Understanding HSMRs

A Toolkit on Hospital Standardised Mortality Ratios

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Introduction

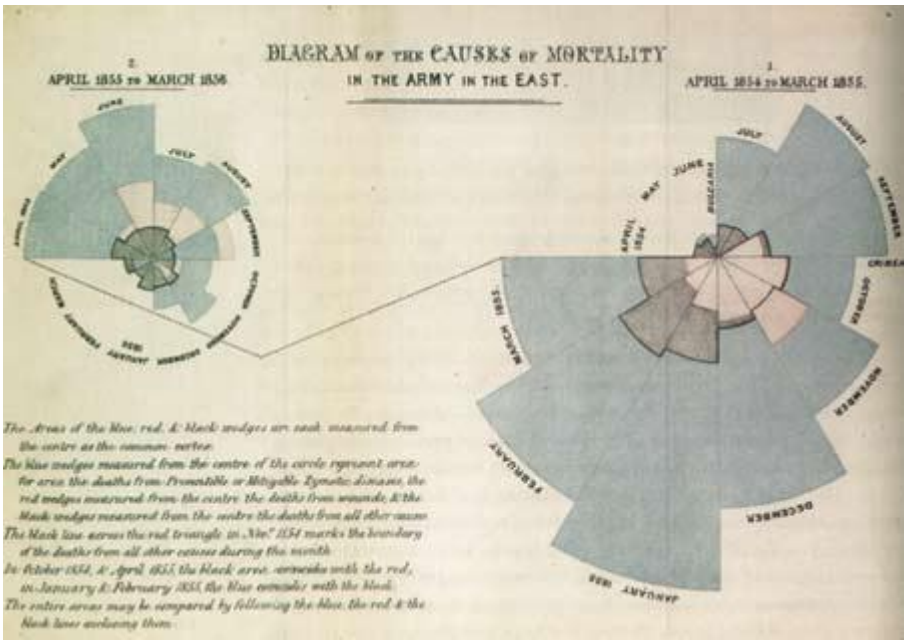
In 1859 Florence Nightingale found that her analysis of in-hospital death rates in London showed wide variation that could not be explained by differences in the health of local populations. She went so far as to state that uniform hospital statistics would "enable us to ascertain the relative mortality of different hospitals as well as of different diseases and injuries at the same and at different ages, the relative frequency of different diseases and injuries among the classes which enter hospitals in different countries, and in different districts of the same country" (Nightingale (1863), p.159). Wide variations in English hospital inpatient death rates have been observed over the many years since, and concerns have been expressed that such variations could reflect important differences in the quality of medical care available in different hospitals.

Dr Foster has been analysing and publishing mortality data for almost a decade and believe it to be an effective indicator for the quality of the services that English hospitals provide. Looking forward, our ambition is to be able to include indicators of quality that incorporate patient experience data as well as data that provide alternative views.

There is a long-running debate amongst academics and NHS organisations on HSMRs, which is one that we welcome as it encourages the continued scrutiny of hospital performance and methods of measuring it. This toolkit was written in this context and it lays out the history, methodology and correct way to interpret and use HSMRs to improve quality.

HSMRs continue to be a useful indicator when used effectively. HSMRs should not be used in isolation. They provide an indication of where a problem might exist and should be used as a trigger for investigation. Issues such as coding, variation in palliative care activity and under-reporting of comorbidities can lead to high HSMRs, but where these have been ruled out it is important to note there may be a problem with the quality of care delivered by that organisation.

Diagram of the causes of mortality April 1854 – March 1855 by Florence Nightingale



Source: Cohen, (1984) Florence Nightingale, Scientific American 250 p, 128-137

The History of HSMRs

Dr Foster has been analysing mortality data since 2000. In 2001 we published our original *Hospital Guide*, which included the first national publication of standardised hospital death rates in the world. We continue to publish these data each year, helping to fulfil the legacy of the inquiry into children's heart surgery at the Bristol Royal Infirmary.[1] Professor Jarman was a member of that inquiry.

Since the Bristol Inquiry, Professor Jarman and the Dr Foster Unit at Imperial College London has continually refined and improved the methodology for calculating HSMRs. For example, it has taken into account palliative care episodes, has refined casemix adjustments and has changed the classification system to improve the identification of conditions included in the HSMR population. Today, over 70 per cent of NHS acute trusts use HSMR analysis to monitor clinical outcomes in their hospitals via Dr Foster's Real Time Monitoring tool (RTM).

What is the HSMR?

The HSMR is a calculation used to monitor death rates in a trust. The HSMR is based on a subset of diagnoses which give rise to 80% of in-hospital deaths. HSMRs are based on the routinely collected administrative data often known as Hospital Episode Statistics (HES), Secondary Uses Service Data (SUS) or Commissioning Datasets (CDS). The HSMR was conceived by Professor Sir Brian Jarman, director of the Dr Foster Unit at Imperial College, London.

Measuring hospital performance is complex. Dr Foster understands that complexity and is clear that HSMRs should not be used in isolation, but rather considered with a basket of other indicators that give a well rounded view of hospital quality and activity.

HSMRs in the news

The Healthcare Commission[2] investigation into Mid Staffordshire Hospital NHS trust brought HSMRs into the news once again. The Commission notes that it was only after the publication of the 2007 Dr Foster Hospital Guide, where the trust was named as having a significantly high HSMR that the trust and the SHA took notice and began to investigate the problem. The trust was criticised for assuming that data anomalies were causing the high rate when in fact the Healthcare Commission found failings in the quality of care. Indeed they conclude:

"Trusts [must] be able to get access to timely and reliable information on comparative mortality and other outcomes, conduct objective and robust reviews of mortality rates and individual cases, rather than assuming errors in data."

Following the 'Mid Staffs' investigation the government set up an independent enquiry chaired by Robert Francis QC and reported in February 2010[3]. There is a specific section on mortality statistics which is very supportive of the sharing of these data, both in the form of publishing and working with clinicians and managers to understand outcomes. It fully endorses the principles that underpin the work of Dr Foster:

"The development and publication of comprehensive, reliable and clearly understood, statistically based information about the performance of hospitals is clearly vital not only to the NHS to assist in the management and provision of high quality health service, but also to enable the public to judge for themselves the standard of performance achieved, to inform their own healthcare choices"

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[1] http://www.bristol-inquiry.org.uk/

[2] Now Care Quality Commission

[3] http://www.dh.gov.uk/en/Publicationsandstatistics/Publications/PublicationsPolicyAndGuidance/DH_113018

"It is therefore particularly important that such information should be available from unimpeachably independent and reliable sources, and that it should be accompanied by clear explanations of what any figures mean, and, just as importantly, what they do not mean."... "The contribution made in this field by Professor Jarman's Unit and Dr Foster Intelligence is considerable."

The government now publishes HSMRs on the NHS Choices website (www.nhs.uk). It also publishes SMRs which show mortality rates for certain procedures.

HSMR: an international indicator

The HSMR is gaining in currency as a useful indicator of patient safety. In the USA, the Institute for Healthcare Improvement (IHI) has adopted HSMR analyses in their campaigns to improve the safety of patients. These include the Move Your Dot™ initiative, which gives advice and guidance to US hospitals on how to lower mortality rates. The IHI views this as "one of many current approaches being used to improve healthcare safety".[4] In England the Patient Safety First Campaign being led by the National Patient Safety Agency (NPSA) is using HSMRs as a high level tracking measure. HSMRs are also monitored routinely in other countries such as Canada and the Netherlands.

[4] Reducing Hospital Mortality Rates (Part 2)'. J Whittington, T Simmonds, D Jacobsen. IHI Innovation Series white paper. Cambridge, MA: Institute for Healthcare Improvement; 2005. Available: www.IHI.org

The Debate

HSMRs have been subject to much peer-review and are now widely used. Nevertheless, they remain the subject of a long-running debate in relation to their use and interpretation.

The HSMR is a measure of overall mortality, but it should be used in conjunction with other indicators in the assessment of the quality of care. Analysis of mortality in individual diagnoses and procedures, as well as the examination of other outcome and process indicators is invaluable in explaining and exploring variations between trusts.

Dr Foster is committed to continuing our work in making these data public. We aim to do this in a developmental way, helping trusts to understand their figures and ultimately improve patient care where necessary. The *Hospital Guide* annually publishes the names of trusts that have been determined as 'outliers', which means their results are significantly different to what is expected. An outlier is a data point that falls outside the control limits. These limits are set at 99.8 per cent, so it is unlikely the outliers are caused by chance. Therefore they are said to display 'special cause variation', where performance diverges significantly from the national rate.

In June 2008, a team from the University of Birmingham, led by Dr Mohammed A Mohammed, published a report commissioned by West Midlands Strategic Health Authority (SHA) entitled 'Probing Variations in Hospital Standardised Mortality Ratios in the West Midlands'. The report was highly critical of Hospital Standardised Mortality Ratios (HSMR).

The report explores a number of explanations for variations in HSMR:

- Coding depth
- Community provision
- The failing hospital hypothesis
- The quality of care hypothesis
- The 'constant risk fallacy'

Coding depth

The report claims a significant negative correlation in three of the four hospitals examined with an increase in the average Charlson index associated with a drop in HSMR.

Contradicting their claims, results given within the report show only two out of the four hospitals with a weak but significant relationship between HSMR and the Charlson index ($p<0.05$). The report's own 'bias corrected' HSMRs (estimates adjusted for coding bias) do not alter the fact that the hospitals concerned remain outside 99.8 per cent control limits. There is a much stronger relationship between property prices and HSMRs, illustrating the fallacy of assuming a causal relationship from a correlation of temporal trends. Using national data, findings by the Dr Foster Unit at Imperial College London in their paper, *Monitoring hospital mortality: A response to the University of Birmingham report on HSMRs* suggest only a weak relationship between coding depth and HSMR.[5]

[5] http://tinyurl.com/davumc

Community provision

The report finds a negative correlation between HSMR and the proportion of deaths occurring in community establishments.

There was no mention of statistical significance in this chapter. Brian Jarman's original 1999 BMJ HSMR paper looked at the issue of community provision and found that adjusting for this made only very small differences to the HSMR. A more recent analysis of all deaths (including deaths outside of hospital) shows a very strong correlation (R2=0.922) of HSMRs calculated using 30-day in and out of hospital deaths, with HSMRs calculated using just in-hospital deaths.

The failing hospital hypothesis

The report looks at the relationship between HSMRs and some potential indicators chosen by the authors of a 'failing organisation', and concludes there is little evidence supporting a link between these indicators and HSMR.

Although for many variables the report found no relationship, it did suggest a relationship between staff members' views and attitudes towards their workplace. The report highlights a negative relationship between patient survey variables and mortality, particularly 'respect and dignity shown' (i.e. low respect shown = high mortality). Clearly these are interesting results, and further work is required to explain them.

The quality of care hypothesis

The authors look at the relationship between case-note reviews in six hospitals for stroke and fractured neck of femur (FNOF) and deaths in 'low risk' patients at one trust in the West Midlands. They conclude there is little evidence of a link between process of care measures and HSMR.

However, the process of care measures looked at were limited and did not include *C-difficile*, wound infections, bed sores, missed antibiotics, poor fluid control, hospital acquired chest infection rates, suture line leaks, etc. Despite this, in 33 per cent of deaths, they did find areas of concern about patient care which may have contributed to, or did in fact cause, the patient's death. Forty per cent of these had a hospital acquired infection.

There are other external indications about the process of care at some of the hospitals contributing to the report. The hospital that contributed to the 'low risk' case-note review was reported to have one of the highest proportions of deaths involving *C-difficile* infections in England (Health Statistics Quarterly, 2008). One of the other hospitals with a high HSMR, and contributing to the report's case-note reviews, has been Mid Staffordshire Hospital, severely criticised by the Healthcare Commission for its emergency care.

The validity of the Dr Foster methodology and the constant risk fallacy

The final chapter (and a subsequent paper Mohammed A Mohammed 2009 BMJ Evidence of methodological bias in hospital standardised mortality ratios: *retrospective database study of English hospitals*) suggests that the 'constant risk fallacy' can bias results. The chapter focuses on at least two issues that might contribute to this constant risk fallacy: information bias and the proportionality assumption. It provides HSMR estimates 'adjusted' for bias which show reduction in two of the highest HSMR hospitals and it suggests that the HSMR methodology is 'riddled' with the constant risk fallacy.

It is widely acknowledged that all statistical models are flawed ("all models are wrong but some are useful"). Some are less flawed than others, but the authors' selection of the four trusts at the extremes of the distribution across the region will tend to exaggerate the flaws in any model. However, despite adjusting for the potential bias highlighted in the report, the four hospitals examined still remain in their bands (outside 99.8 per cent control limits).

The HSMR is a summary figure, designed to give an overview of mortality within a trust, and we accept it will hide a considerable number of differences in the risk profiles across different factors in the model, but we do not see why this should decrease the value of the HSMR as a summary figure used in conjunction with other measures.

Appendix 9 of the Francis enquiry is a detailed review of mortality statistics produced by two Harvard academics. It concludes that the Mohammed A Mohammed et al paper, *'Evidence of methodological bias in hospital standardised mortality ratios: retrospective database study of English hospitals'*, should not be used as an excuse to ignore high HSMRs or write them off as being methodologically flawed. The author's state:

"We are disturbed by the final sentence summarising the author's conclusions: "In other words, quality of care should remain innocent until proven guilty". This is a hospital-centric admonition, but certainly not one that would be acceptable to most patients or to the regulators entrusted with ensuring the quality of their care. We accept that there is no single, perfect mechanism for assessing health care quality. We also agree that every statistical quality monitoring algorithm, including Dr Foster, should be critically examined by experts to determine its validity. However, we believe that in the case of Mid Staffordshire, there were so many different warning flags from different entities, using different approaches, and over multiple time periods, that it would have been completely irresponsible not to aggressively investigate further."

Understanding HSMRs

How the HSMR is calculated (for full methodology see appendix A)

The HSMR 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 casemix. 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 HSMR will be greater than 100.

For all of the 56 diagnosis groups, the observed deaths are the number that have occurred following admission 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 for every patient.

Most Recent Modifications in 2011

Benchmarks

All benchmarks have been updated and now include values for 2010/11.

The Dr Foster Unit at Imperial College has made four methodological upgrades to the Hospital Standardised Mortality Ratio (HSMR) risk models to improve case-mix adjustment and make the methodology more statistically robust. The four changes are:

- **Only use data from 2000/2001 onwards:**
    - As we now have 15 years of data, and the early years are of lesser quality, and perhaps reflect different patterns of care, we are only going to use the most recent years of better quality data from 2000/01 onwards.
- **Remove ethnicity from the case-mix model:**
    - Although coding is improving, ethnicity is variably recorded across trusts. In some cases, up to 50% of admissions record ethnicity as unknown and this unequal recording may be very slightly biasing some of our indicators. We have therefore going to remove it from the case-mix model (although you will still be able to analyse by ethnicity in our quality solution, Real Time Monitoring).
- **Improved Charlson weightings for interaction:**
    - The effect of comorbidity differs by age. We are now taking this into account in our case-mix model. The inclusion of interaction terms is widely used in the literature.
- **Better adjustment for age:**
    - Where previously the HSMR model required at least 20 deaths per age group we now only need 10 deaths per group. This better adjustment for age will give us a better prediction of death for each patient.

What does this mean?

The improvements to the methodology mean greater power in the modelling for most diagnoses within Dr Foster's Real Time Monitoring tool, strengthening the insight that can be gleaned by users from the drill-down capabilities. These upgrades are fundamentally about improving the underlying models that compose the HSMR.

This also means that all English HSMR's will change slightly to reflect the impact of the new risk model. Early estimates show that for 2010/11, three trusts will improve banding, one trust will go

from ‘as expected’ to ‘higher than expected’ and that all other acute hospital trusts will stay within the same band.

Differences in HSMR’s are likely to range from – 4.3 points to + 2.7 points. However, for 65% of trusts the difference will be ± 1 point or lower, for 84% of trusts the difference will be ± 1.5 points or lower and for 95% of trusts the difference will be ± 2 points or lower. Therefore only 5% of trusts will have a difference in their HSMR of greater than ± 2 points.

Adjustment for case mix

Risks take into account those patient characteristics that are most strongly correlated with death and which reflect the patient’s risk profile rather than the way in which the hospital has treated them. These factors are:

- Sex
- Age on admission (in five year bands up to 90+)
- Interactions between age on admission (in five year bands up to 90+) and Charlson co-morbidity score
- Admission method (non-elective or elective)
- Socio-economic deprivation quintile of the area of residence of the patient (based on the Carstairs Index)
- Diagnosis/procedure subgroup
- Co-morbidities (based on Charlson score)
- Number of previous emergency admissions
- Year of discharge (financial year)
- Whether or not Palliative care
- Month of admission
- Source of admission

We currently adjust for the presence of palliative care episodes by including it in the risk adjustment model. If any episode in the spell has treatment function code 315 or contains Z515 in any of the diagnosis fields, then it is defined as “Palliative”, all others are termed “Non-palliative”.

Bandings and statistical processes

Usually we display each HSMR 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)
- 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 and the trust is classified as an outlier.

In classifying HSMRs as "high", "low" or "within the expected range", we use statistical banding to account for random chance and minimize false positives. We use 99.8 per cent control limits to determine whether an HSMR is high or low. This means that if an HSMR is outside the control limit there is only a small possibility (0.2 percent) that this is due to chance. Only hospitals that 'pass' this control limit test are grouped as high or low and all others are classed as within the expected range.

In order to ascertain statistical significance:

- To be high, a hospital must have an HSMR above 100 and have this value above the upper control limit. A hospital with an HSMR above 100 but with the data point within the control limits is classed as 'within the expected range.'
- To be low, a hospital must have an HSMR below 100 and have this value below the lower control limit. A hospital with an HSMR above 100, but with the data point within the control limits, is classed as 'within the expected range.'

Confidence Intervals vs Control Limits

Dr Foster Intelligence only publishes data using the 99.8 per cent control limit statistical test. In our Real Time Monitoring tool we use the 'more liberal' 95 per cent confidence interval banding. This is to give clinicians and managers an early warning of potential problems

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 are 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[6]. For further information, please read David Spiegelhalter's informative paper [7]. The Eastern Region Public Health Observatory also has a large resource of relevant information and tools available online. (www.erpho.org.uk).

[6] http://statpages.org/

[7] Funnel plots for comparing institutional performance". (Stat Med2005 Apr 30; 24(8):1185-202)

To achieve statistical significance using confidence intervals:

- To be high, a hospital must have an HSMR above 100 and the lower confidence interval must also be above 100. A hospital with an HSMR above 100 but with the lower confidence interval below 100 is classed as 'within the expected range.'

- To be low, a hospital must have an HSMR below 100 and the upper confidence interval must also be below 100. A hospital with an HSMR below 100 but with the upper confidence interval above 100 is classed as 'within the expected range.'

Mortality alerts – not the same as HSMRs

The Dr Foster Unit at Imperial College London is an independent academic unit funded in part by Dr Foster Intelligence. This unit writes to trusts when an alert occurs on cumulative sum charts, another kind of statistical process control chart for a variety of individual diagnosis and procedure groups. These charts are run each month, and alerts are considered with a probability of a false alarm less than 0.1% (this is a higher threshold than the default of 1% on the RTM tool) and other restrictions are also applied to exclude some diagnoses including cancer and vague symptoms and signs. They also exclude diagnostic procedures such as endoscopies and alerts with fewer than five deaths.

The two senior academics at the unit, Professor Sir Brian Jarman and Dr Paul Aylin, examine each alert and decide whether the trust should be notified or not. They look more carefully at alerts from specialist trusts, to examine possible casemix reasons for an alert. The Care Quality Commission is notified of the alert when it is sent to the trust chief executive. These notifications are carried out in confidence and Dr Foster Intelligence is not party to which notifications are sent out.

Investigating a high HSMR – best practice

HSMR must not be considered a punitive measure but rather as an indicator for organisations as a whole to monitor their mortality. HSMRs can be used to identify potential issues early, thereby giving the organisation an opportunity to make sustainable changes to their service delivery. To facilitate this we recommend that should an organisation be shown as an outlier for HSMR that they use the following investigation pathway:

1. Check coding

Has the trust submitted incorrect data or applied different data codes to other trusts across the UK? Poor depth of coding can also affect the HSMR, i.e. when there are no or few secondary codes.

A trust can improve its coding by encouraging coders and clinicians to work more closely together (some organisations have coders attached to specific specialities) so they can better understand each others' roles and limitations; they could encourage clinicians to use a Körner Medical Records (KMR) to determine the most appropriate primary diagnosis and procedure code ; they also need to ensure that staff inputting data entry such as DOB, Sex, Discharge dates etc are properly recorded on the PAS system understand the importance of the work they are doing and it impacts on the organisation.

2. Casemix

Has something extraordinary happened within the time frame i.e. an abnormal run of severely ill patients in a short period of time?

Is co-morbidity coding correct? Check the co-morbidity coding to identify the true casemix of the patient. No or poor co-morbidity coding can affect the HSMR.

3. Structure

Does the organisation and its surrounding healthcare partners work in a different way to other trusts across the country? Do they have different care pathways i.e. end of life care in the hospital or NHS funded hospices? Other structural differences such as no weekend discharges or nurse-led discharge teams should be considered too.

4. Process

At this point start considering that there is a potential issue with quality of care. Where service delivery needs to be reviewed, issues can be identified after monitoring and investigating alerts. Information systems such as RTM can help with this.

5. Individual or team

Very occasionally the investigation will lead you to an individual or team. Where there is a commonality of personnel involved or a particular team, nurse or department, see what extra support they need in order for them to deliver the best possible care.

HSMR checklist

Do's

- Monitor regularly – monthly, bi-monthly
- Report to the board quarterly
- Form or use existing regular reporting groups such as mortality and morbidity meetings and patient safety committees which normally include external delegates including PCTs
- Flag and audit every in-hospital death
- Investigate each alert in an open and transparent way
- Involve your clinicians in any investigation i.e. at mortality and morbidity meetings
- Be open with commissioners and the SHA/Monitor through the formation or use of your patient safety committee
- Use Real-Time Monitoring (RTM) to drill down if you have a high HSMR and examine procedural and diagnostic SMRs
- Contact Dr Foster Intelligence for help with the data

Don'ts

- Assume it is just coding
- Ignore the problem
- Think HSMR is the only indicator that matters
- Use HSMRs in isolation
- Try and assign blame
- Be complacent if your HSMR is low, also check SMRs
- Wait for external organisations to raise concerns. Instead, use RTM and Dr Foster to monitor your HSMR and advise on best practice
- Ignore the need for training on both RTM and HSMRs

Monitoring HSMR using Real Time Monitoring (RTM)

Successful use of HSMR monitoring can be more effective by the implementation of the Real Time Monitoring tool within an organisation. A lot of the best practice described below will fall out of the processes introduced as part of this implementation.

It is recommended that you have:

- An internal reporting process set up for monitoring and reporting on RTM alerts in general that could be used to monitor HSMR; it is important to investigate all RTM alerts not just the HSMR.
- Monthly monitoring of CUSUM alerts based on the individual diagnoses or procedures are useful in detecting any short term changes, whereas the HSMR itself should be monitored at least quarterly.
- The Clinical Governance, Risk, or similar teams set up to monitor patient outcomes, should take a lead on monitoring the HSMR and RTM CUSUM alerts and investigation of alerts using the investigation pathway suggested. Outcomes should then be shared with the Clinical Directors, Medical Directors, and Clinical Governance or clinical teams within each directorate affected for audit and comment.
- The inclusion of an mortality agenda item on mortality and morbidity team agendas or at the patient safety committee meeting:
    - Ensure clinical involvement, and limit a 'blame' culture developing
    - Ensure a feeling of transparency and inclusion
    - Patient Safety Committees meetings ensure transparency as they normally include external delegates including representatives from the PCT.
- A steering group that meets monthly as part of the RTM/HSMR implementation process to:
    - Ensure that reports are being monitored
    - Ensure users have had the training necessary to understand and use RTM and HSMRs
    - Ensure the process is embedded within the organisation's reporting process
    - HSMR monitoring should be discussed quarterly in preparation for completing a report for the board about changes to HSMR, investigation outcomes and action plans to improve patient outcomes and care pathways.

If you are showing as an outlier or an alert has gone off within a time frame then these should be investigated immediately. If you are an outlier a trend analysis should be carried out to identify if there was a particular point in time when you became an outlier, so you can understand what changed at this point, i.e. coding, new staff, and change in practice. Put in place plans that ensure changes are implemented and monitor any improvement in patient outcomes to ensure these are sustainable.

It is important whilst using HSMR as a performance indicator not to lose sight of your organisation's performance in other areas i.e. have alerts gone off in other diagnoses or procedures and do these have an impact on the HSMR?

HSMR as a data group should not be used to look at overall performance in outcomes such as length of stay, readmissions or day cases as HSMR looks at a very specific, restricted set of patients and could lead to some misleading results.

Recalibrating the benchmark and risk models

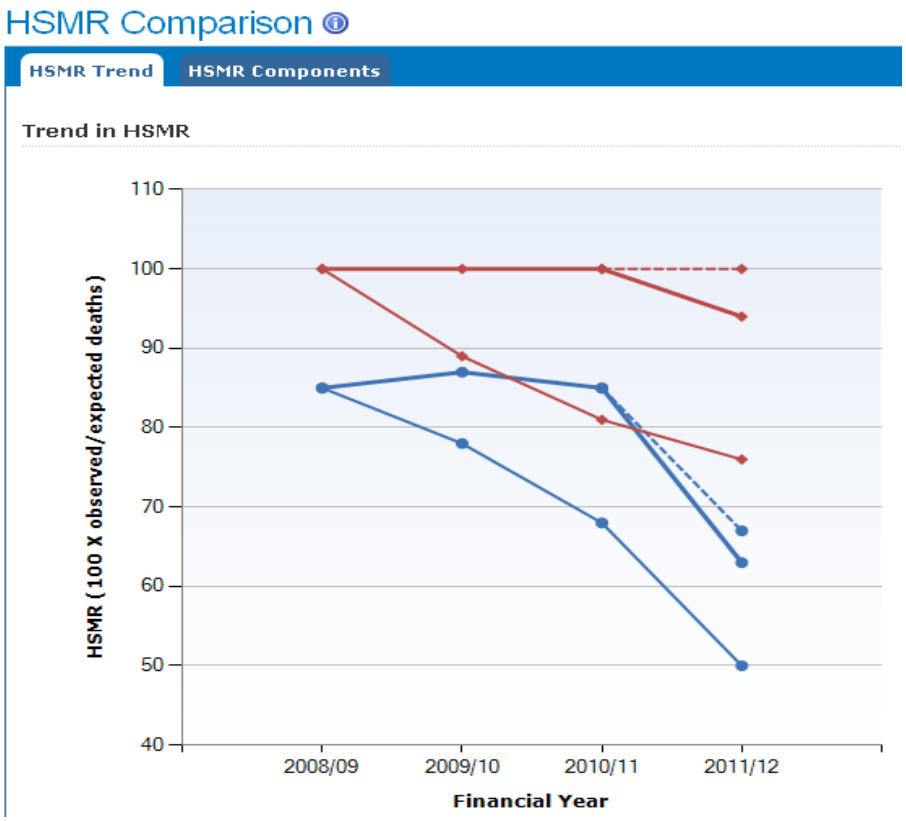
Each year, usually in September Dr Foster Intelligence and the Dr Foster Unit at Imperial College London recalculate the expected values and the risk estimates which are used to produce HSMRs. This is to take into account the changing patterns of in-hospital deaths and volume of admissions which alter year on year. The reasons for this include:

- Adding another year of data into the model
- Improving the risk adjustment
- Refreshing historic data

Due to the natural decline in mortality all trusts will see their most recent HSMR increase following this update. Unfortunately this means a few trusts change 'banding' and some may find their HSMR becomes significantly higher than expected when provisional results have indicated that the HSMR will be 'within the expected range'. Your customer support manager will make contact with those trusts likely to be affected and please make contact yourself if you require further information

In 2009 Dr Foster received feedback from trusts that they would like some advance warning of this benchmark change. We have created a new HSMR report, which is a module of RTM and aims to give users greater understanding of the context for their trust performance in particular how the national mortality rate and their expected rate are changing; The new report provides a comparison of HSMRs locally and nationally. It is also the first time that 99.8 per cent control limits are included in RTM

Specifically the report provides users with the ability to track a rebased estimate of their HSMR and compare it with the trend across the country and for a selection of peers. The report goes on to demonstrate the relationship between the trust's HSMR and some of the key input variables to the measure, the proportion of work coded as palliative care and the amount of work coded with high comorbidities. If you have any questions about the report please contact your local customer support manager.



Source: Dr Foster RTM management information tool

Case study – Peterborough and Stamford Hospitals NHS Foundation Trust

Hospital Trust reduces HSMR from 'significantly high' to expected

The challenge

Peterborough and Stamford Hospitals NHS Foundation Trust (PSHFT) has taken a range of measures to reduce their HSMR from 112 for the year 2008-09 to 100 for the year 2009-10, moving from 'significantly high' to 'as expected' within a year. The Trust used Dr Foster's Real Time Monitoring solution to identify key areas of concern, established a monthly mortality group and focused on building relationships between coders and clinicians.

The solution

The Trust used Dr Foster's software solutions and analytical services with the support of their local Dr Foster customer support manager, to significantly reduce their HSMR. The same customer support manager works in tandem with the newly formed monthly 'Mortality Group'.

The Mortality Group was established to examine reports at Trust wide level and from each clinical business unit. Regular reports and analysis of HSMR comparisons across all the East of England Strategic Health Authority (SHA) Acute Trusts includes monitoring six significant diagnosis groups, any changes in HSMR and any areas of concern

Chris Wilkinson, Director of Nursing & Infection Prevention and Control, said: "Dr Foster gave us impartial and expert support in improving our knowledge about, and monitoring of, HSMR. Our monthly meetings, supported by Dr Foster, have led to informed and prioritised actions to improve patient safety and to reduce our HSMR. Our partnership with clinicians, coders, managers and our Dr Foster customer support manager has been fundamental to achieving such success."

PSHFT used the information gained from Dr Foster's informatics tool, Real Time Monitoring (RTM) to identify six diagnosis groups with a higher mortality than expected for their Trust. They use this ongoing monitoring system to identify any changes in order that they might address them immediately.

The six areas include: Pneumonia; Cerebrovascular disease (Stroke); Congestive Heart Failure; Acute myocardial infarction; Septicaemia; and Urinary tract infections.

Identifying clinical coding errors has been very important in helping to reduce the HSMR. Over 600 patient health records involving the Clinical Coding and Clinical Audit & Effectiveness team and the Associate Medical Director were reviewed and clinical teams reviewed the patient pathways of over 20% of the diagnosis groups. Two additional diagnosis groups were also reviewed: COPD and Fluid and electrolyte management.

The outcome

The clinical Coding department have developed clear guidelines with full involvement of the clinicians on documentation of particular diagnosis groups e.g. pneumonia. The Trust was shown as coding differently from other SHA Acute Trusts. Where problems with clinical coding were identified corrections have been undertaken.

The ongoing work of the Mortality Group and the continued involvement of the Dr Foster Customer Support manager ensures the optimisation of the Dr Foster software solution, RTM, to identify potential issues and to address them collaboratively within the Trust before they become a problem.

Further reading

- Aylin P, Bottle A, "Intelligent Information: A National System for Monitoring Clinical Performance" HSR: Health Services Research 43:1, Part I (February 2008)
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Technical Document

HSMR Mortality Indicators Full Methodology

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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 11 years of inpatient and day case records from Hospital Episode Statistics (HES) for the period 2000/01 to 2005/06, and Secondary Uses Service (SUS) for 2006/07 to 2010/11. 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 July 2011.

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 2005/06 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 less than 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 2010 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	2000/01 to 2005/06	Frozen	HES	HESID	Rolled forward to Stage 2	Considered to be finished
2	2006/07 to 2009/10	Frozen	SUS (Jan08, Mar09, Apr10, Apr11 extracts) + Stage 1 orphans	SEX +DOB +HOMEADD	Rolled forward to Stage 3	Episodes in superspells ending in later years unlinked and rolled forward to Stage 3
3	2010/11 onwards	Monthly refresh	SUS (Cumulative from Apr10) + Stage 2 orphan	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.

3.2 Diagnosis derivation

We use the 56 diagnostic groups which contribute to 83% 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 of CCS group	C statistics
2	Septicemia (except in labour)	0.792
12	Cancer of oesophagus	0.833
13	Cancer of stomach	0.829
14	Cancer of colon	0.843
15	Cancer of rectum and anus	0.856
17	Cancer of pancreas	0.775
19	Cancer of bronchus, lung	0.780
24	Cancer of breast	0.949
27	Cancer of ovary	0.852
29	Cancer of prostate	0.884
32	Cancer of bladder	0.932
38	Non-Hodgkin's lymphoma	0.833
39	Leukaemias	0.812
42	Secondary malignancies	0.815
43	Malignant neoplasm without specification of site	0.789
55	Fluid and electrolyte disorders	0.793
59	Deficiency and other anaemia	0.788
68	Senility and organic mental disorders	0.677
100	Acute myocardial infarction	0.759

101	Coronary atherosclerosis and other heart disease	0.868
103	Pulmonary heart disease	0.790
106	Cardiac dysrhythmias	0.856
107	Cardiac arrest and ventricular fibrillation	0.692
108	Congestive heart failure, nonhypertensive	0.679
109	Acute cerebrovascular disease	0.729
114	Peripheral and visceral atherosclerosis	0.890
115	Aortic, peripheral, and visceral artery aneurysms	0.854
117	Other circulatory disease	0.817
122	Pneumonia	0.838
125	Acute bronchitis	0.849
127	Chronic obstructive pulmonary disease and bronchiectasis	0.714
129	Aspiration pneumonitis, food/vomitus	0.711
130	Pleurisy, pneumothorax, pulmonary collapse	0.809
131	Respiratory failure, insufficiency, arrest (adult)	0.745
133	Other lower respiratory disease	0.830
134	Other upper respiratory disease	0.897
145	Intestinal obstruction without hernia	0.829
148	Peritonitis and intestinal abscess	0.865
149	Biliary tract disease	0.925
150	Liver disease, alcohol-related	0.701
151	Other liver diseases	0.824
153	Gastrointestinal haemorrhage	0.831
154	Noninfectious gastroenteritis	0.874
155	Other gastrointestinal disorders	0.894
157	Acute and unspecified renal failure	0.740
158	Chronic renal failure	0.883
159	Urinary tract infections	0.801
197	Skin and subcutaneous tissue infections	0.907
199	Chronic ulcer of skin	0.797
224	Other perinatal conditions	0.753
226	Fracture of neck of femur (hip)	0.756
231	Other fractures	0.826
233	Intracranial injury	0.779
237	Complication of device, implant or graft	0.839
245	Syncope	0.784
251	Abdominal pain	0.936

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 or 5) 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
Diagnosis subgroup	Based on official CCS sub-groups within each CCS group	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)	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 50. We have expanded the coding definition of some conditions such that more patients are identified as having those conditions. Only secondary diagnoses (DIAG2-DIAG14) are now considered. There is now greater variation in weights between conditions and the Charlson index (the sum of the weights) is treated as a continuous variable (limited to the range 0-50) for the purposes of risk adjustment.	n/a
Emergency admissions in previous 12 months (admicount12)	Calculated as the number of superspells in the previous 365 days for the same patient (using the general pseudonymised patient identifier). This includes the current spell, if it is an emergency admission. Possible values are 0, 1, 2, 3+	n/a
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		n/a
Source of admission	Home - Initial spell and ADMISORC=19 Transfer (Acute) - Linked transfer from another acute NHS provider Other place - Initial spell and all other ADMISORC values Transfer (Non-acute) - Linked transfer from another non-acute NHS provider Transfer (Unknown) - ADMIMETH=81 or ADMISORC=49-53 but no previous spell found Birth - Initial spell and ADMIMETH=82-83 Transfer (Internal) - Linked transfer from this NHS provider Unknown (non-transfer) - ADMISORC=98-99	No

4. Risks

4.1 Denominator

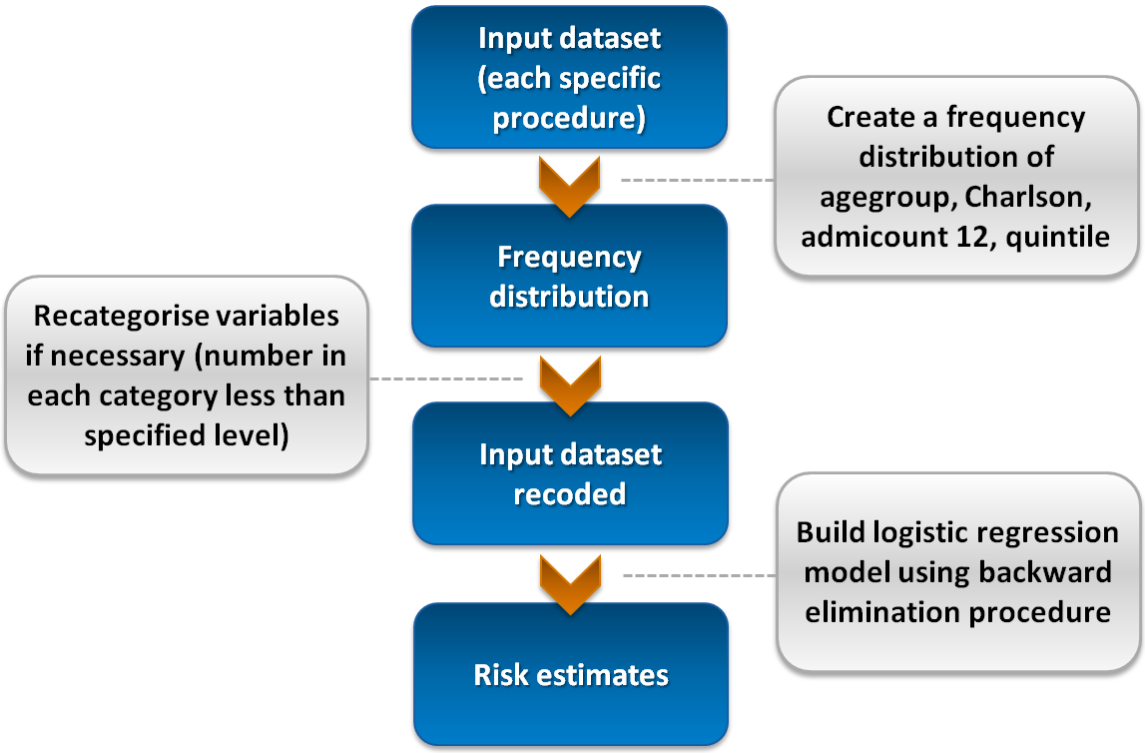
We exclude day cases (spells where CLASSPAT = 2 in first episode) from our risk models and where there is more than one spell with the same diagnostic group (CCS) in a superspell, we include only the first occurring spell.

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 10 events. Starting from the first (lowest) category, we combine it with the next lowest category if it contains fewer than 10 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 10 events then it is combined with the second last category as one group. Figure 1 shows the sequence of our approach.

Figure 1



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 2010/11) 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. Changes in 2009

Benchmarks

All benchmarks have been updated and now include values for 2008/09.

Diagnosis groups

- A few ICD10 diagnosis codes have been moved between diagnosis groups. The only code with significant volume is I739 “Peripheral vascular disease, unspecified” which has been shifted from “Other circulatory disease” to “Peripheral and visceral atherosclerosis” - both groups are included in the HSMR.
- In place of DFI’s own sub-groups which were designed specifically for mortality risk adjustment, we have adopted the official Clinical Classification System (CCS) sub-groups which have wider application and overall improve case-mix adjustment (see note below).

Charlson comorbidities

The original Charlson weights were derived about 25 years ago in the USA. We wanted to update them (e.g. HIV had the highest weight then but its mortality has fallen greatly since, particularly in hospitalised patients) and calibrate them on English data due to differences in coding practice and hospital patient population characteristics. We had advice from some clinical coders on current English coding practice and, where possible, also assessed the consistency of comorbidity recording among admissions for the same patient. As a result:-

- We have expanded the coding definition of some conditions such that more patients are identified as having those conditions.
- Only secondary diagnoses (DIAG2-DIAG14) are now considered.
- There is now greater variation in weights between conditions and the Charlson index (the sum of the weights) is treated as a continuous variable (limited to the range 0-50) for the purposes of risk adjustment.

The Charlson index is calculated for each episode separately; the score used in the risk modelling is therefore taken from the same episode from which the diagnosis or procedure information is taken.

Additional variables

- Risks are adjusted for three additional variables:-
    - Ethnicity (6 categories)
    - Source of admission (7 categories)
    - Month of admission

7. Changes in 2010

Benchmarks

All benchmarks have been updated and now include values for 2009/10.

8. Changes in 2011

Benchmarks

All benchmarks have been updated and now include values for 2010/11.

In addition, we have made the following changes:

- Use of discharges from 2000/1 onwards, thereby discarding previous years; these early years are considered to be less relevant to today and of poorer data quality
- Drop ethnic group (ETHNIC) from all models (there is appreciable variation in ethnicity recording between hospitals even though the national level has improved)
- Include interaction between age group and Charlson if significant (intuitive and commonly done in the literature)
- Recategorise age, deprivation quintile and admicount12 so that each category has at least 10 rather than 20 outcomes (this gives better adjustment)

9. Relevant publications

- Jen MH; Bottle A; Kirkwood G; Johnston R; Aylin P. The performance of automated case-mix adjustment regression model building methods in a health outcome prediction setting. Health Care Manag Sci 2011;14:267-278
- Bottle A, Aylin P. Comorbidity scores for administrative data benefited from adaptation to local coding and diagnostic practices. J Clin Epidemiol 2011 (in press).
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- 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. Stats Med 2005 Apr 30;24(8):1185-202.
- Sundararajan V et al. New ICD-10 version of the Charlson Comorbidity Index predicted in-hospital mortality. Journal of Clinical Epidemiology 2004; 57: 1288–1294.

Appendix A. Charlson comorbidity conditions

The original Charlson weights were derived about 25 years ago in the USA. We wanted to update them (e.g. HIV had the highest weight then but its mortality has fallen greatly since, particularly in hospitalised patients) and calibrate them on English data due to differences in coding practice and hospital patient population characteristics. We had advice from some clinical coders on current English coding practice and, where possible, also assessed the consistency of comorbidity recording among admissions for the same patient. As a result:-

- We have expanded the coding definition of some conditions such that more patients are identified as having those conditions.
- Only secondary diagnoses (DIAG2-DIAG14) are now considered.
- There is now greater variation in weights between conditions and the Charlson index (the sum of the weights) is treated as a continuous variable (limited to the range 0-50) for the purposes of risk adjustment.

Condition No.	Condition Name	New Coding	New Weight	Old Weight
1	Acute myocardial infarction	I21, I22, I23, I252, I258	5	1
2	Cerebral vascular accident	G450, G451, G452, G454, G458, G459, G46, I60-I69	11	1
3	Congestive heart failure	I50	13	1
4	Connective tissue disorder	M05, M060, M063, M069, M32, M332, M34, M353	4	1
5	Dementia	F00, F01, F02, F03, F051	14	1
6	Diabetes	E101, E105, E106, E108, E109, E111, E115, E116, E118, E119, E131, E131, E136, E138, E139, E141, E145, E146, E148, E149	3	1
7	Liver disease	K702, K703, K717, K73, K74	8	1
8	Peptic ulcer	K25, K26, K27, K28	9	1
9	Peripheral vascular disease	I71, I739, I790, R02, Z958, Z959	6	1
10	Pulmonary disease	J40-J47, J60-J76	4	1
11	Cancer	C00-C76, C80-C97	8	2
12	Diabetes complications	E102, E103, E104, E107, E112, E113, E114, E117, E132, E133, E134, E137, E142, E143, E144, E147	-1	2
13	Paraplegia	G041, G81, G820, G821, G822	1	2
14	Renal disease	I12, I13, N01, N03, N052-N056, N072-N074, N18, N19, N25	10	2
15	Metastatic cancer	C77, C78, C79	14	3
16	Severe liver disease	K721, K729, K766, K767	18	3
17	HIV	B20, B21, B22, B23, B24	2	6

Appendix B. Formula for calculating Carstairs

The formula was used to calculate the Carstairs index for each Output Area (OA) derived from 2001 census within the UK (England, Wales, Scotland, and Northern Ireland). The figures were normalised for the UK as a whole. Output areas were allocated into quintiles based on resident population, giving an equal total population in each quintile.

Unemployment variable: table KS0009b – Economic activity – males

unemp: KS09b0005 -> unemployed males over 16

unempd: KS09b0001 -> males over 16

No car variable: table UV062 – Cars or vans

nocar: UV0620002 -> households without a car or van

nocard: UV0620001 -> all households

Overcrowding variable: table UV058 – Persons per room

overcrow: UV0580004 + UV0580005 -> households with over 1.0 persons per room

overcrod: UV0580001 -> all households

Low social class variable: table UV050 – Approximated social grade

lowclass: UV0500005 + UV0500006 -> number of persons in a grade D or E classified household

lowclasd: UV0500001 -> all people

Calculation:

* delete all the records with no household residents (Census unit without people)

* compute proportions:

  unempp = (unemp/unempd) *100

  nocarp = (nocar/nocard) *100

  overcrop = (overcrow/overcrod) *100

  lowclasp = (lowclass/lowclasd) *100

* compute z-values for unempp, nocarp, overcrop, lowclasp

* Carstairs Index = sum of z-values for the four variables

[Note: The multiplication by 100 is not necessary as it cancels out in the normalisation process]

If you require mapping of ICD10 codes to CCS groups, please contact Dr Foster

About Dr Foster

Dr Foster aims to help bridge the gap between data and knowledge. One of Dr Foster Intelligence's key objectives is to promote the development of an information culture in the NHS by providing appropriate information and analysis to clinicians and managers in order to help them deliver the best quality healthcare.

The Dr Foster Unit at Imperial College London has developed pioneering methodologies that enable fast, accurate identification of potential problems in clinical performance – and areas of high achievement.

Dr Foster works to a code of conduct that prohibits political bias and requires it to act in the public interest. The code is monitored by the Ethics Committee, an independent body chaired by **Professor Alan Maynard**, Director, Health Policy Unit, York University and Chair, York Health Services NHS Trust.

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