Supplemental Material

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eAppendix 1. Detailed Inclusion Criteria

A. Commercial Claims

Our analytic sample includes commercial claims for the ten most common professional anesthesiology services in HCCI data among commercial payers in outpatient hospital and ambulatory surgery center (ASC) places of service in 2016-2017. Within the outpatient and ASC settings, these ten most common anesthesia procedure codes account for 60.1% of anesthesia commercial claims in the HCCI data for 2016-2017. The procedure codes included in our analytical sample are presented in Appendix Exhibit 1.1.

We identified 4.5 million commercial claims for these ten procedure codes in the HCCI data for 2016-2017 at an outpatient or ASC setting. After data exclusions (detailed below), there are 3.59 million commercial claims in our analytical sample.

B. Medicare Advantage Claims

Our analytical sample also includes Medicare Advantage (MA) claims for the same ten professional anesthesiology services. Within the outpatient and ASC settings, these ten most common anesthesia procedure codes account for 65% of anesthesia MA claims in the HCCI data for 2016-2017. The procedure codes included in our analytical sample are presented in Appendix Exhibit 1.1.

We identified 2.7 million MA claims for these ten procedure codes in the HCCI data for 2016-2017 at an outpatient or ASC setting. After data exclusions (detailed below), there are 1.87 million MA claims in the sample.

C. Data Exclusions

We identified and excluded the following data issues from our analytical sample:

1. Claims for patients with unhealthy conditions. These are identified based on modifiers.¹

2. Claims where the provider type cannot be determined because the modifiers are missing.

3. Scenarios where there are more than two claims identified for the same patient on the same service date for the same procedure code.²

4. Scenarios where the provider identification is inconsistent with the number of claims identified. These include the following: 1) modifier on claim indicates that procedure was personally performed by an anesthesiologist or CRNA but there are two claims identified in the data for that procedure; or 2) modifier on claim indicates the

¹ The modifiers are P3, P4, P5 and P6. These claims were exclude because of inconsistency in whether or not additional units for patient health were incorporated into the reported units on claims.

² We assumed that if the anesthesia procedure was performed by anesthesiologist-CRNA supervisory dyad, then there should be only two claims filed (one from the anesthesiologist and one from the CRNA).
procedure was performed by anesthesiologist-CRNA supervisory dyad but there is only one claim identified in the data for that procedure.

5. Other data anomalies include 1) claims with missing provider zip codes; 2) claims where the providers are located in US Territories; 3) claims with inconsistent values for network indicator or place of service across claim lines; 3) claims with zero or negative values for charges or allowed amounts; and 4) scenarios where the anesthesiologist supervised more than four concurrent procedures (modifier = AD).

6. Claims where the charge or allowed amount is three standard deviation from the mean.
### Anesthesia Procedures Included in Analysis

<table>
<thead>
<tr>
<th>CPT Code</th>
<th>Description</th>
<th>Commercial</th>
<th>Medicare Advantage</th>
</tr>
</thead>
<tbody>
<tr>
<td>00810</td>
<td>Anesthesia for lower intestinal endoscopic procedures</td>
<td>1,490,635</td>
<td>675,065</td>
</tr>
<tr>
<td></td>
<td></td>
<td>41.6%</td>
<td>36.1%</td>
</tr>
<tr>
<td>00740</td>
<td>Anesthesia for upper gastrointestinal endoscopic procedures</td>
<td>573,726</td>
<td>308,141</td>
</tr>
<tr>
<td></td>
<td></td>
<td>16.0%</td>
<td>16.5%</td>
</tr>
<tr>
<td>00142</td>
<td>Anesthesia for procedures on eye; lens surgery</td>
<td>291,984</td>
<td>615,310</td>
</tr>
<tr>
<td></td>
<td></td>
<td>8.1%</td>
<td>32.9%</td>
</tr>
<tr>
<td>01400</td>
<td>Anesthesia for surgical arthroscopic procedures on knee joint</td>
<td>242,007</td>
<td>37,276</td>
</tr>
<tr>
<td></td>
<td></td>
<td>6.7%</td>
<td>2.0%</td>
</tr>
<tr>
<td>00840</td>
<td>Anesthesia for procedures on the lower abdomen</td>
<td>234,875</td>
<td>29,415</td>
</tr>
<tr>
<td></td>
<td></td>
<td>6.6%</td>
<td>1.6%</td>
</tr>
<tr>
<td>00170</td>
<td>Anesthesia for intraoral procedures, including biopsy</td>
<td>171,309</td>
<td>3,379</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4.8%</td>
<td>0.2%</td>
</tr>
<tr>
<td>01480</td>
<td>Anesthesia for procedures on bones of lower leg, ankle, and foot</td>
<td>151,764</td>
<td>43,440</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4.2%</td>
<td>2.3%</td>
</tr>
<tr>
<td>01810</td>
<td>Anesthesia for procedures on the forearm, wrist and hand</td>
<td>144,866</td>
<td>60,947</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4.0%</td>
<td>3.3%</td>
</tr>
<tr>
<td>00400</td>
<td>Anesthesia for procedures on the thorax</td>
<td>143,460</td>
<td>56,168</td>
</tr>
<tr>
<td></td>
<td></td>
<td>4.0%</td>
<td>3.0%</td>
</tr>
<tr>
<td>00790</td>
<td>Anesthesia for procedures on the upper abdomen</td>
<td>140,898</td>
<td>38,781</td>
</tr>
<tr>
<td></td>
<td></td>
<td>3.9%</td>
<td>2.1%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td><strong>3,585,524</strong></td>
<td><strong>1,867,922</strong></td>
</tr>
<tr>
<td></td>
<td></td>
<td>100%</td>
<td>100%</td>
</tr>
</tbody>
</table>

Source: Authors’ Analysis of 2016-2017 HCCI commercial and Medicare Advantage claims data.
Appendix 2. Conversion Factor Methodology

A. Conversion Factor and Medicare Ratio Calculations

Conversion Factors
The conversion factors based on billed charges and allowed amounts for independent anesthesiologists and CRNAs are calculated as follows:

1. Charges CF = Charge / (base units + time units)

2. Allowed Amount CF = Allowed Amount / (base units + time units)

3. The base units are determined by CMS for each procedure code and are available online by year.\(^3\)

4. The time units are pulled from the “units” variable in the claims data.

5. Since we excluded unhealthy patients from our sample, we do not need to account for the patients’ health in our conversion factor calculations.

The conversion factors based on allowed amounts for Anesthesiologist-CRNA supervisory dyad\(^4\) are calculated as:

1. Allowed Amount CF = (Allowed Amount *2) / (base units + time units)

2. The conversion factors corresponding to billed charges cannot be calculated for medically directed procedures. It is not clear in our data whether the charges in the claims are divided in half amongst the anesthesiologist and CRNA. It appears that in some instances the charges have been divided in half in the claims, whereas in other instances, it appears that they both applied their full charges.

Comparison to Traditional Medicare
The charge and allowed amount conversion factors are compared to traditional Medicare using the anesthesia conversion factors published by CMS.\(^5\) The Medicare conversion factors are merged to the claims data based on zip codes and year. The national average Medicare conversion factor based on data published by CMS is $22.31 for the 2016-2017 time period.\(^6\) The percentages of allowed amount CF and charge CF to traditional Medicare are calculated at the claim level.

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\(^3\) The base units for the anesthesia CPT codes are available online at [https://www.cms.gov/Center/Provider-Type/Anesthesiologists-Center](https://www.cms.gov/Center/Provider-Type/Anesthesiologists-Center)

\(^4\) This calculation is based on CMS payment policy, and there is also documentation that this is the computation used in the commercial market by UnitedHealthcare; accessed June 2020, URL: [https://www.uhcprovider.com/content/dam/provider/docs/public/policies/comm-reimbursement/COMM-Anesthesia-Policy.pdf](https://www.uhcprovider.com/content/dam/provider/docs/public/policies/comm-reimbursement/COMM-Anesthesia-Policy.pdf)

\(^5\) The anesthesia conversion factors are available online at [https://www.cms.gov/Center/Provider-Type/Anesthesiologists-Center](https://www.cms.gov/Center/Provider-Type/Anesthesiologists-Center)

\(^6\) The national average Medicare conversion factors are calculated based on CMS anesthesia conversion factors data at the locality level.
B. Sensitivity Analyses

Commercial Claims
More than 50% of commercial claims in our analytical sample have unit values of 1 across all procedure codes. It is unclear in our data whether the unit value of 1 represents 15 minutes or if that is the default value if the time units are not available. The mean in-network allowed amount CFs are consistently higher for claims with unit values of 1 than for claims with unit values greater than 1. The discrepancies are larger for some procedure codes than others (Appendix Exhibit 2.1). We do not see this discrepancy when comparing mean in-network allowed amounts for these two group of claims (unit values of 1 versus unit values greater than 1) (Appendix Exhibit 2.1). If we include claims with unit values of 1, we may inadvertently cause an upward bias in the conversion factor calculations. As a conservative resolution to this data issue, we use a subset of claims where the unit values are not equal to 1 for our primary analyses pertaining to conversion factors. To assess the sensitivity of our analyses to this exclusion criteria, we repeated our conversion factor analyses using the mean and median units of each procedure codes from the MA claims as a proxy for the time units for the commercial claims where the unit values are equal to 1. Appendix Exhibit 2.2 compares the mean in-network and out-of-network conversion factors across three samples: 1) conversion factors from our primary analysis based on subset of commercial claims with unit values not equal to 1; 2) all commercial claims where the mean units from MA claims are used as a proxy for time when the unit value is 1; and 3) all commercial claims where the median units from MA claims are used as a proxy for time when the unit value is 1. Of the three samples, the conversion factors calculated from our primary analysis are the most conservative for all provider types. For independent anesthesiologists, the mean in-network allowed amount CF are pretty aligned across the three samples. The mean ranges from $82 to $88. For independent CRNAs, there is minimal variation in the mean in-network allowed amount CFs across the three samples. The mean ranges from $57 to $70. For anesthesiologist-CRNA supervisory dyads, there is some variation in the mean in-network allowed amount CF across the three samples. The mean ranges from $65 to $82 for anesthesiologists-supervisors and $60 to $77 for CRNAs supervisee. Notably, our empirical analysis of 2016-2017 commercial claims estimated a mean commercial in-network allowed amount CF ($82) for direct anesthesiologists’ services slightly higher than that self-reported by a convenience sample of anesthesiologists in the American Society of Anesthesiologists’ annual survey ($79 in 2017).7

Medicare Advantage Claims
 Approximately 30% of MA claims in our analytical sample have unit values of 15 or more. It appears that the unit values in our data may be a mix of 15-minute increments and actual minutes. The mean in-network allowed amount CF for MA claims with unit values of 15 or more are much lower than the MA claims with unit values of 10 or less. After converting the unit values of 15 or more to 15-minute increments, the mean in-network allowed amount CF

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for this set of claims are aligned with the claims with unit values of 10 or less (Appendix Exhibit 2.3).
Approximately 3.4% of MA claims in our sample have unit values of 10 to 14.99. It is unclear whether these values represent 15-minute increments or actual minutes for the procedures.
For the subset of MA claims with unit values of 10 to 14.99, the mean in-network conversion factors seem reasonable for some procedure codes but not for others after converting the units to 15-minute increments. For instance, for procedure code 00142, the mean in-network conversion factor for independent anesthesiologists before adjusting the units is $6.19. After adjusting the units to 15-minute increments, the mean in-network conversion factor is $20.30. This also holds true for procedure code 00810, where the pre-adjusted mean in-network conversion factor for anesthesiologist is $8.57. After adjusting the units, the mean in-network conversion factor is $24.83.
There are some procedure codes where converting the units to 15-minute increments may not make sense for this group of claims. For instance, for procedure code 00400, the mean in-network conversion factor for anesthesiologist before adjusting the units is $16.95. After converting the units to 15-minute increments, the mean in-network conversion factors increased to $63.96. This is also true for procedure codes 00170, 00840, 01400, 01480 and 01810 (Appendix Exhibit 2.3).
To resolve this issue, we exclude MA claims with unit values of 10 to 14.99 from the conversion factor calculations.

eAppendix Exhibit 2.1. Comparison of Allowed Amount CF and Total Allowed Amounts for Commercial Claims with Unit Values of 1 and Greater than 1

Panel A. Mean In-Network Allowed Amount CF for Independent Anesthesiologists
Panel B. Mean In-Network Allowed Amounts for Independent Anesthesiologists

Source: Authors’ Analysis of 2016-2017 HCCI commercial claims data.
Note: This pattern is also consistent for independent CRNAs and Anesthesiologists-CRNA supervisory dyads.

eAppendix Exhibit 2.2. Sensitivity Analysis

Panel A. Mean In-Network Allowed Amount Conversion Factors by Provider Type
Panel B. Mean Out-of-Network Allowed Amount Conversion Factors by Provider Type

Source: Authors’ Analysis of 2016-2017 HCCI commercial and Medicare Advantage claims data.

eAppendix Exhibit 2.3. Comparison of Allowed Amount CF for MA Claims with Unit Values Less than 10, 10-14.99 and 15 of More

Panel A. Mean In-Network Allowed Amounts CF for Independent Anesthesiologists; Before Adjusting Unit Values to 15-Minute Increments
Panel B. Mean In-Network Allowed Amounts CF for Independent Anesthesiologists; After Adjusting Unit Values to 15-Minute Increments

Source: Authors’ Analysis of 2016-2017 HCCI Medicare Advantage claims data.
eAppendix 3. Provider Structure Categorization

**Procedure Identification**
Claims with the same patient identifier, procedure code, place of service, and service date are assumed to be associated with the same anesthesia procedure for the patient.

**Provider Type**
The type of provider(s) performing the anesthesia procedure are determined using the modifiers and “provcat” variable provided by HCCI (that attempts to identify the provider’s primary specialty). If the modifiers are missing, then the provcat variable is used as the proxy.
The provider type identified for each procedure are based on the following rules:

1. **Anesthesiologist** - The procedure has one claim and the modifier is AA (Performed personally by an anesthesiologist).

2. **CRNA** - The procedure has one claim and the modifier is QZ (CRNA service without medical direction by a physician).

3. **Anesthesiologist-CRNA supervisory dyad** - The procedure has two claims and one of the modifiers is QY or QK and the other modifier is QX.

The provider type was identified using modifiers for 90.8% of the commercial claims and 99.2% of the MA claims in our analytical sample.
The breakdown of the provider type in our analytical sample is presented in Appendix Exhibit 3.1.
### eAppendix Exhibit 3.1. Provider Structure Composition

<table>
<thead>
<tr>
<th>Provider Type</th>
<th>Description</th>
<th>Commercial</th>
<th>Medicare Advantage</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td># of Procedure s</td>
<td>% of Procedure s</td>
</tr>
<tr>
<td>ANES-CRNA</td>
<td>Anesthesiologist-CRNA (medical direction by the physician)</td>
<td>553,248</td>
<td>18.2%</td>
</tr>
<tr>
<td>ANES</td>
<td>Anesthesiologist (personally performed)</td>
<td>1,319,606</td>
<td>43.5%</td>
</tr>
<tr>
<td>CRNA</td>
<td>CRNA (without supervision)</td>
<td>1,159,422</td>
<td>38.2%</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td><strong>3,032,276</strong></td>
<td><strong>100%</strong></td>
</tr>
</tbody>
</table>

Source: Authors’ Analysis of 2016-2017 HCCI commercial and Medicare Advantage claims data.
Appendix 4. Cost-sharing and Network Status in MA Plans

We observed that out-of-network anesthesiology service utilization was much higher among MA plan claims (41.2%) than commercial claims (8.3%) (Appendix Exhibit 4.1). Prior work by Daria Pelech has also documented higher rates of out-of-network utilization among MA plans than commercial plans.\(^8\)

This high out-of-network anesthesiology service utilization raised concerns about the potential for high out-of-pocket expenditures for the MA plan enrollees. We evaluated the cost-sharing burden for MA plan enrollees as the sum of co-payment, co-insurance, and deductible amounts reported on claims in our analytic sample. Average cost-sharing for MA patients for the anesthesiology services included in our analysis is $12.51 (8.5% of the allowed amount) for out-of-network services, compared with $5.47 (3.6% of the allowed amount) for in-network services. We conclude that high out-of-network anesthesiology service utilization does not result in substantial out-of-pocket burden for MA plan enrollees.

Appendix Exhibit 4.1. Network Status for Anesthesia Services among Commercial and Medicare Advantage Claims

<table>
<thead>
<tr>
<th>Network Status</th>
<th>Commercial</th>
<th>Medicare Advantage</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Anesthesiologist-CRNA Dyad</td>
<td>Anesthesiologist</td>
</tr>
<tr>
<td>In-Network</td>
<td>86.7%</td>
<td>87.7%</td>
</tr>
<tr>
<td>Out-of-Network</td>
<td>5.7%</td>
<td>7.4%</td>
</tr>
<tr>
<td>Unknown</td>
<td>7.6%</td>
<td>4.8%</td>
</tr>
</tbody>
</table>

Source: Authors’ Analysis of 2016-2017 HCCI commercial and Medicare Advantage claims data.
Note: There are no unknown network status for Medicare Advantage claims in our data sample. Anesthesiologist-CRNA dyads are considered out-of-network if either the anesthesiologist or the CRNA (or both) is out-of-network. If one provider has unknown network status but the other has in-network status, the dyad’s network status is considered unknown.

\(^8\) Daria M. Pelech. Prices for Physicians’ Services in Medicare Advantage and Commercial Plans. Medical care Research and Review. 2018;77(3):236-248. URL: https://doi.org/10.1177/1077558718780604
**Appendix 5. Distributions of Allowed Amounts and Charges**

**Appendix Exhibit 5.1. Distribution of Percentage of Allowed Amount and Charges Conversion Factors Relative to Traditional Medicare**

![Chart showing the distribution of allowed amounts and charges conversion factors for different providers.]

Source: Authors’ Analysis of 2016-2017 HCCI commercial and Medicare Advantage claims data.

Note: The allowed amount and charge conversion factors include in-network, out-of-network, and unknown network status claims and exclude claims for anesthesiologist-CRNA supervisory dyads.
Appendix Exhibit 5.2. Distribution of Allowed Amount and Charges Conversion Factors among Commercial and MA Claims

Source: Authors’ Analysis of 2016-2017 HCCI commercial and Medicare Advantage claims data.
Note: The allowed amounts and charges includes in-network, out-of-network, and unknown network status claims and exclude claims for anesthesiologist-CRNA supervisory dyads.