HSMR mortality indicators

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CONTENTS

Overview 3
Methodology 3
1. Data sources 3
1.1 Data period 3
2. General data processing 3
2.1 Cleaning 3
2.2 Area-level deprivation 3
2.3 Trust mergers 3
3. “Intelligent” data processing 3
3.1 Linkage 4
3.2 Diagnosis derivation 5
3.3 Outcome derivation 6
3.4 Derivation of additional parameters for risk adjustment 6
4. Risks 7
4.1 Denominator 7
4.2 Logistic regression models 7
4.3 Estimate of risk 8
4.4 Quality of risk model (the ‘C statistic’) 8
5. Calculation of HSMR 9
6. Future work currently in progress 9
7. Relevant publications 10
Appendix A. Charlson comorbidity conditions 11

Overview

Measures of survival are an important measure of the quality of care provided by hospitals. Florence Nightingale was one of the first people to identify the importance of measuring survival rates and in the 1860s, she highlighted the variation in survival rates for hospitals across London. Today, many clinicians routinely monitor the survival rates in their services, and use them to improve care.

The analyses are derived from routinely collected hospital data. The statistical process control charts have been adjusted to take into account a range of factors that can affect the survival rates, but which are beyond the control of the individual hospital, for example, the age and sex of the patient or whether they have another medical condition.

Methodology

1. Data sources

Mortality indicators are based on the analysis of 13 years of inpatient and day case records from Hospital Episode Statistics (HES) for the period 1996/97 to 2004/05, NHS-Wide Clearing Service (NWCS) for 2005/06 and Secondary Uses Service (SUS) for 2006/07 to date. These are data that are routinely collected within the health service for administrative purposes and not specifically for clinical audit. There may be issues regarding coverage, completeness and accuracy that need to be considered when interpreting the results.

1.1 Data period

Data are extracted for analysis through SUS by the Dr Foster Unit at Imperial College on the 9th of each month.

Please note all data years and derived values in this methodology (eg c statistics) are correct as of the date of this document but are subject to change over time as the data is refreshed monthly and the methodology updated yearly. Please contact Dr Foster Intelligence if you require the most up-to-date detail.

2. General data processing

2.1 Cleaning

These data are cleaned according to established HES guidelines with one or two minor additions/modifications. More detailed information is available on request.

2.2 Area-level deprivation

The population-weighted quintiles of the Carstairs deprivation score calculated by 2001 Census Output Area are then added to the data by matching on the patient's postcode. More detailed information is available on request.

2.3 Trust mergers

As hospitals merge and services reorganised, provider codes (PROCODE) may change from one year to the next. In order to track hospitals over time, the provider codes need to be unified, i.e. just one code needs to identify each trust throughout. To date, provider codes have been unified as of the trust status at June 1st 2008.

3. "Intelligent" data processing

3.1 Linkage

The data are in the form of consultant episodes (the continuous period during which the patient is under the care of one consultant), which need to be linked into admissions (or "spells"). Records are assumed to belong to the same person if they match on date of birth, sex and postcode (DOB, SEX,HOMEADD) as the NHS number is either not available or not recorded accurately enough across the whole period for which we have data. For the period from 2000/01 to 2004/05 we have used HESID as a patient identifier. This links patients together based on either their NHS number (with other fields added) or their local patient identifier (with other fields added). A detailed algorithm on how the HESID was derived by the Department of Health is available on request from the NHS Information Centre.

Only ages within the ranges 1-120 and 7001-7007 (special values to indicate age in months for children under 1 year) are considered valid. Duplicate records (those with the same combination of provider, date of birth, sex, postcode, date of admission and episode number (PROCODE, DOB, SEX, HOMEADD, EPISTART, EPIEND, EPIORDER), unfinished episodes, those with missing/invalid ADMIDATE and regular attenders (CLASSPAT=3,4) are excluded. Some spells have the same date of admission (ADMIDATE) but different dates of discharge (DISDATE). This is not valid unless the patient was discharged and readmitted on the same day: if not, the spell with the earliest DISDATE was arbitrarily taken to be the valid one. Episodes relating to the invalid spell are excluded at this stage. Remaining episodes are sorted by provider, date of birth, sex, postcode, date of admission, date of discharge and episode number (PROCODE, DOB, SEX, HOMEADD, ADMIDATE, DISDATE, EPIORDER). Episodes are not required to be in strict sequence, only in chronological order. For example, if the first one had EPIORDER=01, the second one had EPIORDER=03 and the last one of the same spell had EPIORDER=99, then the three episodes are treated just the same as if they were numbered 01, 02 and 03 (as most multi-episode spells are). However a spell must have at least one episode with EPIORDER=01 otherwise it is considered invalid and excluded. Spells with invalid length of stay (DISDATE < ADMIDATE) are also excluded.

Spells ending in transfer to another NHS hospital are linked together ("superspell"), allowing for a difference between discharge from the first trust and admission to the next trust of up to two days, using ADMIMETH= 81 or DISDEST/ADMISORC values of 49-53 (which refer to NHS providers).

Data come from a number of sources and episodes are linked across years according to the method described in Table 1. Episodes ending on or after 1st April 2008 are refreshed monthly on a cumulative basis.

Table 1

Stage	Year of EPIEND	Status	Data source	Patient identifier used for linkage	Orphaned FCEs in unfinished spells [1]	Superspells [2]
1	1996/97 to 1999/00	Frozen	HES	SEX +DOB +HOMEADD	Excluded [3]	Considered to be finished
2	2000/01 to 2004/05	Frozen	HES	HESID	Rolled forward to Stage 3	Considered to be finished
3	2005/06	Frozen	NWCS (final extract Jan 2007) + Stage 2 orphans	SEX +DOB +HOMEADD	Rolled forward to Stage 4	Considered to be finished
4	2006/07	Frozen	SUS (Apr06 to Nov07 from Jan 2008 extract) + Stage 3 orphans	SEX +DOB +HOMEADD	Rolled forward to Stage 5	Episodes in superspells ending in later years unlinked and rolled forward to Stage 5
5	2007/08 onwards	Monthly refresh	SUS (Cumulative	SEX +DOB	Excluded	Considered to be finished

		(soon to be frozen)	from Apr07) + Stage 4 orphans	+HOMEADD		
6	2008/09 onwards	Monthly refresh	SUS (Cumulative from Apr07) + Stage 4 orphans	SEX +DOB +HOMEADD	Excluded	Considered to be finished

Notes:-
1 Spells which are missing an episode with a valid DISDATE or an episode with SPELEND="Y" and valid EPIEND.
2 Transfers are not linked across stage boundaries except between stages 4 & 5.
3 Episodes ending in later years related to these orphans will be linked into spells which are missing a first episode. These "widows" are also excluded.

3.2 Diagnosis derivation

We use the 56 diagnostic groups which contribute to 80% of in-hospital deaths in England. All 56 groups are listed in Table 2, and further information on the Clinical Classification System (including the ICD codes making up the groups) is available at http://www.ahrq.gov/data/hcup/icd10usrgd.htm.

For each spell we assign a diagnosis based on the primary diagnosis in the first episode of care. However, if the primary diagnosis is a vague symptom or sign we look to the second episode (of a multi-episode spell) to derive a diagnosis.

Table 2

CCS group	Description and C statistic for in-hospital mortality	
2	Septicemia (except in labor)	0.774
12	Cancer of oesophagus	0.813
13	Cancer of stomach	0.809
14	Cancer of colon	0.830
15	Cancer of rectum and anus	0.844
17	Cancer of pancreas	0.768
19	Cancer of bronchus, lung	0.779
24	Cancer of breast	0.935
27	Cancer of ovary	0.843
29	Cancer of prostate	0.859
32	Cancer of bladder	0.917
38	Non-Hodgkin's lymphoma	0.805
39	Leukaemias	0.814
42	Secondary malignancies	0.796
43	Malignant neoplasm without specification of site	0.800
55	Fluid and electrolyte disorders	0.766
59	Deficiency and other anaemia	0.755
68	Senility and organic mental disorders	0.664
100	Acute myocardial infarction	0.743
101	Coronary atherosclerosis and other heart disease	0.862
103	Pulmonary heart disease	0.778
106	Cardiac dysrhythmias	0.834
107	Cardiac arrest and ventricular fibrillation	0.702
108	Congestive heart failure, nonhypertensive	0.647
109	Acute cerebrovascular disease	0.705
114	Peripheral and visceral atherosclerosis	0.895
115	Aortic, peripheral, and visceral artery aneurysms	0.873
117	Other circulatory disease	0.853
122	Pneumonia (except that caused by tuberculosis or sexually transmitted disease)	0.800
125	Acute bronchitis	0.826
127	Chronic obstructive pulmonary disease and bronchiectasis	0.686
129	Aspiration pneumonitis, food/vomitus	0.716
130	Pleurisy, pneumothorax, pulmonary collapse	0.810
131	Respiratory failure, insufficiency, arrest (adult)	0.738
133	Other lower respiratory disease	0.873
134	Other upper respiratory disease	0.926
145	Intestinal obstruction without hernia	0.819
148	Peritonitis and intestinal abscess	0.868

149	Biliary tract disease	0.912
150	Liver disease, alcohol-related	0.700
151	Other liver diseases	0.850
153	Gastrointestinal haemorrhage	0.802
154	Noninfectious gastroenteritis	0.881
155	Other gastrointestinal disorders	0.895
157	Acute and unspecified renal failure	0.741
158	Chronic renal failure	0.873
159	Urinary tract infections	0.804
197	Skin and subcutaneous tissue infections	0.904
199	Chronic ulcer of skin	0.784
224	Other perinatal conditions	0.953
226	Fracture of neck of femur (hip)	0.743
231	Other fractures	0.804
233	Intracranial injury	0.753
237	Complication of device, implant or graft	0.809
245	Syncope	0.764
251	Abdominal pain	0.935

3.3 Outcome derivation

We define our death outcome when the patient dies in hospital at the end of their stay in hospital (superspell). The spell in which death occurs (DISMETH = 4) may be post-transfer, but deaths are assigned to all the trusts in the superspell.

3.4 Derivation of additional parameters for risk adjustment

Table 3

Parameter	Definition	Excluded if invalid
Admission method	If ADMIMETH = 11,12,13 in last episode of spell with valid ADMIMETH, then “Elective” else “Non-elective”	Yes, if no episodes in spell contain valid ADMIMETH
Age group	Age on admission in 5-year bands (<1 year,1-4,5-9,…90+)	Yes, if no episodes in spell contain valid age on admission
Year of discharge	Financial year of date of discharge at the end of the superspell	Yes, if no episodes in spell have either valid DISDATE or SPELEND=”Y” and valid EPIEND
Deprivation quintile	Derived from postcode on the episode in the spell in the diagnosis dominant episode	No
Diagnostic subgroup	Based on 3 digit ICD10 codes within each CCS group only applies to non CCS groups	n/a
Sex	Derived from the episode with the first valid value (1 or 2) of SEX, going backwards from the end of the spell.	Yes, if no episodes in spell contain valid SEX
Comorbidity (Charlson score)	For each spell the episode which is dominant for diagnosis is considered to be the first episode unless the first diagnosis in the first episode is a vague “R” code in which case we use the second episode. If that does not exist or has a “R” code in the first position, we revert to the first episode. The CHARLSON score for a spell is calculated as the sum of the scores for each of the conditions (see Appendix A) in the diagnosis-dominant episode (a condition can only be counted once in a spell). This score is capped at 6.	n/a
Emergency admissions in	Calculated as the number of superspells in the previous 365 days for the same patient (using the general pseudonymised	n/a

previous 12 months	patient identifier). This includes the current spell, if it is an emergency admission.	
Palliative care	If any episode in the spell has treatment function code 315 or contains Z515 in any of the diagnosis fields, then “Palliative” else “Non-palliative”.	n/a
Month of admission	For respiratory diseases only	n/a

4. Risks

4.1 Denominator

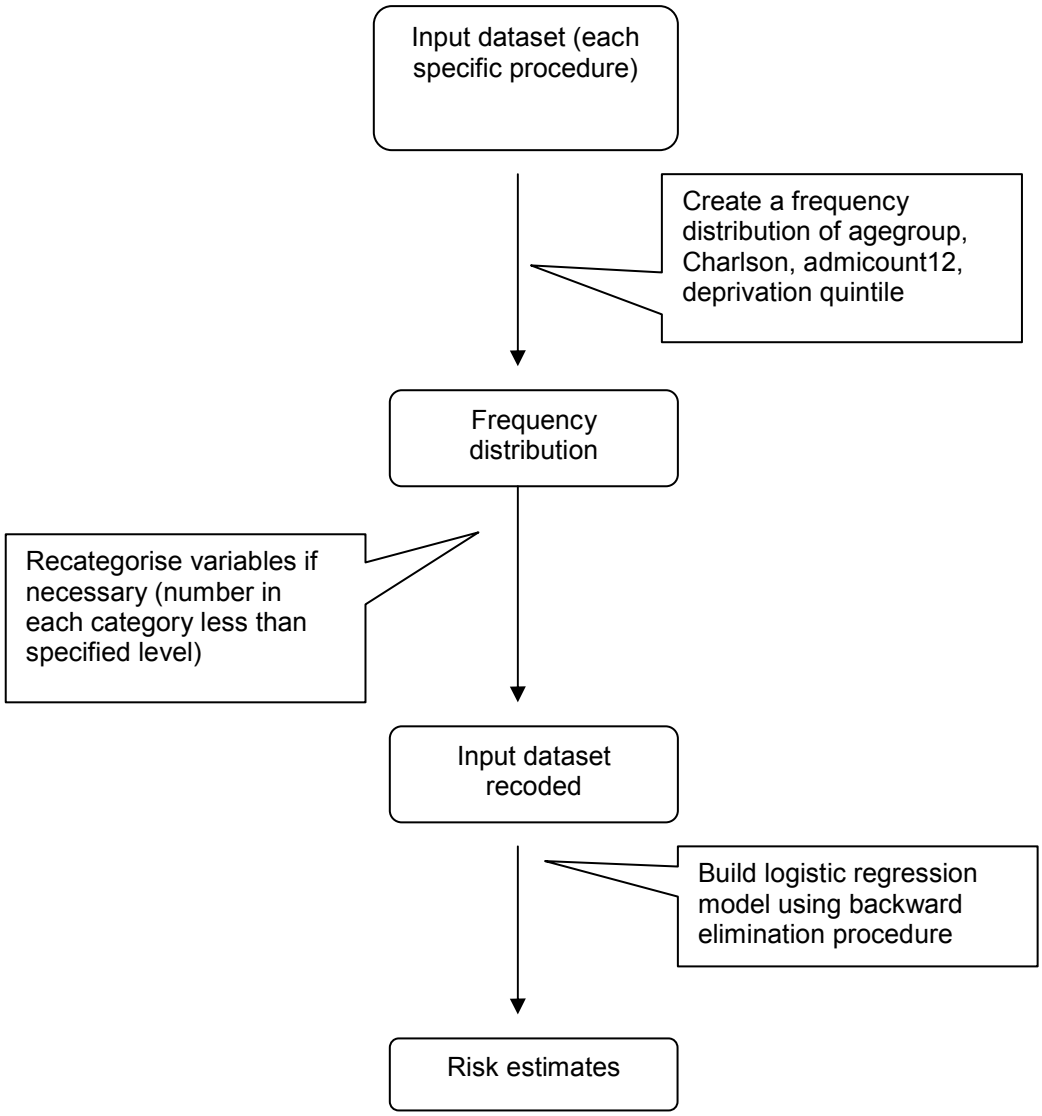
We exclude day cases (spells where CLASSPAT = 2 in first episode) from our risk models and where there is more than one spell with the same diagnositic group (CCS) in a superspell, we include only the first occurring spell.

4.2 Logistic regression models

For each diagnosis group (CCS) we derive predicted probabilities for inpatient in-hospital mortality by fitting logistic regression models using SAS V9.1. We apply SAS’s inbuilt backwards elimination procedure for variable selection, which starts with a model including all the selected explanatory variables and then automatically removes the variable with smallest F-statistic at each step until all the non-significant variables (using a cut-off of P>0.1) have been excluded.

We use the variables defined in Table 3 as our predictors. We recategorise four variables – age group, deprivation, comorbidity and number of previous admissions – depending on the absolute number of events, so that each category contains at least 20 events. Starting from the first (lowest) category, we combine it with the next lowest category if it contains fewer than 20 events and continue combining until that total has been reached. We then inspect the next highest category and repeat the process as necessary. If the last category is left with fewer than 20 events then it is combined with the second last category as one group. Figure 1 shows the sequence of our approach.

Figure 1 The sequence of risk modelling



4.3 Estimate of risk

The risk estimate (R) for each inpatient is calculated from the table of log odds produced by the risk modelling process (Appendix B) as follows:

R = exp(sum(logodds)) / (1+exp(sum(logodds)))

For day cases, R=0.

Risk estimates for data in years after the last year included in the risk model (currently 2007/08) are calculated using the log odds value for the last year in the model.

4.4 Quality of risk model (the 'C statistic')

The success of case-mix adjustment for accurately predicting the outcome (discrimination) was evaluated using the area under the receiver operating characteristic curve (c statistic). The c statistic is the probability of assigning a greater risk of death to a randomly selected patient who died compared with a randomly selected patient who survived. A value of 0.5

suggests that the model is no better than random chance in predicting death. A value of 1.0 suggests perfect discrimination. In general, values less than 0.7 are considered to show poor discrimination, values of 0.7-0.8 can be described as reasonable and values above 0.8 suggest good discrimination. These c-statistics are given in table 2.

5. Calculation of HSMR

The SMR is a method of comparing mortality levels in different years, or for different sub-populations in the same year, while taking account of differences in population structure. The ratio is of (observed) to (expected) deaths, multiplied conventionally by 100. Thus if mortality levels are higher in the population being studied than would be expected, the SMR will be greater than 100.

For all of the 56 diagnosis groups, the observed deaths are the number that have occurred following admission (as recorded in CDS) in each NHS Trust during the specified time period.

The expected number of deaths in each analysis is the sum of the estimated risks of death.

Each HSMR is plotted on a funnel plot. Funnel plots (a type of statistical process control charts) are a graphical method used to assess variation in the data and are used to compare different trusts over a single time period. Funnel plots are so named because they use control limits which form a 'funnel' around the benchmark and reflect the expected variation in the data.

Each funnel plot has three lines:

- a centre line, drawn at the mean (the National average, RR=100)
- an upper control-limit (drawn three sigma above the centre line, upper 99.8 per cent control limit – upper red line)
- a lower control limit (drawn three sigma below the centre line - lower 99.8 per cent control limit)

Data points falling within the control limits are consistent with random or chance variation and are said to display 'common-cause variation'; for data points falling outside the control limits, chance is an unlikely explanation and hence they are said to display 'special-cause variation'- that is, where performance diverges significantly from the national rate.

The distinction between control limits and confidence intervals is important; although they are very similar in construction and the difference between the two is subtle. Control limits have been used because they offer hypothesis tests whereas (strictly speaking) confidence intervals do not. Control limits come from the Poisson distribution and are calculated using an exact method using visual basic routines made available by John C Pezzullo (http://statpages.org/). For further information, please read David Spiegelhalter's informative paper "Funnel plots for comparing institutional performance". (Stat Med 2005 Apr 30;24(8):1185-202). The Eastern Region Public Health Observatory also has a large resource of relevant information and tools available online (www.erpho.org.uk).

6. Future work currently in progress

As part of the continual development of the HSMR in improving the casemix models, we are looking at making some small changes. It is likely that these will not have a great impact on the overall HSMR figures, but may have more impact on individual diagnosis or procedure groups. We are looking to incorporate an update to the Charlson co-morbidity index to include more ICD codes to pick up more cases of AMI, Dementia, Diabetes, Renal Disease and HIV. These contribute to the Charlson Index of Comorbidity for which we adjust in our risk models. We will be changing our diagnosis subgroups (used in the model) from ICD 3digits to published CCS subgroups, and we will be examining the impact of incorporating ethnicity, source of admission and calendar quarter of admission into the risk model. In addition, we will be re-evaluting how we handle palliative care and adjusting for seasonal variation for all diagnoses (if significant).

7. Relevant publications

Jarman B, Gault S, Alves B, Hider A, Dolan S, Cook A, Hurwitz B, Iezzoni LI. Explaining Differences in English Hospital Death Rates Using Routinely Collected Data. *BMJ* 1999;318:1515-1520

Bottle A, Aylin P. Intelligent Information: a national system for monitoring clinical performance. Health Services Research 2008;43:10-31

Aylin P; Bottle A. Are hospital league tables calculated correctly? A commentary. Public Health. (06 Sep 2007).

Aylin P; Bottle A; Majeed A. Use of administrative data or clinical databases as predictors of risk of death in hospital: comparison of models. BMJ 2007;334: 1044

Aylin P; Lees T; Baker S; Prytherch D; Ashley S. (2007) Descriptive study comparing routine hospital administrative data with the Vascular Society of Great Britain and Ireland's National Vascular Database. Eur J Vasc Endovasc Surg 2007;33:461-465

Bottle A, Aylin P, Majeed A. Identifying patients at high risk of emergency hospital admissions: a logistic regression analysis. JR Soc Med, Aug 2006; 99:406-414

Bottle A, Aylin P. Mortality associated with delay in operation after hip fracture: observational study. BMJ 2006;332:947-951

Spiegelhalter D. Funnel plots for institutional comparison. Quality and Safety in Health Care 2002 Dec;11(4):390-1.

Spiegelhalter DJ. Funnel plots for comparing institutional performance. Stat Med 2005 Apr 30;24(8):1185-202.

Vijaya Sundararajan et al. New ICD-10 version of the Charlson Comorbidity Index predicted in-hospital mortality. Journal of Clinical Epidemiology 57 (2004) 1288–1294

Appendix A. Charlson comorbidity conditions

Condition	ICD10 diagnosis codes	Score
Acute myocardial infarction	I21, I22, I252	1
Congestive heart failure	I50	1
Peripheral vascular disease	I71, I790, I739, R02, Z958, Z959	1
Cerebral vascular disease	I60, I61, I62, I63, I65, I66, G450, G451, G452, G458, G459, G46, I64, G454, I670, I671, I672, I674, I675, I676, I677, I678, I679, I681, I682, I688, I69	1
Dementia	F00, F01, F02, F051	1
Pulmonary disease	J40, J41, J42, J44, J43, J45, J46, J47, J67, J44, J60, J61, J62, J63, J66, J64, J65	1
Connective tissue disease	M32, M34, M332, M053, M058, M059, M060, M063, M069, M050, M052, M051, M353	1
Peptic ulcer disease	K25, K26, K27, K28	1
Liver disease	K702, K703, K73, K717, K740, K742, K746, K743, K744, K745	1
Diabetes	E109, E119, E139, E149, E101, E111, E131, E141, E105, E115, E135, E145	1
Diabetes with complications	E102, E112, E132, E142, E103, E113, E133, E143, E104, E114, E134, E144	2
Hemiplegia or paraplegia	G81, G041, G820, G821, G822	2
Renal disease	N03, N052, N053, N054, N055, N056, N072, N073, N074, N01, N18, N19, N25	2
Cancer	C0, C1, C2, C3, C40, C41, C43, C45, C46, C47, C48, C49, C5, C6, C70, C71, C72, C73, C74, C75, C76, C81, C82, C83, C84, C85, C883, C887, C889, C900, C901, C91, C92, C93, C940, C941, C942, C943, C945, C947, C95, C96	2
Metastatic cancer	C77, C78, C79, C80	3
Severe liver disease	K729, K766, K767, K721	3
HIV	B20, B21, B22, B23, B24	6