

Supplementary tables

Table 1: All-cause mortality and serious adverse events by age and sex. †Mortality based on patients undergoing surgery 2012-2017 only.

Age (years)	Sex	Number at risk	Number of events	30-days Incidence % (95% CI)	Number of events	90-days Incidence % (95% CI)
Mortality†						
50-64	Male	1865	2	0.11% (0.03 to 0.43)	4	0.21% (0.08 to 0.57)
65-74		2898	3	0.10% (0.03 to 0.32)	9	0.31% (0.16 to 0.60)
75-84		2175	10	0.46% (0.25 to 0.85)	17	0.78% (0.49 to 1.26)
85+		305	12	3.93% (2.23 to 6.93)	17	5.57% (3.46 to 8.97)
50-64	Female	2311	1	0.04% (0.01 to 0.31)	3	0.13% (0.04 to 0.40)
65-74		6603	7	0.11% (0.05 to 0.22)	12	0.18% (0.10 to 0.32)
75-84		7410	10	0.13% (0.07 to 0.25)	25	0.34% (0.23 to 0.50)
85+		1444	13	0.90% (0.52 to 1.55)	31	2.15% (1.51 to 3.05)
Myocardial infarction						
50-64	Male	4758	4	0.08% (0.03 to 0.22)	9	0.19% (0.10 to 0.36)
65-74		6309	9	0.14% (0.07 to 0.27)	16	0.25% (0.16 to 0.41)
75-84		4270	12	0.28% (0.16 to 0.49)	24	0.56% (0.38 to 0.84)
85+		637	7	1.10% (0.52 to 2.31)	9	1.41% (0.74 to 2.72)
50-64	Female	6660	2	0.03% (0.01 to 0.12)	3	0.05% (0.01 to 0.14)
65-74		15258	24	0.16% (0.11 to 0.23)	26	0.17% (0.12 to 0.25)
75-84		16716	41	0.25% (0.18 to 0.33)	52	0.31% (0.24 to 0.41)
85+		3446	22	0.64% (0.42 to 0.97)	22	0.64% (0.42 to 0.97)
Pulmonary embolism						
50-64	Male	4758	6	0.13% (0.06 to 0.28)	9	0.19% (0.10 to 0.36)
65-74		6309	6	0.10% (0.04 to 0.21)	10	0.16% (0.09 to 0.29)
75-84		4270	12	0.28% (0.16 to 0.49)	17	0.40% (0.25 to 0.64)
85+		637	4	0.63% (0.24 to 1.67)	4	0.63% (0.24 to 1.67)
50-64	Female	6660	10	0.15% (0.08 to 0.28)	14	0.21% (0.12 to 0.35)
65-74		15258	24	0.16% (0.11 to 0.23)	33	0.22% (0.15 to 0.30)
75-84		16716	36	0.22% (0.16 to 0.30)	55	0.33% (0.25 to 0.43)
85+		3446	8	0.23% (0.12 to 0.46)	14	0.41% (0.24 to 0.69)
Lower respiratory tract infection						
50-64	Male	4758	35	0.74% (0.53 to 1.02)	43	0.90% (0.67 to 1.22)
65-74		6309	63	1.00% (0.78 to 1.28)	79	1.25% (1.00 to 1.56)
75-84		4270	107	2.51% (2.07 to 3.03)	140	3.28% (2.78 to 3.87)
85+		637	66	10.36% (8.14 to 13.19)	81	12.72% (10.23 to 15.81)
50-64	Female	6660	57	0.86% (0.66 to 1.11)	76	1.14% (0.91 to 1.43)
65-74		15258	147	0.96% (0.82 to 1.13)	194	1.27% (1.10 to 1.46)
75-84		16716	277	1.66% (1.47 to 1.86)	356	2.13% (1.92 to 2.36)
85+		3446	118	3.42% (2.86 to 4.10)	141	4.09% (3.47 to 4.83)
Acute kidney injury						
50-64	Male	4758	23	0.48% (0.32 to 0.73)	27	0.57% (0.39 to 0.83)
65-74		6309	43	0.68% (0.51 to 0.92)	46	0.73% (0.55 to 0.97)
75-84		4270	81	1.90% (1.53 to 2.36)	87	2.04% (1.65 to 2.51)
85+		637	23	3.61% (2.40 to 5.43)	30	4.71% (3.29 to 6.74)
50-64	Female	6660	13	0.20% (0.11 to 0.34)	20	0.30% (0.19 to 0.47)
65-74		15258	83	0.54% (0.44 to 0.67)	101	0.66% (0.54 to 0.80)
75-84		16716	149	0.89% (0.76 to 1.05)	183	1.09% (0.95 to 1.27)
85+		3446	60	1.74% (1.35 to 2.24)	71	2.06% (1.63 to 2.60)
Urinary tract infection						
50-64	Male	4758	12	0.25% (0.14 to 0.44)	15	0.32% (0.19 to 0.52)
65-74		6309	32	0.51% (0.36 to 0.72)	50	0.79% (0.60 to 1.05)
75-84		4270	48	1.12% (0.85 to 1.49)	71	1.66% (1.32 to 2.10)
85+		637	23	3.61% (2.40 to 5.43)	31	4.87% (3.42 to 6.92)
50-64	Female	6660	27	0.41% (0.28 to 0.59)	38	0.57% (0.42 to 0.78)
65-74		15258	102	0.67% (0.55 to 0.81)	145	0.95% (0.81 to 1.12)
75-84		16716	226	1.35% (1.19 to 1.54)	309	1.85% (1.65 to 2.07)
85+		3446	123	3.57% (2.99 to 4.26)	150	4.35% (3.71 to 5.11)
Cerebrovascular event						
50-64	Male	4758	4	0.08% (0.03 to 0.22)	6	0.13% (0.06 to 0.28)
65-74		6309	9	0.14% (0.07 to 0.27)	14	0.22% (0.13 to 0.37)
75-84		4270	12	0.28% (0.16 to 0.49)	23	0.54% (0.36 to 0.81)
85+		637	3	0.47% (0.15 to 1.46)	4	0.63% (0.24 to 1.67)
50-64	Female	6660	0	0.00% (0.00 to 0.00)	0	0.00% (0.00 to 0.00)
65-74		15258	8	0.05% (0.03 to 0.10)	23	0.15% (0.10 to 0.23)
75-84		16716	30	0.18% (0.13 to 0.26)	47	0.28% (0.21 to 0.37)
85+		3446	15	0.44% (0.26 to 0.72)	20	0.58% (0.37 to 0.90)

Supplementary tables

Table 2: Estimates of lifetime risk of implant revision or any further shoulder operation, stratified by age and sex

Age (years)	Sex	Lifetime risk of implant revision	Lifetime risk of any further shoulder surgery
50-54	Male	19.34% (18.93 to 19.75)	29.75% (29.20 to 30.30)
55-59		23.61% (23.20 to 24.02)	31.86% (31.36 to 32.37)
60-64		15.86% (15.57 to 16.14)	24.22% (23.82 to 24.62)
65-69		12.94% (12.75 to 13.13)	20.36% (20.09 to 20.64)
70-74		10.55% (10.38 to 10.73)	16.94% (16.64 to 17.24)
75-79		8.03% (7.89 to 8.17)	13.14% (12.86 to 13.43)
80-84		7.06% (6.88 to 7.24)	9.08% (8.83 to 9.32)
85+		3.81% (3.65 to 3.97)	4.37% (4.20 to 4.55)
50-54	Female	19.79% (19.41 to 20.18)	28.01% (27.52 to 28.49)
55-59		19.02% (18.72 to 19.31)	27.87% (27.47 to 28.27)
60-64		15.20% (15.00 to 15.41)	22.61% (22.30 to 22.91)
65-69		12.42% (12.25 to 12.59)	19.41% (19.16 to 19.67)
70-74		9.28% (9.18 to 9.37)	14.08% (13.89 to 14.27)
75-79		6.42% (6.35 to 6.49)	9.88% (9.75 to 10.01)
80-84		4.25% (4.18 to 4.31)	7.63% (7.44 to 7.83)
85+		2.68% (2.62 to 2.75)	3.70% (3.59 to 3.80)

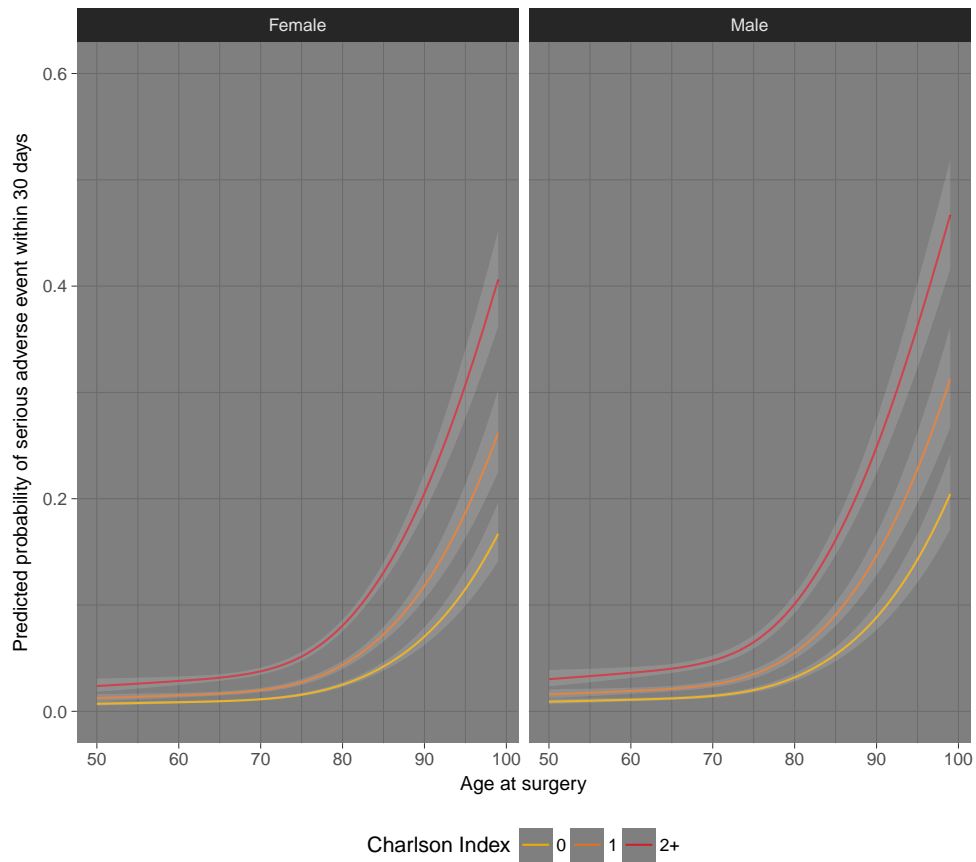
Supplementary tables

Table 3: Estimated revision risk at 3, 5, 10 and 15 years stratified by age and sex. Risk calculated as 1 minus Kaplan Meier survival function. Presented in table as total number of cases performed, estimate, 95% confidence intervals and number remaining at risk (n)

Age (years)	Total cases	Male			
		3 years	5 years	10 years	15 years
50-54	1013	8.91% (7.23 to 10.97) n=695	11.57% (9.58 to 13.95) n=529	16.37% (13.68 to 19.53) n=229	20.58% (16.64 to 25.29) n=67
55-59	1491	7.99% (6.63 to 9.61) n=985	12.78% (10.96 to 14.87) n=727	20.13% (17.53 to 23.07) n=321	23.86% (20.39 to 27.82) n=80
60-64	2254	7.6% (6.5 to 8.87) n=1525	10.43% (9.09 to 11.95) n=1141	13.66% (11.94 to 15.61) n=403	16.67% (13.96 to 19.83) n=89
65-69	3092	6.62% (5.73 to 7.64) n=1952	8.97% (7.88 to 10.21) n=1394	12.82% (11.28 to 14.55) n=462	13.79% (11.96 to 15.87) n=100
70-74	3217	6.34% (5.48 to 7.32) n=1934	8.48% (7.43 to 9.68) n=1318	10.73% (9.36 to 12.28) n=379	11.5% (9.80 to 13.47) n=56
75-79	2786	6.46% (5.53 to 7.55) n=1560	7.68% (6.6 to 8.92) n=1015	9.06% (7.61 to 10.78) n=203	9.06% (7.61 to 10.78) n=28
80-84	1484	5.4% (4.28 to 6.79) n=765	7.09% (5.66 to 8.85) n=437	8.37% (6.58 to 10.63) n=69	8.37% (6.58 to 10.63) n=5
85+	637	4.36% (2.93 to 6.47) n=271	4.36% (2.93 to 6.47) n=153	4.36% (2.93 to 6.47) n=11	4.36% (2.93 to 6.47) n=2

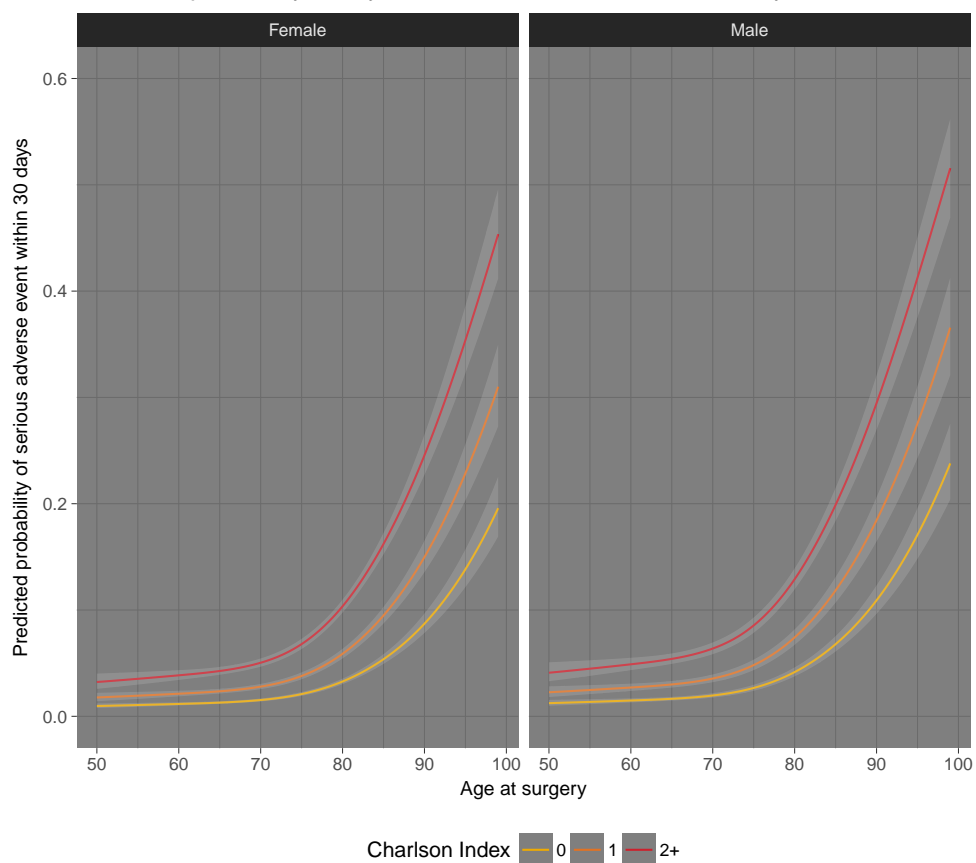
Age (years)	Total cases	Female			
		3 years	5 years	10 years	15 years
50-54	1076	7.78% (6.23 to 9.7) n=759	11.3% (9.36 to 13.6) n=596	16.28% (13.76 to 19.2) n=311	19.89% (16.62 to 23.72) n=116
55-59	1942	7.71% (6.54 to 9.07) n=1395	10.85% (9.41 to 12.48) n=1072	16.3% (14.33 to 18.51) n=494	19.11% (16.57 to 21.98) n=137
60-64	3642	5.99% (5.22 to 6.87) n=2615	9.14% (8.15 to 10.24) n=2010	13.05% (11.71 to 14.54) n=802	15.72% (13.84 to 17.83) n=227
65-69	6306	5.39% (4.81 to 6.03) n=4206	7.16% (6.47 to 7.92) n=3056	10.55% (9.58 to 11.62) n=1176	12.67% (11.22 to 14.29) n=260
70-74	8952	5.18% (4.71 to 5.71) n=5768	6.9% (6.32 to 7.53) n=4162	9.12% (8.35 to 9.95) n=1326	9.96% (9.00 to 11.01) n=242
75-79	9902	4.2% (3.79 to 4.65) n=6259	5.51% (5.01 to 6.05) n=4344	7.00% (6.33 to 7.72) n=1219	7.13% (6.43 to 7.91) n=189
80-84	6814	3.24% (2.81 to 3.73) n=4128	4.02% (3.52 to 4.59) n=2734	4.94% (4.28 to 5.69) n=582	4.94% (4.28 to 5.69) n=55
85+	3446	2.6% (2.08 to 3.25) n=1966	2.89% (2.32 to 3.59) n=1170	3.28% (2.59 to 4.16) n=164	3.28% (2.59 to 4.16) n=11

Supplementary figure 1a:
Predicted probability of any serious adverse event within 30 days



Logistic regression based on 58054 cases, 2045 events. Model validation: c-statistic 0.72, Brier score 0.03

Supplementary figure 1b:
Predicted probability of any serious adverse event within 90 days



Logistic regression based on 58054 cases, 2677 events. Model validation: c-statistic 0.72, Brier score 0.04

Supplementary methodology notes:

OPCS-4 codes are regularly updated with new codes to reflect evolving medical technology. The standard version used for this study was OPCS-4.7 (mandated for HES use since April 2014). The NHS Technology Reference data Update Distribution provides reference datasets to cross reference these codes to older versions of the OPCS-4. These were applied to the dataset to ensure full capture of relevant cases since 1998. Specifically, in OPCS-4.2, shoulder replacements were identified with the addition of specific anatomy codes. Subsequent to that, standalone shoulder replacement codes are used.

There are 20 diagnosis fields ("DIAG_") in HES which use the ICD-10 coding system. ICD-10 uses a tree structure for codes with up to 5 digits available in HES. Therefore, diagnoses can be identified with fewer digits if the intention is to include all of the subsequent branches. Primary diagnosis codes were based on the information recorded in the FIRST diagnosis field only. Past medical history was taken into account to identify previous conditions which were highly likely to contribute to the indication for surgery. The following hierarchy was used to apply these in generating the final main indication: 1. Bone tumour, 2. Acute trauma, 3. Previous trauma, 4. Avascular necrosis, 5. Inflammatory, 6. Osteoarthritis and cuff tear arthropathy, 7. Other

The Charlson Comorbidity Index was calculated using the Stata function `-charlson` (Vicki Stagg, 2006. "CHARLSON: Stata module to calculate Charlson index of comorbidity," Statistical Software Components S456719, Boston College Department of Economics, revised 13 Sep 2017).

The following pages of tables describe the relevant OPCS-4 and ICD-10 codes used in this study.

Primary procedure codes

Main code	Anatomy code
W431	Z685
W431	Z691
W431	Z814
W431	Z814
W431	Z814
W441	Z814
W441	Z814
W451	Z814
W451	Z814
W491	n/a
W494	n/a
W501	n/a
W504	n/a
W511	n/a
W515	n/a
W581	Z691
W581	Z813
W581	Z814
W961	n/a
W965	n/a
W971	n/a
W975	n/a
W981	n/a
W986	n/a
O061	n/a
O071	n/a
O081	n/a

Revision procedure codes (OPCS-4)

Main code	Anatomy code	Main code	Anatomy code	Main code	Anatomy code	Main code	Anatomy code
W430	n/a	W459	Z814	W980	Z813	W601	One of Z813, Z814, Z891
W430		W490	Z814	W982	Z814	W602	
W430		W492	Z814	W983		W603	
W430		W493	Z814	W984		W608	
W432		W498	Z814	W985		W609	
W432		W499	Z814	W987		W611	
W432		W500	Z814	W988		W612	
W432		W502	Z814	W989		W613	
W433		W503	Z814	O060		W618	
W433		W508	Z814	O062		W619	
W433		W509	Z814	O063		W621	
W433		W510	Z814	O068		W622	
W433		W512	Z814	O069		W628	
W438		W513	Z814	O070		W629	
W438		W514	Z814	O072		W631	
W438		W518	Z814	O073		W632	
W438		Z685	W519	Z814	O078	n/a	
W439	Z691	W580		O079		W639	
W439	Z814	W580		O080		W641	
W439	Z814	W580		O082		W642	
W439	Z685	W582		O083		W648	
W440	Z691	W582		O084		W649	
W442	Z814	W582		O088			
W443	Z814	W960		O089			
W443	Z685	W962	n/a	X071			
W448	Z691	W963		X072			
W449	Z814	W964		W572			
W450	Z814	W966		W573			
W452	Z814	W968		W574			
W453	Z685	W969		W575			
W453	Z691	W970		W579			
W454	Z814	W972		Y037			
W454	Z814	W973					
W454	Z685	W974	Z691				
W454	Z691	W976	Z813				
W454	Z814	W978	Z814				
W458	Z814	W979	Z691				

Reoperation procedure codes (OPCS-4)

Procedure description	Main code	Anatomy code	Notes
Subacromial decompression or ACJ excision	O291		
	W572	Z812, Z814	Z814 only before 2009
	W844	Z812, Z814, Z891	
	T621	Z814, Z891	
	T622		
	T626		
	T628		
T629			
Rotator cuff repair	T791		
	T793		
	T794		
	T795		
	T641	Z742	
	T642		
	T643		
	T744		
	T648		
	T649		
	T67		
	T68		
Relocation of dislocated prosthesis	W652	Z813, Z814, Z891	
	W658		
	W689		
	W662		
	W668		
	W669		
	W672		
	W674		
	W678		
W679			
Stabilisation procedure	O27		
	W77		Not W776
	W841		
	W842		
	W72	Z813, Z814, Z891	
	W73		
	W74		
W75			

Reoperation procedure codes (OPCS-4) - continued

Procedure description	Main code	Anatomy code	Notes
MUA +/- capsular release	W911	Z813, Z814, Z891	
	W913		
	W918		
	W919		
	W781		
	W784		
	Y421		
	Y428		
	Y429		
Fracture fixation (excluding prosthesis revision)	W19	Z691,	Not W191
	W20	Z692,	
	W21	Z693,	
	W22	Z813,	
	W23	Z814,	
	W24	Z891	Not W241
	W25		
	W26		
	W651		
	W653		
	W654		
	W656		
	W661		
	W663		
	W664		
	W671		
	W673		
	W677		
	W332		
	O172		
O173			
O175			
O178			
O179			
Synovectomy	W691	Z813, Z814, Z891	
	W692		
	W693		
	T711		

Primary indication codes

Indication	Primary ICD-10 code	ICD-10 codes in patient history	OPCS-4 codes in patient history	
			Main code	Anatomy code
	EITHER	OR	OR	
Tumour	C795			
	C400			
	M122			
	C81			
	C82			
	C83			
	C84			
	C85			
	C90			
	D160			
	C764			
Acute trauma	S420			
	S421			
	S422			
	S427			
	S429			
	S430			
	S431			
	S434			
	S435			
Previous trauma	M125	S420	O27	
	M191	S421	W77	Not W776
	T846	S422	W841	
	M8721	S427	W842	
	M8722	S429	W72	Z813, Z814, Z891
	M8401	S430	W73	
	M8402	S431	W74	
	M8411	S434	W75	
	M8412	S435	W652	
			W658	
			W689	
			W662	
			W668	
			W669	
			W672	
			W674	
			W678	
		W679		

Primary indication codes - continued

Indication	Primary ICD-10 code	ICD-10 codes in patient history	OPCS-4 codes in patient history	
			Main code	Anatomy code
	EITHER	OR	OR	
AVN	M8701			
	M8702			
	M8711			
	M8712			
	M8731			
	M8732			
	M8741			
	M8742			
	M8751			
	M8752			
	M8761			
	M8762			
	M9051			
	M9052			
Inflammatory	M02			
	M03			
	M05			
	M06			
	M07			
	M08			
	M09			
	M10			
	M11			
	M12			
OA/Cuff Tear arthropathy	M15		T791	
	M19		T793	
	S460		T794	
	M751		T795	
			T641	Z742
			T642	
			T643	
			T744	
			T648	
			T649	
			T67	
			T68	

Serious systemic complications

Condition	ICD-10 code	Descriptor
Pulmonary embolism	I26	Pulmonary embolism
Myocardial infarction	I21	Acute myocardial infarction
	I22	Subsequent myocardial infarction
Lower respiratory tract infection	J12	Viral pneumonia, not elsewhere classified
	J13	Pneumonia due to Streptococcus pneumoniae
	J14	Pneumonia due to Haemophilus influenzae
	J15	Bacterial pneumonia, not elsewhere classified
	J16	Pneumonia due to other infectious organisms, not elsewhere classified
	J18	Pneumonia, organism unspecified
	J22	Unspecified acute lower respiratory infection
	J86	Pyothorax
	J440	Chronic obstructive pulmonary disease with acute lower respiratory infection
	J851	Abscess of lung with pneumonia
J690	Aspiration pneumonia	
Acute kidney injury	N17	Acute renal failure
Urinary tract infection	N10	Acute tubulo-interstitial nephritis
	N300	Acute cystitis
	N308	Other cystitis
	N309	Cystitis, unspecified
	N390	Urinary tract infection, site not specified
Cerebrovascular event	I60	Subarachnoid haemorrhage
	I61	Intracerebral haemorrhage
	I62	Other nontraumatic intracranial haemorrhage
	I63	Cerebral infarction
	I64	Stroke, not specified as haemorrhage or infarction