NBER WORKING PAPER SERIES

THE EFFECT OF ORGANIZATIONS ON PHYSICIAN PRESCRIBING: THE CASE OF OPIOIDS

M. Kate Bundorf
Daniel Kessler
Sahil Lalwani

Working Paper 31785
http://www.nber.org/papers/w31785

NATIONAL BUREAU OF ECONOMIC RESEARCH
1050 Massachusetts Avenue
Cambridge, MA 02138
October 2023

The Effect of Organizations on Physician Prescribing: The Case of Opioids
M. Kate Bundorf, Daniel Kessler, and Sahil Lalwani
NBER Working Paper No. 31785
October 2023
JEL No. I11,L2

ABSTRACT

In theory, there are several reasons why physician organizational form might affect the price, quantity, and quality of physician services. In this paper, we examine the effect of three aspects of physician organizational form on opioid prescribing: the number of physicians in the physician's group (if any); the physician's integration with or employment by a hospital or hospital system; and the average age of the other physicians in the physician's group. We present three key findings. First, all else held constant, group physicians prescribe far fewer opioids, and prescribe them more appropriately, than do solo physicians. Second, although physicians who are employed by a hospital or practice in a hospital-owned group prescribe fewer opioids than do independent physicians, there is evidence that this difference may be due to differences in the other characteristics of physicians who are hospital-integrated rather than a causal effect. Third, we find substantial peer effects on opioid prescribing. Physicians in groups with a higher average age (excluding the physician him- or herself) prescribe more intensively and are more likely to write inappropriate opioid prescriptions than physicians in younger groups – holding constant the physician's own age and other characteristics of his or her group.

M. Kate Bundorf
Sanford School of Public Policy
Duke University
Durham, NC 27708
and NBER
kate.bundorf@duke.edu

Daniel Kessler
Stanford University
434 Galvez Mall
Stanford, CA 94305
and NBER
fkessler@stanford.edu

Sahil Lalwani
Stanford University
slal36@law.stanford.edu

I. Introduction

Over the last two decades, consolidation in markets for health services has changed the types of organizations in which physicians work. This consolidation has taken two main forms: vertical integration of physicians and hospitals, and horizontal integration of physicians into groups. Ownership of physician practices by hospitals increased across all physician specialties from 2007-2017 (Nikpay, Richards, and Penson 2018). By 2018, more than half of physicians and 72 percent of hospitals were associated with a vertically integrated hospital system (Furukawa et al. 2020). The share of physicians in groups, and the size of groups, has also increased. The proportion of physicians in large groups had started to increase by 2010 (Welch et al. 2013); since then, small groups have consolidated into large groups (Muhlestein and Smith 2016).

In theory, there are several reasons why physician organizational form might affect the price, quantity, and quality of physician services. On one hand, integration may increase efficiency by enhancing coordination across settings of care, expanding the ability of physicians to invest in new technology, increasing monitoring of individual physicians' treatment decisions, and achieving economies of scale (Pope and Birge 1996; McCullough and Snir 2010; Post, Buchmueller, and Ryan 2018). On the other hand, as several studies (discussed below) demonstrate, larger organizations may also accrue greater market power, reducing efficiencies generated through competition. Finally, integration with a hospital or membership in a group may affect the composition of a physician's peer group, and in turn affect treatment decisions. Several studies have demonstrated that a worker's peers affect his or her individual productivity, both in general and in medical practice in particular (Avdic et al. 2023). Physicians are more likely to share patients with other physicians in the same group (Geissler, Lubin, and Ericson

2020) and the number and type of physicians with whom a physician shares patients are associated with Medicare utilization (Landon et al. 2018).

Many previous studies, discussed below, seek to assess empirically the effects of physician organizational form. This work finds that both vertical and horizontal integration have led to higher market prices. Evidence on the effects of vertical and horizontal integration on quantity and quality is more mixed, and research on peer effects is quite limited.

In this paper, we examine how physician organizational form affects a measure of health care use that has not been previously considered in this literature: opioid prescribing. Opioid prescribing has important implications for patients. The volume of prescribed opioids approximately tripled from 1999 to 2015 (Guy et al. 2017), and several indicators suggest that at least some of this expansion in prescribing is medically inappropriate (Baker, Bundorf, and Kessler 2020). Several studies have documented both that variation across physicians exists in opioid prescribing and that patients treated by high-prescribing physicians are more likely to use opioids long term and be diagnosed with opioid use disorder (Barnett et al. 2017; Barnett et al. 2019; Eichmeyer and Zhang 2022; Eichmeyer and Zhang 2023). While researchers have examined individual physician characteristics associated with opioid prescribing behavior (Baker, Kessler and Vaska 2022; Schnell and Currie 2018) and have documented the importance of geographic location in determining opioid prescribing (Finkelstein et al. 2022), we are unaware of any work examining either how the type of organization within which a physician works or the characteristics of a physician's peers affects opioid prescribing.

We match several measures of the intensity and appropriateness of opioid prescribing to Medicare beneficiaries by primary care physicians at the individual-physician level with data on that physician's personal characteristics, organizational form, peers, patient characteristics, and

geographic location. We consider one aspect of a physician's peers: their average age. In earlier work, one of us demonstrated a substantial age gradient in opioid prescribing: older physicians prescribe a much greater volume of opioids (Baker, Kessler, and Vaska 2022). In this paper, we focus on how a physician's prescribing changes when the physician changes the type of organization in which she practices. We isolate the effect of changes in organizational form and peer age from other characteristics of a physician's personal characteristics, patient characteristics, and geographic location.

We present three key findings. First, all else held constant, group physicians prescribe far fewer opioids, and prescribe them more appropriately, than do solo physicians. There is a small negative effect of group size (large versus small groups) on prescribing, but the most striking difference is between members of a group of any size and solo physicians. Almost all of this effect is on the intensive margin, i.e., on the volume of opioids prescribed conditional on prescribing any opioids rather than the probability of prescribing any opioids. Second, although physicians who are employed by a hospital or practice in a hospital-owned group[1] prescribe fewer opioids than do independent physicians, there is evidence that this difference may be due to differences in the other characteristics of physicians who are hospital-integrated rather than a causal effect. Third, we find substantial peer effects on opioid prescribing. Physicians in groups with a higher average age (excluding the physician him- or herself) prescribe more intensively and are more likely to write inappropriate opioid prescriptions than physicians in younger groups – holding constant the physician's own age and other characteristics of his or her group.

The magnitude of our estimated effects is substantial. Physicians who switched from solo practice in 2014 to a group of any size in 2018 reduced opioid prescribing by 3.35 to 4.63

[1] In the remainder of the paper, we follow the convention in the literature and categorize hospital-employed physicians together with physicians in hospital-owned groups.

more days than did physicians who remained in solo practice in 2014 and 2018. Evaluated at the solo practice 2014 average of 25.11 days supplied per patient-year (Table 1), physicians who switched from solo in 2014 to group practice in 2018 reduced their prescribing by 13.3 to 18.4 percent more, depending on the size of the practice to which they switched, than did physicians who remained in solo practice in 2014 and 2018 (= 3.35 / 25.11 to 4.63 / 25.11), all else held constant. Peer effects are comparable in magnitude. Conditional on being in a group, physicians in groups with an average age of 30-39 prescribed 3.66 fewer days, as compared to physicians in groups with an average age of 65+, all else (including a physician's own age) held constant. The magnitudes of our estimated effects on opioid/benzodiazepine overlap, a measure of inappropriate prescribing, are similar to those of our estimated effects of days supplied, except for the effects of group average age, which are somewhat smaller. Our estimates suggest that physician organizational form, and the composition of physicians in the organization in which a physician works, are important determinants of their opioid prescribing, and in turn, their quality of care.

The remainder of our paper proceeds in five sections. Section II reviews the large literature on the effects of physician organization (including peer effects) on price, quantity, and quality of care. Section III explains our data and analysis sample in detail. Section IV presents our regression models and the assumptions necessary to identify a causal effect of organizational form on prescribing in each model. Section V presents our results, and Section VI concludes.

II. Previous Literature

A large empirical literature seeks to assess the effects of physician organizational form on the price, quantity, and quality of physician services. This work documents that both vertical and horizontal integration of physicians have led to higher prices for health care services. One arm of this work focuses on the effects of vertical integration, particularly integration of physicians and hospitals. Using different data sources from different time periods, these studies all find that hospital-integrated physicians charge higher prices than those who are not hospital-integrated (Neprash et al 2015; Capps, Dranove, and Ody 2018; Godwin et al. 2021; Curto, Sinaiko, and Rosenthal 2022). Baker, Bundorf, and Kessler (2020) examine a related question – the effects of integration across specialties in the form of multispecialty practice – and find that physicians charge higher prices when they are integrated with other specialties.

Another arm focuses on the effects of horizontal integration. These studies largely examine the effect on physician prices of market concentration, as measured by the Hirschman-Herfindahl Index (HHI), since increases in the size of groups mechanically increase market concentration (Fulton 2017). These studies find that physicians in more concentrated markets charge higher prices (Dunn and Shapiro 2014; Baker et al. 2014). In more recent work, Hausman and Lavetti (2021) separately identify the effects of group size and market concentration. They find that increases in group size at the establishment level lead to lower prices, but that consolidation across establishments leads to higher prices.

Evidence on the effects of vertical and horizontal integration on quantity and quality is more mixed. Studies of the effects of vertical integration generally find no quality benefits (Casalino et al. 2018; Baker et al. 2020; Koch, Wendling, and Wilson 2021; Saghafian et al. 2023; but see Carlin, Dowd, and Feldman 2015 for a counterexample), but find increased

referrals to lower quality hospitals (Baker, Bundorf, and Kessler 2016), higher Medicare and commercial insurance spending on outpatient services (respectively, Whaley et al. 2021 and Ho et al. 2020), greater use of inappropriate imaging (Young et al. 2021), and a shift from low-cost ambulatory surgery centers to high-cost hospital outpatient departments (Richards, Seward, and Whaley 2022).

Studies of the effects of horizontal integration on quantity and quality, taken together, are inconclusive. In early work, Ketcham, Baker, and MacIsaac (2007) find that patients of group physicians received more intensive treatment and had better health outcomes after heart attack than patients of solo physicians. Along these lines, Dunn and Shapiro (2018) find that cardiologists in more concentrated markets perform more intensive procedures, which leads to fewer readmissions but no significant effect on mortality. In more recent work, Casalino et al. (2018) find that large groups have more readmissions than small groups. (Using the same data sources but examining changes over time rather than cross-sectional relationships, Baker et al. (2020) find no association between group size and Medicare spending or readmission rates.) Zhang et al. (2020) find a negative association between the share of patients served by large groups and Medicare spending. Beaulieu et al. (2023) find a small positive association between group size and process measures of quality (i.e., provision of preventive care and patient experience), but mixed effects on outcomes such as readmission rates or mortality.

The studies of the effect of horizontal integration on quantity and quality have important limitations. For example, Dunn and Shapiro (2018), who study horizontal integration among physicians, do not control for differences in hospital ownership, and none of the other studies of organizational size control for differences in physician market concentration. In light of the mechanical relationship between physician group size and concentration, and the documented

effects opposing effects of group size and concentration (Hausman and Lavetti 2021), the absence of controls for physician market concentration makes the associations between group size and quality in this work difficult to interpret.

Evidence on peer effects is more limited. Consistent with peer effects, Doyle and Staiger (2021) find that physicians who switch into groups with a greater average treatment intensity immediately increase their individual treatment intensity, but do not have better patient health outcomes.[2] Using clinical registry data from Sweden, Avdic et al. (2023) find that migrating cardiologists' stent choices rapidly adapt to their peers' choices after relocation, but that the quantity of treatment and health outcomes remain largely unchanged despite the change in practice styles.

Our study contributes to the literature on the effects of physician organization by examining a measure of health care use – drug prescribing. We focus on opioids which allows us to examine both intensity and appropriateness of prescribing. We also address some of the limitations of prior literature. Our models isolate the effects of group size, hospital ownership, physician market concentration, and peer effects. We model a peer effect – the age of other physicians in a physician's practice – which is not itself a function of treatment decisions. And, we identify the effects of group size and hospital ownership based on physicians who changed their group size, effectively controlling for time-invariant characteristics of physicians that may be associated with their group size and hospital ownership status.

[2] However, because this study cannot disentangle peer effects from other characteristics of the group, it does not provide causal evidence of peer effects.

III. Data

We begin with all the physicians serving Medicare beneficiaries with full-year Part D coverage in Medicare's Research Identifiable 20% Part D Event (PDE) claims sample in 2014 or 2018. We include physicians serving both traditional Medicare fee-for-service and Medicare Advantage beneficiaries. We match each physician in the sample by NPI to records in the Medicare Provider Practice and Specialty File (MD-PPAS) to obtain the physician's age, gender, and specialty. We examine physicians who were at least 30 years old in 2014 or 2018 with valid gender. We assign a single county of practice to each physician based on the location in the 20% carrier file from which the physician billed the largest volume of charges. We assign physicians in our sample to 7 age cohorts: [30,40), [40,45), [45,50), [50,55), [55,60), [60,65) and 65+.

In each year, we attribute to each physician all of the beneficiaries for whom the physician wrote any prescriptions in that year. We then characterize the physician's patient population by calculating the average of the characteristics of attributed patients. Using CMS' Master Beneficiary Summary File (MBSF) data for 2014 and 2018, we calculate the age, gender, race (Black vs non-Black), original Medicare eligibility status (disabled vs aged vs both), current Medicare eligibility status, dually eligible status (12 months of dual coverage or not) and patient health mix of the physician's patients in the year. We use all of the 62 patient health characteristics in the MBSF, which include extremely detailed information on acute, chronic, and mental health conditions.[3] We group patients into different age cohorts (<65, 65-74, 75-84, >84) than the physicians because the distribution of patients is highly skewed to older ages.

We calculate several measures of the intensity and appropriateness of opioid prescribing. For all physicians, we calculate days supplied of opioids per attributed patient; for physicians

[3] See the Appendix for a list, and https://resdac.org/cms-data/files/mbsf-27-cc and https://resdac.org/cms-data/files/mbsf-other-conditions for a detailed description.

prescribing at least one opioid, we calculate days supplied and the number of overlapping opioid/benzodiazepine prescriptions per attributed patient.[4] We determine which drug claims are for opioids based on National Drug Code (NDC) on the claim and *CDC's Opioid NDC and Oral MME Conversion File*. We exclude prescriptions for buprenorphine because it is mainly prescribed for opioid use disorder rather than for pain.

To investigate how opioid prescribing varies by group and hospital-integration status and other group characteristics, we assign each physician in each year to a group based on the tax identification number (TIN) the physician uses to bill Medicare. We then aggregate TINs based on the Welch-Bindman method and TINs that share a common legal name in a given hospital referral region (Baker, Bundorf, and Kessler 2018). Similar to county practice location, we assign each physician to the group (if any) that represents the largest volume of charges the physician billed to Medicare in a given year. We categorize physicians as solo or group, and categorize groups as small (2-10 physicians), medium (11-100), or large (> 100). We also calculate the average age of physicians in each group for each group physician as the average age of all the other physicians in the group. We classify physicians as hospital-integrated if more than 90 percent of the individual physician's or group's claims have a place of service that is a hospital or are associated with a hospital outpatient claim.

After calculating group and hospital-integration status, and other group characteristics, we limit our analysis sample to those physicians who report a specialty of "family practice," "geriatrics" or "internal medicine" (i.e., primary care physicians (PCPs)). Primary care is the most frequently utilized health service and the source of nearly half of all of the opioids prescribed (Eichmeyer and Zhang 2023).

[4] This is a standard measure of inappropriate prescribing because of the danger, especially to older individuals, of concomitant use of opioids and benzodiazepines (Huang et al. 2016).

We construct an HHI of physician market concentration in county *c* at year *t* following the method used by Kessler and McClellan (2000), Dunn and Shapiro (2014, 2018), and others:

$$HHI_{ct} = \Sigma_{j\ serving\ county\ c} v_{cjt} \times \Sigma_{zipcode\ k\ served\ by\ j} b_{kjt} \times \Sigma_{j\ serving\ zipcode\ k} a^2_{jkt}$$

where *j* and *k* index group and patient zip codes, respectively; a_{jkt} is the share of charges from Medicare patients who live in zip *k* served by group *j*; b_{kjt} is the share of charges from Medicare patients served by group *j* who live in zip *k*; and v_{cjt} is the share of office visits (number of claims) from Medicare patients who live in county *c* served by group *j*. The b_{kjt}-weighting in HHI_{it} assumes that the characteristics of group *j*'s market depends on the weighted average of all of the zip-code patient residence areas that it serves; the v_{ijt}-weighting defines a county's characteristics as the weighted average of all of the groups that serve patients who live in county *c*. We calculate the above separately for "*Family Practice*" and "*Internal Medicine*" specialties, and average the two weighted by the number of visits (number of claims) for each in county *c* in year *t* (we are not able to calculate an HHI for geriatricians due to the relatively small number of physicians reporting this specialty).

IV. Models

To isolate the effects of organizational form on opioid prescribing from other factors that may be correlated with it, we specify the following regression model:

$$Y_{ict} = \alpha_c + \beta_t + G_{it}\gamma + H_{it}\delta + A_{it}\theta + GA_{it}\varphi + X_{it}\pi + \epsilon_{ict},$$

Where

i, c, t index physicians, practice counties, and years (2014 or 2018), respectively;

Y is days supplied or the proportion of patients with opioid/benzodiazepine overlap;

α is a fixed effect for the county of the physician's practice;

β is a year fixed effect;

G is a vector of indicators for group status;

H is a vector of indicators for hospital integration status;

A is a vector of indicators for physician age;

GA is a vector of indicators for the average age in a physician's group;

X is a vector of physician HHI and patient characteristics; and

ε is an error term.

Our model seeks to investigate the effect of several dimensions of organizational form on opioid prescribing. It seeks to isolate the effect of group and hospital-integration status from other patient and physician characteristics. It also seeks to isolate the effect of characteristics of physician groups (i.e., group size and the average age of physicians in the group) from other physician and patient characteristics.. As discussed above, older physicians prescribe more opioids, and so we investigate whether the presence of older physicians in a group (as measured by the group's physicians' average age) affects the prescribing behavior of other physicians in the group.

We specify two versions of our model: basic and expanded. Our basic model defines G as a vector of indicators for group size (small, medium, or large (vs. solo as the base group)) and H as a scalar = 1 for hospital-integrated (vs. independent as the base group) physicians. This model identifies the effect of group and hospital integration under two assumptions: a) that there are no characteristics of physicians omitted from the model that are correlated with G or H, and Y and b) selection into or out of the sample is not correlated with G or H, and Y.

To investigate the validity of these assumptions, we specify an expanded model. Our expanded model divides solo and group physicians (and, analogously, independent and hospital-

integrated physicians) into switchers, stayers, leavers, and joiners. We define a switcher as a physician who is present in the sample in both years and changed status from group to solo, solo to group, or a group of one size to a group of another size; a stayer as a physician who is present in the sample in both years and had the same solo/group size status; a leaver as a physician who was present in the sample in 2014 but not 2018; and a joiner as a physician who is present in the sample in 2018 but not 2014. Our expanded model separately estimates the effects of solo/group size for switchers, stayers, leavers, and joiners by year. Comparing the estimated effects of switchers and stayers will show whether there are omitted time-invariant characteristics of physicians that are correlated with G or H, and Y. Differences in time-invariant characteristics of physicians by group or hospital-integration status will affect the estimates for stayers but not the estimates for switchers.

Our expanded model thus stratifies physicians into 24 solo/group size categories: solo, small-, medium-, and large-group switchers observed in 2014 and 2018 (8 categories = 4 * 2 years); solo, small-, medium-, and large-group stayers observed in 2014 and 2018 (8 categories = 4 * 2 years); solo, small- medium-, and large-group joiners (observed in 2018 only, 4 categories); and solo, small-, medium-, and large-group leavers (observed in 2014 only, 4 categories). The base group is 2014 solo stayers. As specified above, we also include a year fixed effect common to all categories. The vector G in our expanded model thus contains 22 indicators (omitting indicators for the base group and 2018 solo stayers (which would be equal to a linear combination of the year fixed effect and the other group variables)).

Our expanded model similarly stratifies physicians into 12 hospital integration categories: independent and integrated switchers observed in 2014 and 2018 (4 categories = 2 * 2 years); independent and integrated stayers observed in 2014 and 2018 (4 categories = 2 * 2 years);

independent and integrated joiners (in 2018 only, 2 categories); and independent and integrated leavers (in 2014 only, 2 categories). The base group is 2014 independent stayers. The vector H in our expanded model thus contains 8 indicators (omitting indicators for the base group; 2018 independent stayers (which would be equal to a linear combination of the year fixed effect and the other integration variables); and for independent joiners and leavers (which, if included, would make the hospital-integration joiner and leaver indicators equal to a linear combination of the group joiner and leaver variables)).

V. Results

Table 1 presents the means and standard deviations of the variables used in our analysis sample. The leftmost column of the Table presents statistics for the full sample; other columns present statistics for solo vs. group and independent vs. hospital-integrated physicians.

The top panel of the table presents statistics for our dependent variables. On average, physicians in our sample prescribed 13.12 days of opioids per attributed patient per year. Solo physicians prescribed more than twice the volume of group physicians. For 2014 and 2018 pooled, solo physicians prescribed 22.72 days of opioids, as compared to 11.22 days for group physicians. Days supplied falls monotonically with group size. Small-group physicians prescribed 15.55 days, as compared to 11.27 for medium-group and 9.43 for large-group physicians. Similarly, independent physicians prescribed almost twice as many opioids as hospital-integrated physicians: 14.03 days per patient-year as compared to 7.41. This pattern is roughly consistent over time, overlaid by the well-known downward trend in opioid prescribing across all physicians.

Variation in prescribing by organizational form occurred on both the intensive and extensive margins. Conditional on writing at least one opioid prescription, solo physicians prescribed 25.39 days of opioids, as compared to 13.22 days for group physicians. Of the 315,353 (=163,298 + 152,055) physician-years in our sample, 269,984 or 85.6 percent wrote at least one opioid prescription (= 13.12 / 15.32), with a larger number of solo than group physicians writing at least one opioid prescription (where group physicians' days supplied is defined as the average across group sizes, weighted by the number of physician-years in each group, or 22.72 / 25.39 = 0.895 > 11.22 / 13.22 = 0.849) and a larger number of independent than hospital-integrated physicians writing at least one opioid prescription (14.03 / 16.18 = 0.867 > 7.41 / 9.39 = 0.789).

The same patterns occur in opioid/benzodiazepine overlap. Solo physicians were much more likely to have patients with overlapping opioid/benzodiazepine prescriptions as compared to group physicians (0.187 versus 0.114), again with a monotonically-declining gradient by group size and a downward trend over time. And, independent physicians were much more likely to have patients with overlapping opioid/benzodiazepine prescriptions as compared to hospital-integrated physicians (0.133 versus 0.080).

Other physician and patient characteristics, however, may explain at least part of these differences in prescribing by organizational form. Solo physicians are much older than group physicians (58.04 years vs. 48.43 years), with age monotonically declining by group size. In addition, solo physicians are in more competitive physician markets than group physicians (HHI = 0.13 vs. 0.19). In previous work, older physicians (Baker, Kessler, and Vaska 2022) and physicians who face more competition for patients from nurse practitioners (Currie, Li, and Schnell 2023) have been shown to prescribe more opioids.

Differences in the 62 patient health conditions from the MBSF may also explain differences in prescribing by organizational form. We summarize the relationship between patient health status and prescribing patterns by calculating the predicted value of days supplied per patient-year for each physician based on a simple regression model with days prescribed as the dependent variable and with the share of the physician's patients with each of the 62 patient health conditions and a year fixed effect as covariates.[5] The row labeled "predicted days supplied based on 62 health indicators" presents averages of those predicted values by organizational form. By construction, for the full sample, the average predicted value of days equals its average actual value. The remaining columns show, for example, that the health of solo physicians' patients explains some (although only a small share) of the difference between solo and group physicians' prescribing. Based only on patient health, solo physicians would have prescribed 13.90 days of opioids per patient-year, as compared to 12.96 days per patient-year for group physicians. This difference of 1.06 days accounts for just over 8 percent of the total difference between solo and group physicians (0.082 = (13.90 – 12.96) / (22.72 – 11.22)).

On the other hand, solo and independent physicians' patients are less likely to have entered Medicare due to disability and less likely to be currently eligible due to disability, as compared to group and hospital-integrated physicians, respectively. Since disability is strongly positively associated with opioid use in Medicare (e.g., Jeffrey, Hooten, et al. 2018), this patient-characteristic difference would suggest that, all else equal, solo and independent practitioners would prescribe *fewer* days of opioids than their group and hospital-integrated counterparts.

Table 2 introduces our results by presenting estimates from our basic model using days supplied as the dependent variable. Column (1) presents results from a more parsimonious

[5] We present this summary statistic instead of presenting the shares of patients with each of the 62 health conditions, which would be at best very difficult to interpret.

version of the basic model that includes only G and H as regressors. Consistent with Table 1, Table 2 shows that group and hospital-integrated physicians both prescribe fewer opioids than do their solo and independent counterparts. Columns (2) – (4) show that including provider age, patient characteristics, and the characteristics of individual physicians reduces the estimated effects of group and hospital-integration status slightly. Column (5) shows that including physician group characteristics (HHI and average age) substantively reduces the estimate of group status. The fact that observable characteristics of organizational form beyond simple measures of group and hospital-integration status are correlated with opioid prescribing behavior suggests further investigation into the sensitivity of the results to the model's assumptions about unobservable characteristics.

The remainder of this section presents results from our expanded model on days supplied of opioids, days supplied conditional on writing at least one opioid prescription, and the rate of opioid/benzodiazepine overlap. As in Table 2, all standard errors are clustered at the practice county level.

Figure 1 presents estimates of the effect of group size for switchers on days supplied. These estimates represent changes in prescribing by physicians who switch between groups of different sizes (or solo practice) relative to changes by physicians who remain in solo practice throughout the study period (solo stayers). The error bars report 95 percent confidence intervals. Figure 1 contains two key results. First, physicians who switched from solo in 2014 to a group of any size in 2018 reduced their days prescribed more than did solo stayers with 95 percent confidence intervals that reject a null effect. Second, the extent of reduction is statistically indistinguishable across groups of different sizes; the 95 percent confidence intervals for

physicians who switched from solo in 2014 to a group of any size in 2018 span the range of effects.

The left panel of the figure reports the effect of group size for physicians who switched from smaller groups (or solo) in 2014 to larger groups in 2018. Physicians who switched from solo in 2014 to a group of any size in 2018 reduced prescribing by 3.35 to 4.63 more days than did solo stayers with 95 percent confidence intervals that span the range of effects. These effects are economically important as well as statistically significant. Evaluated at the solo 2014 average of 25.11 days supplied per patient-year (Table 1), physicians who switched from solo in 2014 to group in 2018 reduced their prescribing by 13.3 to 18.4 percent more than did solo stayers (= 3.35 / 25.11 to 4.63 / 25.11). Changes in prescribing by physicians who switched from small groups in 2014 to medium or large groups in 2018 are statistically indistinguishable from those by solo stayers at a 5 percent level of significance.[6]

The right panel of the figure reports the effect of group size for physicians who switch in the opposite direction – from larger to smaller groups (or solo). These physicians increase their opioid prescribing. Physicians who switch from a large group in 2014 to solo in 2018 show the largest increase, of 6.69 days (95 percent confidence interval from 4.97 to 8.41) relative to changes by solo stayers; physicians who switch from a large group in 2014 to a medium group in 2018 show the smallest increase, of 1.7 days (95 percent confidence interval from 0.88 to 2.52). In contrast to the decreases in prescribing by physicians who switch from smaller to larger

[6] Physicians who switched from medium to large groups actually increased prescribing slightly (0.96) relative to the change by solo stayers. The effect of switching from medium in 2014 to large in 2018 is not necessarily equal to the difference between the effect of switching from solo in 2014 to large in 2018 and the effect of switching from solo in 2014 to medium in 2018. This is because large18 – medium14 = (large18 – solo14) – (medium18 – solo14) only if medium18 = medium14, a constraint that our expanded model does not impose.

groups, the increases in prescribing by physicians who switch from larger to smaller groups are all statistically significant.

Figure 2 presents estimates of the effect of group size for stayers on days supplied. These estimates represent levels of prescribing by physicians in 2018 and 2014, respectively, in a group of a given size, relative to solo-stayer physicians in the same year. The magnitudes of the estimates of group size for stayers' levels of prescribing are slightly larger than (although generally within the confidence intervals of) the magnitudes of the estimates of group size on switchers' changes in prescribing. The similarity of the magnitudes of the estimates of the effect of group status on stayers' levels to those of switchers' changes is evidence that the estimates are not driven by time-invariant unobserved differences between physicians of different group status.

For example, small group physicians in 2018 prescribed 3.81 fewer days (vs. solo in 2018) as compared to the estimate of the effect of switching from solo in 2014 to small group in 2018 (Figure 1, -3.35 days +/- 1.57). Large group physicians in 2014 prescribed 7.98 fewer days (vs. solo in 2014) as compared to the estimate of the effect of switching from large group in 2014 to solo in 2018 (Figure 1, 6.69 days +/- 1.72).

Figure 3 presents estimates of the effect of hospital integration on days supplied for switchers (left panel) and stayers (right panel). Estimates in the left panel represent changes in prescribing by physicians who switched hospital-integration status relative to changes by physicians who remained independent throughout the study period (independent stayers); estimates in the right panel represent levels of prescribing by hospital-integrated physicians in 2018 and 2014 relative to independent-stayer physicians in 2018 and 2014 (respectively). The results in Figure 3 do not provide strong evidence of a causal effect of hospital integration. Although physicians who switched from integrated in 2014 to independent in 2018 increased

their prescribing by 2.15 more days than do independent stayers, physicians who switched from independent in 2014 to integrated in 2018 did not significantly reduce their prescribing more than did independent stayers. In addition, the magnitudes of the estimates of integration for stayers' levels of prescribing are statistically significantly larger than the magnitudes of the estimates of integration on switchers' changes in prescribing. The difference between the magnitudes of the estimates of the effect of integration on stayers' levels and those of switchers' changes suggests that the estimates may be driven by time-invariant unobserved differences between physicians of different integration status.

Figure 4 presents estimates of the effect of physician age (left panel) and the average age of physicians in each physician's group (right panel) on days supplied. Consistent with Baker, Kessler and Vaska (2022), physician age has a generally monotonically positive effect on opioid prescribing, with younger physicians prescribing fewer days and older physicians prescribing more days. Physicians aged 30-39 prescribed 5.91 fewer days than did physicians aged 65+ (the base group) – more than the magnitude of the effect of switching from solo to group of 3.35 to 4.63 days. The difference between physicians aged 40-64 and those aged 65+ declines with age from age 40 to 64, with physicians aged 60-64 prescribing 0.19 more days than physicians aged 65+ (95 percent confidence interval from -0.22 to 0.6).

The average age of physicians in each physician's group affects a physician's prescribing behavior by approximately as much as does a physician's own age. For every age category except the youngest physicians (aged 30-39) – for whom the effect of own age is significantly greater – the confidence intervals of own age and average group age overlap. Physicians in groups with higher average ages generally prescribe more days, although the effects of the average age in a group are not statistically distinguishable across age categories.

Figure 5 presents estimates analogous to those in Figure 1, but excludes physicians who did not write any opioid prescriptions in the sample year, and so estimates the effect of organizational form on the intensive margin only (N = 269,984 for the models underlying Figure 4 as compared to N = 315,353 for the models underlying Figure 1, reflecting the fact that 45,369 physician-years had zero days supplied). The estimates in Figure 5 are very similar in magnitude to the estimates in Figure 1. For example, physicians who switched from solo in 2014 to a group of any size in 2018 reduced their prescribing by 3.36 to 5.24 more days than did solo stayers (as compared to 3.35 to 4.63 days from Figure 1); conversely, physicians who switched from a group of any size in 2014 to solo in 2018 increased their prescribing by 4.14 to 6.41 more days than did solo stayers (as compared to 4.31 to 6.69 days from Figure 1). Measured relative to the mean days supplied conditional on writing at least one opioid prescription, the magnitude of the effect on the intensive margin is also similar to the magnitude of the effect on both the intensive and extensive margins. Evaluated at the solo 2014 average of 27.44 days supplied per patient-year, conditional on writing at least one opioid prescription (Table 1), physicians who switched from solo in 2014 to group in 2018 reduced their prescribing by 12.2 to 19.1 percent more than did solo stayers (= 3.36 / 27.44 to 5.24 / 27.44). This demonstrates that essentially all of the effect of group status occurs on the intensive margin.

Figures 6 and 7 are analogous to Figures 1 and 4, respectively, substituting the share of patients with opioid/benzodiazepine overlap as the dependent variable for days supplied. Like Figure 5, the models underlying Figures 6 and 7 are based on the 269,984 physicians who wrote at least one opioid prescription.

Figure 6 shows that the magnitude of the effect of group status on the share of patients with opioid/benzodiazepine overlap is similar to the magnitude of the effect on days supplied,

when measured in percentage terms. Physicians who switched from solo in 2014 to a group of any size in 2018 reduced their overlapping prescribing by 2.7 to 3.8 percentage points more than did solo stayers; conversely, physicians who switched from a group of any size in 2014 to solo in 2018 increased their overlapping prescribing by 1.8 to 2.7 percentage points more than did solo stayers. Evaluated at the solo 2014 average of 18.9 percentage points overlap per patient-year (Table 1), physicians who switched from solo in 2014 to a group of any size in 2018 reduced their share of patients with an overlap by 14.3 to 20.1 percent more than do solo stayers (= 2.7 / 18.9 to 3.8 / 18.9). As with days supplied, the extent of reduction (increase) in overlap for physicians who switched to a group of any size from solo (from a group of any size to solo) in Figure 6 is statistically indistinguishable across groups of different sizes. The 95 percent confidence intervals for physicians who switched from solo in 2014 to a group of any size in 2018 (from a group of any size to solo) span the range of effects.

Figure 7 presents estimates of the effects of physician age and the average age of physicians in each physician's group on the share of patients with an overlapping prescription. As with days supplied, physician age has a generally monotonically positive effect on the extent of overlap, with younger physicians writing fewer overlapping prescriptions and older physicians writing more overlapping prescriptions. For example, physicians aged 30-39 wrote 4.4 percentage points fewer overlapping prescriptions than did physicians aged 65+. The difference between physicians aged 40-64 and physicians aged 65+ declines with age from age 40 to 64, with physicians aged 60-64 prescribing 1.5 percentage points fewer overlapping prescriptions than physicians aged 65+. The magnitude of the effect on overlap of age relative to group status is similar to the magnitude of the effect on days supplied of age relative to group status. As with

days supplied, the difference between the youngest and oldest physicians in overlap is larger than the magnitude of the effect of switching from solo to a group of any size.

Physicians in groups with higher average ages generally wrote more overlapping prescriptions, although the effects of the average age in a group are not statistically distinguishable across age categories. In contrast with days supplied, the average age of physicians in each physician's group affects overlap prescribing by less than a physician's own age. For no age category do the confidence intervals of own age and average group age overlap. For example, physicians in a group with an average age of 30-39 wrote 1.7 percentage points fewer overlapping prescriptions than physicians in a group with an average age of 65+ (confidence interval from 0.9 to 2.5). By comparison, physicians aged 30-39 wrote 4.4 percentage points fewer overlapping prescriptions than physicians aged 65 + (confidence interval from 4.2 to 4.6).

VI. Conclusion

Understanding how physician organizations affect health care use is a first-order problem in health economics. Over the past 20 years, physicians have transitioned from independent, largely solo practitioners to members of large groups that are often integrated with hospitals. Although it is empirically well-established that this transition has led to higher prices for physician services, empirical evidence about its effects on health care use and quality is more mixed. This is not surprising, since changes in physician organizational form have the potential to affect use and quality through many channels, including through peer effects. Previous research shows that physicians are more likely to share patients with other physicians in the same

group (Geissler, Lubin, and Ericson 2020) and the number and type of physicians with whom a physician shares patients are associated with Medicare utilization (Landon et al. 2018).

In this paper, we examine how three key features of physician organizations – group status and size, the average age of the other physicians in a physician's group, and whether the physician is employed by or in a practice owned by a hospital or health system – affect an important component of health care use – opioid prescribing. We construct measures of the intensity and appropriateness of opioid prescribing for approximately 200,000 primary care physicians serving Medicare beneficiaries (including enrollees in Medicare Advantage) in 2014 and 2018. To this information, we match other physician characteristics (age and gender); the characteristics of each physician's practice setting, including not only the three characteristics above but also the county and concentration (HHI) of the physician's market; and highly detailed characteristics of the physician's patients, including 62 different health characteristics, age, gender, race, and disability status (both current and historical). We identify the effects of group and hospital-integration status based on physicians who switched their organizational form between 2014 and 2018 to eliminate the possibility that our estimates are due to time-invariant characteristics of physicians' prescribing behavior that may be correlated with their organizational form.

We present three main findings. First, group physicians prescribe fewer days of opioids than solo physicians, and prescribe them more appropriately, all else held constant. Physicians who switched from solo practice in 2014 to a group of any size in 2018 reduced prescribing by 3.35 to 4.63 more days than did physicians who remained in solo practice throughout the study period (solo stayers). Evaluated at the solo 2014 average of 25.11 days supplied per patient-year, this translates into a 13.34 to 18.4 percent greater reduction in days than solo stayers. In

addition, physicians who switched from solo in 2014 to a group of any size in 2018 reduced their rate of overlapping opioid/benzodiazepine prescribing – a standard measure of inappropriate care – by 2.7 to 3.8 percentage points more than do solo stayers. Evaluated at the solo 2014 average of 18.9 percentage points overlap per patient-year (Table 1), this translates into a reduction of 14.3 to 20.1 percent more overlap than solo stayers.

Almost all of the effects on days supplied are on the intensive margin, indicating that the differences we observe are not driven by the 14.4 percent of physicians (= 45,369 / 315,353, Table 1) who prescribe no opioids. None of these differences can be explained by geography (which accounts for a significant share of differences in opioid prescribing, Guy et al. 2017) since we control for the county of each physician's practice. And only a small part of these effects can possibly be explained by differences in patient characteristics. The 62 patient health characteristics in our model – including measures of mental health, chronic illness, and substance-use disorders – explain 0.94 days (= 13.90 – 12.96, Table 1) of the raw difference of 11.5 days (= 22.723 – 11.22, Table 1) between solo and group physicians. Moreover, solo physicians' patients are less likely to have entered Medicare due to disability and less likely to be currently eligible due to disability – a patient characteristic that is strongly positively associated with opioid use. These validity checks all suggest that the observed difference in prescribing between solo and group physicians is causal rather than due to unobserved characteristics of physicians associated with their organizational form.

Second, although there are large raw differences in opioid prescribing between independent and hospital-integrated physicians, the evidence that the raw differences in prescribing between these groups is causal is much weaker. The change in days supplied by physicians who switch from independent to hospital integrated is statistically indistinguishable

from the change by independent stayers. And the estimated change in days by physicians who switch from hospital integrated to independent is significantly smaller in absolute value than the estimated differences in levels for hospital-integrated stayers, relative to the levels for independent stayers.

Third, there are substantial peer effects on opioid prescribing. Consistent with earlier work, we find very large effects of a physician's *own* age on the volume and appropriateness of opioid prescribing: older physicians prescribe more opioids and are more likely to have patients with opioid/benzodiazepine overlap. This is not surprising in light of research (reviewed in Baker, Kessler, and Vaska (2022)) that finds that older physicians are less likely to follow current standards of care and more likely to use low-value services than their younger counterparts.

In this paper, we extend this work to test the hypothesis that the individual physician age effect on opioid prescribing spills over to other physicians in the same group. We find that physicians in groups with older colleagues prescribe more opioids, and prescribe them less appropriately, than physicians in groups with younger colleagues – after holding constant the physician's own age. The effects of a physician's peers' age is comparable to a physician's own age (at least for days supplied), indicating that peer effects in this context are important.

Our paper has several limitations. Because our research design is observational in nature, we cannot rule out the possibility that physicians who switch from solo to group, or group to solo, would have prescribed differently due to unobservable characteristics that caused them to switch, even if they did not actually switch. But even if our estimated effect of group status is not causal, it is still relevant: at the very least, our results show that solo physicians prescribe more intensively and less appropriately than group physicians, highlighting an opportunity to

reduce opioid prescribing in general and inappropriate opioid prescribing in particular. We also cannot say for certain that physician age, or physician groups' average age, *per se* has a causal effect on physicians' prescribing behavior. Groups with older physicians may differ in dimensions (other than geographic location, market competitiveness, size, and hospital-integration status, for which we control) that we do not observe but are correlated with opioid prescribing. Finally, we do not identify the effect of prescribing behavior on health outcomes, so our conclusion about appropriateness is based on intermediate endpoints only. Future work might further explore how peer effects other than age affect not only opioid prescribing but also other measures of quality of care, including health outcomes.

Our research provides important insights for understanding how the structure of physician organizations influences quality of care. Our results suggest that horizontal integration is more likely to have a causal effect on physician behavior with respect to health care use and quality than vertical integration with hospitals. Peer effects are an important source of quality differences by group size although we cannot rule out that other mechanisms such as financial incentives or administrative mechanisms also influence quality. Group size has an effect on prescribing even after controlling for the age of physicians in the group. This residual could be driven by peer effects through different channels as well as other group features.

Table 1: Means and (Standard Deviations), Dependent Variables

		Group				Hospital Integration	
	All	Solo	Small Group	Medium Group	Large Group	Independent	Hospital-Integrated
Days Supplied per patient-year	13.12	22.72	15.55	11.27	9.43	14.03	7.41
	(22.29)	(34.86)	(22.95)	(17.83)	(15.93)	(22.96)	(16.45)
Days Supplied, 2014	15.33	25.11	17.23	12.99	11.30	16.34	8.97
	(23.96)	(36.02)	(23.36)	(19.20)	(17.74)	(24.58)	(18.37)
Days Supplied, 2018	10.74	19.59	13.33	9.30	7.78	11.55	5.77
	(20.09)	(33.03)	(22.21)	(15.90)	(13.93)	(20.80)	(13.96)
Days Supplied,	15.32	25.39	17.67	13.15	11.36	16.18	9.39
conditional on >0 opioid rx	(23.38)	(35.92)	(23.69)	(18.61)	(16.84)	(23.94)	(18.01)
Days Supplied,	17.44	27.44	19.17	14.77	13.30	18.40	10.94
conditional on >0 opioid rx, 2014	(24.82)	(36.79)	(23.87)	(19.82)	(18.54)	(25.34)	(19.76)
Days Supplied,	12.91	22.57	15.60	11.19	9.57	13.68	7.62
condition on >0 opioid rx, 2018	(21.38)	(34.49)	(23.28)	(16.82)	(14.88)	(21.99)	(15.59)
Overlapping opioid/benzodiazepine rx	0.127	0.187	0.146	0.114	0.100	0.133	0.080
	(0.174)	(0.199)	(0.174)	(0.164)	(0.161)	(0.175)	(0.157)
Overlapping opioid/benzodiazepine rx,	0.133	0.189	0.150	0.120	0.104	0.140	0.087
2014	(0.172)	(0.194)	(0.171)	(0.164)	(0.158)	(0.173)	(0.159)
Overlapping opioid/benzodiazepine rx,	0.119	0.183	0.141	0.106	0.097	0.126	0.071
2018	(0.175)	(0.205)	(0.176)	(0.163)	(0.163)	(0.177)	(0.154)
Number of unique physicians	196,851	33,883	38,492	61,647	90,496	172,970	33,988
# Physicians 2014	163,298	29,489	29,629	43,770	60,410	140,898	22,400
# Physicians 2018	152,055	22,604	22,520	38,302	68,629	130,921	21,134
Number of unique physician counties	2,250	1,919	1,927	1,441	818	2,209	1,255
# counties 2014	2,156	1,830	1,755	1,248	688	2,120	1,007
# counties 2018	1,984	1,609	1,507	1,190	639	1,924	940

Table 1 (continued): Means and (Standard Deviations)

		Group				Hospital Integration	
Physician Practice Characteristics	All	Solo	Small Group	Medium Group	Large Group	Independent	Hospital-Integrated
Physician Age	50.01	58.04	51.79	48.37	47.10	50.68	45.84
	(11.77)	(10.50)	(11.61)	(11.37)	(10.95)	(11.77)	(10.85)
Physician Gender (Female)	0.376	0.246	0.335	0.382	0.443	0.374	0.391
Practice HHI	0.18	0.13	0.17	0.20	0.19	0.18	0.19
	(0.12)	(0.09)	(0.12)	(0.14)	(0.13)	(0.12)	(0.14)
Beneficiary Characteristics							
Predicted Days Supplied	13.12	13.90	14.00	13.18	12.40	13.26	12.23
Based on 62 Health Indicators	(6.23)	(5.79)	(5.95)	(6.35)	(6.34)	(5.91)	(7.85)
Age	71.42	72.03	71.36	71.11	71.40	71.56	70.53
	(5.12)	(4.65)	(4.95)	(5.06)	(5.39)	(4.97)	(5.92)
Female	0.611	0.600	0.613	0.613	0.613	0.613	0.598
	(0.155)	(0.128)	(0.141)	(0.154)	(0.171)	(0.151)	(0.183)
Black	0.131	0.131	0.121	0.124	0.141	0.127	0.156
	(0.200)	(0.209)	(0.189)	(0.192)	(0.205)	(0.196)	(0.220)
Dual Eligible	0.273	0.292	0.271	0.287	0.258	0.260	0.356
	(0.227)	(0.244)	(0.228)	(0.224)	(0.220)	(0.222)	(0.238)
Original Eligibility = Disabled	0.288	0.261	0.287	0.310	0.287	0.277	0.360
	(0.189)	(0.177)	(0.187)	(0.188)	(0.194)	(0.183)	(0.207)
Current Eligibility = Disabled	0.181	0.160	0.18	0.195	0.181	0.173	0.231
	(0.161)	(0.146)	(0.158)	(0.159)	(0.167)	(0.155)	(0.182)
Number of unique physicians	196,851	33,883	38,492	61,647	90,496	172,970	33,988
# Physicians 2014	163,298	29,489	29,629	43,770	60,410	140,898	22,400
# Physicians 2018	152,055	22,604	22,520	38,302	68,629	130,921	21,134
Number of unique physician counties	2,250	1,919	1,927	1,441	818	2,209	1,255
# counties 2014	2,156	1,830	1,755	1,248	688	2,120	1,007
# counties 2018	1,984	1,609	1,507	1,190	639	1,924	940

Table 2: Determinants of Days Supplied of Opioids

	(1)	(2)	(3)	(4)	(5)
Group (vs. solo)					
Large	-12.338	-12.19	-11.965	-9.981	-7.67
	(0.666)	(0.554)	(0.498)	(0.480)	(0.674)
Medium	-10.138	-11.484	-11.279	-9.623	-7.443
	(0.683)	(0.500)	(0.456)	(0.444)	(0.668)
Small	-6.559	-8.283	-8.194	-7.158	-5.184
	(0.557)	(0.437)	(0.415)	(0.408)	(0.619)
Hospital-integrated	-4.714	-5.838	-5.849	-5.441	-4.821
(vs. independent)	(0.348)	(0.390)	(0.366)	(0.354)	(0.357)
Provider Age					
30-39				-6.45	-6.171
				(0.245)	(0.238)
40-44				-3.238	-3.016
				(0.215)	(0.211)
45-49				-1.784	-1.627
				(0.195)	(0.191)
50-54				-0.888	-0.788
				(0.195)	(0.194)
55-59				-0.17	-0.101
				(0.203)	(0.203)
60-64				0.356	0.392
				(0.200)	(0.198)
Group Average Age					
30-39					-3.728
					(0.691)
40-44					-4.255
					(0.617)
45-49					-2.7
					(0.557)
50-54					-1.323
					(0.551)
55-59					-1.61
					(0.584)
60-64					-1.249
					(0.617)
Physician County	N	Y	Y	Y	Y
Patient Characteristics	N	N	Y	Y	Y

Notes: Heteroscedasticity-consistent standard errors clustered by county. N = 315,353; All models include year fixed effect; models (4) and (5) include physician HHI and gender.

Figure 1: Effect on Days Supplied of Group Size for Switchers
Δ = 2018 Level – 2014 Level

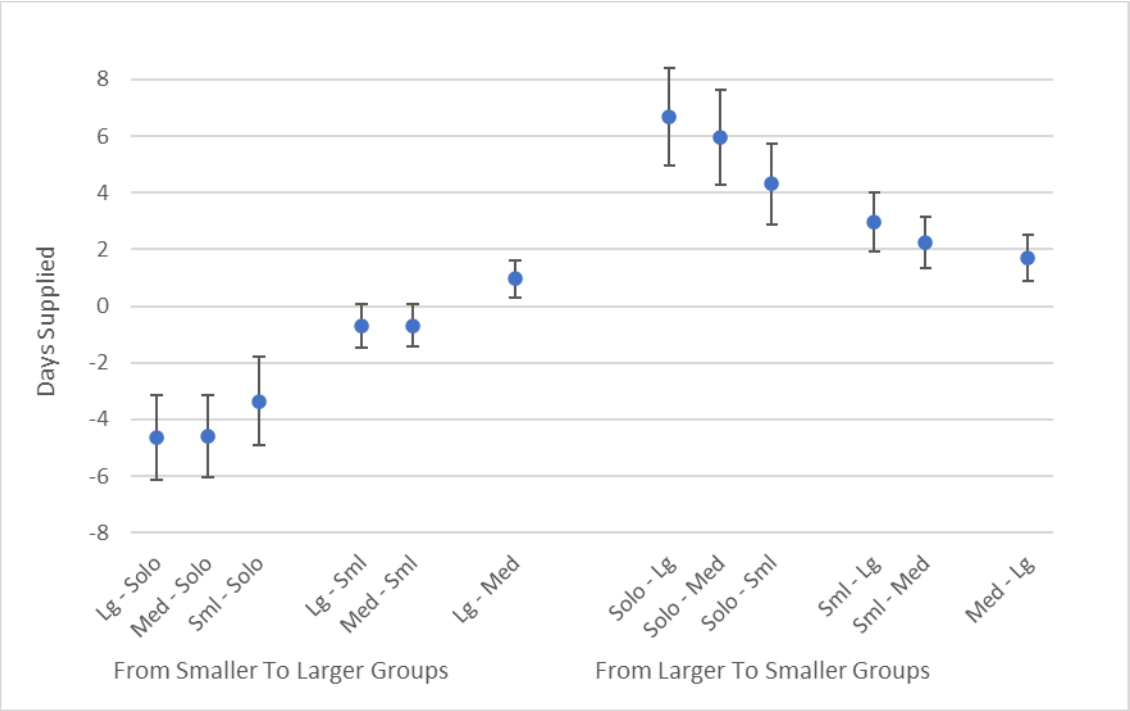


Figure 2: Effect on Days Supplied of Group Size for Stayers
2018 and 2014 Levels

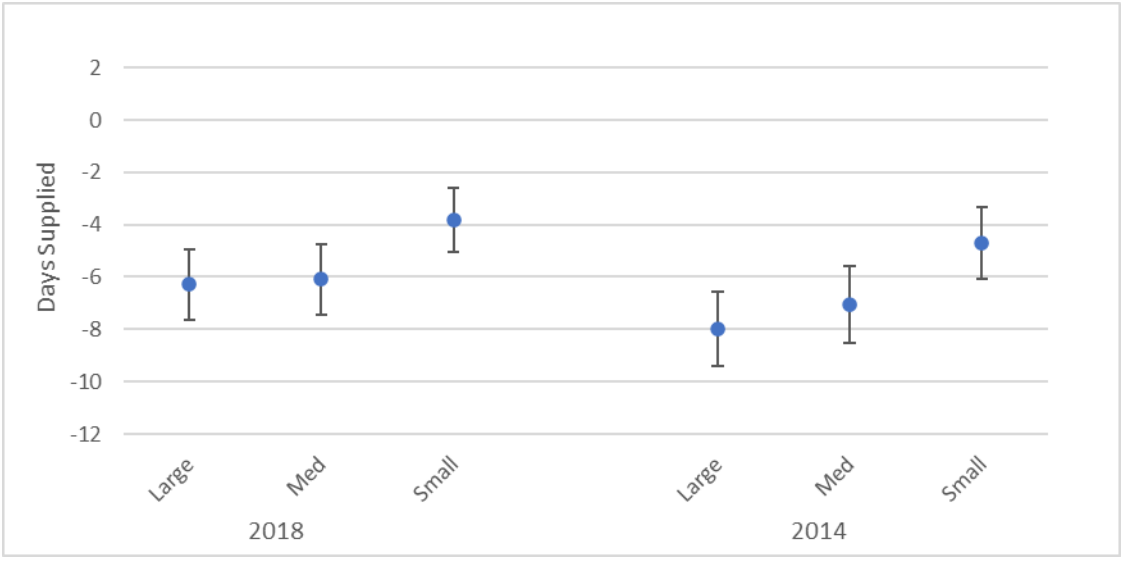


Figure 3: Effect on Days Supplied of Hospital Integration Status for Switchers and Stayers

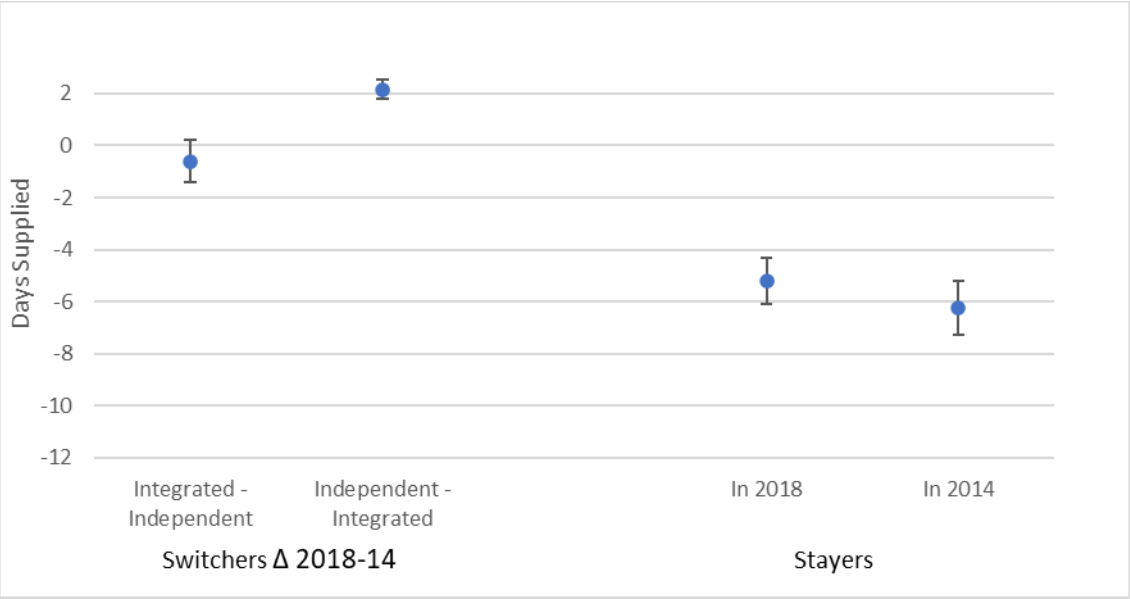


Figure 4: Effect on Days Supplied of Physician's Own Age and Group Average Age

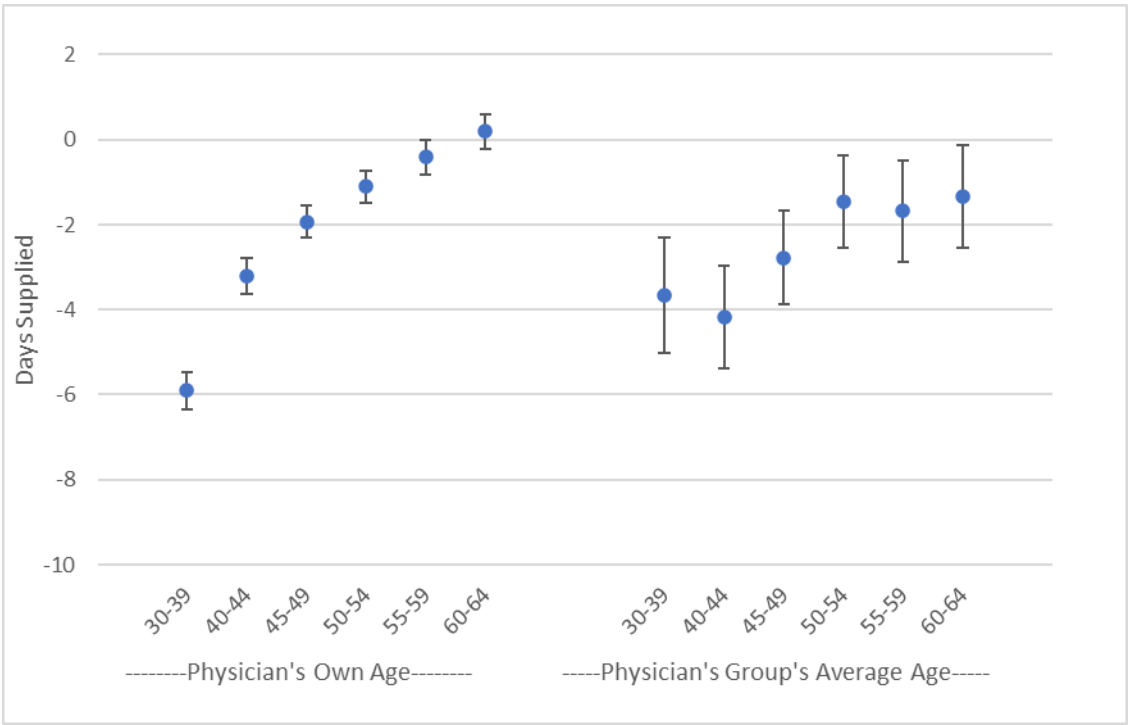


Figure 5: Effect on Days Supplied of Group Size for Switchers
Δ = 2018 Level – 2014 Level, Opioid Prescribers Only

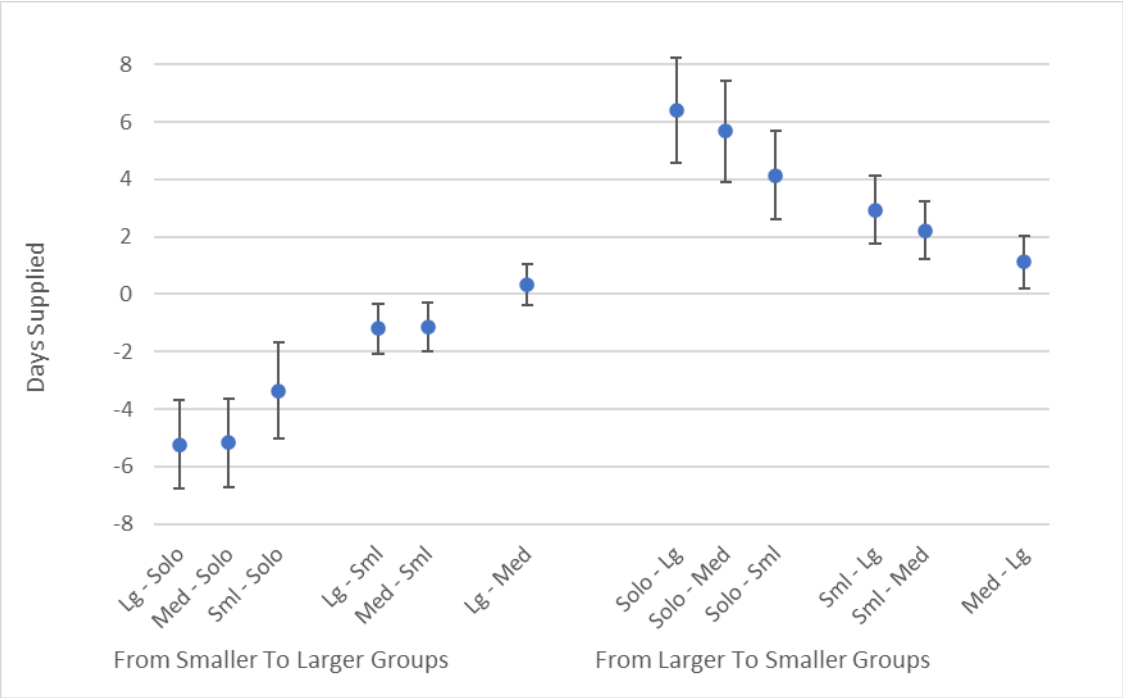


Figure 6: Effect on Opioid/Benzodiazepine Overlap of Group Size for Switchers
Δ = 2018 Level – 2014 Level, Opioid Prescribers Only

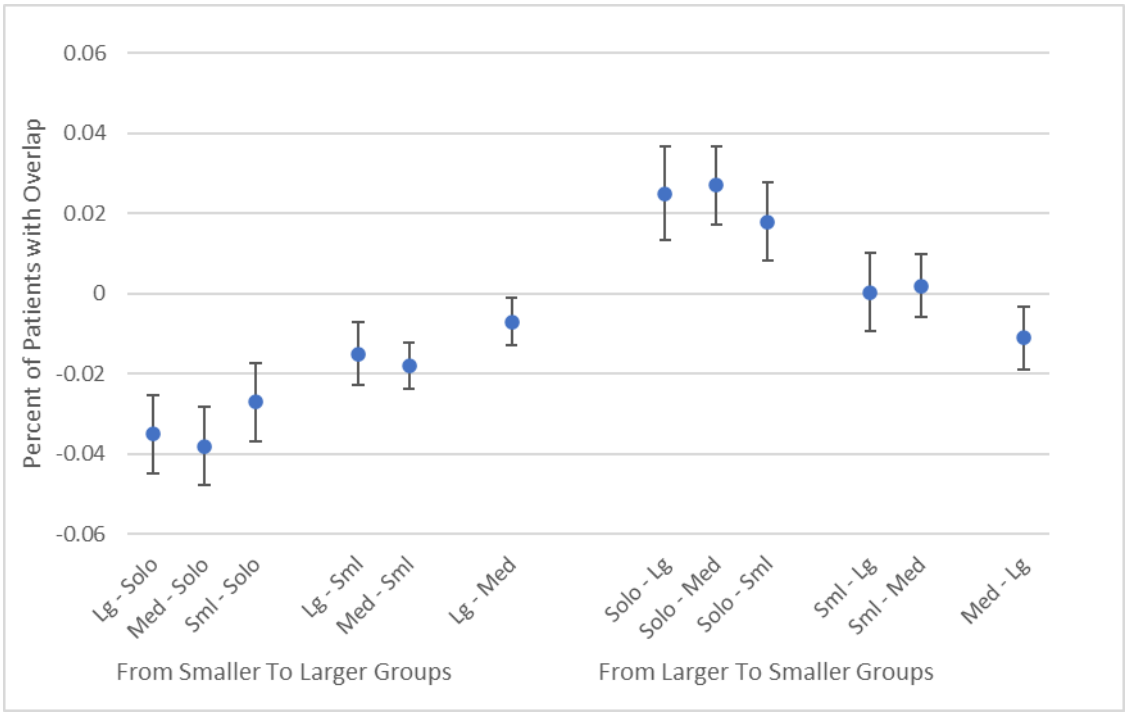
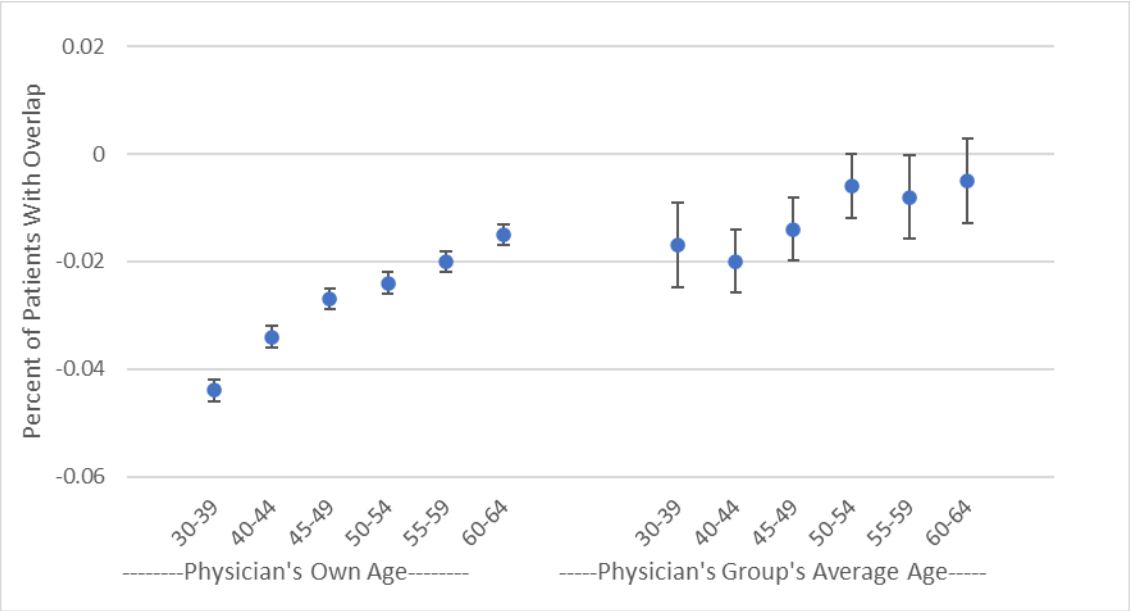


Figure 7: Effect on Opioid/Benzodiazepine Overlap of Physician's Own Age and Group Average Age



Appendix

Chronic Conditions Controls

Acute Myocardial Infarction, Alzheimer's Disease, Alzheimer’s Disease and Related Disorders or Senile Dementia, Anemia, Asthma, Atrial Fibrillation, Benign Prostatic Hyperplasia, Cataract, Chronic Kidney Disease, Chronic Obstructive Pulmonary Disease, Heart Failure, Diabetes, Glaucoma, Hip/Pelvic Fracture, Ischemic Heart Disease, Depression, Osteoporosis, Rheumatoid Arthritis / Osteoarthritis, Stroke / Transient Ischemic Attack, Breast Cancer, Colorectal Cancer, Prostate Cancer, Lung Cancer, Endometrial Cancer, Hyperlipidemia
Hypertension, Acquired Hypothyroidism.

Other Chronic or Potentially Disabling Conditions Controls

ADHD and Other Conduct Disorders, Alcohol Use Disorder, Anxiety Disorder, Autism, Bipolar Disorder, Traumatic Brain Injury and Nonpsychotic Mental Disorders due to Brain Damage, Cerebral Palsy, Cystic Fibrosis and Other Metabolic Developmental Disorders, Major Depressive Affective Disorder, Drug Use Disorder, Epilepsy, Fibromyalgia, Chronic Pain and Fatigue, Sensory - Deafness and Hearing Impairment, Viral Hepatitis (General), Human Immunodeficiency Virus and/or Acquired Immunodeficiency Syndrome (HIV/AIDS), Intellectual Disabilities and Related Conditions, Learning Disabilities, Leukemias and Lymphomas, Liver Disease, Cirrhosis and Other Liver Conditions (excluding Hepatitis), Migraine and other Chronic Headache,Mobility Impairments, Multiple Sclerosis and Transverse Myelitis, Muscular Dystrophy, Obesity, Other Developmental Delays, Overarching OUD Disorder, Diagnosis and Procedure Basis for OUD, Opioid-Related Hospitalization or ED Use of Medication-Assisted Treatment (MAT), Personality Disorders, Post-Traumatic Stress Disorder, Peripheral Vascular Disease, Sickle Cell Disease, Schizophrenia, Schizophrenia and Other Psychotic Disorders, Spina Bifida and Other Congenital Anomalies of the Nervous System, Spinal Cord Injury, Tobacco Use Disorders, Pressure Ulcers and Chronic Ulcers, Sensory - Blindness and Visual Impairment.

Regression Results

	Days Supplied		Days Supplied | Days>0		Overlap	
Group Size						
Large Join	-8.6473	0.7465	-9.0386	0.8020	-0.0657	0.0041
Large Leav	-12.0181	0.8189	-11.2286	0.8305	-0.0643	0.0043
Med Join	-10.0807	0.7307	-10.5970	0.7840	-0.0684	0.0040
Med Leav	-11.5406	0.8007	-11.0564	0.8229	-0.0539	0.0042
Sml Join	-8.4146	0.7923	-8.2648	0.8949	-0.0579	0.0048
Sml Leav	-9.1650	0.7966	-8.4963	0.8288	-0.0382	0.0041
Solo Join	-3.6636	0.7978	-1.7881	1.0115	-0.0108	0.0065
Solo Leav	-1.7877	0.5990	-0.4487	0.6510	-0.0076	0.0032
Switcher(0,1] X 2014	-2.4021	0.5587	-2.6843	0.5770	-0.0086	0.0034
Switcher(0,1] X 2018	-2.0217	0.5383	-2.5735	0.5765	-0.0102	0.0042
Switcher(1,10] X 2014	-6.3289	0.6491	-6.7163	0.6675	-0.0285	0.0038
Switcher(1,10] X 2018	-5.7483	0.7942	-6.0397	0.8492	-0.0351	0.0042
Switcher(10,100] X 2014	-7.9831	0.7609	-8.2452	0.7783	-0.0373	0.0040
Switcher(10,100] X 2018	-7.0040	0.6863	-7.8689	0.7393	-0.0468	0.0040
Switcher>100 X 2014	-8.7084	0.7937	-8.9821	0.8265	-0.0354	0.0048
Switcher>100 X 2018	-7.0279	0.7023	-7.9199	0.7411	-0.0440	0.0042
Stayer(1,10] X 2014	-4.6750	0.6981	-4.7231	0.7181	-0.0175	0.0035
Stayer(1,10] X 2018	-3.8124	0.6190	-4.1835	0.6494	-0.0201	0.0036
Stayer(10,100] X 2014	-7.0648	0.7540	-7.3823	0.7685	-0.0313	0.0037
Stayer(10,100] X 2018	-6.0805	0.6866	-6.8037	0.7248	-0.0404	0.0038
Stayer>100 X 2014	-7.9772	0.7337	-8.0681	0.7439	-0.0426	0.0042
Stayer>100 X 2018	-6.2910	0.6796	-6.7911	0.7075	-0.0462	0.0042
Hospital Integration						
JoinerHowned	-2.6298	0.3937	-2.8584	0.4456	-0.0201	0.0036
JoinerNotHowned	0 (	omitted)	0.0000	(omitted)	0.0000	(omitted)
LeaverHowned	-4.4653	0.4537	-4.7596	0.5316	-0.0255	0.0030
LeaverNotHowned	0 (	omitted)	0.0000	(omitted)	0.0000	(omitted)
SwitcherNotHowned X 2014	-5.0915	0.3987	-4.6697	0.4205	-0.0275	0.0027
SwitcherNotHowned X 2018	-3.5870	0.3779	-3.3262	0.4282	-0.0255	0.0030
SwitcherHowned X 2014	-5.7336	0.4804	-5.5963	0.5065	-0.0281	0.0039
SwitcherHowned X 2018	-5.6882	0.4636	-5.3910	0.5015	-0.0371	0.0032
StayerHowned X 2014	-6.2401	0.5206	-6.2415	0.5496	-0.0340	0.0031
StayerHowned X 2018	-5.1982	0.4480	-5.2690	0.4821	-0.0406	0.0033
pcp_hhi	1.3723	2.1582	2.4192	2.1857	0.0295	0.0173
Physician Gp Age [30,40)	-3.6612	0.6989	-3.7070	0.7191	-0.0167	0.0039
Physn Gp age [40,45)	-4.1733	0.6155	-4.4384	0.6434	-0.0198	0.0032
Physn Gp age [45,50)	-2.7823	0.5603	-2.9100	0.5878	-0.0136	0.0030

Physn Gp age [50,55)	-1.4605	0.5497	-1.5468	0.5896	-0.0065	0.0030
Physn Gp age [55,60)	-1.6829	0.5777	-1.6839	0.6176	-0.0078	0.0032
Physn Gp age [60,65)	-1.3388	0.6134	-1.1504	0.6552	-0.0055	0.0037
Physn age [30, 40)	-5.9052	0.2338	-7.2952	0.2487	-0.0444	0.0015
Physn age [40,45)	-3.2078	0.2167	-4.1180	0.2430	-0.0344	0.0015
Physn age [45,50)	-1.9273	0.1947	-2.7605	0.2117	-0.0274	0.0014
Physn age [50,55)	-1.1137	0.1939	-1.9015	0.2134	-0.0242	0.0013
Physn age [55,60)	-0.4093	0.2053	-1.0462	0.2244	-0.0199	0.0014
Physn age [60,65)	0.1881	0.2005	-0.3957	0.2124	-0.0155	0.0014
Physn gender	-0.8703	0.1080	-0.5407	0.1345	-0.0038	0.0009
prop_spiinj_medicare	-5.2141	2.9711	-9.6074	5.2162	-0.0012	0.0284
prop_ulcers_medicare	-4.8083	0.8120	-8.1087	1.2026	-0.0316	0.0090
prop_visual_medicare	-3.8905	2.0446	-6.8535	3.3475	0.0413	0.0236
prop_toba_medicare	1.7632	1.0117	0.3730	1.6622	-0.0321	0.0081
prop_ptra_medicare	-13.9826	2.0906	-21.2977	3.4649	-0.1298	0.0237
prop_schiot_medicare	-1.4880	1.4151	-2.7105	2.1806	0.0270	0.0170
prop_spibif_medicare	-5.8532	3.5455	-4.9512	5.7300	0.0015	0.0430
prop_obesity_medicare	-7.8120	0.6641	-11.6309	1.0414	-0.0625	0.0064
prop_othdel_medicare	-10.5283	3.2512	-18.5289	5.8529	-0.0851	0.0351
prop_pvd_medicare	4.0734	0.6444	6.8551	0.9388	0.0310	0.0071
prop_psds_medicare	-9.5730	1.9392	-16.3000	3.2670	-0.0153	0.0192
prop_schi_medicare	-13.0775	1.8180	-23.4260	3.1422	-0.0634	0.0216
prop_leuklymph_medicare	-1.3290	1.7666	-1.5238	2.9622	-0.0662	0.0162
prop_liver_medicare	-6.9943	0.8234	-11.3593	1.3861	-0.0578	0.0108
prop_migraine_medicare	-4.8157	1.2957	-5.1102	1.9854	-0.0274	0.0132
prop_mulscl_medicare	-0.7930	3.3160	-0.6087	5.2371	0.0346	0.0320
prop_musdys_medicare	-5.8512	6.6617	4.5746	11.9515	0.0419	0.0710
prop_mobimp_medicare	1.4599	1.0413	3.0438	1.6397	0.0646	0.0142
prop_drug_medicare	3.6960	1.7751	9.3669	2.8776	0.0019	0.0123
prop_hearim_medicare	-6.6152	0.8188	-11.1258	1.2899	-0.0408	0.0100
prop_hepviral_medicare	3.7268	1.6636	8.6924	2.8102	0.0346	0.0150
prop_hivaids_medicare	-7.9433	2.5638	-9.3102	3.4364	0.0447	0.0172
prop_intdis_medicare	-15.7621	1.4251	-27.7487	2.3386	-0.0298	0.0197
prop_leadis_medicare	1.6945	4.2527	1.3189	7.9433	-0.0220	0.0445
prop_brainj_medicare	-4.5525	2.3781	-6.5237	3.8364	-0.0732	0.0273
prop_cerpal_medicare	-5.1584	2.4090	-6.5236	3.8807	0.0357	0.0337
prop_cysfib_medicare	-4.8029	1.9741	-4.6838	3.0810	0.0272	0.0244
prop_depsn_medicare	-0.1425	1.0425	0.3814	1.8845	-0.0293	0.0100
prop_epilep_medicare	-5.0120	1.0782	-11.4427	1.9744	-0.0159	0.0134
prop_fibro_medicare	21.5425	0.9912	33.0871	1.4533	0.0416	0.0065
prop_acp_medicare	9.1768	2.5950	20.7939	4.9654	0.0658	0.0215
prop_anxi_medicare	6.9505	0.9213	11.1381	1.4502	0.2150	0.0086
prop_alco_medicare	-14.0896	1.3629	-23.3889	2.2125	-0.0532	0.0142

prop_autism_medicare	-18.8311	2.9185	-31.0193	5.6542	-0.0893	0.0561
prop_bipl_medicare	-4.5740	1.2573	-8.1842	2.1581	-0.0130	0.0136
prop_cancer_colorectal	-0.7601	1.3278	-1.7401	2.1010	-0.0602	0.0167
prop_cancer_prostate	-0.0817	1.2650	0.3498	2.0480	-0.0088	0.0158
prop_hyperp	-3.1750	0.7231	-5.2928	1.2126	-0.0131	0.0127
prop_hypert	2.8828	0.5636	3.1562	0.9129	0.0089	0.0063
prop_hypoth	-2.4109	0.5776	-1.4097	0.9294	0.0243	0.0063
prop_cancer_lung	0.9608	1.7633	1.4849	2.7313	-0.0272	0.0181
prop_cancer_endometrial	-4.9682	2.5141	-8.2312	3.5424	-0.0258	0.0443
prop_anemia	-2.6360	0.5322	-3.5588	0.8352	-0.0028	0.0052
prop_asthma	-10.2783	0.8159	-16.5584	1.3337	-0.0375	0.0093
prop_hyperl	-7.8063	0.5174	-10.3156	0.7370	-0.0273	0.0052
prop_depression	1.1524	0.8800	0.2226	1.5272	0.0181	0.0090
prop_osteoporosis	-4.1431	0.7007	-4.4836	1.1557	-0.0521	0.0088
prop_ra_oa	11.2932	0.7939	17.5271	1.1936	0.0136	0.0071
prop_stroke_tia	-4.6105	0.8294	-8.7326	1.3594	-0.0386	0.0103
prop_cancer_breast	-0.3814	1.1592	1.1725	1.8598	-0.0270	0.0118
prop_copd	-3.6048	0.6958	-5.2721	1.1927	-0.0284	0.0073
prop_chf	-0.7644	0.6758	-1.1598	1.0852	0.0060	0.0078
prop_diabetes	2.4472	0.5884	3.8456	0.8618	0.0287	0.0058
prop_glaucoma	-2.7343	0.6618	-2.2237	1.1289	0.0268	0.0096
prop_hip_fracture	4.0997	2.0934	4.6424	3.0869	0.0007	0.0217
prop_ischemicheart	-3.3640	0.5847	-5.6152	0.8588	-0.0023	0.0058
prop_ami	-11.3021	1.4723	-22.9494	2.4732	-0.1036	0.0175
prop_alzh	6.2821	1.1936	9.7048	1.8896	0.0508	0.0132
prop_alzh_demen	8.6890	0.8172	13.5386	1.2627	0.0623	0.0091
prop_atrial_fib	-5.7857	0.5980	-9.0085	1.0427	-0.0649	0.0090
prop_cataract	-1.7116	0.5725	-0.3404	0.8805	0.0278	0.0070
prop_chronickidney	-8.7585	0.5856	-13.1443	0.9673	-0.0852	0.0063
prop_dual_elgbl	0.4075	0.4641	-1.2620	0.5826	-0.0418	0.0044
prop_entlmt_rsn_curr	7.8193	1.7883	9.0107	2.8010	0.0369	0.0179
prop_entlmt_rsn_orig	16.9270	0.7566	26.3617	1.1846	0.0498	0.0063
prop_Black	-0.1404	0.6430	-1.6816	0.7745	-0.0799	0.0037
prop_Female	-1.7425	0.4405	-3.9160	0.7017	0.0039	0.0041
prop_65t74	0.2068	1.5994	-3.0517	2.5588	0.0313	0.0168
prop_75t84	-0.2543	1.5891	-4.6945	2.5667	0.0176	0.0163
propt_gt84	3.3138	1.6575	0.3212	2.5806	0.0170	0.0172
prop_lt65	0 (	omitted)	0.0000	(omitted)	0.0000	(omitted)
year = 2018	-6.2056	0.2673	-5.8055	0.2760	-0.0062	0.0022
_cons	22.2049	1.8092	26.7555	2.7014	0.1709	0.0168

References

Avdic D, Ivets M, Lagerqvist B, Sriubaite I, Providers, Peers, and patients. How do physicians' practice environments affect patient outcomes? Journal of Health Economics 2023;89:102741.

Baker LC, Bundorf MK, Kessler DP, The effects of medicare advantage on opioid use, Journal of Health Economics 2020;70:102278.

Baker LC, Bundorf MK, Kessler DP, Does Multispecialty Practice Enhance Physician Market Power?, American Journal of Health Economics 2020;6(3):324-47.

Baker LC, Bundorf MK, Kessler DP, The effect of hospital/physician integration on hospital choice, Journal of Health Economics 2016;50:1-8.

Baker LC, Bundorf MK, Royalty AB, Levin Z, Physician Practice Competition and Prices Paid by Private Insurers for Office Visits, JAMA 2014;312(16):1653-62.

Baker LC, Kessler DP, Vaska GK, The Relationship Between Provider Age and Opioid Prescribing Behavior, American Journal of Managed Care 2022;28(5):223-8.

Baker LC, Pesko M, Ramsay P, Casalino LP, Shortell SM, Are Changes in Medical Group Practice Characteristics Over Time Associated With Medicare Spending and Quality of Care, Medical Care Research and Review 2020;77(5):402-15.

Barnett ML, Olenski AR, Jena AB, Opioid-Prescribing Patterns of Emergency Physicians and Risk of Long-Term Use, NEJM 2017;376:663-73.

Barnett ML, Zhao X, Fine MJ, et al., Emergency Physician Opioid Prescribing and Risk of Long-term Use in the Veterans Health Administration: an Observational Analysis, JGIM 2019;34(8):1522-9.

Beaulieu ND, Chernew ME, McWilliams M, et al., Organization and Performance of US Health Systems, JAMA 2023;329(4):325-35.

Capps C, Dranove D, Ody C, The effect of hospital acquisitions of physician practices on prices and spending, Journal of Health Economics 2018;59:139-52.

Carlin CS, Dowd B, Feldman R, Changes in Quality of Health Care Delivery after Vertical Integration, Health Services Research 2015;50(4):1043-68.

Casalino LP, Ramsay P, Baker LC, et al., Medical Group Characteristics and the Cost and Quality of Care for Medicare Beneficiaries, Health Services Research 2018;53(6):4970-96.

Curton V, Sinaiko AD, Rosenthal MB, Price Effects of Vertical Integration and Joint Contracting Between Physicians and Hospitals in Massachusetts, Health Affairs 2022;41(5):741-50.

Doyle JJ and Staiger B, Physician Group Influences on Treatment Intensity and Health: Evidence from Physician Switchers, NBER WP 2021:29613.

Dunn A and Shapiro AH, Do Physicians Possess Market Power?, Journal of Law and Economics 2014;57:159-93.

Dunn A and Shapiro AH, Physician Competition and the Provision of Care: Evidence From Heart Attacks, American Journal of Health Economics 2018;4(2):226-61.

Eichenmeyer S and Zhang J, Pathways into Opioid Dependence: Evidence from Practice Variation in Emergency Departments, AEJ: Applied 2022;14(4):271-300.

Eichenmeyer S and Zhang J, Primary care providers' influence on opioid use and its adverse consequences, Journal of Public Economics 2023;217:104784.

Fulton BD, Health Care Market Concentration Trends in the United States: Evidence and Policy Responses, Health Affairs 2017;36(9):1530-8.

Finkelstein A, Gentzkow M, Li D, Williams HL, What Drives Risky Prescription Opioid Use? Evidence From Migration, NBER WP 2022: 30471.

Furukawa MF, Kimmey L, Jones DJ, Machta RM, Guo J, Rich EC, Consolidation Of Providers Into Health Systems Increased Substantially, 2016-18, Health Affairs 2020;39(8):1321-5.

Geissler KH, Lubin B, Ericson KMM, The Role of Organizational Affiliations in Physician Patient-Sharing Relationships, Medical Care Research and Review 2020;77(2):165-75.

Godwin J, Arnold DR, Fulton BD, Scheffler RM, The Association between Hospital-Physician Vertical Integration and Outpatient Physician Prices Paid by Commercial Insurers: New Evidence, Inquiry 2021;58:1-10.

Guy GP, Zhang K, Bohm MK, Losby J, Lewis B, Young R., et al., Vital signs: changes in opioid prescribing in the United States,2006-2015. MMWR Morb. Mortal. Wkly. Rep. 2017;66(26):697–704.

Hausman N and Lavetti K, Physician Practice Organization and Negotiated Prices: Evidence from State Law Changes, AEJ: Applied 2021;13(2):258-96.

Ho V, Tapaneeyakul S, Metcalfe L, et al., Using Medicare data to measure vertical integration of hospitals and physicians, Health Services and Outcomes Research Methodology 2020;20:1-12.

Ketcham JD, Baker LC, MacIsaac D, Physician Practice Size and Variations In Treatments and Outcomes: Evidence From Medicare Patients with AMI, Health Affairs 2007;26(1):195-205.

Koch TG, Wendling BW, Wilson NE, The Effects of Physician and Hospital Integration on Medicare Beneficiaries' Health Outcomes, Review of Economics and Statistics 2021;103(4):725-39.

Landon BE, Keating NL, Onnela JP, Patient-Sharing Networks of Physicians and Health Care Utilization and Spending Among Medicare Beneficiaries, JAMA Internal Medicine 2018;178(1):66-73.

McCullough JS and Snir EM, Monitoring technology and firm boundaries: Physician-hospital integration and technology utilization, Journal of Health Economics 2010;29:457-67.

Muhlestein DB and Smith NJ, Physician Consolidation: Rapid Movement From Small To Large Group Practices, 2013-15, Health Affairs 2016;35(9):1638-42.

Neprash HT, Chernew ME, Hicks AL, Gibson T, McWilliams JM, Association of Financial Integration Between Physicians and Hospitals With Commercial Health Care Prices, JAMA Internal Medicine 2015;175(12):1932-9.

Nikpay SS, Richard MR, Penson D, Hospital-Physician Consolidation Accelerated In The Past Decade In Cardiology, Oncology, Health Affairs 2018;37(7):1123-7.

Pope GC and Burge RT, Economies of Scale in Physician Practice, Medical Care Research and Review 1996;53(4):417-40.

Post B, Buchmueller T, Ryan AM, Vertical Integration of Hospitals and Physicians: Economic Theory and Empirical Evidence on Spending and Quality, Medical Care Research and Review 2017:75(4):399-433.

Richards MR, Seward JA, Whaley CM, Treatment consolidation after vertical integration: Evidence from outpatient procedure markets, Journal of Health Economics 2022;81:102569.

Saghafian S, Song LD, Newhouse JP, et al., The Impact of Vertical Integration on Physician Behavior and Health Care Delivery: Evidence from Gastroenterology Practices, NBER WP 2023: 30928.

Schnell M and Currie J, Addressing the Opioid Epidemic: Is There a Role for Physician Education? AJHE 2018;4(3):383-410.

Welch WP, Cuellar AE, Stearns SC, Bindman AB, Proportion Of Physicians In Large Group Practices Continued To Grow In 2009-11, Health Affairs 2013;32(9):1659-66.

Whaley CM, Zhao X, Richards M, Damberg CL, Higher Medicare Spending On Imaging and Law Services After Primary Care Physician Group Vertical Integration, Health Affairs 2021;40(5):702-9.

Young GJ, Zepeda D, Flaherty S, Thai N, Hospital Employment of Physicians In Massachusetts Is Associated With Inappropriate Diagnostic Imaging, Health Affairs 2021;40(5):710-8.

Zhang J, Chen Y, Einav L, et al., Consolidation of primary care physicians and its impact on healthcare utilization, Health Economics 2021;30:1361-73.