Online Appendix For: The Impact of Organizational Boundaries on Healthcare Coordination and Utilization

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I Sample construction

Attributing patients to PCPs We attribute each patient to their plurality PCP in a given year based on the patient's Evaluation & Management (E&M) visit in that year. When the number of E&M visits is tied, we first use the total number of visits; if there is still a tie, we then select randomly.

To index PCP, we adopted the taxonomy classification from Geissler et al. (2020). That classification maps physicians' taxonomy to five groups—primary care, medical specialist, surgical specialist, excluded specialist, non-physician. In this study, we index physicians in the first two groups as PCP.

Identifying PCP exits Our main analysis analyzes two types of PCP exit—relocation and retirement.

To identify PCP relocation events, we first assign each PCP a plurality HRR based on the total number of outpatient visits in a year. About 90% of PCPs only practice in one HRR each year. We then index PCPs whose plurality HRRs changed as relocating PCPs.

To identify PCP retirements, we looked at the national claims sample. If the last year in which the PCP bills any claims is before the end of our study period—2016, the PCP is identified as retired.

Defining concentration measures Both organizational concentration and provider concentration measures are initially constructed using all outpatient Carrier visits. To identify care delivered in an outpatient setting, we restrict to Carrier claims with place of service listed in Appendix Table A9. About 85% of visits measured in the Carrier claim file are classified as outpatient care by this definition.

Defining multispecialty organization By combining claims with the physician specialty taxonomy from Geissler et al. (2020), we develop a definition of a multispecialty organization. For an organization in a year, if at least 10% of claims are with PCPs *and* at least 10% are with non-PCPs, then the organization is indexed as a multispecialty organization.

Utilization decomposition Results reported in Appendix Table A8 decompose total utilization into several components of interest. To investigate the effect of organizational care concentration on different types of utilization, we separate the total utilization into inpatient, outpatient office visits, emergency department, testing and imaging, and other types of outpatient.

- Inpatient utilization: This outcome combines all claims from the Inpatient file, along with Carrier file claims that indicate inpatient hospital place of service (place of service code is "23 Inpatient Hospital").

- Outpatient visits: This outcome combines claims from the Carrier and Outpatient files. Carrier file claims are included here if they do not meet the criteria below for imaging/testing or emergency department care *and* the care was provided in an office or an hospital outpatient department (places of service code equal to "11 Office" or "22 Outpatient Hospital").

- Testing and imaging: This outcome is from the Carrier and Outpatient files. They are constructed using the Berenson-Eggers Type of Service (BETOS) codes and revenue center codes. More specifically, for Carrier claims, an imaging or lab test is a claim with BETOS code starting with "I" or "T" *and* place of service is outpatient. For claims in the Outpatient files, they are included if the revenue center codes are in Appendix Table A10.

- Emergency department: This outcome is based on the Carrier and Outpatient files. For Carrier claims, they are included if the place of service is Emergency room at hospital or the procedures codes indicate emergency department (HCPCS codes 99281-99285). Outpatient claims are included if the revenue center indicates emergency room or professional fee related to emergency room. (i.e. revenue center codes 0450-0459 or 0981)

Preventive care measurement The preventive service outcomes reported in Appendix Table A7 were constructed using HCPCS codes and ICD codes, following the procedure defined by Curto et al. (2019). Some of the preventive services we study are recommended by the US Preventive Services Task Force (USPTF), with age- and/or gender-specific guidelines. For any guideline with evidence level "C" or better, we limit the sample to the USPTF recommended population.[15]

[15]USPTF guidelines are available here: `https://www.uspreventiveservicestaskforce.org/uspstf/topic_search_results?topic_status=P`. Accessed Aug. 12, 2021.

More specifically

- Mammogram: recommended by USPTF for women age 50–74.
  We limit to women ages 65–74.
- Pap smear: not recommended by USPTF for women over 65.
  We limit to women (any age).
- Pelvic exam: not recommended by USPTF for women over 65.
  We limit to women (any age).
- Prostate cancer screening: recommended by USPTF for men age 55–69.
  We limit to men age 65–69.
- Flu vaccine: no USPTF guideline governs flu vaccination, but indicated annually for all ages and genders.
  No sample restrictions.
- Colorectal cancer screening: recommended by USPTF for age 45–84.
  We limit to 65–84.
- Cardiovascular screening: no USPTF guideline exists governing cardiovascular screening of this type (including blood cholesterol level tests.)
  No sample restrictions.

II Organization Identifiers

We use Tax Identifcation Numbers (TINs) to identify organizations in our main analysis, but TINs are not a perfect measure of organizational boundaries. Large health systems could use more than one TIN for payments. Using data from 2016, we compare TIN affiliations with another organization identifier——the Group Practice ID (PAC ID) assigned by PECOS and reported in the Physician Compare file.

For most organizations, we could map the two IDs one-to-one. Among physicians affiliated with one organization, 94.5% of PAC IDs have only one TIN. For the impact of the ID definition on our organizational concentration measure, Appendix Figure A5 shows the percentiles of organizational concentration using the two different identifiers. The dots lay very close to the 45-degree line (the green line), showing that there is a very high correlation between the percentile of TIN and PAC IDs.

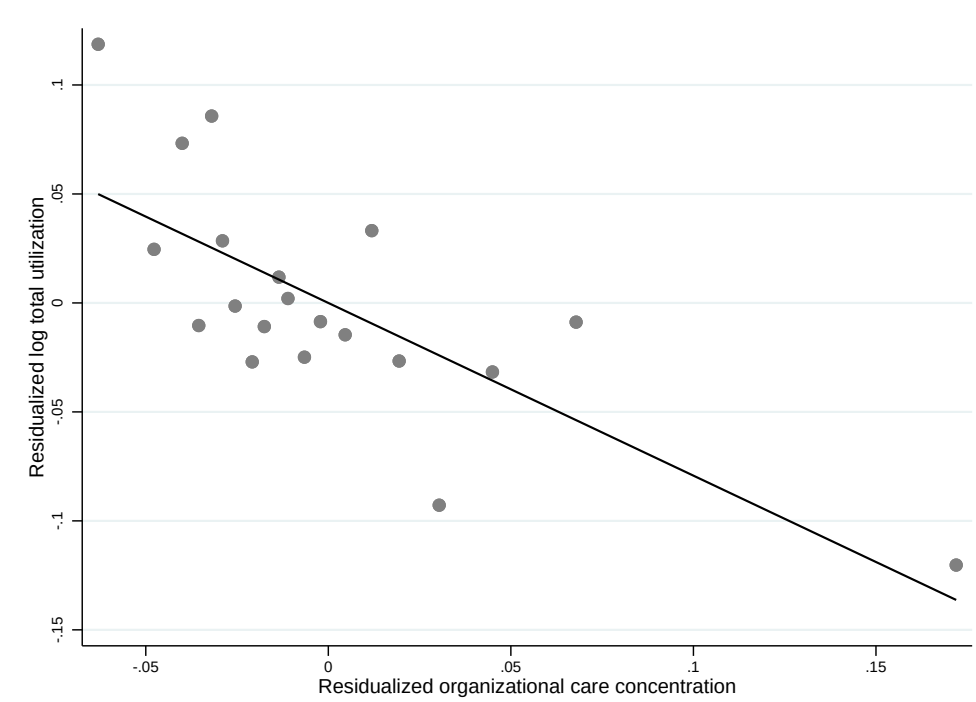
We were particularly concerned about the possibility of ID-induced measurement error for large physician networks. Physician networks often have multiple TINs, although they

contract as a single organization. Based on network comparisons from Geissler et al. (2020), we investigated three large contracting networks in Massachusetts that have the greatest tendency to keep referrals within the network, suggesting a functional organizational identity with practical effects on care patterns. For these three networks, Atrius Health, Fallon Clinic (Reliant Medical Group), and Southcoast Physicians Network, we found 1141, 479, and 433 individual health care providers, respectively. Further, although all three networks have multiple TINs, 98%–99% of claims for affiliated physicians were billed to one TIN for each network. This provides reassuring evidence that TINs provide a useful measure of organizational boundaries that aligns closely with alternative definitions.

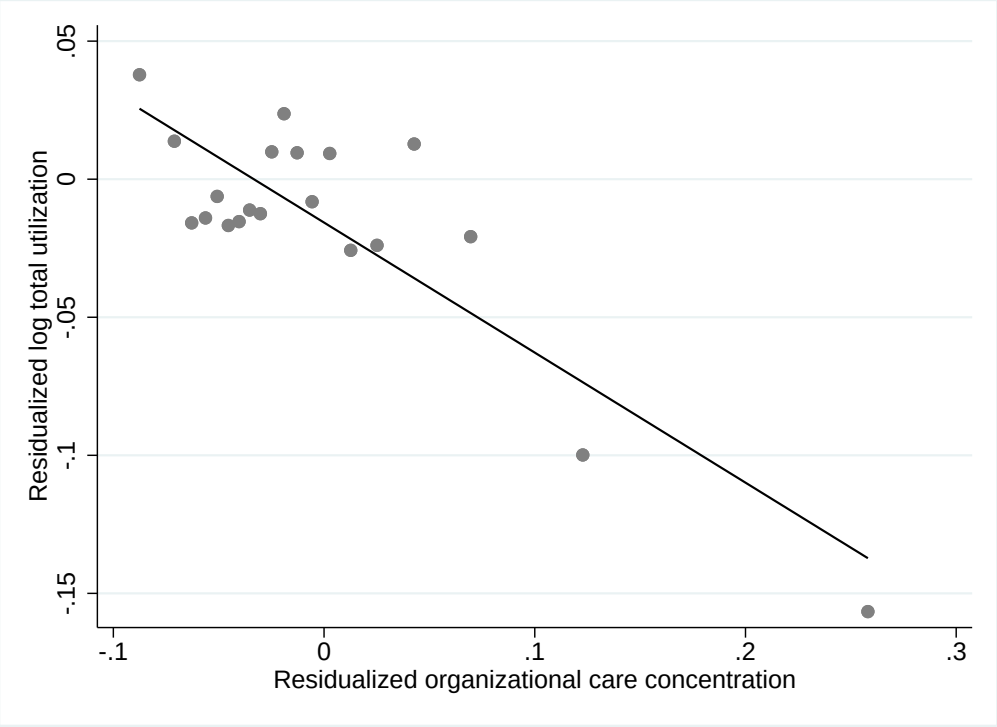
Appendix Tables and Figures

Figure A1: Relationship between Organizational Concentration and Healthcare Utilization (residualized by provider concentration).

(A) HRR level



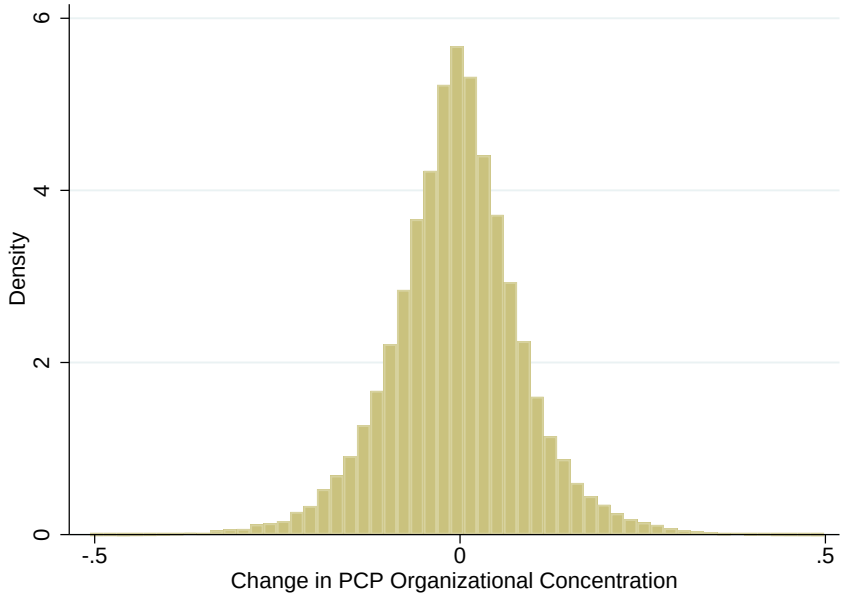
(B) PCP level



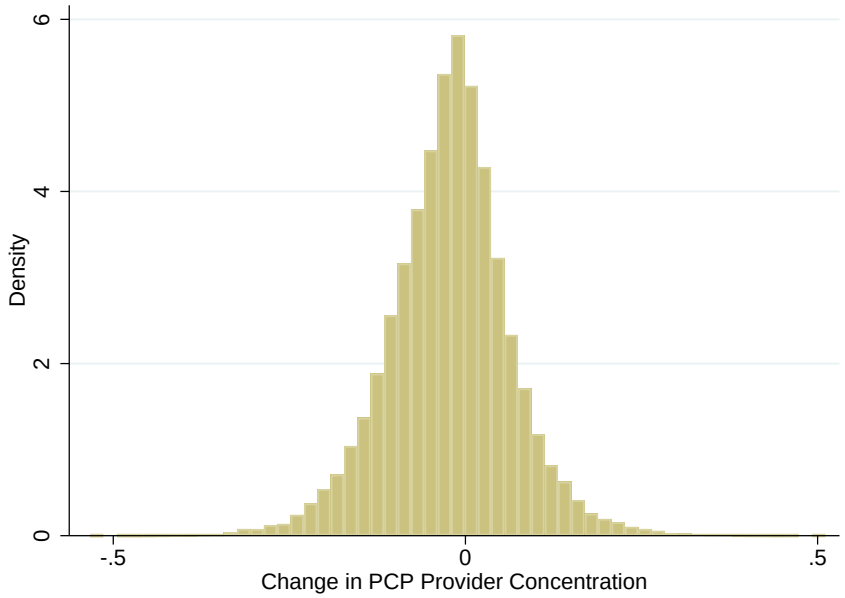
Notes: These binned scatterplots show the relationship between residualized organizational concentration and residualized total healthcare utilization. Panel (A) shows the relationship between these measures averaged at the Hospital Referral Region level. Panel (B) shows the relationship between these measures averaged at the PCP level: an observation is a PCP, and displays the average log utilization and organizational concentration of their attributed patients.

Figure A2: Histograms of change in PCP concentration before and after PCP exit

(A) Distribution of change in PCP Organizational Concentration

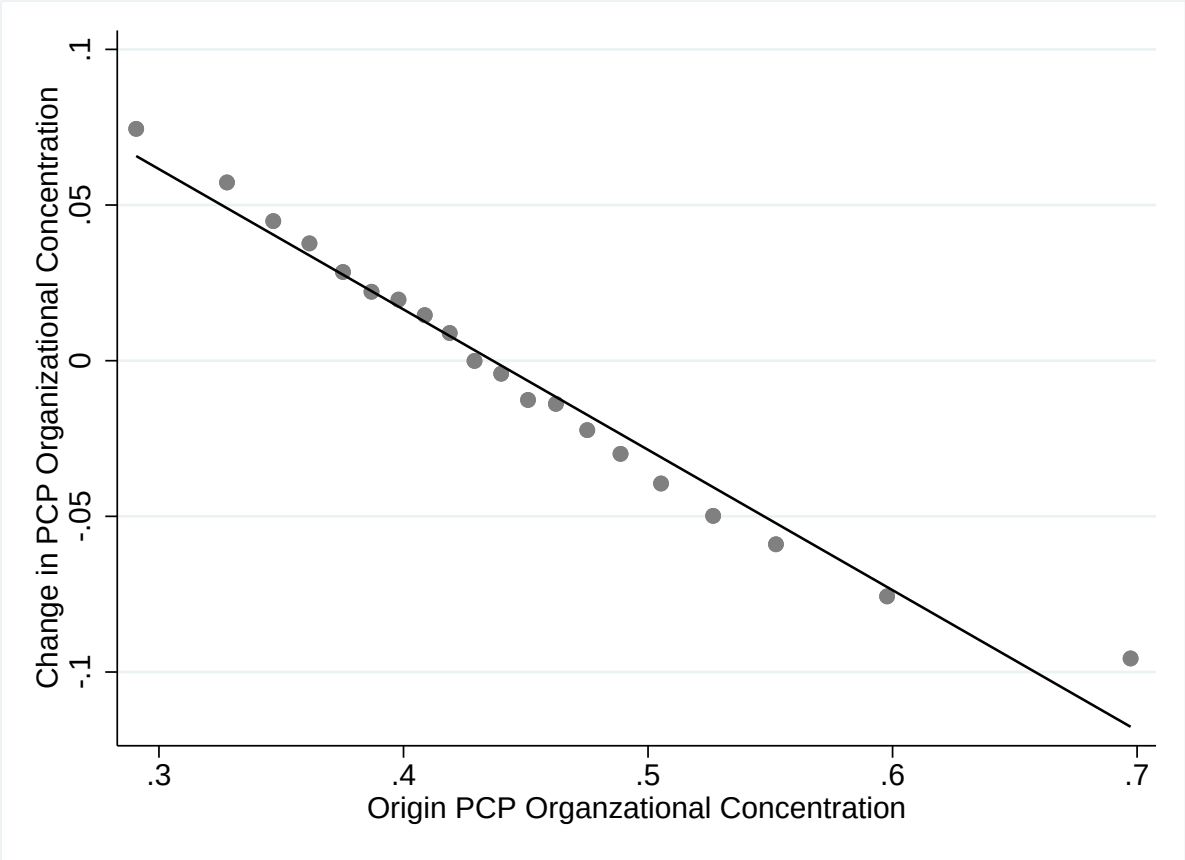


(B) Distribution of change in PCP Provider Concentration



Notes: The two subplots show histograms illustrating the distribution of changes in PCP concentration measures after vs. before PCP exit. These numbers are calculated as the concentration measure of the patient's plurality PCP in the period +1 after their PCP exits minus the concentration measure of their exiting PCP in period -1.

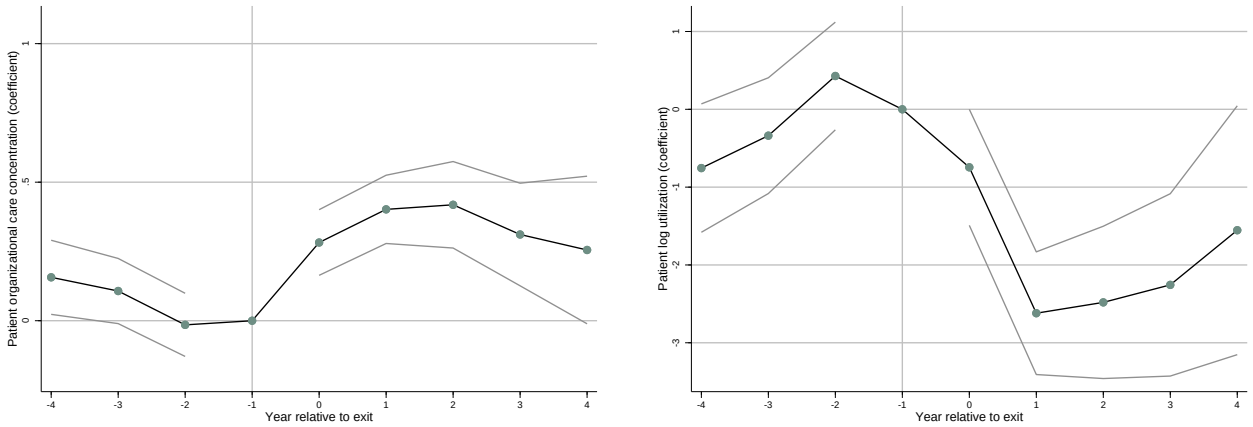
Figure A3: Simple binscatter illustrating the identifying variation



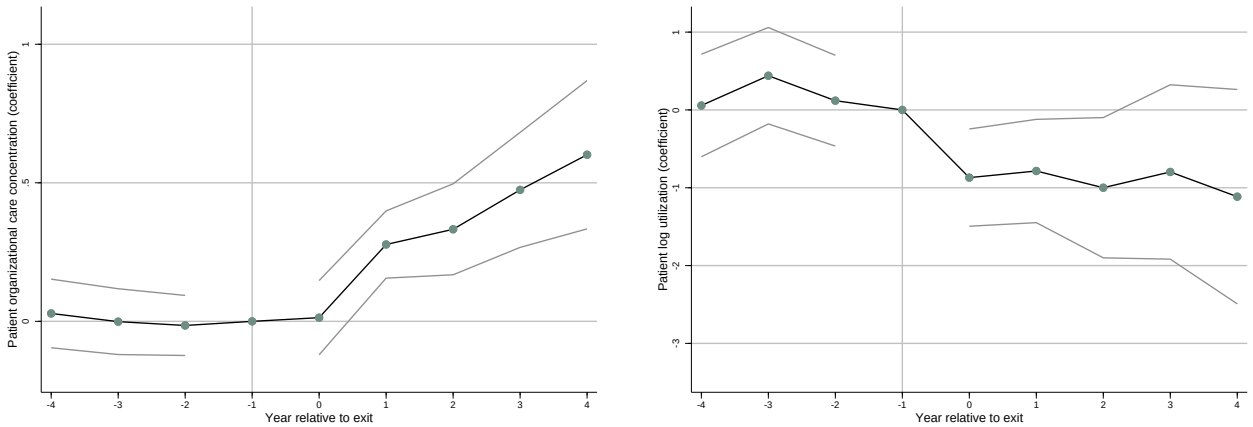
Notes: The figure illustrates the variation underlying the first stage of our IV regressions. It shows that patients whose original PCP has higher organizational concentration on average experience a decrease in their PCP's organizational concentration after the original PCP exits. Panel B illustrates the reduced form, showing that patients whose original PCP had higher organizational concentration on average experience an increase in total utilization after the original PCP exits.

Figure A4: PCP exit event study, split by level of origin PCP concentration

A. Origin PCP has low organizational concentration

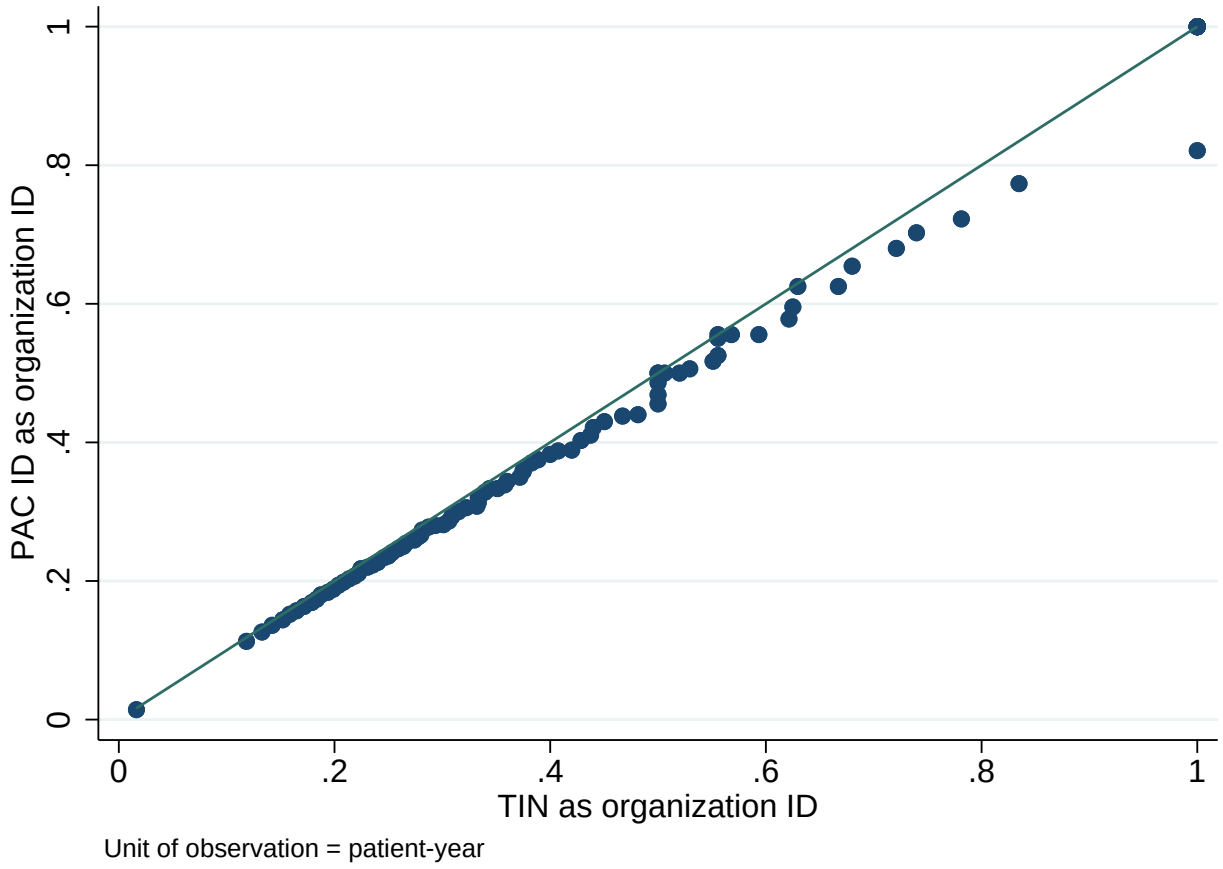


B. Origin PCP has high organizational concentration



Notes: These plots parallel results shown in Figure 5, but estimated on restricted samples. In Panel A, the sample includes only patients whose origin PCP had below-median organizational concentration; these patients are likely to have experienced an increase in organizational concentration after their original PCP exits. In Panel B, the sample includes only patients whose origin PCP had above-median organizational concentration; these patients are likely to have experienced a decrease in organizational concentration after their original PCP exits. Panel A specifications have 175,390 observations; Panel B specifications have 175,392 observations.

Figure A5: Q-Q plot of organizational concentration



Notes: This figure compares the percentiles of organizational concentration measure using PAC ID as organization ID to the percentiles using TIN as organization ID. The line is the 45-degree line. Each dot is a percentile.

Table A1: Standard deviation of concentration measures

	Std. Dev.
A. Patient level	
Organizational concentration	0.244
Provider concentration	0.248
B. PCP level	
Organizational concentration (after E.B. shrinkage)	0.096
Organizational concentration (raw)	0.108
Provider concentration (after E.B. shrinkage)	0.083
Provider concentration (raw)	0.095
C. Hospital referral regional level	
Organizational concentration	0.047
Provider concentration	0.028

Notes: This table summarizes the variation in provider concentration and organization concentration at different levels of aggregation. Panel A reports the standard deviation of patient-level concentration measures (N=9,177,819). Panel B reports the standard deviation of PCP-level concentration measures before and after Empirical Bayes shrinkage (based on 2012 concentration levels for 615,148 PCPs). Panel C reports the standard deviation of region-level concentration measures. In all three panels, there is one observation per patient, so high volume PCPs (in Panel B) and regions (in Panel C) have greater weight in this calculation.

Table A2: Additional specifications of PCP exit analysis

	A. Reduced form results			
	(1)	(2)	(3)	(4)
	$OrgConc_{it}$	$Log(total\ utilization)_{it}$		
$OrgConc^{PCP}_{i,orig} \times post_{it}$	-0.204***	0.733***	0.412***	0.459***
	(0.010)	(0.053)	(0.065)	(0.066)
	B. Difference in differences results			
	(5)	(6)	(7)	(8)
	$OrgConc_{it}$	$Log(total\ utilization)_{it}$		
$\Delta OrgConc_{PCP(i)} \times post_{it}$	0.402***	-1.023***	-0.228***	-0.307**
	(0.010)	(0.058)	(0.083)	(0.087)
PCP provider concentration			X	X
PCP characteristics & org. size				X

Notes: In Panel A, this table shows the results of the reduced form regressions underlying the instrumental variable results reported in Table 3. In Panel B, this table estimates a difference in differences equation without using the instrumental variable strategy to predict variation in the change in organizational concentration after a PCP exit. For the difference in differences specification, the key independent variable of interest is the change in the patient's PCPs' organizational concentration one year after the exit minus one year before the exit. All specifications (in both panels) control for calendar year fixed effects, event time fixed effects, and patient fixed effects. In specifications 1 and 5, the outcome variable is the individual patient's realized organizational concentration and in specifications 2-4 and 6-8 the outcome variable is the patient's log of total utilization. Specifications 3 and 4 include a second instrumental variable: original PCP's provider concentration multiplied by a post indicator. Specifications 7 and 8 also control for the change in PCP provider concentration. Specifications 4 and 8 controls for PCP characteristics: gender, experience quintile indicators, training indicators (internal medicine vs. family practice), and the PCP's organization size (log total number of claims billed to the PCP's TIN, and the log number of unique providers billing to the PCP's TIN). Standard errors have two-way clustering at PCP and patient levels.
*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Table A3: Impact of organizational concentration and provider concentration

Instrumental Variables				
Second stage	(1)	(2)	(3)	(4)
	$ProvConc_{it}$	Log($total\ utilization$)$_{it}$		
$OrgConc_{it}^{PCP}$			-1.625***	-2.385***
			(0.287)	(0.440)
$ProvConc_{it}^{PCP}$	0.787***	-1.880***	-0.652**	0.303
	(0.023)	(0.131)	(0.263)	(0.416)
First stage F-stat.	57,293	57,293	8951	4648
PCP characteristics & org. size				X

Notes: This table reports the results of instrumental variables regressions similar to those reported in Table 3, but now providing further detail on the relationship between PCP provider concentration and care utilization. Column 1 reports a specification similar to that in column 1 of Table 3, but replacing the endogenous and instrumental variables related to PCP organizational concentration with analogous variables describing PCP provider concentration, and changing the outcome variable to be patient-level provider concentration. Columns 3 and 4 are identical to the specifications reported in columns 3 and 4 of Table 3, which include both PCP organizational concentration and PCP provider concentration as endogenous variables, but here we report the coefficient on PCP provider concentration. There are 304,954 patient-year observations. Standard errors have two-way clustering at PCP and patient levels. See notes to Table 3 for further details.
*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Table A4: Instrumental variable analysis of PCP exits, additional controls

Instrumental Variables			
Second stage	(1)	(2)	(3)
	$Log(total\ utilization)_{it}$		
$OrgConc_{it}^{PCP}$	-2.385***	-2.255***	-2.215***
	(0.440)	(0.418)	(0.427)
First stage F-stat.	4648	5073	4882
PCP provider conc.	X	X	X
PCP characteristics	X	X	X
PCP org. size (log)	X		
PCP org. size (5 bins)		X	X
PCP multi-specialty practice			X

Notes: See notes to Table 3. For reference, specification (1) replicates the results reported in (4) of Table 3. Column 2 substitutes the control for number of physicians and number of claims in the organization with 5 quintile indicator variables for each measure of organization size. Column 3 adds a control variable for multi-specialty practice.
*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Table A5: Instrumental variable analysis of PCP exits, alternative functional forms for provider concentration

Instrumental Variables			
Second stage	(1)	(2)	(3)
	$Log(total\ utilization)_{it}$		
$OrgConc_{it}^{PCP}$	-2.385***	-2.366***	-2.929***
	(0.440)	(0.439)	(0.363)
First stage F-stat.	4648	3151	4606
PCP provider concentration	X	X	X
PCP characteristics	X	X	X
PCP organizational size	X	X	X
PCP provider concentration quadratic		X	
Spline N generalists seen by patient			X
Spline N specialists seen by patient			X

Notes: See notes to Table 3. For reference, specification (1) replicates the results reported in (4) of Table 3. In specification (2), we add a quadratic term in PCP provider concentration as an additional endogenous variable. To identify the model, we add an additional quadratic instrumental variable as well: $(OrgConc_{i,orig}^{PCP})^2 post_{it}$. In specification (3), the regression adds new control variables that account for the number of distinct providers each patient sees. Specifically, these specifications control for a 4-knot spline in the number of generalist providers (as defined in Table A1: family practice, internal medicine training, or geriatrics training) and a 4-knot spline in the number of specialist providers (with any other training type). Standard errors have two-way clustering at PCP and patient levels.
*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Table A6: Organizational concentration and repeated imaging

	(1) Mean of dependent variable	(2) Coefficient on $OrgConc_{it}$
Dependent variable:		
Total imaging scans	1.448	-1.504
		(0.987)
Total repeated imaging	0.280	-0.226
		(0.517)

Notes: Each row corresponds to a regression. The specifications match that reported in column (4) of Table 3, but with alternative dependent variables. Sample size is 304,954.

*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Table A7: Organizational concentration and preventive care

	Sample size	Mean of dependent variable	Coefficient on $OrgConc_{it}^{PCP}$
Dependent variable:			
Mammogram †	59,022	0.695	0.352
			(0.615)
Pap smear	189,368	0.144	-0.218
			(0.189)
Pelvic exam	189,368	0.125	0.085
			(0.168)
Prostate cancer screening †	12,605	0.354	0.655
			(1.306)
Flu shot	304,954	0.672	0.261
			(0.216)
Colorectal screening †	242,103	0.163	-0.799***
			(0.183)
Cardiovascular screening	304,954	0.905	0.297
			(0.389)

Notes: Each row corresponds to a regression. The specifications match that reported in column (4) of Table 3, but with alternative dependent variables.
† indicates a type of care that is recommended by the US Preventive Services Task Force for the age and sex group in the regression sample. For more details on the construction of these outcomes see Appendix I.
*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Table A8: Instrumental variable analysis of PCP exits, spending decomposition

			Dependent variable:			
			(1)	(2)	(3)	(4)
	Mean utilization (in $)	Sample with > 0 spending (for col. 3)	Utilization (in $)	Any utilization (indicator)	Log(Utilization) (if > 0)	Log(1+Utilization)
Spending category:						
Total utilization	7517	304,953	-14,088***		-2.385***	-2.387***
			(5399)		(0.440)	(0.440)
Inpatient (hosp. & prof.)	3008	44,245	-5867	-0.085	0.097	-1.107
			(3870)	(0.137)	(1.448)	(1.248)
Outpatient visits (hosp. & prof.)	2346	304,854	-438	-0.010**	-1.707***	-1.767***
			(1924)	(0.004)	(0.357)	(0.358)
Outpatient testing & imaging (hosp. & prof.)	1351	289,979	-4202**	-0.313***	-1.236**	-2.675***
			(1759)	(0.072)	(0.533)	(0.635)
Emergency department	357	76,854	-1009**	-0.273*	-1.787***	-2.365**
			(407)	(0.151)	(0.641)	(1.006)
Other (incl. home health, urgent care, etc.)	454	226,637	-516	-1.581***	-2.825***	-9.579***
			(381)	(0.174)	(0.623)	(1.067)

Notes: See notes to Table 3. This table replicates the instrumental variable specification reported in Table 3 specification (4) with alternative outcome variables that decompose Medicare billing depending on the type of bill. For details on how we define each category of spending, see Appendix I. The full sample size is 304,954; column 3 sample size varies by row and is reported in the table.
*** $p < 0.01$, ** $p < 0.05$, * $p < 0.1$

Table A9: List of place of service codes included as outpatient care

Place of Service Code	Place of Service Name
05	Indian Health Service Free-standing Facility
07	Tribal 638 Free-standing Facility
11	Office
17	Walk-in Retail Health Clinic
20	Urgent Care Facility
22	On Campus-Outpatient Hospital
49	Independent Clinic
50	Federally Qualified Health Center
53	Community Mental Health Center
57	Non-residential Substance Abuse Treatment Facility
58	Non-residential Opioid Treatment Facility
62	Comprehensive Outpatient Rehabilitation Facility
65	End-Stage Renal Disease Treatment Facility
71	Public Health Clinic
72	Rural Health Clinic

Notes: These codes are used to identify claims in the Medicare Carrier File for services that take place in an outpatient facility.

Table A10: List of revenue center codes included as testing and imaging codes

Revenue Center Code	Short description
0300-0319	Laboratory
0320-0329	Radiology diagnostic
0400-0409	Other imaging services
0482	Cardiology-stress test
0483	Cardiology-Echocardiology
0610-0619	Magnetic resonance technology
0730-0749	EKG/ECG
0971	Professional fees-laboratory
0972	Professional fees-radiology diagnostic

Notes: These revenue center codes are used to identify outpatient testing and imaging claims.