AHRQ Quality Indicators

Estimating Risk-Adjustment Models Incorporating Data on Present on Admission

Overview

This document describes the current AHRQ Quality Indicator (AHRQ QI) risk-adjustment methodology incorporating data on Present on Admission (POA). After a summary of the POA data element, the document discusses how POA has been used in the past in the development and implementation of the AHRQ QI, and how that approach has been critiqued in the literature. The document then discusses the general intent of the current approach and provides a general overview of the methodology.

Appendix-A presents the statistical methods used and how the approach is implemented in the AHRQ QI software. Appendix-B presents a table of AHRQ QIs that use POA. Finally, Appendix-C provides an example of the methodology for the Patient Safety Indicator Post-Operative Sepsis (PSI #13).

Present on admission

Present on Admission (POA) was added as a data element to the UB-04 in fiscal year 2008 (effective March 1, 2007). Prior to adoption in the uniform bill there were earlier state-specific data elements for diagnosis codes present on admission in California and New York. The POA data element applies to each principal and secondary diagnosis code and provides a means of distinguishing pre-existing co-morbidities from complications that occur during the hospitalization of interest. POA is defined as "present at the time the order for inpatient admission occurs. Conditions that develop during an outpatient encounter, including emergency department, are considered as present on admission."[1]

The Deficit Reduction Act of 2005 (DRA) required an adjustment in Medicare Diagnosis Related Group (DRG) payments for certain hospital-acquired conditions. In order to implement the provisions of the DRA, hospitals were required by law to submit POA information on diagnoses for inpatient discharges on or after January 1, 2008 (unless otherwise exempt from the requirement)[2]

In addition, several states have adopted POA in the hospital discharge data submitted by hospitals to either the state department of health or the state hospital association. Nine (9) states provide this data element for the 2007 State Inpatient Databases (SID) created by AHRQ under the Healthcare Cost and Utilization (HCUP) project (http://hcup-us.ahrq.gov).

Prior uses of POA for the AHRQ QI

The concept of POA has informed both the development and implementation of the AHRQ QI. For example, cases where the outcome of interest is more likely than not to be POA are excluded

[1] National Uniform Billing Committee, UB-04 Data Specifications Manual (American Hospital Association)
[2] Change Request 5499, Pub 100-04 Medicare Claims Processing Manual (May 11, 2007)

from the denominator of several indicators (e.g. cases with a principal diagnosis code for the outcome of interest). Similarly, the set of conditions used in the risk-adjustment were selected based on an assessment of whether the condition was more likely than not to be POA.

Since Version 3.1 of the AHRQ QI software the POA data element has been used in the calculation of the indicators where the data are available. The software included an option to use the data element to identify cases for exclusion and to identify whether a condition was a co-morbidity in the risk-adjustment. Some states that collect POA data used this option in public reports using the AHRQ QI software Version 3.1

Critique in the literature

Several studies have looked at the impact of POA on the identification of cases and hospital rates. A study by Pine and colleagues (2007) supported the value of adding POAs and numerical laboratory values to administrative databases in terms of the predictive power of the risk-adjustment models[3] Medical record abstraction of difficult to obtain key clinical findings was not supported on that same basis. A study by Houchens and colleagues (2008) examined the impact of POA on Patient Safety Indicator (PSI) case identification and rate calculation and found material impacts for three of the 13 PSI included in the analysis[4] Finally, a study by Glance and colleagues (2008) used POA-enhanced administrative data from California to evaluate the predictive performance of the APR-DRG risk-of-mortality subclass for the Inpatient Quality Indicators (IQI) mortality measures[5] All of these studies found some impact on the relative performance of hospitals once POA data were included.

In addition, many of the AHRQ QIs have recently been submitted to the National Quality Forum (NQF) under the consensus development process for endorsement consideration. For a few of the indicators, the NQF conditioned endorsement on the use of POA data (e.g., foreign body left in during procedure, pediatric pressure ulcer). For other indicators the final reports anticipated that POA data would be used as soon as it was available.

General intent of the new methodology

The general intent that informed the current risk-adjustment model was to develop an approach that used all of the available data (with or without the POA data element) for calculating the comparative benchmarks and risk-adjusted rates. The approach was to be incremental in that the estimation would improve over time as additional states and payers adopted POA. From the perspective of individual hospitals, each hospital could decide whether or not it was worth the additional effort to collect POA data (i.e., whether the hospital's relative performance would be materially impacted). Such a general approach could be applied to other types of enhanced administrative data (e.g., laboratory, key clinical findings, etc.).

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[3] Pine M, Jordan HS, Elixhauser A, Fry DE, Hoaglin DC, Jones B, Meimban R, Warner D, Gonzales J. Enhancement of claims data to improve risk adjustment of hospital mortality. JAMA. 2007 Jan 3;297(1):71-6.

[4] Houchens RL, Elixhauser A, Romano PS.. How often are potential patient safety events present on admission? Jt Comm J Qual Patient Saf. 2008 Mar;34(3):154-63.

[5] Glance LG, Osler TM, Mukamel DB, Dick AW. Impact of the present-on-admission indicator on hospital quality measurement: experience with the Agency for Healthcare Research and Quality (AHRQ) Inpatient Quality Indicators. Med Care. 2008 Feb;46(2):112-9.

Overview of the methodology

This section provides a brief overview of the methodology. Appendix A provides detail on the statistical methodology. Appendix B provides a table of the AHRQ QIs that use POA data. Appendix C provides an example for PSI #13. There are six (6) steps in the methodology.

Step 1. Determine whether the discharge has Present on Admission data

The method does not assume that every discharge record in the input data file has or does not have POA data. POA may be available in some states and not other states, some hospitals within states and not other hospitals, or some discharges within hospitals and not other discharges. For example, Critical Access Hospitals are exempt from POA reporting. A hospital may collect POA for Medicare patients but not non-Medicare patients.

The software automatically determines whether or not each discharge record contains POA data using data reported on the discharge record.

Step 2. Create discharge level flags for the indicator

The software creates flags that indicate whether the discharge record meets the criteria for the outcome of interest or the population at risk for the given AHRQ QI. For those discharge records with POA data, the software creates a flag that indicates whether the outcome of interest was present on admission or whether the discharge record has an excluding condition. An excluding condition is defined as a condition where the outcome of interest, if present, is more likely to be POA or less likely to be preventable.

2a. Create Flag for Outcome of Interest and Population at Risk

The software creates a data element that flags whether or not the discharge record meets the criteria for inclusion in the outcome of interest (numerator), the population at risk (denominator) or meets neither of these conditions (i.e., it is missing).

2b. Create Flag for Exclusion based on Present on Admission

For a discharge record that contains POA data, the software creates another data element that flags whether or not the discharge record meets the criteria for exclusion from the population at risk (denominator) using the secondary diagnosis codes and corresponding POA codes.

For a discharge record that does not contain POA data the value of the data element is equal to missing.

Step 3. Create discharge level flags for covariates

For the Patient Safety Indicators (PSI), the software creates flags that indicate whether the discharge record meets the criteria for one of twenty-five (25) comorbidities that are used as covariates in the risk adjustment model. For the Inpatient Quality Indicators (IQI), the software creates flags that indicate the risk-of-mortality subclass (minor, moderate, major, extreme) for each APR-DRG. For those discharge records with POA data, the software

creates a second set of data elements that do not consider secondary diagnosis codes that are not present on admission when assigning comorbidity or risk-or-mortality flags.

The software creates discharge level flags for covariates for all discharge records that meet the inclusion criteria for the population at risk. The software also creates another set of discharge level flags for covariates for discharge records that contain POA data. The difference between the two sets of flags is that comorbidities that are not present on admission (that is, complications) are not flagged as comorbidities.

Step 4. Calculate Predicted Value for Covariate

For discharge records with POA data the actual value of the data element for each covariate is used. For each discharge records without POA data, the software calculates a predicted value for each covariate. For demographic and severity of illness covariates, the data elements are the same because these covariates are POA by definition. For comorbidity covariates, the software uses a 2x2 table of probabilities calculated on the discharges in the reference population with POA data. The four probabilities represent the following situations

1. The covariate with POA is not present if the covariate ignoring POA is not present
2. The covariate with POA is present if the covariate ignoring POA is not present
3. The covariate with POA is not present if the covariate ignoring POA is present
4. The covariate with POA is present if the covariate ignoring POA is present

There is one 2x2 table per covariate. For discharge records without POA data, the predicted value for each comorbidity covariate is equal to the probability that the second or fourth situation above is true.

Step 5. Calculate Predicted Values for Each Discharge Record

Using either the actual or predicted values for the covariates, the software calculates three predicted values for each discharge record. The first is the predicted value of the outcome given the covariate values ignoring POA. The second is the predicted value of the outcome given the covariate values using POA (either actual or predicted). The third is the predicted value of the data element that flags discharges for exclusion from the population at risk (denominator) g given the covariate values using POA (either actual or predicted).

Step 6. Calculate Observed, Expected and Risk-adjusted Rate for Each Hospital

The observed and expected rate for each hospital is an aggregate of the actual and predicted values for each discharge record in that hospital.

At the hospital level, the software sums the number of flagged cases in the numerator and the number of flagged cases in the numerator that are either flagged as POA or predicted as POA. These two values are used to calculate the observed rate. The software then sums the number of predicted cases estimated by the prediction module to yield the expected rate. The calculation of the risk-adjusted rate is the same as in previous versions, using the indirect standardization method.

Appendix A. Statistical Methodology

Preface

The appendix introduces the statistical notation that describes the model, identifies the modeling goals and the estimated equations, and explains the process for model fitting and software implementation. Table A1 presents information on how values for the POA data element are determined.

1. Statistical Notation

Here is the general statistical notation used to describe the model:

- Y_{ij} = Indicator for the i^{th} patient in the j^{th} hospital
  - Y_{ij} =1 if the patient experiences the outcome of interest, 0 otherwise

- P_{ij} =Indicator of whether the outcome of interest (represented by Y_{ij}) is POA - determined from the POA data.
  - Note that P_{ij} will equal 0, by definition, if Y_{ij} =0, but that P_{ij} could equal either 0 or 1 when Y_{ij} =1. P_{ij} is not observed on everyone.

- Z_{ij} = Vector of explanatory variables associated with the i^{th} patient in the j^{th} hospital, based on administrative records with no POA data.
  - Z_{ij} is observed for everyone.

- X_{ij} =Vector of improved explanatory variables associated with the i^{th} patient in the j^{th} hospital, based on administrative records with POA data.
  - X_{ij} is not observed on everyone.

Table A1. Values for the Present on Admission Data Element

ICD-9-CM Guidelines	Description	AHRQ QI Data Element	Description
Y - Yes	Present at the time of inpatient admission	1	Diagnosis present at admission
N – No	Not present at the time of inpatient admission	0	Diagnosis not present at admission
U - Unknown	Documentation is insufficient to determine if condition is present on admission	0	Diagnosis not present at admission
W – Clinically undetermined	Provider is unable to clinically determine whether condition was present on admission or not	1	Diagnosis present at admission
E - Unreported/Not used	Exempt from POA reporting	1	Diagnosis present at admission
1 - Yes	Present at the time of inpatient admission	1	Diagnosis present at admission
0 – No	Not present at the time of inpatient admission	0	Diagnosis not present at admission

Source: http://www.cms.hhs.gov/HospitalAcqCond/05_Coding.asp#TopOfPage

2. Modeling Goals

The modeling goal is to predict $\pi_{ij} = Pr(Y_{ij}=1|P_{ij}=0,X_{ij})$, where we assume $Logit(\pi_{ij}) = x_{ij} \cdot \beta$. A subcomponent of the model is the prediction of $r_{ij} = Pr(P_{ij}=1|X_{ij})$, where we assume $Logit(r_{ij}) = x_{ij} \cdot \alpha$. In order to account for the anticipated within-hospital correlation among Y_{ij} responses, the model uses a Generalized Estimating Equations (GEE) approach. A random effects approach was considered, but was discarded because the multiple observed hospitals with no cases were compromising the random effect estimates.

3. Likelihood Equations

If POA data are available (and hence x_{ij} and P_{ij} are observed), the model maximizes the following likelihood, where r(x) is the probability that P=1, given the observable characteristics of X.

$$L = f(X \mid Z)(\pi(x)^{(1-P)})^{Y} (1 - \pi(x)^{(1-P)})^{(1-Y)} r(x)^{P} (1 - r(x))^{(1-P)}$$

When x_{ij} and/or P_{ij} is not observed, the model must integrate/sum over the missing data P and X. Information about both of these may be obtained in the variables Z that are generally observed.

$$L = \int \sum_{P=0,1} f(X \mid Z)(\pi(x)^{(1-P)})^{Y} (1 - \pi(x)^{(1-P)})^{(1-Y)} r(x)^{P} (1 - r(x))^{(1-P)} dx$$

4. Model Fitting Approach using MCMC

The models are fit using Markov chain Monte Carlo (MCMC) estimation. MCMC is an algorithm for sampling from a probability distribution based on constructing a Markov chain that has the desired distribution as its equilibrium distribution. The state of the chain after a large number of steps is then used as a sample from the desired distribution. The quality of the sample improves as a function of the number of steps.

The model establishes X|Z using a series of 2x2 tables, and establishes P|X using a logistic regression modeling approach. The model then predicts values of X where missing using X|Z, and imputes values of P where missing using P|X creating an MCMC simulated analysis dataset.

The model establishes Y|X, P=0 by fitting the logistic regression model Y|X for the subset of the MCMC simulated analysis dataset in which P=0. These steps are repeated many times until parameter estimates reach convergence. The analysis also fits the models two ways, using a GEE approach that accounts for within-hospital correlation when the GEE model fits, or using a simple logistic regression modeling approach when it does not fit.

5. Implementation in Software

The model is implemented in the AHRQ QI software using a prediction module for applying model results to patient records from a selected hospital (or group of hospitals). The model uses a consistent MCMC approach to impute values of P and X (where missing) prior to applying parameter estimates, averaging the predicted values of Y over many simulations.

Appendix B. Table of AHRQ QIs that use POA

Table B1 denotes which AHRQ QIs use POA and how they use POA data (i.e., for technical specifications or risk adjustment).

Table B1. AHRQ QI Uses of POA

	Measure Specifications *	Risk Adjustment
IQI #08 - Esophageal Resection Mortality		X
IQI #09 - Pancreatic Resection Mortality		X
IQI #11 - AAA Repair Mortality		X
IQI #12 - CABG Mortality		X
IQI #13 - Craniotomy Mortality		X
IQI #14 - Hip Replacement Mortality		X
IQI #15 - AMI Mortality		X
IQI #16 - CHF Mortality		X
IQI #17 - Acute Stroke Mortality		X
IQI #18 - GI Hemorrhage Mortality		X
IQI #19 - Hip Fracture Mortality		X
IQI #20 - Pneumonia Mortality		X
IQI #30 - PTCA Mortality		X
IQI #31 - Carotid Endarterectomy Mortality		X
IQI #32 – AMI Mortality WO Transfer		X
PSI #03 - Pressure Ulcer	X	X
PSI #04 - Death among Surgical Inpatients with Serious Treatable Complications		X
PSI #05 - Foreign Body left in During Procedure	X	
PSI #06 - Iatrogenic Pneumothorax	X	X
PSI #07 - Central Venous Catheter-related BSI	X	X
PSI #08 - Post-op Hip Fracture	X	X
PSI #09 - Post-op Hemorrhage or Hematoma	X	X
PSI #10 - Post-op Physiologic & Metabolic Derangement	X	X
PSI #11 - Post-op Respiratory Failure	X	X
PSI #12 - Post-op PE or DVT	X	X
PSI #13 - Post-op Sepsis	X	X
PSI #14 - Post-op Wound Dehiscence		X
PSI #15 - Accidental Puncture or Laceration	X	X
PSI #16 - Transfusion Reaction	X	
PSI #17 - Birth Trauma - Injury to Neonate		
PDI #01 - Accidental Puncture or Laceration	X	X

PDI #02 - Pressure Ulcer	X	X
PDI #03 - Foreign Body left in During Procedure	X	
PDI #05 - Iatrogenic Pneumothorax	X	X
PDI #06 - Pediatric Heart Surgery Mortality		X
PDI #08 - Post-op Hemorrhage or Hematoma	X	X
PDI #09 - Post-op Respiratory Failure	X	X
PDI #10 - Post-op Sepsis	X	X
PDI #11 - Post-op Wound Dehiscence		X
PDI #12 - Central Venous Catheter-related BSI	X	X
PDI #13 - Transfusion Reaction	X	
NQI #01 - Iatrogenic Pneumothorax in Neonates	X	X
NQI #02 - Neonatal Mortality		X
NQI #03 - Blood Stream Infections in Neonates	X	X

Appendix C. Example Using Postoperative Sepsis (PSI #13)

The following example demonstrates the steps used to calculate the hospital risk-adjusted rate for the Patient Safety Indicator Postoperative Sepsis (PSI #13) in the AHRQ QI software

Step 1. Determine whether the discharge has Present on Admission data

Table C1 shows the number and percent of discharge records that had present on admission (POA) data in the Version 4.1 reference population (2007 SID) for one or more principal or secondary diagnosis codes overall and for discharge records in the denominator of Postoperative Sepsis.

Table C1. Number and Percent of Discharges with Present on Admission Data

	Overall	Postoperative Sepsis
No Present on Admission Data	18,365,066	557,822
Present on Admission Data	9,004,680	252,377
Total	27,369,746	810,199
No Present on Admission Data	67.1%	68.8%
Present on Admission Data	32.9%	31.1%
Total	100.0%	100.0%

Source: HCUP State Inpatient Databases (SID). Healthcare Cost and Utilization Project (HCUP). 2007. Agency for Healthcare Research and Quality, Rockville, MD. www.hcup-us.ahrq.gov/sidoverview.jsp.

Step 2. Create discharge level flags for the indicator

Table C2 shows the number and percent of discharge records flagged for PSI 13. Note that in discharge records with POA data, P = 38.3%, which is the percent of cases flagged in the outcome of interest that would be excluded from the population at risk [1,436 / (1,436 +2,312)].

Table C2. Number and Percent of Discharges by Flag

	Discharges without POA Data	Discharges with POA Data		
tpps13/ qpps13 (P)	**Missing**	**0**	**1**	**Total**
0	549,614	248,629	0	798,243
1	8,208	2,312	1,436	11,956
Total	557,822	250,941	1,436	810,199
0	98.53%	98.51%	0.00%	98.51%
1	1.47%	0.92%	0.57%	1.49%
Total	100.00%	99.43%	0.57%	100.00%

Source: HCUP State Inpatient Databases (SID). Healthcare Cost and Utilization Project (HCUP). 2007. Agency for Healthcare Research and Quality, Rockville, MD. www.hcup-us.ahrq.gov/sidoverview.jsp.
Note: tpps13 = inclusion in numerator; qpps13 = inclusion in denominator; (P) = cases flagged in outcome of interest excluded from population at risk because outcome is POA; 0 – does not meet inclusion; 1 = meets inclusion.

Step 3. Create discharge level flags for covariates

Table C3 shows the proportion of cases flagged for covariates both without (Z) and with (X) POA data. The fourth column shows the proportion of cases flagged for a covariate without (Z) POA data that are flagged for a covariate with (X) POA data. For demographic and severity of illness covariates, the proportion is 1.0 because these covariates are POA by definition. For comorbidity covariates, fewer cases are flagged with POA data because secondary diagnosis codes that are not present on admission are not counted as comorbidities.

Table C3. Proportion of Cases Flagged for Covariates

		All Discharges	Discharges with POA Data		
	Covariate	**Without POA Z**	**Without POA Z**	**With POA X**	**Pr(X=1 if Z=1) X / Z**
N		810,199	252,377	252,377	
CV1	FEMALE	0.562	0.568	0.568	1.000
CV2	POPCAT 5to8	0.082	0.084	0.084	1.000
CV3	POPCAT 9to13	0.312	0.316	0.316	1.000
CV4	POPCAT 14to14	0.130	0.128	0.128	1.000
CV5	POPCAT 15to15	0.122	0.121	0.121	1.000
CV6	POPCAT 16to16	0.115	0.114	0.114	1.000
CV7	POPCAT 17to17	0.078	0.078	0.078	1.000
CV8	POPCAT 18to18	0.042	0.042	0.042	1.000
CV9	MDRG 503	0.052	0.053	0.053	1.000
CV10	MDRG 505	0.009	0.008	0.008	1.000
CV11	MDRG 508	0.028	0.025	0.025	1.000
CV12	MDRG 601	0.014	0.013	0.013	1.000
CV13	MDRG 602	0.054	0.051	0.051	1.000
CV14	MDRG 806	0.023	0.024	0.024	1.000
CV15	MDRG 1003	0.010	0.012	0.012	1.000
CV16	MDRG 1104	0.010	0.009	0.009	1.000
CV17	MDC 4	0.015	0.014	0.014	1.000
CV18	MDC 5	0.157	0.138	0.138	1.000
CV19	MDC 7	0.017	0.016	0.016	1.000
CV20	MDC 8	0.182	0.194	0.194	1.000
CV21	MDC 10	0.014	0.013	0.013	1.000
CV22	MDC OTHER	0.178	0.182	0.182	1.000
CV23	TRNSFER	0.021	0.022	0.022	1.000
CV24	COMORB CHF	0.043	0.037	0.029	0.781
CV25	COMORB VALVE	0.035	0.039	0.036	0.930
CV26	COMORB PULMCIRC	0.008	0.008	0.006	0.792
CV27	COMORB HTN_C	0.565	0.569	0.530	0.931
CV28	COMORB PARA	0.017	0.017	0.014	0.812
CV29	COMORB CHRNLUNG	0.187	0.181	0.165	0.910

		All Discharges	Discharges with POA Data		
	Covariate	**Without POA Z**	**Without POA Z**	**With POA X**	**Pr(X=1 if Z=1) X / Z**
CV30	COMORB HYPOTHY	0.106	0.107	0.100	0.939
CV31	COMORB RENLFAIL	0.054	0.050	0.046	0.912
CV32	COMORB LIVER	0.013	0.015	0.014	0.934
CV33	COMORB OBESE	0.118	0.122	0.115	0.940
CV34	COMORB WGHTLOSS	0.017	0.015	0.008	0.556
CV35	COMORB ALCOHOL	0.016	0.015	0.014	0.910
CV36	COMORB DEPRESS	0.089	0.087	0.081	0.925

Source: HCUP State Inpatient Databases (SID). Healthcare Cost and Utilization Project (HCUP). 2007. Agency for Healthcare Research and Quality, Rockville, MD. www.hcup-us.ahrq.gov/sidoverview.jsp.
Note: X = covariate for discharge records that contain POA data; Z = covariates for all discharge records that meet the inclusion criteria for the population at risk.

Step 4. Calculate Predicted Value for Covariates

Table C4 shows the predicted value for each X comorbidity is equal to the probability that X = 1 if Z = 0 or the probability that X = 1 if Z = 1.

Table C4. Predicted Value for X Comorbidities

	Covariate	**Pr(X=0 if Z=0)**	**Pr(X=1 if Z=0)**	**Pr(X=0 if Z=1)**	**Pr(X=1 if Z=1)**
CV24	COMORB CHF	1.000	0.000	0.219	0.781
CV25	COMORB VALVE	1.000	0.000	0.070	0.930
CV26	COMORB PULMCIRC	1.000	0.000	0.208	0.792
CV27	COMORB HTN_C	1.000	0.000	0.069	0.931
CV28	COMORB PARA	1.000	0.000	0.188	0.812
CV29	COMORB CHRNLUNG	1.000	0.000	0.090	0.910
CV30	COMORB HYPOTHY	1.000	0.000	0.061	0.939
CV31	COMORB RENLFAIL	1.000	0.000	0.088	0.912
CV32	COMORB LIVER	1.000	0.000	0.066	0.934
CV33	COMORB OBESE	1.000	0.000	0.060	0.940
CV34	COMORB WGHTLOSS	1.000	0.000	0.444	0.556
CV35	COMORB ALCOHOL	1.000	0.000	0.090	0.910
CV36	COMORB DEPRESS	1.000	0.000	0.075	0.925

Source: HCUP State Inpatient Databases (SID). Healthcare Cost and Utilization Project (HCUP). 2007. Agency for Healthcare Research and Quality, Rockville, MD. www.hcup-us.ahrq.gov/sidoverview.jsp.
Note: X = covariate for discharge records that contain POA data; Z = covariates for all discharge records that meet the inclusion criteria for the population at risk.

Step 5. Calculate Predicted Values for Each Discharge Record

Table C5 shows the predicated value calculations for a typical discharge record without POA data (and therefore predicted values of X and P).

Note that the predicted value for Y for this discharge record is less for X (0.0138) than for Z (0.0241) because a portion of the flagged comorbidities are assumed to be complications and not comorbidities (and therefore the case has lower risk at the time of admission). For this discharge record, a high percentage of these predicted values for Y are estimated to be POA [P = (0.0117 / 0.0138) = 84.8%]

Table C5. Calculation of Predicted Rate for a Typical Discharge Record

	Covariate	Z	Beta(Y|Z)	[Y|Z] Z*Beta(Y|Z)	X	Beta(Y|X)	[Y|X] X*Beta(Y|X)	Beta(P|X)	[P|X] X*Beta(P|X)
N		1	-5.311	-5.311	1.000	-5.7350	-5.7350	-6.4847	-6.4847
CV1	FEMALE	1	-0.122	-0.122	1.000	-0.1235	-0.1235	-0.1465	-0.1465
CV2	POPCAT 5to8	0	-0.691	0.000	0.000	-0.7197	0.0000	-0.6386	0.0000
CV3	POPCAT 9to13	0	-0.215	0.000	0.000	-0.2364	0.0000	-0.2013	0.0000
CV4	POPCAT 14to14	0	0.172	0.000	0.000	0.2241	0.0000	0.1100	0.0000
CV5	POPCAT 15to15	0	0.239	0.000	0.000	0.2263	0.0000	0.3277	0.0000
CV6	POPCAT 16to16	0	0.346	0.000	0.000	0.3517	0.0000	0.5081	0.0000
CV7	POPCAT 17to17	1	0.348	0.348	1.000	0.4246	0.4246	0.4192	0.4192
CV8	POPCAT 18to18	0	0.223	0.000	0.000	0.2117	0.0000	0.4607	0.0000
CV9	MDRG 503	1	1.671	1.671	1.000	1.6736	1.6736	1.7494	1.7494
CV10	MDRG 505	0	1.608	0.000	0.000	1.7746	0.0000	1.3679	0.0000
CV11	MDRG 508	0	1.976	0.000	0.000	2.0771	0.0000	1.8880	0.0000
CV12	MDRG 601	0	1.910	0.000	0.000	1.8172	0.0000	2.2487	0.0000
CV13	MDRG 602	0	1.975	0.000	0.000	1.9532	0.0000	2.1467	0.0000
CV14	MDRG 806	0	0.709	0.000	0.000	0.7684	0.0000	0.6485	0.0000
CV15	MDRG 1003	0	2.137	0.000	0.000	2.4280	0.0000	1.5548	0.0000
CV16	MDRG 1104	0	2.058	0.000	0.000	1.7282	0.0000	2.5752	0.0000
CV17	MDC 4	0	2.108	0.000	0.000	1.3874	0.0000	2.7557	0.0000
CV18	MDC 5	0	1.547	0.000	0.000	1.5981	0.0000	1.5599	0.0000
CV19	MDC 7	0	1.656	0.000	0.000	1.7631	0.0000	1.6060	0.0000
CV20	MDC 8	0	0.693	0.000	0.000	0.6943	0.0000	0.7259	0.0000
CV21	MDC 10	0	1.691	0.000	0.000	1.7033	0.0000	1.8318	0.0000

	Covariate	Z	Beta(Y|Z)	[Y|Z] Z*Beta(Y|Z)	X	Beta(Y|X)	[Y|X] X*Beta(Y|X)	Beta(P|X)	[P|X] X*Beta(P|X)
CV22	MDC OTHER	0	1.460	0.000	0.000	1.3926	0.0000	1.6430	0.0000
CV23	TRNSFER	0	0.806	0.000	0.000	0.2728	0.0000	1.2464	0.0000
CV24	COMORB CHF	0	1.044	0.000	0.000	0.9675	0.0000	1.2503	0.0000
CV25	COMORB VALVE	0	0.120	0.000	0.000	0.2732	0.0000	0.0960	0.0000
CV26	COMORB PULMCIRC	0	0.371	0.000	0.000	0.7252	0.0000	0.0787	0.0000
CV27	COMORB HTN_C	0	-0.903	0.000	0.000	-1.0830	0.0000	-0.5593	0.0000
CV28	COMORB PARA	0	0.547	0.000	0.000	0.3763	0.0000	0.8010	0.0000
CV29	COMORB CHRNLUNG	0	0.110	0.000	0.000	0.1458	0.0000	0.0994	0.0000
CV30	COMORB HYPOTHY	0	-0.404	0.000	0.000	-0.4823	0.0000	-0.3385	0.0000
CV31	COMORB RENLFAIL	0	0.568	0.000	0.000	0.6512	0.0000	0.5405	0.0000
CV32	COMORB LIVER	0	0.417	0.000	0.000	0.4547	0.0000	0.3996	0.0000
CV33	COMORB OBESE	0	-0.028	0.000	0.000	-0.0169	0.0000	0.0303	0.0000
CV34	COMORB WGHTLOSS	0	1.871	0.000	0.000	2.1109	0.0000	2.0168	0.0000
CV35	COMORB ALCOHOL	0	0.413	0.000	0.000	0.5053	0.0000	0.2468	0.0000
CV36	COMORB DEPRESS	1	-0.286	-0.286	0.925	-0.5912	-0.5469	0.0343	0.0317
	Sum of Column			-3.7006			-4.2647		-4.4308
	Predicted value			0.0241			0.0138		0.0117

Source: HCUP State Inpatient Databases (SID). Healthcare Cost and Utilization Project (HCUP). 2007. Agency for Healthcare Research and Quality, Rockville, MD. www.hcup-us.ahrq.gov/sidoverview.jsp. Note: the predicted value is equal to exp(sum) / [1+exp(sum)]. The beta coefficients are provided with the AHRQ QI software in a comma-delimited file called gee_psi13_RegressionAnalysisGee.csv. The column heading for the Beta(Y|X) is MCMC[Y|X;P=0].Note: X = covariate for discharge records that contain POA data; Z = covariates for all discharge records that meet the inclusion criteria for the population at risk; Y = outcome.

Step 6. Calculate Observed, Expected and Risk-adjusted Rate for Each Hospital

Table C6 shows the calculation for a typical hospital and some typical discharge records. Note that some of the discharge records have POA data (records 4, 6 and 8) and some do not.

At the hospital level, the sum of column A is the number of flagged cases in the numerator (Y). The sum of column F is the number of flagged cases in the numerator that are either flagged as POA (P) or predicted as POA (P|X). The sum of column H is the expected number of cases in the numerator.

Table C6. Predicted Value for X Comorbidities

Discharge	**Denom.**	**Y**	**[Y|Z]**	**[Y|X]**	**P**	**[P|X]**	**E / C**	**1-F**	**C*G**
		A	**B**	**C**	**D**	**E**	**F**	**G**	**H**
Record 1	1	1	0.02411	0.01478	.	0.01176	0.7957	0.2043	0.0030
Record 2	1	1	0.02411	0.01478	.	0.01176	0.7957	0.2043	0.0030
Record 3	1	0	0.00224	0.00134	.	0.00109	0.0000	1.0000	0.0013
Record 4	1	0	0.07063	0.05094	0	0.02703	0.0000	1.0000	0.0509
Record 5	1	0	0.00257	0.00125	.	0.00173	0.0000	1.0000	0.0013
Record 6	1	0	0.00209	0.00120	0	0.00084	0.0000	1.0000	0.0012
Record 7	1	0	0.01511	0.00970	.	0.00948	0.0000	1.0000	0.0097
Record 8	1	1	0.09408	-	1	0.04448	1.0000	0.0000	0.0000
Record 9	1	1	0.03075	0.02053	.	0.00934	0.4549	0.5451	0.0112
More . . .									
Hospital		**Y**					**POA**		**Expected**
Sum	1953	18					5		16.0108
Average		0.00921					0.00256		0.00819
Hospital		**Observed**							**Expected**
Rate		0.00667							0.00821
O/E		0.811							
Risk-adjusted		0.00709							

Source: HCUP State Inpatient Databases (SID). Healthcare Cost and Utilization Project (HCUP). 2007. Agency for Healthcare Research and Quality, Rockville, MD. www.hcup-us.ahrq.gov/sidoverview.jsp. Note: the actual formula for column F is more complicated but the approximate value shown here is correlated with the actual value at 0.980.
Note: X = covariate for discharge records that contain POA data; Z = covariates for all discharge records that meet the inclusion criteria for the population at risk; Y = outcome.