



HEALTH CARE  
COST INSTITUTE

# 2018 - 2019 Healthy Marketplace Index

## **Technical Appendix**

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## Table of Contents

<b>1. SAMPLE CONSTRUCTION .....</b>	<b>1</b>
1.1 Claim Line Inclusion Criteria .....	1
1.1.1 Area Inclusion Criteria .....	1
1.1.2 Member Inclusion Criteria.....	2
1.2 Aggregating claim lines to service claims.....	2
1.3 Claim Inclusion Criteria.....	2
<b>2. SPENDING, USE, PRICE INDEX METHODOLOGY .....</b>	<b>4</b>
2.1 Identifying a Set of Common Services.....	4
2.2 Aggregating Claims to the CBSA, Year, Service Level .....	5
2.3 Calculating Weighted Service Price, Use, and Total Spending for Service Category .....	7
2.4 Using Weighted Measures to Construct Spending, Price and Use Indices for Each Service Category .....	8
2.5 Using Service Category Indices to Construct Overall Indices .....	10
2.6 Using Index Values to Create Reported Measures .....	12
<b>3. INPATIENT HOSPITAL MARKET CONCENTRATION INDEX.....</b>	<b>14</b>
3.1 Defining A CBSA’s Hospital Market .....	14
3.2 Calculating hospital system level Herfindahl-Hirschman Index .....	15
3.3 Defining areas that experienced merger activity.....	17



# 1. Sample Construction

Using HCCI claims data, we constructed a sample of health care services provided in geographic areas across the country in each year. The HCCI claims data are primarily organized at the claim line level. That is, for a service performed, the claim filed is broken up into multiple claim lines. To construct a service level sample from the claim line level data, we aggregated data from all claim lines associated with each service. This aggregated service will be referred to as a service claim.

## 1.1 Claim Line Inclusion Criteria

### 1.1.1 Area Inclusion Criteria

To be included in our sample, a claim line had to be associated with an individual from and a service provided within one of our analysis areas. We performed our analysis at the Core-Based Statistical Area (CBSA) level.

The CBSAs included in the study had to meet certain population, coverage, and utilization criteria. First, the sample CBSAs had to have a minimum average HCCI coverage of 10% over the 5-year period (2012-2016). Yearly HCCI coverage estimates were calculated by dividing HCCI's member years (total member months divided by 12) within a CBSA by the American Community Survey (ACS) 5-year average employer sponsored insurance (ESI) population in that same CBSA.<sup>1</sup> Each sample CBSA had to have an average of at least 25,000 member years in the HCCI data from 2012-2016. Using data from the American Hospital Association (AHA), included CBSAs had to have a minimum of 5 distinct, non-governmental General Medical and Surgical Hospitals. Finally, to comply with HCCI's data masking rules, the sample CBSAs had to have a total of at least 125 admissions, taking place at 3 distinct hospitals within the HCCI data, for every year studied. This resulted in a final geographic sample of 112 CBSAs across 43 states.

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<sup>1</sup> Two different 5-year estimates were provided by the American Community Survey (ACS). For 2012-2014, we used the 2010-2014 5-year ACS estimate as the denominator when determining HCCI percent coverage in that CBSA in each of those three years. For 2015 and 2016, we used the 2012-2016 5-year ACS estimate as the denominator.



## 1.1.2 Member Inclusion Criteria

We included all claim lines associated with members who were both in our study analysis CBSAs and a part of the sample population. For a member month to be included in the sample population, the member, in that given month, needed to be under the age of 65 and have an identifiable gender in the data. Additionally, they had to have ESI, non-individual coverage with one of the following plan types: Health Maintenance Organization, Preferred Provider Organization, Point of Service Plan, or Exclusive Provider Organization. Using these member months, we calculated our sample's member year totals by CBSA and by year to determine the CBSA sample. We subsequently cleaned and analyzed their associated inpatient, outpatient, and professional service claims. In total, the HMI sample spans over 1.78 billion service claims from 132 million member years across the study, 2012 - 2016.

## 1.2 Aggregating claim lines to service claims

We define a service claim as all claim lines for an individual with common dates and service codes. We define service codes distinctly in each high-level service category (inpatient, outpatient, and professional). For inpatient claims, we define a service code as DRG codes. For outpatient and professional claims, we define service codes as the combination of CPT code and CPT code modifier. For the remainder of this document, we use CPT code to refer to the combination of CPT code and CPT code modifier.

When aggregating claim lines to the service claim level, we summed all allowed amounts (the actual amount paid to for the claim) from each claim line associated with a particular service claim. Allowed amounts comprise both the insurer's payment to a provider as well as any out-of-pocket spending (copayments, coinsurance, or deductibles) by the patient. We define the sum of these allowed amounts as the total spending on a service claim.

## 1.3 Claim Inclusion Criteria

We apply distinct inclusion exclusion criteria for claim lines from each service category (inpatient, outpatient, and professional). For inpatient services, we exclude inpatient service claims with overlapping lengths of stays. For example, if the same individual had two claims on the same date (one for a service code indicating Simple Pneumonia and Pleurisy (DRG 193) and another service code indicating Heart Failure and Shock



(DRG 291)) both service claims would be excluded from our sample. We also excluded inpatient service claims where any of the claim lines took place at a non-General Acute Care (GAC) hospital or if they were associated with a pre-Major Diagnostic Category (MDC) code. Included service claims needed to have consistent types of bill codes that indicated an inpatient hospital visit. Service claims were excluded if they did not take place at a GAC, non-governmental, non-military hospital found in the AHA data, or if there were claim lines which indicated the service claim took place at multiple hospitals.

For outpatient services, the sample was limited to service claims that consisted of claim lines with only the following type of bill codes: hospital outpatient, hospital laboratory services, ambulatory surgery center, any of the eight types of clinics (rural health, hospital based or independent renal dialysis center, freestanding, outpatient rehabilitation, comprehensive outpatient rehabilitation, community mental health, federally qualified health, and other), or a freestanding emergency medical facility. We found the number of units most commonly associated with each CPT code in each year. Service claims with unit counts differing from their corresponding CPT code and year combination's mode of units were excluded to ensure reported prices were the price of the most typical visit for that service code in that year.

For professional services, the sample was limited to service claims comprised of office, urgent care facility, inpatient hospital, outpatient hospital, hospital laboratory services, emergency room, ambulatory surgery center, or independent laboratory place of service codes. Similar to the outpatient claims, professional visits had to have the same number of units as their corresponding national mode units to be included. For all three categories, once aggregated to the service claim level, we omitted claims with invalid, ungroupable, missing, or inconsistent service codes.

Additionally, we excluded claims with extreme length of stay or costs. We only included inpatient service claims with lengths of stay under 180 days. Outpatient and physician services had to occur on a single day. Across all categories, we excluded service claims with a total charge amount less than or equal \$1 or a total spending amount (the actual amount paid to the providers including any patient cost sharing) less than or equal to \$1. We also excluded services with a total spending to total charge ratio less than or equal to 20 percent. Finally, the inpatient sample was further trimmed by removing the top and bottom 1% of service claims based off their total spending.



## 2. Spending, Use, Price Index Methodology

Using our sample of service claims, we constructed per capita spending, per capita use, and price indices at the CBSA level. The indices compare how much each CBSA in our sample spent on a representative service code, used a representative service code, and the price paid for a representative service code.

### 2.1 Identifying a Set of Common Services

We constructed a set of common services for each service category (inpatient, outpatient, and professional). To do so, we first aggregated the number of service claims for each service code within each calendar year for each category. We restricted the service codes included in our set of common service codes to meet two criteria: (1) a service code must appear in each year of our data and (2) a service code must be present in at least 80% of CBSAs in our sample. For each category, we then constructed a set of the most common service codes (“common services”) observed in our base year (2012) meeting our inclusion criteria:

- Inpatient Services: the 100 DRG codes with the highest share of nationwide inpatient admissions in 2012
- Outpatient Services: the 500 CPT code with the highest share of nationwide outpatient procedures in 2012
- Professional Services: the 500 CPT code with the highest share of nationwide professional procedures in 2012

We additionally constructed an “overall” set of services as the union of the set of common services for inpatient, outpatient and professional categories. An [accompanying document](#) presents the service codes included in our market baskets for each category. These service codes comprise the majority of all service claims used as well as spending on all service codes by our sample over our time frame:

Year	Overall		Inpatient		Outpatient		Professional	
	Percent of Spending	Percent of Services	Percent of Spending	Percent of Services	Percent of Spending	Percent of Services	Percent of Spending	Percent of Services
2012	63.2%	80.3%	63.0%	78.1%	61.0%	80.1%	64.6%	80.3%
2013	63.0%	80.2%	63.2%	78.6%	60.6%	79.8%	64.4%	80.3%
2014	62.6%	79.2%	62.6%	79.0%	60.3%	78.8%	64.1%	79.3%
2015	62.1%	78.6%	62.1%	79.0%	60.1%	77.2%	63.5%	78.9%
2016	61.6%	78.4%	62.2%	79.0%	59.0%	76.4%	63.1%	78.8%



## 2.2 Aggregating Claims to the CBSA, Year, Service Level

Using our service claim level data set, we calculated the total spending and use for each service code within our sets of common services in each CBSA in each year. We define the total spending on a service code as the sum of the total spending on each service claim for that service code in each CBSA in each year. We define use as the count of claims (i.e., number of times a service code was provided) for a service code in each CBSA in each year. We then define the average price of each service code in each CBSA in each year as the total spending on each service divided by its use. More formally, given each service claim  $c$  in the set of service claims  $C_{gts}$  for each service code  $s$ , in CBSA  $g$ , in year  $t$ , we define these measures as follows:

Total spending per capita on service code  $s$  in CBSA  $g$  in year  $t$

$$PC\ Spend_{tgs} = \frac{Spend_{tgs}}{Avg.Member\ Years_{tg}}; Spend_{tgs} = \sum_{c \in C_{tgs}} Spend_{tgsc}$$

Here,  $Avg.Member\ Years_{tg}$ , refers to the sum of all member months in CBSA  $g$  in year  $t$  divided by 12.

Total use per capita of service code  $s$  in CBSA  $g$  in year  $t$

$$PC\ Use_{tgs} = \frac{Use_{tgs}}{Avg.Member\ Years_{tg}}; Use_{tgs} = \sum_{c \in C_{tgs}} 1$$

Average price on service code  $s$  in CBSA  $g$  in year  $t$

$$\overline{Price}_{tgs} = \frac{PC\ Spend_{tgs}}{PC\ Use_{tgs}} = \frac{Spend_{tgs}}{Use_{tgs}} = \frac{\sum_{c \in C_{tgs}} Spend_{tgsc}}{\sum_{c \in C_{tgs}} 1}$$



We compute these measures at the national level for each year:<sup>2</sup>

Total spending per capita on service code  $s$  nationally in year  $t$

$$PC\ Spend_{ts} = \frac{\sum_{g \in G} Spend_{tgs}}{\sum_{g \in G} Avg.\ Member\ Years_{tg}}$$

Total use per capita of service code  $s$  nationally in year  $t$

$$PC\ Use_{ts} = \frac{\sum_{g \in G} Use_{tgs}}{\sum_{g \in G} Avg.\ Member\ Years_{tg}}$$

Average price on service code  $s$  nationally in year  $t$

$$\overline{Price}_{ts} = \frac{PC\ Spend_{ts}}{PC\ Use_{ts}} = \frac{Spend_{ts}}{Use_{ts}}$$

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<sup>2</sup> Here  $G$  represents the set of all sample CBSAs (defined in Section 1.1.1 of the methodology).





## 2.3 Calculating Weighted Service Price, Use, and Total Spending for Service Category

We computed weighted measures for each service category (inpatient, outpatient, professional Services). We calculated each service code's weight as the total spending (nationally) on that service code divided by the total spending (nationally) on all of our common services in that service code's respective category in our base year, 2012. For a given service code, our service weights should be interpreted as the share of total spending on our set of common services in its respective category. For example, for a knee replacement (an *inpatient* service code), we calculated its weight as the share of spending on our set of common *inpatient* service codes accounted for by knee replacements (nationally) in 2012. More formally, for a service code  $s$  in category  $f$  belonging to our set of common  $f$  services  $S_f$  in our base year (2012), we defined the service weight for service code  $s$  as follows:

$$w_{sf} = \frac{\sum_{g \in G} Spend_{2012gs}}{\sum_{s \in S_f} \sum_{g \in G} Spend_{2012gs}}$$

Using our service weights, we computed weighted price, per capita service use of, and per capita total spending on our common set of services for each category. To do so, we took the weighted product of the average price, per capita use, and per capita total spending on each service code within our set of common services.

Weighted per capita spending for category  $f$  in CBSA  $g$  in year  $t$ :

$$w PC Spend_{tg}^f = \prod_{s \in S_f} [PC Spend_{tgs}]^{w_{sf}}$$

Weighted per capita use for category  $f$  in CBSA  $g$  in year  $t$ :

$$w PC Use_{tg}^f = \prod_{s \in S_f} [PC Use_{tgs}]^{w_{sf}}$$

Weighted price for category  $f$  in CBSA  $g$  in year  $t$ :

$$w \overline{Price}_{tg}^f = \prod_{s \in S_f} [\overline{Price}_{tgs}]^{w_{sf}}$$

These measures can be interpreted as the price of a representative service (within our set of common services) in each category of services, the per person use of that representative service, and the per person total spending on that representative service.



## 2.4 Using Weighted Measures to Construct Spending, Price and Use Indices for Each Service Category

We calculated indices using our weighted measures by comparing the weighted spending, use, and price measures in each CBSA to a national-level, static reference point. To calculate a reference point, we similarly constructed weighted spending, use and price measures at the national level in 2012 (the study's base year).

Weighted per capita spending for category  $f$  nationally in year  $t$ :

$$w PC Spend_{2012}^f = \prod_{s \in S_F} [PC Spend_{2012s}]^{w_{sf}}$$

Weighted per capita use for category  $f$  nationally in year  $t$ :

$$w PC Use_{2012}^f = \prod_{s \in S_F} [PC Use_{2012s}]^{w_{sf}}$$

Weighted price for category  $f$  in nationally in year  $t$ :

$$w \overline{Price}_{2012}^f = \prod_{s \in S_F} \left[ \frac{PC Spend_{2012s}}{PC Use_{2012s}} \right]^{w_{sf}}$$

Using our weighted CBSA level measures and weighted national level measures, we constructed our spending, use and price indices for each medical service category (Inpatient, Outpatient, and Professional Services):

Per Capita Spending Index for category  $f$ :

$$T_{tg}^f = \frac{w PC Spend_{tg}^f}{w PC Spend_{2012}^f} = \frac{\prod_{s \in S_F} [PC Spend_{tgs}]^{w_{sf}}}{\prod_{s \in S_F} [PC Spend_{2012s}]^{w_{sf}}} = \prod_{s \in S_F} \left[ \frac{PC Spend_{tgs}}{PC Spend_{2012s}} \right]^{w_{sf}}$$

Per Capita Use Index for category  $f$ :

$$U_{tg}^f = \frac{w Use_{tg}}{w Use_{2012}} = \frac{\prod_{s \in S_F} [PC Use_{tgs}]^{w_{sf}}}{\prod_{s \in S_F} [PC Use_{2012s}]^{w_{sf}}} = \prod_{s \in S_F} \left[ \frac{PC Use_{tgs}}{PC Use_{2012s}} \right]^{w_{sf}}$$

Price Index for category  $f$ :

$$P_{tg}^f = \frac{w \overline{Price}_{tg}}{w \overline{Price}_{2012}^f} = \frac{\prod_{s \in S_F} [\overline{Price}_{tgs}]^{w_{sf}}}{\prod_{s \in S_F} [\overline{Price}_{2012s}]^{w_{sf}}} = \prod_{s \in S_F} \left[ \frac{\overline{Price}_{tgs}}{\overline{Price}_{2012s}} \right]^{w_{sf}}$$



One convenient property of this methodology is that the per capita spending index is equal to the product of the price and use indices:

$$P_{tg}^f = \prod_{s \in S_F} \left[ \frac{\overline{Price}_{tgs}}{\overline{Price}_{2012s}} \right]^{w_{sf}} = \prod_{s \in S_F} \left[ \frac{\left( \frac{PC\ Spend_{tgs}}{PC\ Use_{tgs}} \right)}{\left( \frac{PC\ Spend_{2012s}}{PC\ Use_{2012s}} \right)} \right]^{w_{sf}} = \frac{\prod_{s \in S_F} \left[ \frac{PC\ Spend_{tgs}}{PC\ Spend_{2012s}} \right]^{w_{sf}}}{\prod_{s \in S_F} \left[ \frac{PC\ Use_{tgs}}{PC\ Use_{2012s}} \right]^{w_{sf}}} = \frac{T_{tg}^f}{U_{tg}^f}$$

$$T_{tg}^f = P_{tg}^f * U_{tg}^f$$



## 2.5 Using Service Category Indices to Construct Overall Indices

In addition to computing spending, use, and price indices for each service category (inpatient, outpatient, and professional services) for each CBSA in each year, we also computed overall spending, use and price indices for each CBSA in each year. We computed our overall indices as the weighted product of the category indices. In other words, the overall price index is the weighted product of our inpatient, outpatient, and professional service price indices.

We weighted the service category level indices by using the share of all medical spending on our set of common services (the union of our set of medical services for each distinct category) accounted for by the spending on our common set of category  $f$  services in our base year (2012):

$$w_f = \frac{\sum_{s \in S_f} \sum_{g \in G} Spend_{2012gs}}{\sum_{f \in \{IP, OP, PH\}} \sum_{s \in S_f} \sum_{g \in G} Spend_{2012gs}}$$

Using these weights, we computed our overall spending, use, and price indices:

Per Capita Spending Index (overall):

$$T_{tg} = \prod_{f \in F} [T_{tg}^f]^{w_f};$$

Per Capita Use Index (overall):

$$U_{tg} = \prod_{f \in F} [U_{tg}^f]^{w_f}$$

Price Index (overall):

$$P_{tg} = \prod_{f \in F} [P_{tg}^f]^{w_f}$$



These overall weighted measures can be thought of as treating the union of the sets of common services for each of the three medical files as one, large set of common services. Note, that our overall measures are mathematically equivalent to the measures computed prior, where we defined our service weight as the share of overall spending on each service code within our overall set common services, and created a weighted measure for our one, common set of services. For example, consider our overall price index:

$$\begin{aligned}
 P_{tg} &= \prod_{f \in \{IP, OP, PH\}} [P_{tg}^f]^{w_f} \\
 &= \prod_{f \in \{IP, OP, PH\}} \left[ \prod_{s \in S_f} \left[ \frac{\overline{Price}_{tgs}}{\sum_{g \in G} \overline{Price}_{2012gs}} \right]^{w_{sf}} \right]^{w_f} \\
 &= \prod_{s \in S_{IP} \cup S_{OP} \cup S_{PH}} \left[ \frac{\overline{Price}_{tgs}}{\sum_{g \in G} \overline{Price}_{2012gs}} \right]^{w_s}
 \end{aligned}$$

Where our service weights are defined as follows:

$$\begin{aligned}
 w_s &= \frac{\sum_{g \in G} Spend_{2012gs}}{\sum_{f \in \{IP, OP, PH\}} \sum_{s \in S_f} \sum_{g \in G} Spend_{2012gs}} = \frac{\sum_{g \in G} Spend_{2012gs}}{\sum_{s \in S_f} \sum_{g \in G} Spend_{2012gs}} * \frac{\sum_{s \in S_f} \sum_{g \in G} Spend_{2012gs}}{\sum_{f \in \{IP, OP, PH\}} \sum_{s \in S_f} \sum_{g \in G} Spend_{2012gs}} \\
 &= w_{sf} * w_f
 \end{aligned}$$



## 2.6 Using Index Values to Create Reported Measures

To facilitate interpretation of our spending, use, and price indices, we report index values as the percent of the national average in each year and the cumulative growth within each CBSA relative to the base year. Below, we use the price index as an example for how we can compute these measures given our index values. One could analogously compute similar measures using our per capita spending and use indices.

Percent of National Median

$$\begin{aligned}
 Pct. Natl. Avg. \quad t_g &= \frac{P_{tg}^f}{P_{tM}^f} = \frac{\left( \frac{w \overline{Price}_{tg}}{w \overline{Price}_T} \right)}{\left( \frac{w \overline{Price}_{tM}}{w \overline{Price}_T} \right)} = \frac{w \overline{Price}_{tg}}{w \overline{Price}_{tM}} = \frac{\prod_{s \in S_F} [\overline{Price}_{tgs}]^{w_{sf}}}{\prod_{s \in S_F} [\overline{Price}_{tMs}]^{w_{sf}}} \\
 &= \prod_{s \in S_F} \left[ \frac{\overline{Price}_{tgs}}{\overline{Price}_{tMs}} \right]^{w_{sf}}
 \end{aligned}$$

We divide the index value for each CBSA  $g$  by the index value for the median CBSA  $M$  in each year. Note that this value is equivalent to the weighted product of the price ratio for each service code in our set of common services for a particular CBSA relative to the median CBSA.

Percent of 2012

$$\frac{P_{tg}^f}{P_{2012g}^f} = \frac{\left( \frac{w \overline{Price}_{tg}}{w \overline{Price}_{2012}} \right)}{\left( \frac{w \overline{Price}_{tg}}{w \overline{Price}_{2012}} \right)} = \frac{w \overline{Price}_{tg}}{w \overline{Price}_{2012g}} = \frac{\prod_{s \in S_F} [\overline{Price}_{tgs}]^{w_{sf}}}{\prod_{s \in S_F} [\overline{Price}_{2012gs}]^{w_{sf}}} = \prod_{s \in S_F} \left[ \frac{\overline{Price}_{tgs}}{\overline{Price}_{2012gs}} \right]^{w_{sf}}$$

To compare the changes in a CBSA's prices over time, we compute the ratio between a CBSA's price index value in a given year to the index value in our base year (2012). Note that this is equivalent to taking the weighted product of the price growth for each service code within the CBSA between the given year and our base year in our set of common services.



### Comparing Two Index Values

$$\frac{P_{tA}^f}{P_{tB}^f} = \frac{\left(\frac{w \overline{Price}_{tA}}{w \overline{Price}_{2012}}\right)}{\left(\frac{w \overline{Price}_{tB}}{w \overline{Price}_{2012}}\right)} = \frac{w \overline{Price}_{tA}}{w \overline{Price}_{tB}} = \frac{\prod_{s \in S_F} [\overline{Price}_{tAs}]^{w_{sf}}}{\prod_{s \in S_F} [\overline{Price}_{tBs}]^{w_{sf}}} = \prod_{s \in S_F} \left[\frac{\overline{Price}_{tAs}}{\overline{Price}_{tBs}}\right]^{w_{sf}}$$

We can also compare the price levels between two CBSAs by taking the ratio of their index values. (In this example, we compare CBSAs *A* and *B*). Note that this ratio is equivalent to the weighted product of the price ratio between the two CBSAs for each service code in our set of common services.



## 3. Inpatient Hospital Market Concentration Index

Limiting our full sample only to those claims that occurred at an inpatient facility, we constructed a Herfindahl-Hirschman Index (HHI) measure at the CBSA level. These index values are intended to provide descriptive, relative comparisons of the inpatient facility market concentration between the CBSAs within our sample. A high HHI level indicates high market concentration in the area, which typically signifies a lack of local market competition.

### 3.1 Defining A CBSA's Hospital Market

Our concentration measure is best thought of as a “patient-flow” HHI where we treat the market as the set of hospital systems at which patients from a particular CBSA receive care. More formally, for CBSA  $g$  in year  $t$ , we consider the market to consist of all hospitals to which individuals who reside in CBSA  $g$  in year  $t$  are admitted.

Previous work has argued that “patient flow” concentration measures are more robust to the use of alternative geographic market definitions than a “geographic-based” concentration measures – where a market defined as all providers located within a geographic area.<sup>3</sup>

It is important to note that our HHI measures for each CBSA were calculated based on market definitions that were not chosen to represent product markets suitable for regulatory or antitrust enforcement purposes. Rather, our geographic measures were chosen to weigh both the relevance of our HHI measure to a broad spectrum of research and policy evaluations and our ability to publicly report an HHI measure at a local level. As such, our measures should not be used or interpreted to inform regulatory or antitrust conclusions.

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<sup>3</sup> John Graves, “Defining Markets for Health Care Services,” health-care-markets, accessed August 20, 2019, <https://graveja0.github.io/health-care-markets/>.





## 3.2 Calculating hospital system level Herfindahl-Hirschman Index

Given our market definition, we compute an HHI measure as the sum of squared hospital system shares of inpatient admissions for individuals from CBSA  $g$  in year  $t$ . To do so, we first count admissions for each hospital  $h$  in system  $s$  for members from CBSA  $g$  in year  $t$  for the set of hospitals to which they are admitted:

$$Admits_{hsgt} = \sum_{a \in A_{hsgt}} 1_{ahsgt}$$

Here,  $A_{hsgt}$  represents the set of admissions at hospital  $h$  in system  $s$  for individuals for members from CBSA  $g$  in year  $t$ .

Next, we sum the count of admissions for each hospital  $h$  in system  $s$  for members from CBSA  $g$  in year  $t$  to the system level.

$$Admits_{sgt} = \sum_{h \in H_{sgt}} Admits_{hsgt}$$

Here,  $H_s$  represents the set of all hospitals  $h$  admitting members from CBSA  $g$  belonging to system  $s$  in year  $t$ .<sup>4</sup> If a hospital does not belong to a system, we treat the hospital as its own system ( $Admits_{sgt} = Admits_{hsgt}$ ).

Finally, we can count all admissions for members from CBSA  $g$  in year  $t$ :

$$Admits_{gt} = \sum_{a \in A_{gt}} 1_{agt}$$

Note that the set of admissions for members from CBSA  $g$  in year  $t$  ( $A_{gt}$ ) is equivalent to the union of sets of admissions for each hospital  $h$  in system  $s$  for individuals from which members of CBSA  $g$  are admitted in year  $t$ :

$$A_{gt} = \bigcup_{h \in H_{gt}} A_{hsgt} ; H_{gt} = \bigcup_{s \in S_{gt}} H_{sgt}$$

Here,  $S_{gt}$  represents the set of hospital systems containing at least one hospital which admits a member from CBSA  $g$  in year  $t$ .

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<sup>4</sup> This is equivalent to expanding the set of hospitals  $h$  in system  $s$  to include all hospitals in system  $s$  in year  $t$ , regardless of whether they admit individuals from CBSA  $g$ .



Given these system level admission counts, we can compute our HHI measure as the sum of squared system shares of admissions for members from CBSA  $g$  in year  $t$ :

$$HHI_{gt} = \sum_{s \in S_{gt}} \left[ \frac{Admits_{sgt}}{Admits_{S_{gt}}} \right]^2$$

As before,  $S_{gt}$  represents the set of hospital systems containing at least one hospital which admits a member from CBSA  $g$  in year  $t$ .



### 3.3 Defining areas that experienced merger activity

Due to our use of patient-flow data, our HHI measure could vary for many reasons – some of which may be unrelated to market consolidation. For example, a market could maintain the same number of hospitals, systems, and beds/practitioners in each hospital – yet our HHI could vary from year to year.

In order to look at markets where changes in HHI were more plausibly related to market consolidation, we identified CBSAs in our sample where there was hospital merger activity. To determine whether a CBSA experienced hospital merger activity, we used publicly available data from the Health Care Pricing Project.<sup>5</sup> These data were alongside Cooper et al. (2018) which explores variation in commercial and Medicare prices across the country.<sup>6</sup>

Using these data, we identified all CBSAs which contained at least one hospital system with both an acquiring hospital and an acquired (“target”) hospital in either 2013 or 2014. This allowed us to identify CBSAs in which a hospital system acquired another hospital in the same CBSA between 2012 and 2014. We labeled these CBSAs as experiencing merger activity between 2012 and 2014.

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<sup>5</sup> On the *Health Care Pricing Project* website, the data set we used is publicly available as “Merger Data”.

<sup>6</sup> Cooper, Zack, Stuart V. Craig, Martin Gaynor, and John Van Reenen. “The price ain’t right? Hospital prices and health spending on the privately insured.” *The Quarterly Journal of Economics* 134, no. 1 (2018): 51-107. <https://academic.oup.com/qje/article-abstract/134/1/51/5090426>.