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Physician Practice Pattern Variation: Using Data Mining and Predictive Modeling to Identify and Control Costly Treatment Patterns

David C. Ogden, SAS Institute Inc.

ABSTRACT

Health insurance providers want to control the ever-increasing cost of health care while ensuring quality outcomes. Learn how SAS® Enterprise Guide® and SAS® Enterprise Miner™ can be used to identify which physicians are generating excessive costs and which practice patterns are leading to cost-reduction opportunities. This analysis of physician practice pattern variation focuses on an automated layered reporting method for producing actionable results with output to Microsoft Excel and Microsoft Word.

The challenge is to devise an approach to model the expected costs associated with treating a given condition (for example, upper-respiratory infections). This discussion covers the three main areas of this type of project: standardized data preparations, explanatory modeling, and information delivery (highlighting an approach to turning analytical output into actionable information).

INTRODUCTION

One day, Dr. Sue was visited by a patient of hers who has had repeated bouts of sinusitis. This patient has responded well to a particular antibiotic in the past. Dr. Sue tries that approach again, prescribing a round of inexpensive antibiotics. In fact, Dr. Sue has developed a pattern of treating this condition with antibiotics.

Across town, on the same day, Dr. Bob was visited by a patient of his who has had repeated bouts of sinusitis. Dr. Bob decides it's not only time to use the CAT scanner in his facility, but it is also time to refer this patient to an ear, nose, and throat (ENT) specialist. Ultimately, his patient has surgery to address the chronic sinusitis. History has shown us that Dr. Bob has a pattern of using the CAT scanner in his office, as well as referring patients to specialists.

These doctors have developed very different practice patterns for treating sinusitis. These practice patterns have very different cost structures. Even with evidence-based standards for treating this condition, there is still tremendous variability in practice patterns for treating sinusitis.

Many health insurance providers and related organizations are concerned with the ever-increasing costs of health care. Even after adjusting for population growth and shifts in age distribution, the cost of US health care has grown at a significantly faster rate than can be explained by simple inflation. Most projections, such as what is shown in Figure 1, show that this observed growth in health-care costs will only continue.

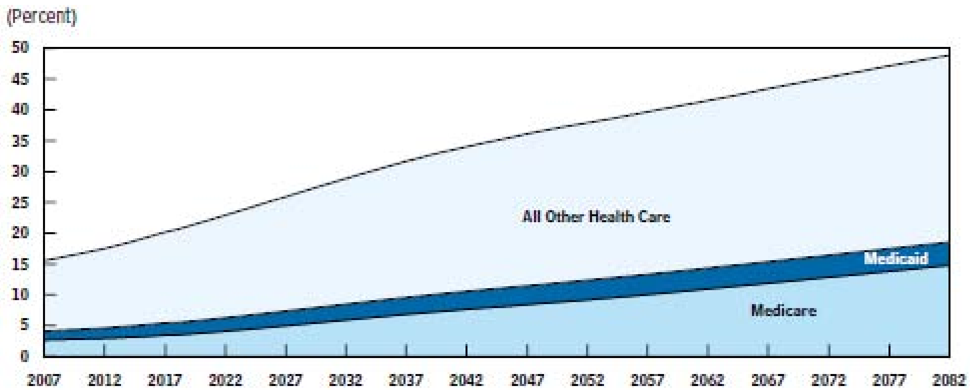

Figure 1. Projected Spending on Health Care as a Percentage of Gross Domestic Product (Source: US Congressional Budget Office)

The purpose of this paper is to outline an analytic approach for quantifying excessive costs caused by physician practice pattern variation (PPPV), to understand the root causes of variability, and to identify opportunities to reduce the costly variability of treatments and services provided.

COST VARIANCE MODELING

The goal of reducing costs is certainly not unique to the health-care industry. Whether costs are being generated by units manufactured, products sold, services provided, or patients treated, there is a challenge in determining the underlying drivers of costs. To understand how to reduce costs in any industry, you must identify where the excessive costs are coming from.

But, how do you define *excessive*?

Actual costs are easy to measure. And, you might decide that identifying excessive costs is as simple as determining which units (or products or people) are generating the highest actual costs. In the health-care industry, if you used this approach and simply identified which physicians generated the highest dollar amount of insurance claims, there would be no notion of how much cost they *should* be generating. Given the mix of patients who they treat, their location and facilities, and the types of conditions in which they specialize, how much cost should they generate?

A key concept in the development of the PPPV solution is to determine *expected* costs. The approach to determine expected costs is to use cost variance modeling. This terminology and approach is not widely used. But, I have found this approach useful in various industries and for various analytic objectives.

Cost variance modeling is a fusion of outlier detection, statistical process control concepts, predictive (or explanatory) modeling, and analysis of variance.

First, consider the concept of outlier detection. When developing a predictive model, perhaps through linear regression, it is often useful to determine whether there are any anomalies in the data, such as any extreme values that could cause the regression algorithm to produce a nonrobust model. When developing a regression model, outliers are often removed from the input data. Figure 2 shows how you might use a residual analysis to visually spot an outlier.

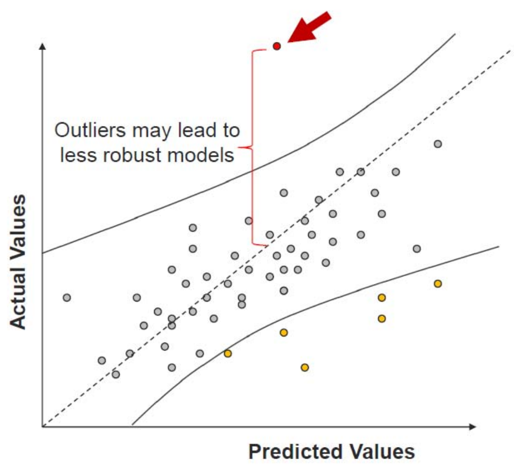

Figure 2. Sample Residual Plot Showing Possible Outlier

When an outlier is detected, for predictive modeling purposes, it is often thrown out. For cost variance modeling, and specifically for PPPV, the outliers should not be thrown out. The task is to determine what is causing the costly outliers. This is closely aligned with the concepts of quality control or statistical process control. As shown in Figure 3, in statistical process control, spotting outliers is just the beginning of determining their underlying causes. As a result, outliers could be systemically removed from future occurrences.

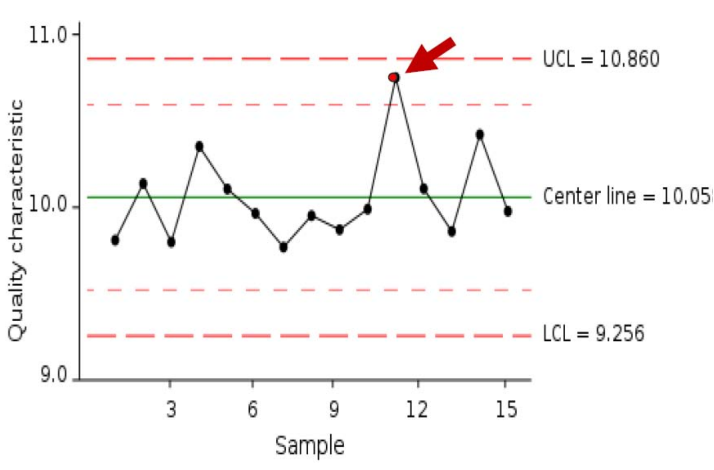

Figure 3. Sample Control Chart Showing Possible Out-of-Control Event

For PPPV, you need to identify the costly outliers by determining which physicians are generating more than expected costs. Figure 4 shows how the relationship between expected costs and actual costs is used to establish which physicians are generating more than expected costs, which are generating less than expected costs, and which are within an acceptable zone of tolerance. (In an acceptable zone, actual costs are approximately equal to expected costs.)

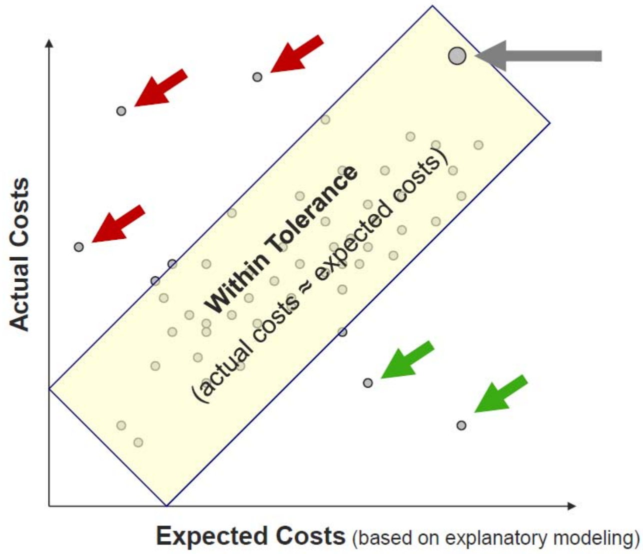

Figure 4. Comparison of Actual and Expected Costs with Dots Representing Physicians

If each dot in Figure 4 represents a physician, then dots identified with red arrows are of particular interest because those are the physicians generating significantly higher costs than expected.

To fully understand the relevance of the cost variance modeling concept, you should pay close attention to the physician identified in Figure 4 by the gray arrow pointing to the large dot. This physician has the highest actual costs. However, this physician's expected costs are approximately equal to the actual costs, and are, therefore, within the zone of tolerance. In other words, for this example, the focus on where to remove costs would not be on the physician who is generating the highest actual costs.

Before you can determine which physicians are generating higher than expected costs, you need a methodology for calculating expected costs.

MODELING EXPECTED COSTS

Modeling expected costs is a mixture of science and art, and determining what should be included in the equation can lead to a philosophical discussion. But, as a starting point, you need to establish the general form of any equation to be used for modeling expected costs. Regardless of industry, the general form is:

$$\text{expected cost} = a_1{*}X_1 + a_2{*}X_2 + a_3{*}X_3 + \ldots + a_n{*}X_n$$

X_i is a measure of variable units for a particular cost-driving factor. a_i represents the cost per unit of X_i.

That's the scientific part: having an equation that quantifies an expected value. The artistic aspect is twofold:

1. The equation should be explanatory, not predictive. (There is more on this later.)
2. You should determine which cost-driving factors (X_is) should be included in the equation. This might lead to difficult, philosophical considerations.

First, it is important to understand the difference between an explanatory model and a predictive model. For many modeling applications, the need is to develop a predictive model. In these situations, the model is used to predict an outcome when necessary input is provided. For a predictive model, it is relatively straightforward to determine whether your model is good using a variety of goodness-of-fit statistics and using a holdout sample. If your predictive model accurately predicts the future on a holdout sample of data, and subsequently makes accurate predictions after implementation, then your predictive model is good.

However, the goal of modeling expected costs is primarily to determine red flags that have occurred in the past and not necessarily to predict the future. The measure of goodness for an explanatory model designed to quantify historical expectations is not so well defined. This is why an explanatory model is an art form and there is potential for philosophical considerations.

Before you can structure an equation to quantify the expected costs generated by physicians, it's essential that you thoroughly understand the implications of what you might choose to include in the explanatory equation. To determine what should be included in the equation, consider a simplified example from a hypothetical shipping company known as ReadyShip.

ReadyShip's business is providing ground transportation of boxed packages. ReadyShip employs 1,000 drivers. These drivers essentially drive vans all day, picking up and delivering packages. ReadyShip calls its drivers "roadies." Each roadie generates costs in two fundamental ways—his hourly pay and the gas consumed while driving his route.

One approach to modeling the expected costs for each roadie is:

expected cost for roadie = a_1*X_1 + a_2*X_2

X_1 is a measure of hours worked and a_1 represents an hourly pay rate. X_2 is a measure of miles driven and a_2 represents a cost per mile for gas.

This equation is probably a very accurate predictive model. With values for hours worked and miles driven, this equation would accurately predict the resulting costs.

However, you do not want to accurately predict the costs. You want to know how much costs each roadie should have generated. Should the roadie have worked as many hours as he did? Some roadies might be wasting time by stopping at too many convenience stores. Should he have driven as many miles as he did? Some roadies might be choosing very inefficient driving routes and adding unnecessary mileage to their deliveries. To develop an explanatory model that tells you how much costs the roadie should have generated, you might choose a different set of inputs for the equation. For example, you might want to measure each roadie's total number of stops, the average distance from the distribution center to each stop on his route, the number of packages that he delivered, the average weight and size of each package, indicators for the number of deliveries to loading docks versus malls, and so on.

The purpose of this example is to emphasize the following points:

1. The goal is not to accurately predict costs. The goal is to determine expected costs.
2. Deciding what to include in the equation requires a bit of art (coupled with knowledge of the business processes).
3. Deciding what to include in the equation is not based on what does drive costs, but rather what should drive costs.

To apply these points to the task of modeling expected costs for physicians, you can start by brainstorming about all of the factors that do drive costs, but you ultimately need to decide what should drive costs. In the context of PPPV, this exercise takes on different flavors, depending on which health conditions you address. To maintain focus in this paper, upper-respiratory infections (URI) are considered, specifically three types: otitis media, sinusitis, and tonsillitis.

A first pass at deciding what should be included in the modeling results in the following:

expected costs = f(# and types of URI episodes treated, patient overall health, mix of patient demographics, physician's specialty and demographics)

Notice what is not included in the equation. There are no measures for the specific treatments and services used by the physician for treating the condition. You could have included the number of episodes referred to radiology, the number of episodes treated with antibiotics, the number of episodes involving particular types of labs, and so on. If you had, you would produce an equation that precisely predicted the resulting costs. But, you must remain aware that the purpose is to determine the expected costs. If you include measures for every single type of treatment and service used by a physician, then you will have an accurate model of actual costs, but not a good model for describing what should have happened.

This opens the door for difficult philosophical questions. For example, a fundamental question is whether to include measures for the number and types of surgeries performed. Clearly, if a patient goes to surgery for the treatment of a URI, the patient will incur much higher costs than a patient who is treated with a simple round of antibiotics. If you choose to include measures for surgeries in the equation, then you are deciding that surgeries are expected whenever a physician decides to use surgery as part of his or her practice pattern. If you decide to not include measures for surgeries in the equation, then you are deciding that surgeries are optional procedures. This sort of decision represents the biggest philosophical question to answer before developing the equation, and it requires input from medical professionals.

It is my opinion that measures for surgeries should be included in the equation to quantify expected costs. If not, the equation would need to include a vast array of medical history data on each patient as a proxy for determining whether surgery is justified. Certainly, the equation should include some measures of patient health, but probably not so many measures as to completely explain whether surgery was necessary or expected. Of course, the premise is not that every decision the physician makes is perfect. If that were the case, there would be no reason to model expected costs in the first place.

As a quick sidebar, when referencing a *physician*, this is not necessarily referring to the treating physician. You might want to model the responsible physician. When grouping claims into episodes, it is possible to identify a responsible physician and to track all costs incurred for the episode across all physicians providing treatments.

If you decide to include surgeries as part of equation, then the second pass at deciding what should be included in the modeling results in the following:

expected costs = f (# episodes otitis media with *major* surgery treated, # episodes otitis media with minor surgery treated, # episodes otitis media with no surgery treated, # episodes sinusitis with surgery treated, # episodes sinusitis without surgery treated, # episodes tonsillitis with surgery treated, # episodes tonsillitis without surgery treated, patient overall health, mix of patient demographics, physician's specialty and demographics)

If you structure the data appropriately, you can formulate the equation to have all coefficients be a cost per episode. For example, consider the following equation:

Parameter	Annual Cost per Episode		Parameter	Annual Cost per Episode
Intercept	$14.87		Board Certified = Yes	$13.31
Otitis Media w/o surgery	$71.14		geography = A	$100.28
Otitis Media w/ minor surgery	$1,288.54		geography = B	$27.27
Otitis Media w/ major surgery	$2,655.17		geography = C	$10.09
Sinusitis w/o surgery	$249.17		geography = X	$3.15
Sinusitis w/ surgery	$4,927.00		geography = Y	($5.27)
Tonsilitis w/o surgery	$50.94		geography = Z	($7.81)
Tonsilitis w/ surgery	$2,059.70		License yrs (cost per year per episode)	($0.58)
Age 5-18	$53.92		Specialty = EmergencyMed	$236.00
Age 19-30	($12.55)		Specialty = ENT	$145.28
Age 31+	($84.22)		Specialty = Pediatrics	$31.99
total patient-health-index-squared	$72.45		Specialty = OTHER	$125.77

Figure 5. Sample Equation for Calculating Annual Costs for Physicians Treating URIs

This is a sample equation and should be used only as a guide to developing an equation. Though these coefficients are realistic, they are not intended to be used for the calculation of expected URI costs.

The underlying data used to generate this equation is a summary of metrics per physician. The summarization of the data is structured to provide each metric as a summary of episodes. In the equation, the terms in the right column represent demographic information for the physician. Consider the indicator for **Board Certified**. The metric is not a simple indicator of whether the physician is board certified. Rather, the data is structured so that the board certification indicator is weighted by the number of episodes treated. Thus, the coefficient of $13.31 suggests that if a physician is board certified, the physician's expected annual costs (for treating URI episodes) will be $13.31 greater, per episode, than a peer who is not board certified.

To see how this equation is applied, consider the following data. This data represents the metrics collected for a physician:

Parameter	Episode Count (weighted)		Parameter	Episode Count (weighted)
Intercept	n/a		Board Certified = Yes	207
Otitis Media w/o surgery	64		geography = A	0
Otitis Media w/ minor surgery	34		geography = B	0
Otitis Media w/ major surgery	1		geography = C	0
Sinusitis w/o surgery	27		geography = X	0
Sinusitis w/ surgery	9		geography = Y	207
Tonsilitis w/o surgery	29		geography = Z	0
Tonsilitis w/ surgery	43		License yrs (cost per year per episode)	2,070
Age 5-18	83		Specialty = EmergencyMed	0
Age 19-30	56		Specialty = ENT	207
Age 31+	68		Specialty = Pediatrics	0
total patient-health-index-squared	912.9		Specialty = OTHER	0

Figure 6. Sample Metrics for a Physician Treating a URI

You can see in Figure 6 that this physician treated 207 URI episodes, broken down by type of URI (for example, 64 otitis media episodes treated without surgery). This physician treated all types of URIs, as well as all age ranges, is board certified, practices in geography Y, and is an ENT. Furthermore, there is a measure of patient health risk, summed across all episodes. The raw health index used for each patient has a range of 1 to 5. To calculate the overall health risk in this equation, the health index is squared and summed across all episodes. Thus, the value of 912.9 reflects an average health risk of 2.1 (the square root of 912.9/207). To understand how the data is used, you must remember that the data is structured to be a count of episodes or a metric weighted by the count of episodes. Notice that the metrics associated with patient ages sum to 207 (the total episode count). Also, notice that the metric for board certification is equal to the total episode count. This physician was board certified for each episode treated. Therefore, the impact of board certification (on total costs) is multiplied by the number of episodes. The value of 2,070 for the **License yrs** metric indicates that this physician has been licensed for 10 years (10*207=2070). The coefficient represents a cost per episode per year licensed.

To calculate the total expected annual costs for this physician (represented in Figure 6), you multiply those quantities by the coefficients in Figure 5. In doing so, you see the impact of each factor on the expected annual costs (rounded to whole dollars).

Parameter	Expected Annual Cost		Parameter	Expected Annual Cost
Intercept	$15		Board Certified = Yes	$2,754
Otitis Media w/o surgery	$4,553		geography = A	$0
Otitis Media w/ minor surgery	$43,810		geography = B	$0
Otitis Media w/ major surgery	$2,655		geography = C	$0
Sinusitis w/o surgery	$6,728		geography = X	$0
Sinusitis w/ surgery	$44,343		geography = Y	($1,092)
Tonsilitis w/o surgery	$1,477		geography = Z	$0
Tonsilitis w/ surgery	$88,567		License yrs (cost per year per episode)	($1,201)
Age 5-18	$4,476		Specialty = EmergencyMed	$0
Age 19-30	($703)		Specialty = ENT	$30,073
Age 31+	($5,727)		Specialty = Pediatrics	$0
total patient-health-index-squared	$66,134		Specialty = OTHER	$0

Figure 7. Expected Costs by Cost-Driving Factor for a Physician Treating a URI

The multivariate equation in Figure 5, multiplied by the relevant metrics in Figure 6, gives you the dollar impact of each factor, as seen in Figure 7. Summing the costs across each factor, it is determined that this physician's expected cost for treating these 207 episodes of URIs is equal to $286,863. A different physician treating the same mix of episodes, but practicing in a different geography, with a different patient mix, and having a different specialty, would have different expected costs. Similarly, a physician treating in the same geography, with a similar patient mix, having the same specialty, but with a different mix of URI episodes (for example, all tonsillitis, but no sinusitis) would have a different value for expected costs.

After calculating the expected cost of $286,863 for this physician (let's say this is Dr. Bob), the next step is to compare that value to the actual costs incurred by Dr. Bob. If the actual costs are significantly higher than expected, then you would subsequently red-flag this physician, and you would want to understand what specific practice patterns led to the higher costs. That process is discussed in more detail in the "Information Delivery" section.

Before you look at the format of information delivery, take a step back and evaluate precisely what data is needed to develop the expected costs model.

DATA SUMMARIZATION

Once you have the equation generally formulated, you can design an input data set for a modeling exercise. To formulate the equation, start with a list of possible drivers of cost. As with any modeling exercise, you don't know what final form the equation will take. Going back to the general form of the equation for URI, you need to add more detail to the following terms to design the appropriate input data set:

patient overall health, mix of patient demographics, and physician's specialty and demographics

Not all needed data elements will be available, but the following lists many of the metrics specific to developing the expected costs model for physicians treating URIs:

patient overall health

- presence of comorbidities, such as indicators for heart disease, cancer, and so on
- count of past URI episodes
- recent body weight change and blood pressure readings
- indicator for being a smoker
- participation in wellness programs (for example, indicator for smoking-cessation program)

mix of patient demographics

- age
- gender
- marital status

physician's specialty and demographics

- specialty
- years since obtaining medical license
- geographic location
- indicator for board certification

There are two important considerations when collecting and summarizing this data.

1. Because you are modeling expected costs at the physician level, all data needs to be summarized at the physician level.
2. Because you want the resulting equation to provide cost-per-episode coefficients, all metrics should be reflected as a count of episodes or a metric weighted by a count of episodes.

To address the first consideration, the physician should be thought of as a key by which all data is summarized and joined. For example, when collecting metrics on each patient's count of past URI episodes, a metric can be independent of any single physician. But, ultimately, this patient-specific metric is summarized at the physician level. This linkage might be via a physician_ID being associated with an episode_key, which might, in turn, be associated with a patient.

To address the second consideration, think of the episode as the original layer of detail. Each episode is associated with a patient and a physician. Suppose that one of the metrics that you want to summarize is patient age in the form of age ranges (for example, 5-18, 19-30, and 31+). Each episode detail could receive a binary (0 or 1) indicator for whether the patient is age 5-18, captured in a variable called Age_5_18. Then, when summarizing Age_5_18 from episode detail to the physician level, the resulting metric is a count of all episodes associated with patients of age 5 to

18. And, the coefficient of the Age_5_18 metric represents the incremental expected costs (positive or negative) for each episode involving a patient of that age range.

For modeling expected costs, instead of predicting actual costs, you must remember that you do not want to include every scrap of information about each episode. For example, from medical claims data, you would certainly identify which episodes were treated with expensive anti-inflammatory drugs, which involved expensive labs and radiology, and so on. However, if you were to summarize all of this information at the physician level and use that information in the equation, the result would not be a model of expected costs.

So far, the discussion on data has focused on the data needed to develop the expected costs model. However, there is another important goal in summarizing the data—information delivery. Suppose that you have developed the expected costs model and determined that Dr. Bob's expected costs (for last year for treating URIs) was $286,863. Furthermore, suppose that Dr. Bob's actual costs was $426,722. There is a positive delta between actual and expected costs of nearly $140,000 for Dr. Bob. What the model does not tell you is precisely what caused that delta. To determine what caused the delta, you need an effective tool for decomposing that $140,000 delta into specific services and treatments used by Dr. Bob that caused the excessive costs.

Structuring the input data to allow for an investigation of what caused the excessive costs requires that the episode detail is maintained. Thus, for the purposes of modeling expected costs, the episode detail is summarized at the physician level. However, for the purposes of investigating the cause of the excessive costs (as shown in the "Information Delivery" section), there is a need to drill down into the specific services and treatments. Because each company's data is unique, the intent of this paper is not to identify specific data elements and tables involved in this process. Rather, you should be able to take the information from this paper and use it to identify the relevant data elements and sources found within your company.

INFORMATION DELIVERY

The output from the expected costs model determines which physicians are generating actual costs that are approximately equal to expected costs. In addition, it determines which physicians are generating actual costs that are unusually higher or lower than expected costs. To transform this output into actionable business information, you need to first establish a rule for red-flagging physicians. As a starting point, calculate the delta (equal to actual costs minus expected costs) for each physician. There will be physicians with significantly higher than expected costs on a percentage basis. For example, if Dr. Sue has an expected cost of $1,000, and her actual cost generated was $10,000, then Dr. Sue generated 10 times the cost that you would expect. However, Dr. Sue might not be a physician who you would like to investigate, simply because her annual actual costs are relatively low. If you want to devise a strategy to remove costs from the business, you would have to investigate hundreds or thousands of physicians like Dr. Sue.

Your focus should be on identifying the physicians with the largest opportunity measured in dollars. After calculating the delta for each physician, you can flag the top 5% of physicians in terms of positive deltas. Experience shows that a vast majority of the cost-reduction opportunity is found by focusing on this limited number of physicians. In this example, Dr. Bob is among the 5% that you would want to investigate because there is nearly $140,000 of cost-reduction opportunity for him.

One approach is to simply make Dr. Bob aware of his $140,000 delta, and trust that he will correct his practice patterns if correction is warranted. However, a much better approach is to generate actionable output that highlights precisely which treatments and services are causing the delta. To do this, start with the end in mind. Suppose that you have determined, through a bit of lucky ad hoc analysis, the following information about Dr. Bob:

- There is a particular CPT code, found on claims associated with otitis media episodes treated by this physician, which occurs far more frequently than expected. (This is when his results are compared to his peers of the same specialty.)

Suppose that you see a particular layer 4 report (where layer 4 refers to the lowest level of detail that you can analyze in terms of particular treatments provided). For example:

MD: Bob
Specialty: ENT
Type of URI: Otitis Media w/o Surgery
Episode Count = 64
Service: Injections
Subcategory: Injections Specialist Other
Layer 4 Code Type: CPT Full

Layer 4 Code	Layer 4 Item Description	Peer Group Utilization	Provider Utilization	Peer Group Cost per Episode	Provider Cost per Episode
95165	**PROFESSIONAL SERVICES SUPERVISION & PROV**	**6.26%**	**31.25%**	**$540.85**	**$678.11**
95120	IMMUNOTHERAPY,ALLERGENIC EXTRACT,SINGLE	0.58%	0.00%	$67.56	$0.00
95125	IMMUNOTHERAPY,ALLERGENIC EXTRACT,MULTIPL	0.58%	0.00%	$229.71	$0.00
9516559	PROFESSIONAL SERVICES SUPERVISION & PROV	0.02%	0.00%	$13.00	$0.00
95170	ALLERGEN IMMUNOTHERAPY SERVICES	0.02%	0.00%	$7.50	$0.00

Figure 8. Sample Layer 4 Report Showing Physician Over-Utilization for a Service Associated with URI

You know that Dr. Bob treated 64 episodes of otitis media without surgery last year. If he used CPT code 95165 as often as his peers, then he would have used this CPT code on only four episodes. However, Dr. Bob charged this particular CPT code (95165) on 20 episodes. Perhaps this is a relevant finding, and perhaps this information should be shared with Dr. Bob.

But first, you need to develop a systematic plan for how to uncover all interesting results. The report in Figure 8 is for a small subset of possible treatments and services that can be provided by Dr. Bob. Across all of the types of URI episodes that Dr. Bob treats, there are hundreds of CPT codes, hundreds of drug codes, dozens of surgery codes, and so on. Given the vast number of detailed codes associated with Dr. Bob's practice patterns for treating URIs, if you were to generate all possible reports, there would be a large number of reports to view, just for this single physician. If you were to generate all reports for all practicing physicians treating URIs, you would have a mountain of information to sift through. In fact, suppose that you have 5,000 physicians treating URIs, and you want to produce a report that shows detailed treatment patterns for each combination of physician, type of URI (tonsillitis with surgery, tonsillitis without surgery, and so on), and type of service (imaging, lab, pharmaceuticals, and so on). (This information is exemplified in Figure 8.) This would result in approximately 250,000 reports. Producing all of these reports is not efficient. Sifting through these reports in an ad hoc manner is not effective.

To take the results of the expected costs model and produce actionable information, you need an automated approach to generating only those reports that are relevant. This is only those reports that identify a practice pattern leading to higher than expected costs.

It exceeds the scope of this paper to detail exactly how this type of automated reporting system can be built in SAS®, but the following depicts an example of automated reports generated in SAS Enterprise Guide. In the following automated drill down, only the relevant reports are generated, and the areas of focus are automatically highlighted to identify where higher than expected costs are found.

For this drill-down example, another physician is introduced—Dr. Al, the Allergist. The equation determines that Dr. Al has generated approximately $30,000 of excessive costs (the difference between actual and expected) in total. Dr. Al treats several types of URIs, and in the first layer of drill down, you want to determine which types of URIs are of most interest.

You know that Dr. Al treats both sinusitis and otitis media. Using an equation structured like the equation shown in Figure 5, you can simply plug in the sinusitis-specific metrics for Dr. Al. In other words, even though the equation is developed for the physician overall, you can collect metrics such as the age-related metrics, the health-risk-related metrics, and so on, for only the sinusitis episodes, and you can then calculate Dr. Al's expected costs for treating 103 episodes of sinusitis. Similarly, you can do the same thing for the otitis media episodes, and determine that the primary cause of Dr. Al's $30,000 delta is a $25,000 delta for sinusitis alone.

For reference, this physician level of reporting is called Layer 0, and the type of URI (that is, sinusitis with surgery, sinusitis without surgery, and so on) is called a Layer 1 drill down. Just as you can automate the identification of the top 5% of physicians in terms of cost delta (difference from expected), you can also automate the identification of which types of URIs are causing the excessive costs for each physician. You do this by aggregating the metrics to the physician and type of URI level, and then running those metrics through the expected cost equation. To drill down further, you need to define the further layers of drill down. For example:

Layer 0 = physician (for example, Dr. Al).
Layer 1 = type of URI by physician (for example, sinusitis without surgery for Dr. Al).
Layer 2 = type of service by type of URI by physician. Likely types of service include consultation, imaging, injections, lab, pharmaceuticals, and surgery.
Layer 3 = subcategory of service by type of service by type of URI by physician. Subcategories of services include mapping individual CPTs, drug codes, surgery codes, and so on, into categories that provide insight at a layer of detail below the type of service. Specifics for this type of mapping are at the discretion of the company

implementing this approach. For example, consider these subcategories for types of injection services—allergens, antibiotics, vaccines, steroids, and so on.
Layer 4 = individual CPT codes, drug codes, and surgery codes by subcategory of service by type of service by physician.

A drill down from Layer 0 to Layer 1 (from physician to type of URI) can be automated by quantifying expected costs for each type of URI (for a physician) from the expected costs equation, where the inputs are metrics collected for a specific type of URI (for example, based on only sinusitis without surgery episodes).

To drill down to Layer 2, report key metrics for each type of service only for those Layer 1 results that have been red-flagged. For Dr. Al, the Layer 2 report follows:

MD: Albert
Specialty: Allergy
Type of URI: Sinusitis w/o Surgery
Episode Count = 103

Type of Service	Peer Group Utilization	Provider Utilization	Peer Group Cost per Episode	Provider Cost per Episode
Consultation	17.2%	28.2%	$213	$231
Imaging	9.5%	12.6%	$377	$394
Injections	**32.6%**	**44.7%**	**$586**	**$973**
Lab	12.4%	11.7%	$81	$44
MedCare	75.9%	85.4%	$253	$322
Other	4.0%	1.9%	$477	$851
Pharma	67.7%	72.8%	$229	$190
Surgeries	2.9%	5.8%	$214	$249

Figure 9. Sample Layer 2 Report Showing Physician Over-Utilization

In Figure 9, **Peer Group** can be defined as a *specialty*. The report shown in Figure 9 is an automated report generated with SAS, and it is not a manually formatted report. This automated process includes highlighting injections for this example. This begs the question, “What is the logic for highlighting this one particular row, **Injections**?” Because the expected costs model is not structured to model the expected costs for each type of service or for any level of detail below Level 1, you need some business rules to determine which Layer 2 results should be flagged. To determine which type(s) of service should be flagged, allocate the delta (that you calculated at Level 1) to each type of service, and determine which type(s) of service account for a majority of the delta.

The logic for this allocated delta is as follows:

1. Calculate an approximate expected cost, abbreviated Approx EC.
2. Approx EC = physician’s episode count * peer group utilization * peer group cost per episode.
3. Calculate an interim delta (interim value of actual minus expected costs).
4. Interim delta = actual cost for type of service – Approx EC for type of service.
5. Allocate the actual delta (for the type of URI for the physician) across types of service as a percentage of the interim delta. This approach produces a delta value by type of service that sums to the delta calculated at the type of URI level.

Looking at the Layer 2 report in Figure 9, you see that Dr. Al used injections for 44.7% of the 103 episodes of sinusitis without surgery that he treated, while his peers (other allergists) used injections for only 32.6% of their sinusitis without surgery episodes. Furthermore, you see that Dr. Al has a significantly higher cost per episode for injections compared to his peers. However, it was neither a comparison of utilization nor of cost per episode that led to injections being highlighted for Dr. Al. Rather, the injections type of service was flagged as a result of a behind-the-scenes calculation for the allocated delta.

A similar approach to allocating the delta (taking the delta allocated to Layer 2 and further allocating it to the next level of detail) enables you to generate a Layer 3 report that shows more detail for injections:

Subcategory of Service	Peer Group Utilization	Provider Utilization	Peer Group Cost per Episode	Provider Cost per Episode
Inj_Allergen_Immuno	27.3%	43.7%	$281	$387
Inj_Antibiotics	0.3%	0.0%	$74	$0
Inj_Immuno_Vaccine	0.2%	0.0%	$9	$0
Inj_Specialist_Other	**26.4%**	**42.7%**	**$430**	**$621**
Inj_Steroids	2.5%	1.0%	$10	$12
Inj_Undefined	0.0%	0.0%	$205	$0

Figure 10. Sample Layer 3 Report Showing Physician Over-Utilization

In Figure 10, subcategories are defined as roll-ups of CPT codes.

A similar approach enables you to generate a Layer 4 report.

Layer 4 Code	Layer 4 Item Description	Peer Group Utilization	Provider Utilization	Peer Group Cost per Episode	Provider Cost per Episode
95165	**PROFESSIONAL SERVICES SUPERVISION & PROV**	**26.27%**	**42.72%**	**$427.15**	**$611.19**
9516559	**PROFESSIONAL SERVICES SUPERVISION & PROV**	**0.50%**	**10.68%**	**$46.17**	**$39.45**
95125	IMMUNOTHERAPY,ALLERGENIC EXTRACT,MULTIPL	0.21%	0.00%	$145.50	$0.00
95170	ALLERGEN IMMUNOTHERAPY SERVICES	0.21%	0.00%	$268.90	$0.00
95144	PROFESSIONAL SERVICES SUPERVISION & PROV	0.04%	0.00%	$11.00	$0.00
9516576	PROFESSIONAL SERVICES SUPERVISION & PROV	0.04%	0.00%	$260.00	$0.00

Figure 11. Sample Layer 4 Report Showing Physician Over-Utilization

Layer 4 codes can be CPT, drug, or surgery codes, as appropriate.

In this Layer 4 report, you see that Dr. Al has used a particular CPT code (95165) more frequently his peers. Furthermore, this is a fairly expensive treatment, as seen in the cost per episode numbers for both the peer group and Dr. Al. Though the information in this paper has been anonymized, the results are real. In fact, after implementing this layered reporting system, which is based on the expected costs model, it was found that many of the allergists who were red-flagged had a portion of their excessive costs traced to apparent over-utilization of CPT code 95165. This finding is only one example of the insight to be gained by implementing a comprehensive PPPV detection methodology as described in this paper. This finding of the over-utilization of CPT code 95165 was without any prior knowledge that this issue might exist. After finding this recurring issue among allergists, I did some Internet research on this particular CPT code. The results of my Internet research, which could be easily repeated by you, were quite interesting! It seems that improper billing of this particular CPT code has been of great interest within the medical community.

CONCLUSION

With the detection methodology described in this paper, all practice patterns that generate excessive costs can be identified and quantified.

Although this methodology was not developed with the intent of identifying fraudulent patterns of claims, this methodology has the potential for doing just that. The practice patterns that are identified might not be innocent inefficiencies.

Any efforts to reduce costs should be done with an eye always on treatment outcomes. The approach described in this paper does not tell you which treatments are most effective at curing disease or increasing good health. However, the approach could certainly be expanded to include patient outcomes. Just as you can use this approach to model expected costs and analyze the practice patterns driving excessive costs, you could use this approach to model expected health outcomes and analyze the practice patterns driving positive health outcomes.

Ultimately, quantifying and identifying the causes of excessive costs, coupled with an analysis of health outcomes, could assist you in developing standards of care for a variety of health conditions. If PPPV methodology were to become widespread, it could provide a significant contribution to addressing the ongoing rise in health-care costs.

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CONTACT INFORMATION

Your comments and questions are valued and encouraged. You can contact the author at David.Ogden@sas.com.