

# Measuring the Quality of Inpatient Care: Risk-Adjusted Indices for Comparing Rates of Mortality, Complications, Readmissions, and Patient Safety Events

*M. Thane Forthman, D.H.A.* is managing principal of The Delta Group, Inc. based in Greenville, SC. Dr. Forthman has served on the editorial review board of the *International Journal for Quality in Health Care* (Oxford University Press) and *Hospital Benchmarks*; **Robert S. Gold, M.D.** is chief executive officer of DCBA, Inc. based in Atlanta, GA; **Henry G. Dove, Ph.D.** is a principal at Casemix Consulting, LLC and lecturer at the Department of Health Policy and Administration, Yale University, Hamden, Connecticut; **Richard D. Henderson, M.B.A.**, is a principal at The Delta Group.

## Abstract

This paper describes a risk-adjustment method for profiling hospitals and physicians on key measures of clinical quality using readily available administrative data. By comparing actual and expected rates of mortality, complications, readmissions, and patient safety events this method enables providers to identify both favorable and adverse outcomes performance. Key terms: *Risk-Adjustment, Risk-adjusted Mortality Index, Risk-Adjusted Complications Index, Risk-Adjusted Readmissions Index, and Risk-Adjusted Patient Safety Index.*

## INTRODUCTION

Over the past decade the healthcare industry has witnessed an unparalleled disclosure of hospital-specific comparative outcomes information to the public. Clearly, there has been a growing consensus among a broad array of federal, state, association, business, and consumer stakeholders around the importance of public reporting of hospital quality measures, including those that measure clinical outcomes and the patient's perception of care. Many initiatives have developed across the country designed to increase accountability for and public awareness of differences in the quality of hospital services. Specifically, in 1997 the Joint Commission on Accreditation of Healthcare Organizations (JCAHO) announced the ORYX initiative, which integrated clinical outcomes and other performance measurement data into the hospital accreditation process as part of the JCAHO's Agenda for Change.<sup>1</sup> By design, the ORYX

initiative includes many of the same quality measures launched by the Center for Medicare and Medicaid Services (CMS) Ninth Scope of Work (9SOW). The 9SOW quality indicators are being collected by state Quality Improvement Organizations to improve the quality of care for beneficiaries by ensuring that care meets professionally recognized standards of medical care. Given the importance of the Medicare program to hospitals, hospitals are becoming increasingly accountable to federal quality standards. In 2003 CMS instituted a pay-for-performance pilot program to reward hospitals with exemplary quality performance and penalize those with sub-standard performance.<sup>2</sup> Furthermore, the Agency for Healthcare Research and Quality (AHRQ) is now required to report to Congress on the state of the nation's healthcare quality. A report of these findings is now released annually to the public in the form of a "National Health Care Quality Report." The intent of the report is to measure safety, effectiveness, timeliness, and patient centeredness. In 1999, the National Quality Forum (NQF) was created in response to the national quality improvement agenda proposed by the President's Advisory Commission on Consumer Protection and Quality. The NQF was founded to develop and implement a national strategy for healthcare quality measurement and reporting. The CMS is supporting NQF to develop quality indicators that can be reported and measured at a national level. The American Hospital Association, the Federation of American Hospitals, and the Association of American Medical Colleges have also embarked on a national initiative to collect and report

hospital quality performance information on a voluntary basis.<sup>3</sup> The CMS, along with the JCAHO, and the AHRQ support the initiative as the beginning of an ongoing effort to make hospital performance information more accessible to the public, payers, and providers of care. From an employer perspective, increased accountability and public awareness has been established with the formation of the Leapfrog Group, founded in 2000 by the Business Round Table (BRT), a national association of Fortune 500 companies representing 150 public and private organizations that provide health benefits to more than 34 million consumers across all 50 states. The BRT launched the Leapfrog initiative to address patient safety and quality issues in the U.S. healthcare system and to recognize health plans and hospitals that implement the Leapfrog's quality standards.<sup>4</sup> As with the other national initiatives, the JCAHO and the CMS are working with the Leapfrog Group to consistently accomplish these objectives. Other organizations, such as HealthGrades, WebMD, and Consumer Reports, have joined the campaign through the release of hospital reports cards and various awards designed to recognize providers that achieve commendable levels of quality performance.<sup>5</sup> Similarly *U.S. News & World Report*<sup>5</sup> and *Modern Healthcare*<sup>6</sup>, as well as other media organizations, continue to promote public awareness through the publication of annual hospital rankings.

It would be difficult to imagine that a more pervasive culmination of efforts could exist to press the issue of publicly available hospital quality reporting. However, with all this reporting activity, it is imperative to recognize that since significant differences in demographic and clinical risk factors exist among patients treated across providers, a medically meaningful and statistically reliable risk adjustment tool is needed to make accurate comparisons of clinical outcomes. As Localio states,

Organizations seeking to compare the quality of hospitals and physicians through outcome data need to recognize that simplistic methods applicable to large samples fail when applied to the outcomes of typical patients such as those admitted for pneumonia. Although these comparisons are much in demand, careful attention must be paid to their statistical methods to ensure validity and fairness.<sup>7</sup>

While the usefulness and validity of the various quality measures deployed across the industry may vary, they nonetheless point to a growing desire for the public to make more informed choices regarding the selection of healthcare providers. In fact, a recent study performed by GE Healthcare indicates that one of the most important trends that should be considered in a hospital's strategy development is that quality reporting is shifting from value-add to essential. In this study, Vachon maintains,

Metrics around quality and performance will drive everything that matters in healthcare going forward, from payer reimbursement and consumer choice to investment strategies that deliver results. Consumers and payers want to get the best care possible for their dollar, and the current economic crisis has only added greater urgency to their efforts.<sup>8</sup>

Given the foregoing, the purpose of this article is two-fold: to describe a risk-adjustment method for validly assessing clinical outcomes across providers and, secondly, to demonstrate how this method can be used by providers to identify adverse events in order to improve quality and to document favorable outcomes for promotion to purchasers

and consumers. A description of how each of the risk-adjustment models was constructed and validated is presented in the next section.

## **RISK-ADJUSTED QUALITY OF CARE MEASURES**

It is not possible, either conceptually or technically, to construct an all-inclusive index to measure the quality of inpatient care. However, The Delta Group has constructed separate risk-adjusted indices which validly measure four important components of quality—rates of mortality, complications, readmissions, and patient safety events. The specific indices developed by The Delta Group are the risk-adjusted mortality index (RAMI), the risk-adjusted complications index (RACI), the risk-adjusted readmissions index (RARI), and the risk-adjusted patient safety index (RAPSI). The RAMI, RACI, and RARI are based on the earlier research performed at the Commission on Professional and Hospital Activities (CPHA) through funding provided by CMS (formerly HCFA).<sup>9-12</sup> The RAPSI is based on recent patient safety research completed by Stanford University under subcontract with AHRQ.<sup>13</sup>

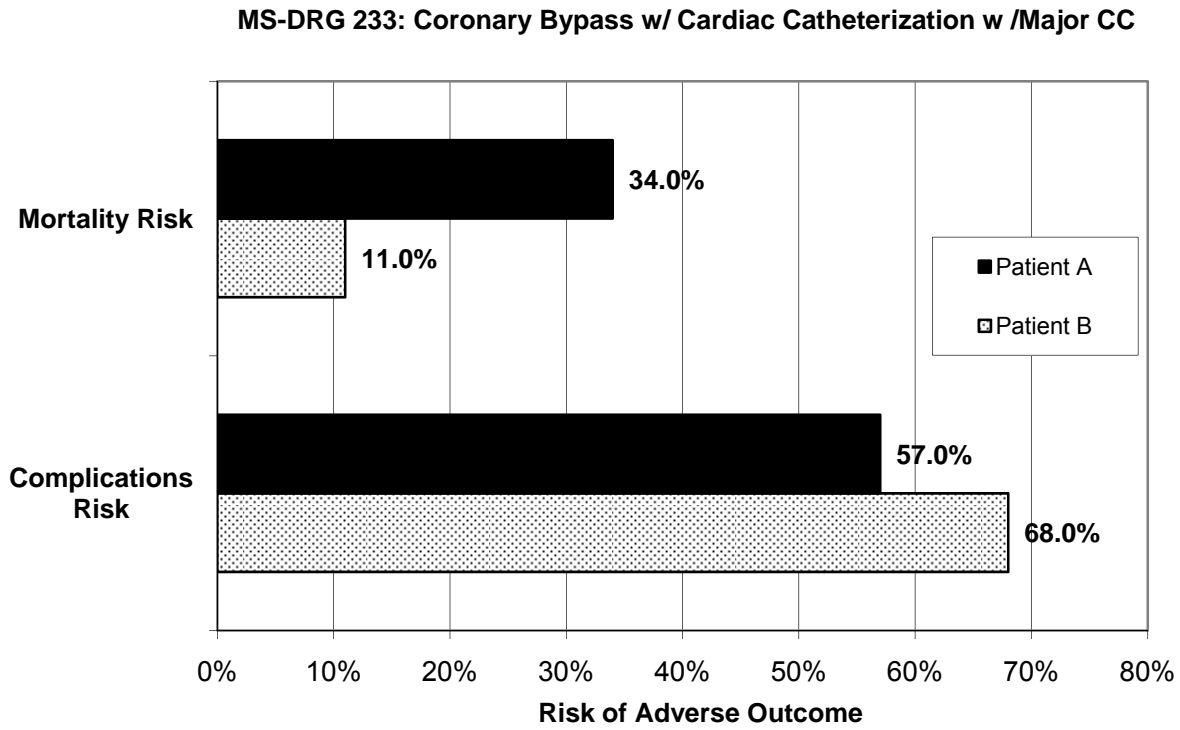
The risk models rely on readily available administrative data which can be used to assess risk factors relating to the patient's diagnoses (principal and secondary), surgical procedures, age, gender, and complications and comorbidities (CCs). Work by Iezzoni and colleagues has shown that risk adjustment methods that rely solely on this type of administrative data perform quite well when compared to methods that require additional record abstracting.<sup>14</sup> However, risk-adjustment should not be confused with severity adjustment. While numerous severity measures exist which account for some patient clinical characteristics, most have been constructed to measure a patient's

increased need for resource consumption in order to assess utilization outcomes such as charges, costs, and length of stay. Moreover, severity narrowly implies that each patient has some degree of severity associated with their principal diagnosis and that this degree defines their risk level. Yet, in reality, a patient may be in general good health but still at risk for a particular adverse outcome because of age, sex, comorbidity, health behavior, or other characteristics unrelated to the severity of their principal diagnosis.<sup>15</sup> Risk adjustment, on the other hand, accounts for the wide range of patient characteristics that may increase the probability for adverse clinical outcomes for a given patient. Figure 1 demonstrates the need for risk adjustment even after severity of illness has been accounted for using Medicare Severity Diagnosis-Related Groups (MS-DRGs). This finding is consistent with research performed at Harvard Medical School and Beth Israel Deaconess Medical Center which concluded that even severity adjustment methods such as All Payer Refined-DRGs (APR-DRGs), Disease Staging, and MedisGroups did not adequately explain differences in death rates across hospitals.<sup>16</sup>

### **Risk-Adjustment Methodology**

Risk factors for calculating the mortality model, complications model, readmissions model, and patient safety model were independently applied within clusters of MS-DRGs using binary logistic regression. The predictive variables for mortality, complications, and readmissions include the patient's age, gender, number of major chronic conditions, and number of other significant comorbidities. The list of major chronic conditions covers 1,229 diagnosis codes and represents illnesses such as emphysema, diabetes, and cancer. The list of other significant comorbidities encompasses 1,374 diagnosis codes and comprises illnesses such as acute appendicitis, bacterial pneumonia, and encephalitis.

**Figure 1.** Differences in Risk of Adverse Outcomes within the Same MS-DRG



The risk factors for predicting the occurrence of patient safety events include MS-DRG cluster, age, gender, and number of AHRQ-specified comorbidities. The 1,254 comorbidities identified by AHRQ to significantly increase the risk of patient safety events include conditions such as aortic valve disorders, endocarditis, and congestive heart failure. A summary of the predictive variables used for each of the aforementioned risk models is displayed in Table 1.

Logistic regression was selected since each of the outcomes to be predicted (i.e., death, presence of a complication, and readmission) could only be classified into one of two categories (either they occurred or they did not occur). The logistic regression model estimated the risk of each outcome for each patient at risk using a nationally representative database comprised of 27 million discharges from general, acute, non-federal hospitals across 39 states. The database was nationally representative with respect to hospital bed size, teaching status, urban/rural designation, and geographic location. The risk estimate for each outcome was accomplished by weighting patient records using the beta coefficients associated with the corresponding predictive variables in the regression model and the intercept term. This produced the overall probability value for each outcome based on the normative experience of patients with similar clinical characteristics.

The clustering of MS-DRGs was necessary because many of the risk factors associated with an increased risk of death or complications for a clinical condition were used as the basis for MS-DRG patient classification (e.g., presence or absence of CCs and discharge status). For instance, simple pneumonia and pleurisy is assigned to MS-DRGs 193-195 based on the designation of “with major CC, with CC, or without CC”. Similarly, MS-DRGs 280-285 represent acute myocardial infarction (AMI) cases, but the MS-DRG

assignments vary by discharge status (alive or expired) and are further stratified based on the presence or absence of CCs. Consequently, MS-DRGs were combined into clinically related clusters to determine how CCs and other factors were associated with an increased risk of adverse outcomes within each disease category. The clustering process was applied across all MS-DRGs which resulted in 746 distinct clinical categories. For ease of analysis, once the models were applied to the MS-DRG clusters, most of the results were unbundled and summarized at the individual MS-DRG level. The method used to cluster MS-DRGs was essentially the same as the CMS “adjacent” DRG methodology developed by the Health Systems Management Group at Yale University to combine DRGs “with and without CCs.”<sup>17</sup> The actual structure of specific MS-DRG clusters is shown in Figure 2.

Hospital facility characteristics such as ownership type, bed size, teaching status, residency training program status, rural or urban designation, and occupancy level were not used in the regression models since these characteristics do not adjust for a *patient’s* legitimate clinical risk.<sup>18</sup> Instead, they represent the institutional risk associated with being admitted to a particular type of facility. The importance of excluding hospital characteristics cannot be overstated since the inclusion of these characteristics would grossly distort each of the risk models by arbitrarily lowering and raising the standard of care across hospitals--even when the demographic and clinical characteristics of the patients are identical. Furthermore, since institutional risk is one of the residual variables that should be carefully evaluated by purchasers and providers, the use of hospital characteristics is counter-intuitive and therefore lacks face validity with employers, payers, and the medical community at large.<sup>19</sup>

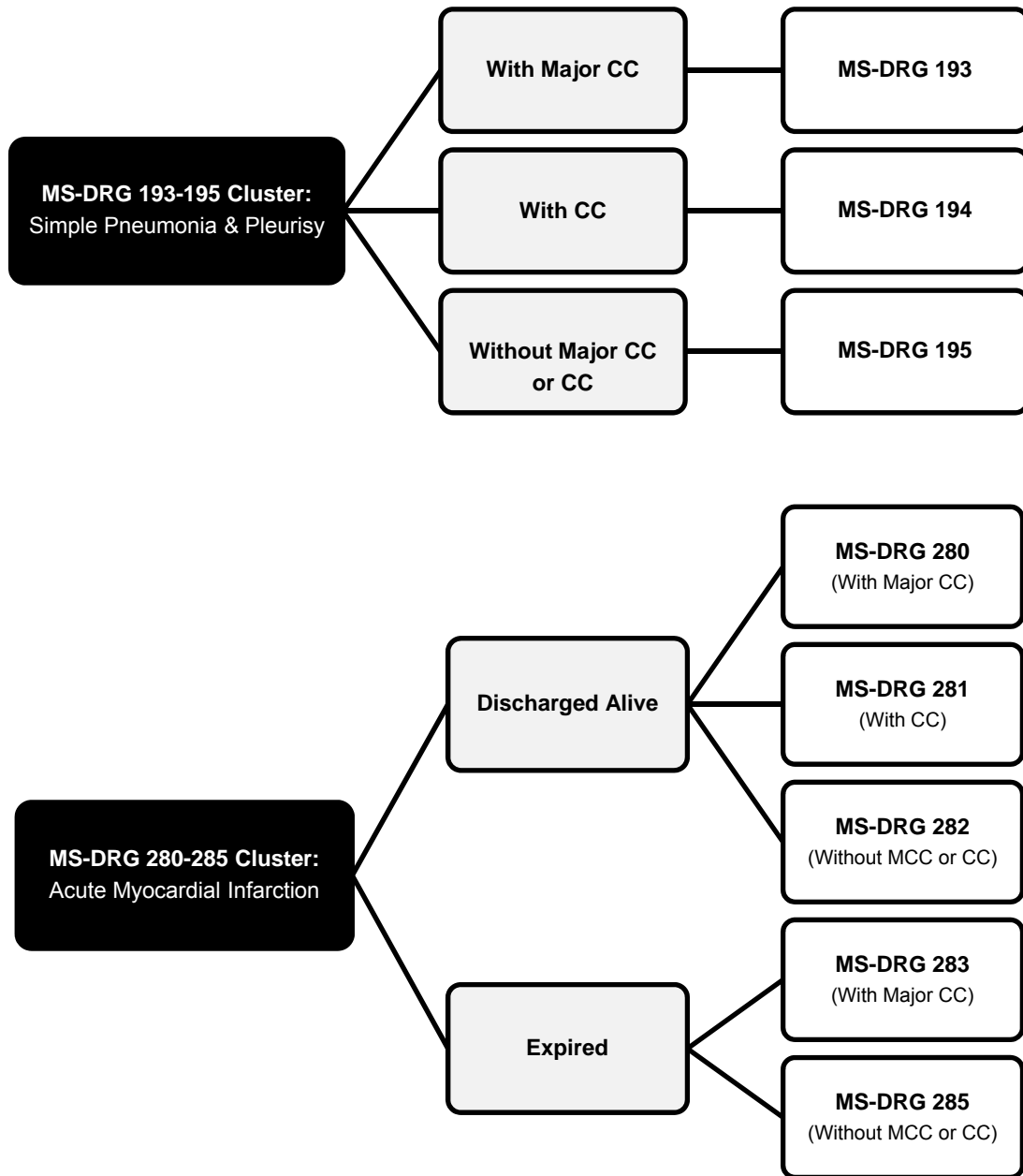
### **Risk-Adjusted Mortality Index**

The risk-adjusted mortality index (RAMI) was developed to measure the extent to which a provider’s

**Table 1.** Summary of Predictive Variables by Risk Model

Predictive Variables	Mortality Model	Complications Model	Readmissions Model	Patient Safety Model
<b>Demographic</b>				
• Age	✓	✓	✓	✓
• Gender	✓	✓	✓	✓
<b>Clinical</b>				
• MS-DRG Cluster	✓	✓	✓	✓
• # of Major Chronic Conditions	✓	✓	✓	
• # of Other Significant Comorbidities	✓	✓	✓	
• # of AHRQ-Specified Comorbidities	✓	✓	✓	✓

**Figure 2.** Structure of Specific MS-DRG Clusters



inpatient mortality rate is higher or lower than expected for specific diagnoses and procedures given the risk factors of the patient population, where an index of 1.00 indicates the actual mortality rate equals the expected rate. The RAMI model excludes all patients with do-not-resuscitate (DNR) and palliative care codes, as well as, all MS-DRG clusters with less than 300 cases nationally (due to insufficient statistical power). Additionally, complications of care were excluded as risk factors so the patient's illness level at the time of admission could be measured in order to assess the risk of the patient's primary medical problem and related comorbidities prior to medical intervention. Clinicians designated 48 post-surgical and 110 post-obstetrical conditions on the CMS major CC and CC list to be complications of care, or iatrogenic events. This list includes problems such as accidental operative laceration, postoperative infection, and obstetrical shock.

### **Risk-Adjusted Complications Index**

The risk-adjusted complications index (RACI) was developed to identify the extent to which a provider's post-surgical and post-obstetrical complication rates during a hospital stay are higher or lower than expected for particular diagnoses and procedures given the risk factors of the patient population, where an index of 1.00 indicates the actual complication rate is equal to the expected rate. The RACI model excludes newborns, all cases which died, all cases that were transferred to other short-term hospitals, and MS-DRG clusters with less than 300 cases nationally. A list of the post-surgical and post-obstetrical complications screened by the RACI is displayed in Table 2.

### **Risk-Adjusted Readmissions Index**

The risk-adjusted readmissions index (RARI) was developed to measure the extent to which a

provider's actual readmission rate is higher lower than expected for specific diagnoses and procedures given the risk factors of the patient population, where an index of 1.00 indicates the actual readmission rate is equal to the expected rate. Importantly, the RARI only measures unanticipated readmissions to the same hospital within 30 days of discharge. Since the purpose of the readmissions model is to identify adverse outcomes, certain types of readmissions were excluded such as readmissions that would ordinarily be either scheduled (e.g., chemotherapy) or unavoidable (e.g., multiple admissions for AIDS patients and cancer patients). Additionally, cases that were transferred to another short-term hospital, cases that died during the first admission, and newborns were excluded from the model. Moreover, a case was only considered a readmission if the patient's subsequent hospital stay was in the same MS-DRG or related service line as the first admission. Lastly, MS-DRG clusters with less than 300 cases nationally were excluded from analysis.

### **Risk-Adjusted Patient Safety Index**

The risk-adjusted patient safety index (RAPSI) was developed to identify the extent to which a provider's actual rate of patient safety events during a hospital stay for particular diagnoses and procedures are higher or lower than expected given the risk factors of the patient population, where an index of 1.00 indicates the actual rate of patient safety events equals the expected rate. Given that AHRQ's patient safety indicator (PSI) methodology is limited to only evaluating an individual PSI occurrence (e.g., PSI 6: Iatrogenic Pneumothorax) across a broad range of unrelated MS-DRG clusters aggregately, a notable benefit of RAPSI is that it allows for the global screening of all PSIs at risk at the individual MS-DRG level as well as the clinical category level (e.g., cardiac care, orthopedic care, and etc.). Without the use of the RAPSI methodology important evaluations of this type are not possible. Without the use of

**Table 2. List of Post-Surgical and Post-Obstetrical Complications**

**Post-Surgical Complications**

- |   |  |
|---|--|
| 1. Accidental Cut in Medical Care NEC                           | 25. Iatrogenic Pneumothorax                                    |
| 2. Accidental Cut in Medical Care NOS                           | 26. Infected Postoperative Seroma                              |
| 3. Accidental Cut/Hemorrhage in Infusion                        | 27. Non-Healing Surgical Wound                                 |
| 4. Accidental Cut/Hemorrhage in Injection                       | 28. Other Specific Complication Procedural NEC                 |
| 5. Accidental Cut/Hemorrhage in Surgery                         | 29. Other Postoperative Infection                              |
| 6. Accidental Cut/Hemorrhage w/ Catheterization                 | 30. Other Respiratory Complications                            |
| 7. Accidental Cut/Hemorrhage w/ Enema                           | 31. Persistent Postoperative Fistula                           |
| 8. Accidental Cut/Hemorrhage w/ Heart Catheter                  | 32. Postoperative Complication NOS                             |
| 9. Accidental Cut/Hemorrhage w/ Scope Exam                      | 33. Post-Op Reaction to Foreign Substance Accidentally Left In |
| 10. Accidental Cut/Hemorrhage, Perfusion NEC                    | 34. Postoperative Shock  |
| 11. Accidental Operative Laceration                             | 35. Postoperative Wound Disruption                             |
| 12. Accidental Puncture or Laceration of During a Procedure     | 36. Postoperative Respiratory Failure                          |
| 13. Cataract Fragment from Cataract Surgery                     | 37. Reaction - Other Vascular Device/Graft                     |
| 14. Complications Due to Cardiac Device, Implant, or Graft      | 38. Seroma Complicating Procedure                              |
| 15. Complications Due to Renal Dialysis Device, Graft           | 39. Surgical Complication - Hypertension                       |
| 16. Complications Due to Vascular Access Device, Implant, Graft | 40. Surgical Complication - Body System NEC                    |
| 17. Disruption External Wound                                   | 41. Surgical Complication - Digestive                          |
| 18. Disruption Internal Wound                                   | 42. Surgical Complication - Nervous System                     |
| 19. Emphysema Resulting From Procedure                          | 43. Surgical Complication - Peripheral Vascular System         |
| 20. Foreign Body Accidentally Left In During Procedure          | 44. Surgical Complication - Respiratory                        |
| 21. Hematoma Complication Procedural                            | 45. Surgical Complication - Urinary Tract                      |
| 22. Hemorrhage Complication Procedural                          | 46. Surgical Complication - Heart                              |
| 23. Iatrogenic CV Infarction/Hemorrhage                         | 47. Vascular Complications of Medical Care                     |
| 24. Iatrogenic Pulmonary Embolism/Infarction                    | 48. Ventilator Associated Pneumonia                            |

**Post-Obstetrical Complications**

- |  |   |
|--|---|
| 1. Acute Renal Failure, Delivered w/ Postpartum        | 29. Delivery w/ 4 Degree Laceration, Delivered        |
| 2. Acute Renal Failure, Postpartum                     | 30. Delivery w/ 4 Degree Laceration, Postpartum       |
| 3. Amniotic Embolism, Postpartum                       | 31. Delivery w/ 4 Degree Laceration, Unspecified      |
| 4. Amniotic Embolism, Delivered                        | 32. Delayed P/P Hemorrhage, Delivered with P/P        |
| 5. Amniotic Embolism, Delivered with P/P               | 33. Delayed P/P Hemorrhage, Postpartum                |
| 6. Cerebrovascular Disorder, Delivered with P/P        | 34. Disrupted C-Section Wound, Delivered with P/P     |
| 7. Cerebrovascular Disorder, Postpartum                | 35. Disrupted C-Section Wound, Postpartum             |
| 8. CNS Complication in Delivery, Postpartum            | 36. Disrupted C-Section Wound, Unspecified            |
| 9. CNS Complication Labor/Delivery, Delivered          | 37. Disrupted Perineum, Delivered with P/P            |
| 10. CNS Complication, Delivered with P/P               | 38. Disruption Perineum, Postpartum                   |
| 11. Complicated Delivery NEC, Delivered with P/P       | 39. Heart Complication in Delivery, Delivered         |
| 12. Complicated Delivery NEC, Postpartum               | 40. Heart Complication, Delivered with P/P            |
| 13. Complicated Delivery NOS, Delivered with P/P       | 41. Heart Complication, Postpartum                    |
| 14. Complicated Delivery NOS, Postpartum               | 42. High Vaginal Laceration, Delivered                |
| 15. Complicated Labor/Delivery NOS, Delivered          | 43. High Vaginal Laceration, Postpartum               |
| 16. Complication of Anesthesia NOS, Delivered          | 44. High Vaginal Laceration, Unspecified              |
| 17. Complication of Anesthesia NOS, Delivered with P/P | 45. Injury, Pelvic Organ NEC, Postpartum              |
| 18. Complication of Anesthesia, Postpartum             | 46. Inversed Uterus, Postpartum                       |
| 19. Complication of Anesthesia, Postpartum             | 47. Laceration of Cervix, Delivered                   |
| 20. Complication of Anesthesia NEC, Delivered          | 48. Laceration of Cervix, Postpartum                  |
| 21. Complication of Anesthesia NEC, Delivered with P/P | 49. Laceration of Cervix, Unspecified                 |
| 22. Damage to Pelvic Joint, Delivered                  | 50. Major Puerperal Infection, Delivered with P/P     |
| 23. Damage to Pelvic Joint, Postpartum                 | 51. Major Puerperal Infection, Postpartum             |
| 24. Damage to Pelvic Joint, Unspecified                | 52. Major Puerperal Infection, Unspecified            |
| 25. Deep Vein Thrombosis, Postpartum                   | 53. Maternal Hypotension Syndrome, Delivered          |
| 26. Delivery w/ 3 Degree Laceration, Delivered         | 54. Maternal Hypotension Syndrome, Delivered with P/P |
| 27. Delivery w/ 3 Degree Laceration, Postpartum        | 55. Maternal Hypotension Syndrome, Postpartum         |
| 28. Deliver w/ 3 Degree Laceration, Unspecified        | 56. Obstetrical Air Embolism, Delivered               |
| 57. Obstetrical Air Embolism, Delivered with P/P       | 60. Obstetrical Injury, Pelvic Organ NEC, Unspecified |
| 58. Obstetrical Air Embolism, Postpartum               | 61. Obstetrical Perineal Laceration NOS, Delivered    |
| 59. Obstetrical Injury, Pelvic Organ NEC, Delivered    | 62. Obstetrical Perineal Laceration NOS, Unspecified  |

**Post-Obstetrical Complications (continued)**

- |   |   |
|---|---|
| 63. Obstetrical Perineal Trauma NEC, Delivered            | 87. P/P Coagulation Deficiency, Delivered with P/P  |
| 64. Obstetrical Perineal Trauma NEC, Unspecified          | 88. Perineal Laceration NOS, Postpartum             |
| 65. Obstetrical Perineal Trauma NOS, Delivered            | 89. Perineal Trauma NEC, Postpartum                 |
| 66. Obstetrical Perineal Trauma NOS, Unspecified          | 90. Perineal Trauma NOS, Postpartum                 |
| 67. Obstetrical Pyemic Embolism, Delivered                | 91. Postpartum Coagulation Deficit, Postpartum      |
| 68. Obstetrical Pyemic Embolism, Delivered with P/P       | 92. Postpartum Hemorrhage NEC, Delivered with P/P   |
| 69. Obstetrical Pyemic Embolism, Postpartum               | 93. Postpartum Hemorrhage NEC, Postpartum           |
| 70. Obstetrical Shock, Delivered                          | 94. Puerperal Cerebrovascular Disorder, Delivered   |
| 71. Obstetrical Shock, Delivered with Postpartum          | 95. Pulmonary Complication in Delivery, Delivered   |
| 72. Obstetrical Shock, Postpartum                         | 96. Pulmonary Complication, Postpartum              |
| 73. Obstetrical Surgical Complication, Delivered with P/P | 97. Pulmonary Complication, Delivered w/ Postpartum |
| 74. Obstetrical Trauma NEC, Antepartum                    | 98. Pulmonary Embolism NEC, Delivered               |
| 75. Obstetrical Trauma NEC, Delivered                     | 99. Pulmonary Embolism NEC, Delivered with P/P      |
| 76. Obstetrical Trauma NEC, Delivered with P/P            | 100. Pulmonary Embolism NEC, Postpartum             |
| 77. Obstetrical Trauma NEC, Postpartum                    | 101. Pulmonary Embolism NOS, Delivered              |
| 78. Obstetrical Trauma NEC, Unspecified                   | 102. Pulmonary Embolism NOS, Delivered W P/P        |
| 79. Obstetrical Trauma NOS, Antepartum                    | 103. Pulmonary Embolism NOS, Postpartum             |
| 80. Obstetrical Trauma NOS, Delivered                     | 104. Rupture Uterus NOS, Delivered                  |
| 81. Obstetrical Trauma NOS, Delivered with P/P            | 105. Third-Stage Hemorrhage, Delivered with P/P     |
| 82. Obstetrical Trauma NOS, Postpartum                    | 106. Third-Stage Hemorrhage, Postpartum             |
| 83. Obstetrical Trauma NOS, Unspecified                   | 107. Thrombosis NEC, Delivered                      |
| 84. Other Obstetrical Complications, Delivered            | 108. Thrombosis NEC, Delivered with P/P             |
| 85. Other Obstetrical Complications, Delivered with P/P   | 109. Thrombosis NEC, Postpartum                     |
| 86. Other Obstetrical Surgical Complications, Postpartum  | 110. Thrombosis Postpartum, Delivered with P/P      |

the RAPSI methodology important evaluations of this type are not possible.

The RAPSI model excludes the following AHRQ patient safety indicators due to inconsistent coding practices among hospitals or the prevalence of false positives: complications of anesthesia, accidental puncture and laceration, transfusion reaction, and death in low mortality DRGs. The model also excludes MS-DRG clusters with less than 300 cases nationally. A list of the 16 patient safety events screened by RAPSI is provided in Table 3 and include adverse events such as iatrogenic pneumothorax, postoperative respiratory failure, and postoperative sepsis.

### Validation of the Risk Models

Significant effort was taken to construct medically meaningful and statistically reliable models for risk-adjusting comparisons of mortality, complications, readmissions, and patient safety events. A summary of the steps taken to ensure the validity of each of the risk models is as follows:

1. Only demographic and clinical characteristics of patients were used as predictive variables in each of the risk models.
2. Risk factors were modeled for RAMI, RACI, RARI, and RAPSI using a large, representative data base which covered all payer classifications and case types except neonates.
3. Statistical analysis was performed on each of the models using an R-square ( $R^2$ ) and C-statistic. Specifically, the  $R^2$  was calculated by comparing observed rates to predicted rates across an independent data set that was not used to fit the models. The resultant  $R^2$  values for the models were shown to be .94 for RAMI, .93

for RACI, .97 for RARI, and .93 for RAPSI; where 1.0 would indicate a perfect linear relationship between observed and predicted rates. Models with  $R^2$  values greater than .50 are generally considered to have good predictive power. While  $R^2$  values are commonly reported for dichotomous data, they are referred to as pseudo- $R^2$ 's since the statistic was specifically designed to identify the amount of variation explained using continuous data. Hence, the findings derived from pseudo- $R^2$ 's can be less reliable for determining the actual predictive capability of dichotomous models. Consequently, a C-statistic was calculated from the receiver-operator characteristic (ROC) curve to determine the extent to which each model correctly predicted their respective dichotomous outcome; where a C-statistic of less than .50 indicates that flipping a coin would provide greater predictive power. The resultant C-statistics yielded .87 for RAMI, .68 for RACI, .59 for RARI, and .54 for RAPSI.

A summary of the statistical measures used for validating each model's predictive capability is provided in Table 4. An overview of the various outcome analyses that can be performed using the risk models is discussed in the next section.

### CLINICAL QUALITY ANALYSIS

There are a variety of data bases available for conducting valid comparisons of provider outcomes (both for hospitals and physicians). The data bases rely on patient discharge abstracts and include:

- CMS Medicare Provider Analysis and Review (MedPAR) files which represent all Medicare discharges from short-term, general, non-federal U.S. hospitals.

**Table 3.** List of Patient Safety Events Screened by RAPSI

<b>Patient Safety Events</b>	
1.	Failure to rescue
2.	Decubitus ulcer
3.	Foreign body left in during procedure
4.	Iatrogenic pneumothorax
5.	Selected infections due to medical care
6.	Postoperative hip fracture
7.	Postoperative hemorrhage or hematoma
8.	Postoperative physiologic and metabolic derangements
9.	Postoperative respiratory failure
10.	Postoperative pulmonary embolism or deep vein thrombosis
11.	Postoperative sepsis
12.	Postoperative wound dehiscence in abdominopelvic surgical patients
13.	Birth Trauma—Injury to Neonate
14.	Obstetric Trauma—Vaginal Delivery with Instrument
15.	Obstetric Trauma—Vaginal Delivery without Instrument
16.	Obstetric Trauma— Cesarean Delivery

**Table 4.** Summary of R-Squares and C-Statistics by Risk Model

<b>Category by Statistic</b>	<b>Mortality Model</b>	<b>Complications Model</b>	<b>Readmissions Model</b>	<b>Patient Safety Model</b>
<b>Overall</b>				
• R <sup>2</sup>	.94	.93	.97	.93
• C-Statistic	.87	.68	.59	.54
<b>Medical</b>				
• R <sup>2</sup>	.93	--	.96	.90
• C-Statistic	.83	--	.57	.59
<b>Surgical</b>				
• R <sup>2</sup>	.94	.93	.98	.94
• C-Statistic	.89	.68	.59	.63

-- Not available (complications model only reports on post-surgical and post-obstetrical cases)

- Public domain all payer statewide data bases which include: Arizona, Arkansas, California, Colorado, Connecticut, Florida, Georgia, Illinois, Iowa, Louisiana, Maine, Maryland, Missouri, Massachusetts, Nevada, New Hampshire, New Jersey, New York, North Carolina, Ohio, Oregon, Pennsylvania, Rhode Island, South Carolina, Tennessee, Texas, Utah, Vermont, Virginia, Washington, West Virginia, Wisconsin, and Wyoming (certain restrictions may apply regarding data access and reporting in each state).
- Proprietary UB-data from individual hospitals and consortia (including networks, alliances, and multi-hospital systems).

Application of the risk models for analysis of hospital outcomes is displayed in Table 5 using Medicare data from the CMS MedPAR file. Actual and expected rates of mortality, complications, and patient safety events for coronary bypass with cardiac catheterization with major CC (MS-DRG 233) are shown, along with the respective risk-adjusted indices for each hospital (actual hospital names are available on the MedPAR file, but were omitted for the sake of a generalized example). The expected rates represent the national rates for patients with similar demographic and clinical characteristics as those of the hospital under analysis. The risk-adjusted indices were calculated by taking the actual rates for mortality, complications, and patient safety events for each hospital and dividing them by the expected rates generated from the respective regression models. Hence, an index greater than 1.0 indicates the actual rate is higher than expected (e.g., an index of 1.20 indicates that the actual rate is 20 percent higher than expected), whereas an index less than 1.0 indicates the actual rate is lower than expected (e.g., an index of .80 indicates that the actual rate is 20 percent

lower than expected). A 95 percent confidence interval was also calculated for each index to determine whether the difference between a hospital's performance and the national norm was statistically significant or merely due to normal variation in the data.

The benchmarks were derived by ranking all hospitals in the national data base from lowest to highest on each risk-adjusted index and then identifying a cluster of providers that were performing at the 75<sup>th</sup> percentile. Thus, the benchmark represents providers whose performance is better than 75 percent of the providers in the data base for the particular outcome.

An analysis of Table 5 shows all hospitals have mortality indices that are higher than expected nationally. However, these findings are not shown to be statistically significant. Consequently, the variation in mortality should be attributed to random variation rather than to poor quality of care. With regard to complications, hospitals A, C, and E have RACIs that are lower than expected nationally for bypass surgery, while hospitals B and D are both higher than expected nationally. Each of these indices are shown to be statistically significant at a confidence level of 95% which suggests that quality improvement opportunities exist since variation can be attributed to special causes. Comparison of all hospitals to the RACI benchmark reveals that providers A and E are performing better than the benchmark indicating they are among the top performing providers in the nation. On the other hand, hospitals B and D are incurring over \$104,000 and \$87,000 respectively in additional resource consumption due complication rates that are much higher than the benchmark. The opportunity for hospitals B and D to reduce their cost of care by improving their rates of complications demonstrates a well-known continuous quality improvement (CQI) principle that better quality can actually cost less. Additional analysis reveals that hospitals D and E are shown to have rates of patient safety events that are significantly higher than

**Table 5. DRG Mortality and Complications Comparison by Provider**

**MS-DRG 233: Coronary Bypass with Cardiac Catheterization with Major CC**  
 Cardiac Surgery

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)	(11)	(12)
Provider	# of Cases	Actual Mortality Rate (%)	Expected Mortality Rate (%)	Risk-Adjusted Mortality Index (RAMI)*	Actual Complication Rate (%)	Expected Complication Rate (%)	Risk-Adjusted Complications Index (RACI)*	Effect of RACI Benchmark Variance on \$	Actual Patient Safety Event Rate (%)	Expected Patient Safety Event Rate (%)	Risk-Adjusted Patient Safety Index (RAPSI)*
A	447	3.5%	2.3%	1.55	15.4%	36.2%	0.43*	(\$11,119)	2.2%	2.7%	0.82
B	222	2.9%	2.0%	1.45	44.2%	33.1%	1.34*	\$104,619	2.8%	2.6%	1.09
C	201	2.0%	1.5%	1.40	18.8%	28.6%	0.66*	\$12,897	3.7%	2.5%	1.49
D	174	4.1%	3.0%	1.38	45.7%	37.2%	1.23*	\$87,380	10.9%	2.6%	4.21*
E	86	2.4%	1.2%	1.93	13.3%	26.9%	0.49*	(\$14,898)	6.6%	2.4%	2.73*
Peer Group Benchmark	1,130	3.1%	2.1%	1.49	26.1%	33.6%	0.78	\$178,879	5.1%	2.6%	1.98
National Norm				0.78			0.59				0.63
				1.00			1.00				1.00

Data Source: CMS MedPAR File

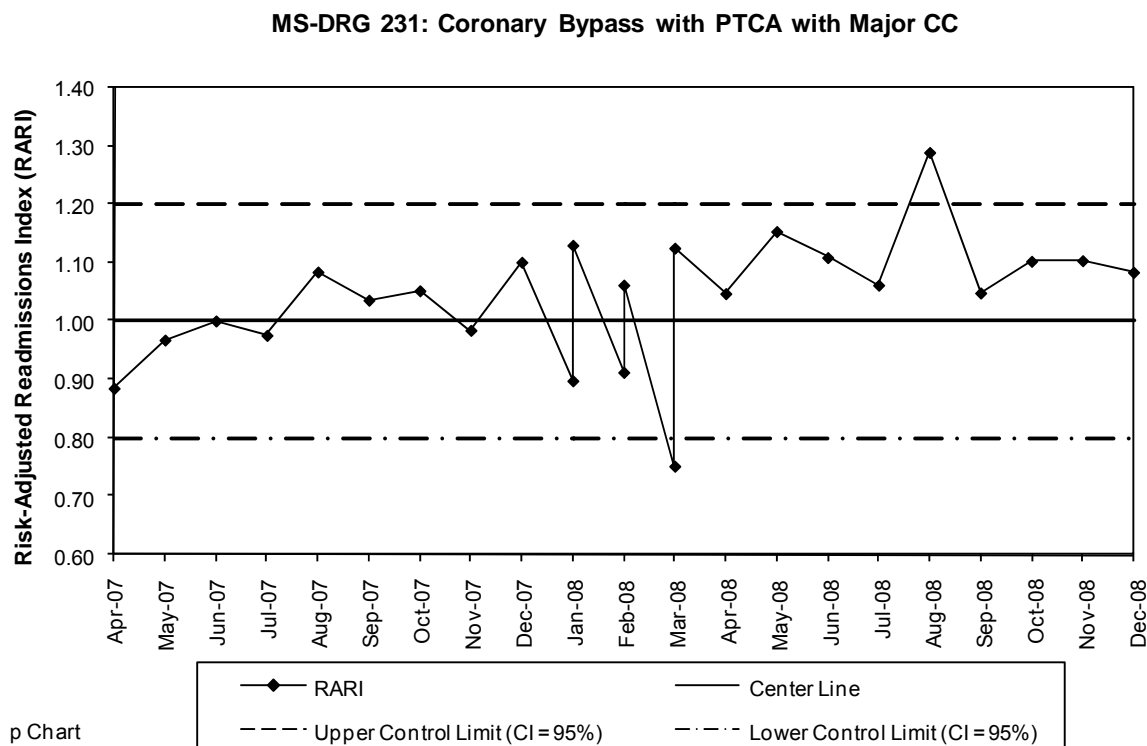
\*Indicates risk-adjusted index is statistically significant at a confidence level of 95%

expected nationally. Another important measure of quality is the hospital's readmission rate. Figure 3 displays a particular hospital's RARI performance using a control chart which reveals that readmissions were lower in March 2008 than expected, but higher in August 2008. The fact that the corresponding data points are outside the upper and lower control limits indicates the observations are statistically significant. If possible, differences in the pattern of care should be evaluated between the two months to identify the special causes of variation and uncover the underlying processes that led to a better than expected readmission rate in March.

### CONCLUSION

This type of risk-adjusted approach to outcomes assessment allows purchasers to validly assess the relative performance of hospitals and physicians on important measures of quality. It also enables hospitals to identify and statistically validate adverse events, establish improvement priorities and objectives, develop quality improvement plans, assess compliance with pay-for-performance initiatives, and identify favorable outcomes for marketing to payers, employers, and consumers. Additionally, it offers an effective process for monitoring new treatment protocols to ensure that cost containment does not compromise the quality of care.

**Figure 3.** Control Chart for Hospital Risk-Adjusted Readmissions Index by Month



## References

1. Braun, B.I., Koss, R.G., and Loeb, J.M. "Integrating Performance Measure Data into the Joint Commission Accreditation Process." *Evaluation and the Health Professions* 3 (September 22, 1999): pp. 283-297.
2. Darr, K. "The Center for Medicare and Medicaid Services Proposal to Pay for Performance." *Hospital Topics* 2 (Spring 2003): pp. 30-32.
3. "Tide Rises on Pay for Performance with Voluntary Reporting Initiative." *Healthcare Financial Management* 58 (3) (March 2004): pp. 120-121.
4. Milstein, A., Galvin, R.S., Delbanco, S.F., Salber, P., and Buck, C.R., Jr. "Improving the Safety of Health Care: The Leapfrog Initiative." *Effective Clinical Practice* 3(6) (November-December 2000): pp. 313-316.
5. Comaro, A. "America's Best Hospitals." *U.S. News & World Report* (July 28, 2003): p.46.
6. Burda, D. "They Just Do It Better." *Modern Healthcare* (Supplement) (September 29, 2003): p.6.
7. Localio, R.A., Hamory, B.H., Sharp, T.J., Weaver, S.L., TenHave, T.R., and Landis, J.R. "Comparing Hospital Mortality in Adult Patients with Pneumonia: A Case Study of Statistical Methods in a Managed Care Program." *Annals of Internal Medicine* 122 (2) (1995): pp. 125-131.
8. Vachon, M. "Six Trends for Your Next Strategy Session Agenda." *Healthcare Executive* 24 (3) (Supplement) (May/June 2009): p. 1.
9. DesHarnais, S.I., L.F. McMahon, Jr., and R.T. Wroblewski. "Measuring Outcomes of Hospital Care Using Multiple Risk-Adjusted Indexes." *Health Services Research* 26 (4) (October 1991): pp. 425-445.
10. DesHarnais, S.I. "Current Uses of Large Data Sets to Assess the Quality of Providers: Construction of Risk-Adjusted Indexes of Hospital Performance." *International Journal of Technology Assessment in Health Care* 6 (1990): pp. 229-238.
11. DesHarnais, S.I., L.F. McMahon, Jr., R.T. Wroblewski, and A.J. Hogan. "Measuring Hospital Performance: The Development and Validation of Risk-Adjusted Indexes of Mortality, Readmissions, and Complications." *Medical Care* 28 (12) (December 1990): pp. 1127-1141.
12. DesHarnais, S.I., J.D. Chesney, R.T. Wroblewski, S.T. Fleming, and L.F. McMahon, Jr. "The Risk-Adjusted Mortality Index: A New Measure of Hospital Performance." *Medical Care* 26 (12) (December 1988): pp. 1129-1148.
13. *Patient Safety Indicators Overview*. AHRQ Quality Indicators. February 2006. Agency for Healthcare Research and Quality, Rockville, MD.
14. Iezzoni, L.I., A.S. Ash, M. Shwartz, J. Daly, J.S. Hughs, and Y.D. Mackiernan. "Predicting who Dies Depends on how Severity is Measured: Implications for Evaluating Patient Outcomes." *Annals of Internal Medicine* 123(1995): pp. 763-770.
15. Pine, M. and Pine, J. "Standardization of Terms and Analytical Methods for Performance Evaluation: Achievable Goal or Impossible Dream?" *Managed Care Quarterly* 3 (3) (Summer 1995): 11.

16. Iezzoni, L.I. "The Risk of Risk Adjustment." *Journal of the American Medical Association* 278 (19) (November 1997): p. 1600.
17. Edwards, N., D. Honemann, D. Burley, and M. Navarro. "Refinement of the Medicare Diagnosis-Related Groups to Incorporate a Measure of Severity." *Health Care Financing Review* 16 (2) (1994): 48.
18. Iezzoni, L.I. ed. Risk Adjustment for Measuring Health Care Outcomes. Ann Arbor: Health Administration Press (1994): pp. 30-32, 200.
19. DesHarnais, S.I., et al. (1990): 1127-1128.