Technical Appendix for Outcome Measures

Study Overview

This is a report on data used, and analyses done, by MPA Healthcare Solutions (MPA, formerly Michael Pine and Associates) for Consumers' CHECKBOOK/Center for the Study of Services (CHECKBOOK/CSS) for use in public reporting on performance of surgeons and hospitals.

Analyses were done to identify and count serious adverse outcomes and compute the probability of occurrence of these adverse outcomes for cases in 17 procedural categories. Adverse outcomes included in the study were: inpatient mortality, prolonged risk-adjusted length-of-stay (prRALOS), 90-day post-discharge mortality, and readmission within 90 days of discharge. The analyses were done for cases in qualifying acute care hospitals using the CMS Inpatient LDS dataset for cases discharged on or after January 1, 2010 and on or before December 31, 2014.

Additionally, analyses were done to identify and count serious adverse outcomes and get probabilities for adverse outcomes for cases in 6 medical categories for inpatient mortality, prRALOS, and 90-day post-discharged mortality in qualifying acute care hospitals using the CMS Inpatient LDS dataset for calendar years 2012 through 2014.

Logistic regression analysis was used to estimate the probabilities of the adverse outcomes of interest and adjust each provider's rates for the external risks of these adverse outcomes' occurring.

Actual counts and computed probabilities were used to calculate risk-adjusted rates for individual surgeons or hospitals for:

- Any inpatient adverse outcome (inpatient death or prolonged length-of-stay if not an inpatient death)
- Death within 90 days of discharge (inpatient or post-discharge death)
- For surgeons but not hospitals, any adverse outcome (inpatient death, prolonged length-of-stay if not an inpatient death, death within 90 days after discharge, or readmission within 90 days after discharge)

Specific combinations of procedure codes were identified and grouped to define 17 procedural categories (see Appendix A). Cases with multiple qualifying procedures were assigned to a procedural category based on chronology where the earliest procedure took precedence. The procedural categories were created in a hierarchical order to handle situations where multiple procedures occurred on the same date and would result in assignment to different procedural categories. In these cases, the procedure category with the lowest rank took precedence. The 6 medical categories were defined by specific principal diagnosis codes and specific procedure codes whose occurrence would exclude a case from the category (Appendix F).

Logistic regression equations included as independent variables: age, gender, year of the intervention, selected principal and secondary diagnostic codes, and combinations of procedure codes and diagnosis codes specific to each procedural or medical category. MPA has documented lists of diagnostic and procedural codes that appear in one or more predictive equations.

These analyses did not employ a hierarchical modeling approach. Over the years, MPA has reviewed and considered incorporating a hierarchical approach. MPA's conclusion has consistently been that its non-hierarchical methods are well-suited to provide relevant comparative analyses and MPA has not been convinced that a hierarchical approach would provide a better assessment of provider performance. Using its non-hierarchical approach, MPA can combine estimated probabilities from two or more different outcomes (e.g., inpatient mortality and post-discharge mortality), use different risk models for different subcategories of procedures (e.g., open cardiac procedures and other cardiac procedures) before combining subcategories, and estimate regression models for risk on the subcategory of good-coding hospitals (discussed below) and apply these models to all hospitals. The methods described here meet the needs of a reporting system both for professionals and for consumers.

Category Selection

Subgroups of individual categories may have lengths of stay that fundamentally differ from each other even though they are part of the same clinical category and have other outcomes measures that behave similarly. Since risk-adjusted length of stay is the foundation of the control chart analysis that is used to identify prRALOS outliers, these subgroups may dilute or distort the accuracy of the prRALOS metric. For example, open aortic surgery patients will have significantly different lengths of stay from endovascular cases, even though they are both part of the overall Aortic Surgery Category. To address this problem, subgroups were defined within procedural categories where appropriate, and separate length of stay models were created for the subgroups. PrRALOS outliers were identified for each subgroup and then aggregated to create the observed prRALOS outlier list for a category. A total of 26 length of stay models were created from the 17 procedural categories.

Hospital level analyses were performed for all 17 categories. However, to increase the number of observed events and increase comparative power in analyses of physician performance, several categories were aggregated. This was done when the same type of surgeon would likely be performing any of the procedures in the combined categories. Nine of the 17 groups were used to create four sets of two groups or three groups where one would expect the same physicians to perform in each of the groups within a set, thus enhancing the volume and statistical significance of the combined groups in a final physician-level report. Predicted probabilities and actual outcomes can be calculated for each of the nine groups that make up the four combined groups, after which total observed and total predicted outcomes can be computed for each combined set of groups.

Study Population

Hospitals (and their related cases) were excluded from the analysis if they had fewer than 20 total qualifying cases over the four-year interval from 2011 through 2014 for procedural categories and three years from 2012 through 2014 for medical categories. Cases failed to qualify for the analysis and were **excluded** if any of the following conditions were met:

- Care was not delivered at an acute care/critical access hospital
- Age < 65
- Gender not equal to male or female
- Missing Patient ID, Hospital ID, Principal Diagnosis, Admission Date, or Discharge Date
- Discharge status of:
    - discharged/transferred to a Federal hospital
    - left against medical advice or discontinued care

- still a patient
- Admission transferred from:
    - Another hospital
    - An Ambulatory Surgical Center
- Readmissions within 90 days of another qualifying case into the same analytic category as a prior admission
- A diagnosis for palliative care coded as present at admission (diagnosis codes: V667x)

Also, cases were identified with a discharge status of (i) discharged/transferred to other short term general hospital for inpatient care or (ii) discharged/transferred to another type of institution for inpatient care. If the subsequent admission could not be identified in the dataset, the case was excluded.

Finally, if a subsequent admission was identified and occurred on the day of discharge or the day after discharge (i.e., a “bounce-back” readmission), the index case was extended by the time spent at the receiving hospital if:

- The DRG at the receiving hospital was not a rehabilitation DRG
- The DRG at the receiving hospital was not on our list of excluded readmissions

These rules for rolling up transfers into the index case were also used for cases that were “Discharged to a psychiatric hospital” or “transferred to another facility (NOS)”.

Accuracy of Attribution of Operating Physician to Cases

The physician responsible for the surgery in each case was identified by the "claim operating physician NPI number" on the claim record in the CMS LDS file. This field is the field CMS's coding rules say is to be used by the hospital filing the claim "to uniquely identify the physician with the primary responsibility for performing the surgical procedure(s)." Providers billing Medicare warrant the accuracy of information they supply as part of the billing and payment process. Assuming hospitals’ coding of operating physicians meets required standards of accuracy, there should be no problem with mis-attribution of cases to individual surgeons in these analyses.

To gain additional insight into the accuracy of coding attribution, we used the following two methods:

First, for each analytic category, operating physicians were grouped by specialty. The physician specialty was identified using the National Provider Identifier (NPPES) file, a public data file available from CMS. Specialty information included in this file is provided and maintained by the individual physicians. Checks by Consumers' CHECKBOOK and others have determined that the specialties identified in the NPPES file are generally accurate but are sometimes missing or appear to be inaccurate in comparison, for instance, to specialties identified in files maintained by the American Medical Association or the

American Board of Medical Specialties. Our checks found that for about 90% of cases in each analytic category, the specialty listed for the case is one of the specialties we have identified as routinely performing operations in that category. Because of the imperfect identification of specialties in the NPPES file and because some physicians who list themselves in one specialty may actually perform operations that are not generally performed by that specialty, it is not surprising that some procedures performed by physicians in NPPES-identified specialties not commonly performing these procedures actually were performed by physicians in those specialties, even though those specialties are not commonly associated with those procedures. Therefore, a 90% result was considered consistent with a reasonably high level of coding accuracy. On the other hand, the fact that cases are coded to a physician in an appropriate specialty does not prove that the attribution is correct (for example, it is possible that a physician's partner may have performed the procedure).

Second, MPA compared counts of cases by operating physician identified in the CMS LDS file to corresponding counts by operating physician generated during previous analyses using data from a CMS Research Identifiable File (RIF). In this RIF database, operating physicians are not identified in an inpatient database (as they are in the CMS LDS file), but can be identified in linked Medicare Part B physician-generated claims. MPA did counts by physician for total knee replacement and for CABG using 2011 and 2012 RIF data for the state of Texas.

To compare operating physician volumes for Texas hospitals based on LDS data and on RIF data, comparable category definitions for total knee replacement and CABG surgery were applied to these two data sets For each procedure, the total volumes of cases for each operating physician based on the CMS LDS data and on RIF Part B data were compared. Because some qualifying hospital procedures in the RIF database did not have corresponding Part B operating physician claims and because there were fewer total qualifying hospital procedures in the RIF database than in the LDS database, the total volume of cases for each operating physician in the LDS database was adjusted to reflect these differences. After these adjustments, case counts per physician from the two sources generally were within 10 percent of each other.

Selection and Use of Good-coding Hospitals for Model Development

A set of ten screens designed to assess the quality of hospital Present-on-Admission coding[1] were applied to all hospitals. The results of each screen were aggregated to assign a final score to each hospital in the dataset. Hospitals with scores greater than eighty percent (referred to here as "good-coding hospitals") were used to create a dataset that was used for all model development.

Present-on-Admission Coding

Before logistic regression models were run on qualifying cases in qualifying hospitals, present-on-admission codes were amended in all cases in all hospitals when necessary according to specific rules to accurately reflect diagnoses that almost always are present-on-admission (comorbidities) and diagnoses that should never be present-on-admission in elective surgical cases (complications).

Identification of Live Discharges with Prolonged Risk-Adjusted Post-Operative Lengths of Stay (prRALOS)

[1] Pine M, Fry DE, Jones BL, Meimban RJ: Screening algorithms to assess the accuracy of present-on admission coding. Perspect Health Inf Manag 2009; 6: 2 Epub Feb 11.

After this recoding was performed, a methodology mirroring that previously published[2], [3] was performed for each procedural and medical category to identify patients with prRALOS. An iterative approach was followed to create a final set of control charts for each hospital with sufficient volume for each procedural and medical category. For procedural categories, the process was modified to account for variance in physician practice within a hospital. Patients who were discharged alive and were found to have a standardized post-operative length of stay that exceeded the upper control limit for a procedure or the upper control limit for a medical episode at the hospital from which the patient was discharged were classified as having prolonged risk-adjusted post-operative length of stays. Unlike counts of recorded complications, this surrogate for hospital-acquired complications is very reproducible and does not depend on how hospital-acquired secondary diagnoses are coded at different hospitals or by different abstractors. Hospitals with abnormally high upper control limits were dropped from the final case-level report.

Creation of Predictive Models for Inpatient Mortality

Stepwise logistic regression was used to derive inpatient mortality predictive models for each procedural and medical category using the data set of cases at identified good-coding hospitals. The total number of cases that were used to build the model, the number of events and the corresponding percentage of events, and the c-statistic for the final inpatient mortality models were all documented by MPA.

Creation of Predictive Models for Inpatient Prolonged Risk-Adjusted Length of Stay

Stepwise logistic regression was used to derive a post-operative prRALOS predictive model for each procedural and a prRALOS predictive model for each medical category using a subset of cases at identified good-coding hospitals containing only patients that were discharged alive. The total number of cases that were used to build the model, the number of events and the corresponding percentage of events, and the c-statistic for the final prRALOS models were all documented by MPA.

Predictive Models for Readmission within 90 Days of Discharge

Stepwise logistic regression was used to derive the following individual 90-Day Readmission predictive models for each procedural and medical category using a subset of cases at identified good coding hospitals that did not die prior to readmission:

- readmission without prRALOS and
- readmission with prRALOS

Readmissions were identified as cases admitted to an acute care facility within 90 days of discharge from a qualifying admission when the readmission a) did not qualify as a readmission bounce-back and, for surgical groups only, b) did not have a DRG appearing on a list of DRG exclusions. Cases discharged in the last 90 days of the study data were excluded from these models. A Final General 90-day readmission model was built by combining these two individual models. The total number of cases that were used to build the final model, the number of events and the corresponding percentage of events, and the c-statistic for the final readmission models were all documented by MPA.

[2] Fry DE, Pine M, Jones BL, Meimban RJ: Adverse Outcomes in Surgery: Redefinition of Post-operative Complications. Am J Surg 2009; 197:479-84.

[3] Fry DE, Pine M, Jones BL, Meimban RJ: Control charts to identify adverse outcomes in elective colon resection. Am J Surg 2012; 203:392-6.

Predictive Models for Post-discharge Mortality within 90 Days of Discharge

Stepwise logistic regression was used to derive the following individual 90-Day Post-Discharge Mortality predictive models for each procedural and medical category using the subset of cases at identified good coding hospitals that were discharged alive:

post-discharge mortality without a prRALOS and without a readmission,

post-discharge mortality with a prRALOS and without a readmission,

post-discharge mortality with or without a prRALOS and without a readmission, and

post-discharge mortality with or without a prRALOS and with a readmission

Post-discharge mortalities were identified as deaths within 90 days of discharge. Cases discharged in the last 90 days of the study data were excluded from these models. A Final General 90-day post-discharge mortality model was built by combining these four individual models. The total number of cases that were used to build the model, the number of events and the corresponding percentage of events, and the c-statistic for the final post-discharge mortality models were documented by MPA.

Application of Predictive Models

For each procedural category, predictive models were built on three years of LDS data (2012-2014), and were applied to five years of data (2010-2014). For the medical categories, 2012-2014 data were used to compute predicted rates.

The following predicted rates were computed from the models:

A. Probability of an inpatient mortality
B. Probability of a patient discharged alive with a prRALOS
C. Probability of a patient discharged alive with a prRALOS, and was readmitted within 90 days of discharge
D. Probability of a patient discharged alive without a prRALOS, and was readmitted within 90 days of discharge
E. Probability of a patient discharged alive with a prRALOS, and was readmitted and died within 90 days of discharge
F. Probability of a patient discharged alive without a prRALOS, and was readmitted and died within 90 days of discharge
G. Probability of a patient discharged alive with a prRALOS, was not readmitted within 90 days of discharge, but died within 90 days of discharge
H. Probability of a patient discharged alive without a prRALOS, was not readmitted within 90 days of discharge, but died within 90 days of discharge

These probabilities were calculated using a set of conditional probabilities. For example, probability of a patient discharged alive with a prRALOS (condition B above), is equal to the probability of a patient discharged alive multiplied by the probability of having a prRALOS given live discharge. Condition C above would be computed as the probability of a patient discharged alive, multiplied by the probability of having a prRALOS given live discharge, multiplied by the probability of being readmitted within 90 days of discharge given discharge alive and prRALOS.

Each conditional probability was standardized to the corresponding modeling population. For example, the predicted probability of a patient with a prRALOS, given live discharge, was standardized so that the sum of the predicted prRALOS rates equal the sum of observed prRALOS rates for the subset of live discharge cases. Once the predicted probabilities of the intersection of those adverse outcomes were calculated, they were then used to compute the following four aggregated adverse outcomes rates.

Inpatient Adverse Outcomes

Patients were classified as having had an inpatient adverse outcome if they either died or had a prRALOS during hospital care. The predicted inpatient adverse outcome rate is calculated as the probability of inpatient mortality plus the probability of prRALOS with live discharge. Using the above notation, it can be shown as

$$P(ao\_ip) = A + B.$$

90-day Mortality (Inpatient and 90-days Post-discharge)

Patients were classified as having had a 90-day mortality if they died during the hospital stay, or within 90 days post-discharge. The predicted 90-day mortality rate is calculated as the probability of inpatient mortality plus the probability of post-discharge mortality, which can occur in four of the conditions above (E, F, G, H), i.e.

$$P(ipmort90) = A + E + F + G + H.$$

90-day Readmission

Patients were classified as having had a 90-day readmission if they had a readmission within 90 days post-discharge. If a patient had an inpatient mortality, they will not have a readmission. Thus, the probability of 90-day readmission is conditional on live discharge cases. Two conditions were included in the predicted probabilities of 90-day readmission given live discharge:

1. Probability of a patient with a prRALOS and a 90-day readmission given live discharge
2. Probability of a patient with a routine length of stay and a 90-day readmission given live discharge

The probability of a 90-day readmission conditional on live discharge is calculated as:

$$P(\text{readmit90 given live}) = (C + D) / (1 – A)$$

Total Adverse Outcomes

Patients were classified as having had a total adverse outcome if they had at least one of the following adverse outcomes: inpatient mortality, prRALOS, 90-day readmission , or 90-day post-discharge mortality.

The predicted total adverse outcome rate is calculated as the sum of probabilities of four conditions:

1. Probability of an inpatient mortality
2. Probability of a patient discharged alive with a prRALOS
3. Probability of a patient discharged alive without a prRALOS, and was readmitted within 90 days of discharge
4. Probability of a patient discharged alive without a prRALOS, was not readmitted within 90 days of discharge, but died within 90 days of discharge

The probability of a total adverse outcome is calculated as:

$$P(ao\_tot) = A + B + D + H$$

Appendix A: Procedure Group Definitions

Cardiac Surgery

Group 01: Heart Valve Surgery

Qualifying Procedure Code(s): 351y;y=1,2 ; 352y;y=1,2,3,4 ; 3533

Group 02: CABG

Qualifying Procedure Code(s): 361x

Group 03: Percutaneous Coronary Intervention

Qualifying Procedure Code(s): 0066; 1755; 360y; y=6, 7, 9

Group 04: Non-Coronary PCI Cardiac Interventions / Implanted Defibrillator Devices

Qualifying Procedure Code(s): 3552; 3597; 372y; y=6, 7; 3734; 0051; 3794

Vascular Surgery

Group 05: Aortic Surgery

A: Open Aortic Surgery

Qualifying Procedure Code(s): 3925; 384y; y=4, 5, 6

B: Endovascular Aortic Surgery

Qualifying Procedure Code(s): 3971

Group 06: Endarterectomy/Angioplasty Head/Neck Vessels

A: Endarterectomy Head/Neck Vessels

Qualifying Procedure Code(s): 3812

B: Percutaneous Angioplasty Head/Neck Vessels

Qualifying Procedure Code(s): 0061

Group 07: Lower Extremity and Other Endovascular Procedures

A: Open Lower Extremity Procedures

Qualifying Procedure Code(s): 3818

B: Endovascular Procedures

Qualifying Procedure Code(s): 3950

Thoracic Surgery

Group 08: Pulmonary Surgery

Qualifying Procedure Code(s): 322y; y=0, 9; 323y; y=0, 9; 324y; y=1, 9; 325y; y=0, 9

Orthopedic Surgery

Group 09: Open Reduction-Internal Fixation Femur Fracture

Qualifying Procedure Code(s): 7935

Group 10: Total Hip / Knee Replacement

Qualifying Procedure Code(s): 815y; y=1, 2, 3, 4, 5

Group 11: Cervical Fusion / Refusion

Qualifying Procedure Code(s): 810y;y=2,3 ; 813y;y=2,3

Group 12: Non-Cervical Fusion / Refusion

Qualifying Procedure Code(s): 810y;y=4,5,6,7,8 ; 813y;y=4,5,6,7,8 ; 816y;y=3,4

Group 13: Non-Fusion Spinal Surgery

Qualifying Procedure Code(s): 8051

Abdominal Surgery

Group 14: Major Small and Large Bowel Surgery

A: Open Major Small and Large Bowel Surgery

Qualifying Procedure Code(s): 456x ; 457x ; 458x ; 486y;y=2,3 ; 485x

B: Laparoscopic Intestinal Surgery

Qualifying Procedure Code(s): 173x

Group 15: Gastric Surgery

A: Open Gastric Surgery

Qualifying Procedure Code(s): 43yb;y=5,6,7; 438y; y=1,9; 439y; y=1,9; 446y; y=4, 5, 6

B: Laparoscopic Gastric Surgery

Qualifying Procedure Code(s): 446y;y=7,8

C: Bariatric Surgery

Qualifying Procedure Code(s): 4382 ; 443y;y=1,8,9 ; 449y;y=5,6

Group 16: Cholecystectomy

A: Open Cholecystectomy

Qualifying Procedure Code(s): 5122

B: Laparoscopic Cholecystectomy

Qualifying Procedure Code(s): 5123

Urologic Surgery

Group 17: Prostatectomy / Cystectomy / Nephrectomy

A: Nephrectomy

Qualifying Procedure Code(s): 554x ; 5551

B: Cystectomy

Qualifying Procedure Code(s): 576x ; 577x

C: Prostatectomy

Qualifying Procedure Code(s): 60yx; y=3,4,5

Appendix B: Inpatient Mortality

Summary statistics for final risk-adjustment models for inpatient mortality are shown below:

Group 01: Heart Valve Surgery

N = 95,753

n mortality = 3,328

% mortality = 3.48%

c-statistic = 0.750

Group 02: CABG

N = 95,894

n mortality = 1,905

% mortality = 1.99%

c-statistic = 0.768

Group 03: Percutaneous Coronary Revascularization

N = 255,091

n mortality = 7,496

% mortality = 2.94%

c-statistic = 0.879

Group 04: Non-Coronary PCI Cardiac Interventions / Implanted Defibrillator Devices

N = 81,677

n mortality = 693

% mortality = 0.85%

c-statistic = 0.796

Group 05: Aortic Surgery

N = 48,921

n mortality = 1,428

% mortality = 2.92%

c-statistic = 0.875

Group 06: Endarterectomy/Angioplasty Head/Neck Vessels

N = 105,657

n mortality = 476

% mortality = 0.45%

c-statistic = 0.803

Group 07: Lower Extremity and Other Endovascular Procedures

N = 89,687

n mortality = 2,208

% mortality = 2.46%

c-statistic = 0.806

Group 08: Pulmonary Surgery

N = 57,319

n mortality = 1,133

% mortality = 1.98%

c-statistic = 0.822

Group 09: Open Reduction-Internal Fixation Femur Fracture

N = 127,256

n mortality = 2,901

% mortality = 2.28%

c-statistic = 0.779

Group 10: Total Hip / Knee Replacement

N = 891,640

n mortality = 3,878

% mortality = 0.43%

c-statistic = 0.901

Group 11: Cervical Fusion / Refusion

N =	39,518
n mortality =	166
% mortality =	0.42%
c-statistic =	0.865

Group 12: Non-Cervical Fusion / Refusion

N =	167,312
n mortality =	509
% mortality =	0.30%
c-statistic =	0.813

Group 13: Non-Fusion Spinal Surgery

N =	17,611
n mortality =	31
% mortality =	0.18%
c-statistic =	0.760

Group 14: Major Small and Large Bowel Surgery

N =	219,783
n mortality =	11,540
% mortality =	5.25%
c-statistic =	0.857

Group 15: Gastric Surgery

N =	36,501
n mortality =	1,016
% mortality =	2.78%
c-statistic =	0.888

Group 16: Cholecystectomy

N =	2,738
n mortality =	2,125
% mortality =	1.54%
c-statistic =	0.842

Group 17: Prostatectomy / Cystectomy / Nephrectomy

N =	70,513
n mortality =	452
% mortality =	0.64%
c-statistic =	0.853

Appendix C: Prolonged Risk-Adjusted Length of Stay (Live Discharges)

Summary statistics for final risk-adjustment models for prolonged standardized hospital length of stay are shown below:

Group 01: Heart Valve Surgery

N = 92,425

n prLOS = 7,392

% prLOS = 8.00%

c-statistic = 0.711

Group 02: CABG

N = 93,989

n prLOS = 7,210

% prLOS = 7.67%

c-statistic = 0.724

Group 03: Percutaneous Coronary Revascularization

N = 247,595

n prLOS = 30,142

% prLOS = 12.17%

c-statistic = 0.779

Group 04: Non-Coronary PCI Cardiac Interventions / Implanted Defibrillator Devices

N = 80,984

n prLOS = 8,263

% prLOS = 10.20%

c-statistic = 0.707

Group 05: Aortic Surgery

N = 553

n prLOS = 3,786

% prLOS = 7.97%

c-statistic = 0.736

Group 06: Endarterectomy/Angioplasty Head/Neck Vessels

N = 105,181

n prLOS = 7,777

% prLOS = 7.39%

c-statistic = 0.767

Group 07: Lower Extremity and Other Endovascular Procedures

N = 87,479

n prLOS = 6,794

% prLOS = 7.77%

c-statistic = 0.701

Group 08: Pulmonary Surgery

N = 56,186

n prLOS = 3,695

% prLOS = 6.58%

c-statistic = 0.698

Group 09: Open Reduction-Internal Fixation Femur Fracture

N = 124,355

n prLOS = 7,410

% prLOS = 5.96%

c-statistic = 0.715

Group 10: Total Hip / Knee Replacement

N =	887,762
n prLOS =	47,948
% prLOS =	5.40%
c-statistic =	0.760

Group 11: Cervical Fusion / Refusion

N =	39,352
n prLOS =	2,924
% prLOS =	7.43%
c-statistic =	0.782

Group 12: Non-Cervical Fusion / Refusion

N =	166,803
n prLOS =	9,343
% prLOS =	5.60%
c-statistic =	0.714

Group 13: Non-Fusion Spinal Surgery

N =	17,580
n prLOS =	807
% prLOS =	4.59%
c-statistic =	0.699

Group 14: Major Small and Large Bowel Surgery

N =	208,243
n prLOS =	15,811
% prLOS =	7.59%
c-statistic =	0.678

Group 15: Gastric Surgery

N =	35,485
n prLOS =	2,569
% prLOS =	7.24%
c-statistic =	0.731

Group 16: Cholecystectomy

N =	135,948
n prLOS =	9,399
% prLOS =	6.91%
c-statistic =	0.696

Group 17: Prostatectomy / Cystectomy / Nephrectomy

N =	70,061
n prLOS =	3,785
% prLOS =	5.40%
c-statistic =	0.694

Appendix D: 90-Day Post-Discharge Readmission

Summary statistics for final risk-adjustment models for readmission are shown below:

Group 01: Heart Valve Surgery

N =	84,199
n post-discharge readmission =	20,602
% post-discharge readmission =	24.47%
c-statistic =	0.642

Group 02: CABG

N =	85,916
n post-discharge readmission =	16,889
% post-discharge readmission =	19.66%
c-statistic =	0.667

Group 03: Percutaneous Coronary Revascularization

N =	227,149
n post-discharge readmission =	51,064
% post-discharge readmission =	22.48%
c-statistic =	0.686

Group 04: Non-Coronary PCI Cardiac Interventions / Implanted Defibrillator Devices

N =	74,493
n post-discharge readmission =	17,933
% post-discharge readmission =	24.07%
c-statistic =	0.677

Group 05: Aortic Surgery

N =	43,379
n post-discharge readmission =	7,926
% post-discharge readmission =	18.27%
c-statistic =	0.674

Group 06: Endarterectomy/Angioplasty Head/Neck Vessels

N =	96,724
n post-discharge readmission =	11,580
% post-discharge readmission =	11.97%
c-statistic =	0.679

Group 07: Lower Extremity and Other Endovascular Procedures

N =	79,279
n post-discharge readmission =	26,433
% post-discharge readmission =	33.34%
c-statistic =	0.671

Group 08: Pulmonary Surgery

N =	51,030
n post-discharge readmission =	9,074
% post-discharge readmission =	17.78%
c-statistic =	0.642

Group 09: Open Reduction-Internal Fixation Femur Fracture

N =	108,965
n post-discharge readmission =	24,174
% post-discharge readmission =	22.19%
c-statistic =	0.656

Group 10: Total Hip / Knee Replacement

N =	809,355
n post-discharge readmission =	75,294
% post-discharge readmission =	9.30%
c-statistic =	0.722

Group 11: Cervical Fusion / Refusion

N =	35,854
n post-discharge readmission =	3,767
% post-discharge readmission =	10.51%
c-statistic =	0.665

Group 12: Non-Cervical Fusion / Refusion

N =	152,207
n post-discharge readmission =	19,449
% post-discharge readmission =	12.78%
c-statistic =	0.660

Group 13: Non-Fusion Spinal Surgery

N =	16,332
n post-discharge readmission =	1,910
% post-discharge readmission =	11.69%
c-statistic =	0.661

Group 14: Major Small and Large Bowel Surgery

N =	187,455
n post-discharge readmission =	43,990
% post-discharge readmission =	23.47%
c-statistic =	0.674

Group 15: Gastric Surgery

N =	31,830
n post-discharge readmission =	5,589
% post-discharge readmission =	17.56%
c-statistic =	0.725

Group 16: Cholecystectomy

N =	123,839
n post-discharge readmission =	20,701
% post-discharge readmission =	16.72%
c-statistic =	0.682

Group 17: Prostatectomy / Cystectomy / Nephrectomy

N =	63,926
n post-discharge readmission =	8,477
% post-discharge readmission =	13.26%
c-statistic =	0.745

Appendix E: 90-Day Post-Discharge Mortality (with or without a Preceding Readmission)

Summary statistics for final risk-adjustment models for mortality are shown below:

Group 01: Heart Valve Surgery

N =	85,242
n post-discharge mortality =	2,798
% post-discharge mortality =	3.28%
c-statistic =	0.833

Group 02: CABG

N =	86,659
n post-discharge mortality =	1,826
% post-discharge mortality =	2.11%
c-statistic =	0.849

Group 03: Percutaneous Coronary Revascularization

N =	229,911
n post-discharge mortality =	7,538
% post-discharge mortality =	3.28%
c-statistic =	0.852

Group 04: Non-Coronary PCI Cardiac Interventions / Implanted Defibrillator Devices

N =	75,436
n post-discharge mortality =	3,240
% post-discharge mortality =	4.30%
c-statistic =	0.855

Group 05: Aortic Surgery

N =	43,812
n post-discharge mortality =	1,284
% post-discharge mortality =	2.93%
c-statistic =	0.840

Group 06: Endarterectomy/Angioplasty Head/Neck Vessels

N =	97,450
n post-discharge mortality =	1,699
% post-discharge mortality =	1.74%
c-statistic =	0.829

Group 07: Lower Extremity and Other Endovascular Procedures

N =	81,223
n post-discharge mortality =	5,621
% post-discharge mortality =	6.92%
c-statistic =	0.819

Group 08: Pulmonary Surgery

N =	51,792
n post-discharge mortality =	1,933
% post-discharge mortality =	3.73%
c-statistic =	0.850

Group 09: Open Reduction-Internal Fixation Femur Fracture

N =	114,542
n post-discharge mortality =	11,198
% post-discharge mortality =	9.78%
c-statistic =	0.805

Group 10: Total Hip / Knee Replacement

N =	816,547
n post-discharge mortality =	15,332
% post-discharge mortality =	1.88%
c-statistic =	0.937

Group 11: Cervical Fusion / Refusion

N =	36,060
n post-discharge mortality =	450
% post-discharge mortality =	1.25%
c-statistic =	0.903

Group 12: Non-Cervical Fusion / Refusion

N =	152,968
n post-discharge mortality =	1,850
% post-discharge mortality =	1.21%
c-statistic =	0.885

Group 13: Non-Fusion Spinal Surgery

N =	16,397
n post-discharge mortality =	173
% post-discharge mortality =	1.06%
c-statistic =	0.883

Group 14: Major Small and Large Bowel Surgery

N =	192,417
n post-discharge mortality =	10,658
% post-discharge mortality =	5.54%
c-statistic =	0.850

Group 15: Gastric Surgery

N =	32,480
n post-discharge mortality =	1,429
% post-discharge mortality =	4.40%
c-statistic =	0.901

Group 16: Cholecystectomy

N =	125,659
n post-discharge mortality =	4,409
% post-discharge mortality =	3.51%
c-statistic =	0.868

Group 17: Prostatectomy / Cystectomy / Nephrectomy

N =	64,408
n post-discharge mortality =	1,200
% post-discharge mortality =	1.86%
c-statistic =	0.879

Appendix F: Medical Group Definitions

Group 01: Acute Myocardial Infarction (including AMI with PTCA or CABG)

Qualifying Diagnosis code(s): 410x1

Group 02: Obstructive Pulmonary Disease

Qualifying Diagnosis code(s): 4912x ; 49yxx, y=2,3,4,6

Group 03: Heart Failure

Qualifying Diagnosis code(s): 39891 ; 402x1 ; 404xy;y=1,3 ; 428xx

Group 04: Primary Pneumonia

Qualifying Diagnosis code(s): 48yxx,y=0,1,2,3,4,5,6; 4870x

Group 05: Cerebrovascular Accident (ischemic and hemorrhagic)

Qualifying Diagnosis code(s): 43yxx, y=0,1,2; 43yx1;y=3,4

Group 06: Non-Surgical Gastrointestinal Hemorrhage

Qualifying Diagnosis code(s): 53y0x;y=1,2,3,4 ; 53y2x;y=1,2,3,4 ; 53y4x;y=1,2,3,4 ; 53y6x;y=1,2,3,4 ; 535x1 ; 5378y;y=3,4 ; 5620y;y=2,3 ; 5621y;y=2,3 ; 5693x ; 56985 ; 578xx

Appendix G: Inpatient Mortality

Summary statistics for final risk-adjustment models for inpatient mortality are shown below:

Group 01: Acute Myocardial Infarction

N = 174,461

n mortality = 18,010

% mortality = 10.32%

c-statistic = 0.805

Group 02: Obstructive Pulmonary Disease

N = 482,844

n mortality = 6,588

% mortality = 1.36%

c-statistic = 0.792

Group 03: Congestive Heart Failure

N = 623,766

n mortality = 27,965

% mortality = 4.48%

c-statistic = 0.764

Group 04: Primary Pneumonia

N = 573,769

n mortality = 23,881

% mortality = 4.16%

c-statistic = 0.800

Group 05: Cerebrovascular Accident (ischemic and hemorrhagic)

N =	361,643
n mortality =	27,907
% mortality =	7.72%
c-statistic =	0.843

Group 06: Non-Surgical Gastrointestinal Hemorrhage

N =	346,959
n mortality =	9,712
% mortality =	2.80%
c-statistic =	0.836

Appendix H: Prolonged Risk-Adjusted Length of Stay (Live Discharges)

Summary statistics for final risk-adjustment models for prolonged standardized hospital length of stay are shown below:

Group 01: Acute Myocardial Infarction

N =	156,451
n prRALOS =	10,006
% prRALOS =	6.40%
c-statistic =	0.640

Group 02: Obstructive Pulmonary Disease

N =	476,256
n prRALOS =	21,015
% prRALOS =	4.41%
c-statistic =	0.643

Group 03: Congestive Heart Failure

N =	595,801
n prRALOS =	32,393
% prRALOS =	5.44%
c-statistic =	0.674

Group 04: Primary Pneumonia

N =	549,888
n prRALOS =	25,699
% prRALOS =	4.67%
c-statistic =	0.685

Group 05: Cerebrovascular Accident (ischemic and hemorrhagic)

N =	333,736
n prRALOS =	19,230
% prRALOS =	5.76%
c-statistic =	0.735

Group 06: Non-Surgical Gastrointestinal Hemorrhage

N =	337,247
n prRALOS =	18,931
% prRALOS =	5.61%
c-statistic =	0.684

Appendix I: General 90-Day Post-Discharge Readmission

Summary statistics for final risk-adjustment models for prolonged standardized hospital length of stay are shown below:

Group 01: Acute Myocardial Infarction

N =	136,275
n post-discharge readmission =	50,112
% post-discharge readmission =	36.77%
c-statistic =	0.654

Group 02: Obstructive Pulmonary Disease

N =	429,483
n post-discharge readmission =	154,297
% post-discharge readmission =	35.93%
c-statistic =	0.631

Group 03: Congestive Heart Failure

N =	516,350
n post-discharge readmission =	223,631
% post-discharge readmission =	43.31%
c-statistic =	0.603

Group 04: Primary Pneumonia

N =	484,523
n post-discharge readmission =	154,326
% post-discharge readmission =	31.85%
c-statistic =	0.658

Group 05: Cerebrovascular Accident (ischemic and hemorrhagic)

N =	293,814
n post-discharge readmission =	79,051
% post-discharge readmission =	26.91%
c-statistic =	0.656

Group 06: Non-Surgical Gastrointestinal Hemorrhage

N =	300,737
n post-discharge readmission =	88,802
% post-discharge readmission =	29.53%
c-statistic =	0.671

Appendix J: 90-Day Post-Discharge Mortality without Readmission

Summary statistics for final risk-adjustment models for post-discharge mortality are shown below:

Group 01: Acute Myocardial Infarction

N =	144,072
n post-discharge mortality =	19,412
% post-discharge mortality =	13.47%
c-statistic =	0.782

Group 02: Obstructive Pulmonary Disease

N =	440,210
n post-discharge mortality =	35,741
% post-discharge mortality =	8.12%
c-statistic =	0.794

Group 03: Congestive Heart Failure

N =	545,130
n post-discharge mortality =	81,762
% post-discharge mortality =	15.00%
c-statistic =	0.748

Group 04: Primary Pneumonia

N =	507,455
n post-discharge mortality =	59,858
% post-discharge mortality =	11.80%
c-statistic =	0.809

Group 05: Cerebrovascular Accident (ischemic and hemorrhagic)

N =	307,448
n post-discharge mortality =	29,946
% post-discharge mortality =	9.74%
c-statistic =	0.824

Group 06: Non-Surgical Gastrointestinal Hemorrhage

N =	309,773
n post-discharge mortality =	25,032
% post-discharge mortality =	8.08%
c-statistic =	0.830