



WHITE PAPER

Imputing Allowed Amounts

Development and validation of an encounter-level
allowed amount imputation model

Summary

Komodo Health® has developed a suite of analytical methods to impute healthcare cost data. The analytical methods are based on publicly available Centers for Medicare & Medicaid Services (CMS) Medicare Fee-for-Service (FFS) pricing methodologies and patterns gleaned from 4.4 billion claims across 8.7 billion claim lines of actual allowed amounts internally warehoused at Komodo. The imputation methodology developed by Komodo is capable of imputing allowed amounts for claims across all payer segments and all service types, including FFS, hospital prospective payment, and pharmacy.

When compared against a basket of external benchmarks, Komodo's annual total cost of care per member falls within a narrowly defined range established by those benchmarks. Using 2019 data (to avoid any confounding due to COVID-19), total cost of care per member with commercial group coverage ranges from \$5,834 to \$6,290, with Komodo's total cost of care falling in the middle of that range at \$6,055,10.

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Introduction

Health insurance claims records with financial fields such as allowed amounts are critical to a variety of research disciplines, including health economics research, health services research, outcomes research, and actuarial sciences. Due to the protected nature of payer-provider rate negotiations, financial data is commonly redacted from many commercially available claims data sources. Establishing a reliable methodology for imputing financial fields holds the promise of greatly expanding the universe of claims data available to researchers.

Methods

Data sources: Komodo's foundational data asset, known as the Healthcare Map®, is built upon a set of patient and encounter records representing the full spectrum of healthcare information, including lab records, EMR extracts, hospital insights, genomics, and medical claims. Additionally, Komodo's Healthcare Map has data-linking capabilities to further enrich patient characteristics and healthcare encounters as more sources are integrated. While most health economics datasets are based on payer-complete "closed" data, the medical claim domain of the Healthcare Map is unique in that it includes closed payer-complete data as well as open-provider and healthcare intermediary—derived data. The Healthcare Map is vast: In the five-year period from 2018 to 2022, it included 166 million unique closed patients, 12 billion professional claims, 2.1 billion institutional claims, and 18 billion pharmacy claims. All medical and pharmacy claims were processed through Komodo's allowed amount imputation engine.

Data processing: Encounter records from Komodo's various suppliers are consolidated, harmonized, and de-duplicated into a unified warehouse of healthcare

encounters. Outlier trimming is performed on the units value of professional claims; claims with excessive and erroneous units are occasionally paid by health plans, which can lead to overestimation of allowed amounts when re-priced. Outlier trimming constrains the units value to prevent these excessive estimates. Where available, Medicare Medically Unlikely Edits (MUEs) are used to define a maximum acceptable units value. If an MUE is not established, units values are constrained using a ceiling based on the 95th percentile of the distribution for each particular service.

Medical cost imputation: Imputation of medical costs leverages a combination of two different rate-imputation methodologies:

1. Medicare-based

- ▶ While Medicare FFS pricing methodologies can be highly complex, they are publicly available and well understood. The degree to which other payers' payment rates vary relative to Medicare has been studied extensively in the literature^{2,5,9}.
- ▶ Komodo first processes all medical claims using the appropriate base Medicare pricing approach, including locality and hospital weight-specific adjustments. Then, for non-Medicare claims, adjustment factors sourced from the literature are applied. Adjustment factors range from 37% for the Medicaid service with the lowest relative payment to 240% for the commercial service with the highest relative payment.

2. All-payer actuals-based

The Healthcare Map contains actual allowed amounts for 8.7 billion claim lines across 4.4 billion claims in the five-year period from 2018 to 2022. While this represents a large repository of actual allowed amounts data, it's still only a subset of Komodo's entire Healthcare Map; hence the need for imputations.

Closed vs. Open Data

Closed, payer-complete data contains a full claims history for all enrolled members and is especially useful for studies that track patient cohorts longitudinally over time.

Open, provider-complete sources include claims records captured by non-payer entities, such as clearinghouses, revenue cycle operators, or providers directly. These data can enrich cross-sectional analysis and provide unique value in analyzing the downstream impact of claim denials, which are not typically visible through closed sources.

Diagnosis-Related Groups and Ambulatory Payment Classification Imputation

In order to accurately price both inpatient and outpatient hospital encounters, which are typically paid under prospective payment systems, it's necessary to first assign the appropriate diagnosis-related group (DRG) or set of ambulatory payment classifications (APCs) for each encounter, which then determines the payment rate. In addition to their roles in rate setting, DRGs and APCs represent an important convention in the categorization of hospital encounters and are critical for many hospital utilization and outcomes research analyses.

- **DRG imputation source:** Komodo utilizes the Medicare Severity Diagnosis Related Groups (MS-DRGs) library, which is provided and maintained by CMS, to assign DRG codes based on patient information, diagnosis codes, and procedure codes.
- **APC imputation source:** Komodo utilizes a Healthcare Common Procedures Coding System (HCPCS)-APC crosswalk, which is provided and maintained by CMS, to map Healthcare Common Procedure Codes (HCPCS) to their respective APC codes.

Patterns observed in this allowed amount database are used to create price imputations, which can be applied across the broader Healthcare Map®. Imputations are calculated based on adjusted measures of central tendency, conditional on payer type and care setting (facility or non-facility based).

Medicare- and actuals-based estimates are then synthesized using a proprietary algorithm developed by Komodo. Based on Komodo's proprietary pricing algorithm, the Medicare-based or actuals-based rates will be selected; in other cases, a blended rate based on a weighted average of the two may be used. Imputed rates are assigned universally across all medical claims, even if an actual record may be present in Komodo's underlying Healthcare Map. Universal imputation allows Komodo to support a broader range of customer use cases and ensures consistency across records. Komodo's rate-setting algorithm is calibrated to ensure that total costs and costs at the service category level (e.g., drug, hospital inpatient, outpatient, professional, etc.) match established benchmarks (see Results section in next column).

Rx cost imputation: Actual amounts are available for 38% of Rx plan-paid amounts and 70% of Rx patient-paid amounts. In contrast to Komodo's medical claims imputations, Rx actuals are included where available. For the remaining 62% and 30%, respectively, plan- and patient-paid amounts are imputed using the median value for each NDC conditional on payer type. Totaling the plan-paid and patient-paid amount columns provides the total allowed amount for an Rx encounter.

Results

After fully implementing Komodo's cost imputation model, summary statistics were developed and comparisons against external benchmarks were conducted to evaluate the model's performance.

Fill rates: In the five-year period from 2018 to 2022, the total claim-level fill rate for the imputed cost columns was 98.5%. Category-specific fill rates were calculated across three types of encounters: pharmacy claims, inpatient facility claims, and all other claims (referred to as "Non-IP" in Table 1). Category-specific fill rates ranged from 95% to 99.5%.

TABLE 1: Fill Rates

(Output based on product release as of January 2023)

Table and Claim Type	Financial Column	Fill Rate*
Pharmacy	Plan- and patient-paid amounts	100%
Hospital Inpatient	Allowed amount	95%
Non-IP (HOPD, professional, DME, etc.)	Allowed amount	97%
Total claim-level fill rate	Allowed amounts (Mx), plan- and patient-paid amounts (Rx)	98.8%

**Claim-level fill rate, 2018–2022.*

Utilization: For a benchmark, 2019 service category level data on the commercial group population from the Health Care Cost Institute’s (HCCI) 2020 Cost and Utilization Report³ supplemental data file was used. HCCI is an independent non-profit research institute whose 2019 commercially insured claims database included data from four large health plans representing more than 55 million covered lives⁴.

The HCCI data was used due to the large sample size and well-established methodology, and 2019 data was used to avoid any idiosyncratic effects related to the COVID-19 pandemic. Utilization rates were calculated by taking the total number of services utilized during the calendar year divided into the total number of patient-years during the calendar year, including partial-enrollment years. Komodo and HCCI utilization rates matched closely, with a maximum category-level difference of 7% for testing services and a minimum difference of 0.3% for inpatient services.

TABLE 2: Utilization Metrics

Rates per 1K by category compared to HCCI, 2019
(Output based on product release as of January 2023)

	Procedures	Imaging	Testing	E&M	Hospital IP
Komodo	930	1,816	9,606	5,833	44
HCCI	939	1,821	9,002	5,535	44

Total cost of care: To assess annual total cost of care at the patient level, three other comparators were identified in addition to HCCI: Minnesota Community Measurement’s 2020 Health Care Cost & Utilization report⁶, results from a 2017 Agency for Healthcare Research and Quality (AHRQ) study using Truven MarketScan data, and a second set of results from the same AHRQ study using data from OptumLabs¹⁰. The AHRQ results were trended out to 2019 using a 4.3% inflator derived from HCCI’s total cost of care increases over the 2016–2019 period.

Consistent with the calculation approach for utilization rates, total annual costs for members with commercial group coverage were divided into the total number of patient years, accounting for partial-enrollment years. Komodo total annual costs were \$6,055, compared to \$5,834 for HCCI — a \$6,290 projected value based on the AHRQ MarketScan results and a \$6,236 projected value based on the AHRQ OptumLabs results. All four of these estimates are clustered closely together; the range between the highest and lowest results is \$456, with Komodo close to the middle of that range. The Minnesota Community Measurement total of \$7,524 represents an outlier, likely due to high healthcare costs in that particular state, but it is nonetheless useful in illustrating the high variance in costs that is possible across populations.

► Annual Total Cost of Care (\$K), Komodo vs. Comparators (by year)

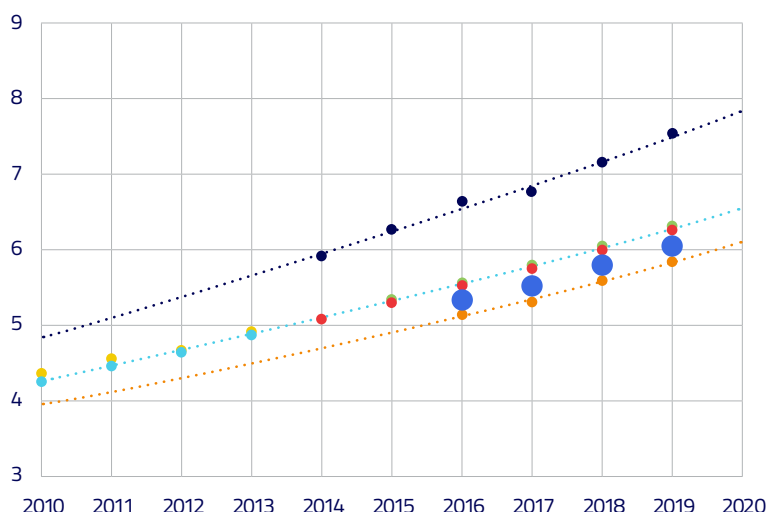
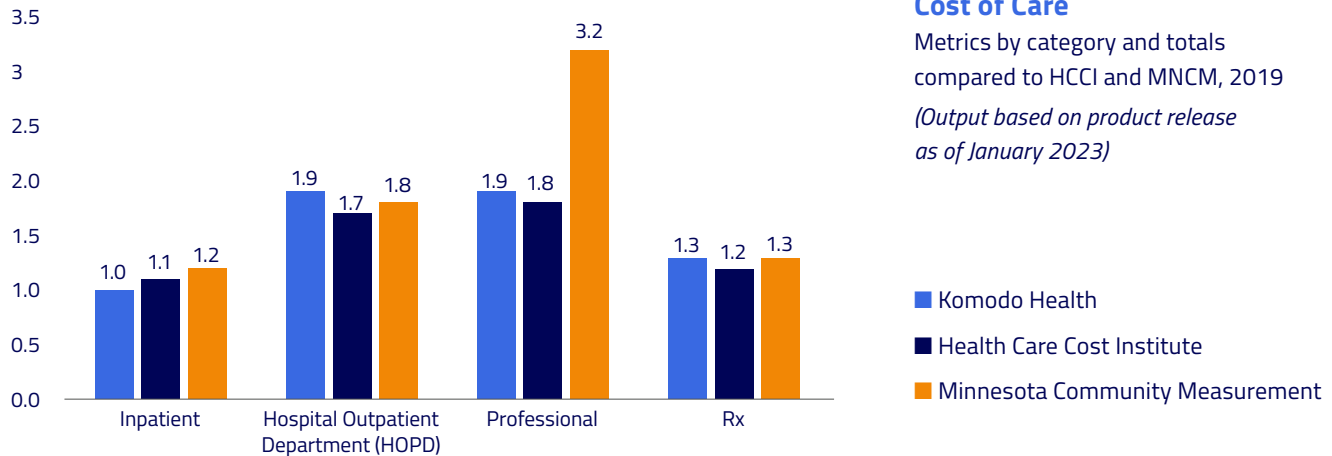


CHART 1: Total Cost of Care

Metrics by category and totals compared to HCCI and MNMCM, 2019
(Output based on product release as of January 2023)

- Komodo Health
- Minnesota Community Measurement
- Health Care Cost Institute
- OptumLabs¹⁰
- OptumLabs¹⁰ (projected)
- MarketScan¹⁰
- MarketScan¹⁰ (projected)

Total Cost of Care (\$K) per Member by Service Type, 2019



**CHART 2:
Service Category Level
Cost of Care**

Metrics by category and totals compared to HCCI and MNMCM, 2019

(Output based on product release as of January 2023)

Cost of care by service category: Member-level annual costs of care were categorized by service type and compared against HCCI and Minnesota Community Measurement, the two available comparators. Minnesota Community Measurement again represents an outlier but is included to demonstrate the variations possible in healthcare costs across populations. While some minor fluctuations exist, Komodo cost estimates are generally consistent with HCCI at the service category level.

Intended Use Cases

Komodo's Healthcare Map, when enhanced with Komodo's cost-data imputation methodology and linking capabilities, can address a wide range of health economics-related use cases. However, there are certain situations that fall outside Komodo's intended use cases:

Recommended	Not Recommended
<ul style="list-style-type: none"> ▶ Total cost/HCRU ▶ Cost by burden of disease ▶ Cost by payer channel ▶ Impact of therapy claim denial on patient outcomes ▶ Provider-level resource-utilization analysis 	<ul style="list-style-type: none"> ▶ Assessment of actual reimbursement rates for specific payers or providers

Discussion

Payment-rate imputation is a complex undertaking with a wide variety of prospective and fee-for-service reimbursement methodologies in use and rates that vary across payer types. Komodo's rate-imputation methodology uses a suite of rate-imputation approaches to account for this complexity, and the results closely match those of several established benchmarks.

Limitations

While category-level and total cost of care results are well calibrated and match external benchmarks, it is likely that, for individual claim lines, some residual error persists, both above and below the actual allowed amount of the claim.

- ▶ Komodo's price-imputation process produces imputed rates that are substantially smoothed, with lower variance than raw, unadjusted healthcare costs. There are advantages to using a smoothed pricing index; for example, it eliminates incidental spikes or troughs in costs due to idiosyncrasies in negotiated rates. However, for some applications, unsmoothed estimates that more closely match the large pricing variance observed in actual healthcare costs may be preferable.
- ▶ Komodo's current imputation methodology provides insights on imputed allowed amounts, which may limit use cases requiring actual allowed amounts or other cost data variables. Komodo plans to continue developing enhancements such as additional financial columns to address an even broader range of cost-related use cases.

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