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RESEARCH ARTICLE

Physician Market Structure, Patient Outcomes, and Spending: An Examination of Medicare Beneficiaries

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Objective. To understand the impact of changes in physician market structure on clinical outcomes and health care utilization.

Data Sources. 2005–2012 Medicare fee-for-service claims and enrollment data.

Study Design. We consider the effect of cardiology market structure on utilization and health outcomes for four patient populations. We estimate the risk-adjusted impact of competition using multivariate regression models.

Principal Findings. The study finds that an increase in consolidation leads to statistically and economically significant increases in negative health outcomes. For example, we find that moving from a zip code at the 25th percentile of cardiology market concentration to one at the 75th percentile would be associated with 5 to 7 percent increases in risk-adjusted mortality for three of the sample populations. We also found higher expenditures in more concentrated markets. For example, moving from a zip code at the 25th percentile of cardiology market concentration to one at the 75th would be associated with 7 to 11 percent increases in expenditures, depending on sample population.

Conclusions. Our estimates indicate that increases in cardiology market concentration are associated with worse health outcomes and higher health care expenditures. Some effects may be attributed to vertical as well as horizontal changes.

Key Words. Competition, physicians, Medicare, cardiology

Local markets for physician services have become increasingly concentrated (Baker et al. 2014; Dunn and Shapiro 2014; Kleiner, White, and Lyons 2015). This is due, in part, to new physicians choosing to work in large practices, but physician markets have also experienced a recent uptick in merger activity.¹ Many of the most rapidly growing practices have been connected to hospital systems.

Although some stakeholders argue that the consolidation of markets for physician services offers benefits because larger practices may enjoy economies of scale (Hough 2001; Hough, Liu, and Gans 2011; Butcher 2012) or

scope (Shih et al. 2008), others worry about the effect on physicians' incentive to provide high-quality care (U.S. Department of Justice and Federal Trade Commission, 2004). An emerging empirical literature has begun to shed light on the debate, finding evidence that more horizontally concentrated physician markets have higher commercial insurance reimbursement rates (Schneider et al. 2008; Baker et al. 2014; Dunn and Shapiro 2014; Sun and Baker 2015; Carlin, Feldman, and Dowd 2016).² But many questions remain unanswered. We extend the literature by analyzing how physician market concentration relates to clinical quality and health service utilization.³

Our analysis considers these issues in the context of local heart specialist (i.e., cardiologist) markets. We focus on cardiology because related conditions are a leading cause of death.⁴ Moreover, the literature suggests that cardiology markets have become especially concentrated (Baker et al. 2014; Dunn and Shapiro 2018), partially as a result of hospitals acquiring cardiology groups (Song et al. 2015; Koch, Wendling, and Wilson 2017).⁵ To estimate the impact of competition, we first leverage rich data on Medicare fee-for-service beneficiaries' treatment histories to identify four overlapping sets of patients exposed to cardiology markets. We then assess the relationship between market concentration and the exposed patients' outcomes using a standard approach to estimating plausibly causal effects of health care market concentration (Zwanziger, Melnick, and Mann 1990; Kessler and McClellan 2000).

The results of our regression analyses imply that differences in concentration are associated with statistically and economically significant changes in patients' health outcomes. In three of our sample populations, we find that patients residing in a zip code at the 75th percentile of cardiology market concentration would have an approximately 5 to 7 percent greater chance of risk-adjusted mortality as compared with observably identical patients residing in a zip code at the 25th percentile of physician market concentration. We find similar results for other outcomes, including the incidence of acute myocardial infarctions (AMIs), emergency room (ER) visits, and readmissions. The negative correlation between concentration and quality is consistent with economic models that predict increased concentration will reduce quality when prices are administratively determined (Gaynor 2006).⁶

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In addition to correlating concentration with lower clinical quality, our analyses show that overall expenditures on health services increase as competition declines. For example, moving from a zip code at the 25th percentile of cardiology market concentration to one at the 75th percentile would be associated with an 7 to 11 percent increase in total expenditures, depending on the sample population.⁷ The impact of concentration on spending appears driven by higher payments for services provided in hospitals, especially for outpatient services, which outweigh modest reductions in average spending on physician services. As the higher total expenditures are not associated with improvements in health outcomes, our results indicate that reductions in competition lead to an unambiguous deterioration in the value of health care being provided. The fact that much—though not all—of the increase in hospital spending comes from an increase in billing for outpatient services is consistent with the fact that increases in horizontal concentration are likely confounded with increased vertical integration. Reimbursement for patients seen in hospitals are substantially higher, giving vertically integrated systems an incentive to shift where physicians provide care (Baker, Bundorf, and Kessler 2014; Neprash et al. 2015; Capps, Dranove, and Ody 2016; Dranove and Ody 2016; Koch, Wendling, and Wilson 2017).

Overall, our results complement other ongoing research on the nonprice effects of physician market concentration. In particular, Dunn and Shapiro (2018) find that cardiologists in more concentrated markets perform more intensive services on commercially insured patients than do otherwise similar ones in less concentrated markets. Broadly consistent with this, we find that concentration increases total expenditures. However, we also find evidence of increased utilization of inpatient services and worse health outcomes. These results are consistent with physician market concentration leading to lower-quality care as has been found in other provider markets (Wilson 2016; Gaynor & Town, 2012b).

THEORETICAL FRAMEWORK

When prices are set administratively, as they are for Medicare beneficiaries, economists expect competition to increase health care providers' quality. The intuition for this expectation comes from a straightforward model requiring assumptions that match the characteristics of physician markets (Gaynor 2006).

First, the model assumes that patients value clinical quality and that they are able to observe it (albeit possibly with noise). There are multiple

sources of information on physicians' quality, which include online resources as well as more traditional ones such as friends and colleagues (Hanauer 2014; Lu and Rui unpublished data). Second, physicians must care about profits. We believe this assumption holds given the rich literature showing that physicians respond to financial incentives (Hennig-Schmidt, Selten, and Wiesen 2011; Coey 2015). Finally, the model assumes that it is costly for physicians to provide better-quality care.⁸ We believe this assumption holds.

Given these assumptions, patients' demand for any given physician will depend on that physician's quality as well as that of the physician's competitors. Competition will tend to induce providers to bear the costs required to provide higher quality care in order to attract patients. We test this hypothesis empirically by looking at how clinical outcomes and expenditures vary at the patient level depending on the structure of their local physician markets. Specifically, we take the level of physician concentration to be the "treatment" variable and then consider how different outcomes vary with it.

Finding that higher market concentration correlates with either deterioration in the quality metrics (without decreased expenditures) or an increase in utilization (without any compensating improvement in quality) implies that competition leads to better value health care. A finding that higher concentration leads to higher spending, but lower incidence of adverse health outcomes has less obvious welfare implications. It could indicate that competition prevents clinicians from spending enough time with patients to effectively help them avoid bad outcomes. Alternatively, it could indicate that with market power, clinicians overprovide clinical quality relative to what a social planner would choose (Gaynor 2006).

METHODS

Study Population of Patients and Organizations

Our analysis relies on 2005–2012 claims and enrollment information for a 5 percent sample of fee-for-service Medicare beneficiaries (approximately 2.5 million persons per year). The claims data include inpatient admissions, hospital outpatient visits, and office-based interactions; these document the procedures performed (e.g., CPT codes for outpatient visits), patients' ailments (e.g., ICD-9 diagnosis codes), and the specific dates on which each "event" occurred.

Using the claims information, we narrow attention to four overlapping samples of patients likely to be affected by differences in cardiology market concentration.⁹ Specifically, we identify patients treated for hypertension, a chronic cardiac condition, an acute cardiac condition, or an AMI. For the first three populations, we identify them using the treatments beneficiaries received in the prior year as indicated by the ICD-9 codes observed in their treatment histories. For the AMI sample, we consider whether or not a patient's beneficiary summary file indicates they suffered a heart attack in a given year.¹⁰

Attending doctors are identified by a unique identifier (either NPI or UPIN). We use the clinicians' tax identification numbers (TINs) to identify provider groups.¹¹

Study Variables

Outcomes. We focus on two groups of outcome variables. First, we consider metrics related to the quality of care: mortality, the incidence of AMIs, an indicator for whether a patient visited an ER, and the number of readmissions. Second, we consider proxies for the utilization of health care services: total expenditures, expenditures to hospitals, expenditures to physicians, and the number of days a patient spent in hospitals. To understand the particular mechanisms that may be at work, we further separate hospital spending into inpatient and outpatient categories.

Measure of Concentration. Our independent variable of interest is the competitiveness of patients' local physician market. To measure competition, we construct "adjusted" measures of the standard Herfindahl–Hirschman Index (HHI) of market concentration, that is, the sum of squared market shares multiplied by 10,000.¹² The HHI is a standard metric used in industrial organization and antitrust to assess the level of competitiveness in markets.¹³ Our adjusted HHI is similar but involves several discrete steps designed to take account of institutional characteristics of health care markets; its broad approach is standard in the literature (Zwanziger, Melnick, and Mann 1990; Kessler and McClellan 2000; Dunn and Shapiro 2014; Capps, Carlton, and David 2017).

We begin by identifying all outpatient claims for services delivered by cardiologists. For each observation, we observe the TIN of the provider associated with the claim. With this information, we construct HHIs based on the allowed amount of spending going to different TINs for patients living in each zip code in each year. As discussed in Kessler and McClellan (2000), these zip-

code-level HHIs may not be good predictors of the level of competition that patients within a zip code are exposed to. This is because the HHIs imply that individual physician groups differentiate their behavior based on the residences of patients, which seems unlikely.

To correct for this problem, we use adjusted measures that assume individual physician groups' quality choices reflect a weighted average of the competitiveness of the markets their patients come from. These adjusted measures are constructed from the original zip-code HHIs in two additional steps. First, physician group-specific HHIs are constructed for each TIN by weighting the zip-code HHIs of their patients by their share of the physician group's total patient pool. Second, the physician-level adjusted HHIs are converted back to the patient zip-code level by weighting each physician group adjusted HHI by the proportion of patients within the zip code going to that physician group.

Our adjusted zip-code concentration measure varies within zip codes over time for three reasons. First, entry, exit, or mergers of cardiology practices will cause the adjusted HHIs to change. These events most closely relate to changes in competition and represent our best source of identification. Second, all else equal, the concentration of a given zip code will also change as the populations of nearby zip codes change because this will alter the physician group-specific concentration measures. Third, concentration will be impacted by differences over time in the relative preference of individuals for different practice characteristics.

Some papers have used distance as an instrument to circumvent the possible endogeneity of adjusted HHIs, but we follow other recent work in not doing so (Capps, Carlton, and David 2017). In our context, the concern would be that patients select into areas based on the quality of providers. However, all else equal, the primary effect of such selection will be to bias the estimate on concentration upwards. In other words, if the patient population was highly mobile in seeking out better physician groups—which we find unlikely given that we are focusing on Medicare beneficiaries—then we would be more likely to find that concentration correlates with better outcomes. Thus, we believe our identification approach is, if anything, biased away from concluding that concentration worsens health care.

We must acknowledge that our measure of concentration likely confounds changes in horizontal structure with changes in vertical structure. This is because, as noted above, hospital-affiliated medical groups have been growing in size, partially as a result of mergers. Therefore, any effects we find may reflect changes in incentives related to vertical integration as well as those

from reduced horizontal competition. We believe the literature suggests that vertical changes are likely to be salient for utilization and spending (Dranove and Ody 2016; Koch, Wendling, and Wilson 2017). However, most of the literature does not support a hypothesis that vertical integration consistently impacts health outcomes (Burns, Goldsmith, and Sen 2013; Koch, Wendling, and Wilson 2016). Therefore, we believe finding any effect on health can be attributed to changes in competition.

Risk-Adjusting Covariates. We account for factors other than concentration that are likely to influence health outcomes and utilization by including a rich set of control variables that capture variation in beneficiaries' comorbidities and demographic backgrounds.

We address demographic variation using categorical variables for different age groups (measured in 5-year increments), gender, and race (white, African American, and other). We account for variation in comorbidities with an indicator for whether the beneficiary suffers from ESRD plus two vectors of indicator variables covering a rich set of chronic conditions. The first vector indicates whether a given beneficiary was diagnosed with various chronic conditions in a given year. The second indicates whether the beneficiary had ever been diagnosed with that chronic condition.¹⁴ To account for unobserved differences in factors like income, wealth, and environmental quality, we use zip-code fixed effects. We address the possibility of systematic intertemporal variation using year indicator variables.

Statistical Analysis

In our econometric analyses, the unit of observation is the beneficiary-year. For all outcome variables, our specifications take the same form:

$$y_{imt} = \alpha \ln (\text{ADJZIPHHI})_{mt-1} + X_{it}\beta + Z_{it-1}\gamma + \delta_t + \eta_m + \varepsilon_{imt},$$

where y_{imt} is the outcome of interest for beneficiary i living in zip-code market m in year t . ADJZIPHHI_{mt-1} is the level of concentration in m in the prior year, X_{it} are contemporary sociodemographic variables of the beneficiary, Z_{it-1} are indicator variables for whether or not the beneficiary was diagnosed with a serious comorbidity in the previous year, δ_t are year fixed effects, η_m are zip-code fixed effects, and ε_{imt} is the idiosyncratic error.¹⁵

The HHI measures are lagged because we believe that the impact of exposure to poor-quality care may take some time to manifest itself. Thus, it makes sense to use the prior year's concentration measure. In addition,

lagging the concentration measure should reduce concerns about simultaneity bias. If a patient received a negative health shock, that would tend to be associated with an increase in utilization. Given that we use the allowed amounts to construct our baseline HHI measure, this would well increase concentration, thereby leading to a false conclusion that concentration negatively impacts patients. By using lagged measures, we reduce this possibility.

Because we include zip-code fixed effects in all models, within zip-code variation in our concentration measure over time identifies competition's effect. We estimate all specifications using ordinary least squares (OLS), making those regressions with binary outcomes linear probability models. We cluster our standard errors at the zip-code level.

DATA ANALYSIS

Characteristics of the Samples

Table 1 shows summary statistics for the different samples and variables used in the paper. The summary statistics show that a high proportion of our sample is female. The sample population's consumption of health care services is weighted toward those provided in hospital-based settings as the combined Medicare and beneficiary expenditures for hospital-based treatments are approximately four times those spent on physician services.

Variation in Concentration

Using one observation for each zip code–year and weighting by the number of beneficiaries, we find large cross-sectional differences in the level of concentration. This can be seen in Figure 1. For example, an observation at the 25th percentile of concentration has an adjusted HHI of 2,306 while a zip code at the 75th percentile has an adjusted HHI of 3,958.

We also find that there is substantial variation in concentration within zip codes over time. For example, we find that the median coefficient of variation for a zip code's adjusted concentration is >0.13 .¹⁶ Moreover, we find that much of the variation in concentration over time reflects the fact that markets are growing more concentrated. In particular, the average patient's zip code had an adjusted HHI of 2,752 in 2005 as compared to 3,365 in 2011. Figure 2 compares the distributions of concentration at the beginning to the end of our sample period and provides further evidence of markets' consolidation. The

Table 1: Summary Statistics

	Hypertension		Chronic Cardiac		Acute Cardiac		AMI	
	Mean	SD	Mean	SD	Mean	SD	Mean	SD
Age	77.30	8.05	77.82	7.70	77.69	7.96	79.06	8.40
Female	1.64	0.48	1.66	0.47	1.66	0.48	1.55	0.50
ESRD $t-1$	0.01	0.09	0.01	0.08	0.01	0.09	0.04	0.19
ADJHHI $t-1$	0.32	0.13	0.32	0.13	0.32	0.13	0.32	0.13
Died	0.06	0.23	0.05	0.21	0.05	0.22	0.17	0.37
AMI	0.01	0.11	0.01	0.10	0.01	0.10	0.07	0.26
Readmissions	0.07	0.40	0.06	0.36	0.07	0.38	0.25	0.81
Visited ER	0.34	0.47	0.32	0.46	0.34	0.47	0.57	0.50
Hospital costs	6,146.96	15,695.58	5,581.50	14,489.14	6,020.21	15,273.66	14,447.56	26,075.60
Physician costs	588.39	587.39	630.04	599.68	655.04	624.71	679.21	660.37
Total costs	6,735.35	15,817.57	6,211.53	14,620.86	6,675.25	15,404.61	15,126.77	26,179.35
Inpatient costs	3,914.71	11,906.49	3,468.08	11,011.62	3,741.53	11,504.18	10,132.11	20,250.80
Outpatient costs	1,746.99	5,063.20	1,703.59	4,798.78	1,823.09	5,143.23	3,225.91	7,710.78
Days in hospital	2.41	7.90	2.07	7.14	2.27	7.55	6.12	12.87
Observations	7,616,752		4,651,140		4,316,207		79,218	

Figure 1: Histogram of Concentration at the Year-Zip-Code Level [Color figure can be viewed at wileyonlinelibrary.com]

Figure 2: Histograms of Zip-Code Concentration over Time

darker histogram shows the distribution of zip-code-level adjusted HHIs for 2005, while the unshaded histogram shows the same distribution in 2011. The figure shows that the distribution of concentration shifted to the right from the beginning to the end of our sample period; there is a much larger tail of highly concentrated markets in the latter period.

Clinical Outcomes Analysis

Table 2 presents risk-adjusted effects of variation in cardiology market concentration on clinical outcomes for the four sample populations.¹⁷ It consistently shows that an increase in concentration correlates with worse health outcomes. Of 16 regressions, 14 show a positive correlation between concentration and the incidence of negative health outcomes. For the non-AMI samples, which have many more observations, only two regressions of 12 show a relationship not statistically significant at conventional levels.

Not only do we find concentration to be a statistically significant predictor of bad health outcomes for patients, but its connection is of economic significance. For example, the estimates imply that a hypertensive patient moving from a zip code at the 25th percentile of concentration to one at the 75th percentile would be expected to have around a 0.3 percentage point higher incidence of mortality. This is equivalent to an approximate 5 percent increase in risk relative to the population mean. The effects are broadly similar for the other quality metrics and populations with effects varying between 1 and 11 percent relative to population means.

Utilization Analysis

Table 3 presents risk-adjusted effects of variation in cardiology market concentration on utilization for the different sample populations. Similar to those shown in Table 2, the utilization results show that concentration is associated with economically and statistically significant consequences. The relationship between concentration and utilization is statistically significant at the conventional levels in all but two of the 16 regressions. We always find higher total expenditures in more concentrated areas. We also consistently find positive, statistically significant relationships between concentration and hospital expenditures (and hospitalization). In contrast, we do not find that physician expenditures have a

Table 2: Effects of Concentration on Clinical Outcomes

<i>Sample</i>	<i>Died</i>	<i>AMI</i>	<i>Visited ER</i>	<i>Log (Readmissions + 1)</i>	<i>N</i>
Hypertension	0.004***	0.001**	0.002***	0.012***	7,616,752
Chronic cardiac	0.003***	0.001*	0.001	0.011***	4,651,140
Acute cardiac	0.005***	-0.000	0.002**	0.013***	4,316,207
AMI	-0.001	0.011	0.006	0.048***	79,218

Notes: Cells contain the estimated coefficient on the concentration measure. Standard errors were clustered at the zip-code level.

* $p < .1$; ** $p < .05$; *** $p < .01$.

Table 3: Effects of Concentration on Expenditures and Utilization

Sample	Log (Hosp Expenditures + 1)	Log (Phys Expenditures + 1)	Log (Total Expenditures + 1)	Log (Hosp Days + 1)	Log (Inpatient + 1)	Log (Outpatient + 1)	N
Hypertension	0.208***	-0.006	0.098***	0.011***	0.049***	0.198***	7,616,752
Chronic cardiac	0.213***	-0.015**	0.083***	0.011***	0.051***	0.202***	4,651,140
Acute cardiac	0.217***	-0.020***	0.089***	0.016***	0.065***	0.197***	4,316,207
AMI	0.324***	0.106	0.160**	0.074*	0.249	0.207**	79,218

Notes: Cells contain the estimated coefficient on the concentration measure. Standard errors were clustered at the zip-code level.

* $p < .1$; ** $p < .05$; *** $p < .01$.

statistically significant positive relationship with concentration. Indeed, we find concentration associated with statistically significant *decreases* in physician utilization in the chronic and acute cardiac condition samples.

Not only are the effects on utilization generally statistically significant, but they often are large in economic magnitude. Depending on sample population, the estimated coefficients imply that a patient moving from a zip code at the 25th percentile of concentration to one at the 75th percentile would experience a 7 to 11 percent increase in total expenditures. These increases are driven by the increased charges from hospitals, which dwarf modest decreases in spending directly to physicians.

DISCUSSION

In this study, we document significant variation in local cardiology markets' concentration. Furthermore, the data suggest a substantial increase in concentration in recent years for most markets. Our regression analyses suggest that these changes in market structure have had economically and statistically significant effects on expenditures and health outcomes.

Specifically, we find that higher concentration is associated with higher total expenditures but also worse health outcomes. While we are unable to say whether the higher expenditures may be associated with nonclinical factors that increase beneficiary utility, these patterns are inconsistent with standard arguments for why provider scale could benefit patients. This fits with other evidence on the average impact of financial integration of physician organizations (Burns, Goldsmith, and Sen 2013).

Our analyses imply that the increased expenditures from cardiology market concentration stem from services provided in hospitals. Spending on physician services often is actually lower in more concentrated markets. This result could have several explanations. First, the increase in hospital spending could reflect that with less competition, physicians shirk on preventative care. This could cause beneficiaries to require more expensive inpatient care. Such shirking might be reasonable if physicians find it especially burdensome relative to its financial benefits. One reason shirking may disproportionately impact preventative care to Medicare patients is that part of the opportunity cost of physicians' time with Medicare patients is time with privately insured patients. Reimbursement for services provided to privately insured patients tends to be substantially higher than those for Medicare beneficiaries.

Second, it is possible that the results are being driven by the fact that horizontal consolidation is confounded with vertical consolidation. After all, hospital acquisitions of physician practices could lead to higher physician market concentration if the acquiring system already employed any physicians. Other research has shown such vertical integration leads to increased hospital billing (see, e.g., Dranove and Ody [2016] and Koch, Wendling, and Wilson [2017]).

To consider the relative validity of the two hypotheses, we estimate models analogous to those in Table 3 for inpatient and outpatient hospital expenditures.¹⁸ If the lack of preventative care explains our results, then we would expect disproportionate increases in inpatient spending. If shifting patients from physician offices into outpatient departments drives the overall increase, then we should observe disproportionately larger increases in outpatient spending.

The results of our mechanism-oriented regressions are shown in the final two regression columns in Table 3. The first column shows the effect of changes in the concentration measure on inpatient spending, while the second shows the effect on outpatient spending. Across the different samples, we observe that both types of spending are higher in more concentrated markets. However, for all but the AMI population, outpatient spending is more sensitive to changes in concentration. While we do not see our results as being dispositive, we interpret the model estimates as suggesting that a large portion of the increase in expenditures associated with higher physician market concentration stems from the fact that hospital systems have become large employers of physicians. Interestingly, the story is reversed for the AMI population. This may suggest that the effect of shirking is especially acute for patients with more life-threatening conditions. We hope that future research can further clarify our findings.

Overall, we see our results as broadly complementary to the work of Dunn and Shapiro (2018) insofar as they too document a connection between cardiology market concentration and increased utilization. However, we have found that concentration negatively impacts clinical quality, while they find small improvements. This discrepancy may reflect differences in the populations studied. They consider the commercially insured population, where prices are negotiated, while we focus on Medicare beneficiaries, where prices are set administratively. We hope that future research can reconcile our findings.

Robustness

We have found our baseline results to be robust. Tables S1 and S2 in Appendix SA2 show the results for models wherein we allowed patients' demographic characteristics to have different effects by county of residence.

This richer specification did not lead to qualitatively different results. Similarly, Tables S3 and S4 show that our conclusions are robust to calculating concentration using shares based on clinical visits rather than allowed spending.¹⁹ Tables S5 and S6 provide additional robustness focusing only on nonrural areas to address concerns about endogeneity. Their results are qualitatively identical to our baseline models.²⁰ Furthermore, we investigated the possibility that we overstated the independence of observations by considering the impact of clustering at a higher level of aggregation. We found no impact on the relative precision of our estimates when clustering at the county level. Details on these robustness models are available upon request.

CONCLUSION

In conclusion, our analysis indicates that increases in concentration in cardiology markets have correlated with worse outcomes for patients as well as increased expenditures. This supports the conclusion that competition provides socially beneficial incentives in physician as well as other provider markets. Moreover, the results align with the large literature documenting physicians' responsiveness to financial incentives, even if the consequences do not benefit patients (Hennig-Schmidt, Selten, and Wiesen 2011; Chandra, Cutler, and Song 2012; Coey 2015). Finally, our results suggest that antitrust agencies have reason for concern not just about price effects but also other forms of consumer harm from consolidation in physician markets.²¹

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Disclosures: None.

Disclaimer: None.

NOTES

1. A recent survey by the American Medical Association (AMA) found that the percentage of physicians in solo practice declined by 25 percentage points (from 44 to 19 percent) between 1983 and 2014. Simultaneously, the share of physicians in practices with 25 or more doctors increased fourfold (from 5 to 20 percent; Kane 2015).
2. See discussion of physician mergers in both practitioner-oriented and scholarly journals (Townsend 2013; Kleiner, White, and Lyons 2015).
3. Studies of hospital mergers and market concentration have often documented a negative link between competition and quality (Vogt and Town 2006; Gaynor & Town, 2012b). Similar connections have also been found in other health care markets (Wilson 2016).
4. See, for example, <https://www.cdc.gov/injury/wisqars/leadingcauses.html>.
5. In future work, we hope to extend our analysis to other specialties. The word “markets” here and elsewhere is used colloquially; no steps have been taken to test whether cardiology would constitute a properly defined antitrust market.
6. This prediction is only unambiguous if the markets for publicly and privately insured patients are separable. There is some evidence consistent with such separation (Coe 2015); however, there is also evidence of spillover effects (Baker 2003).
7. Implied magnitudes calculated using the logarithmic approximation, that is, $\log(x) - \log(y) \approx (x - y)/y$.
8. It is immaterial whether better-quality care requires more physical inputs (e.g., higher cost capital goods) or simply more attention from doctors.
9. Many of the individuals in the more severe condition samples are also in the less severe ones. The table below shows the number of observations in each of the samples and the number that overlap. We have not restricted attention to observations that appear in the regressions.

	<i>Hypertension</i>	<i>Chronic</i>	<i>Acute</i>
Hypertension $N = 7,709,741$	XX		
Chronic $N = 4,687,562$	3,495,300	XX	
Acute $N = 4,358,426$	3,275,848	2,896,232	XX
AMI $N = 79,966$	75,768	34,368	35,310

10. Details on the construction of the analyzed dataset are in Appendix SA2.
11. Using TINs is common in the literature (Baker et al. 2014). Further details on the construction of our analytical samples can be found in Appendix SA2.
12. The HHIs calculated here are not for market areas as spelled out in the *Horizontal Merger Guidelines* (U.S. Department of Justice and the Federal Trade Commission, 2010), so the competitive implications of various concentration levels may not correspond to those suggested by the *Guidelines*. As discussed in Appendix SA2, there are advantages and disadvantages to constructing the HHIs with different measures. We believe that allowed amounts make the most sense as they implicitly

- account for differential incentives that vertically integrated organizations may have.
13. The HHI is an imperfect but standard proxy for the level of competition in a market, and a large number of papers have demonstrated its value as a proxy in health care markets (Gaynor & Town, 2012).
 14. We include indicator variables for all of the chronic conditions covered by the Medicare beneficiary chronic condition summary files. These are as follow: heart attacks, Alzheimer's, atrial fibrillation, cataracts, chronic kidney disease, chronic obstructive pulmonary disease (COPD), congestive heart failure, diabetes, glaucoma, hip fractures, ischemic heart disease, depression, osteoporosis, rheumatoid arthritis and osteoarthritis, stroke and transient ischemic attacks, breast cancer, colon cancer, prostate cancer, lung cancer, endometrial cancer, anemia, asthma, hyperlipidemia, hypertension, hyperplasia, and hypothyroidism.
 15. In our analyses, we assume beneficiaries' outcomes in year t will be affected by the adjusted HHI of their zip code in year $t-1$. This reduces the possibility of simultaneity bias.
 16. The coefficient of variation is defined as the ratio of the standard deviation to the mean. The distribution is plotted in Figure S1 in Appendix SA2, which shows the distribution of the coefficients of variation for concentration evaluated within zip codes.
 17. Complete output tables for the hypertensive population regressions summarized in Tables 2 and 3 are provided in Appendix SA2. See, specifically, Tables S7 and S8.
 18. We exclude the hospital-based spending that was attributed to "other inpatient" services to focus just on those for acute care.
 19. Although not shown, we also found our results to be robust to other permutations of the data and identification. For example, we discretized our measure of concentration and generally found that the concentration variable's effect was concave but monotonic as implied by our preferred specification. In addition, we separately estimated our effects models for zip codes at different levels of the population density distribution. Although there was some variation in the magnitude of the estimated effects, our baseline story broadly held across the different levels. Details are available from the authors upon request.
 20. Rural areas are identified using the 2015 Area Health Resource File data (<https://datawarehouse.hrsa.gov/topics/ahrf.aspx>). Specifically, we use the Rural/Urban Continuum variable. We deem counties to be rural if they are classified as non-metro and smaller than 20,000 in population if adjacent to a metro area.
 21. See, for example, the remarks given by the FTC's Chairwoman at the Antitrust in Healthcare Conference in 2016 (<https://www.ftc.gov/public-statements/2016/05/keynote-address-ftc-chairwoman-edith-ramirez>, as accessed May 25, 2016).

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SUPPORTING INFORMATION

Additional supporting information may be found online in the supporting information tab for this article:

Appendix SA1: Author Matrix.

Appendix SA2: Details on Dataset.

Appendix S1. Data Description.

Appendix S2. Robustness Results.

Figure S1. Histogram of Coefficient of Variation across Zip-Codes.

Table S1. Quality Results with Non-Parametric Demographic Controls.

Table S2. Utilization Results with Non-Parametric Demographic Controls.

Table S3. Quality Results Where HHIs Based on Visits.

Table S4. Utilization Results Where HHIs Based on Visits.

Table S5. Quality Results for Non-Rural Counties.

Table S6. Utilization Results for Non-Rural Counties.

Table S7. Full Quality Regression Results for Hypertensive Sample.

Table S8. Full Utilization Regression Results for Hypertensive Sample.