



CENTER FOR IMPROVING  
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## Prometheus Report for Medicaid/Commercial Populations

### Methodology

The following is a description of the methodology used to create Prometheus reports for procedure-based episodes. It also includes information about the:

- Percentage of procedures that were included (completion rate) by episode type
- Results from an evaluation of the performance of the Prometheus risk adjustment model

We had hoped to also include details about the potentially-avoidable complications (PAC) for each procedure-based episode. Unfortunately, our analysis is not yet complete. Our goal is to report the frequency of the ICD-10 complication codes in the PACs for each procedure-based episode. Some of the complication codes will be very specific and some more vague. With this information, we aim to assess the validity of the PACs.

### Data Sources

The source of the claims data used to create Prometheus procedure-based episodes was the Colorado APCD. Medical and prescription drug claims data for Medicaid and Commercial payers were included. Medicaid data did not include claims for substance use disorder.

The Commercial Prometheus episodes were generated from claims for the period January 2015 through June 2017. The Medicaid Prometheus episodes were generated from claims for the period July 2015 through September 2017. Prometheus runs consist of a one year lookback period, a study period, and a three month run-out period to ensure that episodes that start near the end of the study period can be completed. Hence the Commercial Prometheus run encompasses a study period from January 2016 through March 2017, for 5 quarters, while the Medicaid run encompasses a study period from July 2016 through June 2017, for a 4 quarter run. The Medicaid run uses a different time period to accommodate begin and end dates of the Medicaid fiscal year.

### Attribution of Episode to Facility Provider

For procedural episodes, we utilize the Prometheus method for attributing episodes to facility providers. This method attributes each episode to the facility associated with the triggering inpatient or outpatient claim.

### Cost Measures

Episode costs are calculated as the sum of allowed amounts for facility, professional and pharmacy claims services during the course of an episode. These include inpatient, outpatient ancillary and prescription drug costs for typical (or routine) care associated with the procedure and for treatment of potentially avoidable complications of care (PAC). Costs that can be attributed to more than one episode are split evenly between those episodes.

Most procedural episodes have a look-back period of 30 days and a duration of 90 days post-procedure (or post discharge in the case of procedural episodes triggered by an inpatient procedure).

## Percentage Procedure Grouped

The overall percentage of procedures that were grouped to episodes (completion rate) was 43.6% for Commercial and 43.9% for Medicaid. (See table, below, for completion rates by episode type). Note that there is considerable variation in completion rate by episode type, with extremely low completion rates for cataract surgery and high rates for vaginal delivery. Absolute counts of conditions vary due to the different study period lengths and number of members in the Commercial and Medicaid runs. However the percentages of completion between the two runs are comparable.

## Evaluation of Prometheus Risk Model with APR-DRG

The Prometheus risk model is used to estimate episode and PAC expected costs based on each patient's risk factors; higher expected costs are associated with patients with comorbid conditions that put them at higher risk for complications of care. This information is useful when measuring provider performance. Providers with actual episode costs that are lower than expected are high performing and better at managing high risk patients than providers with actual episode costs that are higher than expected costs.

In order to answer questions about the utility of the Prometheus risk adjustment model and expected cost figures, Payformance conducted an analysis of a few Prometheus procedural episodes for a Medicaid population. The analysis focused on procedural episodes that are triggered by a procedure performed during an inpatient hospitalization. Payformance compared the Prometheus episode expected cost to the APR-DRG relative weight for the associated inpatient hospitalizations for episodes in the data set. They plotted and analyzed the results in order to evaluate the presence or absence of a correlation between the two methods of assessing severity of illness and resource use.

The result showed a strong correlation between episode costs and APR-DRG relative weights for most of the 16 procedure episodes analyzed. Correlation was high overall ( $R^2 = 0.76$ ) and for individual procedural episodes of CABG, hip and knee replacements, lumbar laminectomy and spinal fusion, pacemaker/defibrillator, bariatric and colorectal surgery ( $R^2 > 0.80$ ) but low for coronary angioplasty and C-section and ( $R^2 < 0.40$ ) (See PowerPoint presentation summarizing the methodology and results for this analysis)

## Percentage of Procedure Grouped to Episodes (% Complete) for Commercial and Medicaid Populations

Episode Description	Commercial			Medicaid		
	Incomplete	Complete	% Complete	Incomplete	Complete	% Complete
<b>Bariatric Surgery</b>	781	1,019	56.6%	467	999	68.1%
<b>Breast Biopsy</b>	9,795	6,586	40.2%	1,921	2,952	60.6%
<b>CABG &amp;/or Valve Procedures</b>	1,180	673	36.3%	656	242	26.9%
<b>Cataract Surgery</b>	22,515	7,086	23.9%	10,948	1,010	8.4%
<b>Colonoscopy</b>	97,314	68,053	41.2%	24,365	12,861	34.5%
<b>Colorectal Resection</b>	1,476	1,166	44.1%	749	404	35.0%
<b>Coronary Angioplasty</b>	2,766	1,889	40.6%	1,461	1,039	41.6%
<b>C-Section</b>	5,374	9,527	63.9%	6,300	8,765	58.2%
<b>Gall Bladder Surgery</b>	5,639	5,559	49.6%	4,045	4,304	51.6%
<b>Hip Replacement &amp; Hip Revision</b>	3,811	3,645	48.9%	876	761	46.5%
<b>Hysterectomy</b>	4,742	5,613	54.2%	1,599	1,986	55.4%
<b>Knee Arthroscopy</b>	10,919	9,020	45.2%	2,953	1,610	35.3%
<b>Knee Replacement &amp; Knee Revision</b>	5,955	5,477	47.9%	1,375	1,226	47.1%
<b>Lumbar Laminectomy</b>	3,781	3,247	46.2%	1,157	1,206	51.0%
<b>Lumbar Spine Fusion</b>	2,409	1,069	30.7%	1,016	553	35.2%
<b>Lung Resection</b>	138	122	46.9%	68	57	45.6%
<b>Mastectomy</b>	2,414	2,277	48.5%	584	414	41.5%
<b>Pacemaker / Defibrillator</b>	1,484	676	31.3%	705	417	37.2%
<b>Prostatectomy</b>	399	441	52.5%	41	44	51.8%
<b>Shoulder Replacement</b>	880	568	39.2%	323	52	13.9%
<b>Tonsillectomy</b>	4,842	4,405	47.6%	4,607	4,042	46.7%
<b>Transurethral resection prostate</b>	1,009	546	35.1%	278	148	34.7%
<b>Upper GI Endoscopy</b>	43,510	27,833	39.0%	28,807	15,683	35.3%
<b>Vaginal Delivery</b>	12,987	23,517	64.4%	16,816	26,907	61.5%
	<b>246,120</b>	<b>190,014</b>	<b>43.6%</b>	<b>112,117</b>	<b>87,682</b>	<b>43.9%</b>



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Validating the Risk Adjustment Methodologies:  
Prometheus Analytics (to) APR-DRG

2019.03.11

# APR-DRG relative weights vs. Episode-based risk adjustment comparison, using the Michigan Medicaid claims data

- OBJECTIVE: Validate episode-based risk adjustment methodologies (e.g., Prometheus Analytics) trends with IP-Classification System risk adjustment methodologies commonly applied at State Medicaid agencies (e.g., APR-DRG relative weights).
  - APR-DRG: IP-classification system weights are applied to an individual's inpatient admissions only. All Patients Refined Diagnosis Related Groups (APR-DRG) is a classification system that classifies patients according to their reason of admission, severity of illness, and risk of mortality. (Source #1)
  - Prometheus Analytics: Episode-based weights, developed for each member episode. Episodes cover multiple visits across the continuum of care, including inpatient admissions, outpatient visits, professional, and pharmacy claims. Episode-based risk adjustment methodology is intended to accurately and fairly account for individuals' insurance risk in relation to episode costs. The Prometheus Analytics risk adjustment methodology was developed through a collaboration between the Altarum Institute and researchers from the Schneider Institutes for Health Policy at Brandeis University to develop an episode grouper for the Centers for Medicare and Medicaid Services (CMS). (Source #2)
- RAW DATASET: Michigan Medicaid 10/1/2015 – 3/31/2018, allowed and paid amounts are restricted to proxy pricing logic.
  - Proxy pricing methodology enables users to focus on cost, quality, and utilization holding all other factors constant (e.g., competitive rates, negotiated fee schedules, and market specific adjustments). The methodology for Michigan leverages the Michigan MDHHS Medicaid and CMS Medicare fee schedules.
- TARGET DATASET: Analysis was targeted on 24 procedural episodes, based on Prometheus definitions. (Source #3)
  - Total consideration of member episodes represents approx. \$648M and 192k member episodes
  - Removed Episodes: Eight episodes with nearly no inpatient admissions and thereby associated APR-DRG weight (e.g. COLOS, which is mostly done in outpatient setting) were removed. These account for only about \$226M and 118k member episodes. The eight episodes were: Breast Biopsy, Colonoscopy, Cataract Surgery, Upper GI Endoscopy, Knee Arthroscopy, Mastectomy, Tonsillectomy, Transurethral Resection Prostate
  - Included Episodes: Sixteen episodes with inpatient admissions and significant APR-DRG volume (>11 member episodes per APR-DRG) were included in the analysis. The sixteen episodes were: Bariatric Surgery, Colorectal Resection, C-Section, CABG &/or Valve Procedures, Lumbar Spine Fusion, Hip Replacement & Hip Revision, Knee Replacement & Knee Revision, Vaginal Delivery, Gall Bladder Surgery, Hysterectomy, Lumbar Laminectomy, Lung Resection, Coronary Angioplasty, Pacemaker / Defibrillator, Prostatectomy, Shoulder Replacement
- HYPOTHESIS: APR-DRG relative weight and mean Prometheus expected cost, for each combination of Episode and DRG, will have a linear relationship (i.e., higher the APR-DRG relative weight or severity of illness or resource use, greater the episodic expected cost)

Source:

(1) <https://www.hcup-us.ahrq.gov/db/nation/nis/APR-DRGsV20MethodologyOverviewandBibliography.pdf>

(2) <http://prometheusanalytics.net/sites/default/files/attachments/Risk-Adjustment-Methodology.pdf>

(3) <http://prometheusanalytics.net/deeper-dive/definitions-readable>



# Testing the linear relationship between APR-DRG & Prometheus Expected Costs

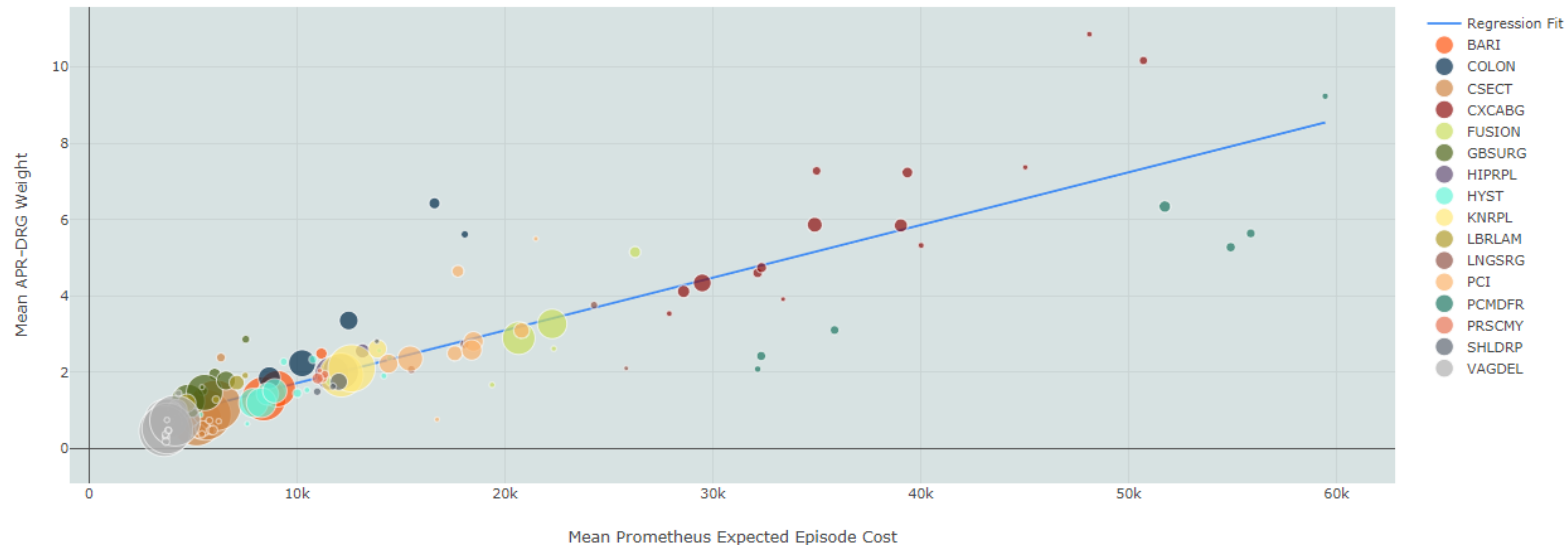
- APPROACH:
  - Identify member episode cohort where IP admissions has significant enough volume to support validation to APR-DRG relative weights. For each episode description, calculate the mean expected cost by APR-DRG.
  - Plot each data point (i.e., Episode – to - APR-DRG pairing)
  - Derive a linear regression, weighing each data point equally.
  - Based on values of Mean Square Error & R-squared and the characteristics of residual plot determine that the linear model is a fit.
  - Determine from here that there exists a linear relationship both in aggregate (e.g., all member episodes) and by each individual member episode description (e.g., CABG)



# APR-DRG & Prometheus Expected Costs, have a significant correlation - in aggregate

Significant amount of correlation between APR-DRG & mean episode-based expected costs, in aggregate & by episode. Given this level of correlation, Prometheus episode-based analytics risk adjustment model appear to be appropriately representing the severity of illness or resource use for each member episode. Having said this, it should be recognized that there is an inherent difference in the intended use of the two models: APR-DRG relative weights for IP cases and Prometheus Analytics for member-episode based analytics.

Mean APR-DRG Weight vs. Mean Prometheus Expected Cost



#### Key Considerations:

Size of bubble represents the volume (capped at 1k) for each data point. The regression fit line was derived applying an equal weighting on each data point. This avoids over-fitting the line to specific episodes (e.g., Maternity-related deliveries represent 86% of data points, 64% of total claims dollars)

118 points plotted, 70k episodes included  
RMSE of fit = 1.018  
R-Squared of fit = 0.76



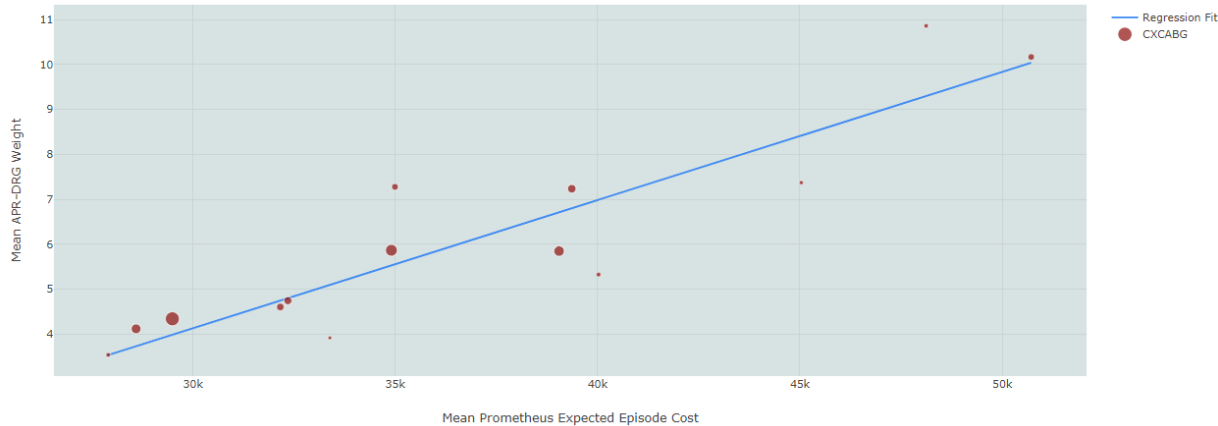
#### Notes:

Root Mean Square Error (RMSE), [https://en.wikipedia.org/wiki/Root-mean-square\\_deviation](https://en.wikipedia.org/wiki/Root-mean-square_deviation)  
R-squared, [https://en.wikipedia.org/wiki/Coefficient\\_of\\_determination](https://en.wikipedia.org/wiki/Coefficient_of_determination)

# APR-DRG & Prometheus Expected Costs, have a significant correlation - by episode

APR-DRG vs. PROM Expected Cost Correlation Analysis  
Episode: Coronary Artery Bypass Graft

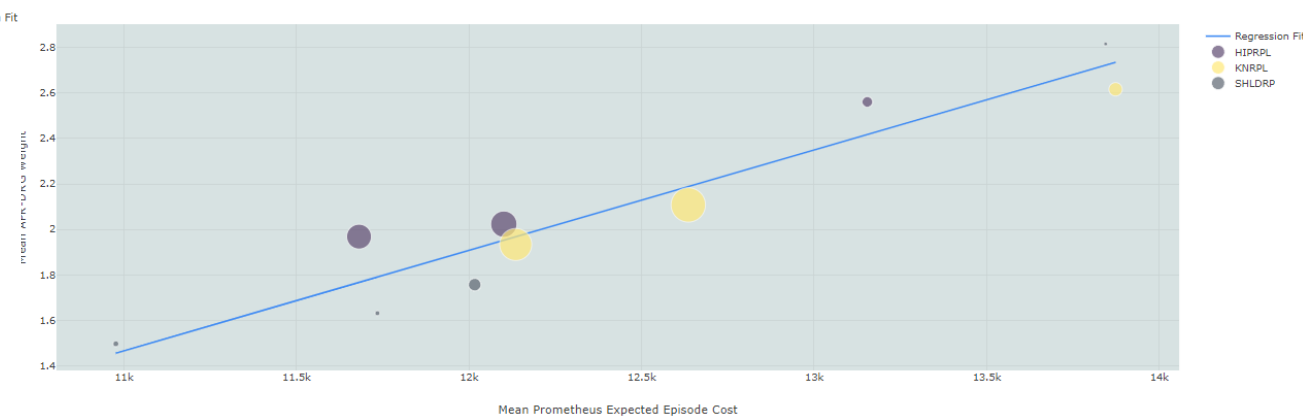
Mean APR-DRG Weight vs. Mean Prometheus Expected Cost



14 points plotted, 1k episodes included  
RMSE of fit = 0.926  
R-Squared of fit = 0.82

APR-DRG vs. PROM Expected Cost Correlation Analysis  
Episode: Hip Replacement & Hip Revision, Knee Replacement & Knee Revision, Shoulder Replacement

Mean APR-DRG Weight vs. Mean Prometheus Expected Cost



10 points plotted, 3k episodes included  
RMSE of fit = 0.122  
R-Squared of fit = 0.91

## Key Considerations:

Size of bubble represents the volume (capped at 1k) for each data point. The regression fit line was derived applying an equal weighting on each data point. This avoids over-fitting the line to specific episodes (e.g., Maternity-related deliveries represent 86% of data points, 64% of total claims dollars)

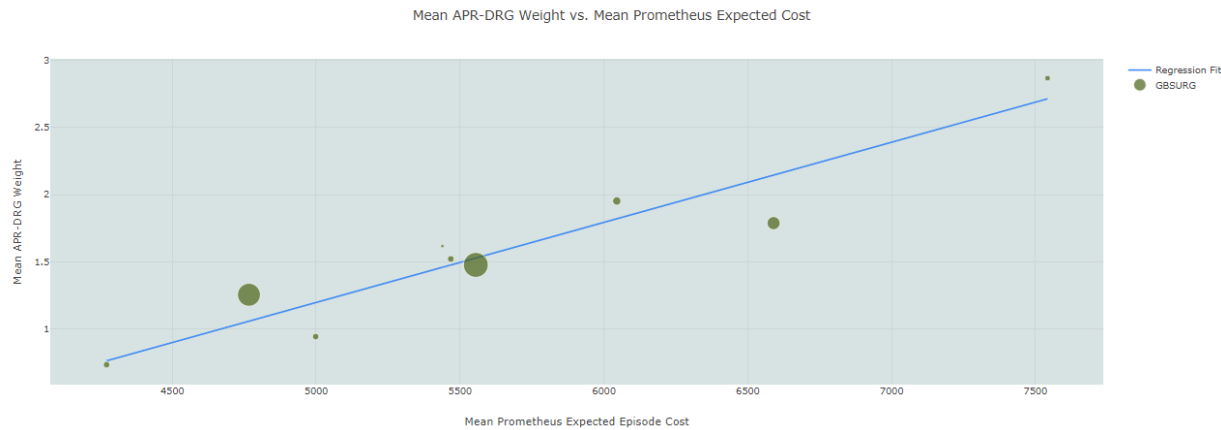


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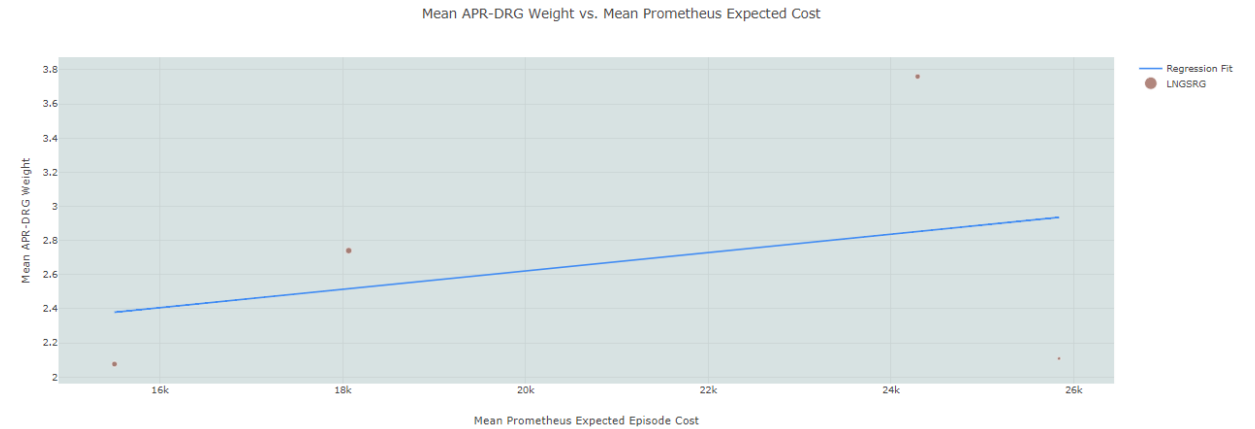
# APR-DRG & Prometheus Expected Costs, have a significant correlation - by episode

APR-DRG vs. PROM Expected Cost Correlation Analysis  
Episode: Gall Bladder Surgery



9 points plotted, 1k episodes included  
RMSE of fit = 0.184  
R-Squared of fit = 0.90

APR-DRG vs. PROM Expected Cost Correlation Analysis  
Episode: Lung Resection



4 points plotted, 96 episodes included  
RMSE of fit = 0.642  
R-Squared of fit = 0.11

### Key Considerations:

Size of bubble represents the volume (capped at 1k) for each data point. The regression fit line was derived applying an equal weighting on each data point. This avoids over-fitting the line to specific episodes (e.g., Maternity-related deliveries represent 86% of data points, 64% of total claims dollars)

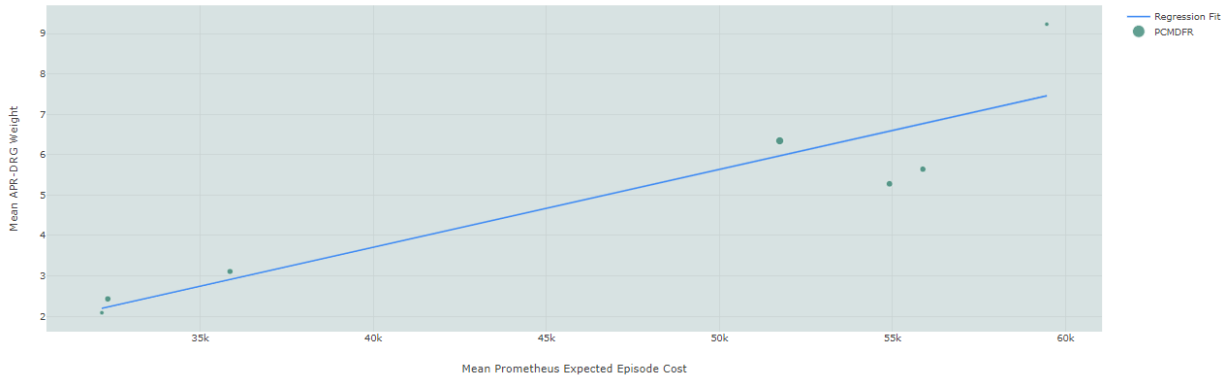


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# APR-DRG & Prometheus Expected Costs, have a significant correlation - by episode

APR-DRG vs. PROM Expected Cost Correlation Analysis  
Episode: Pacemaker / Defibrillator

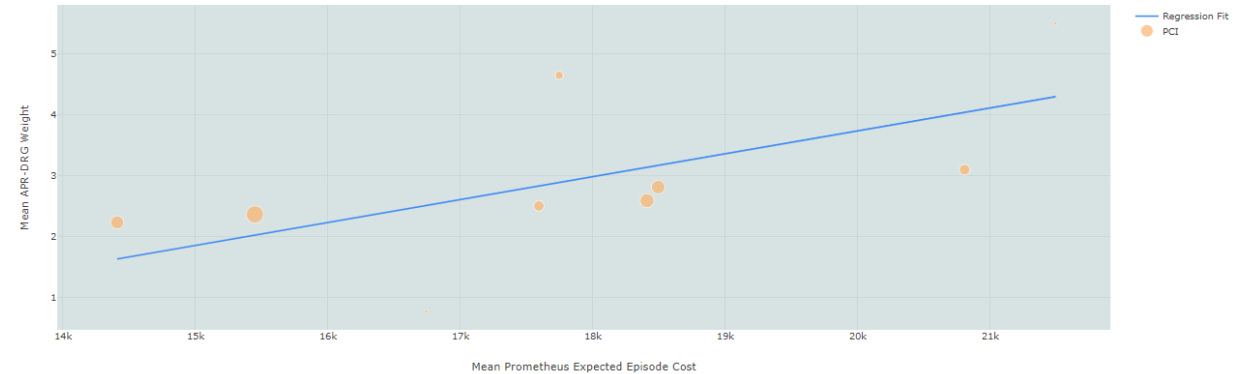
Mean APR-DRG Weight vs. Mean Prometheus Expected Cost



7 points plotted, <1k episodes included  
RMSE of fit = 0.952  
R-Squared of fit = 0.84

APR-DRG vs. PROM Expected Cost Correlation Analysis  
Episode: Coronary Angioplasty

Mean APR-DRG Weight vs. Mean Prometheus Expected Cost



9 points plotted, 1k episodes included  
RMSE of fit = 1.027  
R-Squared of fit = 0.38

## Key Considerations:

Size of bubble represents the volume (capped at 1k) for each data point. The regression fit line was derived applying an equal weighting on each data point. This avoids over-fitting the line to specific episodes (e.g., Maternity-related deliveries represent 86% of data points, 64% of total claims dollars)

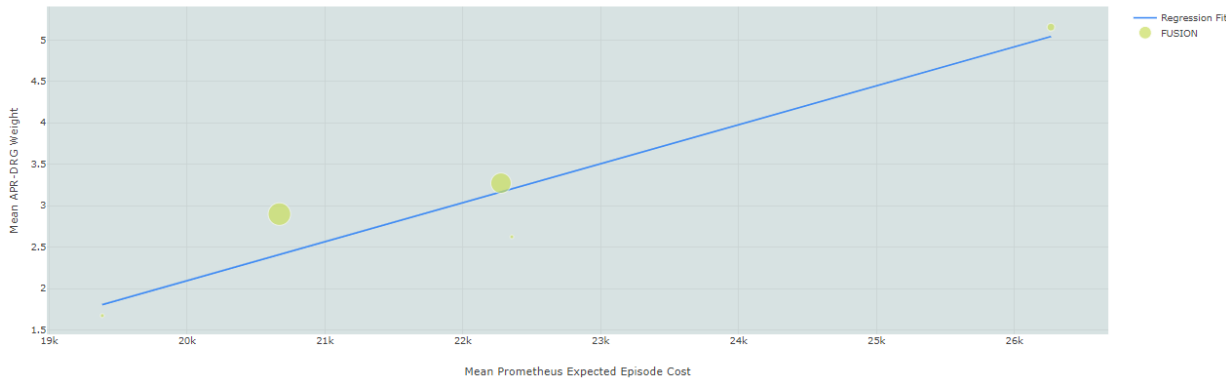


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# APR-DRG & Prometheus Expected Costs, have a significant correlation - by episode

APR-DRG vs. PROM Expected Cost Correlation Analysis  
Episode: Lumbar Spine Fusion

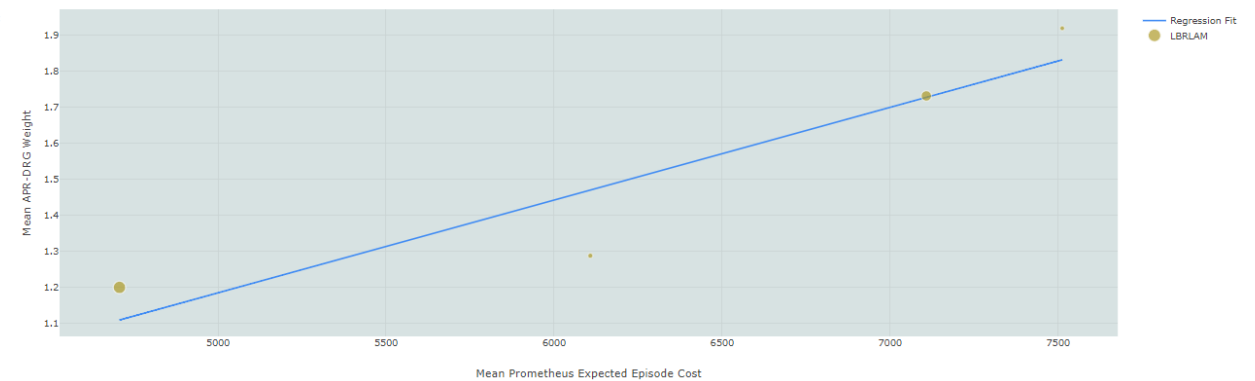
Mean APR-DRG Weight vs. Mean Prometheus Expected Cost



5 points plotted, <1k episodes included  
RMSE of fit = 0.350  
R-Squared of fit = 0.91

APR-DRG vs. PROM Expected Cost Correlation Analysis  
Episode: Lumbar Laminectomy

Mean APR-DRG Weight vs. Mean Prometheus Expected Cost



4 points plotted, <1k episodes included  
RMSE of fit = 0.111  
R-Squared of fit = 0.86

## Key Considerations:

Size of bubble represents the volume (capped at 1k) for each data point. The regression fit line was derived applying an equal weighting on each data point. This avoids over-fitting the line to specific episodes (e.g., Maternity-related deliveries represent 86% of data points, 64% of total claims dollars)

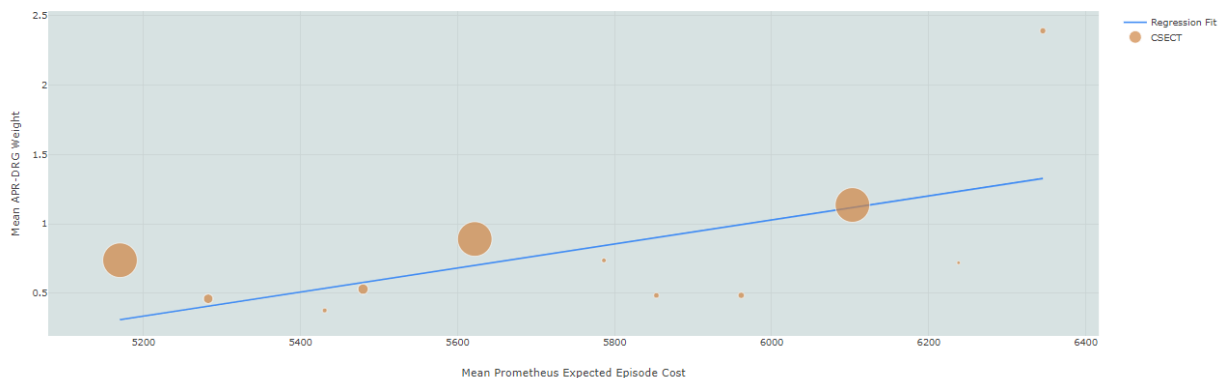


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# APR-DRG & Prometheus Expected Costs, have a significant correlation - by episode

APR-DRG vs. PROM Expected Cost Correlation Analysis  
Episode: C-Section

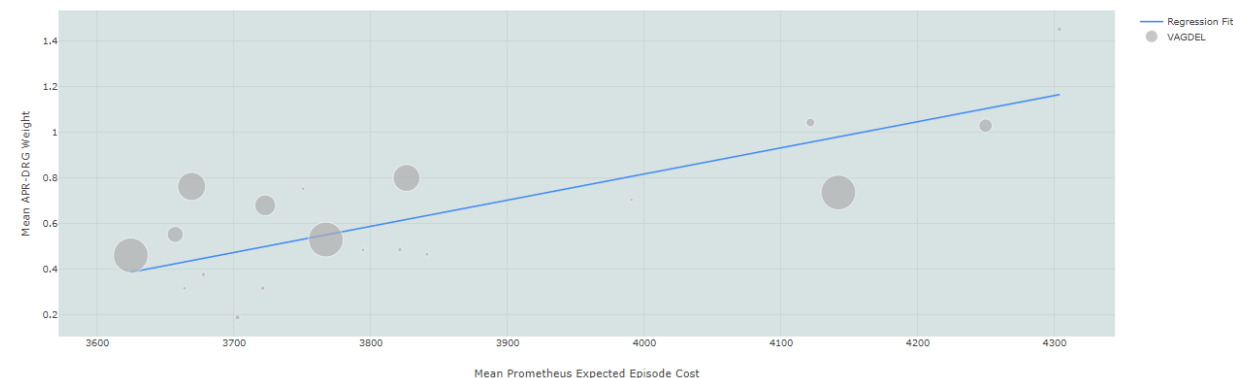
Mean APR-DRG Weight vs. Mean Prometheus Expected Cost



11 points plotted, 19k episodes included  
RMSE of fit = 0.436  
R-Squared of fit = 0.35

APR-DRG vs. PROM Expected Cost Correlation Analysis  
Episode: Vaginal Delivery

Mean APR-DRG Weight vs. Mean Prometheus Expected Cost



19 points plotted, 41k episodes included  
RMSE of fit = 0.177  
R-Squared of fit = 0.64

### Key Considerations:

Size of bubble represents the volume (capped at 1k) for each data point. The regression fit line was derived applying an equal weighting on each data point. This avoids over-fitting the line to specific episodes (e.g., Maternity-related deliveries represent 86% of data points, 64% of total claims dollars)

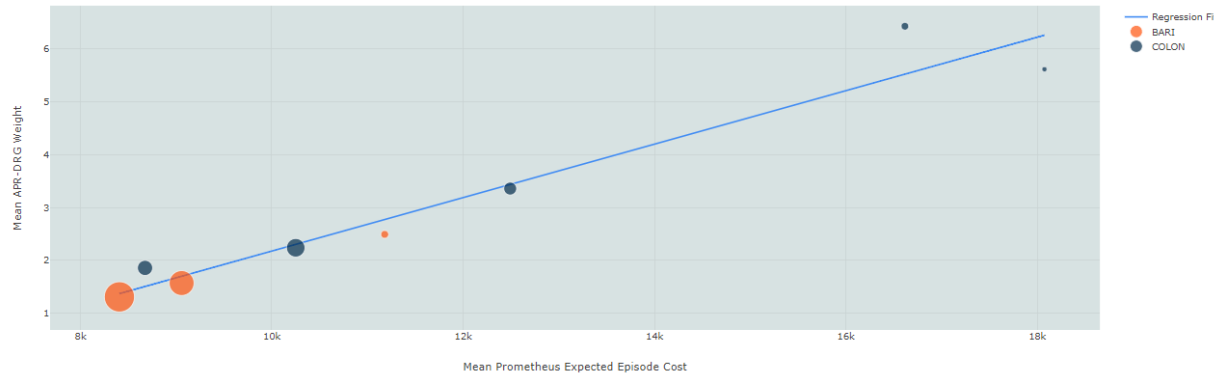


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# APR-DRG & Prometheus Expected Costs, have a significant correlation - by episode

APR-DRG vs. PROM Expected Cost Correlation Analysis  
Episode: Bariatric Surgery, Colorectal Resection

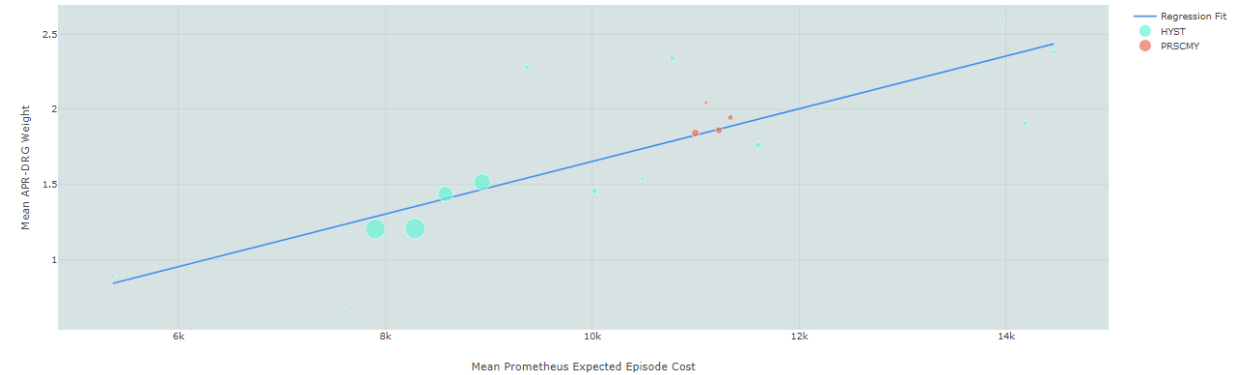
Mean APR-DRG Weight vs. Mean Prometheus Expected Cost



8 points plotted, 2k episodes included  
RMSE of fit = 0.429  
R-Squared of fit = 0.94

APR-DRG vs. PROM Expected Cost Correlation Analysis  
Episode: Hysterectomy, Prostatectomy

Mean APR-DRG Weight vs. Mean Prometheus Expected Cost



18 points plotted, 1k episodes included  
RMSE of fit = 0.303  
R-Squared of fit = 0.65

### Key Considerations:

Size of bubble represents the volume (capped at 1k) for each data point. The regression fit line was derived applying an equal weighting on each data point. This avoids over-fitting the line to specific episodes (e.g., Maternity-related deliveries represent 86% of data points, 64% of total claims dollars)



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