

APPENDIX

Appendix 1. Matching Algorithm.....	2
Appendix 2. Risk Model for Defining Probability of 30-day Death.....	4
Appendix 2a. General Surgery Probability of Death Model.....	4
Appendix 2b. Orthopedic Surgery Probability of Death Model.....	6
Appendix 2c. Vascular Surgery Probability of Death Model.....	7
Appendix 3. Complication Set for 30-day Complications and Failure to Rescue.....	9
Appendix 4. Definitions of Resource Utilization-based Costs and Method of Cost Adjustment for Differences in Nurse Staffing and Skill Mix.....	13
Appendix 5. Correlation and Principal Component Analysis of Nursing Resource Measures.....	16
Appendix 6. Definitions of Principal Procedures.....	17
Appendix 6a. General Surgery.....	17
Appendix 6b. Orthopedic Surgery.....	19
Appendix 6c. Vascular Surgery.....	22
Appendix 7. Complete Matching Results with All Variables.....	24
Appendix 8. Differences in 30-day Mortality after Post-Match Adjustment for Hospital Bed Size and Resident to Bed Ratio.....	38
Appendix 9. Differences in Outcomes after Post-Match Adjustment for State.....	39
Appendix 10. 30-day Costs under Different Definitions.....	40
Appendix 11. 30-day Mortality and Cost Differences Among Matched Patients in Top 15%, Middle 40%, and Bottom 45% of Hospitals.....	41
Appendix 12. Appendix 12. Differences in Hospital Coherence Percentiles among Matched Pairs: Middle Hospitals are Closer to Top Hospitals than to Bottom Hospitals.....	42
Appendix 13. 30-day Mortality Differences Between Matched Patients in Better and Worse Nursing Resourced Hospitals for Common Procedures.....	43
APPENDIX REFERENCES.....	44

Appendix 1. Matching Algorithm

1. Match exactly for the following variables
 - a. ICD-9-CM principal procedures (see eTable2 in the Supplement for complete list)
 - b. Hospital size category
 - i. Small (< 250 beds)
 - ii. Large (\geq 250 beds)
 - c. Hospital teaching status category
 - i. Non-teaching ($0 \leq$ medical residents to beds < 0.05)
 - ii. Minor teaching ($0.05 \leq$ medical residents to beds < 0.25)
 - iii. Major teaching (medical residents to beds \geq 0.25)
 - d. Hospital technology status category
 - i. High technology (capacity to perform coronary artery bypass surgery and/or organ transplantation)
 - ii. Low technology
 - e. Quintiles of risk of 30-day mortality
2. Minimize the Mahalanobis Distance between cases and controls for the following variables
 - a. Age category at admission (years)
 - b. Sex
 - c. Race (% non-Hispanic white)
 - d. Race (% Black)
 - e. Race (% Hispanic)
 - f. Race (% other)
 - g. Emergent admission
 - h. Transfer-in status
 - i. Transfer-in from another hospital's emergency department
 - j. Secondary procedures
 - k. Propensity score for attending a focal (case) hospital
 - l. Comorbidities:
 - i. Congestive heart failure
 - ii. Past myocardial infarction
 - iii. Past arrhythmia
 - iv. Angina
 - v. Valvular disease
 - vi. Unstable angina
 - vii. Hypertension
 - viii. Diabetes
 - ix. Renal dysfunction
 - x. Renal failure
 - xi. Liver disease
 - xii. Cancer
 - xiii. Specific abdominal cancer
 - xiv. Chronic obstructive pulmonary disease
 - xv. Asthma
 - xvi. Post-inflammatory pulmonary fibrosis
 - xvii. Dementia
 - xviii. Stroke
 - xix. Seizure
 - xx. Paraplegia
 - xxi. Hypothyroidism
 - xxii. Collagen vascular disease
 - xxiii. Acquired immunodeficiency syndrome (AIDS)
 - xxiv. Chronic peptic ulcer disease
 - xxv. Congenital coagulopathy / hemophilia
 - xxvi. Coagulopathy
 - xxvii. Cushing's disease
 - xxviii. Grave's disease

- xxix. Hemoglobinopathy
- xxx. Weight loss/malnutrition
- 3. Near Fine Balance was used on the following variables:
 - a. Race (% non-Hispanic white)
 - b. Race (% Black)
 - c. Race (% Hispanic)
 - d. Race (% other)
 - e. Emergency admission
 - f. Comorbidities
 - i. Congestive heart failure
 - ii. Past myocardial infarction
 - iii. Past arrhythmia
 - iv. Angina
 - v. Valvular disease
 - vi. Unstable angina
 - vii. Hypertension
 - viii. Diabetes
 - ix. Renal dysfunction
 - x. Renal failure
 - xi. Liver disease
 - xii. Cancer
 - xiii. Specific abdominal cancer
 - xiv. Chronic obstructive pulmonary disease
 - xv. Asthma
 - xvi. Post-inflammatory pulmonary fibrosis
 - xvii. Dementia
 - xviii. Stroke
 - xix. Seizure
 - xx. Paraplegia
 - xxi. Congenital coagulopathy / hemophilia
 - xxii. Weight loss/malnutrition
 - g. Hospital Size;
 - i. 250-499 beds
 - ii. >500 beds
- 4. Penalties were used on:
 - a. Probability of 30-day death
 - b. Probability of intensive or intermediate care unit admission
 - c. Predicted length of stay
 - d. Predicted 30-day costs
 - e. Continuous measure of hospital resident-to-bed ratio
 - f. Continuous measure of hospital number of beds
- 5. Calipers were placed the propensity score for admission to a focal hospital.

Appendix 2. Risk Model for Defining Probability of 30-day Death

To balance case and control patients on their risk profile, logistic regression models were used to predict each patient's 30-day risk of death. For each surgical group (i.e., general surgery, orthopedic surgery, and vascular surgery), a model was fit to an external dataset of Medicare claims. The external dataset was created by taking a 10% random sample of Medicare patients in California, Florida, New Jersey, and Pennsylvania for the years 2013-2015. Patients in this external dataset were not used for matching. Coefficients for each of the variables were then applied to patients in the matching dataset to assign each patient's risk of 30-day death. The resulting risk scores were then used as a matching variable and to stratify matched pairs by quintiles of 30-day mortality risk.

Appendix 2a. General Surgery Probability of Death Model.

Variable	Estimate (SE)	Odds (95% CI)	Chi Sq	P
Model Intercept	-4.25 (0.31)	0.00 (0.00, 0.00)	184.71	<.0001
Age category (65-69) (reference)	--	--	--	--
Age category (70-74 years)	-0.22 (0.22)	0.80 (0.53, 1.23)	1.04	0.3085
Age category (75-79 years)	0.04 (0.20)	1.04 (0.70, 1.55)	0.04	0.8400
Age category (80-84 years)	0.50 (0.20)	1.65 (1.12, 2.42)	6.32	0.0119
Age category (85+ years)	1.05 (0.19)	2.85 (1.98, 4.11)	31.34	<.0001
Sex (male)	0.12 (0.12)	1.12 (0.90, 1.41)	1.00	0.3166
Emergency admission	0.69 (0.13)	2.00 (1.55, 2.58)	28.05	<.0001
Transfer-in from another hospital's emergency department	0.42 (0.36)	1.53 (0.76, 3.07)	1.43	0.2316
Transfer-in status	-0.39 (0.51)	0.68 (0.25, 1.85)	0.58	0.4468
Major Secondary Procedure	0.35 (0.13)	1.43 (1.12, 1.82)	8.00	0.0047
Comorbidities				
CHF	0.41 (0.13)	1.50 (1.17, 1.93)	10.07	0.0015
Stroke	-0.23 (0.16)	0.80 (0.59, 1.08)	2.16	0.1413
Seizure	0.43 (0.27)	1.54 (0.91, 2.60)	2.54	0.1109
Dementia	0.43 (0.13)	1.53 (1.18, 1.99)	10.24	0.0014
Past Myocardial Infarction	-0.07 (0.17)	0.93 (0.67, 1.30)	0.16	0.6882
Past Arrhythmia	0.02 (0.12)	1.02 (0.81, 1.29)	0.02	0.8753
Unstable Angina	0.30 (0.30)	1.35 (0.75, 2.43)	0.98	0.3234
Angina	0.13 (0.21)	1.13 (0.75, 1.72)	0.36	0.5505
Hypertension	-0.43 (0.19)	0.65 (0.45, 0.94)	5.23	0.0222
Valvular Disease	0.23 (0.12)	1.26 (1.00, 1.59)	3.86	0.0495
Chronic Lung Disease	0.38 (0.12)	1.47 (1.17, 1.84)	10.97	0.0009
Asthma	-0.15 (0.18)	0.86 (0.61, 1.22)	0.71	0.4004
Liver Disease	0.08 (0.14)	1.08 (0.82, 1.43)	0.33	0.5679
Renal Dysfunction	0.85 (0.12)	2.33 (1.84, 2.95)	48.92	<.0001
Renal Failure	0.78 (0.16)	2.17 (1.58, 2.99)	23.08	<.0001
Diabetes	-0.05 (0.12)	0.95 (0.75, 1.19)	0.21	0.6431
Paraplegia	0.43 (0.28)	1.54 (0.89, 2.65)	2.41	0.1209
Collagen Vascular Disease	0.18 (0.19)	1.19 (0.83, 1.72)	0.89	0.3444
Coagulopathy	0.33 (0.47)	1.39 (0.56, 3.46)	0.49	0.4832
Thrombocytopenia	-0.03 (0.24)	0.97 (0.60, 1.55)	0.02	0.8947
Other Coagulopathy	0.59 (0.18)	1.80 (1.28, 2.55)	11.10	0.0009
Post-Inflammatory Pulmonary Fibrosis	0.15 (0.23)	1.17 (0.74, 1.84)	0.45	0.5044
Cancer	-0.19 (0.12)	0.83 (0.66, 1.05)	2.36	0.1249
Abdominal Cancer	0.76 (0.27)	2.14 (1.27, 3.60)	8.14	0.0043
Hypothyroidism	0.04 (0.12)	1.04 (0.82, 1.32)	0.12	0.7263
Weight loss	0.39 (0.12)	1.48 (1.18, 1.86)	11.27	0.0008
Principal Procedures				
Open and other right hemicolectomy (Reference)	--	--	--	--
Laparoscopic sigmoidectomy	-1.00 (0.62)	0.37 (0.11, 1.23)	2.64	0.1042
Total splenectomy	0.58 (0.55)	1.78 (0.61, 5.24)	1.10	0.2952
Suture of duodenal ulcer site	1.17 (0.37)	3.22 (1.56, 6.66)	10.01	0.0016
Open and other resection of transverse colon	0.89 (0.45)	2.44 (1.01, 5.89)	3.92	0.0477

Variable	Estimate (SE)	Odds (95% CI)	Chi Sq	P
Open and other left hemicolectomy	0.55 (0.30)	1.73 (0.97, 3.09)	3.40	0.0650
Open and other sigmoidectomy	0.50 (0.24)	1.64 (1.03, 2.63)	4.27	0.0389
Exteriorization of large intestine	0.07 (0.53)	1.07 (0.38, 3.01)	0.02	0.9013
Laparoscopic appendectomy	-2.05 (0.74)	0.13 (0.03, 0.55)	7.65	0.0057
Other appendectomy	-2.00 (1.04)	0.14 (0.02, 1.04)	3.69	0.0546
Laparoscopic cholecystectomy (5123)	-1.66 (0.28)	0.19 (0.11, 0.33)	35.81	<.0001
Incisional hernia repair	-0.42 (0.76)	0.65 (0.15, 2.88)	0.31	0.5751
Laparoscopic lysis of peritoneal adhesions	-1.24 (0.64)	0.29 (0.08, 1.02)	3.73	0.0533
Other lysis of peritoneal adhesions	0.24 (0.25)	1.27 (0.78, 2.08)	0.94	0.3333
Other abdominal hernia procedures	-0.58 (0.33)	0.56 (0.29, 1.07)	3.10	0.0783
Anterior rectal procedures	-0.40 (0.41)	0.67 (0.30, 1.49)	0.95	0.3285
Bowel anastomoses	-0.58 (0.76)	0.56 (0.13, 2.50)	0.58	0.4479
Bowel procedures, other	-0.32 (0.52)	0.73 (0.26, 2.02)	0.37	0.5426
Other breast procedures	-1.92 (1.02)	0.15 (0.02, 1.09)	3.53	0.0602
Colostomy	-1.40 (0.79)	0.25 (0.05, 1.16)	3.14	0.0765
Femoral hernia repair	0.30 (0.50)	1.34 (0.51, 3.55)	0.35	0.5522
Gallbladder procedures, other	-1.10 (0.38)	0.33 (0.16, 0.70)	8.56	0.0034
Gastrectomy with anastomosis	-0.43 (0.57)	0.65 (0.21, 1.99)	0.57	0.4511
Gastrectomy, other	0.36 (0.46)	1.44 (0.59, 3.53)	0.62	0.4293
Gastric bypass	0.04 (0.58)	1.04 (0.33, 3.27)	0.00	0.9446
Other laparoscopic colon procedures	-1.22 (1.05)	0.29 (0.04, 2.30)	1.36	0.2432
Laparoscopic hemicolectomy	-0.31 (0.32)	0.73 (0.39, 1.38)	0.95	0.3301
Inguinal hernia repair	-1.01 (0.37)	0.37 (0.18, 0.75)	7.45	0.0063
Liver procedures	-0.29 (0.65)	0.75 (0.21, 2.69)	0.20	0.6551
Other open colon procedures	0.96 (0.35)	2.61 (1.33, 5.14)	7.70	0.0055
Ostomy closure	-2.02 (1.04)	0.13 (0.02, 1.02)	3.77	0.0523
Ostomy procedures, other	1.57 (0.39)	4.83 (2.25, 10.35)	16.38	<.0001
Pancreatic procedures, other	-1.12 (1.05)	0.33 (0.04, 2.57)	1.13	0.2877
Proctopexy for fistula repair	-0.10 (0.65)	0.90 (0.25, 3.23)	0.03	0.8738
Rectal resections	-0.70 (1.03)	0.50 (0.07, 3.77)	0.46	0.4991
Small bowel procedures	0.20 (0.23)	1.22 (0.78, 1.91)	0.75	0.3851
Stomach lesion repair	0.66 (0.47)	1.93 (0.77, 4.83)	1.97	0.1608
Stomach procedures, other	-0.47 (0.63)	0.63 (0.18, 2.15)	0.55	0.4585
Thyroid or parathyroid procedures	-0.67 (0.62)	0.51 (0.15, 1.72)	1.18	0.2774
Total pancreatectomy or whipple procedure	-1.16 (0.66)	0.31 (0.09, 1.15)	3.06	0.0804
Colectomy, total	0.94 (0.41)	2.57 (1.16, 5.68)	5.42	0.0200
Umbilical hernia repair	-0.23 (0.77)	0.80 (0.18, 3.57)	0.09	0.7676

The general surgery model for predicted risk of 30-day mortality was run on N=8,459 patients and has a c-statistic of 0.871.

Appendix 2 Appendix b. Orthopedic Surgery Probability of Death Model.

Variable	Estimate (SE)	Odds (95% CI)	Chi Sq	P
Model Intercept	-5.15 (0.32)	0.00 (0.00, 0.00)	257.73	<.0001
Age category (65-69) (reference)	--	--	--	--
Age category (70-74 years)	0.07 (0.27)	1.07 (0.64, 1.82)	0.07	0.7901
Age category (75-79 years)	0.01 (0.26)	1.01 (0.60, 1.70)	0.00	0.9738
Age category (80-84 years)	0.34 (0.25)	1.41 (0.86, 2.30)	1.81	0.1785
Age category (85+ years)	0.98 (0.24)	2.66 (1.67, 4.23)	16.91	<.0001
Sex (male)	0.76 (0.12)	2.14 (1.70, 2.69)	42.34	<.0001
Emergency admission	0.56 (0.17)	1.75 (1.26, 2.41)	11.38	0.0007
Transfer-in from another hospital's emergency department	0.63 (0.25)	1.87 (1.15, 3.04)	6.46	0.0110
Transfer-in status	1.04 (0.40)	2.82 (1.28, 6.21)	6.63	0.0100
Major Secondary Procedure	0.38 (0.19)	1.46 (1.02, 2.10)	4.16	0.0415
Comorbidities				
CHF	0.49 (0.13)	1.64 (1.27, 2.11)	14.64	0.0001
Stroke	0.19 (0.13)	1.21 (0.93, 1.57)	2.00	0.1573
Seizure	0.12 (0.28)	1.13 (0.65, 1.97)	0.19	0.6606
Dementia	0.68 (0.12)	1.97 (1.55, 2.49)	31.22	<.0001
Past Myocardial Infarction	-0.22 (0.17)	0.80 (0.57, 1.12)	1.64	0.2004
Past Arrhythmia	0.11 (0.12)	1.12 (0.88, 1.42)	0.88	0.3495
Unstable Angina	0.24 (0.34)	1.27 (0.65, 2.48)	0.47	0.4937
Angina	-0.10 (0.26)	0.91 (0.54, 1.51)	0.15	0.7006
Hypertension	-0.18 (0.19)	0.84 (0.58, 1.20)	0.92	0.3380
Valvular Disease	0.09 (0.12)	1.10 (0.87, 1.38)	0.61	0.4352
Chronic Lung Disease	0.49 (0.12)	1.63 (1.29, 2.06)	16.83	<.0001
Asthma	-0.15 (0.20)	0.86 (0.58, 1.28)	0.54	0.4614
Liver Disease	0.14 (0.22)	1.16 (0.75, 1.78)	0.43	0.5139
Renal Dysfunction	0.71 (0.12)	2.03 (1.60, 2.58)	33.67	<.0001
Renal Failure	0.47 (0.19)	1.59 (1.10, 2.31)	6.11	0.0134
Diabetes	-0.19 (0.12)	0.82 (0.65, 1.05)	2.48	0.1150
Paraplegia	0.02 (0.29)	1.02 (0.57, 1.80)	0.00	0.9566
Collagen Vascular Disease	-0.20 (0.20)	0.82 (0.55, 1.22)	0.94	0.3321
Coagulopathy	1.23 (0.35)	3.41 (1.70, 6.83)	11.92	0.0006
Thrombocytopenia	0.16 (0.25)	1.17 (0.73, 1.90)	0.42	0.5163
Other Coagulopathy	-0.17 (0.24)	0.85 (0.53, 1.35)	0.48	0.4881
Post-Inflammatory Pulmonary Fibrosis	0.47 (0.22)	1.60 (1.03, 2.48)	4.39	0.0362
Cancer	-0.11 (0.12)	0.90 (0.71, 1.13)	0.86	0.3527
Abdominal Cancer	0.47 (0.58)	1.61 (0.52, 5.02)	0.67	0.4144
Hypothyroidism	-0.04 (0.12)	0.96 (0.76, 1.22)	0.11	0.7427
Weight loss	0.86 (0.13)	2.38 (1.83, 3.09)	41.79	<.0001
Principal Procedures				
Open reduction of fracture (Reference)	--	--	--	--
Internal fixation of bone without fracture reduction, femur	-0.31 (0.25)	0.74 (0.45, 1.20)	1.51	0.2186
Total hip replacement	-1.18 (0.29)	0.31 (0.17, 0.55)	16.21	<.0001
Partial hip replacement	0.05 (0.14)	1.05 (0.80, 1.38)	0.13	0.7171
Total knee replacement	-1.60 (0.32)	0.20 (0.11, 0.38)	24.64	<.0001
Other hip procedures	-1.67 (1.05)	0.19 (0.02, 1.46)	2.55	0.1100
Hip revisions	-0.53 (0.42)	0.59 (0.26, 1.34)	1.59	0.2077
Other knee procedures	-1.36 (0.49)	0.26 (0.10, 0.66)	7.87	0.0050
Lumbar fusion	-1.59 (0.45)	0.20 (0.08, 0.50)	12.19	0.0005
Misc ortho procedures	-2.22 (1.02)	0.11 (0.02, 0.81)	4.69	0.0304
Forearm repair	-1.01 (0.53)	0.37 (0.13, 1.02)	3.69	0.0546
Humerus repair	-0.86 (0.44)	0.43 (0.18, 1.02)	3.71	0.0542

Repairs of the tibia and fibula	-0.59 (0.33)	0.55 (0.29, 1.06)	3.18	0.0745
Other shoulder procedures	-0.99 (0.42)	0.37 (0.16, 0.85)	5.52	0.0188
Other spinal procedures	-0.85 (0.33)	0.43 (0.23, 0.81)	6.85	0.0089
Cervical fusion	-0.94 (0.40)	0.39 (0.18, 0.85)	5.63	0.0177
Dorsal lumbar fusion	-0.94 (0.65)	0.39 (0.11, 1.39)	2.09	0.1480

The orthopedic surgery model for predicted risk of 30-day mortality was run on N=21,061 patients and has a c-statistic of 0.895.

Appendix 2c. Vascular Surgery Probability of Death Model.

Variable	Estimate (SE)	Odds (95% CI)	Chi Sq	P
Model Intercept	-5.63 (0.63)	0.00 (0.00, 0.00)	80.88	<.0001
Age category (65-69) (reference)	--	--	--	--
Age category (70-74 years)	0.38 (0.33)	1.46 (0.76, 2.77)	1.30	0.2537
Age category (75-79 years)	0.54 (0.32)	1.72 (0.92, 3.22)	2.86	0.0909
Age category (80-84 years)	0.76 (0.32)	2.14 (1.15, 3.99)	5.76	0.0164
Age category (85+ years)	1.04 (0.32)	2.82 (1.51, 5.29)	10.47	0.0012
Sex (male)	-0.14 (0.19)	0.87 (0.60, 1.25)	0.57	0.4485
Emergency admission	1.05 (0.20)	2.85 (1.93, 4.22)	27.53	<.0001
Transfer-in from another hospital's emergency department	0.22 (0.32)	1.25 (0.67, 2.33)	0.48	0.4904
Transfer-in status	1.06 (0.48)	2.88 (1.12, 7.39)	4.81	0.0282
Major Secondary Procedure	0.44 (0.19)	1.55 (1.07, 2.24)	5.26	0.0219
Comorbidities				
CHF	-0.07 (0.21)	0.93 (0.62, 1.41)	0.10	0.7467
Stroke	0.28 (0.20)	1.33 (0.89, 1.97)	1.94	0.1631
Seizure	-0.25 (0.45)	0.78 (0.32, 1.88)	0.31	0.5802
Dementia	0.47 (0.21)	1.60 (1.06, 2.43)	4.89	0.0271
Past Myocardial Infarction	0.57 (0.21)	1.76 (1.17, 2.65)	7.43	0.0064
Past Arrhythmia	0.07 (0.20)	1.08 (0.73, 1.58)	0.13	0.7137
Unstable Angina	-0.17 (0.45)	0.84 (0.35, 2.04)	0.14	0.7070
Angina	-0.70 (0.40)	0.50 (0.23, 1.08)	3.08	0.0791
Hypertension	-0.17 (0.40)	0.84 (0.39, 1.84)	0.18	0.6690
Valvular Disease	-0.18 (0.19)	0.83 (0.58, 1.20)	0.95	0.3289
Chronic Lung Disease	0.17 (0.19)	1.18 (0.82, 1.70)	0.78	0.3769
Asthma	-0.59 (0.36)	0.56 (0.28, 1.12)	2.69	0.1012
Liver Disease	0.82 (0.25)	2.27 (1.40, 3.66)	11.13	0.0009
Renal Dysfunction	0.95 (0.21)	2.59 (1.72, 3.90)	20.63	<.0001
Renal Failure	0.15 (0.25)	1.16 (0.71, 1.90)	0.34	0.5575
Diabetes	-0.42 (0.20)	0.66 (0.45, 0.97)	4.50	0.0338
Paraplegia	0.14 (0.36)	1.15 (0.58, 2.32)	0.16	0.6867
Collagen Vascular Disease	0.43 (0.30)	1.54 (0.86, 2.77)	2.08	0.1493
Coagulopathy	-0.29 (0.84)	0.75 (0.14, 3.91)	0.12	0.7328
Thrombocytopenia	0.52 (0.28)	1.69 (0.98, 2.92)	3.52	0.0605
Other Coagulopathy	0.55 (0.25)	1.74 (1.06, 2.85)	4.77	0.0290
Post-Inflammatory Pulmonary Fibrosis	-0.01 (0.38)	0.99 (0.47, 2.08)	0.00	0.9748
Cancer	0.05 (0.19)	1.05 (0.73, 1.52)	0.07	0.7984
Abdominal Cancer	0.07 (0.65)	1.07 (0.30, 3.80)	0.01	0.9152
Hypothyroidism	-0.30 (0.21)	0.74 (0.49, 1.13)	1.96	0.1615
Weight loss	0.38 (0.22)	1.47 (0.95, 2.28)	2.93	0.0868
Principal Procedures				
Endovascular implantation of other graft in the abdominal aorta (Reference)	--	--	--	--
Arteriovenostomy for renal dialysis	0.04 (0.61)	1.04 (0.31, 3.46)	0.00	0.9505
Other (peripheral) vascular shunt or bypass	0.89 (0.48)	2.44 (0.95, 6.26)	3.46	0.0629
Endovascular implantation of branching or fenestrated graft(s) in aorta	0.77 (0.83)	2.16 (0.42, 11.05)	0.85	0.3567

Other endovascular procedures on other vessels	1.17 (0.46)	3.22 (1.30, 8.01)	6.33	0.0119
Other amputation below knee	0.89 (0.52)	2.43 (0.88, 6.73)	2.93	0.0867
Aortic distal bypass	0.92 (0.74)	2.51 (0.59, 10.77)	1.54	0.2141
Artery procedure	1.29 (0.51)	3.64 (1.35, 9.81)	6.52	0.0107
Arteriovenostomy	0.32 (0.64)	1.38 (0.40, 4.80)	0.26	0.6130
Open carotid procedures	-0.86 (0.58)	0.42 (0.14, 1.31)	2.21	0.1370
Endarterectomy of the limbs	0.76 (0.57)	2.14 (0.71, 6.48)	1.81	0.1791
Open abdominal procedures	1.75 (0.51)	5.75 (2.11, 15.71)	11.66	0.0006
Stenting procedures	0.11 (0.69)	1.12 (0.29, 4.28)	0.03	0.8704
Vessel repair	1.77 (0.45)	5.86 (2.41, 14.26)	15.22	<.0001

The vascular surgery model for predicted risk of 30-day mortality was run on N=3,872 patients and has a c-statistic of 0.868.

Appendix 3. Complication Set for 30-day Complications and Failure to Rescue

Complication	Inclusion Criteria	Exclusion Criteria
Bronchospasm	ICD-9: 51911	
Cardiac Emergency	ICD-9: 41001, 41011, 41021, 41031, 41041, 41051, 41061, 41071, 41081, 41091, 4271, 42741, 4275, 78550, 78551, 3761, 3791, 9960, 9961, 9962, 9963, 9964, 9969 CPT: 92950, 92960, 92970, 92971, 92980, 92981, 92982, 92984, 92995, 92996, 92997, 92998	ICD-9: 4275, 78550, 78551, 78559, 7991, 9393, 9963
Cardiac Event	ICD-9: 41189, 42612, 42613, 42682, 42689, 42731, 42781, 42789, 7943199601, 9971, 3606, 3607, 3609, 3778, 3780, 3781, 3782, 3783 CPT: 33206, 33207, 33208, 33210, 33211, 33212, 33213, 33214, 33216, 33217, 33240, 33249, 92953, 93501, 93510, 93511, 93514, 93524, 93526, 93527, 93529	
Cerebrovascular Accident (CVA)/Stroke	ICD-9: 431, 43301, 43311, 43321, 43331, 43381, 43391, 43401, 43411, 43491, 436, 99702	ICD-9: 431, 43301, 43311, 43321, 43331, 43381, 43391, 43401, 43411, 43491, 436, 4380, 43810, 43811, 43812, 43813, 43814, 43819, 43820, 43821, 43822, 43830, 43831, 43832, 43840, 43841, 43842, 43850, 43851, 43852, 43853, 4386, 4387, 43881, 43882, 43883, 43884, 43885, 43889, 4389, 99702, V1253, V1254, V1259,
CHF	ICD-9: 4280, 4281, 42820, 42821, 42823, 42830, 42831, 42833, 42840, 42841, 42843, 4289, 5184, 9971	ICD-9: 39891, 40201, 40211, 40291, 40401, 40403, 40411, 40413, 40491, 40493, 4280, 4281, 42820, 42821, 42822, 42823, 42830, 42831, 42832, 42833, 42840, 42841, 42842, 42843, 4289, 5184,
Coma	ICD-9: 3481, 5722, 78001	
Compartment Syndrome	ICD-9: 9588, 99889	
Decubitus Ulcer	ICD-9: 70700, 70701, 70702, 70703, 70704, 70705, 70706, 70707, 70709, 70720, 70721, 70722, 70723, 70724, 70725,	
Deep Vein Thrombosis	ICD-9: 45340, 45341, 45342, 45350, 45351, 45352, 4536, 45371, 45372, 45373, 45374, 45375, 45376, 45377, 45379, 45381, 45382, 45383, 45384, 45385, 45386, 45387, 45389, 387	
Deep Wound Infection/Wound Complication	ICD-9: 99830, 99831, 99832, 99833, 99859, 9986, 5461, 8604, 8622, 8659, 8670, 8674 CPT: 10180, 11040, 11041, 11042, 11043, 11044, 11045, 11046, 11047	ICD-9: 70700, 70701, 70702, 70703, 70704, 70705, 70706, 70707, 70709, 70720, 70721, 70722, 70723, 70724, 70725,
Disseminated Intravascular Coagulopathy (DIC)	ICD-9: 2866	
Gangrene/Amputation	ICD-9: 72886, 7854, 8400, 8401, 8402, 8403, 8404, 8405, 8406, 8407, 8408, 8409,	ICD-9: , 8400, 8401, 8402, 8403, 8404, 8405, 8406, 8407, 8408, 8409, 8410, 8411,

Complication	Inclusion Criteria	Exclusion Criteria
	8410, 8411, 8412, 8413, 8414, 8415, 8416, 8417, 8418, 8419 CPT: 23900, 23920, 24900, 24920, 24930, 24931, 24940, 25900, 25905, 25909, 25920, 25924, 25927, 25931, 26910, 26951, 26952, 27290, 27295, 27590, 27591, 27592, 27596, 27598, 27880, 27881, 27882, 27886, 27888, 27889, 28800, 28805, 28810, 28820, 28825	8412, 8413, 8414, 8415, 8416, 8417, 8418, 8419
GI Bleed and Blood Loss	ICD-9: 2851, 4560, 45620, 5307, 53082, 53100, 53101, 53120, 53121, 53130, 53131, 53190, 53191, 53200, 53201, 53210, 53211, 53220, 53221, 53230, 53231, 53290, 53291, 53300, 53301, 53310, 53311, 53320, 53321, 53330, 53331, 53390, 53391, 53400, 53401, 53410, 53411, 53420, 53421, 53430, 53431, 53490, 53491, 53501, 53540, 53541, 53551, 53561, 53570, 53571, 53784, 56212, 56213, 5693, 56985, 5780, 5781, 5789 CPT: 43227, 43255, 44366, 44391, 45317, 45334, 75726	ICD-9: 2910, 2911, 2912, 2913, 2914, 2915, 29181, 29182, 29189, 2919, 30300, 30301, 30302, 30303, 30390, 30391, 30392, 30500, 30501, 30502, 30503, 800xx, 801xx, 802xx, 803xx, 804xx, 805xx, 806xx, 807xx, 808xx, 809xx, 810xx, 811xx, 812xx, 813xx, 814xx, 815xx, 817xx, 818xx, 819xx, 820xx, 821xx, 822xx, 823xx, 824xx, 825xx, 827xx, 828xx, 829xx, 830xx, 831xx, 832xx, 833xx, 834xx, 835xx, 836xx, 837xx, 838xx, 839xx, 850xx, 851xx, 852xx, 853xx, 854xx, 860xx, 861xx, 862xx, 863xx, 864xx, 865xx, 866xx, 867xx, 868xx, 869xx, 870xx, 871xx, 872xx, 873xx, 874xx, 875xx, 876xx, 877xx, 878xx, 879xx, 880xx, 881xx, 882xx, 884xx, 887xx, 890xx, 891xx, 892xx, 894xx, 896xx, 897xx, 900xx, 901xx, 902xx, 903xx, 904xx, 925xx, 926xx, 927xx, 928xx, 929xx, 940xx, 941xx, 942xx, 943xx, 944xx, 945xx, 946xx, 947xx, 948xx, 949xx, 952xx, 953xx, 958xx, 4440, 4441, 4442
Hepatitis/Jaundice	ICD-9: 570, 5733	
Hypotension/ Shock/Hypovolemia	ICD-9: 27650, 27651, 27652, 4589, 78550, 78551, 78552, 78559, 7963, 9950, 9954, 99800, 99801, 99802, 99809	
Internal Organ Damage	ICD-9: 34931, 34939, 99811, 99812, 99813, 9982, 3941, 5412, 5419 CPT: 35800, 35820, 35840, 35860	
Intestinal Obstruction	ICD-9: 5570, 56081, 5609, 99741, 99749	ICD-9: 5570, 56081, 5609,
Necrosis of the Bone-Thermal or Aseptic	ICD-9: 73340, 73341, 73342, 73343, 73344, 73345, 73349	
Nerve Compression	ICD-9: 3530, 3532, 7234, 9530, 9531, 9532, 9533, 9534, 9535, 9538, 9539, 9548, 9549, 9550, 9551, 9552, 9553, 9554, 9555, 9556, 9557, 9558, 9559, 9560, 9561, 9562, 9563, 9564, 9565, 9568, 9569, 9570, 9571, 9578, 9579	
Nervous System Complications	ICD-9: 99700, 99701, 99709, 0331, 8914, 8919	

Complication	Inclusion Criteria	Exclusion Criteria
Orthopedic Complication	ICD-9: 99640, 99641, 99642, 99643, 99644, 99645, 99646, 99647, 99649, 99666, 99677, 99678, 7860, 7869, 7971, 7975, 7976	ICD-9: , 0070, 0071, 0072, 0073, 0074, 0075, 0076, 0077, 0080, 0081, 0082, 0083, 0084, 8153, 8155, 8159, 8183, 8185
Osteomyelitis	ICD-9: 73000, 73001, 73002, 73003, 73004, 73005, 73006, 73007, 73008, 73009, 73020, 73021, 73022, 73023, 73024, 73025, 73026, 73027, 73028, 73029, 99667	ICD-9: 73000, 73001, 73002, 73003, 73004, 73005, 73006, 73007, 73008, 73009, 73020, 73021, 73022, 73023, 73024, 73025, 73026, 73027, 73028, 73029, 99667,
Pancreatitis	ICD-9: 5770	
Perforation	ICD-9: 34931, 34939, 5304, 56983, 9982	
Peritonitis	ICD-9: 5670, 5671, 56721, 56722, 56723, 56729, 56738, 56739, 5679, 5695, 5491	
Phlebitis	ICD-9: 4510, 45111, 45119, 4512, 45181, 45182, 45184, 45189, 4519	
Pneumonia, other	ICD-9: 481, 4820, 4821, 4822, 48230, 48231, 48232, 48239, 48240, 48241, 48242, 48249, 48281, 48282, 48283, 48284, 48289, 4829, 485, 486, 514, 99731, 99732, 99739	ICD-9: 042, 1363, 27900, 27901, 27902, 27903, 27904, 27905, 27906, 27909, 27910, 27911, 27912, 27913, 27919, 2792, 2793, 27941, 27949, 2798, 2799, 4800, 4801, 4802, 4803, 4808, 4809, 4830, 4831, 4838, 4841, 4843, 4845, 4846, 4847, 4848, 4870, 4871, 4878, 48801, 48811, 48881,
Pneumonia-Aspiration	ICD-9: 4829, 485, 486, 5070, 5071, 5078, 99731, 99732, 99739	
Pneumothorax/Effusion	ICD-9: 5120, 5121, 5122, 51281, 51282, 51283, 51284, 51289, 5180, 3404, 3406, 3491	
Post-Surgical Complication	ICD-9: 99700, 99701, 9972, 9975, 99851, 99881, 99882, 99889, 9989, 9990, 9991, 9992, 99931, 99932, 99933, 99934, 99939, 99941, 99942, 99949, 99951, 99952, 99959, 99960, 99961, 99962, 99963, 99969, 99970, 99971, 99972, 99973, 99974, 99975, 99976, 99977, 99978, 99979, 99980, 99981, 99982, 99983, 99984, 99985, 99988, 99989, 9999	
Psychosis	ICD-9: 2920, 29211, 29212, 2922, 29281, 29282, 29283, 29284, 29285, 29289, 2929, 2930, 2939, 29420, 29421, 2948, 2949	
Pulmonary embolus	ICD-9: 41511, 41512, 41513, 9581 CPT: 75741, 75743, 75894, 75896, 75940, 78579, 78580, 78582, 78584, 78585, 78586, 78587, 78588, 78591, 78593, 78594, 78599	
Pyelonephritis	ICD-9: 59010, 59011, 5902, 5903, 59080, 59081, 5909	
Renal Dysfunction	ICD-9: 5845, 5846, 5847, 5848, 5849, 7885, 7925, 99668, E8722, E8791, V4511, V560, V561, V562, V5631, V5632, V568, 3895, 3927, 3943, 5494, 5498 CPT: 4054F, 4055F, 90935, 90937, 90945, 90947, 90970, 90997, 90999	ICD-9: 3942, 7925, 99668, 99673, E8722, E8791, V4511, V560, V561, V562, V5631, V5632, V568 CPT: 36833, 90966, 90970, 90989, 90935, 90937, 90940, 90945, 90947, 90999, 99512, 99601, 4051F, 4052F, 4053F, 4054F, 4055F

Complication	Inclusion Criteria	Exclusion Criteria
Respiratory Compromise	ICD-9: 51851, 51852, 51853, 51881, 51889, 7991, 311, 3121, 3129, 9604, 9672 CPT: 31500, 31603, 31605, 31610	
Return to Surgery	ICD-9: 9984, 9987, 311, 3121, 3129, 9604, 9672 CPT: 32110, 32120, 32150, 49002	
Seizure	ICD-9: 78031, 78033, 78039	ICD-9: 34500, 34501, 34510, 34511, 3452, 3453, 34540, 34541, 34550, 34551, 34560, 34561, 34570, 34571, 34580, 34581, 34590, 34591,
Sepsis	ICD-9: 0380, 03810, 03811, 03812, 03819, 0382, 0383, 03840, 03841, 03842, 03843, 03844, 03849, 0388, 0389, 449, 78552, 7907	
Transient Ischemic Attack (TIA)	ICD-9: 4350, 4351, 4352, 4353, 4358, 4359	
Urinary Tract Infection	ICD-9: 5950, 5953, 5959, 5990	

The inclusion and exclusion ICD-9 diagnosis, ICD-9 procedure, and CPT codes were used to define in-hospital complications among surgical patients.

Appendix 4. Definitions of Resource Utilization-based Costs and Method of Cost Adjustment for Differences in Nurse Staffing and Skill Mix

We defined costs by resource utilization, as in previous work.¹⁻⁴

The algorithm is as follows:

A. Exclusions for Non-Acute Care

1. Inpatient Hospital (Part A) File
 - a. Exclude claim for hospitalizations in non-acute settings using 6-digit Medicare hospital ID (hospital identified as other than “Short-term (General and Specialty) Hospital” or “Critical Access Hospital”)
 - i. Include only if the 3rd position of the ID is equal to “0” or if the 3rd and 4th positions are equal to “13”
 - ii. Exclude if 4th, 5th, or 6th position in identifier is not a number
 - b. Exclude claim if DRG = 945 or 946 (Rehabilitation)
2. Outpatient File
 - a. Exclude claim for encounters in non-acute settings using 6-digit Medicare hospital ID (hospital identified as other than “Short-term (General and Specialty) Hospital” or “Critical Access Hospital”)
 - i. Include only if the 3rd position of the ID is equal to “0” or if the 3rd and 4th positions are equal to “13”
 - ii. Exclude if 4th, 5th, or 6th position in identifier is not a number
 - b. Exclude claim if principal diagnosis = V57 or subterms (Care involving use of rehabilitation procedures)
3. Physician/Carrier (Part B) File
 - a. Exclude any claim if the from and through dates fall on or between the admission and discharge dates of a non-acute hospitalization (as defined above) or between the from and through dates of a claim for outpatient care in a non-acute hospital
 - b. Exclude claim if no line item place of service codes from the following list appear:

11 = Office	15 = Mobile Unit
20 = Urgent Care Facility	21 = Inpatient hospital
22 = Outpatient hospital	23 = Emergency room - hospital
24 = Ambulatory surgical center	41 = Ambulance - land
42 = Ambulance - air or water	50 = Federally qualified health centers
65 = End stage renal disease treatment facility	71 = State or local public health clinic
81 = Independent laboratory	
 - c. Exclude claim if principal diagnosis = V57 or subterms (Care involving use of rehabilitation procedures)

B. Resource Utilization-Based Cost Accounting

1. Facility and Accommodation Costs from the Inpatient File:
 - a. Accommodations:
 - i. Determine number of inpatient critical care and non-critical care days from revenue centers in the Inpatient file.
 - ii. Multiply number of critical care/non-critical care days by average daily cost for each type (adjust to 2015 values using the Bureau of Labor & Statistics inflation factor, hospital component - CCM: \$4,866.52; Non-CCM: \$1,594.97)

Revenue Centers for:	
Non-Critical Care	Critical Care
0100-0101 All-inclusive rate-room and board	0200-0205 Intensive Care
0110-0119 Private medical or general	0207-0209 Intensive Care
0120-0129 Semi-private 2 bed (medical or general)	0210-0213, 0219 Coronary Care
0130-0139 Semi-private 3 and 4 beds	
0140-0149 Private (deluxe)	
0150-0159 Room & Board ward (medical or general)	

Hospital-level hourly adjustment =

$$\frac{\text{year}}{365.25 \text{ days}} * \frac{7 \text{ days}}{1 \text{ week}} * \frac{\text{week}}{36 \text{ hours}} * 1.2265$$

$$* \left\{ \left[(\text{RN Ratio}_{\text{Hosp } i} - \text{RN Ratio}_{\text{Ave}}) * \text{RN Salary}_{\text{National Ave}} \right] \right.$$

$$+ \left[(\text{LPN Ratio}_{\text{Hosp } i} - \text{LPN Ratio}_{\text{Ave}}) * \text{LPN Salary}_{\text{National Ave}} \right]$$

$$\left. + \left[(\text{UAP Ratio}_{\text{Hosp } i} - \text{UAP Ratio}_{\text{Ave}}) * \text{UAP Salary}_{\text{National Ave}} \right] \right\}$$

Patient-level adjustment = (hospital-level adjustment)*(patient LOS days)*(24 hours/day)

Average values for staffing ratios, calculated as the average value among our 306 study hospitals:

- RNs/patient: 0.3472
- LPNs/patient: 0.0102
- UAPs/patient: 0.0919

National average salaries in 2014 (figures from the Bureau of Labor Statistics's Occupational Employment Statistics):

Type of Nurse	Nat'l Salary	Hourly Wage w/out Benefits	Hourly Wage w/ Benefits
RN	\$69,790	\$37.15	\$45.57
LPN	\$43,420	\$23.12	\$28.35
UAP	\$26,250	\$13.97	\$17.14

Note. Data source for salary figures⁷

Description of other constants in the formula:

- 365.25 days / (7 days/week) is the estimated number of working weeks in a calendar year.
- 36 is the estimated number of work hours per week.

5. Summary Equation:

$$C_{i,30} = (D_{inp}^{CC} * 4,866.52 + D_{inp}^{NCC} * 1,594.97) + (T_{OR} * 22.30) + AU * 22.55 + ER * 554.12 + \sum RVU_j * 35.84 + RC$$

D_{inp}^{CC} = Number of days in critical care

D_{inp}^{NCC} = Number of days on hospital floor

T_{OR} = Number of minutes in operating room

AU = Number of anesthesia units

ER = Number of emergency room days

RVU_j = Number of all j RVUs from all bills over defined time period that includes all outpatient and office visits

RC = Readmission costs—all costs associated with hospitalization that began within 30 days of readmission

Appendix 5. Correlation and Principal Component Analysis of Nursing Resource Measures

Pearson correlations

	Staffing (2)	Skill Mix (3)	BSN (4)
Nurse work environment (1)	0.16508 (p=0.0002)	-0.08897 (p=0.0442)	0.27527 (p<0.0001)
Staffing (2)	--	0.19172 (p<0.0001)	0.18652 (p<0.0001)
Skill Mix (3)	--	--	0.07802 (p=0.0778)

Spearman correlations

	Staffing (2)	Skill Mix (3)	BSN (4)
Nurse work environment (1)	0.16010 (p=0.0003)	-0.13066 (p=0.0031)	0.26182 (p<0.0001)
Staffing (2)	--	0.21955 (p<0.0001)	0.22653 (p<0.0001)
Skill Mix (3)	--	--	0.07675 (p=0.0827)

Note. The direction of the staffing variable was adjusted to be consistent with the others, so that a higher number can be interpreted as more favorable.

Principal component analysis

Nursing Variable	Principal Component Weight
Nurse work environment	0.529029
Staffing	0.550792
BSN education	0.600448
Skill Mix	0.237104

Appendix 6. Definitions of Principal Procedures

The following lists include the ICD-9-CM principal procedures for this study. Matching of case and controls was exact for each principal procedure. Procedures were formed into Procedure Groups based on anatomical and technical similarity, which allowed the patients to be divided into smaller groups for matching purposes.

Appendix 6a. General Surgery

ICD-9	Procedure Group	Procedure Name
0722	Adrenal Procedures	Unilateral adrenalectomy
0729	Adrenal Procedures	Other partial adrenalectomy
4701	Appendectomy	Laparoscopic appendectomy
4709	Appendectomy	Other appendectomy
4590	Bowel Anastomoses	Intestinal anastomosis, not otherwise specified
4591	Bowel Anastomoses	Small-to-small intestinal anastomosis
4592	Bowel Anastomoses	Anastomosis of small intestine to rectal stump
4593	Bowel Anastomoses	Other small-to-large intestinal anastomosis
4594	Bowel Anastomoses	Large-to-large intestinal anastomosis
4673	Bowel Procedures, Other	Suture of laceration of small intestine, except duodenum
4674	Bowel Procedures, Other	Closure of fistula of small intestine, except duodenum
4675	Bowel Procedures, Other	Suture of laceration of large intestine
4679	Bowel Procedures, Other	Other repair of intestine
8542	Breast Procedures	Bilateral simple mastectomy
8544	Breast Procedures	Bilateral extended simple mastectomy
8523	Breast Procedures	Subtotal mastectomy
8541	Breast Procedures	Unilateral simple mastectomy
8543	Breast Procedures	Unilateral extended simple mastectomy
8545	Breast Procedures	Unilateral radical mastectomy
8547	Breast Procedures	Unilateral extended radical mastectomy
4240	Esophageal Procedures	Esophagectomy, not otherwise specified
4241	Esophageal Procedures	Partial esophagectomy
4242	Esophageal Procedures	Total esophagectomy
427	Esophageal Procedures	Esophagomyotomy
5321	Femoral Hernia Procedures	Unilateral repair of femoral hernia with graft or prosthesis
5329	Femoral Hernia Procedures	Other unilateral femoral herniorrhaphy
5123	Gallbladder Procedures	Laparoscopic cholecystectomy
5122	Gallbladder Procedures	Cholecystectomy
5124	Gallbladder Procedures	Laparoscopic partial cholecystectomy
5132	Gallbladder Procedures	Anastomosis of gallbladder to intestine
5136	Gallbladder Procedures	Choledochoenterostomy
5137	Gallbladder Procedures	Anastomosis of hepatic duct to gastrointestinal tract
5141	Gallbladder Procedures	Common duct exploration for removal of calculus
4438	Gastric Bypass	Laparoscopic gastroenterostomy
4439	Gastric Bypass	Other gastroenterostomy without gastrectomy
5369	Incisional and abdominal hernias	Other and open repair of other hernia of anterior abdominal wall with graft or prosthesis
5361	Incisional and abdominal hernias	Other open incisional hernia repair with graft or prosthesis
5372	Incisional and abdominal hernias	Other and open repair of diaphragmatic hernia, abdominal approach
5375	Incisional and abdominal hernias	Repair of diaphragmatic hernia, abdominal approach, not otherwise specified
5305	Inguinal Hernia Procedures	Repair of inguinal hernia with graft or prosthesis, not otherwise specified
1711	Inguinal Hernia Procedures	Laparoscopic repair of direct inguinal hernia with graft or prosthesis
1712	Inguinal Hernia Procedures	Laparoscopic repair of indirect inguinal hernia with graft or prosthesis

ICD-9	Procedure Group	Procedure Name
1713	Inguinal Hernia Procedures	Laparoscopic repair of inguinal hernia with graft or prosthesis, not otherwise specified
1721	Inguinal Hernia Procedures	Laparoscopic bilateral repair of direct inguinal hernia with graft or prosthesis
1723	Inguinal Hernia Procedures	Laparoscopic bilateral repair of inguinal hernia, one direct and one indirect, with graft or prosthesis
1724	Inguinal Hernia Procedures	Laparoscopic bilateral repair of inguinal hernia with graft or prosthesis, not otherwise specified
5301	Inguinal Hernia Procedures	Other and open repair of direct inguinal hernia
5303	Inguinal Hernia Procedures	Other and open repair of direct inguinal hernia with graft or prosthesis
5302	Inguinal Hernia Procedures	Other and open repair of indirect inguinal hernia
5304	Inguinal Hernia Procedures	Other and open repair of indirect inguinal hernia with graft or prosthesis
5300	Inguinal Hernia Procedures	Unilateral repair of inguinal hernia, not otherwise specified
5314	Inguinal Hernia Procedures	Other and open bilateral repair of direct inguinal hernia with graft or prosthesis
5315	Inguinal Hernia Procedures	Other and open bilateral repair of indirect inguinal hernia with graft or prosthesis
5317	Inguinal Hernia Procedures	Bilateral inguinal hernia repair with graft or prosthesis, not otherwise specified
4571	Large Bowel Resection	Open and other multiple segmental resection of large intestine
4572	Large Bowel Resection	Open and other cecectomy
4573	Large Bowel Resection	Open and other right hemicolectomy
4574	Large Bowel Resection	Open and other resection of transverse colon
4575	Large Bowel Resection	Open and other left hemicolectomy
4576	Large Bowel Resection	Open and other sigmoidectomy
4579	Large Bowel Resection	Other and unspecified partial excision of large intestine
1731	Large Bowel Resection	Laparoscopic multiple segmental resection of large intestine
1732	Large Bowel Resection	Laparoscopic cecectomy
1733	Large Bowel Resection	Laparoscopic right hemicolectomy
1734	Large Bowel Resection	Laparoscopic resection of transverse colon
1735	Large Bowel Resection	Laparoscopic left hemicolectomy
1736	Large Bowel Resection	Laparoscopic sigmoidectomy
1739	Large Bowel Resection	Other laparoscopic partial excision of large intestine
4581	Large Bowel Resection	Laparoscopic total intra-abdominal colectomy
4582	Large Bowel Resection	Open total intra-abdominal colectomy
4583	Large Bowel Resection	Other and unspecified total intra-abdominal colectomy
5022	Liver Procedures	Partial hepatectomy
5029	Liver Procedures	Other destruction of lesion of liver
503	Liver Procedures	Lobectomy of liver
5451	Lysis of Adhesions	Laparoscopic lysis of peritoneal adhesions
5459	Lysis of Adhesions	Other lysis of peritoneal adhesions
4603	Ostomy Procedures	Exteriorization of large intestine
4642	Ostomy Procedures	Repair of pericostomy hernia
4610	Ostomy Procedures	Colostomy, not otherwise specified
4611	Ostomy Procedures	Temporary colostomy
4613	Ostomy Procedures	Other Permanent colostomy
4651	Ostomy Procedures	Closure of stoma of small intestine
4652	Ostomy Procedures	Closure of stoma of large intestine
4601	Ostomy Procedures	Exteriorization of small intestine
4620	Ostomy Procedures	Ileostomy, not otherwise specified
4623	Ostomy Procedures	Other permanent ileostomy
4639	Ostomy Procedures	Other enterostomy
5252	Pancreatic Procedures	Distal pancreatectomy
5259	Pancreatic Procedures	Other partial pancreatectomy

ICD-9	Procedure Group	Procedure Name
526	Pancreatic Procedures	Total pancreatectomy
527	Pancreatic Procedures	Radical pancreaticoduodenectomy
0681	Parathyroidectomy	Complete parathyroidectomy
0689	Parathyroidectomy	Other parathyroidectomy
5493	PD Access Procedure	Creation of cutaneoperitoneal fistula
4862	Rectal Procedures	Anterior resection of rectum with synchronous colostomy
4863	Rectal Procedures	Other anterior resection of rectum
4869	Rectal Procedures	Other resection of rectum
4875	Rectal Procedures	Abdominal proctopexy
4876	Rectal Procedures	Other proctopexy
4879	Rectal Procedures	Other repair of rectum
4849	Rectal Procedures	Other pull-through resection of rectum
4850	Rectal Procedures	Abdominoperineal resection of the rectum, not otherwise specified
4851	Rectal Procedures	Laparoscopic abdominoperineal resection of the rectum
4852	Rectal Procedures	Open abdominoperineal resection of the rectum
4859	Rectal Procedures	Other abdominoperineal resection of the rectum
7072	Repair of Vaginal Fistulas	Repair of colovaginal fistula
7073	Repair of Vaginal Fistulas	Repair of rectovaginal fistula
4561	Small Bowel Resection	Multiple segmental resection of small intestine
4562	Small Bowel Resection	Other partial resection of small intestine
4563	Small Bowel Resection	Total removal of small intestine
415	Splenectomy	Total splenectomy
435	Stomach Procedures	Partial gastrectomy with anastomosis to esophagus
436	Stomach Procedures	Partial gastrectomy with anastomosis to duodenum
437	Stomach Procedures	Partial gastrectomy with anastomosis to jejunum
4389	Stomach Procedures	Open and other partial gastrectomy
4399	Stomach Procedures	Other total gastrectomy
4469	Stomach Procedures	Other repair of stomach
4342	Stomach Procedures	Local excision of other lesion or tissue of stomach
4429	Stomach Procedures	Other pyloroplasty
4466	Stomach Procedures	Other procedures for creation of esophagogastric sphincteric competence
4467	Stomach Procedures	Laparoscopic procedures for creation of esophagogastric sphincteric competence
064	Thyroid Procedures	Complete thyroidectomy
062	Thyroid Procedures	Unilateral thyroid lobectomy
0639	Thyroid Procedures	Other partial thyroidectomy
0650	Thyroid Procedures	Substernal thyroidectomy, not otherwise specified
0651	Thyroid Procedures	Partial substernal thyroidectomy
0652	Thyroid Procedures	Complete substernal thyroidectomy
4442	Ulcer Surgery	Suture of duodenal ulcer site
4441	Ulcer Surgery	Suture of gastric ulcer site
5341	Umbilical Hernia Procedures	Other and open repair of umbilical hernia with graft or prosthesis
5349	Umbilical Hernia Procedures	Other open umbilical herniorrhaphy
5351	Ventral Hernia Repair	Incisional hernia repair
5359	Ventral Hernia Repair	Repair of other hernia of anterior abdominal wall

Appendix 6b. Orthopedic Surgery

ICD-9	Procedure Group	Procedure Name
8156	Ankle Procedures	Total ankle replacement
8005	Arthrotomies	Arthrotomy for removal of prosthesis without replacement, hip
8006	Arthrotomies	Arthrotomy for removal of prosthesis without replacement, knee
8001	Arthrotomies	Arthrotomy for removal of prosthesis without replacement, shoulder

ICD-9	Procedure Group	Procedure Name
7747	Bone Biopsies	Biopsy of bone, tibia and fibula
7805	Bone grafts	Bone graft, femur
7807	Bone grafts	Bone graft, tibia and fibula
8085	Destruction of Lesion, NEC	Other local excision or destruction of lesion of joint, hip
8086	Destruction of Lesion, NEC	Other local excision or destruction of lesion of joint, knee
8081	Destruction of Lesion, NEC	Other local excision or destruction of lesion of joint, shoulder
8151	Hip Procedures	Total hip replacement
8152	Hip Procedures	Partial hip replacement
8140	Hip Procedures	Repair of hip, not elsewhere classified
0073	Hip Procedures	Revision of hip replacement, acetabular liner and/or femoral head only
0071	Hip Procedures	Revision of hip replacement, acetabular component
0072	Hip Procedures	Revision of hip replacement, femoral component
0070	Hip Procedures	Revision of hip replacement, both acetabular and femoral components
8153	Hip Procedures	Revision of hip replacement, not otherwise specified
7855	Internal Fixation	Internal fixation of bone without fracture reduction, femur
7852	Internal Fixation	Internal fixation of bone without fracture reduction, humerus
7857	Internal Fixation	Internal fixation of bone without fracture reduction, tibia and fibula
8154	Knee Procedures	Total knee replacement
806	Knee Procedures	Excision of semilunar cartilage of knee
8076	Knee Procedures	Synovectomy, knee
8144	Knee Procedures	Patellar stabilization
8147	Knee Procedures	Other repair of knee
0080	Knee Procedures	Revision of knee replacement, total (all components)
0083	Knee Procedures	Revision of knee replacement, patellar component
8155	Knee Procedures	Revision of knee replacement, not otherwise specified
0081	Knee Procedures	Revision of knee replacement, tibial component
0082	Knee Procedures	Revision of knee replacement, femoral component
0084	Knee Procedures	Revision of total knee replacement, tibial insert (liner)
7765	Local Excision of Bone Lesion	Local excision of lesion or tissue of bone, femur
7766	Local Excision of Bone Lesion	Local excision of lesion or tissue of bone, patella
7762	Local Excision of Bone Lesion	Local excision of lesion or tissue of bone, humerus
7763	Local Excision of Bone Lesion	Local excision of lesion or tissue of bone, radius and ulna
7767	Local Excision of Bone Lesion	Local excision of lesion or tissue of bone, tibia and fibula
8111	Lower Extremity Fusions	Ankle fusion
8112	Lower Extremity Fusions	Triple arthrodesis
8113	Lower Extremity Fusions	Subtalar fusion
8116	Lower Extremity Fusions	Metatarsophalangeal fusion
7935	Open Reductions	Open reduction of fracture with internal fixation, femur
7922	Open Reductions	Open reduction of fracture without internal fixation, radius and ulna
7932	Open Reductions	Open reduction of fracture with internal fixation, radius and ulna
7921	Open Reductions	Open reduction of fracture without internal fixation, humerus
7931	Open Reductions	Open reduction of fracture with internal fixation, humerus
7926	Open Reductions	Open reduction of fracture without internal fixation, tibia and fibula
7936	Open Reductions	Open reduction of fracture with internal fixation, tibia and fibula
7939	Open Reductions	Open reduction of fracture with internal fixation, other specified bone
8051	Orthoscopies	Excision of intervertebral disc
8026	Orthoscopies	Arthroscopy, knee
7785	Partial Osteotomies	Other partial osteotomy, femur
7786	Partial Osteotomies	Other partial osteotomy, patella
7782	Partial Osteotomies	Other partial osteotomy, humerus
7787	Partial Osteotomies	Other partial osteotomy, tibia and fibula
7756	Repair of Hammer Toe	Repair of hammer toe

ICD-9	Procedure Group	Procedure Name
7865	Repair of Implanted Device in Bone	Removal of implanted devices from bone, femur
7866	Repair of Implanted Device in Bone	Removal of implanted devices from bone, patella
7862	Repair of Implanted Device in Bone	Removal of implanted devices from bone, humerus
7863	Repair of Implanted Device in Bone	Removal of implanted devices from bone, radius and ulna
7867	Repair of Implanted Device in Bone	Removal of implanted devices from bone, tibia and fibula
7869	Repair of Implanted Device in Bone	Removal of implanted devices from bone, other bones
8180	Shoulder Procedures	Other total shoulder replacement
8181	Shoulder Procedures	Partial shoulder replacement
8183	Shoulder Procedures	Other repair of shoulder
034	Spinal and Vertebral Procedures	Excision or destruction of lesion of spinal cord or spinal meninges
0353	Spinal and Vertebral Procedures	Repair of vertebral fracture
0302	Spinal and Vertebral Procedures	Reopening of laminectomy site
0309	Spinal and Vertebral Procedures	Other exploration and decompression of spinal canal
8106	Spinal Fusions	Lumbar and lumbosacral fusion of the anterior column, anterior technique
8107	Spinal Fusions	Lumbar and lumbosacral fusion of the posterior column, posterior technique
8108	Spinal Fusions	Lumbar and lumbosacral fusion of the anterior column, posterior technique
8101	Spinal Fusions	Atlas-axis spinal fusion
8102	Spinal Fusions	Other cervical fusion of the anterior column, anterior technique
8103	Spinal Fusions	Other cervical fusion of the posterior column, posterior technique
8104	Spinal Fusions	Dorsal and dorsolumbar fusion of the anterior column, anterior technique
8105	Spinal Fusions	Dorsal and dorsolumbar fusion of the posterior column, posterior technique
8132	Spinal Refusions	Refusion of other cervical spine, anterior column, anterior technique
8133	Spinal Refusions	Refusion of other cervical spine, posterior column, posterior technique
8134	Spinal Refusions	Refusion of dorsal and dorsolumbar spine, anterior column, anterior technique
8135	Spinal Refusions	Refusion of dorsal and dorsolumbar spine, posterior column, posterior technique
8136	Spinal Refusions	Refusion of lumbar and lumbosacral spine, anterior column, anterior technique
8137	Spinal Refusions	Refusion of lumbar and lumbosacral spine, posterior column, posterior technique
8138	Spinal Refusions	Refusion of lumbar and lumbosacral spine, anterior column, posterior technique
8364	Suture of Tendon	Other suture of tendon
7796	Total Osteotomies	Total osteotomy, patella
7797	Total Osteotomies	Total osteotomy, tibia and fibula
8197	Upper Extremity Procedures	Revision of joint replacement of upper extremity
8184	Upper Extremity Procedures	Total elbow replacement

ICD-9	Procedure Group	Procedure Name
8185	Upper Extremity Procedures	Other repair of elbow
835	Upper Extremity Procedures	Bursectomy
8363	Upper Extremity Procedures	Rotator cuff repair

Appendix 6c. Vascular Surgery

ICD-9	Procedure Group	Procedure Name
3926	Aortic-distal Bypass	Other intra-abdominal vascular shunt or bypass
3922	Aortic-distal Bypass	Aorta-subclavian-carotid bypass
3924	Aortic-distal Bypass	Aorta-renal bypass
3925	Aortic-distal Bypass	Aorta-iliac-femoral bypass
3803	Artery Incisions	Incision of vessel, upper limb vessels
3808	Artery Incisions	Incision of vessel, lower limb arteries
3802	Artery Incisions	Incision of vessel, other vessels of head and neck
3806	Artery Incisions	Incision of vessel, abdominal arteries
3953	AV Fistula Repair	Repair of arteriovenous fistula
8415	Below-Knee Amputation	Other amputation below knee
3927	Dialysis Access	Arteriovenostomy for renal dialysis
3942	Dialysis Access	Revision of arteriovenous shunt for renal dialysis
3943	Dialysis Access	Removal of arteriovenous shunt for renal dialysis
3929	Distal Bypass Procedure	Other (peripheral) vascular shunt or bypass
3812	Endarterectomies	Endarterectomy, other vessels of head and neck
3810	Endarterectomies	Endarterectomy, unspecified site
3813	Endarterectomies	Endarterectomy, upper limb vessels
3818	Endarterectomies	Endarterectomy, lower limb arteries
3814	Endarterectomies	Endarterectomy, aorta
3815	Endarterectomies	Endarterectomy, other thoracic vessels
3816	Endarterectomies	Endarterectomy, abdominal arteries
3971	Endovascular Vessel Repair (AAA)	Endovascular implantation of other graft in abdominal aorta
3978	Endovascular Vessel Repair (AAA)	Endovascular implantation of branching or fenestrated graft(s) in aorta
3979	Endovascular Vessel Repair (AAA)	Other endovascular procedures on other vessels
3974	Endovascular Vessel Repair (non-AAA)	Endovascular removal of obstruction from head and neck vessel(s)
3972	Endovascular Vessel Repair (non-AAA)	Endovascular (total) embolization or occlusion of head and neck vessels
391	Intra-abdominal Venous Shunt	Intra-abdominal venous shunt
3956	Repair of Blood Vessel	Repair of blood vessel with tissue patch graft
3957	Repair of Blood Vessel	Repair of blood vessel with synthetic patch graft
3958	Repair of Blood Vessel	Repair of blood vessel with unspecified type of patch graft
0061	Stenting Procedures	Percutaneous angioplasty of extracranial vessel(s)
0063	Stenting Procedures	Percutaneous insertion of carotid artery stent(s)

ICD-9	Procedure Group	Procedure Name
3949	Vascular, Other	Other revision of vascular procedure
3863	Vessel Excision (non-AAA)	Other excision of vessels, upper limb vessels
3868	Vessel Excision (non-AAA)	Other excision of vessels, lower limb arteries
3834	Vessel Resection and Anastomosis or Replacement (AAA)	Resection of vessel with anastomosis, aorta
3844	Vessel Resection and Anastomosis or Replacement (AAA)	Resection of vessel with replacement, aorta, abdominal
3832	Vessel Resection and Anastomosis or Replacement (non-AAA)	Resection of vessel with anastomosis, other vessels of head and neck
3842	Vessel Resection and Anastomosis or Replacement (non-AAA)	Resection of vessel with replacement, other vessels of head and neck
3846	Vessel Resection and Anastomosis or Replacement (non-AAA)	Resection of vessel with replacement, abdominal arteries
3833	Vessel Resection and Anastomosis or Replacement (non-AAA)	Resection of vessel with anastomosis, upper limb vessels
3848	Vessel Resection and Anastomosis or Replacement (non-AAA)	Resection of vessel with replacement, lower limb arteries

Appendix 7. Complete Matching Results with All Variables

Variable (Percent unless noted)	All Focal Cases	Matched Focal Cases	Matched Controls	All Controls	Standardized Difference before Match	P- value	Standardized Difference after Match	P- value
Number of Patients	87,847	62,715	62,715	212,683				
Age (years, mean)	75.7	76.3	76.4	76.8	-0.14	<.0001	-0.01	0.0065
Age 65-69	25.0	23.4	23.0	20.9	0.10	<.0001	0.01	0.1254
Age 70-74	25.2	24.0	23.5	23.0	0.05	<.0001	0.01	0.0236
Age 75-79	20.4	20.1	20.3	20.7	-0.01	0.0232	-0.01	0.3081
Age 80-84	14.7	15.6	16.1	16.8	-0.06	<.0001	-0.01	0.0496
Age 85+	14.8	16.9	17.2	18.5	-0.10	<.0001	-0.01	0.2015
Race (% non-Hispanic white)	78.6	80.2	81.7	89.6	-0.30	<.0001	-0.04	<.0001
Race (% Black)	4.9	3.9	4.7	3.4	0.08	<.0001	-0.04	<.0001
Race (% Hispanic)	9.2	9.8	8.6	4.6	0.18	<.0001	0.05	<.0001
Race (% other)	7.2	6.1	5.1	2.4	0.23	<.0001	0.05	<.0001
Dual Eligible status	17.2	17.0	15.8	13.2	0.11	<.0001	0.03	<.0001
Sex (% male)	41.9	41.2	41.2	41.2	0.01	0.0005	0.00	0.9771
Probability of 30-day death	2.7	2.9	2.8	3.2	-0.08	<.0001	0.01	0.5670
Predicted ICU or Intermediate Care Utilization (mean)	29.8	29.5	29.4	30.4	-0.02	<.0001	0.00	0.3461
Predicted LOS (mean)	4.2	4.3	4.3	4.4	-0.08	<.0001	0.00	0.5407
Predicted Cost (\$, mean)	1,9687	1,9336	1,9277	1,9673	0.00	<.0001	0.01	0.0740
30-Day Mortality Risk Quintile 1	20.4	20.3	20.3	19.8	0.01	0.0005	0.00	1.0000
30-Day Mortality Risk Quintile 2	20.6	20.0	20.0	19.7	0.02	<.0001	0.00	1.0000
30-Day Mortality Risk Quintile 3	21.4	20.3	20.3	19.4	0.05	<.0001	0.00	1.0000
30-Day Mortality Risk Quintile 4	20.1	20.1	20.1	20.0	0.00	0.6197	0.00	1.0000
30-Day Mortality Risk Quintile 5	17.5	19.2	19.2	21.0	-0.09	<.0001	0.00	1.0000
Emergent admission	24.6	28.0	28.6	34.3	-0.21	<.0001	-0.01	0.0287
Transfer-in	0.4	0.5	0.6	0.9	-0.06	<.0001	-0.02	0.0033
Transfer-in from another hospital's emergency department	1.5	1.8	1.4	1.9	-0.03	<.0001	0.03	<.0001
Major Secondary Procedure	35.1	31.2	30.9	29.0	0.13	<.0001	0.01	0.3506
Comorbidities								
Congestive Heart Failure	15.3	15.7	15.3	16.3	-0.02	<.0001	0.01	0.0473
Past Myocardial Infarction	8.9	8.9	9.1	10.3	-0.05	<.0001	-0.01	0.1314
Past Arrhythmia	30.2	29.9	29.7	31.3	-0.02	<.0001	0.00	0.5452
Angina	4.3	4.3	4.1	5.8	-0.07	<.0001	0.01	0.1102
Valvular Disease	22.7	22.8	23.1	26.3	-0.08	<.0001	-0.01	0.1547
Unstable Angina	1.5	1.6	1.3	1.8	-0.03	<.0001	0.02	0.0004
Hypertension	83.5	85.0	85.8	87.4	-0.11	<.0001	-0.02	0.0001

Variable (Percent unless noted)	All Focal Cases	Matched Focal Cases	Matched Controls	All Controls	Standardized Difference before Match	P- value	Standardized Difference after Match	P- value
Diabetes	32.4	33.0	33.4	34.4	-0.04	<.0001	-0.01	0.1094
Renal Dysfunction	21.2	22.5	22.4	22.5	-0.03	<.0001	0.00	0.7097
Renal Failure	5.6	5.7	5.2	5.1	0.02	<.0001	0.02	0.0005
Liver Disease	10.5	9.5	8.7	8.4	0.07	<.0001	0.03	<.0001
Cancer	37.4	35.3	35.1	36.6	0.02	<.0001	0.01	0.2981
Abdominal Cancer	2.8	1.8	1.5	1.2	0.11	<.0001	0.02	0.0002
Dementia	11.1	12.6	12.7	13.8	-0.08	<.0001	0.00	0.9188
Stroke	14.1	14.5	14.3	15.3	-0.03	<.0001	0.01	0.3513
Seizure	2.0	2.0	1.9	2.2	-0.01	0.0021	0.00	0.4384
Paraplegia	2.7	2.7	2.4	2.4	0.02	<.0001	0.02	<.0001
COPD	20.2	21.3	21.9	25.6	-0.13	<.0001	-0.02	0.0037
Asthma	11.4	10.9	10.2	10.4	0.03	<.0001	0.02	<.0001
Post-Inflammatory Pulmonary Fibrosis	2.6	2.7	2.4	2.7	0.00	0.2692	0.02	0.0001
Hypothyroidism	27.3	27.7	26.3	28.3	-0.02	<.0001	0.03	<.0001
Thrombocytopenia	3.1	3.0	2.5	2.8	0.02	<.0001	0.03	<.0001
Collagen Vascular Disease	9.1	8.7	9.1	10.0	-0.03	<.0001	-0.01	0.0109
AIDS	0.2	0.2	0.1	0.1	0.02	<.0001	0.01	0.0122
Chronic Peptic Ulcer	0.2	0.2	0.1	0.1	0.00	0.4346	0.01	0.1516
Coagulopathy	0.8	0.8	0.7	1.0	-0.02	<.0001	0.01	0.0060
Other Coagulopathy	5.2	5.0	4.0	5.1	0.00	0.4307	0.04	<.0001
Cushings' Disease	0.1	0.1	0.1	0.1	0.01	0.0203	0.00	0.4504
Graves' Disease	0.4	0.4	0.3	0.3	0.01	0.0020	0.00	0.6667
Hemoglobin Disorder	0.0	0.0	0.0	0.0	0.00	0.8085	0.00	0.5966
Weightloss	9.9	9.6	9.3	9.7	0.01	0.0315	0.01	0.0559
Hospital Characteristics								
Large (%)	78.0	73.4	73.4	59.1	0.42	<.0001	0.00	1.0000
Small (%)	22.0	26.6	26.6	40.9	-0.42	<.0001	0.00	1.0000
< 100 beds (%)	1.0	1.2	1.0	3.9	-0.19	<.0001	0.01	0.0003
100-249 beds (%)	21.0	25.4	25.6	37.1	-0.36	<.0001	0.00	0.3891
250-499 beds (%)	39.8	45.4	46.2	43.5	-0.08	<.0001	-0.02	0.0041
500+ beds (%)	38.2	28.0	27.2	15.6	0.53	<.0001	0.02	0.0014
Beds (mean)	460.4	407.2	381.2	317.3	0.69	<.0001	0.12	<.0001
Major teaching (%)	39.7	17.9	17.9	6.6	0.85	<.0001	0.00	1.0000
Minor teaching (%)	18.2	25.0	25.0	29.5	-0.27	<.0001	0.00	1.0000
Nonteaching (%)	42.1	57.0	57.0	63.8	-0.45	<.0001	0.00	1.0000
Resident to bed ratio (mean)	0.3	0.1	0.1	0.1	0.82	<.0001	0.08	<.0001
High technology status	87.7	85.2	85.2	52.3	0.84	<.0001	0.00	1.0000

Variable (Percent unless noted)	All Focal Cases	Matched Focal Cases	Matched Controls	All Controls	Standardized Difference before Match	P- value	Standardized Difference after Match	P- value
Principal Procedures								
Unilateral thyroid lobectomy (062)	0.1	0.1	0.1	0.1	0.01	0.0037	0.00	1.0000
Excision of lesion of thyroid (0631)	---	---	---	---	0.00	0.3173	0.00	1.0000
Other partial thyroidectomy (0639)	0.0	0.0	0.0	0.0	0.01	0.0341	0.00	1.0000
Complete thyroidectomy (064)	0.4	0.3	0.3	0.2	0.05	<.0001	0.00	1.0000
Substernal thyroidectomy, not otherwise specified (0650)	---	---	---	---	0.00	1.0000	0.00	1.0000
Partial substernal thyroidectomy (0651)	0.0	---	---	0.0	0.01	0.0014	0.00	1.0000
Complete substernal thyroidectomy (0652)	0.0	---	---	0.0	0.01	0.0006	0.00	1.0000
Complete parathyroidectomy (0681)	0.0	---	---	0.0	0.01	0.0080	0.00	1.0000
Other parathyroidectomy (0689)	0.2	0.2	0.2	0.1	0.03	<.0001	0.00	1.0000
Unilateral adrenalectomy (0722)	0.2	0.1	0.1	0.0	0.04	<.0001	0.00	1.0000
Other partial adrenalectomy (0729)	---	---	---	---	0.01	0.0097	0.00	1.0000
Bilateral adrenalectomy (073)	---	---	---	---	0.00	1.0000	0.00	1.0000
Laparoscopic repair of direct inguinal hernia with graft or prosthesis (1711)	0.0	---	---	0.0	0.01	0.0464	0.00	1.0000
Laparoscopic repair of indirect inguinal hernia with graft or prosthesis (1712)	0.0	0.0	0.0	0.0	0.01	0.0820	0.00	1.0000
Laparoscopic repair of inguinal hernia with graft or prosthesis, not otherwise specified (1713)	0.0	0.0	0.0	0.0	-0.01	0.0833	0.00	1.0000
Laparoscopic bilateral repair of direct inguinal hernia with graft or prosthesis (1721)	---	---	---	---	-0.01	0.0518	0.00	1.0000
Laparoscopic bilateral repair of indirect inguinal hernia with graft or prosthesis (1722)	---	---	---	---	0.01	0.0497	0.00	1.0000
Laparoscopic bilateral repair of inguinal hernia, one direct and one indirect, with graft or prosthesis (1723)	---	---	---	---	0.00	0.4365	0.00	1.0000
Laparoscopic bilateral repair of inguinal hernia with graft or prosthesis, not otherwise specified (1724)	---	---	---	---	0.00	0.4365	0.00	1.0000
Laparoscopic multiple segmental resection of large intestine (1731)	---	---	---	---	0.00	0.2712	0.00	1.0000
Laparoscopic cecectomy (1732)	0.1	0.1	0.1	0.1	0.00	0.5392	0.00	1.0000
Laparoscopic right hemicolectomy (1733)	1.2	1.1	1.1	1.0	0.02	<.0001	0.00	1.0000
Laparoscopic resection of transverse colon (1734)	0.1	0.1	0.1	0.1	0.00	0.3814	0.00	1.0000
Laparoscopic left hemicolectomy (1735)	0.2	0.2	0.2	0.2	0.01	0.0046	0.00	1.0000
Laparoscopic sigmoidectomy (1736)	0.6	0.6	0.6	0.5	0.01	0.0942	0.00	1.0000

Variable (Percent unless noted)	All Focal Cases	Matched Focal Cases	Matched Controls	All Controls	Standardized Difference before Match	P- value	Standardized Difference after Match	P- value
Other laparoscopic partial excision of large intestine (1739)	0.0	0.0	0.0	0.1	-0.01	0.2265	0.00	1.0000
Total splenectomy (415)	0.2	0.1	0.1	0.1	0.01	0.0030	0.00	1.0000
Esophagectomy, not otherwise specified (4240)	0.0	---	---	0.0	0.01	0.0211	0.00	1.0000
Partial esophagectomy (4241)	0.1	0.1	0.1	0.0	0.03	<.0001	0.00	1.0000
Total esophagectomy (4242)	0.1	---	---	0.0	0.04	<.0001	0.00	1.0000
Esophagomyotomy (427)	0.1	0.0	0.0	0.0	0.04	<.0001	0.00	1.0000
Local excision of other lesion or tissue of stomach (4342)	0.1	0.0	0.0	0.0	0.01	0.0004	0.00	1.0000
Partial gastrectomy with anastomosis to esophagus (435)	0.0	0.0	0.0	0.0	0.01	0.0299	0.00	1.0000
Partial gastrectomy with anastomosis to duodenum (436)	0.0	---	---	0.0	-0.01	0.1874	0.00	1.0000
Partial gastrectomy with anastomosis to jejunum (437)	0.2	0.2	0.2	0.2	0.01	0.0016	0.00	1.0000
Open and other partial gastrectomy (4389)	0.1	0.1	0.1	0.1	0.01	0.0018	0.00	1.0000
Other total gastrectomy (4399)	0.2	0.1	0.1	0.0	0.03	<.0001	0.00	1.0000
Other pyloroplasty (4429)	0.0	0.0	0.0	0.0	0.00	1.0000	0.00	1.0000
Laparoscopic gastroenterostomy (4438)	0.2	0.2	0.2	0.2	0.01	0.0010	0.00	1.0000
Other gastroenterostomy without gastrectomy (4439)	0.1	0.1	0.1	0.1	0.00	0.5960	0.00	1.0000
Suture of gastric ulcer site (4441)	0.1	0.1	0.1	0.1	-0.01	0.0040	0.00	1.0000
Suture of duodenal ulcer site (4442)	0.2	0.2	0.2	0.2	-0.01	0.0009	0.00	1.0000
Other procedures for creation of esophagogastric sphincteric competence (4466)	0.1	0.0	0.0	0.0	0.01	0.0811	0.00	1.0000
Laparoscopic procedures for creation of esophagogastric sphincteric competence (4467)	0.4	0.4	0.4	0.2	0.04	<.0001	0.00	1.0000
Other repair of stomach (4469)	0.0	0.0	0.0	0.0	0.01	0.1839	0.00	1.0000
Multiple segmental resection of small intestine (4561)	0.1	0.1	0.1	0.1	0.00	0.5490	0.00	1.0000
Other partial resection of small intestine (4562)	1.2	1.3	1.3	1.3	-0.01	0.0404	0.00	1.0000
Total removal of small intestine (4563)	---	---	---	---	0.01	0.1931	0.00	1.0000
Open and other multiple segmental resection of large intestine (4571)	0.0	0.0	0.0	0.0	-0.01	0.0428	0.00	1.0000
Open and other cecectomy (4572)	0.1	0.1	0.1	0.1	0.00	0.3138	0.00	1.0000
Open and other right hemicolectomy (4573)	1.2	1.5	1.5	1.7	-0.04	<.0001	0.00	1.0000
Open and other resection of transverse colon (4574)	0.1	0.2	0.2	0.2	-0.02	<.0001	0.00	1.0000

Variable (Percent unless noted)	All Focal Cases	Matched Focal Cases	Matched Controls	All Controls	Standardized Difference before Match	P- value	Standardized Difference after Match	P- value
Open and other left hemicolectomy (4575)	0.4	0.4	0.4	0.5	-0.03	<.0001	0.00	1.0000
Open and other sigmoidectomy (4576)	0.9	1.1	1.1	1.3	-0.04	<.0001	0.00	1.0000
Other and unspecified partial excision of large intestine (4579)	0.2	0.2	0.2	0.2	-0.01	0.2012	0.00	1.0000
Laparoscopic total intra-abdominal colectomy (4581)	0.1	0.0	0.0	0.0	0.02	<.0001	0.00	1.0000
Open total intra-abdominal colectomy (4582)	0.1	0.1	0.1	0.1	0.00	0.3456	0.00	1.0000
Other and unspecified total intra-abdominal colectomy (4583)	0.0	0.0	0.0	0.0	0.01	0.0171	0.00	1.0000
Intestinal anastomosis, not otherwise specified (4590)	---*	---*	---*	---*	0.00	0.4628	0.00	1.0000
Small-to-small intestinal anastomosis (4591)	0.0	---*	---*	0.0	0.00	0.3818	0.00	1.0000
Anastomosis of small intestine to rectal stump (4592)	---*	---*	---*	---*	0.00	1.0000	0.00	1.0000
Other small-to-large intestinal anastomosis (4593)	0.1	0.1	0.1	0.1	0.01	0.1172	0.00	1.0000
Large-to-large intestinal anastomosis (4594)	0.1	0.0	0.0	0.1	0.00	1.0000	0.00	1.0000
Anastomosis to anus (4595)	---*	---*	---*	---*	0.01	0.0567	0.00	1.0000
Exteriorization of small intestine (4601)	0.1	0.1	0.1	0.0	0.01	0.0720	0.00	1.0000
Exteriorization of large intestine (4603)	0.1	0.2	0.2	0.2	-0.01	0.0034	0.00	1.0000
Colostomy, not otherwise specified (4610)	0.1	0.2	0.2	0.2	-0.01	0.0226	0.00	1.0000
Temporary colostomy (4611)	---*	---*	---*	---*	-0.01	0.0448	0.00	1.0000
Permanent colostomy (4613)	0.0	---*	---*	0.0	0.00	0.6109	0.00	1.0000
Ileostomy, not otherwise specified (4620)	0.0	---*	---*	0.0	0.00	0.7180	0.00	1.0000
Temporary ileostomy (4621)	---*	---*	---*	---*	0.01	0.1531	0.00	1.0000
Other permanent ileostomy (4623)	---*	---*	---*	---*	0.00	0.3488	0.00	1.0000
Other enterostomy (4639)	0.1	0.1	0.1	0.1	0.00	0.3382	0.00	1.0000
Repair of pericostomy hernia (4642)	0.1	0.1	0.1	0.1	0.01	0.0162	0.00	1.0000
Closure of stoma of small intestine (4651)	0.2	0.1	0.1	0.1	0.03	<.0001	0.00	1.0000
Closure of stoma of large intestine (4652)	0.2	0.2	0.2	0.2	0.01	0.0109	0.00	1.0000
Suture of laceration of small intestine, except duodenum (4673)	0.0	0.0	0.0	0.0	-0.01	0.2296	0.00	1.0000
Closure of fistula of small intestine, except duodenum (4674)	0.1	0.0	0.0	0.0	0.02	<.0001	0.00	1.0000
Suture of laceration of large intestine (4675)	0.0	0.0	0.0	0.0	0.00	0.6448	0.00	1.0000
Other repair of intestine (4679)	0.0	---*	---*	0.0	0.00	0.8789	0.00	1.0000
Laparoscopic appendectomy (4701)	0.9	1.0	1.0	1.1	-0.02	<.0001	0.00	1.0000
Other appendectomy (4709)	0.2	0.2	0.2	0.3	-0.02	<.0001	0.00	1.0000

Variable (Percent unless noted)	All Focal Cases	Matched Focal Cases	Matched Controls	All Controls	Standardized Difference before Match	P- value	Standardized Difference after Match	P- value
Other pull-through resection of rectum (4849)	0.0	0.0	0.0	0.0	0.01	0.0240	0.00	1.0000
Abdominoperineal resection of the rectum, not otherwise specified (4850)	---*	---*	---*	---*	-0.01	0.1155	0.00	1.0000
Laparoscopic abdominoperineal resection of the rectum (4851)	0.1	0.0	0.0	0.0	0.01	0.0001	0.00	1.0000
Open abdominoperineal resection of the rectum (4852)	0.1	0.1	0.1	0.1	0.02	0.0001	0.00	1.0000
Other abdominoperineal resection of the rectum (4859)	---*	---*	---*	---*	0.00	0.7676	0.00	1.0000
Anterior resection of rectum with synchronous colostomy (4862)	0.1	0.1	0.1	0.1	0.00	0.5876	0.00	1.0000
Other anterior resection of rectum (4863)	0.5	0.5	0.5	0.4	0.01	0.0038	0.00	1.0000
Other resection of rectum (4869)	0.2	0.1	0.1	0.1	0.02	<.0001	0.00	1.0000
Abdominal proctopexy (4875)	0.1	0.1	0.1	0.0	0.02	0.0001	0.00	1.0000
Other proctopexy (4876)	0.1	0.1	0.1	0.1	0.01	0.0002	0.00	1.0000
Other repair of rectum (4879)	---*	---*	---*	---*	0.00	0.5425	0.00	1.0000
Partial hepatectomy (5022)	0.3	0.2	0.2	0.1	0.06	<.0001	0.00	1.0000
Other destruction of lesion of liver (5029)	0.1	0.0	0.0	0.0	0.02	<.0001	0.00	1.0000
Lobectomy of liver (503)	0.1	0.1	0.1	0.0	0.04	<.0001	0.00	1.0000
Cholecystectomy (5122)	0.8	0.8	0.8	0.9	-0.02	<.0001	0.00	1.0000
Laparoscopic cholecystectomy (5123)	4.2	5.2	5.2	5.9	-0.08	<.0001	0.00	1.0000
Laparoscopic partial cholecystectomy (5124)	0.0	---*	---*	0.0	0.00	0.3631	0.00	1.0000
Anastomosis of gallbladder to intestine (5132)	---*	---*	---*	---*	-0.01	0.1934	0.00	1.0000
Choledochoenterostomy (5136)	0.0	0.0	0.0	0.0	0.00	0.8834	0.00	1.0000
Anastomosis of hepatic duct to gastrointestinal tract (5137)	0.1	0.0	0.0	0.0	0.03	<.0001	0.00	1.0000
Common duct exploration for removal of calculus (5141)	0.0	---*	---*	0.0	0.00	0.8556	0.00	1.0000
Exploration of common duct (5151)	---*	---*	---*	---*	0.00	0.6995	0.00	1.0000
Proximal pancreatectomy (5251)	---*	---*	---*	---*	0.01	0.1689	0.00	1.0000
Distal pancreatectomy (5252)	0.3	0.1	0.1	0.1	0.06	<.0001	0.00	1.0000
Radical subtotal pancreatectomy (5253)	---*	---*	---*	---*	0.02	<.0001	0.00	1.0000
Other partial pancreatectomy (5259)	0.0	---*	---*	0.0	0.01	0.0005	0.00	1.0000
Total pancreatectomy (526)	0.1	0.0	0.0	0.0	0.02	<.0001	0.00	1.0000
Radical pancreaticoduodenectomy (527)	0.8	0.3	0.3	0.2	0.09	<.0001	0.00	1.0000
Unilateral repair of inguinal hernia, not otherwise specified (5300)	0.1	0.1	0.1	0.1	-0.01	0.0003	0.00	1.0000

Variable (Percent unless noted)	All Focal Cases	Matched Focal Cases	Matched Controls	All Controls	Standardized Difference before Match	P- value	Standardized Difference after Match	P- value		
Other and open repair of direct inguinal hernia (5301)	0.0	---	*	---	*	0.0	-0.01	0.0457	0.00	1.0000
Other and open repair of indirect inguinal hernia (5302)	0.0	0.0	0.0	0.0	0.0	-0.01	0.0413	0.00	1.0000	
Other and open repair of direct inguinal hernia with graft or prosthesis (5303)	0.1	0.1	0.1	0.2	-0.01	0.0143	0.00	1.0000		
Other and open repair of indirect inguinal hernia with graft or prosthesis (5304)	0.2	0.1	0.1	0.1	0.01	0.1231	0.00	1.0000		
Repair of inguinal hernia with graft or prosthesis, not otherwise specified (5305)	0.2	0.2	0.2	0.3	-0.02	<.0001	0.00	1.0000		
Other and open bilateral repair of direct inguinal hernia with graft or prosthesis (5314)	---	*	---	*	---	*	-0.01	0.0359	0.00	1.0000
Other and open bilateral repair of indirect inguinal hernia with graft or prosthesis (5315)	0.0	---	*	---	*	0.0	0.00	0.2275	0.00	1.0000
Other and open bilateral repair of inguinal hernia, one direct and one indirect, with graft or prosthesis (5316)	---	*	---	*	---	*	0.01	0.1834	0.00	1.0000
Bilateral inguinal hernia repair with graft or prosthesis, not otherwise specified (5317)	0.0	---	*	---	*	0.0	0.00	0.5177	0.00	1.0000
Unilateral repair of femoral hernia with graft or prosthesis (5321)	0.1	0.1	0.1	0.1	-0.01	0.0425	0.00	1.0000		
Other unilateral femoral herniorrhaphy (5329)	0.1	0.1	0.1	0.1	-0.01	0.2023	0.00	1.0000		
Other and open repair of umbilical hernia with graft or prosthesis (5341)	0.1	0.1	0.1	0.1	0.00	0.2723	0.00	1.0000		
Other open umbilical herniorrhaphy (5349)	0.1	0.1	0.1	0.1	0.00	0.3706	0.00	1.0000		
Incisional hernia repair (5351)	0.2	0.2	0.2	0.2	-0.01	0.0363	0.00	1.0000		
Repair of other hernia of anterior abdominal wall (5359)	0.1	0.1	0.1	0.1	-0.01	0.0351	0.00	1.0000		
Other open incisional hernia repair with graft or prosthesis (5361)	0.8	0.8	0.8	0.7	0.02	<.0001	0.00	1.0000		
Other and open repair of other hernia of anterior abdominal wall with graft or prosthesis (5369)	0.2	0.2	0.2	0.2	0.00	0.2604	0.00	1.0000		
Other and open repair of diaphragmatic hernia, abdominal approach (5372)	0.1	0.1	0.1	0.1	0.00	0.3627	0.00	1.0000		
Repair of diaphragmatic hernia, abdominal approach, not otherwise specified (5375)	---	*	---	*	---	*	0.00	0.4148	0.00	1.0000
Laparoscopic lysis of peritoneal adhesions (5451)	0.5	0.5	0.5	0.3	0.02	<.0001	0.00	1.0000		

Variable (Percent unless noted)	All Focal Cases	Matched Focal Cases	Matched Controls	All Controls	Standardized Difference before Match	P- value	Standardized Difference after Match	P- value
Other lysis of peritoneal adhesions (5459)	0.9	1.1	1.1	1.0	-0.01	0.0097	0.00	1.0000
Creation of cutaneoperitoneal fistula (5493)	0.1	0.1	0.1	0.1	0.00	0.7857	0.00	1.0000
Repair of colovaginal fistula (7072)	0.0	0.0	0.0	0.0	0.01	0.1362	0.00	1.0000
Repair of rectovaginal fistula (7073)	0.0	---	---	0.0	0.01	0.1561	0.00	1.0000
Repair of other fistula of vagina (7075)	---	---	---	---	0.01	0.1531	0.00	1.0000
Resection of quadrant of breast (8522)	---	---	---	---	0.01	0.1531	0.00	1.0000
Subtotal mastectomy (8523)	0.1	0.0	0.0	0.0	0.01	0.0009	0.00	1.0000
Unilateral simple mastectomy (8541)	0.3	0.2	0.2	0.2	0.01	0.0025	0.00	1.0000
Bilateral simple mastectomy (8542)	0.1	0.1	0.1	0.1	0.01	0.0018	0.00	1.0000
Unilateral extended simple mastectomy (8543)	0.4	0.4	0.4	0.3	0.01	0.0240	0.00	1.0000
Bilateral extended simple mastectomy (8544)	0.1	0.0	0.0	0.0	0.01	0.0551	0.00	1.0000
Unilateral radical mastectomy (8545)	0.0	---	---	0.0	0.01	0.0273	0.00	1.0000
Unilateral extended radical mastectomy (8547)	---	---	---	---	0.00	1.0000	0.00	1.0000
Revision of hip replacement, both acetabular and femoral components (0070)	0.8	0.6	0.6	0.5	0.04	<.0001	0.00	1.0000
Revision of hip replacement, acetabular component (0071)	0.2	0.1	0.1	0.1	0.01	0.0033	0.00	1.0000
Revision of hip replacement, femoral component (0072)	0.2	0.1	0.1	0.2	-0.01	0.2245	0.00	1.0000
Revision of hip replacement, acetabular liner and/or femoral head only (0073)	0.2	0.1	0.1	0.1	0.02	<.0001	0.00	1.0000
Revision of knee replacement, total (all components) (0080)	0.7	0.6	0.6	0.6	0.01	0.0084	0.00	1.0000
Revision of knee replacement, tibial component (0081)	0.2	0.2	0.2	0.2	0.00	0.7487	0.00	1.0000
Revision of knee replacement, femoral component (0082)	0.3	0.2	0.2	0.2	0.01	0.0008	0.00	1.0000
Revision of knee replacement, patellar component (0083)	0.1	0.1	0.1	0.1	0.00	0.4221	0.00	1.0000
Revision of total knee replacement, tibial insert (liner) (0084)	0.2	0.2	0.2	0.2	0.01	0.0430	0.00	1.0000
Reopening of laminectomy site (0302)	0.0	---	---	0.0	0.00	0.7766	0.00	1.0000
Other exploration and decompression of spinal canal (0309)	3.5	2.8	2.8	2.0	0.09	<.0001	0.00	1.0000
Excision or destruction of lesion of spinal cord or spinal meninges (034)	0.3	0.2	0.2	0.1	0.03	<.0001	0.00	1.0000
Repair of vertebral fracture (0353)	0.1	0.1	0.1	0.1	0.01	0.1285	0.00	1.0000

Variable (Percent unless noted)	All Focal Cases	Matched Focal Cases	Matched Controls	All Controls	Standardized Difference before Match	P- value	Standardized Difference after Match	P- value
Biopsy of bone, tibia and fibula (7747)	0.0	---	---	0.0	0.00	0.4324	0.00	1.0000
Repair of hammer toe (7756)	0.0	---	---	0.0	0.01	0.0358	0.00	1.0000
Local excision of lesion or tissue of bone, humerus (7762)	---	---	---	---	0.00	0.6732	0.00	1.0000
Local excision of lesion or tissue of bone, radius and ulna (7763)	---	---	---	---	0.00	1.0000	0.00	1.0000
Local excision of lesion or tissue of bone, femur (7765)	0.0	0.0	0.0	0.0	0.01	0.0295	0.00	1.0000
Local excision of lesion or tissue of bone, patella (7766)	---	---	---	---	0.00	0.6130	0.00	1.0000
Local excision of lesion or tissue of bone, tibia and fibula (7767)	0.1	0.0	0.0	0.0	0.01	0.1702	0.00	1.0000
Other partial ostectomy, humerus (7782)	---	---	---	---	0.01	0.0010	0.00	1.0000
Other partial ostectomy, radius and ulna (7783)	---	---	---	---	0.00	0.5856	0.00	1.0000
Other partial ostectomy, femur (7785)	0.0	0.0	0.0	0.0	0.01	0.0010	0.00	1.0000
Other partial ostectomy, patella (7786)	0.0	0.0	0.0	0.0	-0.01	0.0150	0.00	1.0000
Other partial ostectomy, tibia and fibula (7787)	0.0	---	---	0.0	0.01	0.0057	0.00	1.0000
Total ostectomy, patella (7796)	---	---	---	---	0.01	0.0921	0.00	1.0000
Total ostectomy, tibia and fibula (7797)	---	---	---	---	0.00	0.4992	0.00	1.0000
Bone graft, humerus (7802)	---	---	---	---	0.00	1.0000	0.00	1.0000
Bone graft, femur (7805)	0.0	---	---	0.0	0.01	0.0647	0.00	1.0000
Bone graft, tibia and fibula (7807)	---	---	---	---	0.01	0.1218	0.00	1.0000
Internal fixation of bone without fracture reduction, humerus (7852)	0.0	0.0	0.0	0.1	-0.01	0.1315	0.00	1.0000
Internal fixation of bone without fracture reduction, femur (7855)	1.1	1.3	1.3	1.4	-0.03	<.0001	0.00	1.0000
Internal fixation of bone without fracture reduction, tibia and fibula (7857)	0.0	0.0	0.0	0.0	0.00	0.2965	0.00	1.0000
Removal of implanted devices from bone, humerus (7862)	0.0	0.0	0.0	0.0	0.01	0.1234	0.00	1.0000
Removal of implanted devices from bone, radius and ulna (7863)	---	---	---	---	0.00	0.3690	0.00	1.0000
Removal of implanted devices from bone, femur (7865)	0.1	0.1	0.1	0.1	0.00	0.9521	0.00	1.0000
Removal of implanted devices from bone, patella (7866)	---	---	---	---	0.00	0.3464	0.00	1.0000

Variable (Percent unless noted)	All Focal Cases	Matched Focal Cases	Matched Controls	All Controls	Standardized Difference before Match	P- value	Standardized Difference after Match	P- value
Removal of implanted devices from bone, tibia and fibula (7867)	0.1	0.0	0.0	0.1	-0.01	0.2052	0.00	1.0000
Removal of implanted devices from bone, other bones (7869)	0.2	0.1	0.1	0.1	0.02	<.0001	0.00	1.0000
Open reduction of fracture without internal fixation, humerus (7921)	---*	---*	---*	---*	0.00	0.7903	0.00	1.0000
Open reduction of fracture without internal fixation, radius and ulna (7922)	---*	---*	---*	---*	0.01	0.0949	0.00	1.0000
Open reduction of fracture without internal fixation, femur (7925)	0.0	---*	---*	0.0	0.00	0.6211	0.00	1.0000
Open reduction of fracture without internal fixation, tibia and fibula (7926)	0.0	---*	---*	0.0	0.00	0.7467	0.00	1.0000
Open reduction of fracture with internal fixation, humerus (7931)	0.9	1.0	1.0	0.9	0.00	0.8339	0.00	1.0000
Open reduction of fracture with internal fixation, radius and ulna (7932)	0.8	1.0	1.0	0.8	0.00	0.5440	0.00	1.0000
Open reduction of fracture with internal fixation, femur (7935)	4.9	6.0	6.0	6.8	-0.08	<.0001	0.00	1.0000
Open reduction of fracture with internal fixation, tibia and fibula (7936)	1.4	1.7	1.7	1.9	-0.04	<.0001	0.00	1.0000
Open reduction of fracture with internal fixation, other specified bone (7939)	0.2	0.1	0.1	0.1	0.02	<.0001	0.00	1.0000
Arthrotomy for removal of prosthesis without replacement, shoulder (8001)	0.0	---*	---*	0.0	0.02	0.0001	0.00	1.0000
Arthrotomy for removal of prosthesis without replacement, hip (8005)	0.1	0.1	0.1	0.1	0.02	0.0001	0.00	1.0000
Arthrotomy for removal of prosthesis without replacement, knee (8006)	0.2	0.2	0.2	0.2	0.01	0.0424	0.00	1.0000
Arthroscopy, shoulder (8021)	---*	---*	---*	---*	-0.01	0.2000	0.00	1.0000
Arthroscopy, knee (8026)	---*	---*	---*	---*	0.00	1.0000	0.00	1.0000
Excision of intervertebral disc (8051)	1.2	1.2	1.2	0.9	0.03	<.0001	0.00	1.0000
Excision of semilunar cartilage of knee (806)	0.1	0.0	0.0	0.1	0.00	0.2546	0.00	1.0000
Synovectomy, knee (8076)	0.1	0.1	0.1	0.1	-0.01	0.0166	0.00	1.0000
Other local excision or destruction of lesion of joint, shoulder (8081)	0.1	0.0	0.0	0.1	0.00	0.8589	0.00	1.0000
Other local excision or destruction of lesion of joint, hip (8085)	0.0	---*	---*	0.0	0.00	0.4409	0.00	1.0000

Variable (Percent unless noted)	All Focal Cases	Matched Focal Cases	Matched Controls	All Controls	Standardized Difference before Match	P- value	Standardized Difference after Match	P- value
Other local excision or destruction of lesion of joint, knee (8086)	0.1	0.0	0.0	0.0	0.00	0.5168	0.00	1.0000
Atlas-axis spinal fusion (8101)	0.2	0.1	0.1	0.1	0.03	<.0001	0.00	1.0000
Other cervical fusion of the anterior column, anterior technique (8102)	2.0	1.9	1.9	1.8	0.02	<.0001	0.00	1.0000
Other cervical fusion of the posterior column, posterior technique (8103)	0.9	0.7	0.7	0.4	0.06	<.0001	0.00	1.0000
Dorsal and dorsolumbar fusion of the anterior column, anterior technique (8104)	0.1	0.0	0.0	0.0	0.03	<.0001	0.00	1.0000
Dorsal and dorsolumbar fusion of the posterior column, posterior technique (8105)	0.7	0.4	0.4	0.2	0.07	<.0001	0.00	1.0000
Lumbar and lumbosacral fusion of the anterior column, anterior technique (8106)	1.6	1.0	1.0	0.7	0.09	<.0001	0.00	1.0000
Lumbar and lumbosacral fusion of the posterior column, posterior technique (8107)	3.2	3.3	3.3	3.0	0.01	0.0003	0.00	1.0000
Lumbar and lumbosacral fusion of the anterior column, posterior technique (8108)	1.3	1.2	1.2	1.3	0.00	0.7500	0.00	1.0000
Ankle fusion (8111)	0.1	0.1	0.1	0.1	0.02	<.0001	0.00	1.0000
Triple arthrodesis (8112)	0.1	0.1	0.1	0.0	0.02	<.0001	0.00	1.0000
Subtalar fusion (8113)	0.0	0.0	0.0	0.0	0.01	0.0209	0.00	1.0000
Tarsometatarsal fusion (8115)	---	---	---	---	0.02	<.0001	0.00	1.0000
Metatarsophalangeal fusion (8116)	---	---	---	---	0.01	0.0004	0.00	1.0000
Arthrodesis of knee (8122)	---	---	---	---	0.01	0.0094	0.00	1.0000
Refusion of other cervical spine, anterior column, anterior technique (8132)	0.0	---	---	0.0	0.01	0.1864	0.00	1.0000
Refusion of other cervical spine, posterior column, posterior technique (8133)	0.0	0.0	0.0	0.0	0.02	<.0001	0.00	1.0000
Refusion of dorsal and dorsolumbar spine, anterior column, anterior technique (8134)	---	---	---	---	0.00	0.3672	0.00	1.0000
Refusion of dorsal and dorsolumbar spine, posterior column, posterior technique (8135)	0.1	0.0	0.0	0.0	0.03	<.0001	0.00	1.0000
Refusion of lumbar and lumbosacral spine, anterior column, anterior technique (8136)	0.0	---	---	0.0	0.01	0.0094	0.00	1.0000
Refusion of lumbar and lumbosacral spine, posterior column, posterior technique (8137)	0.2	0.2	0.2	0.1	0.03	<.0001	0.00	1.0000
Refusion of lumbar and lumbosacral spine, anterior column, posterior technique (8138)	0.0	0.0	0.0	0.0	0.01	0.0020	0.00	1.0000

Variable (Percent unless noted)	All Focal Cases	Matched Focal Cases	Matched Controls	All Controls	Standardized Difference before Match	P- value	Standardized Difference after Match	P- value
Repair of hip, not elsewhere classified (8140)	---	---	---	---	-0.01	0.1573	0.00	1.0000
Patellar stabilization (8144)	---	---	---	---	-0.01	0.3116	0.00	1.0000
Other repair of knee (8147)	0.0	0.0	0.0	0.0	0.00	0.4310	0.00	1.0000
Total hip replacement (8151)	9.9	9.9	9.9	10.5	-0.02	<.0001	0.00	1.0000
Partial hip replacement (8152)	4.2	5.2	5.2	6.0	-0.08	<.0001	0.00	1.0000
Revision of hip replacement, not otherwise specified (8153)	0.1	0.1	0.1	0.0	0.01	0.0829	0.00	1.0000
Total knee replacement (8154)	17.2	18.7	18.7	18.7	-0.04	<.0001	0.00	1.0000
Revision of knee replacement, not otherwise specified (8155)	0.1	0.1	0.1	0.1	0.00	0.8133	0.00	1.0000
Total ankle replacement (8156)	0.2	0.1	0.1	0.1	0.03	<.0001	0.00	1.0000
Other total shoulder replacement (8180)	1.4	1.1	1.1	1.0	0.04	<.0001	0.00	1.0000
Partial shoulder replacement (8181)	0.2	0.3	0.3	0.3	-0.01	0.0995	0.00	1.0000
Other repair of shoulder (8183)	0.0	0.0	0.0	0.0	0.00	1.0000	0.00	1.0000
Total elbow replacement (8184)	0.1	0.1	0.1	0.1	0.02	<.0001	0.00	1.0000
Other repair of elbow (8185)	0.0	---	---	0.0	0.00	0.6109	0.00	1.0000
Revision of joint replacement of upper extremity (8197)	0.2	0.1	0.1	0.1	0.03	<.0001	0.00	1.0000
Bursectomy (835)	0.1	0.1	0.1	0.1	-0.02	<.0001	0.00	1.0000
Rotator cuff repair (8363)	0.1	0.1	0.1	0.1	0.00	0.4119	0.00	1.0000
Other suture of tendon (8364)	0.0	0.1	0.1	0.1	0.00	0.2742	0.00	1.0000
Percutaneous angioplasty of extracranial vessel(s) (0061)	0.5	0.4	0.4	0.4	0.01	0.0066	0.00	1.0000
Percutaneous insertion of carotid artery stent(s) (0063)	0.1	0.0	0.0	0.1	0.00	0.4073	0.00	1.0000
Percutaneous insertion of other extracranial artery stent(s) (0064)	---	---	---	---	0.00	0.5856	0.00	1.0000
Incision of vessel, other vessels of head and neck (3802)	---	---	---	---	0.00	0.5016	0.00	1.0000
Incision of vessel, upper limb vessels (3803)	0.1	0.1	0.1	0.1	-0.01	0.0006	0.00	1.0000
Incision of vessel, abdominal arteries (3806)	0.0	0.0	0.0	0.0	0.00	0.7649	0.00	1.0000
Incision of vessel, lower limb arteries (3808)	0.2	0.2	0.2	0.3	-0.02	0.0002	0.00	1.0000
Endarterectomy, unspecified site (3810)	---	---	---	---	-0.01	0.3768	0.00	1.0000
Endarterectomy, other vessels of head and neck (3812)	3.0	3.6	3.6	3.9	-0.05	<.0001	0.00	1.0000
Endarterectomy, upper limb vessels (3813)	---	---	---	---	-0.01	0.2200	0.00	1.0000
Endarterectomy, aorta (3814)	---	---	---	---	0.00	0.5539	0.00	1.0000

Variable (Percent unless noted)	All Focal Cases	Matched Focal Cases	Matched Controls	All Controls	Standardized Difference before Match	P- value	Standardized Difference after Match	P- value
Endarterectomy, other thoracic vessels (3815)	---	---	---	---	0.03	<.0001	0.00	1.0000
Endarterectomy, abdominal arteries (3816)	0.1	0.0	0.0	0.0	0.02	<.0001	0.00	1.0000
Endarterectomy, lower limb arteries (3818)	0.6	0.7	0.7	0.6	0.00	0.8113	0.00	1.0000
Resection of vessel with anastomosis, other vessels of head and neck (3832)	---	---	---	---	0.00	1.0000	0.00	1.0000
Resection of vessel with anastomosis, upper limb vessels (3833)	---	---	---	---	0.01	0.0494	0.00	1.0000
Resection of vessel with anastomosis, aorta (3834)	0.0	---	---	0.0	0.00	0.5852	0.00	1.0000
Resection of vessel with anastomosis, abdominal arteries (3836)	---	---	---	---	0.00	0.5856	0.00	1.0000
Resection of vessel with anastomosis, lower limb arteries (3838)	---	---	---	---	-0.01	0.2575	0.00	1.0000
Resection of vessel with replacement, other vessels of head and neck (3842)	0.0	---	---	0.0	0.01	0.0385	0.00	1.0000
Resection of vessel with replacement, upper limb vessels (3843)	---	---	---	---	0.01	0.1260	0.00	1.0000
Resection of vessel with replacement, aorta, abdominal (3844)	0.2	0.2	0.2	0.2	0.01	0.0007	0.00	1.0000
Resection of vessel with replacement, abdominal arteries (3846)	---	---	---	---	0.00	0.2158	0.00	1.0000
Resection of vessel with replacement, abdominal veins (3847)	---	---	---	---	0.00	0.2064	0.00	1.0000
Resection of vessel with replacement, lower limb arteries (3848)	0.0	0.0	0.0	0.0	0.00	0.2516	0.00	1.0000
Other excision of vessels, upper limb vessels (3863)	0.0	---	---	0.0	0.00	0.6279	0.00	1.0000
Other excision of vessels, aorta, abdominal (3864)	---	---	---	---	0.00	1.0000	0.00	1.0000
Other excision of vessels, lower limb arteries (3868)	---	---	---	---	0.00	1.0000	0.00	1.0000
Intra-abdominal venous shunt (391)	0.1	0.1	0.1	0.0	0.03	<.0001	0.00	1.0000
Aorta-subclavian-carotid bypass (3922)	0.0	0.0	0.0	0.0	0.00	0.3077	0.00	1.0000
Aorta-renal bypass (3924)	---	---	---	---	0.01	0.1531	0.00	1.0000
Aorta-iliac-femoral bypass (3925)	0.2	0.1	0.1	0.1	0.01	0.0321	0.00	1.0000
Other intra-abdominal vascular shunt or bypass (3926)	0.0	---	---	0.0	0.02	<.0001	0.00	1.0000
Arteriovenostomy for renal dialysis (3927)	0.5	0.5	0.5	0.5	0.00	0.2299	0.00	1.0000
Other (peripheral) vascular shunt or bypass (3929)	1.1	1.2	1.2	1.2	-0.01	0.0125	0.00	1.0000

Variable (Percent unless noted)	All Focal Cases	Matched Focal Cases	Matched Controls	All Controls	Standardized Difference before Match	P- value	Standardized Difference after Match	P- value
Revision of arteriovenous shunt for renal dialysis (3942)	0.3	0.3	0.3	0.2	0.02	<.0001	0.00	1.0000
Removal of arteriovenous shunt for renal dialysis (3943)	0.1	0.1	0.1	0.1	0.00	0.8089	0.00	1.0000
Other revision of vascular procedure (3949)	0.3	0.3	0.3	0.3	0.01	0.0249	0.00	1.0000
Repair of arteriovenous fistula (3953)	0.1	0.0	0.0	0.0	0.01	0.0090	0.00	1.0000
Repair of blood vessel with tissue patch graft (3956)	0.0	---*	---*	0.0	0.01	0.0250	0.00	1.0000
Repair of blood vessel with synthetic patch graft (3957)	---*	---*	---*	---*	0.01	0.1260	0.00	1.0000
Repair of blood vessel with unspecified type of patch graft (3958)	---*	---*	---*	---*	-0.01	0.1934	0.00	1.0000
Endovascular implantation of other graft in abdominal aorta (3971)	1.4	1.4	1.4	1.6	-0.01	0.0010	0.00	1.0000
Endovascular (total) embolization or occlusion of head and neck vessels (3972)	0.3	0.2	0.2	0.1	0.04	<.0001	0.00	1.0000
Endovascular removal of obstruction from head and neck vessel(s) (3974)	0.4	0.4	0.4	0.2	0.03	<.0001	0.00	1.0000
Temporary (partial) therapeutic endovascular occlusion of vessel (3977)	---*	---*	---*	---*	0.01	0.2052	0.00	1.0000
Endovascular implantation of branching or fenestrated graft(s) in aorta (3978)	0.3	0.2	0.2	0.2	0.03	<.0001	0.00	1.0000
Other endovascular procedures on other vessels (3979)	0.8	0.8	0.8	0.7	0.01	0.0005	0.00	1.0000
Other amputation below knee (8415)	0.5	0.6	0.6	0.5	-0.01	0.1167	0.00	1.0000

Note. *values are masked to comply with CMS cell size suppression rules. Among patient matches in the orthopedic surgical groups, the risk groups were so large that we were required to further divide the groups in order to accommodate the requirements of the matching algorithm. The additional division into more risk groups resulted in the loss of 67 pairs. P-values were calculated using group tests, with Fisher's exact test used for binary and Wilcoxon rank sum used for continuous variables.

Appendix 8. Differences in 30-day Mortality after Post-Match Adjustment for Hospital Bed Size and Resident to Bed Ratio

Model	Variable	Point Estimate (SE)	Odds Ratio (95% CI)	Odds Ratio between 75th and 25th percentile	Chi Sq	P-value
General, Orthopedic & Vascular Surgery						
Nursing resources	Better nursing resources	-0.1633 (0.0356)	0.849 (0.792, 0.911)		21.0545	<.0001
Nursing resources + Hospital Char.	Better nursing resources	-0.1472 (0.0370)	0.863 (0.803, 0.928)		15.8265	<.0001
	Number of beds	-0.0250 (0.0322)	0.975 (0.916, 1.039)	0.935 (0.789, 1.108)	0.6016	0.4380
	Resident to bed ratio	-0.3436 (0.2374)	0.709 (0.445, 1.129)	0.942 (0.869, 1.021)	2.0943	0.1478
General Surgery						
Nursing resources	Better nursing resources	-0.1692 (0.0566)	0.844 (0.756, 0.943)		8.9246	0.0028
Nursing resources + Hospital Char.	Better nursing resources	-0.1563 (0.0584)	0.855 (0.763, 0.959)		7.1755	0.0074
	Number of beds	0.0114 (0.0473)	1.012 (0.922, 1.110)	1.031 (0.802, 1.326)	0.0585	0.8088
	Resident to bed ratio	-0.5192 (0.3797)	0.595 (0.283, 1.252)	0.909 (0.793, 1.042)	1.8700	0.1715
Orthopedic Surgery						
Nursing resources	Better nursing resources	-0.2072 (0.0564)	0.813 (0.728, 0.908)		13.4750	0.0002
Nursing resources + Hospital Char.	Better nursing resources	-0.1663 (0.0593)	0.847 (0.754, 0.951)		7.8606	0.0051
	Number of beds	-0.0621 (0.0570)	0.940 (0.840, 1.051)	0.848 (0.630, 1.141)	1.1889	0.2756
	Resident to bed ratio	-1.0792 (0.4422)	0.340 (0.143, 0.808)	0.856 (0.755, 0.970)	5.9572	0.0147
Vascular Surgery						
Nursing resources	Better nursing resources	-0.0673 (0.0783)	0.935 (0.802, 1.090)		0.7398	0.3897
Nursing resources + Hospital Char.	Better nursing resources	-0.0853 (0.0822)	0.918 (0.782, 1.079)		1.0781	0.2991
	Number of beds	-0.0509 (0.0699)	0.950 (0.829, 1.090)	0.877 (0.616, 1.249)	0.5301	0.4666
	Resident to bed ratio	0.7872 (0.4791)	2.197 (0.859, 5.620)	1.163 (0.971, 1.392)	2.6991	0.1004

Note. Coefficients for “number of beds” should be interpreted as the change in 30-day mortality for a 100-unit increase in number of beds.

Appendix 9. Differences in Outcomes after Post-Match Adjustment for State

Model	Variable	Point Estimate (SE)	Odds Ratio (95% CI)	Chi Sq	P-value
General, Orthopedic & Vascular Surgery					
Nursing resources	Better nursing resources	-0.1633 (0.0356)	0.849 (0.792, 0.911)	21.0545	<.0001
Nursing resources + State	Better nursing resources	-0.1180 (0.0488)	0.889 (0.808, 0.978)	5.8345	0.0157
	State, CA	--	--	--	--
	State, FL	0.1747 (0.0676)	1.191 (1.043, 1.360)	6.6771	0.0098
	State, NJ	-0.2186 (0.1248)	0.804 (0.629, 1.026)	3.0675	0.0799
	State, PA	0.1011 (0.0867)	1.106 (0.934, 1.311)	1.3620	0.2432
General Surgery					
Nursing resources	Better nursing resources	-0.1692 (0.0566)	0.844 (0.756, 0.943)	8.9246	0.0028
Nursing resources + State	Better nursing resources	-0.1459 (0.0788)	1.191 (1.043, 1.360)	3.4236	0.0643
	State, CA	--	--	--	--
	State, FL	0.2132 (0.1057)	0.804 (0.629, 1.026)	4.0689	0.0437
	State, NJ	-0.3678 (0.2047)	1.106 (0.934, 1.311)	3.2277	0.0724
	State, PA	-0.0205 (0.1410)	1.106 (0.934, 1.311)	0.0212	0.8843
Orthopedic Surgery					
Nursing resources	Better nursing resources	-0.2072 (0.0564)	0.813 (0.728, 0.908)	13.4750	0.0002
Nursing resources + State	Better nursing resources	-0.1021 (0.0763)	0.903 (0.778, 1.049)	1.7896	0.1810
	State, CA	--	--	--	--
	State, FL	0.2130 (0.1097)	1.237 (0.998, 1.534)	3.7736	0.0521
	State, NJ	-0.1596 (0.1953)	0.852 (0.581, 1.250)	0.6682	0.4137
	State, PA	0.3240 (0.1324)	1.383 (1.067, 1.792)	5.9935	0.0144
Vascular Surgery					
Nursing resources	Better nursing resources	-0.0673 (0.0783)	0.935 (0.802, 1.090)	0.7398	0.3897
Nursing resources + State	Better nursing resources	-0.1201 (0.1099)	0.887 (0.715, 1.100)	1.1944	0.2744
	State, CA	--	--	--	--
	State, FL	-0.00465 (0.1493)	0.995 (0.743, 1.334)	0.0010	0.9752
	State, NJ	-0.0821 (0.2704)	0.921 (0.542, 1.565)	0.0921	0.7615
	State, PA	-0.1799 (0.2022)	0.835 (0.562, 1.242)	0.7919	0.3735

Appendix 10. 30-day Costs under Different Definitions

(1) Intermediate Care Units are Costed as the average of General Unit and ICU Costs

(2) Intermediate Care Units are Costed as ICU Costs

Outcome	Group	All Patients	Patient Risk Quintiles of 30-Day Mortality				
			Q1	Q2	Q3	Q4	Q5
General, Orthopedic & Vascular Surgery							
Number of Pairs		62,715	12,762	12,567	12,741	12,596	12,049
(1) Intermediate Care Unit = Average of General Unit and ICU	Better Nursing	22,029	13,705	15,588	18,805	25,201	38,781
	Worse Nursing	20,867	13,476	14,828	17,673	23,926	36,169
	Difference	1,133	182	702	1,062	1,216	2,627
	P-value	<.0001	0.0128	<.0001	<.0001	<.0001	<.0001
(2) Intermediate Care Unit = ICU	Better Nursing	24,335	14,190	16,379	20,410	28,296	44,601
	Worse Nursing	22,341	13,775	15,408	18,716	26,044	39,647
	Diff	1,932	339	936	1,621	2,220	4,925
	P-value	<.0001	<.0001	<.0001	<.0001	<.0001	<.0001
General Surgery							
Number of Pairs		15,390	575	1,689	3,552	4,780	4,794
(1) Intermediate Care Unit = Average of General Unit and ICU	Better Nursing	30,573	13,244	15,122	19,480	27,649	49,849
	Worse Nursing	28,568	12,229	14,432	18,399	26,520	45,589
	Difference	2,008	899	665	1,010	1,077	4,260
	P-value	<.0001	0.0497	0.0672	0.001	0.0055	<.0001
(2) Intermediate Care Unit = ICU	Better Nursing	34,788	14,003	16,392	21,698	31,358	57,384
	Worse Nursing	31,113	13,071	15,618	19,825	29,077	49,884
	Difference	3,570	848	791	1,806	2,257	7,531
	P-value	<.0001	0.1026	0.0745	<.0001	<.0001	<.0001
Orthopedic Surgery							
Number of Pairs		39,956	11,347	9,915	7,826	5,946	4,922
(1) Intermediate Care Unit = Average of General Unit and ICU	Better Nursing	17,771	13,653	15,684	18,076	22,142	26,573
	Worse Nursing	17,120	13,586	14,934	17,248	21,113	25,584
	Difference	618	40	687	773	954	1,044
	P-value	<.0001	0.5857	<.0001	<.0001	0.0008	0.0073
(2) Intermediate Care Unit = ICU	Better Nursing	19,046	14,069	16,325	19,200	24,375	30,353
	Worse Nursing	17,948	13,823	15,329	18,051	22,652	28,050
	Difference	1,039	180	913	1,120	1,634	2,327
	P-value	<.0001	0.0285	<.0001	<.0001	<.0001	<.0001
Vascular Surgery							
Number of Pairs		7,369	840	963	1,363	1,870	2,333
(1) Intermediate Care Unit = Average of General Unit and ICU	Better Nursing	28,029	14,551	15,393	21,207	28,689	42,009
	Worse Nursing	25,708	12,874	14,458	18,212	26,177	39,165
	Difference	2,283	1,565	898	2,932	2,409	2,818
	P-value	<.0001	0.0002	0.0514	<.0001	0.0004	0.0019
(2) Intermediate Care Unit = ICU	Better Nursing	32,166	15,997	16,971	24,114	33,075	48,842
	Worse Nursing	28,303	13,678	15,729	19,822	28,941	43,428
	Difference	3,814	2,185	1,287	4,194	3,985	5,388
	P-value	<.0001	<.0001	0.0178	<.0001	<.0001	<.0001

Appendix 11. 30-day Mortality and Cost Differences Among Matched Patients in Top 15%, Middle 40%, and Bottom 45% of Hospitals

OVERALL				
Number of Patient Pairs (n=62715)				
30-day mortality	Odds Ratio	Lower 95% CI	Upper 95% CI	p-value
Top 15% vs Bottom 45%	0.8493	0.7921	0.9107	<.0001
Top 15% vs Middle 40%	1.0449	0.9717	1.1236	0.2359
Bottom 45% vs Middle 40%	1.2279	1.1448	1.3172	<.0001
Paired				
30-day nurse-adjusted cost, \$	Difference	Lower 95% CI	Upper 95% CI	p-value
Top 15% vs Bottom 45%	840	694	987	<.0001
Top 15% vs Middle 40%	1314	1169	1459	<.0001
Bottom 45% vs Middle 40%	489	350	629	<.0001
GENERAL SURGERY				
Number of Patient Pairs (n=15390)				
30-day mortality	Odds Ratio	Lower 95% CI	Upper 95% CI	p-value
Top 15% vs Bottom 45%	0.8443	0.7556	0.9435	0.0028
Top 15% vs Middle 40%	1.0506	0.9352	1.1804	0.4057
Bottom 45% vs Middle 40%	1.2389	1.1084	1.3846	0.0002
Paired				
30-day nurse-adjusted cost, \$	Difference	Lower 95% CI	Upper 95% CI	p-value
Top 15% vs Bottom 45%	1300	868	1732	<.0001
Top 15% vs Middle 40%	2044	1608	2482	<.0001
Bottom 45% vs Middle 40%	725	306	1145	<.0001
ORTHOPEDIC SURGERY				
Number of Patient Pairs (n=39956)				
30-day mortality	Odds Ratio	Lower 95% CI	Upper 95% CI	p-value
Top 15% vs Bottom 45%	0.8129	0.7277	0.9079	0.0002
Top 15% vs Middle 40%	1.0191	0.9084	1.1432	0.747
Bottom 45% vs Middle 40%	1.2513	1.1203	1.3977	<.0001
Paired				
30-day nurse-adjusted cost, \$	Difference	Lower 95% CI	Upper 95% CI	p-value
Top 15% vs Bottom 45%	579	450	708	<.0001
Top 15% vs Middle 40%	958	831	1084	<.0001
Bottom 45% vs Middle 40%	392	271	513	<.0001
VASCULAR SURGERY				
Number of Patient Pairs (n=7369)				
30-day mortality	Odds Ratio	Lower 95% CI	Upper 95% CI	p-value
Top 15% vs Bottom 45%	0.9349	0.802	1.0899	0.3896
Top 15% vs Middle 40%	1.0842	0.926	1.2693	0.315
Bottom 45% vs Middle 40%	1.1615	0.993	1.3586	0.0609
Paired				
30-day nurse-adjusted cost, \$	Difference	Lower 95% CI	Upper 95% CI	p-value
Top 15% vs Bottom 45%	1349	762	1935	<.0001
Top 15% vs Middle 40%	1815	1236	2396	<.0001
Bottom 45% vs Middle 40%	541	-12	1094	0.0551

Appendix 12. Differences in Hospital Coherence Percentiles among Matched Pairs: Middle Hospitals are Closer to Top Hospitals than to Bottom Hospitals

Hospital Group Comparisons	Mean	Standard Deviation
Top 15% - Bottom 45%	66.96	12.55
Middle 40% - Bottom 45%	40.86	16.12
Top 15% - Middle 40%	26.10	11.80

The mean represents the average difference in the hospital coherence rank score among matched patient pairs. Larger differences represent greater differences in hospital nursing resources among the matched pairs. The greatest average difference in nursing resources is between matched pairs in the top 15% of hospitals and the bottom 45%. The mean difference in nursing resources was smaller between matched pairs in the top and middle categories of hospitals than the difference in the middle and bottom categories.

Appendix 13. 30-day Mortality Differences Between Matched Patients in Better and Worse Nursing Resourced Hospitals for Common Procedures

	Odds Ratio (95% CI)	p-value	Rate of Mortality in Better Hospitals	Rate of Mortality in Worse Hospitals
GENERAL SURGERY				
Laparoscopic Cholecystectomy (n=3250)	0.98 (0.68 to 1.41)	0.926	0.018	0.018
Open and other right hemicolectomy (n=939)	0.84 (0.60 to 1.17)	0.311	0.079	0.092
All Other General Surgery Procedures (n=11201)	0.83 (0.73 to 0.94)	0.003	0.051	0.059
ORTHOPEDIC SURGERY				
Total Knee Replacement (n=11,741)	1.40 (0.79 to 2.49)	0.248	0.002	0.002
Total Hip Replacement (n=6,227)	0.61 (0.35 to 1.06)	0.074	0.003	0.005
All Other Orthopedic Procedures (n=21,988)	0.81 (0.72 to 0.90)	0.000	0.026	0.032
VASCULAR SURGERY				
Endarterectomy other vessels of head and neck (n=2244)	0.85 (0.49 to 1.49)	0.572	0.010	0.012
Endovascular implantation of other graft in abdominal aorta (n=909)	0.33 (0.17 to 0.66)	0.001	0.013	0.037
All Other Vascular Procedures (n=4216)	1.01 (0.86 to 1.20)	0.866	0.081	0.080

APPENDIX REFERENCES

1. Silber JH, Rosenbaum PR, Kelz RR, et al. Medical and financial risks associated with surgery in the elderly obese. *Ann Surg* 2012;256:79-86.
2. Silber JH, Rosenbaum PR, Ross RN, et al. Template matching for auditing hospital cost and quality. *Health Serv Res* 2014;49:1446-74.
3. Silber JH, Rosenbaum PR, Ross RN, et al. A hospital-specific template for benchmarking its cost and quality." *Health Serv Res* 2014;49:1475-97.
4. Silber JH, Rosenbaum PR, McHugh MD, et al. Comparison of the value of nursing work environments in hospitals across different levels of patient risk. *JAMA Surg* 2016; 151:527-36.
5. Needleman J., Buerhaus PI, Stewart M, et al. Nurse staffing in hospitals: is there a business case for quality? *Health Aff (Millwood)* 2006; 25:204-11.