

Supplemental Digital Content File

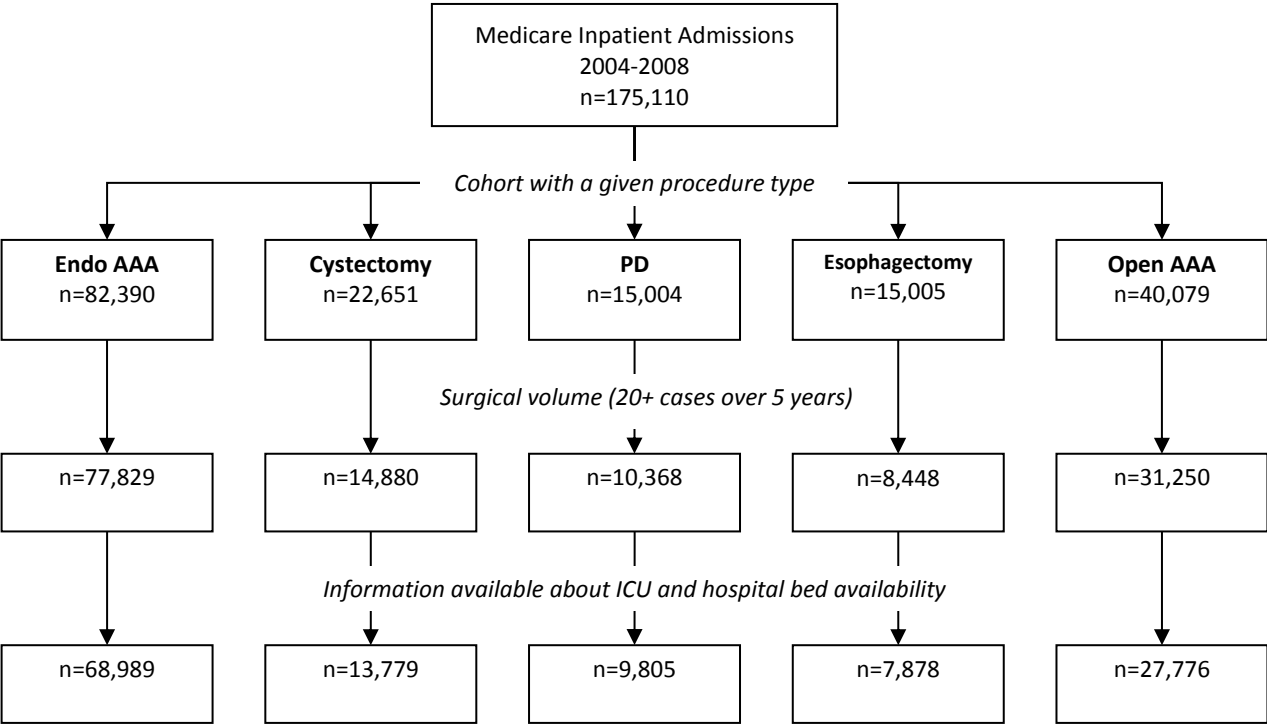
Manuscript: Use of intensive care services for Medicare beneficiaries undergoing major surgical procedures

Table 1. ICD-9-CM codes used to identify five surgical procedures in Medicare data

Procedure	ICD-9-CM Codes	Procedure codes
Esophagectomy		42.40-42.42, 43.99
PD		52.7
Cystectomy		57.70-57.79
Elective Open AAA	441.4 or 441.02	38.34, 38.44, 38.64
Elective Endovascular AAA	441.4 or 441.02	39.71

AAA = abdominal aortic aneurysm; ICD-9-CM = The International Classification of Diseases, Ninth Revision, Clinical Modification; PD = pancreaticoduodenectomy

Figure 1. Flowchart of exclusions of patients and hospitals for each surgical procedure assessed using Medicare data.



AAA = abdominal aortic aneurysm; ICU = intensive care unit; PD = pancreaticoduodenectomy

Table 2. Characteristics of Medicare beneficiaries who received each of five surgical procedures over five years

	Procedures				
	Endo AAA	Cystectomy	PD	Esophagectomy	Open AAA
# of patients in cohort, n	69989	13779	9805	7878	27776
ICU Admission, n (%)	24881 (35.6)	6132 (44.5)	5813 (59.3)	5125 (65.1)	19791 (71.3)
Age, n (%)					
65-69	11611 (16.6)	3075 (22.3)	2444 (24.9)	2380 (30.2)	5826 (21.0)
70-74	16310 (23.3)	3702 (26.9)	2883 (29.4)	2434 (30.9)	7568 (27.3)
75-79	18749 (26.8)	3744 (27.2)	2614 (26.7)	1830 (23.2)	7837 (28.2)
80-84	14991 (21.4)	2429 (17.6)	1453 (14.8)	943 (12.0)	4831 (17.4)
85+	8328 (11.9)	829 (6.0)	411 (4.2)	291 (3.7)	1714 (6.2)
Gender, n (%)					
Male	57041 (81.5)	11252 (81.7)	4885 (49.8)	5833 (74.0)	20137 (72.5)
Female	12948 (18.5)	2527 (18.3)	4920 (50.2)	2045 (26.0)	7639 (27.5)
Race, n (%)					
White	65827 (94.1)	12841 (93.2)	8815 (89.9)	7181 (91.2)	26095 (94.0)
Black	2327 (3.3)	539 (3.9)	552 (5.6)	309 (3.9)	942 (3.4)
Other	1835 (2.6)	399 (2.9)	438 (4.5)	388 (4.9)	739 (2.7)
Charlson comorbidities, n (%)					
0	NA	8605 (62.5)	6284 (64.1)	5154 (65.4)	NA
1	33992 (48.6)	2715 (19.7)	1281 (13.1)	1487 (18.9)	13596 (49.0)
2+	35997 (51.4)	2459 (17.9)	2240 (22.9)	1237 (15.7)	14180 (51.1)
Admission Day, n (%)					
Weekday	58726 (83.9)	12006 (87.1)	7974 (81.3)	6609 (83.9)	23532 (84.7)
Weekend	11263 (16.1)	1773 (12.9)	1831 (18.7)	1269 (16.1)	4244 (15.3)
Number of complications					
0	61511 (87.9)	10589 (76.9)	6843 (69.8)	4436 (56.3)	19164 (69.0)
1	7060 (10.1)	2382 (17.3)	2151 (21.9)	2115 (26.9)	6221 (22.4)
2+	1418 (2.0)	808 (5.9)	811 (8.3)	1327 (16.8)	2391 (8.6)
Hospital length of stay, median (IQR)					
Hospital Mortality, n (%)	723 (1.0)	338 (2.5)	387 (4.0)	541 (6.9)	1334 (4.8)

AAA = abdominal aortic aneurysm; ICU = intensive care unit; IQR = interquartile range; NA = not applicable

(Patients who underwent either open or endo AAA by definition had at least one co-morbidity (peripheral vascular disease); PD = pancreaticoduodenectomy)

Table 3. Characteristics of Medicare beneficiaries who had an endovascular AAA over five years, stratified by hospital ICU use

	ICU use			p-value
	Low (<50%)	Medium (50-90%)	High (>90%)	
# of patients in cohort, n	43,057	16,232	10,700	
ICU Admission, n (%)	8540 (19.8)	11619 (71.6)	10337 (96.6)	<0.001
Age, n (%)				0.013
65-69	7001 (16.3)	2802 (17.3)	1808 (16.9)	
70-74	9977 (23.2)	3832 (23.6)	2501 (23.4)	
75-79	11521 (26.8)	4379 (27.0)	2849 (26.6)	
80-84	9340 (21.7)	3370 (20.8)	2281 (21.3)	
85+	5218 (12.1)	1849 (11.4)	1261 (11.8)	
Gender, n (%)				0.78
Male	35095 (81.5)	13249 (81.6)	8697 (81.3)	
Female	7962 (18.5)	2983 (18.4)	2003 (18.7)	
Race, n (%)				<0.001
White	40613 (94.3)	15205 (93.7)	10009 (93.5)	
Black	1395 (3.2)	572 (3.5)	360 (3.4)	
Other	1049 (2.4)	455 (2.8)	331 (3.1)	
Charlson comorbidities, n (%)				0.013
0	0 (0.0)	0 (0.0)	0 (0.0)	
1	21090 (49.0)	7815 (48.1)	5087 (47.5)	
2+	21967 (51.0)	8417 (51.9)	5613 (52.5)	
Admission Day, n (%)				<0.001
Weekday	36270 (84.2)	13432 (82.8)	9024 (84.3)	
Weekend	6787 (15.8)	2800 (17.2)	1676 (15.7)	

ICU = intensive care

Table 4. Characteristics of Medicare beneficiaries who had cystectomy over five years, stratified by hospital

ICU use

	Low (<50%)	ICU use Medium (50-90%)	High (>90%)	p-value
# of patients in cohort, n	7,401	5,184	1,194	
ICU Admission, n (%)	1848 (25.0)	3628 (70.0)	1142 (95.6)	<0.001
Age, n (%)				0.008
65-69	1715 (23.2)	1123 (21.7)	237 (19.8)	
70-74	1962 (26.5)	1380 (26.6)	360 (30.2)	
75-79	1989 (26.9)	1433 (27.6)	322 (27.0)	
80-84	1316 (17.8)	899 (17.3)	214 (17.9)	
85+	419 (5.7)	349 (6.7)	61 (5.1)	
Gender, n (%)				0.12
Male	5997 (81.0)	4269 (82.3)	986 (82.6)	
Female	1404 (19.0)	915 (17.7)	208 (17.4)	
Race, n (%)				<0.001
White	6907 (93.3)	4806 (92.7)	1128 (94.5)	
Black	294 (4.0)	194 (3.7)	51 (4.3)	
Other	200 (2.7)	184 (3.5)	15 (1.3)	
Charlson comorbidities, n (%)				0.003
0	4687 (63.3)	3200 (61.7)	718 (60.1)	
1	1374 (18.6)	1068 (20.6)	273 (22.9)	
2+	1340 (18.1)	916 (17.7)	203 (17.0)	
Admission Day, n (%)				<0.001
Weekday	6342 (85.7)	4595 (88.6)	1069 (89.5)	
Weekend	1059 (14.3)	589 (11.4)	125 (10.5)	

ICU = intensive care

Table 5. Characteristics of Medicare beneficiaries who had a pancreaticoduodenectomy over five years, stratified by hospital ICU use

	ICU use			p-value
	Low (<50%)	Medium (50-90%)	High (>90%)	
# of patients in cohort, n	3,419	3,977	2,409	
ICU Admission, n (%)	868 (25.4)	2882 (72.5)	2328 (96.6)	<0.001
Age, n (%)				0.153
65-69	810 (23.7)	1008 (25.3)	626 (26.0)	
70-74	1031 (30.2)	1168 (29.4)	684 (28.4)	
75-79	919 (26.9)	1036 (26.0)	659 (27.4)	
80-84	502 (14.7)	616 (15.5)	335 (13.9)	
85+	157 (4.6)	149 (3.7)	105 (4.4)	
Gender, n (%)				0.802
Male	1691 (49.5)	1997 (50.2)	1197 (49.7)	
Female	1728 (50.5)	1980 (49.8)	1212 (50.3)	
Race, n (%)				<0.001
White	3122 (91.3)	3535 (88.9)	2158 (89.6)	
Black	146 (4.3)	252 (6.3)	154 (6.4)	
Other	151 (4.4)	190 (4.8)	97 (4.0)	
Charlson comorbidities, n (%)				0.141
0	2238 (65.5)	2499 (62.8)	1547 (64.2)	
1	421 (12.3)	532 (13.4)	328 (13.6)	
2+	760 (22.2)	946 (23.8)	534 (22.2)	
Admission Day, n (%)				0.225
Weekday	2811 (82.2)	3208 (80.7)	1955 (81.2)	
Weekend	608 (17.8)	769 (19.3)	454 (18.8)	

ICU = intensive care

Table 6. Characteristics of Medicare beneficiaries who had an esophagectomy over five years, stratified by hospital ICU use

	ICU use			p-value
	Low (<50%)	Medium (50-90%)	High (>90%)	
# of patients in cohort, n	1,621	3,786	2,471	
ICU Admission, n (%)	509 (31.4)	2679 (70.8)	2354 (95.3)	<0.001
Age, n (%)				0.864
65-69	513 (31.6)	1121 (29.6)	746 (30.2)	
70-74	497 (30.7)	1161 (30.7)	776 (31.4)	
75-79	360 (22.2)	898 (23.7)	572 (23.1)	
80-84	195 (12.0)	463 (12.2)	285 (11.5)	
85+	56 (3.5)	143 (3.8)	92 (3.7)	
Gender, n (%)				0.016
Male	1245 (76.8)	2782 (73.5)	1806 (73.1)	
Female	376 (23.2)	1004 (26.5)	665 (26.9)	
Race, n (%)				<0.001
White	1463 (90.3)	3448 (91.1)	2270 (91.9)	
Black	48 (3.0)	162 (4.3)	99 (4.0)	
Other	110 (6.8)	176 (4.6)	102 (4.1)	
Charlson comorbidities, n (%)				0.108
0	1080 (66.6)	2475 (65.4)	1599 (64.7)	
1	282 (17.4)	700 (18.5)	505 (20.4)	
2+	259 (16.0)	611 (16.1)	367 (14.9)	
Admission Day, n (%)				0.026
Weekday	1391 (85.8)	3176 (83.9)	2042 (82.6)	
Weekend	230 (14.2)	610 (16.1)	429 (17.4)	

ICU = intensive care

Table 7. Characteristics of Medicare beneficiaries who had an open AAA over five years, stratified by hospital ICU use

	ICU use			p-value
	Low (<50%)	Medium (50-90%)	High (>90%)	
# of patients in cohort, n	1,990	9,725	16,061	
ICU Admission, n (%)	701 (35.2)	7297 (75.0)	15547 (96.8)	<0.001
Age, n (%)				0.32
65-69	424 (21.3)	2102 (21.6)	3300 (20.5)	
70-74	519 (26.1)	2618 (26.9)	4431 (27.6)	
75-79	565 (28.4)	2744 (28.2)	4528 (28.2)	
80-84	357 (17.9)	1697 (17.4)	2777 (17.3)	
85+	125 (6.3)	564 (5.8)	1025 (6.4)	
Gender, n (%)				0.60
Male	1460 (73.4)	7028 (72.3)	11649 (72.5)	
Female	530 (26.6)	2697 (27.7)	4412 (27.5)	
Race, n (%)				<0.001
White	1871 (94.0)	9086 (93.4)	15138 (94.3)	
Black	74 (3.7)	322 (3.3)	546 (3.4)	
Other	45 (2.3)	317 (3.3)	377 (2.3)	
Charlson comorbidities, n (%)				0.11
0	0 (0.0)	0 (0.0)	0 (0.0)	
1	1008 (50.7)	4785 (49.2)	7803 (48.6)	
2+	982 (49.3)	4940 (50.8)	8258 (51.4)	
Admission Day, n (%)				0.026
Weekday	1667 (83.8)	8179 (84.1)	13686 (85.2)	
Weekend	323 (16.2)	1546 (15.9)	2375 (14.8)	

ICU = intensive care

Table 8. Multilevel mixed effects model using Medicare data of patient and hospital-level factors associated with use of intensive care for five surgical procedures. Reference group for Open AAA is all patients in hospitals with percentage of hospital beds designated as ICU beds <5% as only one hospital in this cohort <2.5%

<u>Patient variables</u>	Endo AAA		Cystectomy		PD		Esophagectomy		Open AAA	
	OR (95% CI)	p-value	OR (95% CI)	p-value	OR (95% CI)	p-value	OR (95% CI)	p-value	OR (95% CI)	p-value
Age										
65-69	1		1		1		1		1	
	0.93		1.24	<0.00	1.22		1.18		1.02	
70-74	(0.88,1.00)	0.04	(1.11,1.40)	1	(1.06,1.41)	0.005	(1.01,1.36)	0.031	(0.91,1.13)	0.77
	0.97		1.32	<0.00	1.20		1.23		1.10	
75-79	(0.91,1.03)	0.32	(1.17,1.48)	1	(1.04,1.39)	0.014	(1.05,1.44)	0.012	(0.99,1.23)	0.08
	1.03		1.69	<0.00	1.33		1.34		1.14	
80-84	(0.96,1.10)	0.43	(1.48,1.92)	1	(1.12,1.58)	0.001	(1.10,1.64)	0.003	(1.00,1.29)	0.046
	1.13		2.45	<0.00	1.64		1.38		1.07	
85+	(1.05,1.22)	0.002	(2.03,2.97)	1	(1.23,2.17)	0.001	(0.99,1.91)	0.057	(0.90,1.28)	0.45
Female										
Race										
White	1		1		1		1		1	
	1.16		1.02		1.04		0.94		0.88	
Black	(1.04,1.30)	0.009	(0.83,1.27)	0.83	(0.82,1.32)	0.73	(0.69,1.28)	0.68	(0.71,1.09)	0.25
	1.09		1.16		1.24		0.58	<0.00	1.10	
Other	(0.96,1.24)	0.19	(0.90,1.48)	0.25	(0.95,1.61)	0.11	(0.44,0.76)	1	(0.86,1.40)	0.47
Charlson score										
0			1		1		1			
			1.18		1.08		1.20			
1	1		(1.07,1.32)	0.002	(0.92,1.27)	0.33	(1.03,1.40)	0.022	1	
	1.10	<0.00	0.97		0.89		0.86		1.00	
2+	(1.05,1.14)	1	(0.87,1.08)	0.60	(0.78,1.01)	0.08	(0.74,1.01)	0.071	(0.92,1.08)	0.94
Weekend (vs	0.98	0.51	1.13	0.06	1.00	0.99	1.08	0.34	1.10	0.070

weekday)	(0.93,1.04)		(0.99,1.28)		(0.87,1.15)		(0.92,1.27)		(0.99,1.23)	
<u>Hospital variables</u>										
Median Odds Ratio	6.20		3.59		4.61		3.29		5.12	
Academic (vs non-academic)	(5.62,6.87)		(3.16,4.14)		(3.81,5.74)		(2.81,3.95)		(4.50,5.90)	
Hospital beds	0.89		1.39		0.16		1.28		1.04	
<200	(0.66,1.22)	0.47	(0.80,2.39)	0.24	(0.03,0.80)	0.026	(0.50,3.27)	0.60	(0.70,1.55)	0.83
200-399	1		1		1		1		1	
400-599	0.43		0.91		0.25		0.24		0.75	
600-799	(0.26,0.71)	0.001	(0.34,2.43)	0.85	(0.02,2.86)	0.27	(0.04,1.41)	0.12	(0.35,1.61)	0.46
800-999	0.67		0.79		0.66		0.52		0.73	
1000+	(0.34,1.31)	0.24	(0.24,2.56)	0.70	(0.05,8.51)	0.75	(0.07,3.62)	0.51	(0.29,1.87)	0.52
Average daily census	0.96		0.89		1.80		0.64		1.05	
<200	(0.38,2.39)	0.93	(0.24,3.35)	0.86	(0.12,27.39)	0.67	(0.08,5.10)	0.68	(0.34,3.21)	0.94
200-399	0.76		0.48		1.53		0.43		2.05	
400-599	(0.17,3.52)	0.73	(0.09,2.53)	0.39	(0.07,31.29)	0.78	(0.04,4.67)	0.49	(0.40,10.60)	0.39
600-799	0.86		0.03		0.80		0.95		0.37	
800-999	(0.06,11.53)	0.91	(0.00,0.97)	0.048	(0.01,85.51)	0.93	(0.04,22.97)	0.97	(0.02,6.92)	0.51
1000+	1		1		1		1		1	
Average daily census	0.98		2.91		2.07		3.74		0.97	
<200	(0.66,1.44)	0.91	(1.15,7.40)	0.025	(0.23,18.72)	0.52	(0.61,23.15)	0.16	(0.57,1.66)	0.91
200-399	0.76		2.97		1.14		3.60		0.52	
400-599	(0.38,1.52)	0.44	(0.97,9.03)	0.056	(0.10,13.43)	0.92	(0.48,26.83)	0.21	(0.23,1.17)	0.12
600-799	0.56		4.40		1.74		4.65		0.37	
800-999	(0.17,1.83)	0.34	(1.11,17.50)	0.035	(0.12,26.17)	0.69	(0.53,41.07)	0.17	(0.11,1.30)	0.12
1000+	0.33		57.67		1.72		3.65		0.51	
Number of surgeries annually, median	(0.02,5.07)	0.42	(2.26,1473.36)	0.014	(0.02,143.63)	0.81	(0.17,80.70)	0.41	(0.03,8.52)	0.64
<2500	0.27		90.44		1.60		1.77		0.53	
2500-4999	(0.01,5.43)	0.39	(2.59,3154.97)	0.013	(0.01,218.81)	0.85	(0.06,50.46)	0.74	(0.02,12.84)	0.70
<2500	1		1		1		1		1	
2500-4999	0.70		1.29		20.88		16.81		1.53	
Number of surgeries annually, median	(0.40,1.20)	0.19	(0.41,4.07)	0.66	(0.58,757.98)	0.10	(0.98,289.39)	0.052	(0.65,3.62)	0.33

5000-7499	0.50		0.21		5.74		7.21		1.60	
	(0.26,0.95)	0.035	(0.05,0.84)	0.028	(0.08,390.82)	0.42	(0.28,186.19)	0.23	(0.60,4.26)	0.35
7500-9999	0.35		0.33		6.58		3.82		1.76	
	(0.16,0.74)	0.006	(0.08,1.38)	0.13	(0.09,472.31)	0.39	(0.14,102.22)	0.42	(0.62,5.03)	0.29
10000-12499	0.39		0.23		4.41		3.03		1.63	
	(0.16,0.94)	0.037	(0.05,0.99)	0.048	(0.06,336.57)	0.50	(0.11,84.02)	0.51	(0.51,5.19)	0.41
12500-14999	0.45		0.22		2.21		2.35		1.51	
	(0.16,1.32)	0.15	(0.04,1.06)	0.06	(0.03,174.59)	0.72	(0.08,70.88)	0.62	(0.41,5.59)	0.54
≥15000+	0.77		0.22		5.22		4.98		2.61	
	(0.23,2.64)	0.68	(0.04,1.14)	0.07	(0.06,443.43)	0.47	(0.15,167.76)	0.37	(0.60,11.24)	0.20
Percentage of hospital beds designated as ICU beds										
<2.5%	1		1		1		1			
	0.70		0.56		0.11		0.19			
2.5-4.9%	(0.01,37.24)	0.86	(0.20,1.55)	0.26	(0.02,0.61)	0.012	(0.05,0.75)	0.019	1	
	0.93		1.40		0.23		0.59		1.04	
5-7.4%	(0.02,46.25)	0.97	(0.66,2.94)	0.38	(0.07,0.79)	0.019	(0.23,1.55)	0.29	(0.41,2.59)	0.94
	1.10		0.97		0.36		0.62		0.99	
7.5-9.9%	(0.02,54.84)	0.96	(0.50,1.91)	0.94	(0.12,1.03)	0.06	(0.26,1.49)	0.29	(0.41,2.41)	0.99
	1.81		1.51		0.47		0.96		1.41	
10-12.4%	(0.04,90.34)	0.77	(0.72,3.17)	0.28	(0.14,1.52)	0.21	(0.38,2.41)	0.94	(0.56,3.55)	0.46
	1.45		1.38		0.64		1.49		1.36	
12.5-14.9%	(0.03,73.33)	0.85	(0.64,2.99)	0.41	(0.19,2.19)	0.48	(0.56,3.97)	0.43	(0.52,3.58)	0.53
	1.65								0.88	
≥15%	(0.03,83.72)	0.80	omitted		omitted		omitted		(0.33,2.40)	0.81
Trauma Center	0.93		0.72		0.54		0.44		1.10	
	(0.70,1.24)	0.63	(0.47,1.10)	0.13	(0.25,1.17)	0.12	(0.25,0.79)	0.006	(0.77,1.58)	0.59
Volume of the procedure performed (quintiles)										
1st	1		1		1		1		1	
	0.54		0.59		1.37		0.63		1.88	
2nd	(0.35,0.84)	0.006	(0.33,1.07)	0.08	(0.52,3.56)	0.52	(0.29,1.38)	0.25	(1.10,3.21)	0.021
3rd	0.60	0.023	0.80	0.47	1.06	0.91	0.79	0.57	1.23	0.45

	(0.38,0.93)		(0.43,1.47)		(0.43,2.61)		(0.34,1.81)		(0.72,2.08)	
	0.40	<0.00	0.69		0.96		0.83		0.94	
4th	(0.25,0.63)	1	(0.37,1.27)	0.23	(0.37,2.52)	0.94	(0.37,1.85)	0.65	(0.55,1.61)	0.83
	0.17	<0.00	0.50		0.66		0.36		1.13	
5th	(0.10,0.28)	1	(0.27,0.94)	0.033	(0.25,1.71)	0.39	(0.15,0.86)	0.022	(0.64,1.99)	0.68

AAA = abdominal aortic aneurysm; ICU = intensive care unit; PD = pancreaticoduodenectomy