a vertically integrated physician, there is more opportunity to identify codable diagnoses and conditions. Model 3 shows even larger effects. Among patients with one year or two years attributed to vertically integrated physicians, scores were 22 percent higher, after accounting for patient fixed effects and covariates. Among patients with three or more years, coded severity was 24 percent larger.

In our second approach, we divided patients into groups by exposure type. Our outcome variable, patient HCC coded severity score, remained the same as in our first approach. For estimation, this approach required us to select a treatment group and a control group. The natural choice for the treatment group was the Integrater group. These were patients who, during the study period, had initially been treated by a non-integrated physician, then became treated by an integrated physician and stayed with an integrated physician from that point forward. We think that this group captures an important subset of patients: those whose physicians sell their practices to hospitals, or those whose physicians leave an independent practice for a hospital-affiliated practice. This subset is relevant with respect to external validity. If we are interested in the effects on patient coded severity that might materialize in the future if a hospital acquires a practice, thereby converting its patients from being treated by non-integrated to integrated physicians, then this group most closely resembles that phenomenon. We constructed our preferred control group using inverse probability weighting. We also modeled this analysis using the “Never” and the “Always” integrated as the control groups (see Appendix 5). Our estimate of the effect of vertical integration came from the interaction of a patient being in the “Integrater” group with each of the post-periods.

Figure 3.3 shows our results. We display the predicted values for the annual change in coded severity, adjusted for patient, area, and physician characteristics; the model also includes dummies for each time period to control for cohort effects (i.e. to control for the possibility that Integraters in 2012 may have had different experiences than Integraters in 2015) and each calendar year to control for secular trends (e.g. the population age and clinical severity rise over time, independent of integration exposure). Because we interact all time periods with all levels of the exposure variable, one of the time periods must be chosen as the baseline, such that the Integrater group and the control group will have the same adjusted value. We set this baseline time period to be the last pre-period (t = -1).

Year 1 is the first year in which a patient receives the plurality of his or her care from an integrated physician. Our attribution approach effectively makes Year 0 a partially treated year. Some patients in the Integrater group began seeing vertically integrated physicians prior to those physicians becoming their main attributed physician (i.e. prior to Year 1). A patient need not even change physicians for this to happen. For example, consider a patient with one outpatient visit per month whose physician joins a hospital system in September of 2012. This patient appears treated by a non-integrated physician for 2012 and treated by an integrated physician in 2013, even though four months of 2012 were under the care of an integrated physician. Period 0, corresponding to 2012, is a partly-treated year. Consistent with this rationale, the effect size in Period 0 is positive but smaller than the effect in Period 1.

One of the key assumptions behind this analysis was that the difference between the Integrater group and the control group would have remained constant from the pre-period through the post-period in the absence of treatment. To justify this assumption, we examined whether the trends in changes in coded severity over the pre-period were parallel. A visual inspection of Figure 3.3 suggested these groups were likely to meet the parallel trends requirement. We tested for leading effects: whether the treatment group differed at each point in the pre-period from the comparison group. We found evidence of very small differences between the groups that did not reach major significance levels (Appendix 4). The pre-period differences in times -4, -3, and -2 were associated with p-values of .04, .03, and .09. By contrast, the effects in the post-period were large and highly significant ($p < .00001$). We argue that, given the statistical power to detect differences in our sample size of over 25 million observations, we would need to observe significance levels of $\alpha < 0.01$ to reject any null hypotheses. Moreover, when using the alternative control group of patients always attributed to integrated physicians, we found evidence of parallel slopes; in that alternative specification, the treatment effects were comparable to those we found with our preferred approach (Appendix 3.6 and Appendix 3.7). We therefore conclude that there is good evidence for our core DD assumption.

In our preferred DD specification (Figure 3.3), we found that the coded severity of the integrated group jumped sharply in the first full year of integration, after which severity increases continued to outpace the comparison group. While the graph for the comparison group trends upward at close to a constant slope from the first pre-period to the last post-period, the graph for the Integrater group changes markedly around the time of integration. In Year 0, coded severity increased by about 5 percent (Figure 3.3; see also Appendix 3.6). In Year 1, the first full year of integration, the effect size was 33 percent. Years 2-5 return to smaller effect sizes of between 20 and 24 percent. The observation-weighted average effect over the entire post-period was 20 percent. These effect sizes cohere with our first approach. There, we found effects ranging from about 12 percent to about 24 percent. Our estimates here land near the upper bound of that range.

In our third approach, we used instrumental variables analysis to identify the effect (Figure 3.4). In our first two approaches, despite our use of patient fixed effects and time-varying covariates, there could be at least some residual selection of patients into integrated practices that we could not control. Our two-stage least squares instrumental variables approach attempted to remove any residual endogeneity between trend in coded severity and integration.

The first-stage results display the estimated coefficient of the instrument (percent of physicians in the CBSA who were vertically integrated) on each patient's current-year attribution to a vertically integrated physician (0.462, 95% CI: 0.458 to 0.465). We rejected the two-sided null hypothesis that the coefficient on our instrument was not different from 0 ($t = 253$, $p < .0001$), indicating that the instrument was highly predictive of attribution to a vertically integrated physician (Figure 3.4 and Appendix 3.10).

We regressed our instrument, exogenous covariates, patient fixed effects, and calendar year on the endogenous variable (current-year attribution to a vertically integrated physician) and generated predicted values of current-year attribution to a vertically integrated physician. We used these predicted values in our second-stage estimation (Figure 3.4). The coefficient (0.122, 95% CI: 0.109 to 0.135) on the predicted value represents the local average treatment effect (LATE). Among the patients who were induced to attribution to an integrated physician by the instrument, i.e., among the compliers, our estimates indicated that a year of integration was associated with an increase in coded severity of 0.122; given an unadjusted sample mean of 1.17, this reflects an increase of 10.4 percent. This IV estimate is in the same direction and about one-half the magnitude of the estimates we generated in our previous approaches.

We tested numerous subsamples, measures, and specifications in our statistical approaches (Appendix 3.3, Appendix 3.4, Appendix 3.5, Appendix 3.6, Appendix 3.7, Appendix 3.8, Appendix 3.9). Our results were qualitatively robust to these sensitivity analyses.

Discussion

In this study, patients' coded severity increased by 38-53 percent from 2010 to 2015. We found that treatment by a vertically integrated physician was associated with at least 10 percent higher coded patient severity after accounting for other patient-level characteristics, with some specifications showing effects of up to 24 percent. .These findings imply that the increasing prevalence of hospital-physician integration could substantially raise patients' reported clinical severity and, correspondingly, raise costs to Medicare.

Researchers have debated whether alternative payment models induce integration. Some have concluded that Medicare's ACO program has little to do with provider consolidation[20]; along similar lines, others found that payment reforms pertaining to drug reimbursement did not contribute to vertical integration among oncologists.[21] By contrast, recent work found an association between integration and participation in alternative payment models such as ACOs and comprehensive primary care.[22] Our research does not address whether alternative payment causes vertical integration. It does suggest that by extending coding-maximization protocols to physician practices, integration may help provider systems reach reimbursement goals within alternative payment models.

Related work on provider organizations and coded patient severity has examined the context of Medicare's Shared Savings Program (MSSP).[11] Researchers found that although participation in these Accountable Care Organizations was not associated with changes in coded severity (plausibly because the program does not upwardly adjust reimbursement with increases in patient risk scores), providers were more likely to drop high-risk patients. Our study adds a new result to the literature: that ownership of physician practices matters for the coding of patient illness. Our results show, through multiple specifications, that hospital ownership of physician practices is strongly related to coded patient severity.

Our study has several limitations. The most plausible alternative explanation for our findings is that patients selected into treatment from an integrated physician in a time-varying way. This is reasonable: as patients become sicker, they may be referred to physicians affiliated with a larger medical system. They may also prefer to receive care from integrated settings. The estimates from the instrumental variables analysis, which attempted to address this time-varying selection, are somewhat smaller than results from the other approaches. This suggests the possibility of bias from time-varying selection in the other approaches. Nonetheless, all specifications suggest that the effects on coded severity are still statistically significant and economically important, representing a double-digit increase in coded severity. A further limitation is that we rely on Medicare's administrative claims data, which creates two issues. First, we cannot infer the effects of integration on coded severity among the commercially-insured population. While we cannot comment on whether these coding increases would appear among commercially-insured patients, we suspect that if hospitals extend their coding resources to acquired practices, they likely do so for all patients treated by the practice, suggesting that higher coded severity and higher costs may rise among other patient populations. Second, we cannot observe actual health conditions in our data. It is possible that some or all of the increases in coded severity reflect true changes in the underlying health status of patients, and that hospital systems have done a better job of identifying these changes. Finally, we make simplifying assumptions in order to attribute patients to physicians, and thereby to attribute patients' exposure to vertical integration. We think, though, that a primary care physician who provides the plurality of a patient's care can be reasonably characterized as that patient's main physician for purposes of exposure to vertically integrated systems. To the extent that patients attributed to integrated physicians may have also been treated by some non-integrated physicians, our results are biased toward the null.

The proliferation of hospital-driven integrated delivery systems will likely contribute to increases in Medicare spending through maximizing the reported illness of patients. Although careful documentation of patient disease burden is essential to providing appropriate care and appropriate reimbursement, incorrect coding occurs frequently. A report by the Department of Health and Human Services's Office of Inspector General found increases in the billing of higher-complexity (higher-reimbursement) evaluation and management (E/M) codes from 2001 to 2010. The OIG discovered that 42 percent of E/M codes were incorrectly coded, and that E/M services billed at inappropriately high levels (i.e. “upcoded” E/M visits) accounted for $4.6 billion in Medicare payments in 2010.[23] Similarly, CMS has identified sizable payments attributable to improper claims, amounting to over $28 billion in 2019.[24] Some doubt that the coding increases reflect actual changes in underlying patient condition. In Massachusetts, for example, the state’s Health Policy Commission found widespread evidence of increased coded severity from 2013-2018. Low-acuity discharges decreased while high-acuity discharges increased. Commercial inpatient spending rose more than 10 percent even though inpatient volume declined by over 12 percent. From 2013 to 2017, patients’ coded severity rose by 11.3 percent, equivalent to “an additional 428,000 commercially insured Massachusetts residents with complex diabetes or 920,000 with cerebral palsy.”[25] The report suggests that coding practices, not patient health, drove heightened patient severity scores. A sizable industry has emerged to support provider systems in their efforts to maximize reimbursement. The American Academy of Professional Coders, for example, offers 28 certifications, including “professional service coding,” “professional billing,” and “clinical documentation.” Hospitals often employ full-time medical coders, and virtually all hospitals use electronic medical records. A wide variety of proprietary medical coding software applications plug into EHRs to allow providers to automatically identify the highest appropriate reimbursement for their services. Given these operational factors, in conjunction with hospital incentives in risk-based contracts, it is not surprising that patients whose physicians join hospital systems exhibit increases in coded severity. These increases most immediately affect payers, including Medicare, Medicaid, and commercial payers, who should work with physicians in their networks, particularly those affiliated with hospitals, to ensure that changes in patient coding reflect medical necessity and appropriateness.

Our findings add important insight into the relationship between provider ownership, reimbursement incentives, and billing behavior. While we anticipate that the higher costs associated with higher coded severity will eventually be passed onto patients, the effects of such coding practices on patient care quality is unclear, which we think is a subject for future research. As integrated delivery systems expand, and with them an increase in coded severity, state and federal policymakers tasked with constraining health care spending may need to rethink the role of provider-reported acuity in the reimbursement paradigm.

Chapter 3 References

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Chapter 3 Exhibits

Table 3.1. Sample Characteristics

	Characteristics	No Integrated Years	At Least 1 Integrated Year
Patient Characteristics			
	Number of Patients	4,383,071	1,596,791
	Number of Patient-Years	18,667,858	6,599,115
	Age	72.6	71.5
	Female (%)	59	59
	White	86	84
	Black	9	10
	Hispanic	2	2
	Other	4	4
	Years in Sample from 2010-2016	4.8	4.7
	Years with Vertically Integrated Physician	0	2.6
	Count of conditions	1.96	2.48
	Severity Score	1.11	1.35
	Average Change in Severity 2010-2015	0.38	0.53
	Average Annual Change in Severity	0.1	0.15
Area Characteristics			
	Poverty	13.6	14.6
	High School	86.7	86.6
	College	28.9	26.6
	HHI Hospital (HRR)	1923	2100
	HHI Specialty (HRR)	162	188
	Medicare Advantage (%)	24.8	24.1
Primary Care Physician Characteristics			
	Physician Age	53.4	50.9
	Physician Female (%)	24	28
	Rural (%)	23	33
	Size of Practice (median number of providers)	6	48

Figure 3.1. Changes in Patient Coded Severity Over Study Period by Patient Exposure to Integration

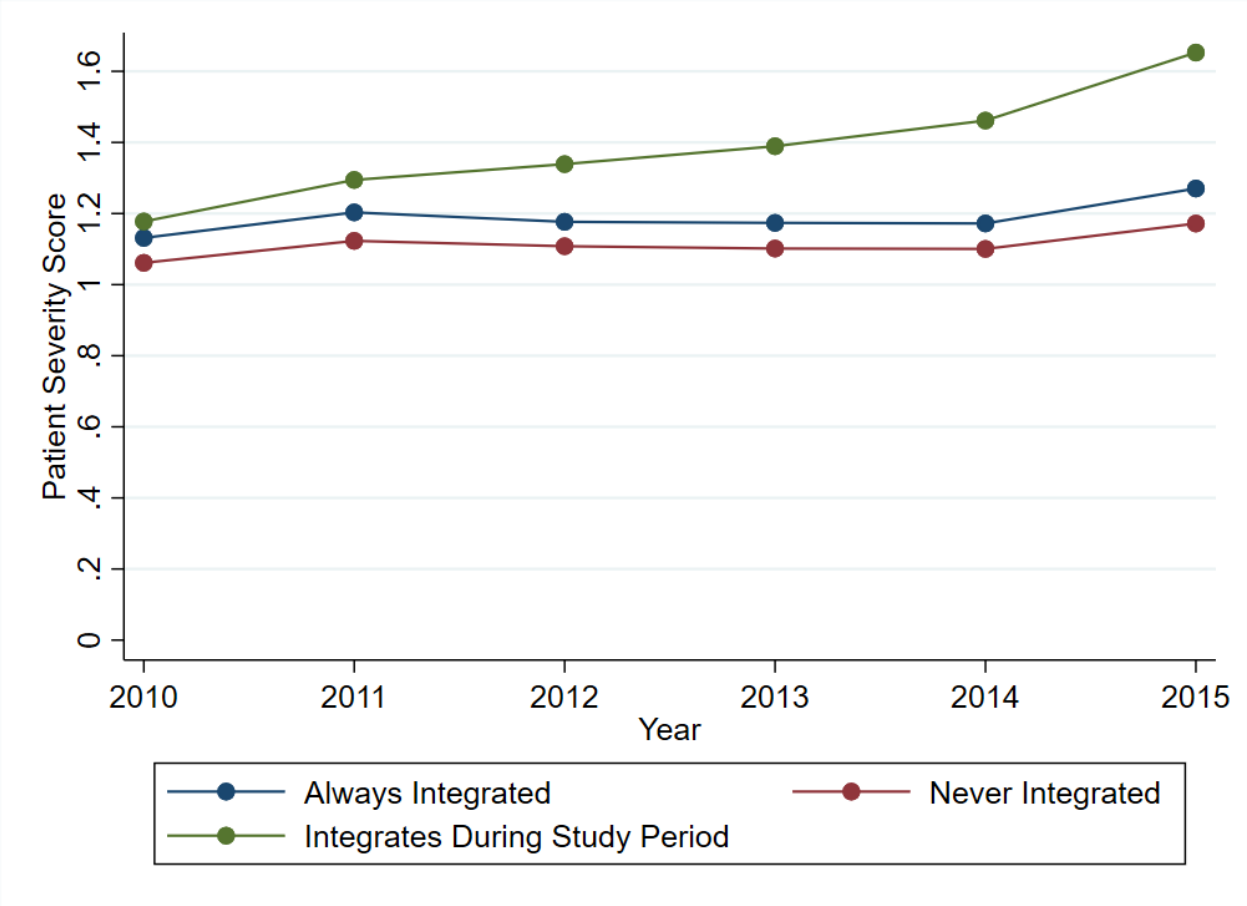
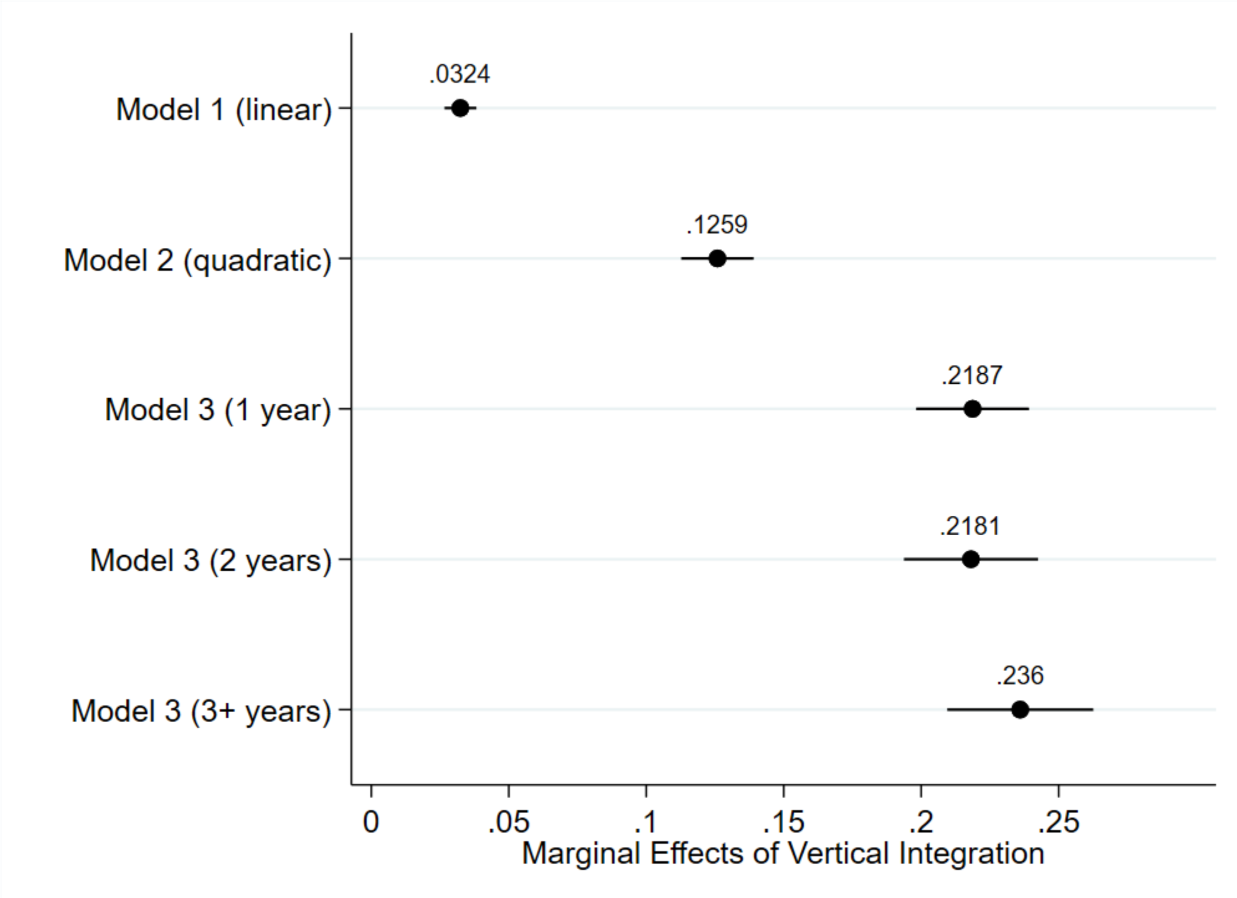


Figure 3.2. Average Marginal Effects on Coded Patient Severity of Treatment from a Vertically Integrated Physician, with 95% Confidence Intervals, by Model Specification



Notes: All models adjusted for covariates, calendar year, and patient fixed effects. The independent variable in Model 1 is the cumulative number of years with a vertically integrated physician (VI). Model 2 adds a term for VI^2. Model 3 uses three dummy variables.

Figure 3.3. Patient Coded Severity Before and After Exposure to Vertically Integrated Physician

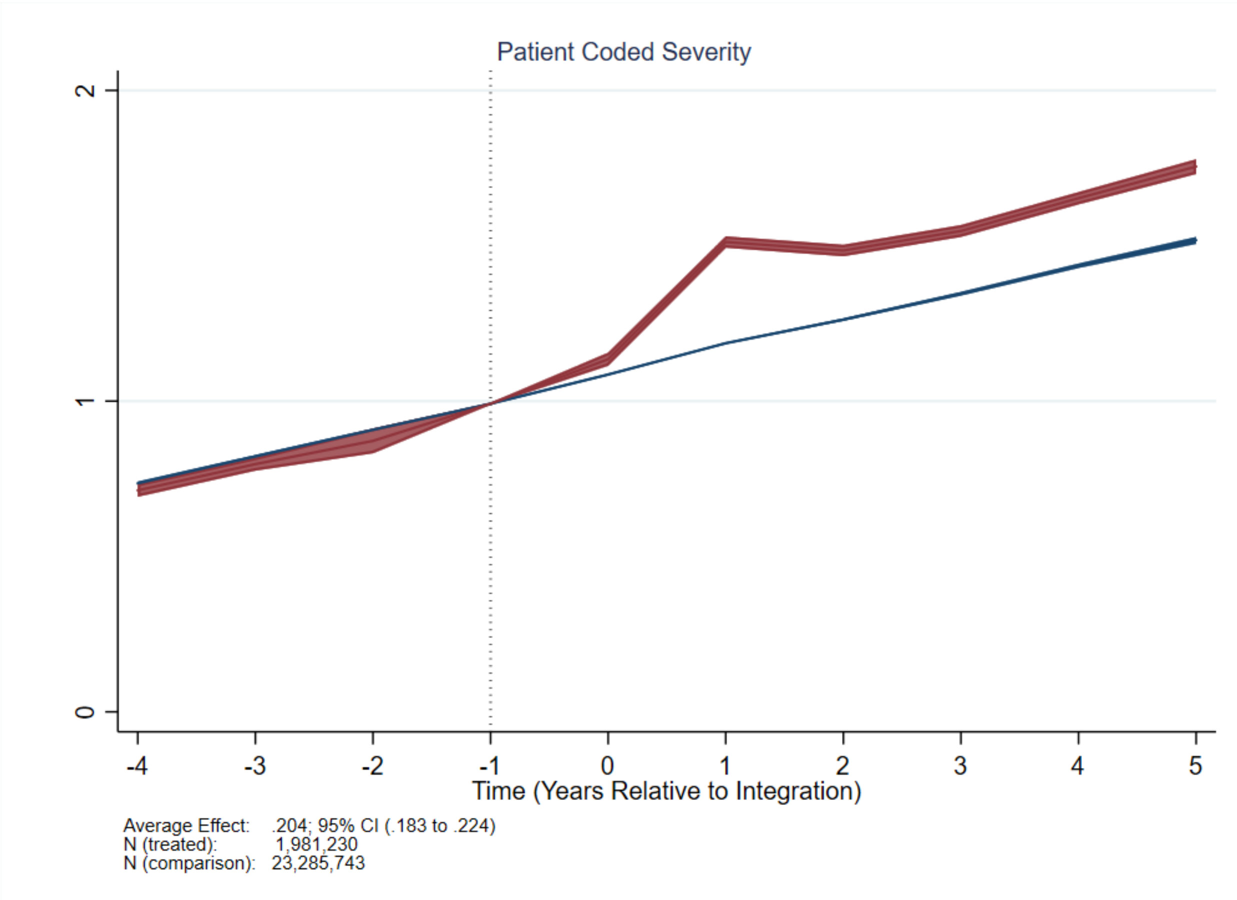
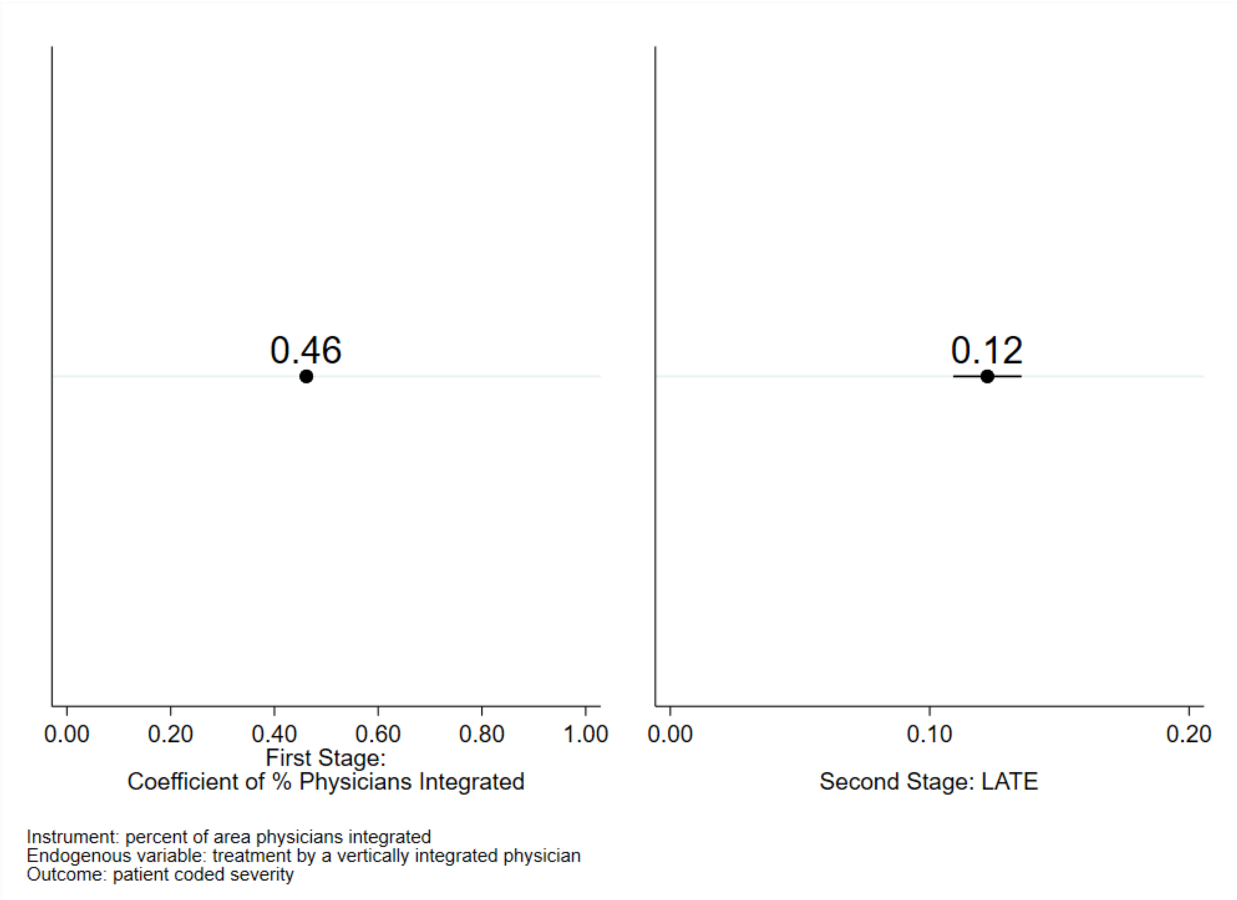


Figure 3.4. Instrumental Variables Estimates of Effect of Vertical Integration on Coded Severity



Chapter 3 Appendix

Appendix 3.1. Sample Flow Diagram

Inclusion Criterion	Remaining Sample Size
Patient-Years 2010-2015	33,947,163
No Medicare Advantage	32,280,538
Part A and Part B	30,723,879
Alive During 2010-2015	30,723,756
Have HCC Score	30,640,142
Have Covariates	28,351,264
Have Primary Care Physician	28,351,264
Physician Variables Present	26,890,971
At least two years of enrollment	25,266,972
Final sample size	25,266,972

Appendix 3.2. Measuring Vertical Integration

We defined integration using a strategy developed by Neprash and colleagues. They utilize the place of service codes found in Medicare claims. During our study period, when a hospital acquired a physician, the physician became eligible to bill under the Hospital Outpatient Department (HOPD) place of service code. The incentives to make this billing change were strong, since reimbursement under an HOPD designation was often higher than under an office designation. We created an indicator for each physician in each year to indicate integration status by counting the number of line items billed in the Medicare Carrier (physician/supplier) claims under an office code and under an HOPD code. When 75 percent or more of these line items were billed under an HOPD code, we classified the physician as integrated. In addition to the Carrier claims, Neprash and colleagues also used the Outpatient claims to reclassify some Carrier claims that were likely miscategorized as having taken place in the office setting. We do not take this additional step because the number of reclassified claims was small (2-3%). Their eMethods (2015) contains a clear explanation of the details in their approach. In addition, we use MD-PPAS data to supplement the claims-based approach. If a physician's tax identifier legal name contains the keywords "medical center," "hospital," "system," "health science center," "health sciences center," or "med ctr," we identify them as integrated.

Appendix 3.3. Marginal effects of vertical integration

Sample: 2 or more years (preferred)	Marginal Effect	95% CI Lower Limit	95% CI Upper Limit	P Value
VI Years Cumulative (VI)	0.0427	0.0419	0.0435	<.0001
VI Squared	0.1538	0.1520	0.1556	<.0001
1 year	0.2743	0.2714	0.2771	<.0001
2 years	0.2813	0.2780	0.2847	<.0001
3 or more years	0.2916	0.2879	0.2952	<.0001
Restricted Sample: 6 years	Marginal Effect	95% CI Lower Limit	95% CI Upper Limit	P Value
VI Years Cumulative (VI)	0.0239	0.0230	0.0249	<.0001
VI Squared	0.1062	0.1038	0.1086	<.0001
1 year	0.2278	0.2237	0.2319	<.0001
2 years	0.199	0.1942	0.2037	<.0001
3 or more years	0.2162	0.2113	0.2210	<.0001

Notes: All models adjusted for covariates, calendar year, and patient fixed effects. Restricted sample includes one observation per patient per year (fully balanced). The results presented in the manuscript are from the sample requiring 2 or more years.

Appendix 3.4. Regression specifications for DD analysis with and without IPW

VARIABLES	(1) DD IPW [Preferred]	(2) DD no IPW
Patient Coded Severity (outcome)		
Treated group	-	-
Time = -4	-0.256***	-0.260***
	(0)	(0)
Time = -3	-0.170***	-0.173***
	(0)	(0)
Time = -2	-0.0841***	-0.0870***
	(0)	(0)
Time = -1 (base)		
Time = 0	0.0939***	0.0919***
	(0)	(0)
Time = 1	0.195***	0.197***
	(0)	(0)
Time = 2	0.271***	0.272***
	(0)	(0)
Time = 3	0.354***	0.356***
	(0)	(0)
Time = 4	0.444***	0.444***
	(0)	(0)

Time = 5	0.526***	0.530***
	(0)	(0)
Leading Effects		
Treated group # time -4	-0.0225**	-0.0166***
	(0.0432)	(4.08e-06)
Treated group # time -3	-0.0247**	-0.0174***
	(0.0313)	(3.13e-10)
Treated group # time -2	-0.0356*	-0.0155***
	(0.0953)	(0)
Treated group # time -1	0	0
Lagged Effects		
Treated group # time 0	0.0494***	0.0562***
	(2.10e-05)	(0)
Treated group # time 1	0.326***	0.332***
	(0)	(0)
Treated group # time 2	0.222***	0.228***
	(0)	(0)
Treated group # time 3	0.202***	0.212***
	(0)	(0)
Treated group # time 4	0.217***	0.227***
	(0)	(0)
Treated group # time 5	0.237***	0.241***
	(0)	(0)
Medicare Advantage penetration	0.000576***	0.000686***
	(0.000636)	(0)

High School	0.000808**	0.000708***
	(0.0302)	(1.68e-09)
College	-0.000116	0.000144**
	(0.563)	(0.0367)
Poverty	-0.000427*	-0.000337***
	(0.0867)	(0.000115)
HHI Hospital (ln)	-0.0181***	-0.0199***
	(0)	(0)
HHI PCP (ln)	0.00855***	0.00987***
	(0)	(0)
Size of Practice	-4.02e-05***	-5.17e-05***
	(6.45e-08)	(0)
Physician Age	-0.00330***	-0.00386***
	(0)	(0)
Physician Female	-0.0351***	-0.0368***
	(0)	(0)
Rural	-0.0664***	-0.0677***
	(0)	(0)
2011.year	0.00189**	0.00212***
	(0.0188)	(1.91e-05)
2012.year	-0.0115***	-0.0117***
	(0)	(0)
2013.year	-0.0189***	-0.0203***
	(0)	(0)
2014.year	-0.0274***	-0.0320***
	(0)	(0)
2015.year (omitted)	-	-

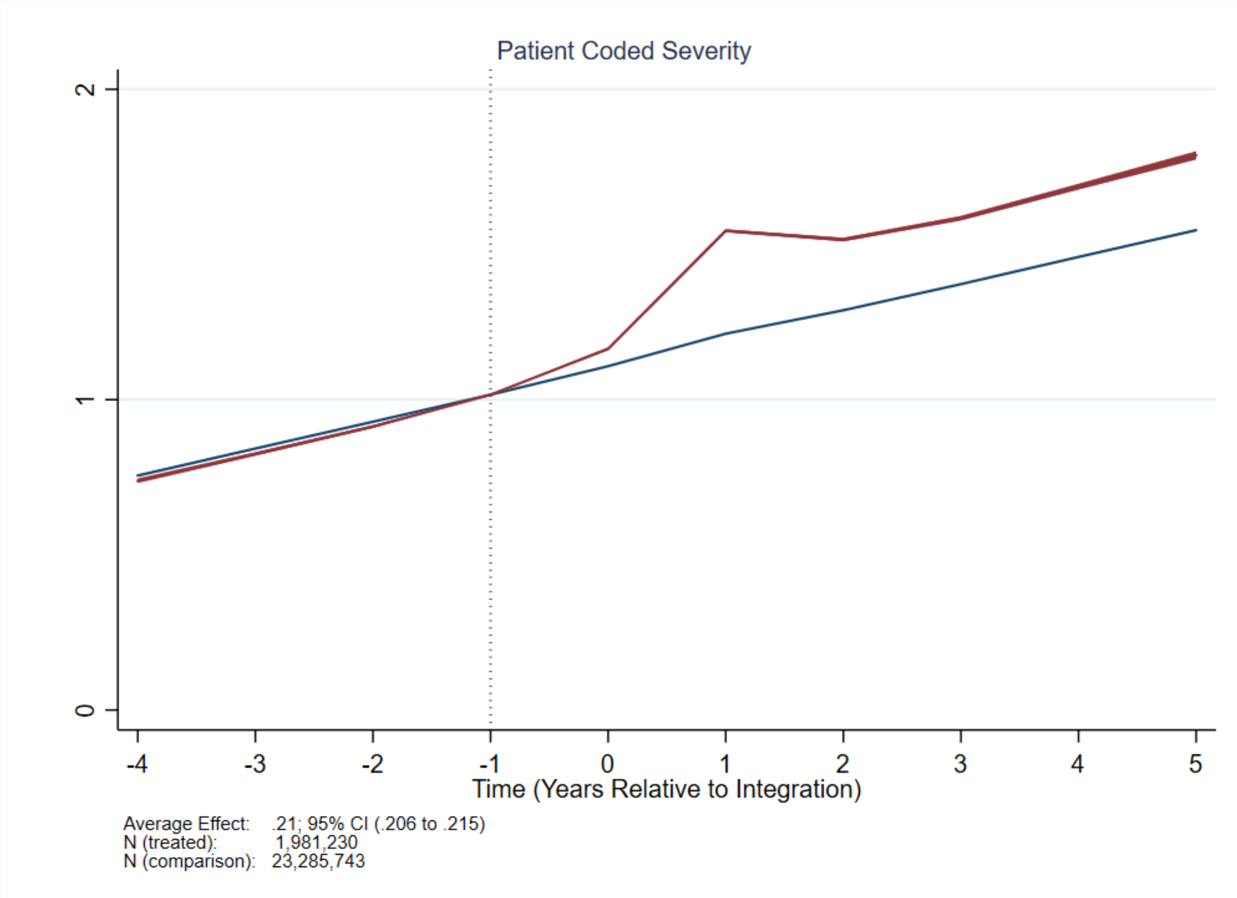
Constant	1.244***	1.287***
	(0)	(0)
Observations	25,240,600	25,240,600
R-squared	0.716	0.706

Notes: DD – difference in differences; IPW – inverse probability weighting; PCP – primary care physician.

Coefficient estimates shown with p-values in parentheses below. Leading effects show the difference between the treatment and comparison groups in the pre-period for each time period; lagged effects show these differences in the post-period.

Model (1) gives the preferred specification, results from which appear in the manuscript. Model (1), using IPW, shows pre-period differences between treatment and control groups that are less statistically significant (no leading effects reach significance levels of .01), indicative of trends that are more parallel. Model (2), not using IPW, shows more significant differences in the pre-period (all leading effects from Model (2) are significant at $p < .001$).

Appendix 3.5. Patient Coded Severity Before and After Integration without IPW



Notes: IPW – inverse probability weighting

This specification does not use IPW; aside from that, the specification is the same as that shown in Figure 3.3 of the manuscript. The effects estimated here (average effect = 0.21) are similar in magnitude to those from Figure 3.3 (average effect = 0.204).

Appendix 3.6. Regression specifications for DD analysis with alternative comparison groups and sample inclusion criteria

VARIABLES	(1) DD IPW [Preferred]	(2) DD with Always	(3) DD with Never	(4) DD using 6 year sample
Patient Coded Severity (outcome)				
Treated group	-	-	-	-
Time = -4	-0.256***	-0.320***	-0.262***	
	(0)	(0)	(0)	
Time = -3	-0.170***	-0.210***	-0.174***	-0.168***
	(0)	(0)	(0)	(0)
Time = -2	-0.0841***	-0.107***	-0.0863***	-0.0839***
	(0)	(0)	(0)	(0)
Time = -1 (base)				
Time = 0	0.0939***	0.0999***	0.0851***	0.0814***
	(0)	(0)	(0)	(0)
Time = 1	0.195***	0.202***	0.171***	0.162***
	(0)	(0)	(0)	(0)
Time = 2	0.271***	0.303***	0.256***	0.247***
	(0)	(0)	(0)	(0)
Time = 3	0.354***	0.403***	0.341***	0.327***
	(0)	(0)	(0)	(0)

Time = 4	0.444***	0.497***	0.425***	0.408***
	(0)	(0)	(0)	(0)
Time = 5	0.526***	0.586***	0.506***	0.493***
	(0)	(0)	(0)	(0)
Leading Effects				
Treated group # time -4	-0.0225**	0.0109**	-0.0135***	
	(0.0432)	(0.0488)	(0.000203)	
Treated group # time -3	-0.0247**	-0.000219	-0.0171***	-0.0792***
	(0.0313)	(0.957)	(8.74e-10)	(0)
Treated group # time -2	-0.0356*	-0.00422	-0.0168***	-0.0377***
	(0.0953)	(0.191)	(0)	(0)
Treated group # time -1	0	0	0	0
Lagged Effects				
Treated group # time 0	0.0494***	0.0548***	0.0638***	0.0642***
	(2.10e-05)	(0)	(0)	(0)
Treated group # time 1	0.326***	0.323***	0.364***	0.236***
	(0)	(0)	(0)	(0)
Treated group # time 2	0.222***	0.204***	0.249***	0.185***
	(0)	(0)	(0)	(0)
Treated group # time 3	0.202***	0.178***	0.234***	0.193***
	(0)	(0)	(0)	(0)
Treated group # time 4	0.217***	0.188***	0.251***	0.215***
	(0)	(0)	(0)	(0)
Treated group # time 5	0.237***	0.185***	0.271***	0.233***
	(0)	(0)	(0)	(0)

Medicare Advantage penetration	0.000576***	-0.000444**	0.000601***	0.000603***
	(0.000636)	(0.0162)	(0)	(7.83e-07)
High School	0.000808**	0.000717**	0.000642***	0.000606***
	(0.0302)	(0.0292)	(4.16e-07)	(0.00228)
College	-0.000116	9.99e-05	0.000208***	0.000130
	(0.563)	(0.610)	(0.00539)	(0.309)
Poverty	-0.000427*	-2.37e-05	-0.000186*	-0.000271*
	(0.0867)	(0.919)	(0.0508)	(0.0634)
HHI Hospital (ln)	-0.0181***	-0.0461***	-0.0166***	-0.0157***
	(0)	(0)	(0)	(0)
HHI PCP (ln)	0.00855***	0.0224***	0.00681***	0.00573***
	(0)	(0)	(0)	(0)
Size of Practice	-4.02e-05***	-7.19e-05***	-6.35e-05***	-5.84e-05***
	(6.45e-08)	(0)	(0)	(0)
Physician Age	-0.00330***	-0.00642***	-0.00285***	-0.00195***
	(0)	(0)	(0)	(0)
Physician Female	-0.0351***	-0.0431***	-0.0326***	-0.0249***
	(0)	(0)	(0)	(0)
Rural	-0.0664***	-0.113***	-0.0598***	-0.0461***
	(0)	(0)	(0)	(0)
2011.year	0.00189**	-0.0138***	0.00389***	
	(0.0188)	(0)	(0)	
2012.year	-0.0115***	-0.0378***	-0.00960***	-0.0340***
	(0)	(0)	(0)	(0)
2013.year	-0.0189***	-0.0516***	-0.0201***	-0.0519***
	(0)	(0)	(0)	(0)
2014.year	-0.0274***	-0.0662***	-0.0329***	-0.0596***

	(0)	(0)	(0)	(0)
2015.year (omitted)	-	-	-	-
Constant	1.244***	1.709***	1.200***	1.125***
	(0)	(0)	(0)	(0)
Observations	25,240,600	3,805,696	20,629,555	8,024,805
R-squared	0.716	0.711	0.705	0.682

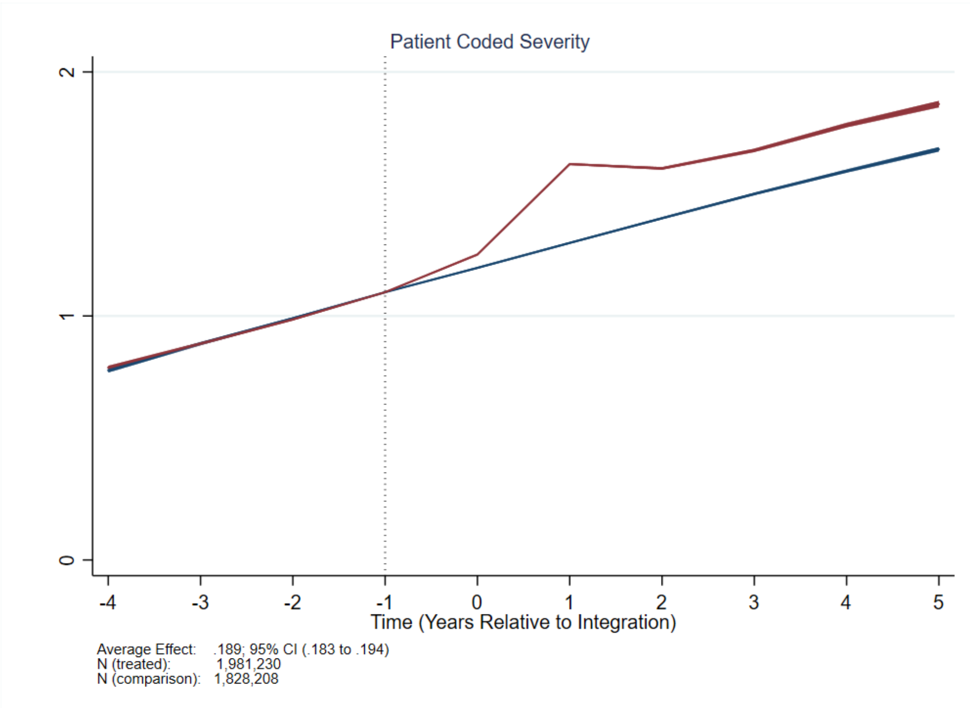
Notes: DD – difference in differences; IPW – inverse probability weighting; PCP – primary care physician.

Coefficient estimates shown with p-values in parentheses below. Leading effects show the difference between the treatment and comparison groups in the pre-period for each time period; lagged effects show these differences in the post-period.

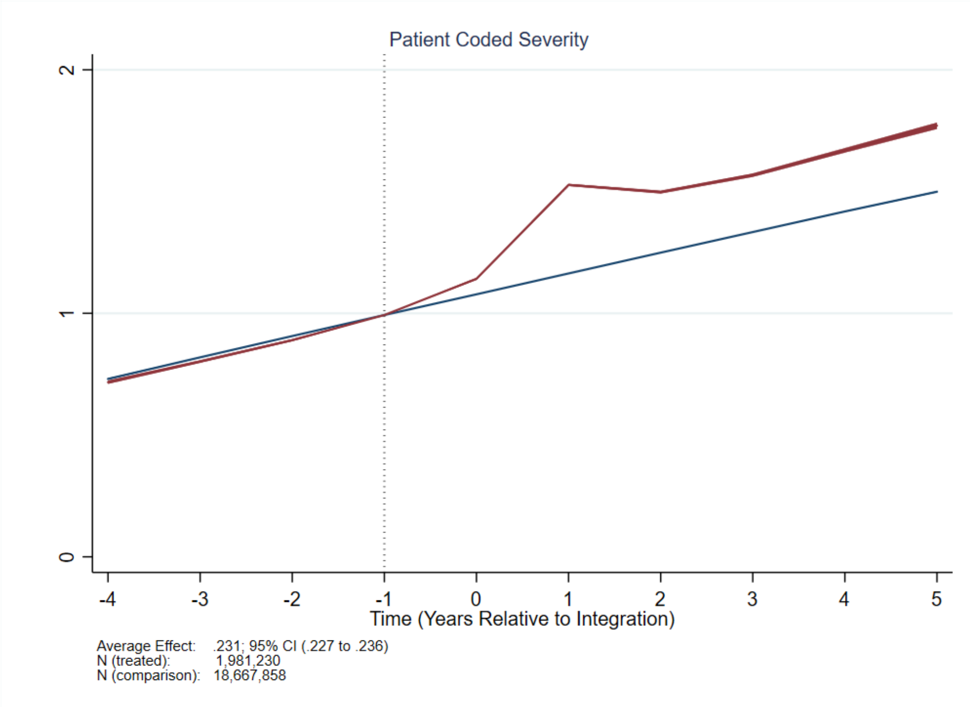
Model (1) gives the preferred specification, results from which appear in the manuscript. Model (2) uses the comparison group of patients who were always treated by an integrated physician rather than a comparison group selected through IPW. Model (3) uses the comparison group of patients who were never treated by an integrated physician. Model (4) replicates Model (3) using a subsample – to be included in Model (4), patients were required to appear in the data for all six years of observation, i.e., we enforced a continuous enrollment criterion. While the lagged effects of Model (4) are surprisingly similar to our preferred specification, Model (4)'s leading effect strongly suggest a violation of the parallel trends assumption (see also Panel 3 of Appendix 3.7).

Appendix 3.7. Patient Coded Severity Before and After Integration with alternative comparison groups and sample inclusion criteria

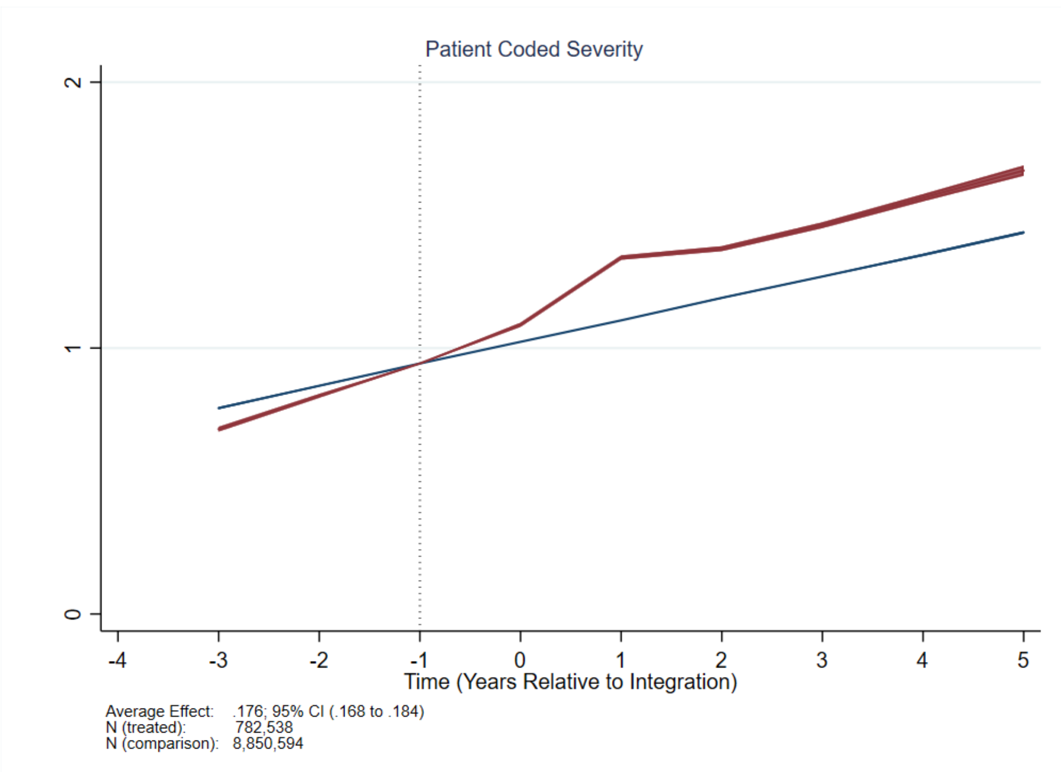
Panel 1. Comparison group: Always treated by vertically integrated physician (Model (2))



Panel 2. Comparison group: Never treated by vertically integrated physician (Model (3))



Panel 3. Continuously enrolled patients (strongly balanced panel) (Model (4))



Appendix 3.8. Regression specifications for DD analysis among single-doctor patients

VARIABLES	(1) DD IPW	(2) Single-doctor IPW	(3) Single-doctor with Never	(4) Single-doctor with Always
Patient Coded Severity (outcome)				
Treated group	-	-	-	-
Time = -4	-0.256***	-0.229***	-0.235***	-0.244***
	(0)	(0)	(0)	(0)
Time = -3	-0.170***	-0.154***	-0.159***	-0.161***
	(0)	(0)	(0)	(0)
Time = -2	-0.0841***	-0.0716***	-0.0784***	-0.0785***
	(0)	(0)	(0)	(0)
Time = -1 (base)				
Time = 0	0.0939***	0.0752***	0.0764***	0.0805***
	(0)	(0)	(0)	(0)
Time = 1	0.195***	0.152***	0.154***	0.161***
	(0)	(0)	(0)	(0)
Time = 2	0.271***	0.230***	0.234***	0.240***
	(0)	(0)	(0)	(0)
Time = 3	0.354***	0.308***	0.312***	0.319***
	(0)	(0)	(0)	(0)
Time = 4	0.444***	0.390***	0.391***	0.397***

	(0)	(0)	(0)	(0)
Time = 5	0.526***	0.467***	0.470***	0.473***
	(0)	(0)	(0)	(0)
Leading Effects				
Treated group # time -4	-0.0225**	0.0810***	0.0787***	0.0791***
	(0.0432)	(0)	(0)	(0)
Treated group # time -3	-0.0247**	0.0425***	0.0396***	0.0369***
	(0.0313)	(8.85e-10)	(0)	(1.20e-08)
Treated group # time -2	-0.0356*	0.0144	0.0124***	0.0107**
	(0.0953)	(0.172)	(0.00288)	(0.0338)
Treated group # time -1	0	0	0	0
Lagged Effects				
Treated group # time 0	0.0494***	-0.00218	-0.00519	-0.00716
	(2.10e-05)	(0.702)	(0.151)	(0.100)
Treated group # time 1	0.326***	0.0225***	0.0180***	0.0158***
	(0)	(0.000821)	(5.93e-06)	(0.00106)
Treated group # time 2	0.222***	0.0311***	0.0237***	0.0239***
	(0)	(3.22e-05)	(6.41e-07)	(2.57e-05)
Treated group # time 3	0.202***	0.0224***	0.0175***	0.0187***
	(0)	(0.00858)	(0.00221)	(0.00547)
Treated group # time 4	0.217***	0.0282***	0.0203***	0.0235***
	(0)	(0.00793)	(0.00585)	(0.00546)
Treated group # time 5	0.237***	0.0235	0.0136	0.0173
	(0)	(0.104)	(0.183)	(0.131)

Medicare Advantage penetration	0.000576***	0.000801**	0.000565***	-0.000239
	(0.000636)	(0.0359)	(5.34e-07)	(0.425)
High School	0.000808**	0.000444	0.000679***	0.000176
	(0.0302)	(0.588)	(0.000101)	(0.717)
College	-0.000116	-0.000559	0.000127	0.000164
	(0.563)	(0.439)	(0.268)	(0.611)
Poverty	-0.000427*	-0.000476	-0.000180	-0.000152
	(0.0867)	(0.341)	(0.160)	(0.643)
HHI Hospital (ln)	-0.0181***	-0.00337	-0.00101	0.00892
	(0)	(0.497)	(0.667)	(0.106)
HHI PCP (ln)	0.00855***	0.00283	0.000627	-7.49e-05
	(0)	(0.334)	(0.506)	(0.978)
Size of Practice	-4.02e-05***	-3.93e-05*	-2.34e-05***	-3.24e-05***
	(6.45e-08)	(0.0722)	(0)	(8.97e-07)
Physician Age	-0.00330***			
	(0)			
Physician Female	-0.0351***			
	(0)			
Rural	-0.0664***	-0.0126***	-0.00990**	0.00454
	(0)	(0.00665)	(0.0188)	(0.584)
2011.year	0.00189**	0.00885***	0.00782***	0.00273
	(0.0188)	(1.86e-10)	(0)	(0.162)
2012.year	-0.0115***	0.00341	-0.00217***	-0.00847***
	(0)	(0.290)	(0.00446)	(6.39e-05)
2013.year	-0.0189***	-0.00812**	-0.0127***	-0.0175***
	(0)	(0.0361)	(0)	(0)
2014.year	-0.0274***	-0.0173***	-0.0259***	-0.0349***

	(0)	(0.00313)	(0)	(0)
2015.year (omitted)	-	-	-	-
Constant	1.244***	0.934***	0.896***	0.869***
	(0)	(0)	(0)	(0)
Observations	25,240,600	11,354,418	10,230,966	1,263,278
R-squared	0.716	0.725	0.720	0.732

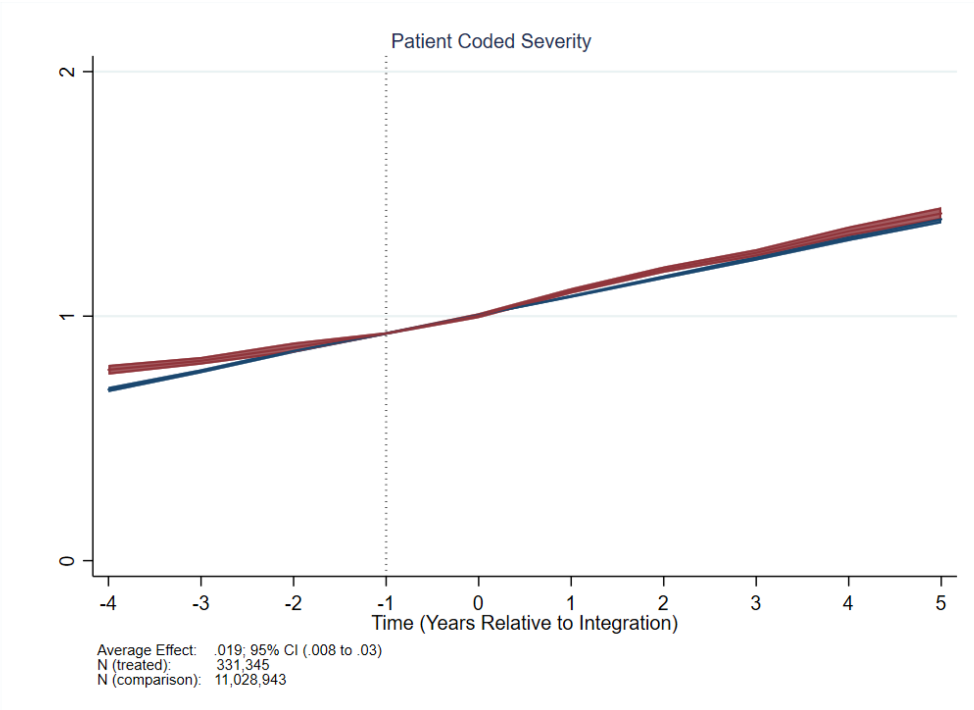
Notes: DD – difference in differences; IPW – inverse probability weighting; PCP – primary care physician.

Coefficient estimates shown with p-values in parentheses below. Leading effects show the difference between the treatment and comparison groups in the pre-period for each time period; lagged effects show these differences in the post-period.

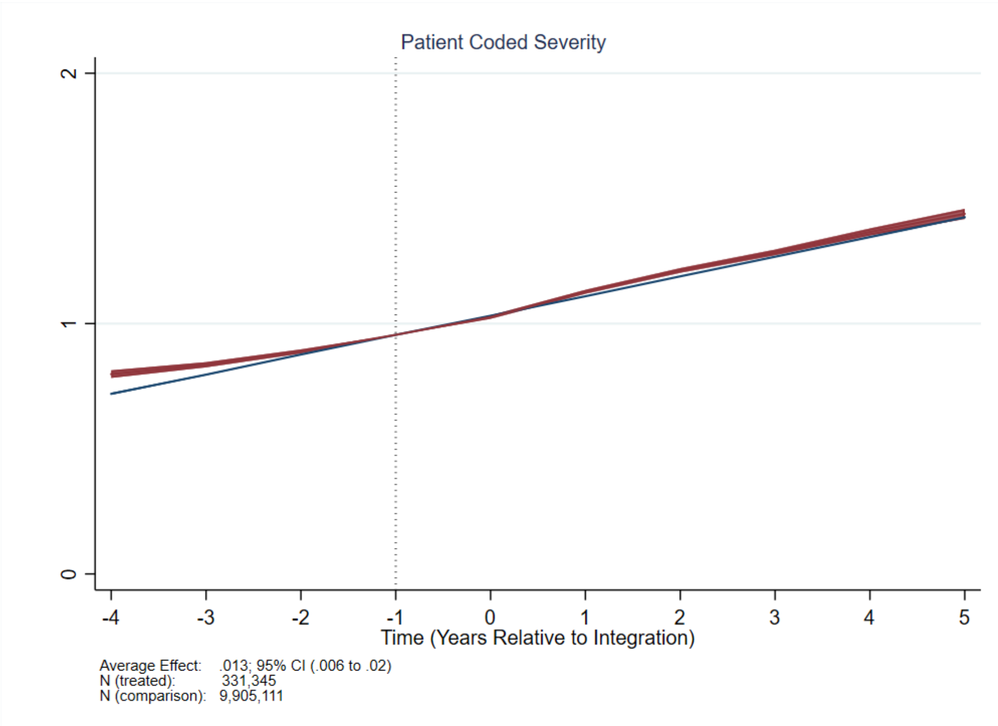
Model (1) gives the preferred specification, results from which appear in the manuscript. Model (2) replicates Model (1) using the subsample of patients whose attributed physician is the same for all periods in which the patient appears in the data. Approximately 44 percent of patients in our sample match this description. Model (3) replicates Model (2) using the comparison group of patients who were never treated by an integrated physician. Model (4) replicates Model (2) using the comparison group of patients who were always treated by an integrated physician.

Appendix 3.9. Patient Coded Severity Before and After Integration Among Single-Physician Patients

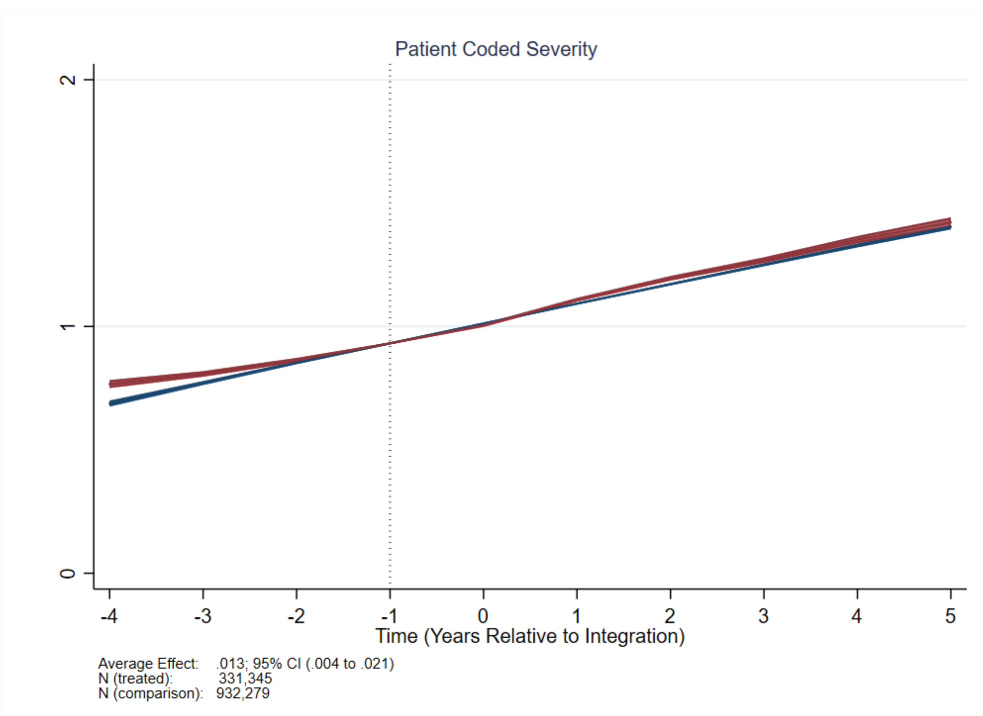
Panel 1. Single-Physician Patients using IPW to select comparison group (Model (2))



Panel 2. Comparison group: Never attributed to vertically integrated physician (Model (3))



Panel 3. Comparison group: Always attributed to vertically integrated physician (Model (4))



Appendix 3.10. Instrumental Variables Estimation

	(1)	(2)
VARIABLES	First Stage	Second Stage
Patient Coded Severity (outcome)		
VI_hat (predicted value of endogenous variable)		0.122***
		(0)
		0.109 - 0.135
VI (endogenous)		
	-	
VI in CBSA (instrument)	0.462***	
	(0)	
	0.458 - 0.465	
Medicare Advantage penetration	-3.89e-05	0.000798***
	(0.150)	(0)
	-9.19e-05 - 1.41e-05	0.000667 - 0.000929
High School	-5.30e-05	0.000770***
	(0.209)	(6.30e-11)
	-0.000136 - 2.97e-05	0.000539 - 0.00100
College	-0.000179***	0.000117*
	(0)	(0.0908)
	-0.000230 - -0.000128	-1.86e-05 - 0.000253

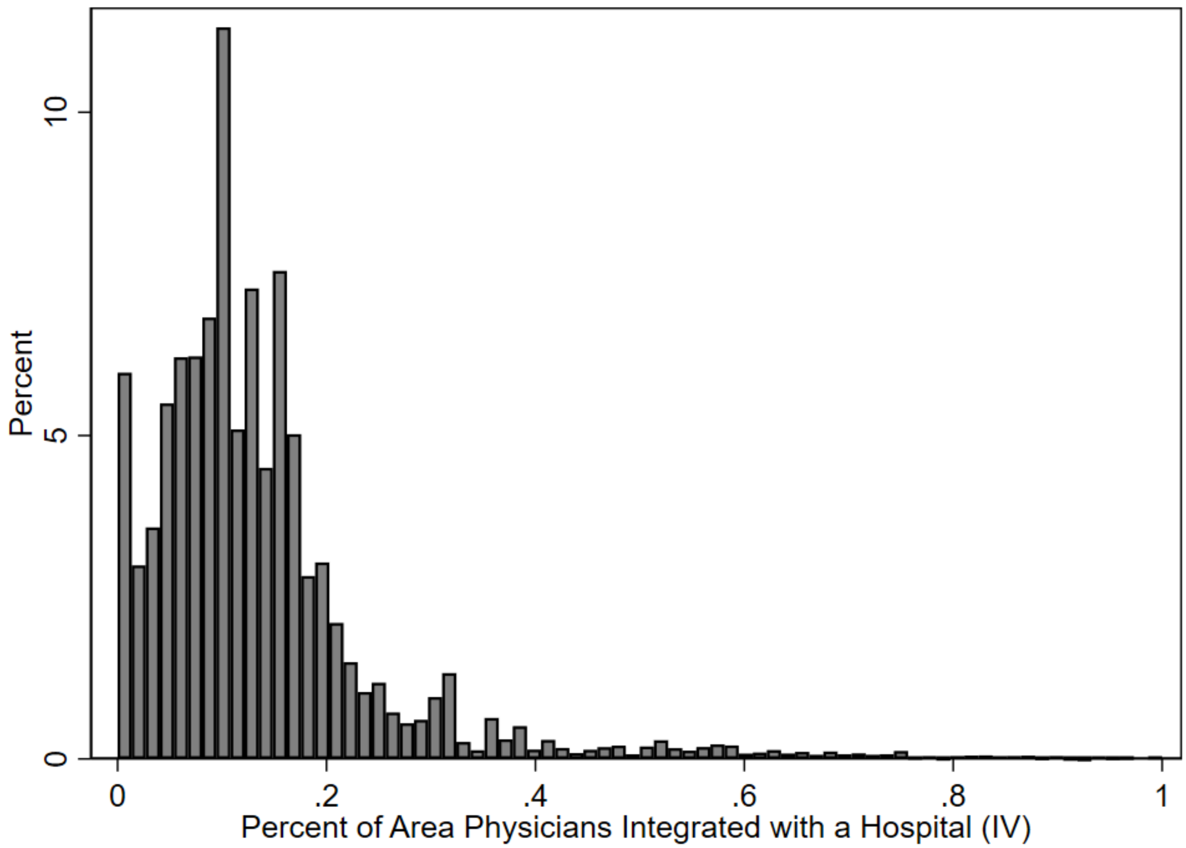
Poverty	-2.57e-05	-0.000401***
	(0.421)	(4.51e-06)
	-8.82e-05 - 3.69e-05	-0.000573 - -0.000230
HHI Hospital (ln)	0.00530***	-0.0200***
	(0)	(0)
	0.00431 - 0.00628	-0.0220 - -0.0180
HHI PCP (ln)	0.00396***	0.0105***
	(0)	(0)
	0.00357 - 0.00435	0.00964 - 0.0113
Size of Practice	0.000200***	-4.84e-05***
	(0)	(0)
	0.000198 - 0.000202	-5.25e-05 - -4.42e-05
Physician Age	-0.00400***	-0.00400***
	(0)	(0)
	-0.00403 - -0.00397	-0.00409 - -0.00391
Physician Female	0.00119***	-0.0375***
	(0.00341)	(0)
	0.000395 - 0.00199	-0.0392 - -0.0358
Rural	0.0393***	-0.0699***
	(0)	(0)
	0.0374 - 0.0411	-0.0733 - -0.0665
year = 2011	0.0228***	0.0992***
	(0)	(0)
	0.0225 - 0.0231	0.0982 - 0.100
year = 2012	0.0276***	0.177***
	(0)	(0)
	0.0272 - 0.0280	0.176 - 0.178
year = 2013	0.0337***	0.260***

	(0)	(0)
	0.0332 - 0.0341	0.259 - 0.262
year = 2014	0.0352***	0.342***
	(0)	(0)
	0.0347 - 0.0357	0.340 - 0.343
year = 2015	0.0400***	0.466***
	(0)	(0)
	0.0394 - 0.0406	0.464 - 0.468
		-
Constant	0.190***	1.191***
	(0)	(0)
	0.181 - 0.200	1.167 - 1.216
Observations	25,240,211	25,240,211
R-squared	0.726	0.705

Notes: CBSA – Core-Based Statistical Area, HHI – Herfindahl Hirschman Index, PCP – primary care physician, VI – patient attribution to vertically integration physician in that year

Coefficient estimates shown with p-values and 95% confidence intervals below. In the first stage, the dependent variable is VI and the regressor of interest is VI in CBSA. In the second stage, the dependent variable is patient coded severity and the regressor of interest is the predicted values of VI from the first stage. The estimated effect of vertical integration on coded severity is given by the coefficient on VI_hat (0.122) divided by the sample mean of coded severity (1.17), or 10.43.

Appendix 3.11. Histogram of Instrumental Variable



Note: IV – instrumental variable

Appendix 3.12. Patient Characteristics over the Distribution of the Instrumental Variable

Variable	25th percentile of IV	50th percentile of IV	75th percentile of IV
Age	71.9	72.5	72.2
Female	58.9	59.2	58.3
Poverty	16.1	12.1	14.7
High School	86.4	88	85.3
College	24.3	29.7	22.6

Appendix 3.13. Predicted HCC Score by Time and Treated Status of Preferred DD Specification

	(1)
VARIABLES	Predicted margins
Comparison at time -4	0.733***
	(0.727 - 0.739)
Comparison at time -3	0.821***
	(0.816 - 0.826)
Comparison at time -2	0.905***
	(0.901 - 0.909)
Comparison at time -1	0.992***
	(0.989 - 0.995)
Comparison at time 0	1.085***
	(1.082 - 1.087)
Comparison at time 1	1.188***
	(1.185 - 1.191)
Comparison at time 2	1.261***
	(1.257 - 1.266)
Comparison at time 3	1.350***
	(1.344 - 1.356)
Comparison at time 4	1.433***
	(1.425 - 1.440)
Comparison at time 5	1.512***
	(1.503 - 1.521)
Treated at time -4	0.712***
	(0.691 - 0.733)
Treated at time -3	0.797***
	(0.776 - 0.818)

Treated at time -2	0.872***
	(0.832 - 0.912)
Treated at time -1	0.992***
	(0.989 - 0.995)
Treated at time 0	1.135***
	(1.114 - 1.157)
Treated at time 1	1.512***
	(1.494 - 1.531)
Treated at time 2	1.485***
	(1.467 - 1.504)
Treated at time 3	1.548***
	(1.529 - 1.567)
Treated at time 4	1.653***
	(1.634 - 1.673)
Treated at time 5	1.754***
	(1.731 - 1.778)
Observations	25,240,599

Chapter 3 Appendix References

Neprash HT, Chernew ME, Hicks AL, Gibson T, McWilliams JM. Association of Financial Integration Between Physicians and Hospitals With Commercial Health Care Prices. *JAMA Intern Med*. 2015;175(12):1-8. doi:10.1001/jamainternmed.2015.4610