

PPC and APR DRG Statistical Methods

Introduction

The 3M™ APR™ DRG classification system categorizes patients based on their severity of illness and risk of mortality at the time of admission. In version 27.0 of the APR classification system, there are 314 APR DRG categories, each of which is subdivided into four subclasses for a total of 1,356 unique patient categories.

Potentially Preventable Complications (PPCs) identify complications that can occur during an admission. There are 64 PPCs. Depending on their clinical characteristics, some patients are totally excluded from the PPC analysis, while others are partially excluded (i.e., cannot be considered for some PPCs, but may be considered for others).

Rates of PPC occurrence can be calculated for each APR DRG category. These rates may be calculated using the occurrence of any PPC, a specific PPC, or a specific number of PPCs (e.g., one, two, three or more). These rates were calculated using the full Maryland dataset. These rates are typically referred to as norms because they reflect the experience of groups of hospitals.

Once the expected occurrence of a PPC is computed, the difference between the observed (actual) occurrence and expected occurrence of a PPC can be multiplied by the PPC marginal charge amount in order to calculate the resource use or savings by PPC. Multiplying the marginal charge amount for each PPC times the case differential between the observed and expected PPC occurrence allows for each PPC to be weighted by an estimated resource use when summed across the various PPC. This total impact allows for the user to financially assess the difference in the observed and expected occurrence of each PPC.

Further, using admission APR DRG categories to control differences in the clinical characteristics between their patients or those of the norm, individual hospitals can compare their PPC rates to those of the normative data. These comparisons will enable them to determine if and how their performance differs from comparable hospitals. A provider's experiences and those of normative populations are likely to be different. This can represent a true difference or can be caused by normal variation. Statistical techniques can be used to determine which of the observed differences in outcomes are most likely to be true differences and which are probably the result of natural variation.

Statistical significance

The statistical techniques calculate the probability that an observed difference in performance between the provider and the norm is due to natural variation. A difference in performance between provider and norm is considered "significant" if the probability that a difference is due to natural variation is small. A difference is considered significant at the 0.05 level if the probability that the observed difference is due to natural variation is five percent or less (i.e., less than one chance in twenty). Significance at the 0.01 level means that this probability is one percent or less.

Three interrelated factors determine whether a difference in performance is significant: the number of observations, the magnitude of the observed difference in performance, and the variability in performance of the hospital and of the norm. A small number of patients, a small observed difference in performance, or high variability within either the provider or the norm (i.e., high standard deviation) increase the probability that the observed difference is due to

chance and does not represent a true difference. Conversely, a large number of patients, a large observed difference between provider and norm, or low variability within both hospital and norm make it more likely that the difference was not due to chance and does represent a true difference.

Further, an observed difference of the same magnitude may be significant in one comparison and not in another. The conclusion that a difference is significant indicates that the hospital and the norm have had true difference in performance.

There are several possible reasons why a difference may not be significant. There may be no true difference, and thus, no significant difference in performance is found. Alternatively, there may be too few observations or too much variability, or both, so that even a true difference cannot be detected. Thus, a difference which is not significant does not necessarily mean that there is no true difference in performance. It may simply mean that there were too few patients or too much variability to conclude that the observed difference was not due to chance.

The comparison of a provider's performance to a norm requires the use of several distinct statistical methods. Outcome variables such as PPC rates are binary variables that indicate the occurrence or non-occurrence of an event such as a complication. Comparisons can be performed for data from a single APR DRG category and subclass, or they can be performed for data pooled across multiple APR DRG categories and subclasses.

Expected Values

The expected value of PPCs is the number of PPCs a hospital, given its mix of patients as defined by APR DRG category and severity of illness level, would have experienced had its rate of PPCs been identical to that experienced by a reference or normative set of hospitals.

The technique by which the expected value or expected number of PPCs is calculated is called indirect standardization. For illustrative purposes, assume that every discharge can meet the criteria for having a PPC, a condition called being "at risk" for a PPC. All discharges will either have no PPCs or will have one and possibly more PPCs. For this exercise, therefore, each discharge either has a PPC or does not have a PPC. The PPC rate is proportion or percent of admissions which have at least one PPC.

The rates of PPCs in the normative database are calculated for each APR DRG category and its severity of illness levels by dividing the observed number of PPCs by the total number of admissions. The PPC norm for a single APR DRG severity of illness level is calculated as follows:

Let:

N = norm

P = Number of discharges with one or more PPCs

D = Number of discharges that can potentially have a PPC

i = An APR DRG category and a single severity of illness level

$$N_i = \frac{P_i}{D_i}$$

For this example, this number is displayed as PPCs per discharge to facilitate the calculations in

the example. Most reports will display this number as a rate per one thousand.

Once a set of norms has been calculated, they can be applied to each hospital. For this example, the computation is for an individual APR DRG category and its severity of illness levels. This computation could be expanded to include multiple APR DRG categories or any other subset of data, by simply expanding the summations.

Consider the following example for an individual APR DRG category.

Table 1 Expected Value Computation Example

1 Severity of illness Level	2 Discharges at risk for PPCs	3 Discharges with PPCs	4 PPCs per discharge	5 Normative PPCs per discharge	6 Expected # of PPCs
1	200	10	.05	.07	14.0
2	150	15	.10	.10	15.0
3	100	10	.10	.15	15.0
4	50	10	.20	.25	12.5
Total	500	45	.09		56.5

For the APR DRG category, the number of discharges with PPCs is 45, which is the sum of discharges with PPCs (column 3). The overall rate of PPCs per discharge, 0.09, is calculated by dividing the total number of discharges with PPCs (sum of column 3) by the total number of discharges at risk for PPCs (sum of column 2), i.e., $0.09 = 45/500$. From the normative population, the proportion of discharges with PPCs for each severity of illness level for that APR DRG category is displayed in column 5. The expected number of PPCs for each severity of illness level shown in column 6 is calculated by multiplying the number of discharges at risk for PPCs (column 2) by the normative PPCs per discharge rate (column 5). The total number of PPCs expected for this APR DRG category is the expected number of PPCs for the severity of illness levels.

In this example, the expected number of PPCs for this APR DRG category is 56.5 compared to the actual number of discharges with PPCs of 45. Thus the hospital had 11.5 fewer actual discharges with PPCs than were expected for this APR DRG category. This difference can be expressed as a percentage difference as well.

APR DRG by SOI categories are excluded from the computation of the actual and expected rates when there are only zero or one at risk admission statewide for the associated APR DRG by SOI category.

Test of Significance

For binary data such as complications, a test of significance of the difference between the actual and expected values can be performed by comparing complication rates separately within each APR DRG category and subclass and then pooled across APR DRG categories and subclasses. The calculation of statistical significance for PPCs uses the Chi-Square test (χ^2) for a single severity of illness level within an APR DRG category and the Cochran-Mantel-Haenszel test (CMH) to calculate statistical significance for PPCs across APR DRG categories and severity of illness levels.

To test for statistical significance, it is assumed that the APR DRG category and severity of illness level for each discharge is known, as well as whether or not a PPC was present or could have been present. The tests of significance are to be calculated with only discharges at risk for PPCs. For the purpose of this discussion, PPC means the presence of one or more major PPCs. But it could be used for any subset of PPCs, e.g., any PPC, patients with two PPCs, discharges with a specific set of PPCs, etc. By extension, if this is known for any discharge, it is known for all of a hospital's discharges, and it is known for any set of hospitals in the data.

It is assumed that each hospital will be a part of the set of hospitals to which it is being compared. As long as a given hospital's percent of discharges is less than 10% of discharges in the set of hospitals, the data from the set of hospitals (which serves as the normative population) will not have to be adjusted by removing the individual hospital.

Single APR DRG category and severity of illness level

The method for computing statistical significance for a single APR DRG category and severity of illness level uses the Chi-Square test (χ^2).

Let:

C = Number of patients with PPCs in hospital
 D = Discharges at risk for PPC in hospital
 F = Number of patients with PPCs in norm
 G = Discharges at risk for PPC in norm

Chi Square is calculated with a 2 * 2 table as follows:

	Actual	Expected	Total
PPC	C	F	C + F
No PPC	D - C	G - F	D - C + G - F
Total	D	G	(D + G)

$$\chi^2 = \frac{((C \times (G - F)) - (F \times (D - C)))^2}{((C + F) \times (D - C + G - F) \times (D) \times (G))}$$

As the degrees of freedom for a 2 * 2 table = 1, the following significance levels can be used:

Significance Level	X²
.1	2.7055
.05	3.8415
.01	6.6349

Across APR DRG categories and severity of illness level

The method for computing statistical significance for data pooled across APR DRG categories and severity of illness level uses the Cochran-Mantel-Haenszel test (CMH).

To calculate statistical significance for PPCs across APR DRG categories and severity of illness

levels, the Cochran-Mantel-Haenszel test (CMH) is used. This test is also available in a number of commercial statistical packages such as SAS.

To calculate a CMH statistic, start with the 2 * 2 matrix used for the Chi Square test. The CMH statistic uses the data from one corner of the matrix and the marginals. It does not matter which corner; all will produce the same results. To simplify matters, we will use the upper left hand corner.

Calculate the expected value and variance of each cell.

Let:

j = APR DRG category and severity of illness level
 E = Expected number of patients with PPCs
 C = Number of patients with PPCs for a hospital
 D = Discharges at risk for PPC for a hospital
 F = Number of patients with PPCs in norm
 G = Discharges at risk for PPC in norm

The expected value is calculated as follows:

$$E(C_j) = \frac{(C_j + F_j) \times (D_j)}{(D_j + G_j)}$$

The variance is calculated as follows:

$$V(C_j) = \frac{((C_j + F_j) \times (D_j - C_j + G_j - F_j) \times (D_j) \times (G_j))}{((D_j + G_j)^2 \times (D_j + G_j - 1))}$$

After, the expected value and variance are calculated, calculate the CMH statistic as follows:

$$M^2 = \frac{\sum_j (C_j - E(C_j))^2}{\sum_j V(C_j)}$$

As the CMH statistic has a chi square distribution with 1 degree of freedom the following significance levels can be used:

Significance Level	χ^2
.1	2.7055
.05	3.8415
.01	6.6349

For the purposes of reporting statistical significance a significance level of .05, $\chi^2 \Rightarrow 3.8415$, will be used. In addition, statistical significance will not be calculated if the overall number of discharges at risk is less than forty or if the number of observed or expected PPCs is less than five.

Estimate of the Marginal Additional Charge of PPCs in Maryland

Objective: Estimate the marginal hospital charge increase when a patient develops a PPC during a hospital stay (i.e., acquired post admission) in Maryland.

Data Source: Maryland inpatient acute care all payer statewide hospital data from July 2007 through June 2008 containing 765,519 discharges were used as the basis for the estimates. In Maryland hospitals are required to specify whether each reported diagnosis was present at admission (POA). Since the requirement to report the POA status of each diagnosis is a new requirement, hospitals with poor quality of the reporting of the POA status were excluded from the analysis. Discharges that died or were transferred to another acute care facility were excluded. Further, discharges with charge values below \$200 or above \$2,000,000 were excluded. Individual case level charges were standardized based the ratio of the statewide average hospital CPC \$9,959.11 to the hospital average CPC (CMI of 1.0). The resultant analysis file contained 659,816 discharges.

Method: Since the marginal charge impact of a PPC, will vary depending on a patient's reason for admission and severity of illness at the time of admission, it was necessary to adjust for these factors in order to determine the marginal charges of a PPC. 3M All Patient Refined Diagnosis Related Groups (APR-DRGs) classify discharges to one of 314 reasons for admission and one of four severity of illness levels (1,256 unique patient categories). Each discharge in the analysis database was assigned to an APR DRG v26.1. Since patients who develop a post admission complication often develop multiple associated complications, it was necessary to adjust for the presence of multiple complications in order to determine the marginal charge of an individual PPC. 3M Potentially Preventable Complications (PPCs) v26 identify 64 different types of post admission complications analyzing 1,450 ICD-9-CM diagnosis codes and a select set of procedure codes. All PPCs present on each discharge (potentially preventable or not) were identified and used in the regression analysis.

A simple linear regression was specified of the form:

$$\text{Charge}_i = \alpha + \beta_j \text{PPC}_{j,i} + \gamma_k \text{APR-DRG}_{k,i} + \varepsilon_i$$

Where:

Charge_i is the total charge standardized for discharge i

APR DRG_{k,i} is a binary variable (0,1) indicating which of the 1,256 APR DRGs was assigned to the ith discharge

PPC_{j,i} is a binary variable (0,1) indicating which of the j PPCs were present for the ith discharge

α is a constant value applied to each discharge in the model. α is the average baseline charge for a reference APR DRG.

γ_k is the coefficient associated with APR-DRG k and measures the marginal additional charge above α that is due to the patient's reason for admission and severity of illness level at the time of admission.

β_j is the coefficient associated with PPC j and measures the marginal additional charge above α that is due to the presence of PPC j

ϵ_i is the residual error of the model for discharge i

The coefficient β_j for each PPC is a measure of the marginal additional charges due to the occurrence of the PPC taking into account the patient's reason for admission, severity of illness and the presence of any other post admission complications (PPCs).

The initial Maryland data set contained 659,816 discharges. 38,211 discharges were assigned to one or more PPCs. Cases in low volume APR-DRGs were omitted from the regression. Further, cases in APR-DRG cells that had significance (t) values below 95% were also omitted from the regression since their coefficients are indicative of too wide a dispersion of values. No effort was made to identify and exclude outlier cases.

Results: A regression model was calculated. For each of the PPC categories, coefficients (additional per case charges) and t-values are shown in table 1 below.

The results of the regression are used for computing the dollar impact for each of the 64 PPCs. The dollar impact is used to create an index of either additional, or averted, resource use based on a hospital's rate of a PPC summed across all PPCs. Eleven (11) PPCs with less predictive t-values (under 1.96) were excluded from the quality based payment adjustment PPC policy. Since the charge values in the regression file used standardized charges, the additional per case charge value for each PPC needs to be converted back to a hospital specific value by the ratio of the hospital CPC divided by the statewide average CPC of \$9,959.11.

PPC 21 and 64 were also excluded from the HSCRC MHAC policy for FY 2010.

Table 1: PPC Regression
(based on FY 08 data)

PPC #	PPC Description	Adm \$	Adm T Value
Shaded PPCs will not be used for the MHAC Initiative- Updated 8/5/09			
1	Stroke & Intracranial Hemorrhage	\$13,066	38.603236
2	Extreme CNS Complications	\$12,051	30.374969
3	Acute Pulmonary Edema and Respiratory Failure without Ventilation	\$5,721	40.425129
4	Acute Pulmonary Edema and Respiratory Failure with Ventilation	\$20,064	60.367208
5	Pneumonia & Other Lung Infections	\$13,561	93.165292
6	Aspiration Pneumonia	\$10,500	43.489609
7	Pulmonary Embolism	\$10,735	26.962321
8	Other Pulmonary Complications	\$7,791	53.427777
9	Shock	\$11,109	42.074928
10	Congestive Heart Failure	\$3,895	19.431952
11	Acute Myocardial Infarction	\$5,643	20.335337
12	Cardiac Arrhythmias & Conduction Disturbances	\$2,418	6.8716698
13	Other Cardiac Complications	\$3,197	7.6846559
14	Ventricular Fibrillation/Cardiac Arrest	\$15,459	41.038245
15	Peripheral Vascular Complications Except Venous Thrombosis	\$12,992	24.113279
16	Venous Thrombosis	\$10,758	44.449833
17	Major Gastrointestinal Complications without Transfusion or Significant Bleeding	\$11,231	34.432863
18	Major Gastrointestinal Complications with Transfusion or Significant Bleeding	\$14,354	23.898709
19	Major Liver Complications	\$10,045	19.089809
20	Other Gastrointestinal Complications without Transfusion or Significant Bleeding	\$8,672	19.123975
21	Clostridium difficile Colitis	\$16,495	61.368894
22	Urinary Tract Infection	\$6,462	55.126985
23	GU Complications Except UTI	\$4,692	11.488989
24	Renal Failure without Dialysis	\$7,920	64.262455
25	Renal Failure with Dialysis	\$41,186	58.790771
26	Diabetic Ketoacidosis & Coma	\$1,445	1.2998569
27	Post-Hemorrhagic & Other Acute Anemia with Transfusion	\$4,256	14.864072
28	In-Hospital Trauma and Fractures	\$4,816	8.8928586
29	Poisonings Except from Anesthesia	\$1,415	2.5293641
30	Poisonings due to Anesthesia	-\$214	-0.044442
31	Decubitus Ulcer	\$18,231	60.306088
32	Transfusion Incompatibility Reaction	\$48,575	13.275425
33	Cellulitis	\$2,864	11.067491
34	Moderate Infectious	\$12,922	46.015837
35	Septicemia & Severe Infections	\$14,088	82.951889
36	Acute Mental Health Changes	\$3,631	13.302443
37	Post-Operative Infection & Deep Wound Disruption Without Procedure	\$15,778	55.698834
38	Post-Operative Wound Infection & Deep Wound Disruption with Procedure	\$30,875	24.884632
39	Reopening Surgical Site	\$13,777	14.66669
40	Post-Operative Hemorrhage & Hematoma without Hemorrhage Control Procedure or I&D Proc	\$6,536	39.763252
41	Post-Operative Hemorrhage & Hematoma with Hemorrhage Control Procedure or I&D Proc	\$11,158	17.164797
42	Accidental Puncture/Laceration During Invasive Procedure	\$3,836	16.569302
43	Accidental Cut or Hemorrhage During Other Medical Care	\$722	0.7864481
44	Other Surgical Complication - Mod	\$12,509	28.382066
45	Post-procedure Foreign Bodies	\$5,203	2.6470991
46	Post-Operative Substance Reaction & Non-O.R. Procedure for Foreign Body	\$6,574	0.9290811
47	Encephalopathy	\$10,182	38.081795
48	Other Complications of Medical Care	\$10,588	41.930328
49	Iatrogenic Pneumothorax	\$7,283	22.107326
50	Mechanical Complication of Device, Implant & Graft	\$14,138	35.609177
51	Gastrointestinal Ostomy Complications	\$20,608	40.248239
52	Inflammation & Other Complications of Devices, Implants or Grafts Except Vascular Infection	\$8,776	31.270093
53	Infection, Inflammation & Clotting Complications of Peripheral Vascular Catheters & Infusions	\$15,073	42.530628
54	Infections due to Central Venous Catheters	\$22,295	40.356236
55	Obstetrical Hemorrhage without Transfusion	\$159	0.9533953
56	Obstetrical Hemorrhage with Transfusion	\$2,137	4.2845441
57	Obstetric Lacerations & Other Trauma Without Instrumentation	\$273	1.0950693
58	Obstetric Lacerations & Other Trauma With Instrumentation	\$646	1.6310622
59	Medical & Anesthesia Obstetric Complications	\$487	1.2749917
60	Major Puerperal Infection and Other Major Obstetric Complications	\$94	0.164819
61	Other Complications of Obstetrical Surgical & Perineal Wounds	\$69	0.1035152
62	Delivery with Placental Complications	\$525	0.8839125
63	Post-Operative Respiratory Failure with Tracheostomy	\$115,361	91.791189
64	Other In-Hospital Adverse Events	\$2,147	6.0351379

Note: Shaded PPCs are excluded