HEALTH CARE
COST INSTITUTE

2020 Healthy Marketplace Index

Technical Appendix

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Introduction

Health care spending in the United States has risen dramatically over recent decades and is projected to continue growing into the future. While this trend holds nationally, there is an increasing body of evidence that the sources of both health care spending levels and growth vary dramatically across the country. It is therefore important to understand the factors associated with health care spending in different areas, and how these factors have and may continue to change over time.

The ***Healthy Marketplace Index (HMI)*** reports a series of metrics which can be used to assess the economic performance of local commercial health care markets. These metrics are intended to facilitate comparable and consistent assessments of health care market performance both across markets and within markets over time. These metrics are additionally intended to be transparent, both in their availability through public use files, and in their construction through a comprehensive methodological documentation.

This document describes how we use Health Care Cost Institute (HCCI) commercial claims database to construct our HMI metrics. From HCCI data, we construct a sample containing the health care claims for individuals receiving commercial health insurance through their employer from 2013 – 2017 residing in one of our 124 sample metro areas across 42 states. These data contain more than 2.9 billion claims from 2013-2017 from more than 30 million individuals annually.

Using our analytic sample of claims, we construct indices of metro area health care spending (“Spending Index”), average health care service prices (“Price Index”), volume of health care services used (“Use Index”), and the cost of the mix of services used (“Service Mix Index”). We construct each of these metrics both at a metro area level, as well as by high level service category (Inpatient, Outpatient, Professional Services) in each metro. Separately, we also construct a measure of inpatient hospital market concentration for each metro area (“Concentration Index”).

We graciously acknowledge continual financial support for this project from the Robert Wood Johnson Foundation.

1. HCCI Claims Data to Construct an Analytic Sample of Claims

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. Our analytic sample consisted of cleaned service claims from enrollees residing in our sample geographic regions (regardless of where services were provided).

1. 1. Defining a Sample Population of Members

Using monthly enrollment data, we constructed a sample of member month observations. 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 age and gender in the data. We also limited our sample of member months to individuals with an identifiable five-digit zip code.

Additionally, we restricted our analysis to member months for individuals with coverage through an employer-sponsored insurance (ESI) plan. Specifically, we limited our sample to individuals with either small or large group commercial insurance coverage with one of the following plan types: Health Maintenance Organization, Preferred Provider Organization, Point of Service Plan, or Exclusive Provider Organization.

1. 2. Assigning Member Months to Core-Based Statistical Areas

Our geographic unit of analysis is the Core-Based Statistical Area (CBSA). Using monthly enrollment data, we mapped the five-digit zip code associated with each member month to a CBSA. Because CBSA definitions change over time, we used a single five-digit zip code to CBSA crosswalk regardless of the year so that a CBSA in our data refers to the same geographical region across time.

To construct our geographic crosswalk, we used a five-digit zip code to CBSA crosswalk constructed by the United States Department of Housing and Urban Development (HUD) from our base year (2013).[1] In cases where a zip code is assigned to multiple CBSAs, we assigned zip codes to the CBSA with the greatest "Total Ratio" followed by the greatest "Residential Ratio".

We also mapped five-digit zip codes to states using the National Bureau of Economic Research's "SSA to FIPS State and County Crosswalk" from our base year (2013).[2]

Member months associated with zip codes that do not match either a CBSA or state from the crosswalk were omitted. Member months whose zip codes matched a state but not a CBSA were assigned to the CBSA "Rest of State – [State Abbreviation]".

We assigned each CBSA to a single state based on the state with the largest share of member months observed in our sample within each CBSA.

1. 3. Aggregating Claim Lines to Claim Level

Prior to aggregating claim lines, we merged on enrollment information based on the month and year in which a claim line occurred – as defined by the dates associated with each claim line. We excluded all claim lines associated with member months that were

[1] Specifically, we use the crosswalk titled "ZIP-CBSA" from the 4th quarter of 2013. Available online from the HUD website: https://www.huduser.gov/portal/datasets/usps_crosswalk.html
[2] Available online from the NBER website: https://data.nber.org/data/ssa-fips-state-county-crosswalk.html

not part of our sample population. We assign each claim line to the CBSA and state associated with the five-digit zip code attached to the relevant member month.

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 the these allowed amounts as the total spending on a service claim.

1. 4. Cleaning Claims to Construct Analytic Sample

We applied separate cleaning procedures inpatient, outpatient, and professional service claims to remove outlier claims.

Inpatient Claims (Admissions)

Our unit of analysis for inpatient service claims were inpatient admissions defined by a combination of year, patient, service code (DRG), and visit dates.

We identified the inpatient facility associated with each claim by encrypted National Plan and Provider Enumeration System Identifiers (NPI). As some inpatient facilities may be assigned multiple NPIs, we mapped all associated NPIs with each facility to a single consolidated, encrypted NPI (cNPI). We excluded claims if they were associated with multiple, non-missing cNPIs across claim lines. Remaining claim lines with missing consolidated cNPIs were assigned the non-missing cNPI within the admission. If a claim contained all missing cNPI values, we assigned it a cNPI of "blank".

Claims were excluded if they contained claim lines with major-diagnostic category (MDC) codes signifying a non-General Acute Care (GAC) hospital discharge or pre-MDC discharge. Claims were excluded if they contained claim lines with unknown or unidentifiable DRG codes. Claim lines with missing DRG values were assigned the non-missing DRG value within the claim. Claims entirely made up of claim lines with missing DRGs were excluded. Claims were excluded if any claim line did not have an inpatient hospital type of bill code.

Claims with lengths of stay over 180 days were excluded as were admissions with discharge dates preceding first admission dates. Claims were excluded with charges less than 1 dollar. Claims were excluded with allowed amounts less than 1 dollar. Claims were excluded if the effective rate (allowed amount divided by charge) was less than 20%. Of the remaining claims, we omitted those with lowest 1% of allowed amounts. The allowed amounts for claims with the highest 1% of allowed amounts were top coded where we assigned the 99th percentile allowed amount within each year to each of these claims.

In the HCCI data, each provider has an attached provider five-digit zip code. We omitted claims associated with multiple provider zip codes. We also mapped these provider zip codes to CBSAs and states using the same crosswalk as with member zip codes. We omitted claims with an identifiable provider zip code which was not associated with one of the 50 states or D.C.

Using each facility identifier (cNPI), we merged on hospital characteristics from the American Hospital Association (AHA) in each year. Using characteristics from the AHA survey, we identified inpatient claims associated with general acute care (GAC) inpatient hospitals.[3]

Outpatient Claims (Procedures / Visits)

[3] Specifically, we defined GAC hospitals as those with relevant control (excluding federal government facilities) and service codes (general medical and surgical).

Our unit of analysis for outpatient claims was the visit or procedure level defined by the combination of year, patient, visit dates, current procedural terminology (CPT) code, CPT modifier code level.

We identified the provider associated with each claim by encrypted National Plan and Provider Enumeration System Identifiers (NPI). Each claim was assigned a single NPI based off the most common non-missing NPI value among the visit claim lines. If the most common NPI value for a claim was tied between 2 or more non-missing NPIs, the NPI that was associated with a greater allowed amount, out-of-pocket payment, or charges (in that order) was assigned to the claim. If a claim contained all missing NPI values, we assigned it a NPI of “blank”.

Claims were excluded if the CPT code was missing – and could therefore not be assigned a service code. Claims were excluded if they were not made up exclusively by claim lines with 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. Claims with lengths of stay greater than one day were excluded (different first and last dates). Claims with units less than 1 were excluded. We calculated the modal units value for each CPT code within each year. We flagged claims in which the units matched the mode units for the corresponding CPT code.

Claims were excluded with charges less than 1 dollar. Claims were excluded with allowed amounts less than 1 dollar. Claims were excluded if the effective rate (allowed amount divided by charge) was less than 20%. Of the remaining claims, we omitted those with lowest 1% of allowed amounts. The allowed amounts for claims with the highest 1% of allowed amounts were top coded where we assigned the 99th percentile allowed amount within each year to each of these claims.

In the HCCI data, each provider has an attached provider five-digit zip code. We omitted claims associated with multiple provider zip codes. We also mapped these provider zip codes to CBSAs and states using the same crosswalk as with member zip codes. We

omitted claims with an identifiable provider zip code which was not associated with one of the 50 states or D.C.

Professional Claims (Procedures / Visits)

Our unit of analysis for professional claims was the visit or procedure level defined by the combination of year, patient, visit dates, current procedural terminology (CPT) code, CPT modifier code level.

We identified the provider associated with each claim by encrypted National Plan and Provider Enumeration System Identifiers (NPI). Each claim was assigned a single NPI based off the most common non-missing NPI value among the visit claim lines. If the most common NPI value for a claim was tied between 2 or more non-missing NPIs, the NPI that was associated with a greater allowed amount, out-of-pocket payment, or charges (in that order) was assigned to the claim. If a claim contained all missing NPI values, we assigned it a NPI of “blank”.

Claims were excluded if the CPT code was missing – and could therefore not be assigned a service code. Claims were flagged if they were made up exclusively by claim lines with the following place of service codes: office, urgent care facility, inpatient hospital, outpatient hospital, hospital laboratory services, emergency room, ambulatory surgery center, or independent laboratory. Claims with lengths of stay greater than one day were excluded (different first and last dates). Claims with units less than 1 were excluded. We calculated the modal units value for each CPT code within each year. We flagged claims in which the units matched the mode units for the corresponding CPT code.

Claims were excluded with charges less than 1 dollar. Claims were excluded with allowed amounts less than 1 dollar. Claims were excluded if the effective rate (allowed amount divided by charge) was less than 20%. Of the remaining claims, we omitted those with lowest 1% of allowed amounts. The allowed amounts for claims with the highest 1% of allowed amounts were top coded where we assigned the 99th percentile allowed amount within each year to each of these claims.

In the HCCI data, each provider has an attached provider five-digit zip code. We omitted claims associated with multiple provider zip codes. We also mapped these provider zip codes to CBSAs and states using the same crosswalk as with member zip codes. We omitted claims with an identifiable provider zip code which was not associated with one of the 50 states or D.C.

Summary Statistics of our Analytic Sample

Our analytic sample spans more than 2.9 billion claims from 2013-2017 across almost 200 million member years. This includes an average of more than 1 million inpatient claims, 70 million outpatient claims, and 400 million professional claims, annually. These claims are attributed to an average of more than 30 million individuals annually.

Our analytic sample comprises a consistent subset of all HCCI claims across our study period. As seen in Table 1, our sample includes between 66-68% of the HCCI universe of claims in each year, and about 75% of total spending (defined as the sum of allowed amounts). Our analytic sample captures a slightly higher percentage of inpatient and professional claims (around 70% of claims and spending) than outpatient claims (around 60% of claims and spending).

Table 1.1. Share of HCCI Universe of Claims, Spending Included in Analytic Sample by Year

Service Category	2013	2014	2015	2016	2017
Share of Claims					
Overall	68%	68%	67%	66%	66%
Inpatient	73%	73%	74%	74%	74%
Outpatient	54%	54%	53%	53%	52%
Professional	71%	71%	70%	70%	69%
Share of Spending (Total Allowed Amounts)					
Overall	76%	76%	76%	76%	75%
Inpatient	71%	71%	70%	71%	70%
Outpatient	71%	72%	72%	72%	73%
Professional	82%	82%	82%	81%	81%

2. Constructing Spending, Use, Price, Service Mix Indices

We compute each of the following metrics using the set of claims in our analytic data set (*C*).

2. 1. Measuring Total Spending, Use at the CBSA-Service, CBSA, National Level

Defining Spending, Use at the CBSA-Year-Service Level

For a given CBSA-year-service combination, we define total spending (y_{gts}) as the sum of allowed amounts on all claims *c* for service *s* in year *t* for all residents of CBSA *g*:

$$y_{gts} = \ Allowed\ Amt_{gts} = \sum_{c \in C_{gts}} Allowed\ Amt_{gtsc}$$

For a given CBSA-year-service combination we define use as the number of claims for service *s* in year *t* for a resident of CBSA *g*:

$$u_{gts} = \sum_{c \in C_{gts}} 1 \ ; \ u_{gts} \geq \ 0$$

Defining Total Spending, Use (Across Services) at the CBSA Level

We define total spending and use by a CBSA-year combination as the sum of spending and use (respectively) on each service s in year t for all residents of CBSA g:

$$y_{gt} = \sum_{s \in S_{gt}} y_{gts} \ ; \ u_{gt} = \sum_{s \in S_{gt}} u_{gts}$$

Here S_{gt} is the subset of services *S* observed in CBSA *g* in year *t:*

$$S_{gt} \ = \ \{s \mid u_{gts} \ > \ 0\}$$

Defining Total Spending, Use (Across Services) at the National Level

We define total spending on and use of our sample set of services *S* nationally in a given year as the sum of spending on and use of each service *s* in year *t* for all residents of CBSA across all CBSAs *g* in our set of sample CBSAs *G* (respectively):

$$y_t = \sum_{g \in G} \sum_{s \in S_{gt}} y_{gts} \; ; \; u_t = \sum_{g \in G} \sum_{s \in S_{gt}} u_{gts}$$

2. 2. Measuring Price at the CBSA-Service Level

Defining Average Price at the CBSA-Service Level

Given these definitions of spending and use, we can re-write spending on service *s* observed in CBSA *g* in year *t* as the product of spending per claim (average price) and the number of claims (use):

$$y_{gts} = \left(\frac{y_{gts}}{u_{gts}}\right) u_{gts} = \bar{p}_{gts} u_{gts}$$

This allows us to define the average price of a service *s* observed in CBSA *g* in year *t* as total spending on that service divided by its use:

$$\bar{p}_{gts} = \frac{y_{gts}}{u_{gts}}$$

Imputing Average Prices at the CBSA-Service Level for Missing Observations

If there are no observations for service *s* in CBSA *g* in year *t*, we impute the price as the adjusted national average price for that service. In particular, we impute this price of that service $\hat{p}_{gts}$ as the national average price for that service deflated by the ratio of the weighted average of prices in CBSA *g* for the services *s* we do observe and the weighted average of prices nationally for that same set of services:

$$\hat{p}_{gts} = \bar{p}_{ts} * \frac{\sum_{s' \in S_{gt}^f} \bar{p}_{gts} * w_s^f}{\sum_{s' \in S_{gt}^f} \bar{p}_{ts} * w_s^f}$$

Using this method of imputing prices for missing CBSA-year-service observations, we define an adjusted price for each service *s* in CBSA *g* in year *t* as follows:

$$\tilde{p}_{gts} = \begin{cases} \bar{p}_{gts} \; if \;\; u_{gts} > 0 \\ \hat{p}_{gts} \;\; if \; u_{gts} = 0 \end{cases}$$

Note that since $\tilde{p}_{gts} \neq \bar{p}_{gts} \Leftrightarrow u_{gts} = 0$, imputing prices for missing CBSA-year-service observations does not change the total spending on any service *s* in any year *t* for residents of any CBSA *g*:

$$\bar{p}_{gts} * u_{gts} \; = \; \tilde{p}_{gts} * u_{gts} \; = \begin{cases} \bar{p}_{gts} * u_{gts} & if \;\; u_{gts} > 0 \\ 0 & if \; u_{gts} = 0 \end{cases}$$

As a result, imputing prices for missing observations does not change our observed total spending at the CSBA-year or national-year level:

$$\mathrm{y}_{gt} = \sum_{s \in S} y_{gts} = \sum_{s \in S_{gt}} \bar{p}_{gts} * u_{gts} = \sum_{s \in S} \tilde{p}_{gts} * u_{gts}$$

$$y_t = \sum_{g \in G} \sum_{s \in S} y_{gts} = \sum_{g \in G} \sum_{s \in S_{gt}} \bar{p}_{gts} * u_{gts} = \sum_{g \in G} \sum_{s \in S} \tilde{p}_{gts} * u_{gts}$$

2. 3. Constructing a Basket of Common Health Care Services

Identifying a Set of Common Claims to Construct a Consistent Service Basket

In order to benchmark health care spending, prices, and utilization, we identified a consistent set of services for which to compare these metrics across areas and over time. From our analytic sample of service claims, we constructed a subset of candidate claims $\tilde{C} \subset C$ omitting claims occurring at uncommon types of facilities and places of service. We omit all inpatient claims that do not occur at general acute care hospitals, and all outpatient and professional claims which do not have valid type-of-bill and place-of-service codes, respectively.[4] Note that our subset of candidate claims is *only* used to identify our set of common service. Once we identified our set of common services, we computed all metrics using our entire analytic sample of claims.

From our set of candidate claims, we then constructed a set of common services within each service category *f* (inpatient, outpatient, and professional), S^f. 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 those which appear in each year of our data. For each category, we then constructed a set of the most common service codes ("common services") observed in the final year of our sample (2017) meeting our inclusion criteria:

- Inpatient Services: among the 100 most frequent service codes (DRG).
- Outpatient Services: among the 500 most frequent service codes (CPT).
- Professional Services: among the 500 most frequent service codes (CPT).

While only being comprised of 1100 services, our set of basket services accounted for more than 75% of the claims and more than 60% of all spending in our analytic sample across years and service categories (Table 2.1). However, we did capture a slightly lower percentage of inpatient and outpatient claims and spending than we do professional services. Importantly, though, the share of claims in our sample captured

[4] We included claims with the following place of service codes: 11, 20, 21, 22, 23, 24, 81.

by our service basket was fairly stable over time. For both outpatient and professional services, we captured a slightly lower percentage of services at the end of our sample than at the beginning of our sample. This was mechanical and primarily due to limiting our set of common services to those observed in every year. Consequently, we omitted claims with service codes (CPT codes) which were used in later years but not in earlier years, and vice-versa. However, as we captured a nearly identical share of spending across years for each service category, these claims for newly introduced CPT codes did not account for a large proportion of the spending in our analytic sample.

Our set of basket services also constituted a majority of claims and spending from the universe of HCCI claims over time (Table 2.2). We captured between roughly 55-60% of all, inpatient, and professional claims across years. We did, however, capture slightly less than 50% of outpatient claims from 2013-2017. The claims for our basket services accounted for more than 45% of all spending. While the percentage of claims we capture varies somewhat by service category, importantly the percentage of inpatient (47%) and outpatient (41%) spending captured were stable over time.

Table 2.1. Share of Analytic Sample Claims, Spending Included in Set of Basket Services by Year

Service Category	Number of Services	2013	2014	2015	2016	2017
Share of Claims						
Overall	1100	86.2%	86.0%	86.0%	87.1%	86.2%
Inpatient	100	76.5%	77.3%	77.7%	78.2%	79.5%
Outpatient	500	88.1%	88.2%	87.1%	86.7%	88.1%
Professional	500	85.9%	85.6%	85.9%	87.2%	85.8%
Share of Spending (Total Allowed Amounts)						
Overall	1100	63.1%	63.4%	63.7%	63.9%	63.5%
Inpatient	100	64.4%	64.7%	64.9%	65.5%	65.8%
Outpatient	500	60.0%	60.7%	61.2%	60.6%	60.1%
Professional	500	64.5%	64.6%	64.8%	65.4%	64.9%

Table 2.2. Share of Universe of HCCI Claims, Spending Included in Set of Basket Services by Year

Service Category	Number of Services	2013	2014	2015	2016	2017
Share of Claims						
Overall	1100	58.6%	58.2%	57.5%	57.8%	56.8%
Inpatient	100	56.1%	56.3%	57.2%	57.8%	59.0%
Outpatient	500	47.2%	47.2%	46.1%	45.6%	45.5%
Professional	500	61.2%	60.7%	60.1%	60.8%	59.5%
Share of Spending (Total Allowed Amounts)						
Overall	1100	47.7%	48.2%	48.2%	48.3%	47.9%
Inpatient	100	45.6%	45.8%	45.7%	46.4%	46.2%
Outpatient	500	42.4%	43.8%	44.1%	43.8%	43.7%
Professional	500	53.0%	53.0%	52.9%	53.0%	52.4%

Constructing a Basket of Health Care Services from our Set of Common Services

Using our set of common services, we constructed a basket of health care services by assigning a weight to each service within each service category. When we constructed our price index, we used these weights to compute a weighted-average price across services within each service category (i.e., across different inpatient services). This enabled us to compare prices for the same market basket of services across geographies and over time.

We assigned weights to each service in our set of common services S^f based on the share of claims they accounted for within each service category nationally in our base year *T*. We assigned the first year in our sample, 2013, to be the base year. More formally, the weight for service *s* is assigned to be its share of all services used *nationally* (across CBSAs g) among our sample services in category *f* (S^f) in our base year T:

$$w_{Ts}^{f} = \frac{u_{Ts}}{u_T} = \frac{\sum_{g \in G} u_{gTs}}{\sum_{s \in S^f} \sum_{g \in G} u_{gTs}}$$

Here, u_{gTs} is defined as in Section 2. 1.

We further assigned each category of service a weight which we used when computing an “Overall” price index

2. 4. Constructing CBSA Level Indices by Category

We constructed Per Capita Spending, Per Capita Use, Price, and Case Mix Indices at the CBSA-Service Category level in each year of our data. Where relevant, we designate our base year T as 2013.

Defining Member Years at the CBSA-Year Level

For a given CBSA-year combination, we define member years as the sum of member months *m* attributed to CBSA *g* in year *t* divided by 12:

$$Mem.Years_{gt} = \frac{1}{12} * \sum_{m \in M_{gt}} 1$$

Here, M_t represents the set of all individuals *i* in our sample population attributed to CBSA *g* in year *t*.

Spending Index

Our spending index measures the average spending accounted for by individuals in each CBSA in each year. To standardize differences in the volume of people in different areas, we computed our spending index as a per-capita metric. Within each category of services *f*, we define per-capita spending as the sum of total spending across services *s* divided by the number of member years in CBSA *g* in year *t*:

$$Y_{gt}^{f} = \sum_{s \in S^{f}} \frac{y_{gts}}{Mem.Years_{gt}}$$

Use Index:

Our use index measures the average volume of health care services accounted for by individuals in each CBSA in each year. To standardize differences in the volume of people in different areas, we computed our use index as a per-capita metric. Within each category of services *f*, in each CBSA *g* in year *t* we define per-capita service use as a simple count of claims per capita across services *s*:

$$U_{gt}^{f} = \sum_{s \in S^{f}} \frac{u_{gts}}{Mem.Years_{gt}}$$

Price Index

Our price index measures the "price" (average spending per service) paid by members residing in each CBSA in each year. To provide a standardized comparison across areas and over time, we measured the average price if each CBSA used services in the same proportions as our national market basket of services. For each category of services *f*, in each CBSA *g* in year *t* we compute our price index using a weighted average of the average prices across services:

$$P_{gt}^{f} = \sum_{s \in S^{f}} \tilde{p}_{gts} * w_{Ts}^{f}$$

Service Mix Index:

Our service mix index measures whether CBSAs use, on average, a more or less expensive mix services than our national basket. For each CBSA g in year t, we define our mix index as the difference between our spending index and the product of our price and use indices.

$$M_{gt}^{f} = Y_{gt}^{f} - (P_{gt}^{f} * U_{gt}^{f})$$

Within each category of services, our use index measures the volume of services used by each CBSA in each year. Our price index measures the average cost per service each CBSA would pay in each year if they used our national basket of services. The product of our price and use indices computes the implied total spending had each

CBSA in each year used services in the same proportion as our national basket given the average price paid for each service and volume of services used:

$$iY_{gt}^{f} = P_{gt}^{f} * U_{gt}^{f}$$

The difference between the actual spending observed and implied spending represents the additional cost of or savings from the mix of services each CBSA used in each year relative to the national basket:

$$M_{gt}^{f} = Y_{gt}^{f} - iY_{gt}^{f} = Y_{gt}^{f} - (P_{gt}^{f} * U_{gt}^{f})$$

Re-writing our expression for our spending index, we can derive an expression for our mix index at the service category level. Our mix index measures the cost of using a different mix of services than the nation by the average price per service multiplied by the difference between the share of all claims on service s in CBSA *g* in year *t* and the share of all claims on service *s* nationally in our base year *T*:

$$M_{gt}^{f} = \sum_{s \in S^{f}} \frac{u_{gts}}{Mem.Years_{gt}} * \sum_{s \in S^{f}} \tilde{p}_{gts} * (w_{gts}^{f} - w_{Ts}^{f})$$

Here w_{Ts}^{f} is defined as above and w_{gts}^{f} represents an analogous CBSA-year specific weight for service *s* – the share of claims on service *s* among all sample services in category *f* in CBSA *g* in year *t*:

$$w_{gts}^{f} = \frac{u_{gts}}{\sum_{s \in S^{f}} u_{gts}}$$

2. 5. Constructing CBSA Level Indices (Across Service Categories)

Using our service category indices, we constructed overall indices across service categories as follows.

Spending Index:

Our overall spending index captures total spending per capita on medical services across service categories. We define total per capita spending as the sum of per capita spending across service categories f in each year *t*:

$$Y_{gt} = \sum_{f \in F} Y_{gt}^{f}$$

Per Capita Use Index

Our overall use index captures total medical service use across service categories. We define total services used per capita as the sum services per capita used across service categories *f* in each year *t*:

$$U_{gt} = \sum_{f \in F} U_{gt}^{f}$$

Price Index

Our overall price index captures the average spending per service across service categories. We calculate an overall price index value as a weighted average of CBSA price index values across service categories in each year *t*:

$$P_{gt} = \sum_{f \in F} P_{gts}^{f} * w_{T}^{f}$$

Here, the weights assigned correspond to the share of total services accounted for by each service category f nationally in our base year T:

$$w_T^f = \frac{U_T^f}{\sum_{f \in F} U_T^f} = \frac{\sum_{s \in S^f} \sum_{g \in G} u_{gTs}}{\sum_{f \in F} \sum_{s \in S^f} \sum_{g \in G} u_{gTs}} ; U_T^f = \sum_{g \in G} U_{gt}^f$$

Note that this measure is equivalent to defining our overall service basket as the union of each of our category service basket and computed our price index as the weighted average prices across service categories:

$$P_{gt} = \sum_{f \in F} P_{gts}^f * w_T^f = \sum_{f \in F} \left(\sum_{s \in S^f} \tilde{p}_{gts} * w_{Ts}^f \right) * w_T^f = \sum_{s \in \tilde{S}} \tilde{p}_{gts} * w_s$$

Where for each service *s* within each service category *f* :

$$w_s = w_{Ts}^f * w_T^f = \left(\frac{\sum_{g \in G} u_{gTs}}{\sum_{s \in S^f} \sum_{g \in G} u_{gTs}} \right) \left(\frac{\sum_{s \in S^f} \sum_{g \in G} u_{gTs}}{\sum_{f \in F} \sum_{s \in S^f} \sum_{g \in G} u_{gTs}} \right) = \frac{\sum_{g \in G} u_{gTs}}{\sum_{s \in S} \sum_{g \in G} u_{gTs}}$$

Service Mix Index:

Our Service Mix index captures the degree to which the difference in spending between a particular CBSA is driven *which* services that CBSA uses. In other words, the degree to which spending in a CBSA is higher (or lower) than the national median due to the use of more (or less) expensive services, on average. More specifically, for each CBSA *g* in year *t*, we define our mix index as the difference between our spending index and the product of our price and use indices.

$$M_{gt} = Y_{gt} - (P_{gt} * U_{gt})$$

Re-writing our expression for our spending index we can derive an expression for our overall mix index:

$$M_{gt} = \underbrace{\sum_{f \in F} U_{gt}^f * \sum_{f \in F} P_{gts}^f * (w_{gt}^f - w_T^f)}_{Cost\ of\ Mix\ Across\ Categories} + \underbrace{\sum_{f \in F} M_{gt}^f}_{Cost\ of\ Mix\ Within\ Categories}$$

Where:

$$w_{gt}^f = \frac{U_{gt}^f}{\sum_{f \in F} U_{gt}^f}$$

Here our mix index incorporates the cost of both the mix of services within service categories as well as across service categories. The cost of mix within service categories is captured as the sum of within category mix indices across categories. The cost of mix across service categories is analogously defined to our within category mix index – that is, the average price of each service category multiplied by the deviation in the share of services attributed to each service category in a given CBSA-year observation relative to our national basket scaled by the volume of services used.

2. 6. Reporting Index Values

Reporting Index Values: Level of Spending / Price / Use / Mix

For each index – both within and across service categories – we reported indices as deviations from the national median. Note that we refer to the national median as the median among our sample of reportable CBSAs and states for the relevant geographic metric (e.g., CBSA index values, state index values, respectively).

For our spending, price, and use indices, we reported index values as percent deviations from the national median. For example, for service category *f*, in CBSA *g*, in year *t*:

Spending Index:

$$\frac{Y_{gt}^{f} - \bar{Y}_{t}^{f}}{\bar{Y}_{t}^{f}}$$

Use Index:

$$\frac{U_{gt}^{f} - \bar{U}_{t}^{f}}{\bar{U}_{t}^{f}}$$

Price Index:

$$\frac{P_{gt}^{f} - \bar{P}_{t}^{f}}{\bar{P}_{t}^{f}}$$

Service Mix Index:

For our service mix index, we reported a slightly different metric because the median service mix is close to zero. This property is intuitive and by construction. The mix index essentially measures the cost (positive or negative) associated with deviating in the mix of services used from the national basket – that is the mix of services used by the entire country. On average, CBSAs tend to use services in the similar proportion as the nation. Deviations from this basket – both in using a more and less expensive mix of services – should therefore be balanced around zero.

As a result, we alternatively reported our service mix index as the percentage deviation in CBSA spending from the national median attributable to using a different mix of services.

$$\frac{M_{gt}^{f} - \bar{M}_{t}^{f}}{\bar{Y}_{t}^{f}}$$

This metric captures the degree to which spending in a particular metro is different from the national median solely due to mix of services that CBSA uses – that is, the proportion of all services used accounted for by each individual service - relative to the nation as a whole. A value of 10%, for example, indicates that in CBSA *g* individuals used a higher proportion of more expensive services than the nation as a whole. As a result, this mix of services used increased spending by 10% relative to the national median. To see this, note that the difference in spending between CBSA *g* and the national Median in year *t* is as follows:

$$Y_{gt}^{f} - \bar{Y}_{t}^{f} = \left(P_{gt}^{f} * U_{gt}^{f} + M_{gt}^{f}\right) - \left(\bar{P}_{t}^{f} * \bar{U}_{t}^{f} + \bar{M}_{t}^{f}\right)$$

$$= \left(P_{gt}^{f} * U_{gt}^{f} - \bar{P}_{t}^{f} * \bar{U}_{t}^{f}\right) + \left(M_{gt}^{f} - \bar{M}_{t}^{f}\right)$$

Here, we can re-write the difference in spending between CBSA *g* and the median CBSA as the sum of the difference between implied spending – assuming a CBSA used the national basket of services given prices paid and volume of services used (the product of price and use indices) – in CBSA *g* and the median CBSA, and the difference in the cost of the actual service mix between CBSA *g* and the median CBSA.

Hence, if we assumed the price and use levels in CBSA *g* were equivalent to the national median, the remaining difference in spending would be equal to the difference between the service mix index for CBSA g and the national median:

$$P_{gt}^{f} = \bar{P}_{t}^{f}, U_{gt}^{f} = \bar{U}_{t}^{f} \Rightarrow Y_{gt}^{f} - \bar{Y}_{t}^{f} = M_{gt}^{f} - \bar{M}_{t}^{f}$$

We can therefore express the difference between per capita spending in CBSA *g* from the national median attributable to the mix of services used in CBSA *g* as follows:

$$\frac{M_{gt}^{f} - \bar{M}_{t}^{f}}{\bar{Y}_{t}^{f}}$$

Note that because we calculated median spending, price, and use measures separately as sample medians, the CBSA with the median price, use, and spending values were not necessarily the same - both across and within service categories. Consequently, the metric we reported does not perfectly match the assumptions laid out. For example, in the CBSA with median inpatient spending, price and use were not necessarily equal to the national median (as assumed above). To understand how this affects our analysis, we constructed a composite median CBSA spending using the median price, use and mix index value for each service category. We subsequently compared how the percent of spending deviation from the national median used to report our mix index differed whether we used actual median spending or composite median spending. Across service categories, the two set of metrics were perfectly (positively) correlated and had nearly identical distributions. Consequently, we chose the simpler method of reporting our mix index (reporting our mix index using sample medians for spending, price and use).

For each of these indices, we reported overall index values (across service categories) analogously.

Reporting Index Values: Change in Spending / Price / Use / Mix over Time

For our spending, price, and use indices, we reported changes in index values as percent changes from our base year. For example, for service category *f*, in CBSA *g*, in year *t*:

Spending Index:

$$\frac{Y_{gt}^{f} - Y_{T}^{f}}{Y_{T}^{f}}$$

Use Index:

$$\frac{U_{gt}^{f} - U_{T}^{f}}{U_{T}^{f}}$$

Price Index:

$$\frac{P_{gt}^{f} - P_{T}^{f}}{P_{T}^{f}}$$

Service Mix Index:

For our service mix index, we reported the percent change in per capita spending accounted for by service mix from our base year to the current year. For example, for service category *f*, in CBSA *g*, in year *t*:

$$\frac{M_{gt}^{f} - M_{gT}^{f}}{Y_{gT}^{f}}$$

To see this, note that the percent change in per capita spending in CBSA g from year *T* to year *t* can be written as follows:

$$\frac{Y_{gt}^{f} - Y_{gT}^{f}}{Y_{gT}^{f}} = \frac{\left(P_{gt}^{f} * U_{gt}^{f} + M_{gt}^{f}\right) - \left(P_{gT}^{f} * U_{gT}^{f} + M_{gT}^{f}\right)}{Y_{gT}^{f}}$$

$$= \left[\frac{P_{gt}^{f} * U_{gt}^{f} - P_{gT}^{f} * U_{gT}^{f}}{Y_{gT}^{f}}\right] + \left[\frac{M_{gt}^{f} - \bar{M}_{t}^{f}}{Y_{gT}^{f}}\right]$$

The latter term, therefore, represents the degree to which spending in CBSA *g* changed solely due to changes in the mix of services CBSA *g* used over time.

For each of these indices, we reported overall index values (across service categories) analogously.

Geographic Levels of Reporting: CBSA Sample Inclusion Criteria

While we calculated all of our metrics using data from every CBSA observed in our analytic sample, we only reported data for a subset of the CBSAs observed in our sample. Further when computing national medians, we only did so among our subset of sample CBSAs.

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 (2013-2017). 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. Each sample CBSA had to have an average of at least 25,000 member years in the HCCI data from 2013-2017. 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. This resulted in a final geographic sample of 124 CBSAs across 42 states.

Geographic Levels of Reporting: State Level Metrics

In addition to CBSA metrics, we also reported state level metrics. These are computed analogously to our CBSA level measures. However, for our state level metrics, we treated the geographic unit of analysis as the state rather than the CBSA. The states reported meet the same reporting criteria as CBSAs.

2. 7. Measuring Service Prices, Use for Sentinel Services

From analytic data set, we pulled all the claims associated with two selected services from each of the three categories of services for a total of 6 services. The selected services were identified by their service codes; DRG for inpatient admissions and the combination of CPT code and CPT code modifier (again referred to as “CPT code” hereafter, however all CPT code modifiers were blank) for outpatient and professional services. The services, corresponding service category, and identifying service code are as follows: C-section delivery (inpatient, DRG 766), vaginal delivery (inpatient, DRG 775), comprehensive metabolic panel (outpatient, CPT 80053), bilateral screening mammography with computer-aided detection (outpatient, CPT G0202), established patient, mid-level office visit (professional services, CPT 99213), and new patient, mid-level office visit (professional services, CPT 99203). These services were selected due to their high prevalence in the HCCI data.

The price for each service claim was the sum of the allowed amounts (the actual amount paid to the providers including any insurer payments and patient cost sharing) associated with that service claim’s individual, common dates, and service code. For inpatient admissions, the price reported does not necessarily encapsulate the entire cost of a typical admission for a given service code as there may exist other ancillary services (such as anesthesia or other professional services) that are not billed under the same DRG code. Additionally, while the specificity of CPT codes prevents the prices reported from excluding additional costs for that service, additional services provided to the individual on the same day would not be included in this analysis’ price measures.

For each CBSA, we measured price as the median price per claim. We measured use as the per capita utilization rate – a count of all claims for each service divided by the number of member years. We reported these prices and use rates as percent differences from the national median for each service and the cumulative percent change from our base year.

We only reported service price and use measures for CBSAs with both sufficient data coverage and service prevalence for each service we report. For the remaining CBSAs

in our sample, we reported state level metrics where the state assigned to each CBSA meets our reporting standards.

3. Constructing 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 Hospital Markets

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 received 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 is defined as all providers located within a geographic area.[5]

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.

[5] 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 computed 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 counted 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*.[6] 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*:

[6] 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*.

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

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

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*:

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

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*.

4. Methodology Robustness

4. 1. Comparing Spending Index Computed Using Different Samples

In computing our spending index, we used a subset of our analytic sample of claims comprised of claims for our set of common services. These services were held constant across time and must be observed in each year. The benefit of this approach is it enables our construction of a market-basket style price index which allows for a consistent comparison of prices across regions and over time. The primary concern of this approach, though, is that there are changes in which services are commonly used over time. In particular, some services are no longer used, new services are introduced, or there is a change in the frequency with which the same services are used. Relatedly, there may also be updates to the codes used to describe the same services. To the extent to which health care spending and health care spending growth are influenced by such changes over time, limiting to a consistent set of services may cause our spending index to mis-represent “true” health care spending and spending growth.

We primarily reported two sets of spending metrics: the level of health care spending in 2017 (reported as a percent difference from the national median) and the change in health care spending from 2013-2017 (reported as a cumulative percent change). To understand how our analysis may be affected if we had used per-capita spending across all HCCI claims (“HCCI Claims”), our *entire* analytic sample of claims (“HMI Claims”), or the subset of analytic claims (“HMI Basket Claims”), we compared the distribution of per person spending values and changes over time computed using each sample, as well as their correlations. This allows us to see whether our methodology caused us to report a meaningfully different set of values than we would have otherwise.

As seen below, in both cases the level of spending in 2017 and the change in spending from 2017 had a similar distribution (Figure 5. 1.) and was highly correlated regardless of analytic sample (Table 5. 1., Table 5. 2.). Combined, these findings suggest that

limiting to our sample basket services did not appreciably impact the spending metrics we report.

Figure 4. 1. The Distribution of Per Capita Spending Level (2017), Changes (2013-2017) by Sample

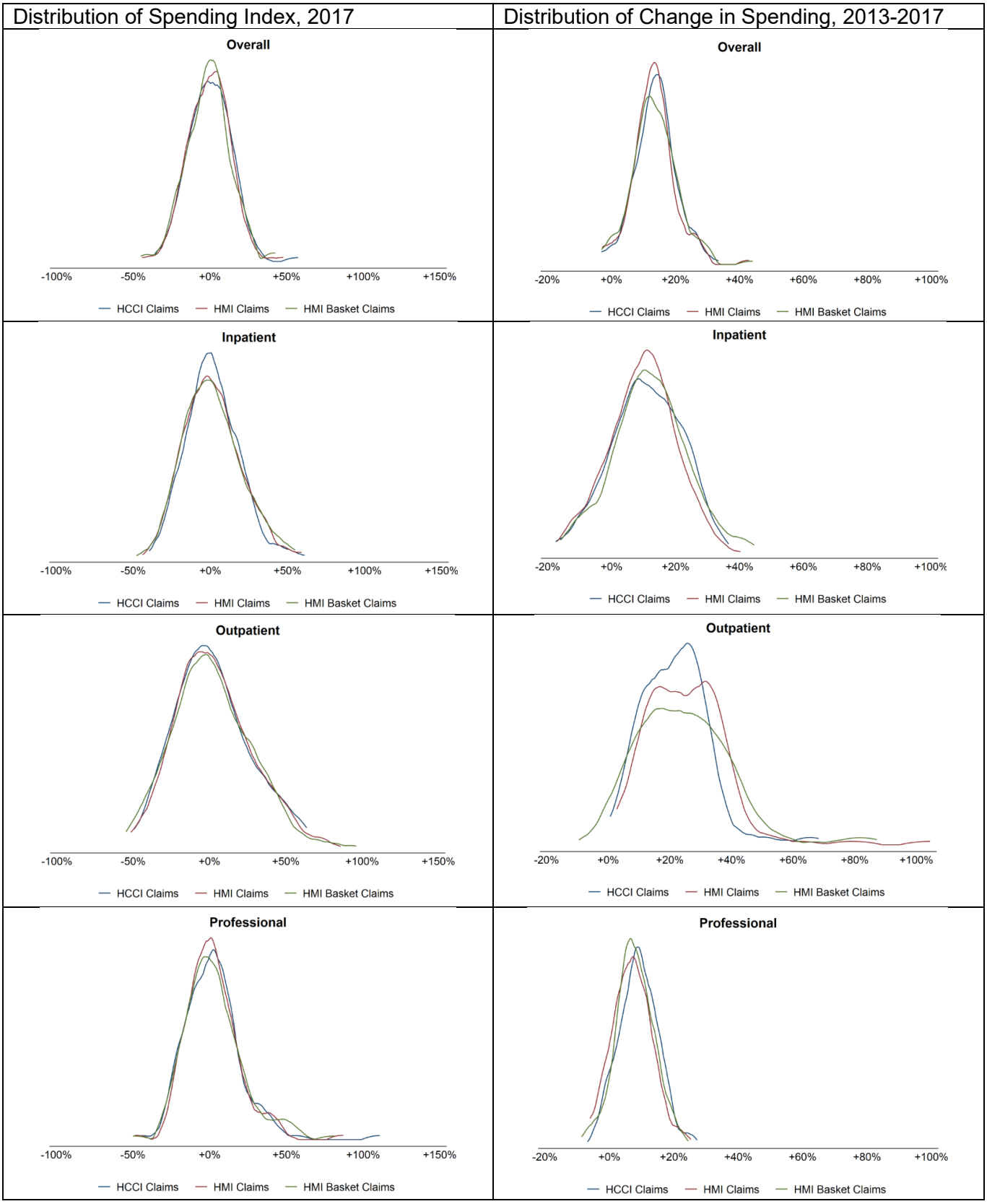


Table 4.1. Correlations between CBSA Level Per Person Spending Metrics by Sample - Percent of National Median, 2017

	ALL HCCI Claims	Analytic Sample	Basket Claims
Overall			
ALL HCCI Claims	1.000		
HMI Claims	0.903	1.000	
HMI Basket Claims	0.804	0.901	1.000
Inpatient			
ALL HCCI Claims	1.000		
HMI Claims	0.783	1.000	
HMI Basket Claims	0.704	0.913	1.000
Outpatient			
ALL HCCI Claims	1.000		
HMI Claims	0.892	1.000	
HMI Basket Claims	0.724	0.863	1.000
Professional			
ALL HCCI Claims	1.000		
HMI Claims	0.956	1.000	
HMI Basket Claims	0.891	0.941	1.000

Table 4.2. Correlations between CBSA Change in Per Person Spending Metrics by Sample - Percent of Change, 2013-2017

	ALL HCCI Claims	Analytic Sample	Basket Claims
Overall			
ALL HCCI Claims	1.000		
HMI Claims	0.928	1.000	
HMI Basket Claims	0.766	0.874	1.000
Inpatient			
ALL HCCI Claims	1.000		
HMI Claims	0.837	1.000	
HMI Basket Claims	0.772	0.938	1.000
Outpatient			
ALL HCCI Claims	1.000		
HMI Claims	0.894	1.000	
HMI Basket Claims	0.685	0.836	1.000
Professional			
ALL HCCI Claims	1.000		
HMI Claims	0.953	1.000	
HMI Basket Claims	0.889	0.946	1.000

4. 2 Methodology Changes Relative to Previous Healthy Marketplace Index Releases

We computed our price index as a weighted arithmetic average of per service prices across services within each category of health care services. The weights were determined by the share of total services within each service category accounted for by each service in our most recent year, 2017. We computed our use index as a simple count of per-capita services used within each service category. In this current iteration of the methodology, claims were assigned to CBSAs based off of where individuals reside.

In previous iterations of the HMI, we computed both price and use indices as a weighted geometric average of per service price and per capita utilization rates. In both cases, the weights were chosen as the share of total spending accounted for by each service within each service category in the first year in our sample (2012). Also, in both cases, previous iterations of the HMI were computed by assigning claims to the CBSAs in which individuals received care.

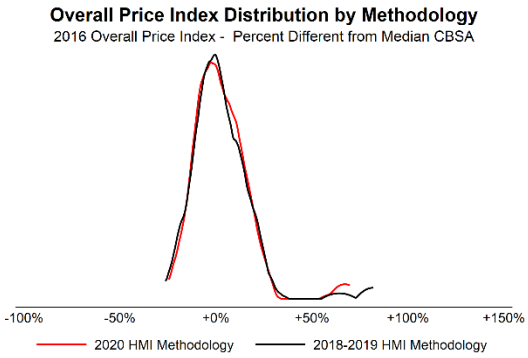
To understand how the change in methodology affected the metrics reported, we compared how the metrics reported in this iteration compare to those reported in the previous iteration. As seen below (**Figure 4.2.**, **4.3.**), the distribution of price levels and changes were almost identical across the methodologies, and the values were highly correlated across service categories. These findings echo previous findings on the similarity of price indices computed using different methods (Johnson and Kennedy, 2020).[7]

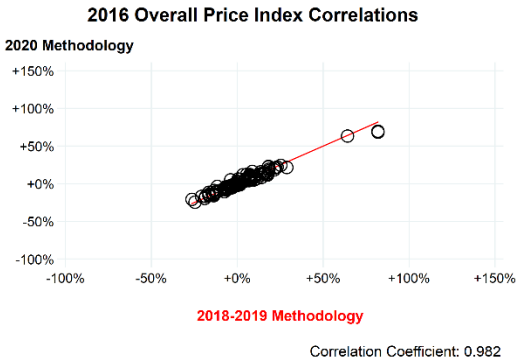
The use indices computed using our current methodology are somewhat different that those computed using previous methodologies. As seen in **Figure 4.4.**, the distribution of use indices were similar for professional services. However, for inpatient and outpatient services, the distributions were slightly different. In particular the distribution of use indices using the new methodology (count of services per capita) were somewhat

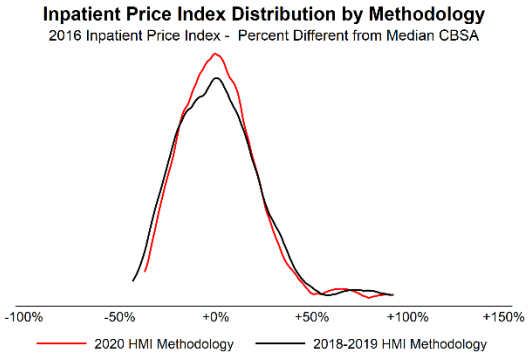
[7]Johnson, W. C. & Kennedy, K. (2020). “Comparing different methods of indexing commercial health care prices.” Health Services Research, 55(1), 113-118. DOI: 10.1111/1475-6773.13242

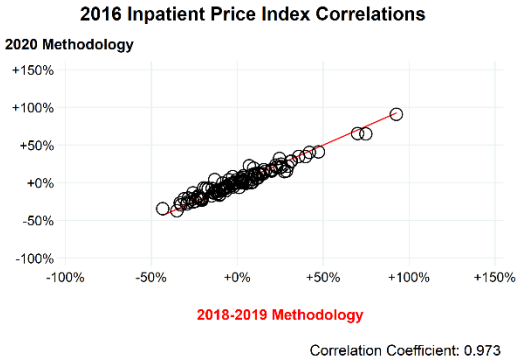
less noisy. While positively correlated, the correlations were somewhat weaker than they were for the price indices computed using different methods. The distributions of changes in use (**Figure 4.5.**) were also somewhat different. Using the new methodology, changes in use were less noisy, were closer to zero, and shifted to the right (on average smaller decreases) relative to the old methodology. These differences were primarily attributable to not weighting use rates across services to be consistent over time (which resulted in overstating use decreases, previously) and measuring use based off of where individuals lived versus where they received care (which resulted in nosier changes in use as, for example, insurance networks changed). Thus, while our use indices appear somewhat different, we consider these differences a methodological improvement.

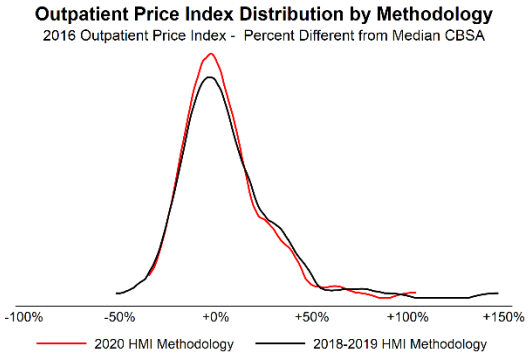
Figure 4. 2. Price Index Distributions, Correlations by Service Category and Methodology: 2016

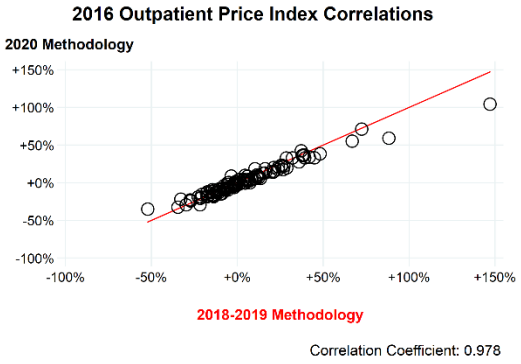


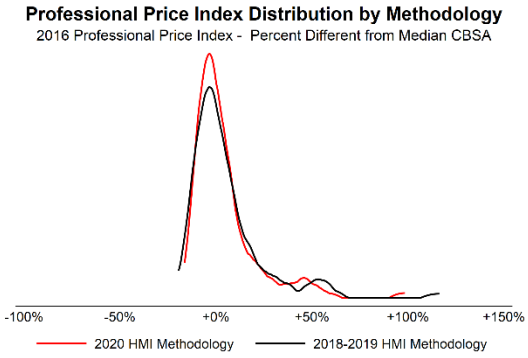












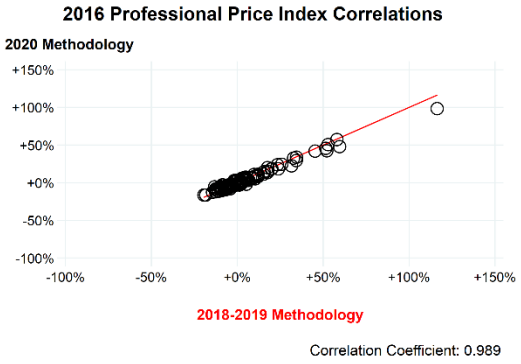
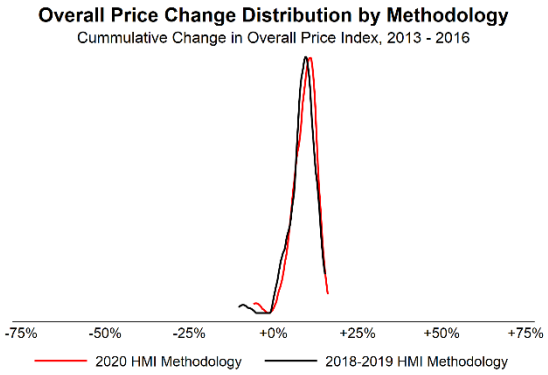
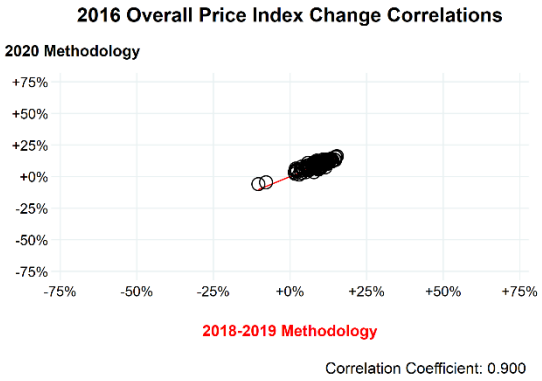
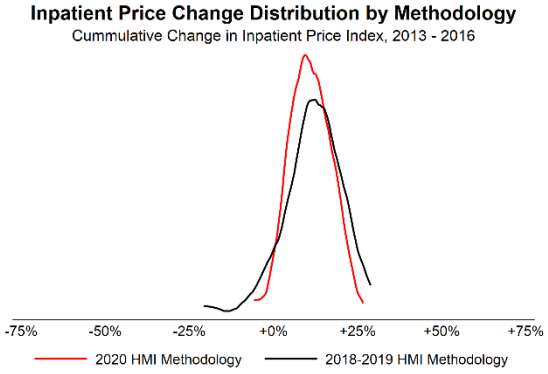
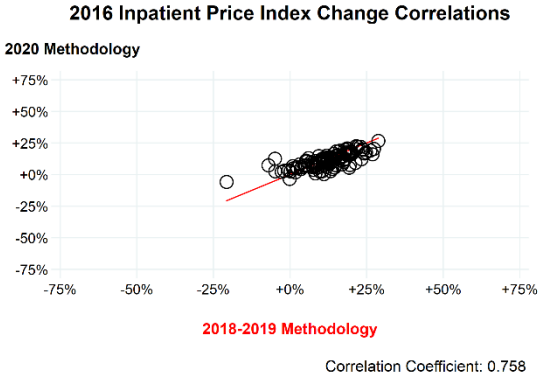


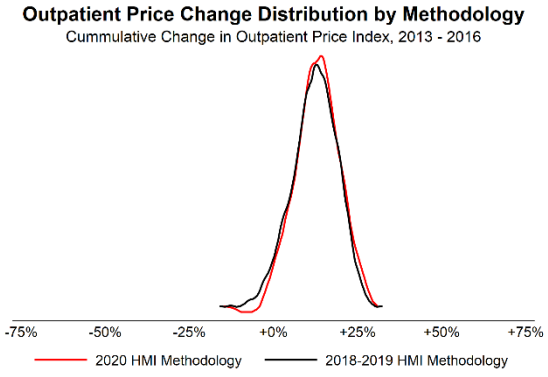
Figure 4. 3. Change in Price Index Distributions, Correlations by Service Category and Methodology: 2013 - 2016

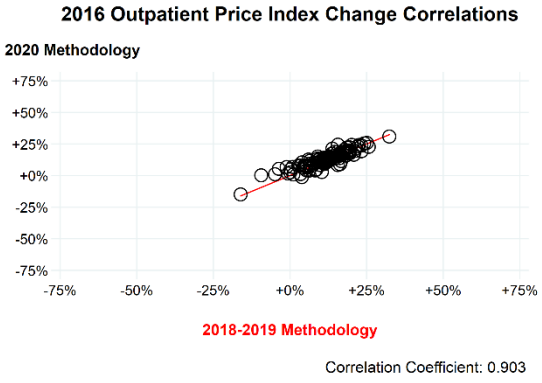


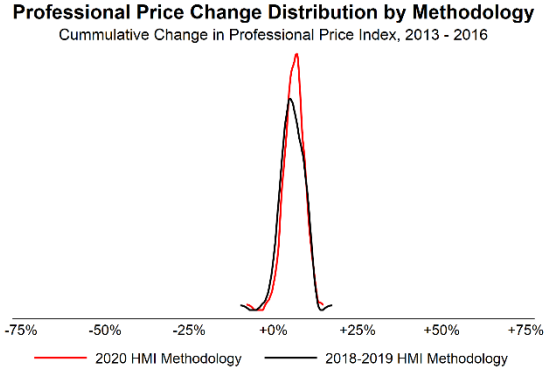












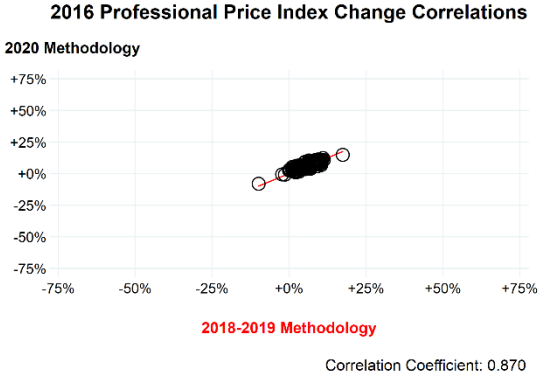
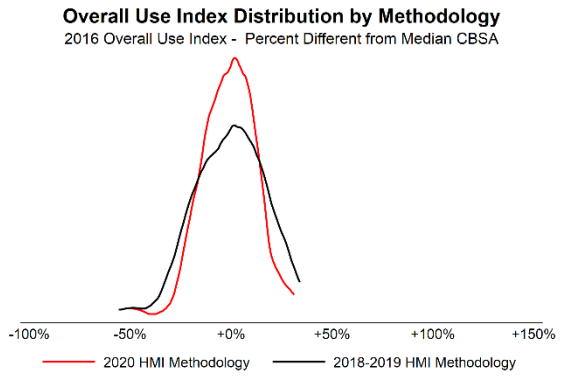
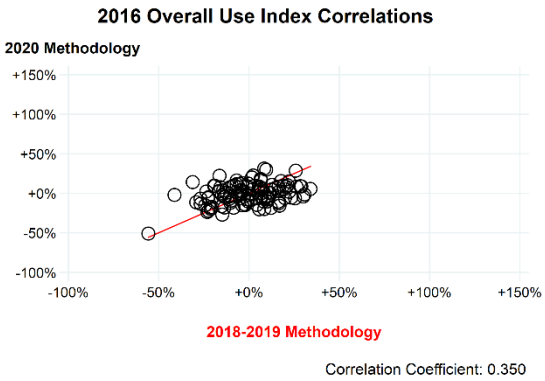
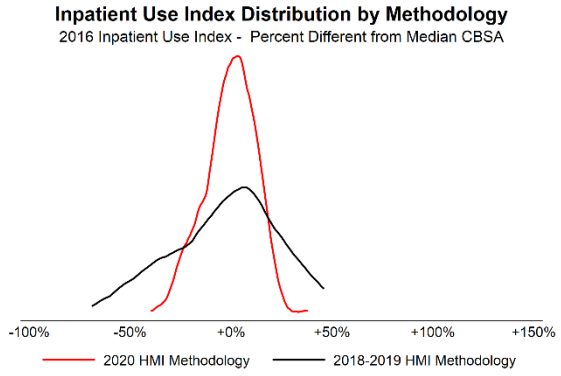
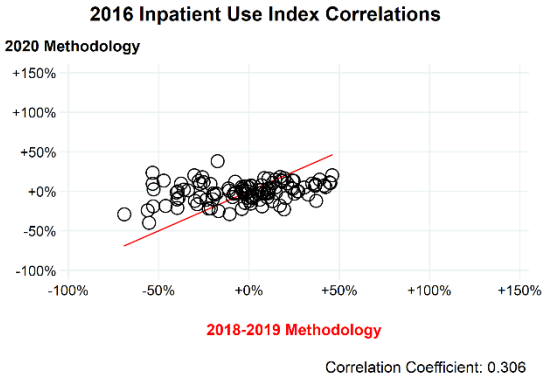


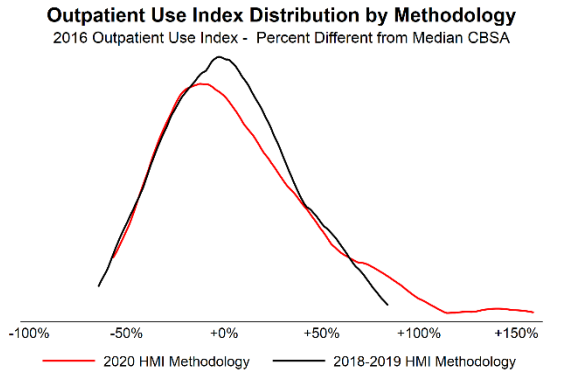
Figure 4. 4. Use Index Distributions, Correlations by Service Category and Methodology: 2016

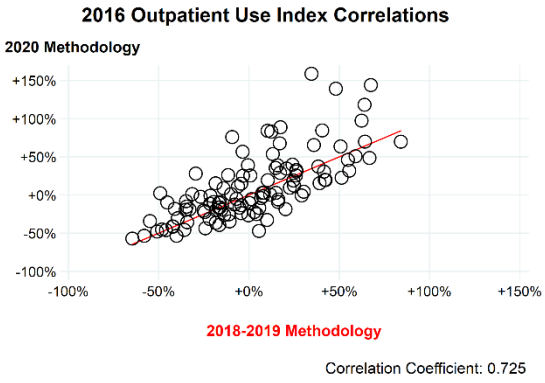


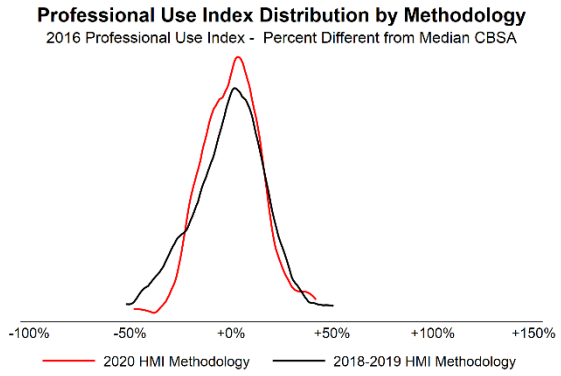












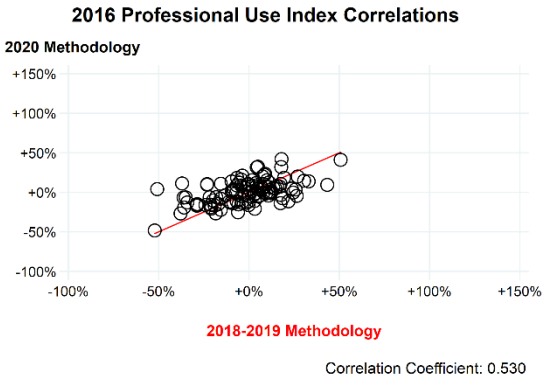


Figure 4. 5. Change in Use Index Distributions, Correlations by Service Category and Methodology: 2013 – 2016