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TECHNICAL APPENDIX: STATES WITH HIGHER HOSPITAL SYSTEM PARTICIPATION HAVE LOWER PER CAPITA HOSPITAL SPENDING

We compared the level of hospital system participation across the United States (U.S.) in 2010 and 2014 and describe whether states with high levels of system participation have lower total hospital spending. Geographic variation in healthcare spending has been the subject of intense study, although prior research has not found a significant relationship between hospital market characteristics and state-level healthcare spending capita. We utilized total health and hospital spending per capita data from the National Health Expenditure Accounts (NHEA) and hospital system information from American Hospital Association (AHA) Annual Survey Database.

STUDY DATA AND SAMPLE

We linked state-level per capita hospital spending, hospital system membership, and hospital characteristics for 2010 and 2014. Our analysis focuses on non-federal, short-term, general acute care hospitals in the 50 U.S. states and Washington, D.C. We limited the sample using data from the AHA. To identify non-federal, short-term, general acute care hospitals we used the AHA's control and service codes and long-term/short-term care variables, respectively. Control codes 12 through 16, 21, 23, and 31 through 33 correspond to non-federal government, non-profit, and investor-owned hospitals included in our sample. We included adult general hospitals (service code 10), and excluded children's and specialty hospitals. We limited the sample based on geography using the AHA state code variable (codes 3 (Marshall Islands), 4 (Puerto Rico), 5 (Virgin Islands), 6 (Guam), and 7 (American Samoa) were excluded). Our final dataset includes 4,562 hospitals in 2010 and 4,430 hospitals in 2014, and hospitals were aggregated to the state level. Summary statistics are presented in Table 1.

Our primary data for state-level per capita hospital spending are the 2010 and 2014 per capita state estimates for hospital services (Table 12) from the Centers for Medicare and Medicaid Services (CMS) Office of the Actuary's NHEA by state of residence data series (NHEA-S).(1) This includes per capita state estimates for hospital services from 1991-2014 for all payers. Since CMS provides the NHEA-S estimates in nominal amounts, we adjusted for inflation to 2017 U.S. dollars using the consumer price index for all urban consumers (CPI-U).(2) State of residence estimates account for consumers receiving care in different states, and are thus useful for measuring spending on behalf of persons residing in a particular state.(3)

We derived hospital system membership from the AHA Annual Survey Database for 2010 and 2014.(4) The AHA defines a system as two or more hospitals owned, leased, sponsored, or contract managed by a central organization. We constructed a state-level system participation variable that represents the proportion of total beds that are part of system hospitals within a state. From this measure, we further constructed system participation indicator variables with

low participation defined as states with a proportion below the 25th percentile, medium participation defined as states with a proportion between the 25th and 75th percentiles, and high participation defined as states with a proportion above the 75th percentile in each year.

We included three hospital characteristics motivated by the existing literature in this study—technology level, patient severity, and the cost of labor. Technology is a key growth driver of health care spending.(5) Patient severity has been shown to be an important driver of geographic variation in health care spending.(6) Labor costs represent the largest segment of hospital costs accounting for 50 to 60 percent of total operating revenue.(7)

Technology level, is measured by the state-level average of the hospital-level Saidin index, weighted by hospital inpatient admissions. The Saidin index is derived from the AHA Survey, and represents a weighted sum of services, with weights based on the share of hospitals that do not offer the service in a base year.(8) It increases with the addition of services, and more so with the addition of relatively rare services. As opposed to an unweighted count of services, the Saidin index may better capture services that are new, expensive, or high-technology, and therefore rare. We calculated the Saidin index using 2010 as our base year. Our basket of services included the 134 clinical and non-clinical hospital service variables available in both the 2010 and 2014 surveys, and our base weights are based on the relative rarity of each service in 2010. Following Spetz (2004), we constructed weights as $a_{k,t}$:

$$a_{k,t} = 1 - \left(\frac{1}{N_t}\right) \sum_{i=1}^{N_t} \tau_{i,k,t}. \quad (1)$$

N_t is the number of hospitals in the U.S., and $\tau_{i,k,t}$ is equal to 1 if hospital i has service k in year t and 0 otherwise.(8) These weights were used to construct the Saidin index $S_{i,t}$ for hospital i in year t:

$$S_{i,t} = \sum_{k=1}^{K} a_{k,t}\, \tau_{i,k,t}. \quad (2)$$

Patient severity is measured as the state-level average of the hospital-level transfer-adjusted case mix index (CMI), weighted by hospital inpatient admissions. The CMS reports provider CMIs in annual Fiscal Year Final Rule and Correction Notice Impact Files.(9) A hospital's CMI represents the average diagnosis-related group (DRG) relative weight for that hospital. We constructed average hospital CMI for 2010 and 2014 using transfer-adjusted CMI based on the corresponding year's Grouper (V25 and V35, respectively) reported in the Final Rule or Correction Notice (when available) Impact File with a three-year lag.

Finally, the cost of labor is measured as the state-level average of the hospital-level wage index, weighted by hospital inpatient admissions. The CMS updates the wage index annually, based on a survey of short-term, acute care hospitals and data derived from "the Medicare Cost Report, the Hospital Wage Index Occupational Mix Survey, hospitals' payroll records, contracts, and other wage-related documentation."(10) It is calculated as the ratio of the labor market area's average hourly wage to the national average hourly wage.

ANALYSIS

DESCRIPTIVE ANALYSIS

We first conducted a descriptive analysis to understand the geographic reach of hospital systems. We classified each system into four categories that correspond to broader degrees of geographic reach—a core-based statistical area (CBSA) system, a state system, a regional system and a national system. All hospital members in a CBSA system are located within a single CBSA. In a state system, hospital members span multiple CBSAs, but are located within a single state. In a regional system, hospital members span multiple states, but are located within one of four U.S. Census regions.[1] Finally, a national system is one in which hospital members span multiple Census regions.

Next, we explored whether or not a relationship between system participation (defined as proportion of total beds that are part of system hospitals) and per capita hospital spending exists at the state level in 2010 and 2014. We categorized system participation using three levels in each year— low (below the 25th percentile), medium (between the 25th and 75th percentiles), and high (above the 75th percentile), and spending was categorized as low (below median) or high (above median), for a total of 6 participation-cost categories.[2] Each state was then categorized into their corresponding participation-cost category.

CROSS SECTIONAL ANALYSIS

We estimated models of state-level per capita hospital spending using multivariate linear regression. For each year of data, we regressed per capita hospital spending on the proportion of beds that are part of system hospitals in a state (continuous variable):

$$spending_s = \beta_0 + \beta_1(\%\ system\ beds)_s + Z_s\gamma + \epsilon_s \quad (3)$$

where *s* denotes state, *Z* is a vector of controls. We also considered a model with a set of indicators for quartile of hospital participation:

$$spending_s = \beta_0 + \beta_1 q1_s + \beta_2 q2_s + \beta_3 q4_s + Z_s\gamma + \epsilon_s \quad (4)$$

where *s* denotes state, *q1* is an indicator for states in the top 25th percentile of proportion of system beds, *q2* is an indicator for states in the 50th-75th percentile of proportion of system beds, *q4* is an indicator for states in the bottom 25th percentile of proportion of system beds, and *Z* is a vector of controls.

[1] The four U.S. Census regions are defined as follows: Northeast (Connecticut, Maine, Massachusetts, New Hampshire, Rhode Island, Vermont, New Jersey, New York, and Pennsylvania); Midwest (Illinois, Indiana, Michigan, Ohio, Wisconsin, Iowa, Kansas, Minnesota, Missouri, Nebraska, North Dakota, and South Dakota); South (Delaware, District of Columbia, Florida, Georgia, Maryland, North Carolina, South Carolina, Virginia, West Virginia, Alabama, Kentucky, Mississippi, Tennessee, Arkansas, Louisiana, Oklahoma, and Texas); West (Arizona, Colorado, Idaho, Montana, Nevada, New Mexico, Utah, Wyoming, Alaska, California, Hawaii, Oregon, and Washington).

[2] Median per capita hospital costs were $3,372 in 2014.

To address confounding, we included technology level, patient severity, and labor costs as covariates. Including these controls helps address concerns that our model suffers from omitted variable bias, specifically whether unobserved characteristics drive both per capita spending and system participation simultaneously. We estimated both models using ordinary least squares with robust standard errors. In addition to unweighted regressions, we also estimated regressions weighted by state population obtained from the U.S. Census American Community Survey 5-year estimates, inpatient admissions obtained from the AHA, and total hospital spending obtained from the NHEA-S as robustness checks.(9) Regression results are presented in Table 2. To make our regression results more interpretable, we calculated predicted hospital spending using the results from equation.(4) State-level predicted costs are presented in Table 3. We conducted the same analyses using 2010 data. Results were similar, and are available upon request.

References

1. CMS Office of the Actuary. Health expenditures by state of residence: summary tables, 1991-2014 [Internet]. [cited 2018 Sep 3]. Available from: https://www.cms.gov/Research-Statistics-Data-and-Systems/Statistics-Trends-and-Reports/NationalHealthExpendData/NationalHealthAccountsStateHealthAccountsResidence.html
2. Bureau of Labor Statistics. Consumer price index - all urban consumers, 2010-2017 [Internet]. 2018. Available from: https://data.bls.gov
3. CMS Office of the Actuary. State Health Expenditure Accounts: Methodology Paper, 1980-2014. Baltimore, MD; 2017 Jun.
4. American Hospital Association. AHA Annual Survey Database [Internet]. 2014 [cited 2018 Sep 10]. Available from: http://www.ahadata.com/aha-annual-survey-database-asdb/
5. Smith S, Newhouse JP, Freeland MS. Income, Insurance, And Technology: Why Does Health Spending Outpace Economic Growth? Health Affairs. 2009 Sep;28(5):1276–84.
6. Finkelstein A, Gentzkow M, Williams H. Sources of Geographic Variation in Health Care: Evidence From Patient Migration. The Quarterly Journal of Economics. 2016 Nov;131(4):1681–726.
7. Shactman D, Altman SH, Eilat E, Thorpe KE, Doonan M. The Outlook For Hospital Spending. Health Affairs. 2003 Nov;22(6):12–26.
8. Spetz J, Maiuro LS. Measuring levels of technology in hospitals. The Quarterly Review of Economics and Finance. 2004 Jul;44(3):430–47.
9. Centers for Medicare and Medicaid Services. Final Rule and Correction Notice Data Files, FY2005 and FY2008 [Internet]. [cited 2018 Sep 13]. Available from: https://www.cms.gov/Medicare/Medicare-Fee-for-Service-Payment/AcuteInpatientPPS/FY2018-IPPS-Final-Rule-Home-Page-Items/FY2018-IPPS-Final-Rule-Data-Files.html
10. Centers for Medicare and Medicaid Services. Wage Index [Internet]. 2018. Available from: https://www.cms.gov/Medicare/Medicare-Fee-for-Service-Payment/AcuteInpatientPPS/wageindex.html

Table 1. State-Level Summary Statistics

	2010				2014			
Variable	**Mean**	**Std. Dev.**	**Min**	**Max**	**Mean**	**Std. Dev.**	**Min**	**Max**
Per Capita Hospital Spending (2017 USD)	3,211	641.2	2,190	5,525	3,448	674.6	2,420	5,419
System Participation	0.63	0.16	0.04	0.91	0.69	0.18	0.05	0.96
Saidin Index	40.3	6.3	26.9	52.9	43.8	6.3	31.5	58.2
Transfer Adjusted Case Mix Index	1.62	0.08	1.48	1.83	1.71	0.08	1.55	1.90
Wage Index	1.00	0.14	0.80	1.41	1.00	0.16	0.78	1.52

Notes: Per capita hospital spending data is from NHEA. Hospital characteristics are based on the sample of non-federal short-term general acute care hospitals in the AHA in 2010 and 2014. System participation and the Saidin index are aggregated to the state level using beds as weights and the case mix index is weighted by inpatient admissions. System participation is measured as the share of hospital beds that belong to a hospital system within a state. The Saidin Index is a measure of hospital technology level. Higher values of the Saidin index imply more technologically intensive services. The transfer adjusted case mix index is a measure of patient severity. The wage index is a measure of area differences in the cost of labor.

Table 2. Association Between System Participation and Per Capita Hospital Spending, 2014

Proportion system beds	-1633*** (395)	-1907*** (580)	-1925*** (604)	-1967*** (523)	-1625*** (366)	-1534*** (459)	-1613*** (490)	-1627*** (434)
System Participation, top 25th percentile (q1)†	-496** (232)	-496*** (156)	-481*** (161)	-480*** (161)	-307 (215)	-411** (162)	-443** (175)	-435** (165)
System Participation, 50th-75th percentile (q2)†	-176 (251)	-332* (167)	-291 (175)	-311* (182)	-81 (212)	-80 (153)	-57 (158)	-86 (154)
System Participation, bottom 25th percentile (q4)†	187 (240)	1.0 (270)	34 (255)	67 (233)	431** (201)	12 (184)	33 (182)	36 (185)
Model controls:								
Saidin Index					Yes	Yes	Yes	Yes
Transfer-Adjusted Case Mix Index Wage Index					Yes	Yes	Yes	Yes
Regression weights:								
Total Population		Yes				Yes		
Inpatient Admissions			Yes				Yes	
Total Hospital Spending				Yes				Yes

Notes: The first row provides estimated coefficients from a regression of state per capita hospital spending on proportion of system beds and other controls; rows 2-3 show the estimated coefficients from a regression of state per capita hospital spending on a set of system participation quartile dummies and other controls. The Saidin Index is a measure of hospital technology level. Higher values of the Saidin index imply more technologically intensive services. The transfer adjusted case mix index is a measure of patient severity. The wage index is a measure of area differences in the cost of labor. Robust standard errors are in parenthesis. Results are similar for 2010 data and are available upon request. †Regression results for quartile indicators compared with 25th-50th percentile of system participation (q3). Significance: ***p<0.01, **p<0.05, *p<0.1

Table 3. Predicted Per Capita State Hospital Costs and Model Controls by State, 2014

State	System Participation	Saidin Index	Transfer Adjusted Case Mix Index	Wage Index	Predicted Costs
Alabama	0.76	37.43	1.69	0.78	$3,065.46
Alaska	0.62	38.43	1.81	1.52	$3,841.19
Arizona	0.81	37.32	1.83	1.10	$3,178.84
Arkansas	0.55	34.68	1.65	0.81	$3,316.13
California	0.75	38.18	1.74	1.39	$3,549.80
Colorado	0.76	40.32	1.84	1.01	$3,328.24
Connecticut	0.74	58.17	1.65	1.28	$4,361.02
Delaware	0.67	57.51	1.69	1.09	$4,310.19
District of Columbia	0.78	50.56	1.89	1.02	$3,747.69
Florida	0.79	41.92	1.64	0.92	$3,322.08
Georgia	0.61	39.14	1.71	0.89	$3,457.05
Hawaii	0.89	35.59	1.70	1.20	$3,077.84
Idaho	0.71	42.57	1.79	0.92	$3,448.15
Illinois	0.70	46.60	1.64	1.00	$3,732.58
Indiana	0.75	43.72	1.67	0.97	$3,494.18
Iowa	0.65	44.82	1.69	0.91	$3,668.35
Kansas	0.43	39.49	1.70	0.87	$3,755.73
Kentucky	0.74	36.42	1.63	0.87	$3,127.56
Louisiana	0.69	39.82	1.68	0.81	$3,317.55
Maine	0.62	43.59	1.65	0.99	$3,732.42
Maryland	0.70	47.41	1.61	0.96	$3,739.79
Massachusetts	0.63	48.74	1.63	1.26	$4,118.73
Michigan	0.80	49.14	1.68	0.97	$3,653.39
Minnesota	0.79	47.24	1.84	1.07	$3,630.30
Mississippi	0.55	37.36	1.61	0.78	$3,416.56
Missouri	0.74	47.41	1.73	0.88	$3,593.83
Montana	0.34	43.05	1.80	1.00	$4,131.16
Nebraska	0.52	44.04	1.75	0.93	$3,839.98
Nevada	0.82	33.08	1.84	1.14	$3,008.69
New Hampshire	0.21	48.34	1.68	1.11	$4,669.90
New Jersey	0.69	51.63	1.67	1.25	$4,142.97
New Mexico	0.84	36.24	1.67	0.91	$2,990.66
New York	0.60	54.17	1.68	1.22	$4,376.53
North Carolina	0.86	48.47	1.74	0.89	$3,453.60
North Dakota	0.52	55.57	1.90	1.00	$4,366.88
Ohio	0.78	48.26	1.71	0.90	$3,599.37
Oklahoma	0.73	39.81	1.67	0.85	$3,273.05

State	System Participation	Saidin Index	Transfer Adjusted Case Mix Index	Wage Index	Predicted Costs
Oregon	0.81	39.03	1.85	1.16	$3,306.22
Pennsylvania	0.75	44.94	1.69	0.97	$3,551.39
Rhode Island	0.96	44.50	1.56	1.14	$3,330.86
South Carolina	0.78	43.03	1.71	0.86	$3,337.30
South Dakota	0.85	53.20	1.74	1.00	$3,753.49
Tennessee	0.85	49.63	1.75	0.84	$3,480.09
Texas	0.79	38.08	1.72	0.91	$3,139.10
Utah	0.83	45.40	1.87	0.95	$3,400.77
Vermont	0.05	48.64	1.64	1.02	$4,897.92
Virginia	0.94	47.99	1.70	0.92	$3,330.51
Washington	0.73	39.34	1.78	1.15	$3,444.21
West Virginia	0.54	40.30	1.62	0.81	$3,588.08
Wisconsin	0.65	43.27	1.72	0.99	$3,652.88
Wyoming	0.31	31.54	1.55	1.00	$3,723.74

Notes: Predicted costs are generated from an unweighted regression of state per capita hospital costs on the share of system hospital beds, the Saidin Index, the transfer-adjusted case mix index, and the wage index.