

**The Ministry of Health and the Health Quality & Safety Commission   
Hospital Standardised Mortality Ratio Model – Methodology Paper (July 2015)**

This guide describes the methodology used by the Ministry of Health (the Ministry) and the Health Quality & Safety Commission (the Commission) to calculate Hospital Standardised Mortality Ratios (HSMRs). Guidance is provided on how to interpret the charts including some additional notes in the form of questions and answers.

**1.0 Background**

The HSMR is the number of observed deaths within 30 days of admission divided by the number of deaths that were predicted for a particular hospital. The HSMR therefore statistically adjusts the crude death rate by taking into account a range of known risk factors that a hospital has little or no control over for example, transfers.

There is no single ideal approach to calculating HSMRs. Different countries use different statistical models to predict the number of deaths in a hospital, given a standard set of national mortality rates. The standard set of rates take into account known influences on mortality such as the distribution of age or sex, primary diagnoses, prior conditions and type of admission.

Monitoring deaths amongst hospital patients has become one of the standard measures used internationally to help monitor the quality of care provided in hospitals. Mortality rates and ratios are only one component of a range of indicators. HSMRs cannot be used to rank hospital quality, or be the basis of calculating ‘avoidable’ deaths within a hospital[[1]](#footnote-1). Interpretation must be made with caution and avoid drawing simplistic conclusions from mortality data alone. Trends should be monitored over time.

HSMRs may be used as an early warning mechanism as part of a suite of indicators that support a quality framework. HSMRs act as a ‘smoke alarm’ for prompting further investigation. Significant changes (special cause variation) in HSMRs may indicate something changing which needs to be understood locally. Similarly a hospital with an HSMR consistently different from the average should seek to understand the cause, as one potential cause for differences in HSMR is variance in the quality of care. Other causes could include unadjusted variance in patient risk factors, differing access to end of life care systems, technology changes and varied coding practice.

***1.1 The New Zealand Context***

HSMRs were made publicly available in 2010/11 and 2011/12 as part of the DHB performance framework. However, the measure was removed from the framework in 2012/13 to allow the Ministry and the Commission to investigate the validity of the historical model. This created an opportunity for the Ministry, the Commission and DHBs to revisit how the information can be more appropriately used in a quality improvement context.

In light of recent international events, the Ministry reviewed a wide range of international variants of HSMR. The events noted by the Ministry include:

* Mid Staffordshire, England
* Constructive use of HSMR in Scotland, and other countries.

The Ministry settled on the Scottish National Health Service’s (NHS) variant as an appropriate methodology to replicate and tailored it to reflect available New Zealand data. The reasons for choosing the Scottish model include:

* the similarity between the Scottish and New Zealand health and data collection systems, making replication of the Scottish methodology more viable
* the Scottish HSMR includes post discharge deaths, addressing a major recognised weakness of the original construction of HSMR.

**2.0 Methodology**

The Ministry and the Commission HSMR is derived from the National Minimum Data Set (NMDS) which is an event level hospital discharge dataset for inpatient and day patient services. Outpatient and emergency department data is from National Non-Admitted Patient Collection (NNPAC) and is not included. The NMDS is joined by National Health Index (NHI) number to the New Zealand mortality database. The data covers all inpatient and community deaths up to 30 days after admission.

NMDS data is selected by calendar year and processed through the Weighted Inlier Equivalent Separations (WIESNZ) 10 filter. WIESNZ10 applies casemix criteria and creates the variable Purchase Unit (PU). Casemix criteria permit the selection of inpatient activity that is more consistent across DHBs.

***2.1 Exclusions***

Events which are excluded from the New Zealand model include obstetric and psychiatric events, neonates and stillbirths and privately funded activities. Events with a length of stay longer than 365 days are also excluded in accordance with New Zealand casemix rules. Admissions which are non-casemix are excluded as this information is incomplete. Admissions where DHB of service is missing is excluded to ensure data quality.

***2.2 Inclusions***

The variables included in the model are: age, sex, admission type, day case, primary diagnosis, deprivation, specialty, transfer and prior morbidities.

Deaths within 30 days from admission, wherever these occur, are included in the model.

Age is adjusted by classifying into one year categories. Sex is categorised as male or female.

The admission type in New Zealand includes acute, arranged and elective. An acute admission is defined as “An unplanned admission on the day of presentation at the admitting healthcare facility. This may have been from the Emergency or Outpatient Departments of the healthcare facility or a transfer from another facility.”[[2]](#footnote-2)

An arranged admission is one where “the admission date is less than seven days after the date the decision was made by the specialist that this admission was necessary, or - the admission relates to normal maternity cases, 37 to 42 weeks gestation, delivered during the event.”2

An Elective admission is where the admission date is seven or more days after the decision was made by the specialist that the admission was necessary.

For the primary diagnosis, 26 clinical groupings are used to describe body systems and major diagnostic categories based on ICD (International Classification of Diseases) codes. These are the diagnoses reported at discharge.

Prior morbidities, as a proxy for comorbidity, are adjusted using the Charlson Comorbidity Index. This index is used to identify patients with any of the 17 conditions as a primary diagnosis 1 year prior to index admission and the appropriate weighting is assigned accordingly. A weighting is applied only once per clinical group.

***2.3 Statistical Technique***

Logistic regression is used to derive a probability for each combination of variables used in the model.

***2.4 Limitations***

The Ministry and the Commission HSMR was developed using the NHS Scotland HSMR as a model and there are some differences in the scope and the way data is collected. This means that the model could not be completely replicated. Variables such as admission source as defined in Scotland and previous emergency admissions are not included due to unavailability of this data in the NMDS dataset. There are also differences in the way data is collected in Scotland and New Zealand. Scotland refers to ‘spells’ whilst the Ministry and the Commission model records patient ‘events’. Due to data unavailability, prior morbidity is based on data 1 year prior to admission rather than five years prior to admission in the Scottish model.

One limitation that all HSMR measures have is that their risk adjustment is necessarily imperfect, as not all variation between patients can be captured in routine administrative data such as the NMDS. In particular the relative acuity of each patient is very hard to capture. The consideration of co-morbidities in the risk adjustment model is in part an attempt to address this, but this is inevitably a limited approach (many very sick patients may have no recorded co-morbidities). This means that any investigation in response to a high or low HSMR should include a consideration of whether there is unadjusted risk to patients affecting the final figure.

**Table 2.4.1 – Variables used in the Ministry of Health and the Commission HSMR**

|  |  |  |
| --- | --- | --- |
|  | **Variable** | **Description** |
| 1 | Sex | Male or Female |
| 2 | Inpatient and Day Case | Inpatient and day case |
| 3 | Speciality | Health Specialty of consultant during period of care (surgical/ non-surgical) |
| 4 | Age | Age used as one year categories to mimic as closely as possible to the Scottish model where age is continuous |
| 5 | Primary Diagnosis Code | Uses 26 clinical groupings. Diagnosis is based on what is reported at discharge |
| 6 | Prior-Morbidity | Uses Charlson Comorbidity index to identify patients with any of the 17 conditions as a primary diagnosis one year prior to index admission. The appropriate weighting is assigned. |
| 7 | Admission type | Elective, acute, arranged |
| 8 | Deprivation Index | New Zealand Deprivation Index  (NZDep06 which is based on Census Data) |

**Table 2.4.2 – Additional notes on the model**

| **Criteria** | **Description** |
| --- | --- |
| Exclusions | * excludes maternity related and psychiatric cases * Neonates and Stillborns * admissions which are non-casemix (as this information is incomplete) * non publicly funded private facilities * admissions where DHB of service is missing (to ensure data quality) * admissions longer than 365 days (following NZ casemix rules) |
| Assessment of the Model | * C-statistic of 0.905 * Note that models with c-statistic more than 0.8 show good discriminatory power. |
| Index period upon which data are based | Base year 2007 |
| Source data | NMDS (inpatient mortality) and mortality data from Births Deaths and Marriages (to include deaths from the community) |
| Technique used to calculate predicted deaths | Logistic regression |
| Presentation | Presented as a ratio of observed and predicted deaths |

**3.0 Interpreting the graphs**

***3.1 Line Graphs***

The “Hospital Standardised Mortality Ratios by Year: National” chart shows the HSMR at national level by calendar year. The “Hospital Standardised Mortality Ratios by Year: [DHB]” chart shows HSMR for a specific DHB by calendar year. The dashed lines show a 99.7 percent control limit around the 2007 national and 2007 DHB average respectively. The year 2007 was chosen as the base year for future comparison. The observed and predicted number of deaths are provided beneath the charts.

***3.2 Box Chart***

The “Hospital Standardised Mortality Ratios by Year: [DHB], 2013” chart shows where each facility or group of facilities are in relation to the national average HSMR, for example hospitals, over a single period of time. The box chart reflects the predicted variation in the data.

The main features of the box chart are:

* a long black centre line in the background is the national average of the year being evaluated.
* a short black vertical line showing the HSMR for a facility or group of facilities
* a dark blue box around the centre line, which shows the variation that would be expected around the average 95 percent of the time. This is equivalent to 2 sigma.
* a light blue region, which extends the box to the variation expected about  
  99.7 percent of the time. This is equivalent to 3 sigma.

Three sigma, or standard errors, with 99.7 percent intervals are used as control limits rather than 2 sigma with 95 percent intervals to reduce the number of false positives. If there were no underlying change in the HSMRs for DHBs, on average 1 of the 20 DHBs would have a statistically significant result outside 95 percent control limits every year purely by chance.

The box charts are not symmetrical. This is because deaths are better modelled by a Poisson distribution than say a normal distribution, especially when there are small numbers of predicted deaths.

If the HSMR (short black vertical line) is within the control limits, these are consistent with common cause for variation. Therefore, there is no special cause variation. However, if data points fall outside the control limits, common cause is a less likely explanation and the data is to display a ‘special cause variation’.

Chart 3 displays HSMR of a specific DHB as well as facilities within that DHB. Very small facilities, which reported 10 or fewer than 10 deaths, were excluded in chart 3, as these were outliers with very wide confidence limits.

1. **Additional Notes**

***4.1 What factors may influence HSMR?***

There are a number of factors that influence hospital mortality, only some of which relate to the quality of healthcare. These include the nature of local health services (for example, which conditions are treated in the hospital compared with community-based services and access to end of life care), the way in which the hospital records and codes data about their admissions including depth of clinical coding and disease severity. Whilst a good attempt is made to take into account evidence-based contributing factors when trying to achieve a “standardised” measure, such adjustments are not perfect and there is always likely to be some element in the final mortality measure that is unrelated to the quality of health care. There will always be room for technical refinement of the model. Any future refinement will likely require an iterative process of consultation and testing.

***4.2 What other quality dimensions need to be considered alongside HSMR?***

HSMR should be looked at alongside other quality indicators such as patient experience and selected safety measures covering healthcare associated infections, falls in hospital, safe surgery and medication safety (the Quality and Safety Markers). These indicators are published regularly on the Commission’s website. For further information on these indicators refer to the following web page:

[http://www.hqsc.govt.nz/our-programmes/health-quality-evaluation/](http://www.hqsc.govt.nz/our-programmes/health-quality-evaluation/projects/health-quality-and-safety-indicators/)

***4.3 What is the base year and how is this set?***

The Ministry and the Commission have chosen to align our methodology with the National Health Service Scotland in regards to setting of a baseline. It is understood that the method is one amongst many ways of observing change and will not adjust for system, technology or coding changes. However, it will serve as a warning signal for investigation for quality improvement purposes. The base year for the Ministry and the Commission model is 2007, and this is the year the model’s logistic regression calculates the probabilities. These probabilities are then applied to inpatient data for the years 2008 to 2013.

It is anticipated that the base year of the model will be reviewed and updated in the future.

***4.4 What are control limits and how are these set?***

Control limits are calculated using 2007 as the base year. These are three standard errors[[3]](#footnote-3) (sigma) above and below the mean. The control limits are extended to later years so each year can be compared to these 2007 limits.

The data is calculated yearly as there is considerable seasonality to the data.

***4.5 Why do the control limits vary so much between facilities?***

The variability in the control limits is largely dependent on the size of the hospitals. Smaller facilities tend to have a greater variability. The control limits are wider for these smaller facilities but the HSMR is more difficult to interpret as there is greater variability.

***4.6 What does a HSMR of 1 mean?***

A HSMR of 1 means that, at an aggregate level, the number of deaths is the same as the predicted number of deaths, according to the predictive values applied to the admitted patients. So in the base year where the actual and the predicted number of deaths are equal, its HSMR is equal to 1.

***4.7 Why does the predicted death number fluctuate each year?***

The predicted deaths will depend upon both the number of patients admitted and the mix of risk factors. As both these change every year, the predicted deaths number for each DHB will also change every year.

***4.8 What does a change over time in HSMR mean? Is a static trend a good thing?***

A change in HSMR, whether increasing or decreasing, should be treated as a trigger for further investigation in order to establish the reasons for the change. A static trend is not necessarily favourable eg, if HSMR does not change much over time but is persistently high is cause for further investigation.

Even within the control limits there may be an important trend to discern. Moving from near one limit to the other may be more important than breaching the control limit.

***4.9 What are outlier results?***

Outlier results refer to points that are beyond the control limits. A control limit is three standard deviations above or below the mean. For the line graphs that display trend over time, the control limits are set based on 2007 baseline data. For the graphs that display single year results across DHBs or facilities, the control limits are set based on the national mean of the year in question. Points that are beyond the control limits indicate a special cause for variation.[[4]](#footnote-4) They signal the need for further investigation at a local level. This could include a stepwise approach at eliminating data quality issues before exploring other possible reasons such as patient casemix, resources and processes of care.[[5]](#footnote-5) Variation within the control limits is consistent with common cause variation.[[6]](#footnote-6)

There will be difficulties in identifying outliers when the data were not designed to be compared across DHBs. Significant changes over time within a facility or DHB will be a better signal for further investigation.

An alert should be followed up by an investigation of other quality indicators such as:

* patient experience
* safety
* workforce
* clinical and operational effectiveness
* leadership and governance[[7]](#footnote-7).

There are also sub-organisational indicators at ward or unit level which could reveal variation at the organisational level[[8]](#footnote-8).

***4.10 How does the revised model differ from the Health Roundtable model?***

The Health Roundtable (HRT) also provides a variation of the HSMR to DHBs. During the development work of the revised model, the Ministry consulted with different stakeholders on the methodology including the HRT.

There are several fundamental differences between the Ministry and the Commission model and the HRT Model. These include:

* The HRT model accounts for hospital deaths only whilst the Ministry and the Commission model considers both hospital and community deaths within 30 days from admission. Thus, the Ministry and the Commission model is able to account for deaths in the community in addition to the hospital deaths.
* The baseline period is wider for HRT compared to the Ministry and the Commission model. Thus HRT is currently using a three year baseline while the Ministry and the Commission model uses a single year baseline which is the year the model’s logistic regression calculates the probabilities for applying to other years.
* The HRT model includes data from Australia and from its members in New Zealand.
* The HRT model excludes palliative care type in order to include only acute care type. The Ministry and the Commission model does not exclude palliative care as these events are not consistently coded across DHBs.
* Other variables which are excluded by the HRT model but are not part of the exclusion criteria in the Ministry and the Commission model are: patients leaving against medical advice, routine dialysis, sudden unexplained deaths and some organ donors. However, these variables may be considered for exclusion in the development of a future model for New Zealand.
* The HRT model does not adjust for socioeconomic deprivation whereas the Ministry and the Commission model uses New Zealand Deprivation Index, based on Census data for this adjustment.

***4.11 Why do the Ministry and the Commission not adjust for palliative care events?***

Current clinical codes recorded in the National Data Collections do not allow any model to comprehensively identify palliative care events. This makes it difficult to understand how palliative care events contribute to differences in DHBs’ HSMRs. The wide variance in coding practice makes exclusion of palliative care deaths a potential risk for distorting the overall ratios. This draft revised model includes deaths outside of hospital which helps reduce, although not eliminate, this potential distortion. This is one of the reasons why DHBs are encouraged to focus on their own results and trends overtime as differences in service provision will drive variances across DHBs.

***4.12 How should HSMR be interpreted?***

HSMR is widely used internationally, but on its own, it is not an indicator of the quality of care provided. It is best used to track changes over time. A sudden increase in HSMR may serve as a ‘flag’ highlighting a trend to investigate.

A secondary use is to see if a particular hospital has a ratio significantly higher or lower than we would have predicted. Again, this may act as a prompt for further enquiries.

It should not be used in isolation and cannot be used to rank hospital performance. There are many factors that influence HSMRs, some of which may be beyond the control of the facility.

***4.13 What do you mean by “significantly higher or lower”?***

Ratios go up or down a little every time they are measured. There are well-established statistical methods that identify which changes or differences are due to chance and which reflect something real. The word “significant” is used to describe changes or differences which the model indicates a pre-determined level of confidence that the observed high or low results are not caused by chance alone.

***4.14 What questions might HSMRs prompt?***

HSMRs will always require further investigation in order to be understood. The questions that HSMRs should prompt include:

* What is the overall ratio made up of?
* What is the variance between different parts of the hospital – are ratios high for some conditions or patient groups and low for others?
* Are there any issues about data or coding of patient conditions that we should take account of?
* Has there been any change recently, and has that change been focused in specific parts of the hospital?
* Are there any issues of quality that we are aware of from other sources? How do HSMRs coincide with these?

***4.15 How are post discharge deaths linked to discharged events?***

The data on deaths is obtained from the New Zealand mortality database and is joined by the National Health Index (NHI) number to the NMDS. Each death is assigned to the last facility of admission. This ensures that deaths are recorded only once to prevent duplication. For example, if a patient is transferred from hospital 1 to hospital 2 and dies in the community, the death is assigned to hospital 2.

***4.16 What further work is planned?***

Early work has commenced with selective DHBs with the aim of applying the information at a more granular level such as health specialty. This will enable local clinical leaders to act quickly and directly addressing any apparent issues emerging from the data. This will also encourage a quality improvement mindset.

Conversation with the sector on this is continuous. There will always be room for technical refinement of the model. Any future refinement will likely require an iterative process of consultation and testing. This includes seeking greater alignment with complementary tools that the sector may be using such as the HRT’s analysis.

1. "However tempting it may be, it is clinically meaningless and academically reckless to use such statistical measures to quantify actual numbers of avoidable deaths." Bruce Keogh, Medical Director of the NHS in England, July 2013 [↑](#footnote-ref-1)
2. National Minimum Dataset (hospital events) data dictionary (version 7.5) [↑](#footnote-ref-2)
3. In Statistics, the standard error is the estimated standard deviation of a sample mean. [↑](#footnote-ref-3)
4. Special cause variation is a similar concept to showing a significant variation. [↑](#footnote-ref-4)
5. Queensland Government (2013), “Guideline for Variable Life Adjusted Display and other National Patient Safety Indicators”, Guideline # QH-HSDGDL-032-1:2013 [↑](#footnote-ref-5)
6. Common cause variation is a similar concept to showing a non-significant variation. [↑](#footnote-ref-6)
7. Keogh B, July 2013, “Review into the quality of care and treatment provided by 14 hospital trusts in England: overview report” [↑](#footnote-ref-7)
8. Berwick D, August, 2013, “A promise to learn, a commitment to act – Improving the Safety of Patients in England” [↑](#footnote-ref-8)