

Appendix: Supplementary tables and figures [posted as supplied by author]

Table A. ICD-9 (*International Classification of Diseases, 9th Edition*) codes

Procedures		ICD-9 codes
Cardiovascular procedures	Coronary artery bypass grafting (CABG)	3610, 3611, 3612, 3613, 3614, 3615, 3616, 3617, 3619, 362, 363, 3631, 3632, 3633, 3634, 3639
	Carotid endarterectomy	3811, 3812
	Valve replacement	3500, 3501, 3502, 3503, 3504, 3505, 3506, 3507, 3508, 3509, 3510, 3511, 3512, 3513, 3514, 3520, 3521, 3522, 3523, 3524, 3525, 3526, 3527, 3528, 3596, 3597, 3599
	Abdominal aortic aneurysm repair	3834, 3844, 3864, 3971, 3973, 3978
Non-cardiovascular procedures	Hip and femur fracture	7855, 7865, 7905, 7915, 7925, 7935, 7945, 7955, 7965, 7975, 7985, 7995
	Colorectal resection	1731, 1732, 1733, 1734, 1735, 1736, 1739, 4571, 4572, 4573, 4574, 4575, 4576, 4579, 458, 4581, 4582, 4583, 4840, 4841, 4842, 4843, 4849, 485, 4850, 4851, 4852, 4859, 4861, 4862, 4863, 4864, 4865, 4866, 4869
	Cholecystectomy and common duct procedures	5121, 5122, 5123, 5124, 5141, 5142, 5143, 5149, 5151, 5159
	Laminectomy	0302, 0309, 805, 8050, 8051, 8059, 8459, 8460, 8461, 8462, 8463, 8464, 8465, 8466, 8467, 8468, 8469, 8480, 8481, 8482, 8483, 8484, 8485
	Excision lysis peritoneal adhesions	545, 5451, 5459
	Fracture or dislocation of lower extremity	7856, 7857, 7858, 7866, 7867, 7868, 7906, 7907, 7908, 7916, 7917, 7918, 7926, 7927, 7928, 7936, 7937, 7938, 7946, 7956, 7966, 7967, 7968, 7976, 7977, 7978, 7986, 7987, 7988, 7996, 7997, 7998
	Lung resection	3220, 3221, 3222, 3223, 3224, 3225, 3226, 3227, 3229, 323, 3230, 3239, 324, 3241, 3249, 325, 3250, 3259
	Hysterectomy	683, 6831, 6839, 684, 6841, 6849, 685, 6851, 6859, 686, 6861, 6869, 687, 6871, 6879, 689
	Amputation of lower extremity	8410, 8411, 8412, 8413, 8414, 8415, 8416, 8417, 8418, 8419
	Nephrectomy	5501, 5502, 5503, 5504, 5511, 5512
	Appendectomy	470, 4701, 4709, 471, 4711, 4719
	Small bowel resection	4561, 4562, 4563
	Pancreatic resection	5251, 5252, 5253, 5259, 526, 527
	Gastrectomy	435, 436, 437, 4381, 4382, 4389, 4391, 4399
	Splenectomy	411, 412, 4141, 4142, 4143, 415, 4193, 4195, 4199
	Esophageal resection	424, 4240, 4241, 4242, 425, 4251, 4252, 4253, 4254, 4255, 4256, 4258, 4259, 426, 4261, 4262, 4263, 4264, 4265, 4266, 4268, 4269

Table B. Association between other surgeon characteristics and operative mortality

	Crude odds ratio (95%CI)	p-value	Adjusted odds ratio* (95%CI)	p-value
Surgeon age (yr)				
<40		Reference		
40-49	0.97 (0.95 to 1.00)	0.05	0.98 (0.96 to 1.01)	0.25
50-59	0.93 (0.91 to 0.96)	<0.001	0.97 (0.94 to 0.99)	0.02
≥60	0.94 (0.92 to 0.97)	<0.001	0.95 (0.92 to 0.99)	0.005
Surgeon sex				
Male		Reference		
Female	1.06 (1.02 to 1.10)	0.004	0.97 (0.93 to 1.01)	0.14
Credentials				
DO		Reference		
MD	0.92 (0.88 to 0.97)	0.002	1.03 (0.93 to 1.14)	0.54
Operative volume	1.00 (1.00 to 1.00)	0.68	0.999 (0.998 to 0.9996)	0.001
Operative volume (quadratic term)	1.00 (1.00 to 1.00)	0.11	1.00 (1.00 to 1.00)	0.01
Operative volume (cubic term)	1.00 (1.00 to 1.00)	0.40	1.00 (1.00 to 1.00)	0.01

*Adjusted for patient characteristics, other surgeon characteristics (medical school and specialty), and hospital fixed effects. Standard errors were clustered at surgeon level.

Table C. The number of deaths in the patient population categorized by age and sex of surgeons

			Surgeon Sex		Sum
			Male	Female	
Number of procedures	Surgeon Age (yr)	<40	132,791 (15.8%)	16,558 (32.0%)	149,349 (16.7%)
		40-49	269,705 (32.1%)	22,398 (43.3%)	292,103 (32.7%)
		50-59	272,318 (32.4%)	10,689 (20.6%)	283,007 (31.7%)
		≥60	165,588 (19.7%)	2,140 (4.1%)	167,728 (18.8%)
	Sum		840,402 (100%)	51,785 (100%)	892,187 (100%)
Number of deaths	Surgeon Age (yr)	<40	8,861 (16.3%)	1,182 (33.5%)	10,043 (17.4%)
		40-49	17,603 (32.5%)	1,544 (43.7%)	19,147 (33.2%)
		50-59	17,201 (31.7%)	655 (18.6%)	17,856 (30.9%)
		≥60	10,543 (19.4%)	149 (4.2%)	10,692 (18.5%)
	Sum		54,208 (100%)	3,530 (100%)	57,738 (100%)

Numbers in parentheses are column percentages.

Table D. Adjusted operative mortality, interaction between surgeon age and sex

		Surgeon Sex		p-value
		Male	Female	
Surgeon Age (yr)	<40	6.6% (6.5% to 6.8%)	6.4% (6.1% to 6.8%)	0.31
	40-49	6.5% (6.4% to 6.6%)	6.4% (6.1% to 6.7%)	0.63
	50-59	6.4% (6.3% to 6.5%)	6.0% (5.5% to 6.5%)	0.07
	≥60	6.4% (6.2% to 6.5%)	6.7% (5.5% to 7.9%)	0.55
	p-for-trend	0.002	0.49	

Adjusted for patient characteristics, surgeon characteristics, and hospital fixed effects. Standard errors were clustered at surgeon level. The interaction between surgeon age and sex was statistically significant ($p=0.03$). The estimate for female surgeons aged ≥ 60 may be unstable as the number of death for this category was small.

Table E. Association between surgeon age and operative mortality, by operative volume

		Surgeon Age (yr)				p-for-trend
		<40	40-49	50-59	≥60	
Operative volume	Low	7.1% (6.3% to 7.8%)	7.1% (6.4% to 7.9%)	7.0% (6.2% to 7.8%)	7.3% (6.5% to 8.1%)	0.69
	Medium	6.7% (6.4% to 6.9%)	6.7% (6.5% to 7.0%)	6.6% (6.3% to 6.8%)	6.3% (6.1% to 6.6%)	0.04
	High	6.6% (6.4% to 6.7%)	6.5% (6.4% to 6.6%)	6.4% (6.3% to 6.5%)	6.3% (6.2% to 6.5%)	0.01

Adjusted for patient characteristics, surgeon characteristics, and hospital fixed effects. Standard errors were clustered at surgeon level. P-value of <0.016 was considered statistically significant. The interaction between surgeon age and operative volume was not statistically significant ($p=0.73$).

Table F. Association between surgeon sex and operative mortality, by operative volume

		Surgeon Sex		p-value
		Male surgeon	Female surgeon	
Operative volume	Low	7.0% (6.5% to 7.5%)	7.4% (6.4% to 8.3%)	0.46
	Medium	6.6% (6.4% to 6.7%)	6.6% (6.2% to 6.9%)	0.90
	High	6.4% (6.4% to 6.5%)	6.1% (5.8% to 6.4%)	0.02

Adjusted for patient characteristics, surgeon characteristics, and hospital fixed effects. Standard errors were clustered at surgeon level. P-value of <0.016 was considered statistically significant. The interaction between surgeon sex and operative volume was not statistically significant (p=0.13).

Table G. Association between surgeon age and operative mortality, by procedure

	No. of procedures (No. of surgeons)	Surgeon Age				P-for-trend
		<40	40-49	50-59	≥60	
Hip and femur fracture	345,738 (16,161)	6.2% (5.9% to 6.6%)	6.2% (5.9% to 6.5%)	6.1% (5.8% to 6.4%)	6.2% (5.9% to 6.5%)	0.44
Cholecystectomy	128,978 (14,187)	2.9% (2.6% to 3.2%)	2.9% (2.7% to 3.1%)	3.1% (2.9% to 3.3%)	3.2% (2.9% to 3.4%)	0.04
Colorectal resection	77,936 (14,622)	11.3% (10.6% to 11.9%)	11.1% (10.5% to 11.6%)	10.9% (10.4% to 11.4%)	10.7% (10.1% to 11.3%)	0.08
Coronary artery bypass grafting	62,018 (2,606)	7.7% (6.3% to 9.0%)	6.1% (5.5% to 6.7%)	6.1% (5.6% to 6.6%)	6.1% (5.5% to 6.7%)	0.21
Fracture/dislocation of lower extremity	56,181 (12,229)	4.2% (3.7% to 4.6%)	4.1% (3.7% to 4.5%)	4.0% (3.6% to 4.4%)	3.5% (3.0% to 3.9%)	0.05
Excision of peritoneal adhesions	54,817 (14,415)	8.6% (7.9% to 9.2%)	8.1% (7.6% to 8.5%)	7.4% (7.0% to 7.9%)	6.9% (6.4% to 7.4%)	<0.001
Appendectomy	37,178 (11,525)	2.7% (2.2% to 3.2%)	3.1% (2.7% to 3.5%)	3.0% (2.6% to 3.4%)	2.5% (2.1% to 2.9%)	0.34
Amputation of lower extremity	27,141 (8,263)	8.4% (7.6% to 9.2%)	8.5% (7.9% to 9.0%)	8.3% (7.7% to 8.9%)	7.4% (6.8% to 8.0%)	0.02
Small bowel resection	20,091 (9,389)	9.2% (8.3% to 10.1%)	9.5% (8.8% to 10.2%)	10.0% (9.2% to 10.7%)	10.7% (9.8% to 11.7%)	0.01
Laminectomy	18,634 (4,571)	2.8% (2.0% to 3.6%)	2.5% (1.9% to 3.1%)	2.1% (1.5% to 2.6%)	2.4% (1.7% to 3.1%)	0.14
Carotid endarterectomy	16,058 (3,431)	2.4% (1.3% to 3.5%)	2.8% (2.2% to 3.3%)	2.5% (2.0% to 3.1%)	3.1% (2.5% to 3.7%)	0.36
Abdominal aortic aneurysm repair	14,708 (3,555)	12.0% (10.7% to 13.3%)	12.6% (11.7% to 13.6%)	11.8% (10.8% to 12.8%)	12.3% (11.1% to 13.6%)	0.80
Valve replacement	11,483 (1,842)	9.3% (6.7% to 11.8%)	7.0% (6.0% to 8.0%)	6.9% (6.0% to 7.8%)	6.6% (5.6% to 7.6%)	0.15
Lung resection	6,197 (1,769)	7.5% (4.8% to 10.2%)	8.8% (7.5% to 10.2%)	8.7% (7.5% to 9.9%)	8.6% (6.8% to 10.3%)	0.82
Hysterectomy	5,395 (2,250)	6.4% (3.7% to 9.1%)	4.6% (2.9% to 6.3%)	4.6% (3.0% to 6.2%)	4.2% (2.4% to 5.9%)	0.25
Nephrectomy	2,985 (1,443)	3.7% (1.8% to 5.6%)	5.0% (3.1% to 6.9%)	5.4% (3.3% to 7.5%)	4.0% (1.7% to 6.4%)	0.75
Gastrectomy	2,696 (2,038)	13.5% (10.7% to 16.2%)	13.4% (11.4% to 15.4%)	14.6% (12.4% to 16.9%)	11.3% (9.0% to 13.7%)	0.42
Splenectomy	2,528 (2,117)	13.8% (11.0% to 16.5%)	15.4% (13.2% to 17.5%)	13.1% (10.8% to 15.3%)	13.0% (10.2% to 15.8%)	0.37
Pancreatic resection	1,086 (600)	10.5% (5.7% to 15.3%)	6.4% (4.0% to 8.8%)	7.6% (5.1% to 10.2%)	8.7% (4.8% to 12.6%)	0.95
Esophageal resection	339 (236)	8.1% (1.7% to 14.4%)	12.3% (6.4% to 18.3%)	13.7% (7.6% to 19.8%)	17.4% (6.6% to 28.2%)	0.16

Adjusted for patient and surgeon characteristics and hospital fixed effects. Standard errors were clustered at surgeon level. P-value of <0.0025 was considered statistically significant. The interaction between surgeon sex and procedure type was statistically significant (p=0.002).

Table H. Association between surgeon sex and operative mortality, by procedure

	Surgeon Sex	No. of procedures (No. of surgeons)	Adjusted operative mortality* (95%CI)	p-value
Hip and femur fracture	Male	334,595 (15,340)	6.2% (5.9% to 6.4%)	0.60
	Female	11,143 (821)	6.0% (5.5% to 6.5%)	
Cholecystectomy	Male	116,920 (12,341)	3.0% (2.9% to 3.2%)	0.11
	Female	12,058 (1,846)	2.8% (2.4% to 3.1%)	
Colorectal resection	Male	70,266 (12,633)	11.0% (10.5% to 11.4%)	0.47
	Female	7,670 (1,989)	10.7% (10.0% to 11.5%)	
Coronary artery bypass grafting	Male	60,800 (2,504)	6.2% (5.8% to 6.7%)	0.54
	Female	1,218 (102)	5.8% (4.2% to 7.3%)	
Fracture/dislocation of lower extremity	Male	54,022 (11,700)	4.0% (3.7% to 4.2%)	0.39
	Female	2,159 (529)	4.4% (3.4% to 5.5%)	
Excision of peritoneal adhesions	Male	48,951 (12,481)	7.7% (7.3% to 8.1%)	0.96
	Female	5,866 (1,934)	7.7% (7.0% to 8.4%)	
Appendectomy	Male	33,129 (10,035)	2.9% (2.7% to 3.1%)	0.33
	Female	4,049 (1,490)	2.6% (2.0% to 3.2%)	
Amputation of lower extremity	Male	25,737 (7,730)	8.2% (7.8% to 8.6%)	0.53
	Female	1,404 (533)	7.8% (6.5% to 9.0%)	
Small bowel resection	Male	17,915 (8,236)	9.9% (9.4% to 10.4%)	0.05
	Female	2,176 (1,153)	8.8% (7.7% to 9.9%)	
Laminectomy	Male	18,114 (4,389)	2.4% (1.9% to 2.9%)	0.16
	Female	520 (182)	3.4% (1.9% to 4.8%)	
Carotid endarterectomy	Male	15,698 (3,299)	2.8% (2.4% to 3.1%)	0.66
	Female	360 (132)	2.4% (0.7% to 4.1%)	
Abdominal aortic aneurysm repair	Male	14,162 (3,357)	12.2% (11.5% to 12.9%)	0.29
	Female	546 (198)	13.6% (11.0% to 16.1%)	
Valve replacement	Male	11,338 (1,791)	7.1% (6.4% to 7.7%)	0.91
	Female	145 (51)	6.9% (3.3% to 10.4%)	
Lung resection	Male	5,948 (1,674)	8.6% (7.7% to 9.4%)	0.19
	Female	249 (95)	11.4% (7.2% to 15.6%)	
Hysterectomy	Male	3,795 (1,522)	5.1% (3.8% to 6.3%)	0.16
	Female	1,600 (728)	3.8% (2.3% to 5.4%)	
Nephrectomy	Male	2,908 (1,391)	4.8% (3.5% to 6.2%)	0.17
	Female	77 (52)	2.0% (0% to 5.9%)	
Gastrectomy	Male	2,521 (1,896)	13.4% (12.1% to 14.6%)	0.97
	Female	175 (142)	13.5% (9.2% to 17.7%)	
Splenectomy	Male	2,247 (1,873)	13.8% (12.5% to 15.2%)	0.65
	Female	281 (244)	14.7% (11.0% to 18.4%)	
Pancreatic resection	Male	1,019 (560)	7.8% (6.2% to 9.4%)	0.81
	Female	67 (40)	7.0% (1.0% to 13.0%)	
Esophageal resection	Male	317 (221)	13.1% (9.4% to 16.7%)	0.58
	Female	22 (15)	9.7% (0% to 20.9%)	

*Adjusted for patient and surgeon characteristics and hospital fixed effects. Standard errors were clustered at surgeon level. P-value of <0.0025 was considered statistically significant. The interaction between surgeon sex and procedure type was not statistically significant (p=0.66).

Table I. Adjusted operative mortality of patients by age and sex of surgeons, elective surgery

	No. of surgeries (No. of surgeons)	Crude operative mortality (95%CI)	Adjusted operative mortality* (95%CI)	Adjusted odds ratio* (95%CI)	p-value*
Surgeon Age					
<40	100,364 (10,258)	2.0% (2.0% to 2.1%)	2.1% (2.0% to 2.2%)	Reference	
40-49	329,864 (18,952)	2.0% (1.9% to 2.0%)	2.1% (2.1% to 2.2%)	1.01 (0.95 to 1.06)	0.86
50-59	361,110 (18,353)	2.1% (2.0% to 2.1%)	2.1% (2.1% to 2.2%)	1.004 (0.95 to 1.06)	0.91
≥60	209,958 (12,435)	2.2% (2.1% to 2.3%)	2.2% (2.1% to 2.2%)	1.03 (0.97 to 1.10)	0.31
Surgeon Sex					
Male	938,009 (43,821)	2.1% (2.1% to 2.1%)	2.1% (2.1% to 2.2%)	Reference	
Female	63,287 (7,418)	1.6% (1.5% to 1.6%)	2.0% (1.9% to 2.2%)	0.94 (0.87 to 1.02)	0.12

*Adjusted for patient characteristics, surgeon characteristics, and hospital fixed effects. Standard errors were clustered at surgeon level.

Table J. Adjusted operative mortality of patients by age and sex of surgeons, without adjustment for operative volume (non-elective surgery)

	No. of surgeries (No. of surgeons)	Crude operative mortality (95%CI)	Adjusted operative mortality* (95%CI)	Adjusted odds ratio* (95%CI)	p-value*
Surgeon Age					
<40	149,349 (10,193)	6.7% (6.6% to 6.9%)	6.6% (6.5% to 6.8%)	Reference	
40-49	292,103 (17,087)	6.6% (6.5% to 6.6%)	6.5% (6.4% to 6.6%)	0.98 (0.95 to 1.01)	0.13
50-59	283,007 (16,144)	6.3% (6.2% to 6.4%)	6.4% (6.3% to 6.5%)	0.96 (0.93 to 0.99)	0.01
≥60	167,728 (10,972)	6.4% (6.3% to 6.5%)	6.4% (6.2% to 6.5%)	0.95 (0.92 to 0.98)	0.003
Surgeon Sex					
Male	840,402 (41,192)	6.5% (6.4% to 6.5%)	6.5% (6.4% to 6.5%)	Reference	
Female	51,785 (4,634)	6.8% (6.6% to 7.0%)	6.4% (6.2% to 6.6%)	0.98 (0.94 to 1.02)	0.32

*Adjusted for patient characteristics, surgeon characteristics (except for operative volume), and hospital fixed effects. Standard errors were clustered at surgeon level.

Table K. Association between years of practice (instead of surgeon age) and operative mortality

	No. of surgeries (No. of surgeons)	Crude operative mortality (95%CI)	Adjusted operative mortality* (95%CI)	Adjusted odds ratio* (95%CI)	p-value
Years since completion of residency program (yr)					
<10	131,137 (10,622)	6.7% (6.6% to 6.9%)	6.6% (6.5% to 6.8%)	Reference	
10-19	150,313 (12,255)	6.4% (6.3% to 6.5%)	6.4% (6.3% to 6.6%)	0.96 (0.93 to 0.995)	0.03
20-29	123,156 (9,803)	6.4% (6.2% to 6.5%)	6.5% (6.3% to 6.6%)	0.97 (0.93 to 1.01)	0.10
≥30	65,406 (5,836)	6.4% (6.2% to 6.6%)	6.3% (6.1% to 6.5%)	0.95 (0.91 to 0.99)	0.02

*Adjusted for patient characteristics, surgeon characteristics, and hospital fixed effects. Standard errors were clustered at surgeon level.

Table L. Adjusted operative mortality of patients by age and sex of surgeons, using different ways to model surgeon age

	Adjusted operative mortality rate* (95%CI)		Adjusted odds ratio* (95%CI)	p-value
	Male surgeons	Female surgeons		
(A) surgeon age categorized in 10-year increments (main model)	6.5% (6.4% to 6.5%)	6.3% (6.1% to 6.5%)	0.97 (0.93 to 1.01)	0.14
(B) surgeon age used as a continuous variable (linear assumption)	6.5% (6.4% to 6.5%)	6.3% (6.1% to 6.5%)	0.97 (0.93 to 1.01)	0.13
(C) surgeon age used as a continuous variable with quadratic and cubic terms (cubic assumption)	6.5% (6.4% to 6.5%)	6.3% (6.1% to 6.5%)	0.97 (0.93 to 1.01)	0.13
(D) surgeon age used as continuous variable with linear splines	6.5% (6.4% to 6.5%)	6.3% (6.1% to 6.5%)	0.97 (0.93 to 1.01)	0.33

*Adjusted for patient characteristics, surgeon characteristics, and hospital fixed effects. Standard errors were clustered at surgeon level.

Table M. Adjusted operative mortality of patients by age and sex of surgeons, accounting for missing data on surgeon age

	No. of surgeries (No. of surgeons)	Adjusted operative mortality* (95%CI)	Adjusted odds ratio* (95%CI)	p-value
Surgeon Age (yr)				
<40	149,349 (10,191)	6.6% (6.5% to 6.7%)	Reference	
40-49	292,064 (17,084)	6.5% (6.4% to 6.6%)	0.98 (0.96 to 1.01)	0.21
50-59	283,010 (16,142)	6.4% (6.3% to 6.5%)	0.97 (0.94 to 0.995)	0.02
≥60	167,641 (10,967)	6.4% (6.2% to 6.5%)	0.95 (0.92 to 0.99)	0.01
Surgeon Sex				
Male	840,230 (41,183)	6.5% (6.4% to 6.5%)	Reference	
Female	51,789 (4,635)	6.3% (6.1% to 6.5%)	0.97 (0.93 to 1.01)	0.13

*Adjusted for patient characteristics, surgeon characteristics, and hospital fixed effects. Standard errors were clustered at surgeon level. The probability of missing data was modeled using physician characteristics, and the regression model for mortality was weighted by the inverse of the predicted probability of observing surgeon age.

Figure A. Distribution of surgeons with varying age by surgeon sex

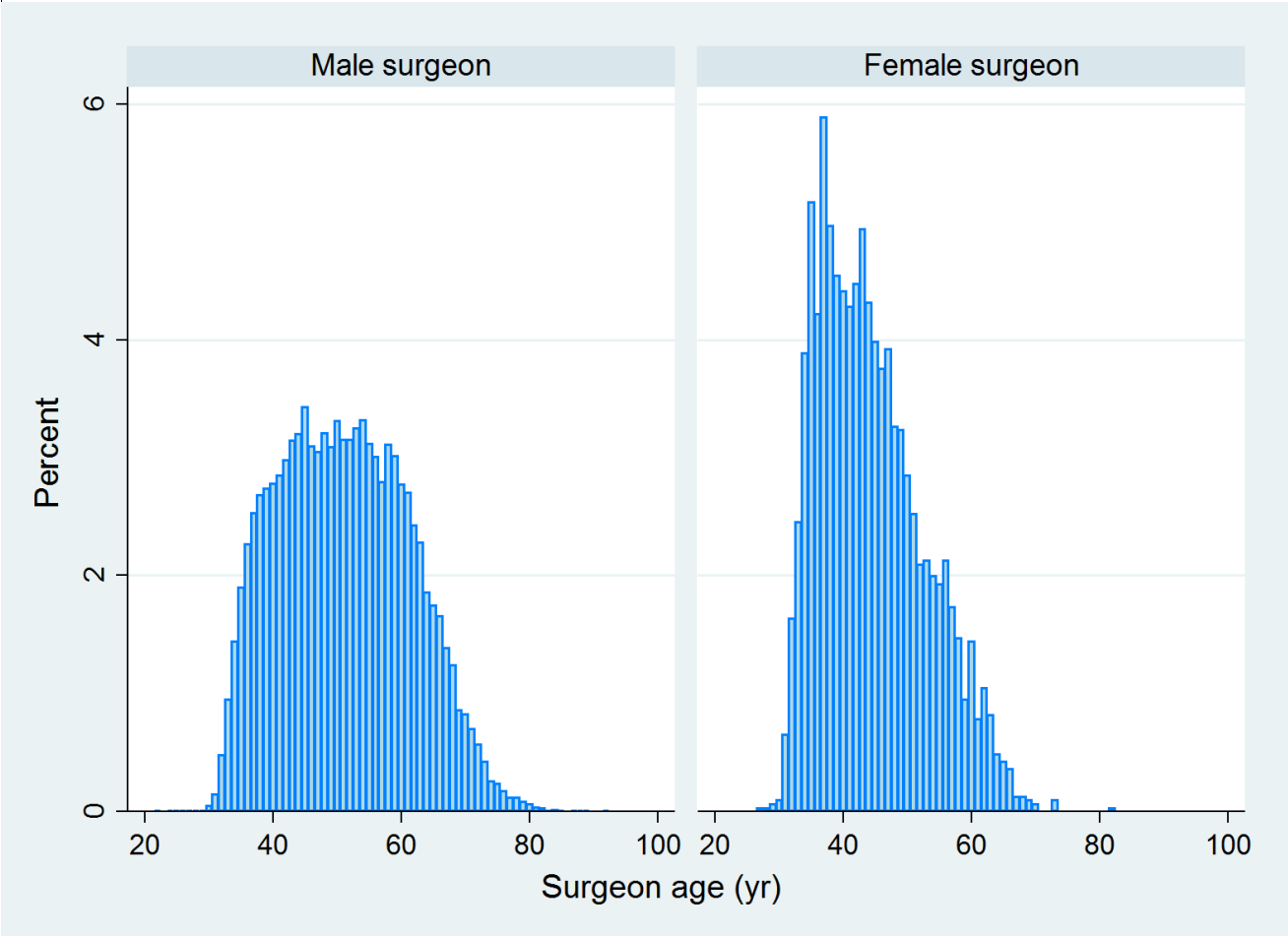
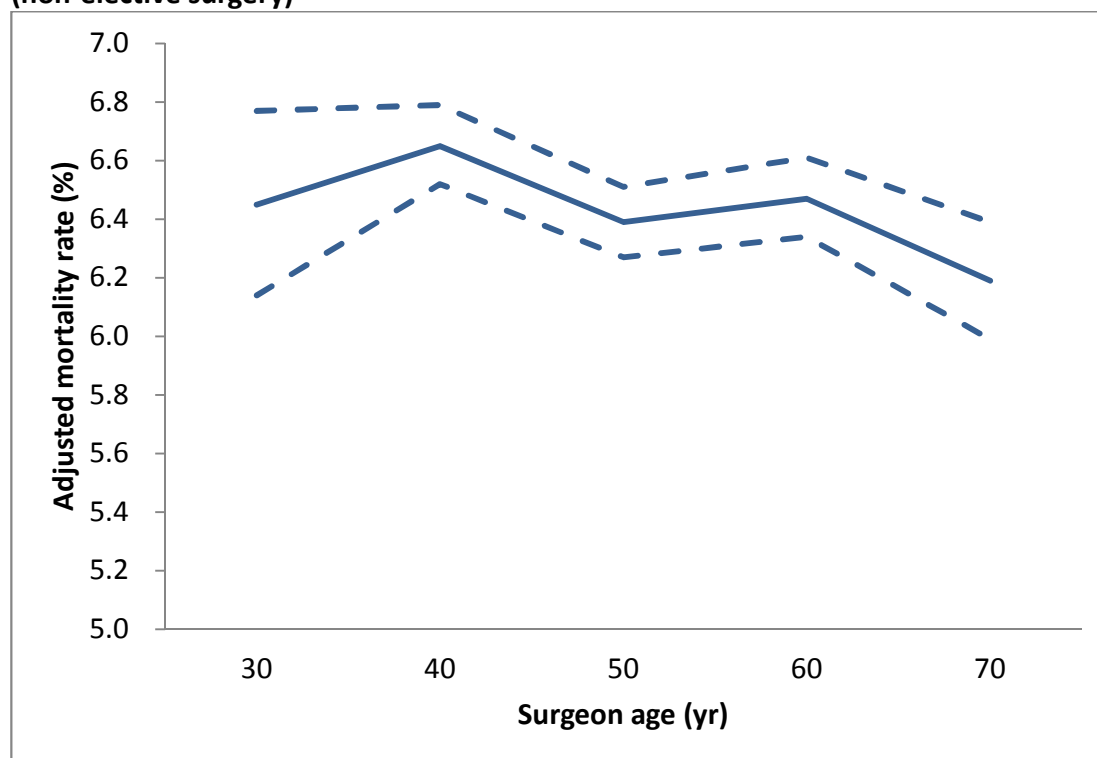


Figure B. Adjusted operative mortality of patients by age of surgeons, using a linear spline model (non-elective surgery)



Adjusted for patient characteristics, surgeon characteristics, and hospital fixed effects. Standard errors were clustered at surgeon level.