

Supplementary Appendix

This appendix has been provided by the authors to give readers additional information about their work.

Supplement to: Finks JF, Osborne NH, Birkmeyer JD. Trends in hospital volume and operative mortality for high-risk surgery. *N Engl J Med* 2011;364:2128-37.

Table 1 (Supplement). Trends in Medicare procedure volumes and the proportion of Medicare patients treated in high-volume hospitals for cancer and cardiovascular operations, 1999-2008

	Year				
	1999-2000	2001-2002	2003-2004	2005-2006	2007-2008
Esophagectomy					
Patients, n	8805	8864	8694	8674	8719
Hospitals, n	1734	1632	1524	1403	1309
Hospital Volume, median (IQR)	4 (2-10)	5 (2-11)	5 (2-14)	7 (3-16)	7 (3-17)
Proportion of patients treated in hospital within top decile by volume, %	39	40	43	45	44
Proportion of patients treated in hospital within top quintile by volume, %	52	52	55	60	59
Pancreatectomy					
Patients, n	6633	7486	8215	8932	10350
Hospitals, n	1308	1303	1110	1016	978
Hospital Volume, median (IQR)	5 (2-14)	6 (2-17)	10 (3-22)	13 (4-28)	16 (5-35)
Proportion of patients treated in hospital within top decile by volume, %	42	46	49	51	52
Proportion of patients treated in hospital within top quintile by volume, %	59	58	63	66	69
Lung Resection					
Patients, n	49056	49723	51362	53456	56307
Hospitals, n	2408	2285	2200	2096	2045
Hospital Volume, median (IQR)	18 (9-32)	19 (10-35)	21 (10-37)	23 (11-42)	25 (12-49)
Proportion of patients treated in hospital within top decile by volume, %	39	40	39	41	41
Proportion of patients treated in hospital within top quintile by volume, %	58	57	58	59	59

	Year				
	1999-2000	2001-2002	2003-2004	2005-2006	2007-2008
Cystectomy					
Patients, n	11258	11593	11953	12278	13167
Hospitals, n	1817	1723	1607	1505	1366
Hospital Volume, median (IQR)	5 (2-10)	6 (3-13)	6 (3-16)	8 (3-22)	10 (4-27)
Proportion of patients treated in hospital within top decile by volume, %	35	40	43	47	47
Proportion of patients treated in hospital within top quintile by volume, %	54	54	55	61	65
AAA Repair					
Patients, n	56333	66909	64645	67288	71170
Hospitals, n	2339	2159	2035	1949	1860
Hospital Volume, median (IQR)	22 (11-42)	32 (15-62)	31 (16-56)	33 (17-58)	32 (17-57)
Proportion of patients treated in hospital within top decile by volume, %	40	44	42	40	37
Proportion of patients treated in hospital within top quintile by volume, %	60	63	61	60	57
CABG					
Patients, n	393043	376016	337430	284252	256716
Hospitals, n	1073	1095	1142	1172	1195
Hospital Volume, median (IQR)	244 (139-408)	214 (129-366)	179 (110-304)	148 (90-249)	130 (80-216)
Proportion of patients treated in hospital within top decile by volume, %	32	31	31	31	30
Proportion of patients treated in hospital within top quintile by volume, %	50	49	48	48	47

	Year				
	1999-2000	2001-2002	2003-2004	2005-2006	2007-2008
Carotid Endarterectomy					
Patients, n	232388	232103	222168	190906	178070
Hospitals, n	2635	2550	2502	2415	2341
Hospital Volume, median (IQR)	77 (40-131)	78 (40-130)	75 (40-125)	67 (36-109)	64 (35-105)
Proportion of patients treated in hospital within top decile by volume, %	39	38	37	37	35
Proportion of patients treated in hospital within top quintile by volume, %	59	58	57	57	55
Aortic Valve Replacement					
Patients, n	74541	80223	85556	87421	95033
Hospitals, n	1013	1064	1105	1139	1161
Hospital Volume, median (IQR)	53 (28-99)	54 (29-105)	57 (30-104)	53 (29-102)	60 (31-108)
Proportion of patients treated in hospital within top decile by volume, %	37	37	37	37	38
Proportion of patients treated in hospital within top quintile by volume, %	55	55	55	54	56

Table 2 (Supplement). Procedure-specific patient characteristics, major co-morbidities and predicted mortality rates* among Medicare patients, 1999-2008

	Year				
	1999-2000	2001-2002	2003-2004	2005-2006	2007-2008
Esophagectomy					
Demographics					
Age, mean (SD)	72.3 (8.1)	72.1 (8.2)	72.0 (8.4)	71.8 (8.4)	71.7 (8.3)
Female, %	28.2	27.4	28.0	27.9	26.8
non-White, %	12.0	12.5	12.8	11.5	11.7
Comorbidities					
3+ Comorbidities, %	28.1	29.8	31.5	34.2	30.0
Congestive heart failure, %	8.7	9.3	9.0	8.7	5.6
Hypertension, %	30.5	33.2	36.6	38.7	38.2
Diabetes, %	11.5	12.0	12.5	13.2	13.4
Chronic lung disease, %	21.3	21.3	23.1	22.7	17.1
Renal Failure, %	1.3	1.9	1.9	3.7	4.0
Predicted mortality, %	9.7	9.5	9.3	9.6	9.3
(95% CI)	(9.5-9.9)	(9.3-9.7)	(9.1-9.5)	(9.4-9.9)	(9.1-9.5)
Pancreatectomy					
Demographics					
Age, mean (SD)	71.5 (9.4)	71.6 (9.3)	71.8 (9.3)	71.8 (9.3)	71.8 (9.2)
Female, %	49.1	50.0	48.9	49.7	50.1
non-White, %	12.5	12.6	12.3	12.3	14.0
Comorbidities					
3+Comorbidities, %	25.0	27.2	30.4	33.4	33.4
Congestive heart failure, %	5.6	5.5	5.3	5.8	3.9
Hypertension, %	33.8	37.8	41.8	44.3	44.8
Diabetes, %	19.3	19.1	20.6	20.6	20.2
Chronic lung disease, %	1.6	2.0	1.9	2.6	7.1
Renal Failure, %	2.9	2.7	3.6	4.9	5.2
Predicted mortality, %	6.8	6.7	6.6	6.4	6.3
(95% CI)	(6.7-7.1)	(6.6-7.0)	(6.4-6.7)	(6.3-6.6)	(6.1-6.4)
Lung Resection					
Demographics					
Age, mean (SD)	72.2 (7.1)	72.2 (7.2)	72.3 (7.4)	72.3 (7.6)	72.3 (7.7)
Female, %	44.0	45.2	45.9	47.4	48.4
non-White, %	9.1	9.5	10.0	10.0	10.4
Comorbidities					
3+ Comorbidities, %	26.6	30.0	32.7	36.4	36.5
Congestive heart failure, %	5.6	6.1	6.1	6.1	4.7
Hypertension, %	38.8	43.4	47.9	51.4	52.8
Diabetes, %	11.2	12.3	13.1	14.1	14.9
Chronic lung disease, %	5.6	6.1	6.1	6.1	4.7
Renal Failure, %	1.2	1.4	1.7	3.5	4.4
Predicted mortality, %	4.8	4.7	4.7	4.7	4.7
(95% CI)	(4.8-4.9)	(4.7-4.8)	(4.6-4.7)	(4.7-4.8)	(4.6-4.7)

	Year				
	1999-2000	2001-2002	2003-2004	2005-2006	2007-2008
Cystectomy					
Demographics					
Age, mean (SD)	73.4 (7.9)	73.3 (8.1)	73.4 (8.0)	73.5 (8.1)	73.6 (8.0)
Female, %	21.2	20.6	20.7	19.9	19.2
non-White, %	7.2	7.7	8.0	7.9	7.1
Comorbidities					
3+ Comorbidities, %	20.8	23.2	27.1	30.9	35.3
Congestive heart failure, %	0.7	0.6	0.7	1.5	5.1
Hypertension, %	34.1	37.4	42.7	45.2	47.5
Diabetes, %	11.8	12.7	13.9	13.7	15.4
Chronic lung disease, %	20.3	20.5	21.2	21.3	17.1
Renal Failure, %	2.1	2.2	3.0	6.8	7.9
Predicted mortality, %	3.7	3.6	3.6	3.9	4.2
(95% CI)	(3.7-3.8)	(3.6-3.7)	(3.6-3.7)	(3.9-4.0)	(4.1-4.3)
AAA Repair					
Demographics					
Age, mean (SD)	74.4 (6.3)	74.8 (6.5)	75.0 (6.7)	75.2 (6.9)	75.4 (7.1)
Female, %	23.8	21.5	21.8	21.5	21.7
non-White, %	5.6	5.7	6.3	6.5	6.7
Comorbidities					
3+ Comorbidities, %	33.5	34.4	36.9	40.3	37.0
Congestive heart failure, %	12.0	11.0	10.6	10.4	3.6
Hypertension, %	53.3	58.1	61.7	65.5	65.9
Diabetes, %	8.5	10.3	11.6	13.4	14.3
Chronic lung disease, %	34.2	34.7	35.4	35.8	31.8
Renal Failure, %	3.0	3.5	3.8	8.3	10.2
Endovascular repair, %	3.6	35.2	47.6	62.2	73.3
Predicted mortality, %	3.5	3.4	3.3	3.6	3.6
(95% CI)	(3.5-3.6)	(3.4-3.4)	(3.3-3.4)	(3.6-3.7)	(3.6-3.7)
CABG					
Demographics					
Age, mean (SD)	72.4 (7.4)	72.3 (7.6)	72.2 (7.8)	72.1 (7.9)	71.9 (8.0)
Female, %	34.5	34.0	33.1	31.9	31.6
non-White, %	9.3	10.0	10.9	11.2	11.7
Comorbidities					
3+ Comorbidities, %	30.6	34.6	38.9	44.7	37.5
Congestive heart failure, %	19.1	19.3	20.5	21.3	8.4
Hypertension, %	58.7	62.4	64.8	66.4	62.9
Diabetes, %	25.2	26.0	26.4	26.3	26.5
Chronic lung disease, %	18.7	20.7	22.0	23.2	19.5
Renal Failure, %	3.5	4.4	5.5	10.6	11.6
Predicted mortality, %	3.8	3.8	3.9	4.4	4.3
(95% CI)	(3.8-3.8)	(3.8-3.8)	(3.9-3.9)	(4.4-4.4)	(4.2-4.3)

	Year				
	1999-2000	2001-2002	2003-2004	2005-2006	2007-2008
Carotid Endarterectomy					
Demographics					
Age, mean (SD)	74.6 (7.0)	74.7 (7.0)	74.7 (7.3)	74.7 (7.4)	74.7 (7.6)
Female, %	43.5	43.3	42.9	42.9	42.5
non-White, %	5.9	6.2	6.5	6.8	7.2
Comorbidities					
3+Comorbidities, %	22.5	25.0	28.8	33.8	33.4
Congestive heart failure, %	7.6	7.6	8.1	8.5	7.0
Hypertension, %	64.4	68.6	73.0	76.0	76.9
Diabetes, %	22.3	23.3	24.8	26.2	26.9
Chronic lung disease, %	16.9	18.5	20.3	22.3	21.1
Renal Failure, %	1.9	2.3	2.7	5.7	7.8
Predicted mortality, % (95% CI)	1.2 (1.2-1.2)	1.2 (1.2-1.2)	1.2 (1.2-1.3)	1.3 (1.3-1.3)	1.3 (1.3-1.3)
Aortic Valve Replacement					
Demographics					
Age, mean (SD)	74.7 (8.0)	74.8 (8.1)	74.8 (8.3)	74.9 (8.3)	75.1 (8.1)
Female, %	43.5	42.9	42.4	41.7	41.4
non-White, %	7.7	7.8	8.1	8.1	8.2
Comorbidities					
3+Comorbidities, %	39.4	43.0	46.6	51.7	35.2
Congestive heart failure, %	36.9	36.6	37.0	36.6	13.5
Hypertension, %	46.1	49.9	52.1	53.3	49.8
Diabetes, %	15.3	15.8	16.7	17.0	17.1
Chronic lung disease, %	18.0	19.5	19.9	21.0	16.1
Renal Failure, %	3.9	4.8	5.8	11.4	11.4
Predicted mortality, % (95% CI)	6.8 (6.8-6.8)	6.9 (6.8-6.9)	6.9 (6.9-7.0)	7.6 (7.6-7.7)	7.0 (7.0-7.1)

*Procedure-specific predicted mortality rates were determined for each patient from analysis of Medicare data from 1999-2000, using a logistic regression model, clustering at the hospital level and controlling for patient characteristics, including age, gender, race, admission acuity, co-morbidities, and socioeconomic status.

Table 3 (Supplement). ICD-9 Procedure and Diagnosis Codes

ICD-9 Procedure Codes							
AAA	CABG	Carotid Endarterectomy	Aortic Valve Replacement	Esophagectomy	Pancreatectomy	Lung Resection	Cystectomy
3834	3510-	3812	3511	4240	5251	323	577
3844	3529		3521	4241	5253	3230	5771
3864			3522	4242	526	3239	5779
3925	3610-			4399	527	324	
3971	3619					3241	
						3249	
						325	
						3250	
						3259	
Exclude if ICD9 Diagnosis code =							
4411	Thoracic aneurysm, ruptured						
4412	Thoracic aneurysm without mention of rupture						
4413	Abdominal aneurysm, ruptured						
4415	Aortic aneurysm of unspecified site, ruptured						
4416	Thoraco-abdominal aneurysm, ruptured						