THE HOSPITAL FRAILTY RISK SCORE - OUTCOMES IN SPECIALISED SERVICES

BACKGROUND

Frailty describes impaired resolution following a stressor event [1]. There is a growing recognition of the utility of frailty to stratify older people based on their likely outcomes in a range of settings [2-11].

A current focus of English National Health Service (NHS) policy is to improve outcomes for older people living with frailty [12]. NHS Specialised Services are commissioned directly by NHS England and cover treatments for conditions requiring specialist clinical input. Examples include Transcatheter Aortic Valve Implantation (TAVI), critical care or complex spinal surgery. Whilst there is growing interest in assessing frailty in older people needing NHS specialised services, there is no standardised approach, making case-mix comparisons difficult. The electronic Frailty Index [3] is used in primary care, but has not been validated for its predictive utility in secondary care or specialised services.

The Hospital Frailty Risk Score (HFRS) was validated in people aged 75 or more who had been admitted to an acute hospital. The HFRS uses International Classification of Disease 10 (ICD-10) codes pertaining elective or non-elective hospital admissions to generate a frailty risk score. This data is routinely submitted by hospitals to populate the Secondary Uses Service (SUS) database. The HFRS uses diagnostic information in an algorithm that identifies the risk of frailty and outcomes such as death or unplanned hospital readmissions [13]. . In the national validation cohort (n=1,013,590), compared with the 42% patients with the lowest risk scores, the 20% patients with the highest HFRSs had increased odds of 30-day mortality (odds ratio 1.71; 95% CI 1.68–1.75), long hospital stay (6.03; 5.92–6.10), and 30-day readmission (1.48; 1.46–1.50). The c-statistics between individuals for these three outcomes were 0.60, 0.68, and 0.56, respectively. The HFRS offers an opportunity to assess frailty as a case-mix characteristic; its relative ease of application makes it an ideal tool for use in national datasets to provide a population perspective.

The aim of this paper was to assess the feasibility of using the HFRS to describe outcomes for older people within specialised services across England.

METHODS

This was a retrospective cohort study using the Secondary Uses Service (SUS) electronic database. SUS is the single, comprehensive repository for healthcare data in England which enables a range of reporting and analyses to support the NHS in the delivery of healthcare services (https://digital.nhs.uk/services/secondary-uses-service-sus). It contains up to 20 ICD-10 diagnosis fields about a patient during their admission to hospital.

The HFRS was applied to national SUS database for people aged 75 or older, admitted between April 2017 to March 2018. The SUS database allows searching of any previous admission (in this case, over the preceding two years) to identify any of the ICD-10 codes used to generate the HFRS. In the original HFRS validation, three categories of low (<5), intermediate (5-15), and high risk (>15) were used based on discrimination between different outcomes [13]. These were renamed mild, moderate and severe frailty to mirror the generally used approach to frailty risk stratification. To capture those individuals with no relevant ICD-10 codes the categories were slightly expanded to include those who were assumed not to have frailty – so an individual with previous hospital admission data containing no HFRS related codes was rated as ‘not frail-. For individuals who had no hospital admission in the preceding two years, the HFRS could not be calculated.

The HFRS was tested on six specialties which were participating in the Specialised Clinical Frailty Network (an improvement programme commissioned by NHS England in 2018; https://www.scfn.org.uk/). These were TAVI (elective and emergency), critical care (all admissions), renal (all dialysis patients), chemotherapy (all forms), spinal surgery (deformity and fracture) and neurosurgery (emergency). Each specialty's population was identified from the SUS database using procedure codes defined by NHS England and through consultation with the NHS England Clinical Reference Groups (CRG). These are groups of clinicians, commissioners, public health experts, patients and carers who advise NHS England on the commissioning of a specialised service (Appendix 1). HFRS was applied to each population and proportions of patients with frailty across the specialty were identified. Where an inpatient episode involving a treatment was involved, the index event was the date of admission for the relevant treatment; each patient was included only once in the data.

We compared the patient volumes identified in the SUS data through speciality codes against existing speciality specific registries, in order to 'sense-check' that we had identified the correct cohorts for each specialty. The total numbers of patients for each specialty data set were cross-referenced with specialty data repositories where these existed including the renal registry (https://www.renalreg.org/wp-content/uploads/2018/06/20th-Annual-Report_web_book.pdf), National Cardiac Audit Programme (https://www.nicor.org.uk/national-cardiac-audit-programme/) and Systemic Anti-Cancer Therapy Dataset (http://www.ncin.org.uk/collecting_and_using_data/data_collection/chemotherapy). Each repository was contacted to cross reference the numbers and the CRG leads reviewed the HFRS data to check the extent to which it correlated with clinical practice in their specialty.

For renal and chemotherapy each patient was included only once in the dataset. For TAVI, neurosurgery, critical care, spinal fracture or spinal deformity, some patients could appear more than once in the dataset, relating to clinical complications following the index admission or further treatment under the same specialty during the study period. In this case, frailty scores and outcomes were calculated per admission, but only the patient's first admission was used for survival estimates.

The main outcomes recorded in SUS relate to service metrics in the year following the index event (admissions, length of stay, readmission), mortality and some treatment specific complications (which had been prioritised by the CRG leads). The method for differentiating an admission from a readmission has been taken from the NHS Digital definition [4]. For 30 day readmissions these were defined as emergency admissions to any hospital in England occurring within 30 days of the last, previous discharge from hospital after admission excluding obstetrics related admissions. As length of stay could not be related to a discrete index event for haemodialysis and chemotherapy, total inpatient days over a year alone were extracted instead of 7-21 day length of stay. Complications are defined in Appendix 1. Mortality was defined as death during an admission either during or following the index admission up until the date the data was extracted in March 2019; out of hospital deaths were not captured.

Analyses were limited to descriptive statistics, capturing the outcomes of interest by frailty risk and survival analyses for time to death. For survival, all admission records following index event were examined to establish date of death. Patients with no date of death recorded were assumed to be alive at the end of the study period or censored in the Kaplan-Meier model. The interval between index event and the date of death was calculated in months, displayed in Kaplan-Meier plots.

No ethical review was undertaken as the work was performed as a service evaluation to aid with commissioning and healthcare planning under the permission of NHS England (https://digital.nhs.uk/services/secondary-uses-service-sus).

RESULTS

Table 1 shows the numbers of older people captured in specialty specific registries (where available) in comparison to those identified using the codes detailed in Appendix 1. Slightly fewer individuals were identified in the TAVI and renal registries as compared to SUS data, and slightly more in the cancer registry; overall, the variance was no greater than 6%.

Table 1 SUS identified vs. registry recorded patients with specialised conditions

Specialty	Specialty registry	People aged 75+ identified in specialty registry	People aged 75+ identified in SUS	Variance
TAVI	NICOR 2017-18	3189	3261	2%
Renal dialysis	Renal registry 2017-18	6269	6474	3%
Cancer chemotherapy	NCRAS/SACT data 2017-18	23,084	21751	6%

Frailty was differentially distributed across the specialties, but for the most part, at least mild frailty was present in the most people aged 75. Around one-third had mild frailty; another third had moderate frailty and one-quarter severe frailty.

Table 2 shows the distribution of frailty risk by HFRS; very few individuals (<2%) could not be risk stratified for frailty risk, as they had no hospital episode (and therefore SUS records) in the previous two years. Frailty was differentially distributed across the specialties, but for the most part, at least mild frailty was present in the most people aged 75. Around one-third had mild frailty; another third had moderate frailty and one-quarter severe frailty.

Table 2 Distribution of frailty risk by HFRS

	Adult Critical Care	Chemotherapy	Neurosurgery	Renal	Spinal Deformity Surgery	Spinal Fracture Surgery	Elective TAVI	Emergency TAVI
Number of people aged 75+ accessing the specialty	56039	21751	1460	6474	92	1460	2157	565
Unable to calculate HFRS - no SUS data on previous two years	1121 (2%)	0 (0%)	0 (0%)	0 (0%)	1 (1%)	18 (1%)	11 (1%)	5 (1%)
Total at risk of frailty by HFRS								
Not frail	3923 (7.1%)	6090 (28.0%)	0 (0%)	0 (0%)	4 (4.3%)	70 (4.8%)	315 (14.6%)	43 (7.6%)
Mild	16251 (29.6%)	8265 (38.0%)	146 (10.0%)	1230 (19.0%)	54 (58.7%)	704 (48.2%)	835 (38.7%)	160 (28.3%)

Moderate	21855 (39.8%)	5438 (25.0%)	584 (40.0%)	2719 (42.0%)	24 (26.1%)	407 (27.9%)	606 (28.1%)	206 (36.5%)
Severe	12889 (23.5%)	1958 (9.0%)	730 (50.0%)	2525 (39.0%)	9 (9.8%)	261 (17.9%)	390 (18.1%)	151 (26.7%)

Some patients appeared more than once in the dataset (TAVI n=6/2706, 0.2%; neurosurgery n=171/1460, 11.7%; critical care n=2270/54918, 4.1%; spinal n=123/1533, 8.0%), relating to clinical complications or further treatment following the index admission during the study period. Table 3 shows the service outcomes following the index treatment event by each specialty. Increasing frailty risk was associated with increased length of stay for the index admission, more days in hospital in the year following intervention (42 days on average for those with high frailty risk) and increased risk of dying in hospital. When death occurred, most of these happened within one year of specialist intervention.

Table 3 Service outcomes following specialised interventions by frailty status

	Adult Critical Care	Chemotherapy	Neurosurgery	Renal	Spinal Deformity Surgery	Spinal Fracture Surgery	Elective TAVI	Emergency TAVI
Median length of stay in days for the index admission (Interquartile range)								
Not frail	6 (4-9)	Not applicable (outpatient setting)		Not applicable (outpatient setting)	13.5 (11-23)	2 (1-5)	3 (2-4)	6 (3-10)
Risk of mild frailty	8 (4-13)		4 (2-6)		8 (4-13)	2 (1-5)	4 (3-5)	7 (4-14)
Risk of moderate frailty	12 (6-21)		5 (3-10)		10 (7-16)	10 (3-22)	4 (3-7)	12 (4-20)
Risk of severe frailty	20 (11-36)		17 (9-26)		31 (16-77)	20 (9-39)	5 (3-9)	15 (7-24)
Proportion of 7/21 day stranded LOS								
Not frail	7%/2%	Not applicable (outpatient setting)		Not applicable (outpatient setting)	100/25%	16/1%	5/ 1%	44/5%
Risk of mild frailty	11%/4%		28/4%		50/9%	17/4%	12/1%	45/8%
Risk of moderate frailty	22%/16%		49/10%		701/13%	55/25%	25/5%	66/22%
Risk of severe frailty	30%/40%		73/25%		89/56%	77/46%	31/8%	72/31%
Median number of inpatient days in the year following treatment initiation (Interquartile range)								
Not frail	7 (4-11)	0 (0-1)			5 (4-14)	3 (2-7)	3 (2-5)	6 (3-14)
Risk of mild frailty	10 (5-17)	2 (0-8)	6 (4-12)	1 (0-5)	8 (4-15)	3 (1-9)	5 (3-10)	11 (5-22)
Risk of moderate frailty	17 (8–32)	12 (5-24)	13 (6-27)	10 (3-21)	17 (9-45)	21 (8-44)	13 (7-24)	21 (12-36)
Risk of severe frailty	43 (23-76)	32 (17-54)	42 (22-71)	34 (18-60)	46 (30-137)	57 (29-98)	38 (19-68)	52 (28-71)
Proportion of patients readmitted within 30 days as an emergency following discharge from index intervention								
Not frail	4%	3%	0%	0%	0%	4%	0%	30%
Risk of mild frailty	6%	15%	11%	12%	6%	5%	0%	33%
Risk of moderate frailty	9%	26%	20%	29%	4%	18%	0%	39%
Risk of severe frailty	14%	30%	35%	34%	22%	26%	0%	36%

Figure 1 shows the survival post-index procedure; severe frailty was a powerful discriminator of the risk of death; between 25-40% of those with severe frailty risk died at 30 months across all specialties (NB only in-hospital deaths captured, not those occurring out of hospital).

Figure 1 Survival curves for 30-month in-hospital mortality post index specialty intervention, by frailty risk

Insert Figure 1 about here

Elective TAVI, emergency TAVI, renal dialysis and spinal surgery patients had an increased risk of complications with frailty (Appendix 2). For neurosurgery patients there was a rise of admissions with a diagnosis of fall within one year of neurosurgery with frailty.

DISCUSSION

This is the first application of the HFRS to a national dataset, describing service outcomes and mortality for older people undergoing a range of specialised interventions. Whilst there were differences in the precise number of individuals identified in registry data vs. SUS data the variance was 6% or less. For those who were identified in SUS data, we have shown that it is feasible as the vast majority (>98%) of patients undergoing specialised interventions could be risk stratified. Within specialised services, the HFRS performs in a manner commensurate with the initial validation – namely that increasing frailty risk is associated with poorer outcomes and often higher use of health care resource in specific cohorts with specialised conditions.

Whilst a strength of this approach is the use of nationally representative data, the HFRS does depend upon coding practice, which is known to vary across the country. However, in the original study [13], coding variation did not alter the direction of the results, suggesting this is random rather than systematic error. SUS data only captures in-hospital deaths, so deaths occurring outside of hospital may have been missed, reducing the number of events and thus the precision of the study. We estimated frailty at the time of the index presentation, but frailty can be dynamic, and may have changed over the course of follow-up, especially following an intervention. It would be interesting to explore the dynamic nature of frailty in future research.

Although useful at a population health level, the HFRS is not designed to be used as a clinical decision making tool – patient assessments should always be individualised. Even frailty tools developed with specific specialised conditions in mind do not exhibit sufficiently robust predictive characteristics to direct individual patient decision-making [2-11]. However, the knowledge of the risk of frailty should sensitise the clinician to think about holistic assessment and prognosis when helping patients decide the right approach to their care. For example, this data has underpinned specialties selected to participate in a national improvement programme designed to enhance the delivery of frailty-attuned care for older people with frailty and specialised conditions (https://www.scfn.org.uk/).

This methodology could be reproduced across other specialties, but also general acute care, to understand population health needs without the need for manual frailty scores. This will provide a standardised approach to population risk stratification that could be used for benchmarking [14], service evaluation or research. It could also be used by commissioners to take account of frailty distributions that vary across different settings [15]. The HFRS is an example of the NHS Long Term plan (https://www.longtermplan.nhs.uk/) commitment to using population health management solutions to match NHS resources to need. It states that by identifying groups of people who are at risk of adverse health outcomes we can predict the value for patients and the system from different health and care interventions.

APPENDIX 1 – CODES USED TO DEFINE PATIENT POPULATIONS

ADULT CRITICAL CARE

Patients with one or more records in the SUS Plus PbR critical care dataset, spells selected from discharges in 2017/18

CHEMOTHERAPY

when the Financial year is 2017/18	
and the patient age is between 19 and 130 (inclusive)	
and the spell or attendance HRG is one of the following	or the spell or attendance includes one of the following procedures
SB02Z - Procure Chemotherapy Drugs for Regimens in Band 2	X701: Procurement of drugs for chemotherapy for neoplasm for regimens in Band 1
SB03Z - Procure Chemotherapy Drugs for Regimens in Band 3	X702: Procurement of drugs for chemotherapy for neoplasm for regimens in Band 2
SB04Z - Procure Chemotherapy Drugs for Regimens in Band 4	X703: Procurement of drugs for chemotherapy for neoplasm for regimens in Band 3
SB05Z - Procure Chemotherapy Drugs for Regimens in Band 5	X704: Procurement of drugs for chemotherapy for neoplasm for regimens in Band 4
SB06Z - Procure Chemotherapy Drugs for Regimens in Band 6	X705: Procurement of drugs for chemotherapy for neoplasm for regimens in Band 5
SB07Z - Procure Chemotherapy Drugs for Regimens in Band 7	X708: Other specified procurement of drugs for chemotherapy for neoplasm in Bands 1-5
SB08Z - Procure Chemotherapy Drugs for Regimens in Band 8	X711: Procurement of drugs for chemotherapy for neoplasm for regimens in Band 6
SB09Z - Procure Chemotherapy Drugs for Regimens in Band 9	X712: Procurement of drugs for chemotherapy for neoplasm for regimens in Band 7
SB10Z - Procure Chemotherapy Drugs for Regimens in Band 10	X713: Procurement of drugs for chemotherapy for neoplasm for regimens in Band 8
SB11Z - Deliver Exclusively Oral Chemotherapy	X714: Procurement of drugs for chemotherapy for neoplasm for regimens in Band 9
SB12Z - Deliver Simple Parenteral Chemotherapy at First Attendance	X715: Procurement of drugs for chemotherapy for neoplasm for regimens in Band 10
SB13Z - Deliver more Complex Parenteral Chemotherapy at First Attendance	X721: Delivery of complex chemotherapy for neoplasm including prolonged infusional treatment at first attendance
SB14Z - Deliver Complex Chemotherapy, including Prolonged Infusional Treatment, at First Attendance	X722: Delivery of complex parenteral chemotherapy for neoplasm at first attendance
SB15Z - Deliver Subsequent Elements of a Chemotherapy Cycle	X723: Delivery of simple parenteral chemotherapy for neoplasm at first attendance
SB16Z - Procure Chemotherapy Drugs for Regimens not on the National List	X724: Delivery of subsequent element of cycle of chemotherapy for neoplasm
SB17Z - Deliver Chemotherapy for Regimens not on the National List	X729: Unspecified delivery of chemotherapy for neoplasm
SB97Z - Same Day Chemotherapy Admission or Attendance	X731: Delivery of exclusively oral chemotherapy for neoplasm
	X738: Other specified delivery of oral chemotherapy for neoplasm
	X739: Unspecified delivery of oral chemotherapy for neoplasm
New patients starting chemotherapy were identified as those which had no such records prior to 2017/18	
The cancer types were categorised by the primary diagnosis using the following groups	
C30-C39: Malignant neoplasms of respiratory and intrathoracic organs	Respiratory/Thoracic
C81-C96: Malignant neoplasms, stated or presumed to be primary, of lymphoid, haematopoietic and related tissue	Haematological/Lymphoma
C00-C97: Malignant neoplasms	Other Cancer
(patients with no primary diagnosis recorded were categorised as 'Not Known'	Not Known

NEUROSURGERY

when the Financial year is 2017/18	
and the treating consultant was a Neurosurgeon (Main Specialty 150)	
and the Primary Diagnosis was one of the following	
S000: Superficial injury of scalp	S053: Ocular laceration without prolapse or loss of intraocular tissue
S001: Contusion of eyelid and periocular area	S054: Penetrating wound of orbit with or without foreign body
S005: Superficial injury of lip and oral cavity	S055: Penetrating wound of eyeball with foreign body
S007: Multiple superficial injuries of head	S057: Avulsion of eye
S008: Superficial injury of other parts of head	S0600: Concussion: without open intracranial wound
S009: Superficial injury of head, part unspecified	S061: Traumatic cerebral oedema
S010: Open wound of scalp	S0610: Traumatic cerebral oedema: without open intracranial wound
S011: Open wound of eyelid and periocular area	S0611: Traumatic cerebral oedema: with open intracranial wound
S012: Open wound of nose	S062: Diffuse brain injury
S013: Open wound of ear	S0620: Diffuse brain injury: without open intracranial wound
S014: Open wound of cheek and temporomandibular area	S0621: Diffuse brain injury: with open intracranial wound
S015: Open wound of lip and oral cavity	S063: Focal brain injury
S017: Multiple open wounds of head	S0630: Focal brain injury: without open intracranial wound
S018: Open wound of other parts of head	S0631: Focal brain injury: with open intracranial wound
S019: Open wound of head, part unspecified	S064: Epidural haemorrhage
S020: Fracture of vault of skull	S0640: Epidural haemorrhage: without open intracranial wound
S0200: Fracture of vault of skull: closed	S0641: Epidural haemorrhage: with open intracranial wound
S0201: Fracture of vault of skull: open	S065: Traumatic subdural haemorrhage
S021: Fracture of base of skull	S0650: Traumatic subdural haemorrhage: without open intracranial wound
S0210: Fracture of base of skull: closed	S0651: Traumatic subdural haemorrhage: with open intracranial wound
S0211: Fracture of base of skull: open	S066: Traumatic subarachnoid haemorrhage
S0220: Fracture of nasal bones: closed	S0660: Traumatic subarachnoid haemorrhage: without open intracranial wound
S0230: Fracture of orbital floor: closed	S0661: Traumatic subarachnoid haemorrhage: with open intracranial wound
S0240: Fracture of malar and maxillary bones: closed	S068: Other intracranial injuries
S0260: Fracture of mandible: closed	S0680: Other intracranial injuries: without open intracranial wound
S027: Multiple fractures involving skull and facial bones	S0681: Other intracranial injuries: with open intracranial wound
S0270: Multiple fractures involving skull and facial bones: closed	S069: Intracranial injury, unspecified
S0280: Fractures of other skull and facial bones: closed	S0690: Intracranial injury, unspecified: without open intracranial wound
S0281: Fractures of other skull and facial bones: open	S091: Injury of muscle and tendon of head
S0290: Fracture of skull and facial bones, part unspecified: closed	S092: Traumatic rupture of ear drum
S0291: Fracture of skull and facial bones, part unspecified: open	S098: Other specified injuries of head
S051: Contusion of eyeball and orbital tissues	S099: Unspecified injury of head

The subset of patients described as 'Subdural Burr Hole' were identified as follows
where the Primary Diagnosis was one of the following
S065: Traumatic subdural haemorrhage
S0650: Traumatic subdural haemorrhage: without open intracranial wound
S0651: Traumatic subdural haemorrhage: with open intracranial wound
and one of the following was recorded as a qualifier to the procedure performed
Y471: Trans-sphenoidal burrhole approach to contents of cranium
Y472: Frontal burrhole approach to contents of cranium
Y473: Transoral burrhole approach to contents of cranium
Y474: Transmastoid burrhole approach to contents of cranium
Y475: Supratentorial burrhole approach to contents of cranium
Y476: Infratentorial burrhole approach to contents of cranium
Y478: Other specified burrhole approach to contents of cranium
Y479: Unspecified burrhole approach to contents of cranium

RENAL

The Renal Dialysis population was identified by inpatient records with a diagnosis code N185 Chronic Kidney Disease Stage 5 (in any position) and diagnosis Z992 Dependence on renal dialysis (in any position).

These criteria yield multiple records during 2017-18 (circa 58,000 records), for the purposes of this analysis only the first record in 2017-18 for this patient group is captured as an ‘index event’ (circa 22,000 patients).

Additionally, those patients who have no inpatient record fitting the above criteria prior to their index event in 2017-18 were flagged. This proxy measure is intended to identify those patients starting dialysis in 2017-18

The overall patient group was selected from inpatient data with the following criteria	
when the Finacial year is 2017/18	
and the patient age is between 19 and 130 (inclusive)	
and the patient had an admission which included both of the following diagnoses	
N185: Chronic kidney disease, stage 5	
Z992: Dependence on renal dialysis	
Patients starting dialysis were identified as those with no such records prior to 2017/18	
Admissions with Sepsis were identified as the following	**Admissions with complications of fistula were identified as the following**
Spell Primary diagnosis as one of	Spell Primary diagnosis as one of
A400: Sepsis due to streptococcus, group A	T814: Infection following a procedure, not elsewhere classified
A402: Sepsis due to streptococcus, group D	T816: Acute reaction to foreign substance accidentally left during a procedure
A403: Sepsis due to Streptococcus pneumoniae	T817: Vascular complications following a procedure, not elsewhere classified
A408: Other streptococcal sepsis	T818: Other complications of procedures, not elsewhere classified
A409: Streptococcal sepsis, unspecified	T823: Mechanical complication of other vascular grafts
A410: Sepsis due to Staphylococcus aureus	T824: Mechanical complication of vascular dialysis catheter
A411: Sepsis due to other specified staphylococcus	T825: Mechanical complication of other cardiac and vascular devices and implants
A415: Sepsis due to other Gram-negative organisms	T827: Infection and inflammatory reaction due to other cardiac and vascular devices, implants and grafts
A418: Other specified sepsis	T828: Other specified complications of cardiac and vascular prosthetic devices, implants and grafts
A419: Sepsis, unspecified	T829: Unspecified complication of cardiac and vascular prosthetic device, implant and graft
	T856: Mechanical complication of other specified internal prosthetic devices, implants and grafts
Admissions to Cardiovascular services were identified as the following	T857: Infection and inflammatory reaction due to other internal prosthetic devices, implants and grafts
Records where the Treatment Function code on admission (first epsiode) is one of	T858: Other complications of internal prosthetic devices, implants and grafts, not elsewhere classified
170 CARDIOTHORACIC SURGERY	
172 CARDIAC SURGERY	
320 CARDIOLOGY	

SPINAL SURGERY

The spinal deformity patient group was selected from inpatient data with the following criteria	
when the Finacial year is 2017/18	**Complications and infections were identified with the following criteria**
and the spell included one of the following as either primary or any secondary procedure	**where any diagnosis recorded was one of the following**
V411: Posterior attachment of correctional instrument to spine	T814: Infection following a procedure, not elsewhere classified
V412: Anterior attachment of correctional instrument to spine	T842: Mechanical complication of internal fixation device of other bones
V413: Removal of correctional instrument from spine	T843: Mechanical complication of other bone devices, implants and grafts
V414: Anterior and posterior attachment of correctional instrument to spine	T844: Mechanical complication of other internal orthopaedic devices, implants and grafts
V418: Other specified instrumental correction of deformity of spine	T846: Infection and inflammatory reaction due to internal fixation device [any site]
V419: Unspecified instrumental correction of deformity of spine	T847: Infection and inflammatory reaction due to other internal orthopaedic prosthetic devices, implants and grafts
V421: Excision of rib hump	T848: Other complications of internal orthopaedic prosthetic devices, implants and grafts
V424: Anterior and posterior epiphysiodesis of spine for correction of deformity	T849: Unspecified complication of internal orthopaedic prosthetic device, implant and graft
V423: Anterolateral release of spine for correction of deformity and graft HFQ	T856: Mechanical complication of other specified internal prosthetic devices, implants and grafts
V424: Anterior and posterior epiphysiodesis of spine for correction of deformity	T857: Infection and inflammatory reaction due to other internal prosthetic devices, implants and grafts
V425: Anterior epiphysiodesis of spine for correction of deformity NEC	T858: Other complications of internal prosthetic devices, implants and grafts, not elsewhere classified
V426: Posterior epiphysiodesis of spine for correction of deformity NEC	T859: Unspecified complication of internal prosthetic device, implant and graft
V428: Other specified other correction of deformity of spine	M463: Infection of intervertebral disc (pyogenic)
V429: Unspecified other correction of deformity of spine	T818: Other complications of procedures, not elsewhere classified
The spinal fracture patient group was selected from inpatient data with the following criteria	
when the Finacial year is 2017/18	
and the spell included one of the following as either primary or any secondary procedure	V458: Other specified other reduction of fracture of spine
V441: Complex decompression of fracture of spine	V459: Unspecified other reduction of fracture of spine
V442: Anterior decompression of fracture of spine	V461: Fixation of fracture of spine using plate
V443: Posterior decompression of fracture of spine NEC	V462: Fixation of fracture of spine using Harrington rod
V444: Vertebroplasty of fracture of spine	V463: Fixation of fracture of spine using wire
V445: Balloon kyphoplasty of fracture of spine	V464: Fixation of fracture of spine and skull traction HFQ
V448: Other specified decompression of fracture of spine	V468: Other specified fixation of fracture of spine
V449: Unspecified decompression of fracture of spine	V469: Unspecified fixation of fracture of spine
V451: Open reduction of fracture of spine and excision of facet of spine	V402: Posterior instrumented fusion of cervical spine NEC
V452: Open reduction of fracture of spine NEC	V403: Posterior instrumented fusion of thoracic spine NEC
V453: Manipulative reduction of fracture of spine	V404: Posterior instrumented fusion of lumbar spine NEC

TRANSAORTIC VALVE IMPLANTATION (TAVI)

when the Financial year is 2017/18	**Patients with complications -**
and the patient age is between 19 and 130 (inclusive)	**Stroke**
and the spell or attendance HRG is one of the following	Patients were identified as having stroke as a complication if one of the following diagnoses was recorded as a secondary diagnosis within the spell
EY20A - Transcatheter Aortic Valve Implantation (TAVI) using Other Approach, with CC Score 8+	I694: Sequelae of stroke, not specified as haemorrhage or infarction
EY20B - Transcatheter Aortic Valve Implantation (TAVI) using Other Approach, with CC Score 0-7	I64X: Stroke, not specified as haemorrhage or infarction
EY21A - Transcatheter Aortic Valve Implantation (TAVI) using Transfemoral Approach, with CC Score 8+	I690: Sequelae of subarachnoid haemorrhage
EY21B - Transcatheter Aortic Valve Implantation (TAVI) using Transfemoral Approach, with CC Score 0-7	I691: Sequelae of intracerebral haemorrhage
	I692: Sequelae of other nontraumatic intracranial haemorrhage
	I693: Sequelae of cerebral infarction
	I694: Sequelae of stroke, not specified as haemorrhage or infarction
	I698: Sequelae of other and unspecified cerebrovascular diseases

Tamponade
Patients were identified as having tamponade as a complication if one of the following diagnoses was recorded as a secondary diagnosis within the spell
I230: Haemopericardium as current complication following acute myocardial infarction
I233: Rupture of cardiac wall without haemopericardium as current complication following acute myocardial infarction
I312: Haemopericardium, not elsewhere classified
S260: Injury of heart with haemopericardium
S260: Injury of heart with haemopericardium
S260: Injury of heart with haemopericardium
I313: Pericardial effusion (noninflammatory)

Patients with complications -

Infection

Patients were identified as having infection as a complication if one of the following diagnoses was recorded as a secondary diagnosis within the spell

A047: Enterocolitis due to Clostridium difficile
A400: Sepsis due to streptococcus, group A
A401: Sepsis due to streptococcus, group B
A402: Sepsis due to streptococcus, group D
A403: Sepsis due to Streptococcus pneumoniae
A408: Other streptococcal sepsis
A409: Streptococcal sepsis, unspecified
A410: Sepsis due to Staphylococcus aureus
A411: Sepsis due to other specified staphylococcus
A412: Sepsis due to unspecified staphylococcus
A413: Sepsis due to Haemophilus influenzae
A414: Sepsis due to anaerobes
A415: Sepsis due to other Gram-negative organisms
A418: Other specified sepsis
A419: Sepsis, unspecified
A490: Staphylococcal infection, unspecified site
B954: Other streptococcus as the cause of diseases classified to other chapters
B956: Staphylococcus aureus as the cause of diseases classified to other chapters
B957: Other staphylococcus as the cause of diseases classified to other chapters
B961: Klebsiella pneumoniae [K. pneumoniae] as the cause of diseases classified to other chapters
B962: Escherichia coli [E. coli] as the cause of diseases classified to other chapters
B963: Haemophilus influenzae [H. influenzae] as the cause of diseases classified to other chapters
B964: Proteus (mirabilis)(morganii) as the cause of diseases classified to other chapters
B965: Pseudomonas (aeruginosa) as the cause of diseases classified to other chapters
B968: Other specified bacterial agents as the cause of diseases classified to other chapters
J09X: Influenza due to identified avian influenza virus
J100: Influenza with pneumonia, other influenza virus identified
J101: Influenza with other respiratory manifestations, other influenza virus identified
J108: Influenza with other manifestations, other influenza virus identified
J110: Influenza with pneumonia, virus not identified
J111: Influenza with other respiratory manifestations, virus not identified
J118: Influenza with other manifestations, virus not identified
J120: Adenoviral pneumonia
J121: Respiratory syncytial virus pneumonia
J122: Parainfluenza virus pneumonia
J123: Human metapneumovirus pneumonia
J128: Other viral pneumonia
J129: Viral pneumonia, unspecified
J13X: Pneumonia due to Streptococcus pneumoniae
J14X: Pneumonia due to Haemophilus influenzae
J150: Pneumonia due to Klebsiella pneumoniae
J151: Pneumonia due to Pseudomonas
J152: Pneumonia due to staphylococcus
J153: Pneumonia due to streptococcus, group B
J154: Pneumonia due to other streptococci
J155: Pneumonia due to Escherichia coli
J156: Pneumonia due to other aerobic Gram-negative bacteria
J157: Pneumonia due to Mycoplasma pneumoniae
J158: Other bacterial pneumonia
J159: Bacterial pneumonia, unspecified
J160: Chlamydial pneumonia
J168: Pneumonia due to other specified infectious organisms
J170: Pneumonia in bacterial diseases classified elsewhere
J171: Pneumonia in viral diseases classified elsewhere
J172: Pneumonia in mycoses
J173: Pneumonia in parasitic diseases
J178: Pneumonia in other diseases classified elsewhere
J180: Bronchopneumonia, unspecified
J181: Lobar pneumonia, unspecified
J182: Hypostatic pneumonia, unspecified
J188: Other pneumonia, organism unspecified
J189: Pneumonia, unspecified
J200: Acute bronchitis due to Mycoplasma pneumoniae
J201: Acute bronchitis due to Haemophilus influenzae
J202: Acute bronchitis due to streptococcus
J203: Acute bronchitis due to coxsackievirus
J204: Acute bronchitis due to parainfluenza virus
J205: Acute bronchitis due to respiratory syncytial virus
J206: Acute bronchitis due to rhinovirus
J207: Acute bronchitis due to echovirus
J208: Acute bronchitis due to other specified organisms
J209: Acute bronchitis, unspecified
J210: Acute bronchiolitis due to respiratory syncytial virus
J211: Acute bronchiolitis due to human metapneumovirus
J218: Acute bronchiolitis due to other specified organisms
J219: Acute bronchiolitis, unspecified
J22X: Unspecified acute lower respiratory infection
J40X: Bronchitis, not specified as acute or chronic

APPENDIX 2 – SPECIALTY SPECIFIC METRICS

Neurosurgery	
	Mean number of admissions within 1 year of surgery
Risk of mild frailty	1.0
Risk of moderate frailty	2.0
Risk of severe frailty	3.0
	Proportion of patients admitted with falls within 18 months of surgery
Risk of mild frailty	12.5%
Risk of moderate frailty	25.9%
Risk of severe frailty	65.9%
Renal	
	Proportion of patients with admission to cardiac services within one year of starting dialysis
Risk of mild frailty	9.0%
Risk of moderate frailty	11.3%
Risk of severe frailty	12.0%
	Proportion of patients readmitted within 365 days with complications/infection
Spinal Deformity Surgery	
Not frail	0%
Risk of mild frailty	7.8%
Risk of moderate frailty	14.9%
Risk of severe frailty	11.1%
Spinal Fracture Surgery	
Not frail	0%
Risk of mild frailty	9.3%

Risk of moderate frailty	16.7%
Risk of severe frailty	11.1%
	Complication rate within admission
Elective TAVI	
Not frail	2.6%
Risk of mild frailty	5.7%
Risk of moderate frailty	14.6%
Risk of severe frailty	15.3%
Emergency TAVI	
Not frail	3.3%
Risk of mild frailty	11.3%
Risk of moderate frailty	26.4%
Risk of severe frailty	29.1%

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