

Spotlight on Measurement

Measuring 30-day mortality following hospitalisation

Considering approaches for ongoing reporting in NSW



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Foreword

At face value, mortality is one of the most easily understood outcomes of healthcare. Unlike many other constructs, such as quality of life or functional status, death is unambiguous, clearly defined and universally resonant for patients, clinicians and managers.

Measures of mortality are however, powerful indicators to be applied judiciously. Influenced by factors such as clinical processes, organisational capacity and integration of care, mortality indicators reflect a broad range of quality issues and can help assess healthcare performance at both a system and hospital level.

While death is always a meaningful event, every death is not a direct reflection of performance. Many deaths are unavoidable, and death may even be an expected outcome in some circumstances. Differences in mortality across hospitals that persist after adjusting for patient-level factors and case mix may however be a reflection of unwarranted clinical variation.

Efforts to improve quality of care also rely on good measurement of performance over time. Time series data can provide feedback on progress and improvement trajectories. Timing of releases of information is crucial. Too infrequent reporting can be criticised for not being reflective of current performance; too frequent reporting can be criticised for not allowing sufficient time for changes to be enacted and for improvements to be discernible. There is a balance to be struck between providing information on a sufficiently regular basis so as to guide and inform improvement efforts on the one hand, and yet not to overwhelm organisations and clinicians with too frequent public releases of information on the other.

In 2013, the Bureau of Health Information released a report — *30-day mortality following hospitalisation, five clinical conditions, NSW, July 2009 – June 2012* — which used a risk-standardised mortality ratio (RSMR) to assess the presence of such variation. The report emphasised that RSMRs cannot in isolation provide unequivocal evidence of either good or poor performance. Most useful as a form of screening tool, they help identify where further assessment of performance may be needed and where improvement efforts could be focused.

This edition of *Spotlight on Measurement* builds on the foundation of its predecessor, published in December 2013. That report described the analytic steps taken to develop and validate the RSMR for application in a NSW context. This edition looks toward future reporting. It explores a range of issues and their implications for mortality measurement and reporting, such as the frequency of data releases, permutations in relative levels of sensitivity and specificity in the measures, and the potential for establishing a mixed approach to reporting that incorporates both summative assessments in public reports and formative assessments made by local providers and managers.

This report aims to clarify the implications of various options, ensuring that mortality measures are used with caution and with an understanding of the impact that various methodological options have on findings. By being transparent about these implications, we hope to contribute to a healthy debate about when and how to use these important measures as part of regular reporting of performance in the NSW context.

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Chief Executive, Bureau of Health Information

Summary

This report explores a range of issues and options for the ongoing measurement and reporting of 30-day mortality in NSW. It builds on a 2013 report that described the development of a risk-standardised mortality ratio (RSMR) for five clinical conditions: acute myocardial infarction, ischaemic stroke, haemorrhagic stroke, pneumonia and hip fracture surgery.¹

This report is structured around three types of criteria used to assess performance measures: relevance and validity; sensitivity and specificity; and actionability and timeliness.

Relevance and validity

The relevance and validity of performance measures assess questions of utility. Does the measure address the information needs of clinicians, managers or policymakers? Is it suited for application in a NSW context? Does it make a unique contribution to a broader set of performance measures?

- Mortality reporting, done well, can play a key role in assessing healthcare performance, providing accountability, and targeting and guiding improvement efforts
- Implications of using the RSMR approach in the mixed hospital sector of NSW were assessed by comparing inclusion and exclusion of private hospital patients in the predictive models and RSMR calculations, with a very minor impact on results
- Recoding same-day discharge and admission as a transfer (correcting for a probable miscode) had a modest impact on results, with one hospital becoming a low mortality outlier for pneumonia

- The validity of the RSMR is supported by an independent audit of ischaemic stroke care conducted by the NSW Agency for Clinical Innovation (ACI). The audit found broad concordance between the RSMR-derived hospital outlier status and audit-based process measures of quality of care.

Sensitivity and specificity

The sensitivity and specificity of performance measures assess questions of statistical discrimination. Does the measure capture meaningful variation across hospitals of different sizes and complexity while minimising 'noise', random variation and bias? Is the measure appropriately calibrated for use in NSW, identifying meaningful outliers?

- Using a three-year measurement period rather than a one-year period increased the number of hospitals reaching the reporting threshold (50 patients) by 13% for hip fracture surgery, 17% for pneumonia, 40% for acute myocardial infarction, 41% for ischaemic stroke, and 167% for haemorrhagic stroke
- Investigations into RSMR sensitivity to poor performance in smaller hospitals found that an RSMR threshold of 1.5 can be used to identify a preponderance of high (but not flagging) RSMRs
- Analyses investigating the impact of including adjustments for socioeconomic status and disease severity found little improvement in the predictive power of the models and few meaningful changes to outlier results.

Actionability and timeliness

The actionability and timeliness of performance measures assess whether results can galvanise and guide performance improvement at a local, regional or system level. Is the information reported in sufficient detail to guide efforts to improve patient care? Are there trade-offs between the timeliness of the data, its reliability and the level of detail available?

- Rolling RSMRs (where measurement periods form a series of overlapping time intervals) are more likely to capture short-term variations in hospital performance compared to discrete measures of the same length. Temporary but marked fluctuations in performance can continue to influence rolling RSMRs for several periods — unlike RSMRs based on discrete periods
- There is a trade-off between the timeliness of reporting on the one hand and the level of detail it is possible to provide on the other. Across the five conditions of interest, between 21% and 50% of deaths occurred after discharge. Using linked patient data captures deaths after discharge. A comparison of unlinked data (which are available after a six-week lag) and linked data (which are available after a seven-month lag) in the construction of funnel plots for ischaemic stroke found that 15 hospitals changed outlier status
- Therefore the use of linked data provided more robust and meaningful RSMRs and incurred only a modest trade-off in terms of timeliness of data
- There is limited benefit however in waiting two and a half years for 'cause of death' data to become available. The majority of deaths are attributed to the condition for which patients were hospitalised. The distribution of cause of death was similar for deaths both in-hospital and after discharge

- Examining hospital RSMRs (observed mortality/expected mortality) over time showed that observed rates varied more than expected rates. Hospital-level variation ranged from –8 to +8 percentage points in the observed rate, and from –2 to +4 percentage points in the expected rate. This suggests the characteristics of patients presenting to each hospital did not change markedly across measurement periods, but that observed mortality was more variable
- Looking across the five conditions of interest, there was generally a good correlation between the RSMR and the observed unadjusted mortality rate.

Implications for future reporting

The utility of the RSMR as a meaningful measure of healthcare performance is well established, both internationally and in a NSW context. The RSMR is based on sophisticated statistical analyses that take account of patient characteristics and hospital case mix.

The results of the analyses in this edition of *Spotlight on Measurement* indicate that for 30-day mortality reporting, a mix of different approaches may be useful. The results support:

- Using the RSMRs as the core measure for making assessments of hospital performance that are fair and reflect differences in the care provided. Such risk-standardised analyses can be time consuming, but are however necessary for summative performance assessment and reporting
- Using unadjusted mortality rates — which can be produced in a more timely way — to provide formative assessments of performance to local providers within the NSW healthcare system.

Introduction and background

Setting the scene

The 2013 Insights Series report

In December 2013, BHI published *30-day mortality following hospitalisation, five clinical conditions, NSW, July 2009 – June 2012* that focused on acute myocardial infarction (AMI), ischaemic stroke, haemorrhagic stroke, pneumonia and hip fracture surgery.

Relative performance on a nominal (named) basis was reported for hospitals that admitted at least 50 patients for each condition of interest over the three-year period July 2009 – June 2012. The number and type* of hospitals reported upon and the distribution of patients is shown in Figure 1.

The principal indicator used in the report, the risk-standardised mortality ratio (RSMR), compares deaths in or out of hospital within 30 days of admission with the ‘expected’ number of deaths. The ‘expected’ number of deaths is generated by a statistical model that takes into account patient characteristics that affect the likelihood of dying following hospitalisation.

RSMRs less than 1.0 indicate lower than expected mortality, and greater than 1.0, higher than expected mortality. Small deviations from 1.0 are not meaningful. Funnel plots are used to determine whether the observed mortality is significantly different from expected, with control limits set at 90% and 95%.

As with any statistic, caution is needed in the interpretation of RSMRs. The measure is not designed to compare hospitals with each other; nor is it a measure of ‘avoidable’ deaths. RSMRs are screening tools that provide an indication of outcomes that differ from what we would expect given a hospital’s case mix, and therefore point to where further assessment may be warranted.

The methods developed for the 2013 BHI report on 30-day mortality formed the foundation for the assessments and sensitivity analyses described in this report.¹⁻³

Figure 1 Number of hospitals and distribution of patients, by peer group, five conditions, July 2009 – June 2012

	Peer group				Private hospitals	Total
	A	BM/BNM	C1/C2	D-F		
Acute myocardial infarction						
Hospitals	15	22	45	78		
Patients	11,823 (40%)	11,212 (38%)	4,604 (16%)	855 (3%)	729 (2%)	29,223
Ischaemic stroke						
Hospitals	15	22	45	52		
Patients	7,141 (50%)	5,026 (35%)	1,527 (11%)	100 (1%)	411 (3%)	14,205
Haemorrhagic stroke						
Hospitals	15	22	43	42		
Patients	2,914 (51%)	1,866 (33%)	663 (12%)	101 (2%)	137 (2%)	5,681
Pneumonia						
Hospitals	17	21	45	95		
Patients	15,628 (35%)	14,026 (32%)	9,797 (22%)	3,048 (7%)	1560 (4%)	44,059
Hip fracture surgery						
Hospitals	14	20	10	0		
Patients	8,144 (51%)	5,769 (36%)	838 (5%)	0	1,085 (7%)	15,836

* For a description of hospital peer groups, see Appendix 1.

Percentages may not sum to 100% due to rounding.

RSMR methods established in 2013

Cohort and outcome definition:

- Patients hospitalised during the measurement period for an acute, emergency admission with a principal diagnosis of the condition of interest
- Patients admitted with a service category of palliative care were excluded from the analysis. Those with a service category of acute care and a palliative care diagnosis code (Z51.5) were included (0.4% of AMI patients; 1.4% ischaemic stroke; 3.2% haemorrhagic stroke; 1.2% pneumonia and 0.5% hip fracture surgery)
- Any 'hospitalisation' that consisted of multiple contiguous acute episodes, including a transfer to another hospital, was combined into a single 'period of care' if the diagnosis did not change
- A transfer or type-change from acute to sub- or non-acute care was considered to be a discharge ending a 'period of care'
- Patients and outcomes were attributed to the first admitting hospital in the period of care²
- For patients who had multiple periods of care for a condition during the study period July 2009 – June 2012 (8% for AMI; 5% for ischaemic stroke; 6% for haemorrhagic stroke; 9% for pneumonia and 3% for hip fracture surgery), only their last period of care was considered in the analysis
- The outcome is death from any cause, in or out of hospital, within 30 days of admission
- If patients were hospitalised near the end of the measurement period, outcomes were captured for a 30-day period, regardless of whether that extended beyond 30 June 2012.

Risk-standardised mortality ratio (RSMR):

- The RSMR is calculated as the ratio of 'observed' deaths to 'expected' deaths
- A random intercept logistic regression model was used to calculate the expected number of deaths

- The model adjusted for patient risk factors and accounted for clustering of patients in hospitals
- Age, sex and comorbidity sets for each condition of interest, defined by the Australian Commission for Safety and Quality in Health Care⁴, were used as a basis for risk adjustment
- A patient's index admission and any admissions in the previous year identified comorbidities
- Only patient characteristics significantly associated with 30-day mortality ($p < 0.05$) were retained in the final model (Figure 2)
- The same risk adjustment variables were used for all time periods but coefficients were recalibrated to calculate the NSW average in each time period
- Outlier hospitals were identified using funnel plot methods, with control limits of 90% and 95% (see Appendix 2)
- Hospitals with < 1.0 expected deaths were excluded from the funnel plots.

Figure 2 Risk adjustment variables, five conditions³

Acute myocardial infarction

Age, STEMI/non-STEMI status, dementia, Alzheimers disease, hypotension, shock, renal failure, heart failure, dysrhythmia, malignancy, hypertension, cerebrovascular disease

Ischaemic stroke

Age, sex, renal failure, heart failure, malignancy

Haemorrhagic stroke

Age, sex, history of haemorrhagic stroke, heart failure, malignancy

Pneumonia

Age, dementia, hypotension, shock, renal failure, other chronic obstructive pulmonary disease, heart failure, dysrhythmia, malignancy, liver disease, hypertension, cerebrovascular disease and Parkinson's disease

Hip fracture surgery

Age, sex, ischaemic heart disease, dysrhythmia, congestive heart failure, acute respiratory tract infection, renal failure, dementia, malignancy

Building on the 2013 Insights Series report

The 2013 report galvanised a range of improvement efforts in the state’s public hospitals.^{5,6} This report looks towards the future, exploring different options for measurement and reporting to support and inform such efforts. It is structured around three sets of criteria used to assess performance measures:

1. **Relevance and validity:** an assessment of the extent to which a measure is useful to local stakeholders. Does it address information needs of clinicians, managers or policymakers? Is it suited for application in a NSW context? Does it make a unique contribution to a broader set of performance measures?
2. **Sensitivity and specificity:** an assessment of the statistical discrimination of a measure. Does it capture meaningful variation across hospitals of different sizes and complexity while minimising ‘noise’, random variation and bias? Is the measure appropriately calibrated for use in NSW, identifying meaningful outliers?
3. **Actionability and timeliness:** an assessment of the extent to which a measure can galvanise and guide performance improvement. Is the information reported in sufficient detail to guide efforts to improve patient care? Are there trade-offs between the timeliness of the data, its reliability and the level of detail available? (Figure 3).

Figure 3 Criteria for developing performance measures for public reporting and their application to mortality

Criteria	Details and application to mortality reporting
Relevance	Mortality is increasingly used internationally to reflect on the performance of hospitals and healthcare systems. Mortality outcomes are sensitive to clinical care and a range of organisational arrangements.
Validity	Methods for measuring mortality should be applicable to and appropriate for data collection, coding conventions, and models of care in a NSW context.
Sensitivity and specificity	Mortality reporting should: <ul style="list-style-type: none"> • Incorporate appropriate risk-adjustment methods • Be specific to real differences in outcomes, rather than random variation • Be sensitive to meaningful differences in outcomes, even in hospitals with smaller volumes of patients.
Actionability	Information released in mortality reporting programs should provide information that can point to variation in care and guide tangible change at the local, regional and system levels.
Timeliness	Mortality reporting programs must strike a balance between the need to produce up-to-date information and: <ul style="list-style-type: none"> • Sufficiently long data collection periods to ensure stability of results for a sizeable proportion of hospitals • The ability to provide sufficiently detailed data on cause of death • Allowing sufficient time between reporting periods for changes in performance to have a discernible effect on outcomes.

Methods for this report

RSMRs were produced for ischaemic stroke for discrete one-, two- and three-year periods and for rolling two- and three-year periods from July 2000 to June 2012 (Figure 4). Variations in RSMRs and the identification of outlier hospitals across a 12-year time period were explored. The analysis was restricted to 48 hospitals that had at least one expected death every year. One expected death is the threshold used by BHI for producing RSMRs. Ratios based on a denominator <1.0 can provide spurious results.

Sensitivity analyses were conducted on the acute myocardial infarction, ischaemic stroke, haemorrhagic stroke, pneumonia and hip fracture surgery cohorts for July 2009 to June 2012 that were used in the 2013 BHI report on 30-day mortality. Risk-adjustment variables from the 2013 report were used (see Figure 2, page 8). The selection of cohorts

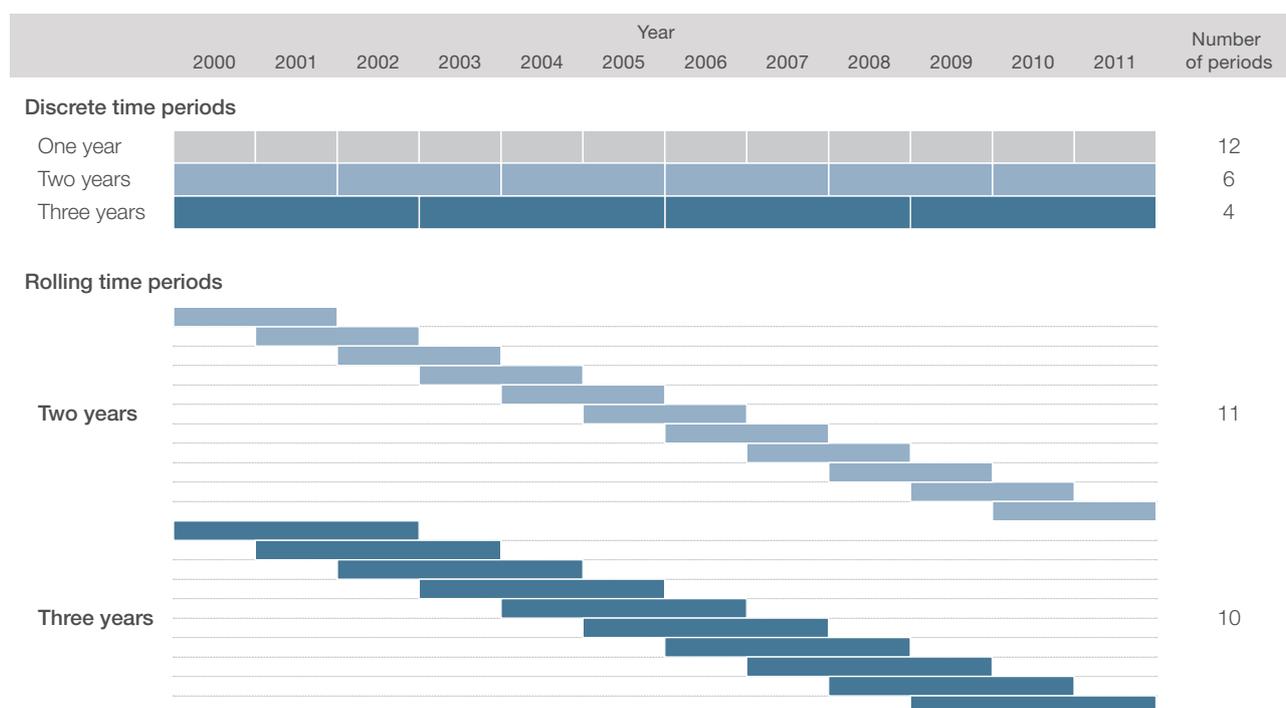
to feature in the figures in this report was based on capacity to illustrate the impact of changes made in the sensitivity analyses.

Data were drawn from the NSW Admitted Patient Data Collection and the NSW Registry of Birth Deaths and Marriages, linked by the Centre for Health Record Linkage (CHeReL) and accessed through Secure Analytics for Population Health Research and Intelligence (SAPHaRI), Centre for Epidemiology and Evidence, NSW Ministry of Health.

Data preparation was conducted and funnel plots were produced in SAS Enterprise Guide 6.1. Modelling was performed in Stata 12.1.

Hospitals are not named in this report but peer groups are noted.

Figure 4 Discrete one-, two- and three-year periods and rolling two- and three-year periods*



* BHI analyses are based on financial years (July – June).

1. Relevance and validity

Why report mortality?

Death is a unique, clearly defined and easily measured event. When expressed in terms of healthcare outcomes, mortality measures resonate with the public, patients, clinicians, managers and policymakers.

While they are regularly used by health agencies internationally to reflect on the performance of hospitals and healthcare systems, there is no consensus on the design of mortality measures. Those in use internationally vary in definition, focus, cohort inclusions, measurement period, reporting frequency, identification of outliers and suppression rules (Figure 5).

Mortality measures are compelling because they can reflect wider system and hospital performance issues.¹³ They are not without controversy however. Hospital-standardised mortality ratios (HSMRs), in particular, have been widely criticised (see box).¹⁴⁻¹⁶

Of course, death is generally regarded to be an adverse outcome. However there are occasions when hospital admission is a response to the terminal phase of advanced and incurable disease. In these cases, death may be inevitable and healthcare providers may, appropriately, not seek to avert it.

The risk of death during or after hospitalisation is related to the nature and severity of a patient's underlying condition, the presence of any comorbidities, and the effectiveness and safety of disease management during and after hospitalisation. Mortality is an outcome that can be influenced by factors outside the control of clinicians and health systems. Hence, the use of mortality data to draw inferences about the relative performance of hospitals requires great care.^{19,20} Measures must make adjustments for patient-level factors and case mix in order to provide fair assessments of hospital performance.

Mortality reporting, done well, can play a key role in evaluating healthcare performance, providing accountability, targeting and guiding improvement efforts, and informing research and knowledge generation.

Despite this potential power, it is important to note that no single indicator is able to fully capture the complexities of performance. Mortality rates, on their own, cannot measure performance or quality of care. They can however target investigations into quality of care and guide efforts to improve.²¹⁻²³

Comparing HSMRs and RSMRs

Hospital-standardised mortality ratios (HSMRs), such as those published by the UK's Dr Foster organisation, are similar to the RSMRs featured in this report in that they assess whether the mortality rate at a particular hospital is higher or lower than expected.

However HSMRs differ from RSMRs in a number of important ways:

1. HSMRs are very broad in scope, including diseases responsible for the top 80% of deaths in hospital. This means that attribution to specific clinical processes is difficult and actionability is often hard to achieve. RSMRs focus on specific conditions, providing more meaningful information for managers and clinicians.
2. HSMRs measure in-hospital mortality only. Recent research has shown the importance of including post-discharge deaths in assessing performance.¹⁴
3. HSMRs are generally based on counts of admissions, meaning that a patient can be counted multiple times. In contrast, RSMRs are based on counts of patients.

There are ongoing concerns about the ability of HSMRs to appropriately risk adjust for factors affecting the likelihood of death given their broad scope.^{15,16} HSMRs have however been successful in galvanising action to improve care in many countries around the world.^{17,18} In a NSW context, where linked data are available, the RSMR offers a more relevant, specific, valid and actionable measure of performance than the HSMR.

Figure 5 Hospital mortality measures in other countries

USA Centers for Medicare & Medicaid Services ⁷	Canadian Institute for Health Information ⁸	England Health & Social Care Information Centre ⁹	England Dr Foster Intelligence ¹⁰	Scotland Information Services Division ¹¹	Statistics Netherlands ¹²
Measure					
Risk-standardised Mortality Rate (RSMR)	Hospital-standardised Mortality Ratio (HSMR)	Summary Hospital-level Mortality Indicator (SHMI)	Hospital-standardised Mortality Ratio (HSMR)	Hospital-standardised Mortality Ratio (HSMR)	Hospital-standardised Mortality Ratio (HSMR), diagnosis-specific Standardised Mortality Ratio (SMR)
Definition					
Deaths within 30 days of admission	Deaths in hospital	Deaths in hospital or within 30 days of discharge	Deaths in hospital	Deaths within 30 days of admission	Deaths in hospital
Focus diagnoses					
Acute myocardial infarction (AMI) Heart failure Pneumonia Chronic obstructive pulmonary disease Ischaemic stroke	Diagnosis groups that account for about 80% of in hospital deaths	All conditions	Diagnosis groups that account for about 80% of in hospital deaths	All conditions	Diagnosis groups that account for about 80% of in hospital deaths
Cohort inclusions					
Age 65+ years enrolled in Medicare. Veterans Affairs beneficiaries also included for AMI, heart failure and pneumonia.	Age 29 days – 120 years	Age 0–120 years	Age 0–120 years	All ages	All ages
Measurement period					
One year and rolling three years	Quarter year and year to date	Rolling 12 months	One year and rolling three years	Quarter year and rolling 12 months	One year and rolling three years
Reporting frequency					
Annually	Quarterly	Quarterly	Annually	Quarterly	Annually
Results					
RSMR with 95% interval estimate	HSMR with 95% confidence interval	Funnel plot with 95% control limits	HSMR with 95% confidence interval, funnel plot with 99.8% control limits	Trend HSMR with regression line	HSMR and SMR with 95% confidence interval, funnel plot with 95% and 99.8% control limits
Suppression rule					
Suppress results for hospitals with fewer than 25 cases	Suppress results for hospitals with fewer than 20 expected deaths				HSMRs and SMRs not calculated for hospitals with fewer than 60 observed deaths in all inpatient admissions

The impact of including or excluding private hospital patients

Analyses in the 2013 BHI report on 30-day mortality included patients admitted to both public and private hospitals. RSMRs were published for public hospitals only as BHI does not have the authority to report private hospital performance.

Collectively, private hospitals had lower than expected mortality for all conditions. This may be a reflection of lower mortality at private hospitals. Alternatively, it may be that the patients at private hospitals were systematically different from patients at public hospitals and the adjustments made by BHI to account for case mix were unable to capture all of these differences.

In producing RSMRs for each condition, BHI adjusts for age, sex and relevant comorbidities. Including private hospital patients had a small impact on the coefficients of the predictive models, producing a dampening effect on each public hospital's expected number of deaths. If the differences in mortality between public and private hospital patients are a reflection of different risk profiles that the modelling is unable to take account of, including private hospital patients in the analyses may unfairly affect the results of public hospitals.

To ensure that fair assessments are made, one option is to exclude private hospital patients from analyses. Sensitivity analyses were conducted to

investigate the impact of excluding private hospital patients from the July 2009 – June 2012 cohorts for all conditions.

Excluding private hospital patients was not expected to change the RSMRs substantially as they comprised only a small proportion of the cohort for each condition (Figure 6). However, even a small change in RSMRs could alter the status of hospitals close to the control limits.

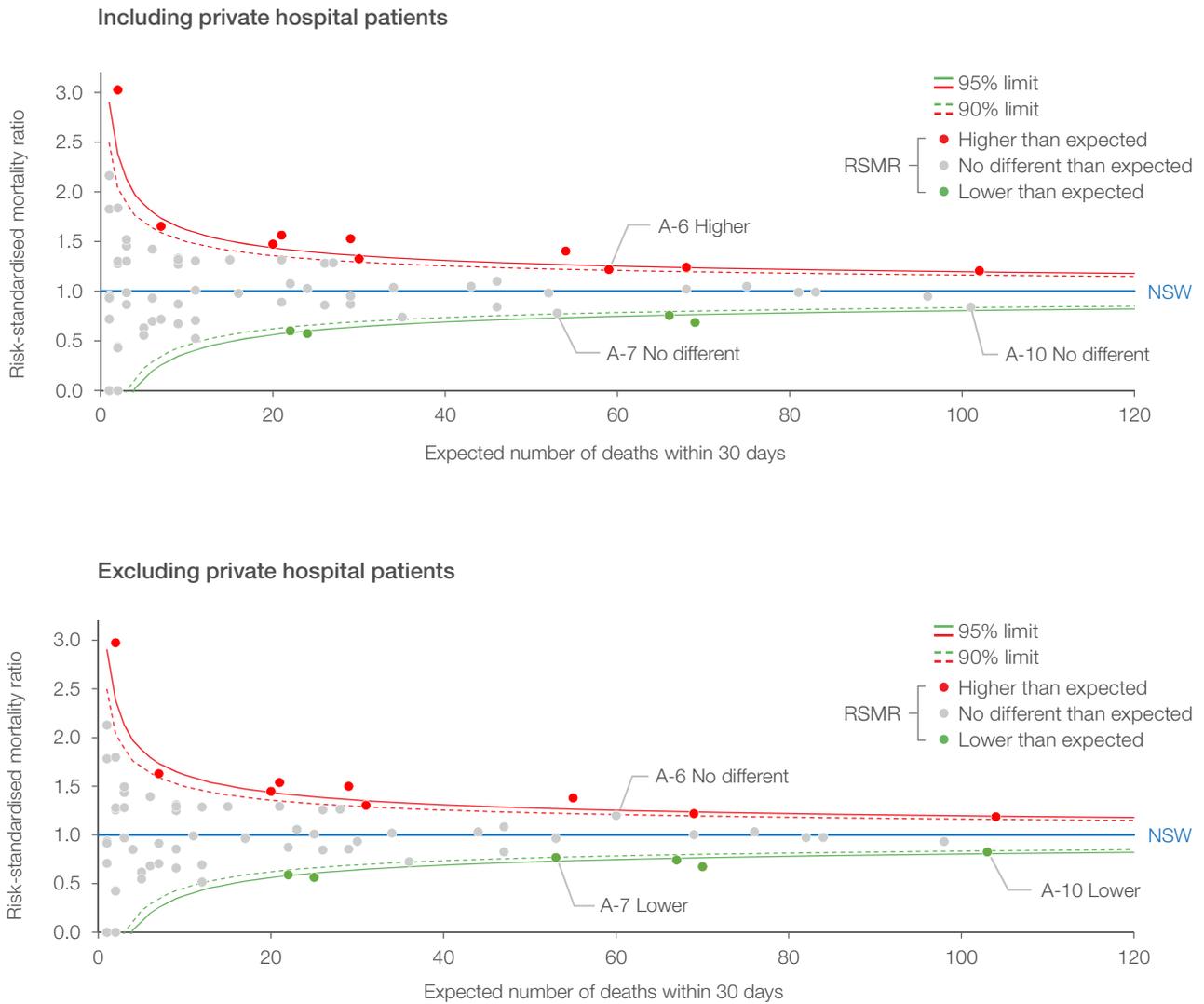
For all five conditions, the variables in the risk adjustment model did not change and the model C-statistics decreased by less than 0.01. Among hospitals with at least one expected death, the RSMRs either did not change (for those hospitals with no observed deaths) or decreased slightly. Across all conditions the maximum decrease in RSMR was 0.05.

There was a change in outlier hospitals for ischaemic stroke and pneumonia. For ischaemic stroke, one hospital was no longer higher than expected and two hospitals became lower than expected (Figure 7). For pneumonia, one hospital became lower than expected. The RSMRs for these hospitals did not change substantially — they were close to the control limits and a small change was sufficient to change their status.

Figure 6 Distribution of patients admitted to public and private hospitals in NSW, July 2009 – July 2012

	Public hospitals	Private hospitals
Acute myocardial infarction	28,494 (98%)	729 (2%)
Ischaemic stroke	13,794 (97%)	411 (3%)
Haemorrhagic stroke	5,544 (98%)	137 (2%)
Pneumonia	42,499 (96%)	1,560 (4%)
Hip fracture surgery	14,751 (93%)	1,085 (7%)

Figure 7 Ischaemic stroke 30-day risk-standardised mortality ratio, NSW public hospitals, July 2009 – June 2012



Coding of transfers between hospitals

Hospital performance measures rely on the quality of the data on which they are based. Linked admitted patient and fact of death data are used by BHI to produce RSMRs. A series of data quality checks are applied to admitted patient data by the data custodian to reduce the risk of anomalies.²⁴ The coding of principal diagnosis in NSW hospitals has been found to be accurate with positive predictive values consistently over 95%.²⁵⁻²⁷ The admitted patient and fact of death data are probabilistically linked by the Centre for Health Record Linkage (CHeReL). The linked data has a false positive rate (incorrect link) and a false negative rate (missed link) of about 5/1000.²⁸

Despite quality checks, inconsistencies in coding occur and this can affect hospitals' results for measures that are based on administrative datasets. One variable in the admitted patient data that may contain anomalies is the mode of separation. Some patients may be incorrectly coded as discharged from hospital when they were in fact transferred to another hospital. This will affect the accuracy of the RSMRs.

In the 2013 BHI report, patients who were transferred between different hospitals during their period of care were attributed to the first hospital to which they were admitted. The reason for this is that the first few hours and days of treatment are crucial to survival, particularly for AMI and stroke. If a patient was transferred but this event was recorded as a discharge, the patient will be incorrectly attributed to the second hospital within a new period of care, and the first hospital will not be included in the analysis.

Figure 8 Patients with same-day discharge and admission, July 2009 – June 2012

Condition	Same-day patients	Total patients	%
Acute myocardial infarction	176	29,223	0.60
Ischaemic stroke	53	14,205	0.37
Haemorrhagic stroke	23	5,681	0.40
Pneumonia	163	44,059	0.37
Hip fracture surgery	<5	15,836	<0.05

Figure 9 Maximum decrease and maximum increase in RSMRs if same-day discharge and admission treated as a transfer, July 2009 – June 2012

Condition	Maximum decrease	Maximum increase
Acute myocardial infarction	-0.222	+0.430
Ischaemic stroke	-0.431	+0.027
Haemorrhagic stroke	-0.120	+0.132
Pneumonia	-0.052	+0.057
Hip fracture surgery	-0.002	+0.015

*RSMRs for hospitals with an expected mortality ≥ 1.0

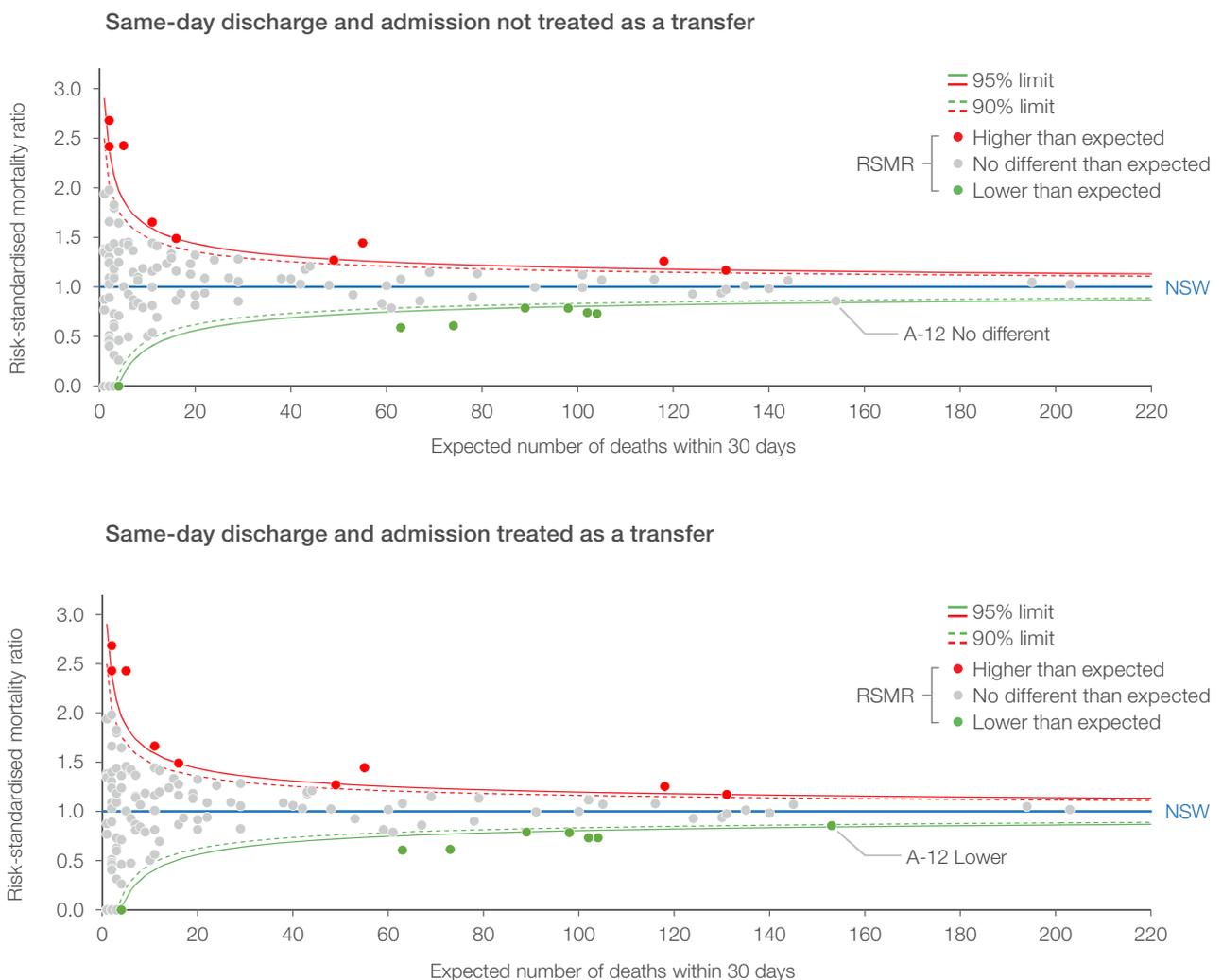
The impact of a potential miscode in the mode of separation was investigated. During the period July 2009 – June 2012 across the five conditions of interest, between 0.05% and 0.60% of the cohorts had a same-day discharge and admission (Figure 8).

Periods of care were reconstructed assuming that patients with same-day discharge and admission had been miscoded and were actually transferred. RSMRs were reproduced and results compared.

The condition most affected was AMI, for which the change in RSMRs ranged from a decrease of 0.222 to an increase of 0.430 (Figure 9).

Outliers were identified for each condition based on the new RSMRs. One hospital became a low mortality outlier for pneumonia (Figure 10). Its RSMR decreased by 0.004 and this was sufficient to change its status. There were no changes to outliers for the other conditions.

Figure 10 Pneumonia 30-day risk-standardised mortality ratio, NSW public hospitals, July 2009 – June 2012



Association between outcome and process measures

Mortality is an important outcome measure — one that gauges the impact or results of healthcare. Outcomes are influenced by issues such as patient risk factors, models of care, and access to different providers of care — meaning that responsibility for performance can be difficult to attribute. Statistical methods such as the RSMR take account of a range of patient-level factors that impact mortality in order to make fair assessments of hospital performance in an effort to ensure that any significant variation measured reflects actual differences in care.

One way to assess whether risk-adjusted outcome measures reflect performance is to compare them with process measures. Process measures focus on the care that was delivered to patients and whether it was in accordance with the evidence base or models of best practice. While 100% concordance is never achieved, establishing an association between outcomes (30-day mortality) and process measures (delivery of evidence-based, high quality care) can support two conclusions. First, it provides validation that the outcome measure is reflecting variation in the quality of care delivered. Second, it means that outlier status can act as a signal to examine those specific processes of care for opportunities to improve.

The Agency for Clinical Innovation (ACI) and its predecessor organisation, the Greater Metropolitan Clinical Taskforce, have since 2002 been engaged in building and strengthening a clinical network for stroke across NSW, seeking to improve processes of care. A key part of the network's activities is the development and application of audit tools to guide quality improvement across the state's public hospitals.

ACI audit tools are evidence-based, and include clinical performance indicators advocated by the National Stroke Foundation.²⁹ A range of stroke care processes are measured, including the proportion of patients admitted to a dedicated stroke unit, the use of timely brain imaging, the provision of appropriate allied health assessments, the recording of neurological observations, and the use of clinical pathways.³⁰

Figure 11 examines patterns of overall performance from recently conducted ACI stroke audits, placing them alongside RSMR results for the period July 2009 – June 2012. The results show some concordance between a hospital's RSMR result and the process measures used in the audit. No hospital with a higher than expected RSMR had strongly favourable relative performance on process measures included in the stroke audit. Conversely, hospitals that performed well in the audit were more likely to record lower than expected RSMRs.

The results suggest that RSMRs have some validity as screening tools to assess performance in stroke care — able to identify where to look for exemplars of excellence as well as where efforts to improve should focus.

Figure 11 Association between RSMR for ischaemic stroke and relative performance in ACI stroke audit

	Hospital 1	Hospital 2	Hospital 3	Hospital 4	Hospital 5	Hospital 6	Hospital 7	Hospital 8	Hospital 9	Hospital 10	Hospital 11	Hospital 12	Hospital 13	Hospital 14
RSMR	●	●	●	●	●	●	●	●	●	●	●	●	●	●
% of patients admitted to a stroke unit/ICU or high-dependency unit			✓	✓		✓			✓					
% of patients with neurological observations recorded in first 24 hours of hospitalisation			✓	✓			✓	✓						
% of patients on stroke clinical pathway during admission	✓	✓	✓						✓					
% of patients receiving swallow test within four hours of admission		✓		✓	✓									
% of patients discharged on an anti-thrombotic (if ischaemic stroke)	✓			✓										
% of patients who received aspirin within 24 hours of admission (if ischaemic stroke)		✓			✓	✓		✓						
% of patients discharged on a statin	✓	✓		✓		✓								
% of patients on prophylaxis for deep vein thrombosis (if immobile)		✓	✓		✓				✓					

- RSMR higher than expected
- RSMR no different than expected
- RSMR lower than expected
- ✓ Favourable performance on audit measure

2. Sensitivity and specificity

Implications of one-, two-, or three-year measurement periods

The length of the measurement period used to produce RSMRs affects the number of hospitals reaching the reporting threshold of 50 patients.

While the modelling approach that underpins the RSMR is applicable to hospitals with a low volume of patients, results for hospitals with very few patients can be disproportionately affected by a small number of deaths. Because of this variability, it is common practice to suppress mortality indicator results for small hospitals. Suppression criteria vary across jurisdictions and agencies. For example, the USA Centers for Medicare & Medicaid Services does not publicly report RSMRs based on fewer than 25 cases;⁷ while the Canadian Institute for Health Information does not publicly report HSMRs based on fewer than 20 expected deaths.⁸

The 2013 BHI report on 30-day mortality included results for NSW public hospitals from peer groups A–C*. However, RSMRs based on fewer than one expected death were excluded from the analysis and RSMRs based on fewer than 50 patients were not publicly reported. This is a conservative approach that sought to avoid unfair judgement of small hospitals where random variation can have a more substantial impact on the value of the RSMR.

For all peer group A–C hospitals to reach the nominal reporting threshold (50 patients), the measurement period would have to be increased beyond three years. However, adopting such a long measurement period has consequences for the interpretation and actionability of results. The RSMRs may be perceived as out-of-date and no longer reflective of current practice, consequently affecting motivation to investigate or change practice in response to the data.

Using a measurement period that is shorter than three years results in a smaller number of hospitals reaching the reporting threshold but the measure is more up-to-date. There is a trade-off between maximising the number of hospitals that can be reported on and providing the most current data that reflects performance.

The analysis summarised in Figure 12 explores the impact of using one-, two- or three-year measurement periods on the number of peer group A–C hospitals reaching the inclusion threshold and the nominal reporting threshold across the five conditions of interest.

Using a three-year measurement period rather than a one-year period increased the number of hospitals reaching the nominal reporting threshold by between 13% (for hip fracture surgery) and 167% (for haemorrhagic stroke). Corresponding increases in the number of reportable hospital results were 40% for acute myocardial infarction, 41% for ischaemic stroke and 17% for pneumonia.

* For a description of hospital peer groups, see Appendix 1

Figure 12 Number of peer group A–C hospitals provided with an RSMR and reaching the nominal reporting threshold with one-, two- and three-year measurement periods, July 2009 – June 2012

			Hospitals (at least one patient with condition of interest)	Hospitals provided with an RSMR (at least one expected death)	Hospitals reaching nominal reporting threshold (at least 50 patients)	
Acute myocardial infarction	One year	2011–12	81	63	47	40% increase
	Two years	2010–12	81	76	56	
	Three years	2009–12	82	77	66	
Ischaemic stroke	One year	2011–12	78	53	34	41% increase
	Two years	2010–12	79	64	39	
	Three years	2009–12	82	71	48	
Haemorrhagic stroke	One year	2011–12	75	59	12	167% increase
	Two years	2010–12	78	70	25	
	Three years	2009–12	80	75	32	
Pneumonia	One year	2011–12	82	78	66	17% increase
	Two years	2010–12	83	79	75	
	Three years	2009–12	83	80	77	
Hip fracture surgery	One year	2011–12	41	37	32	13% increase
	Two years	2010–12	43	38	35	
	Three years	2009–12	44	38	36	

The effect of different measurement periods on outliers

The 2013 BHI report on 30-day mortality used funnel plots with 90% and 95% control limits to determine whether hospital RSMRs were significantly different from expected.

Funnel plots are increasingly used to evaluate hospital performance. Widely considered to provide a fair way to interpret metrics such as RSMRs, funnel plots provide a way to take account of the greater random variability that can affect results in low-volume hospitals.³¹ Smaller hospitals appear to the left of the funnel plot where control limits are wider.

The length of the measurement period used to produce RSMRs affects patient volumes and the confidence that RSMRs are significantly high or low. As the number of years in the measurement period increases, patient volumes and the number of expected deaths increase. These increases mean that within the funnel plot, hospital results shift to the right where estimates are more precise and smaller deviations from the NSW average can be deemed statistically significant.

The impact of different time periods on the funnel plots was investigated with the ischaemic stroke cohort (Figure 13).

Funnel plots were produced for one-, two- and three-year periods (Figure 14). For individual hospitals, as the time period was increased from one to three years, the number of expected deaths (a reflection of patient volumes) increased up to threefold — with resulting shifts to the right within the funnel.

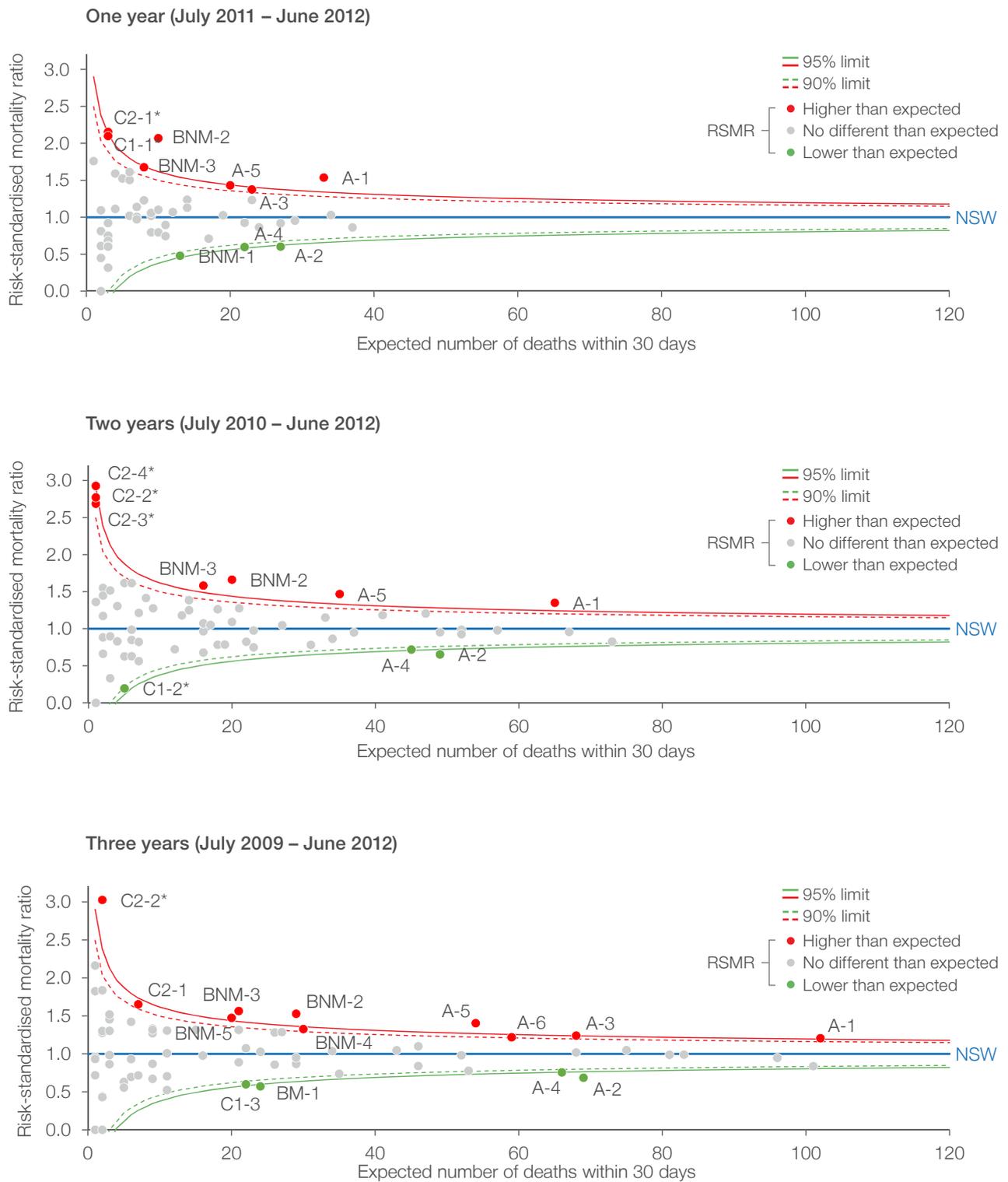
The number of hospitals with significantly higher or lower than expected mortality for ischaemic stroke was compared for discrete one-, two- and three-year periods from July 2000 – June 2012. Hospitals that had at least one expected death every year were included in the analysis. There were 48 hospitals, representing a total of 576 hospital years. The number of hospitals that were high or low in at least one period was greatest for the one-year analysis (28 high and 19 low). However for many hospitals, the outlier status was fleeting — limited to a single time period (Figure 13).

The number of hospital years with high or low mortality was highest for the three-year analysis (84 high and 42 low). Three-year periods capture more systematic variation in mortality outcomes, while one-year periods appear more susceptible to short-term, possibly random, variation.

Figure 13 Ischaemic stroke, higher or lower than expected mortality for discrete one-, two- and three-year periods, July 2000 – June 2012 (48 hospitals with at least one expected death each year)

	Discrete one year	Discrete two years	Discrete three years
Number of hospitals with:			
Higher than expected mortality in at least one period	28	18	16
Lower than expected mortality in at least one period	19	10	8
Number of hospital years with:			
Higher than expected mortality	55	64	84
Lower than expected mortality	29	34	42

Figure 14 Ischaemic stroke 30-day risk-standardised mortality ratio by time period, NSW public hospitals



*Hospitals with fewer than 50 patients. These hospitals would not be publicly reported.

Varying funnel plot control limits

The control limits used in funnel plots to detect outlier hospitals affect the sensitivity and specificity of the measure. The higher the control limit is set, the lower the risk of false positives (flagging a hospital that is not truly different than expected) but the higher the risk of false negatives (failure to flag a hospital that is truly different than expected).

At other agencies, control limits are set at 95% or 99.8%.^{9,10,12} At these levels, there is a small chance (one in 20 and two in 1,000 respectively) that any hospital results outside control limits did not have mortality truly different than expected.

In the development of the 2013 BHI report on 30-day mortality, 99.8% control limits identified few outliers. As the RSMR is designed to be used as a form of screening tool, sensitivity is important. Therefore 90% and 95% control limits were used to reduce the risk of false negatives while not substantially increasing the risk of false positives.

In general, 90% and 95% control limits flagged a greater proportion of large hospitals (peer groups A, BM and BNM) than small hospitals (peer groups C1 and C2).

This may be a reflection of a true difference in performance between small and large hospitals, or a consequence of insufficient precision in RSMRs for small hospitals to allow detection of outliers at 90% and 95% control limits.

To investigate this issue a sensitivity analysis was conducted on the control limits. The number of outliers among small and large hospitals was calculated for 95%, 90% and 80% control limits (Figure 15).

In practice, control limits would not be set at 80% for public reporting because it would greatly compromise specificity and increase the risk of false positives. However, if the proportion of outliers among small hospitals becomes similar to or greater than the proportion among large hospitals, it suggests that additional methods are needed to evaluate performance at small hospitals.

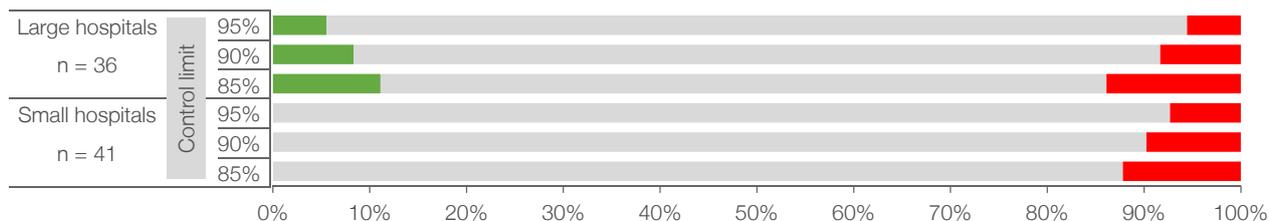
As control limits were lowered, there was a marked increase in the proportion of small hospitals with higher than expected mortality for ischaemic stroke, haemorrhagic stroke and pneumonia (Figure 15).

The effect of lowering control limits on the proportion of hospitals with lower than expected mortality was most discernible among large hospitals, particularly for ischaemic stroke and pneumonia. There was minimal change in the proportion of small hospitals that were low outliers (Figure 15).

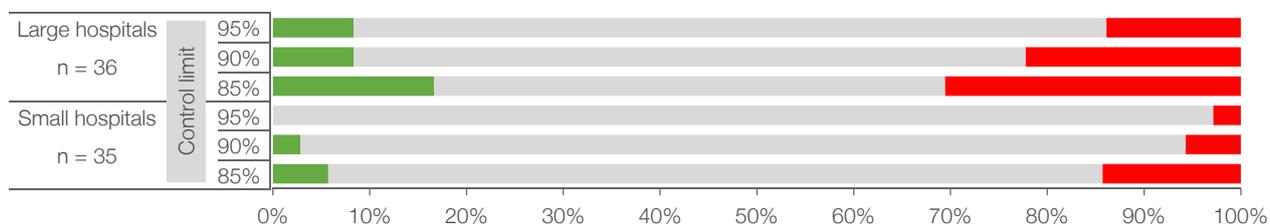
Reducing the control limit did result in an increase in the proportion of high outliers among small hospitals relative to large hospitals for some conditions. This suggests that further analysis, in addition to funnel plots with 90% and 95% control limits, may be required to assess performance in small hospitals.

Figure 15 Higher or lower than expected mortality at 80%, 90% and 95% control limits, by small hospitals (peer groups C1 and C2) and large hospitals (peer groups A, BM and BNM), July 2009 – June 2012

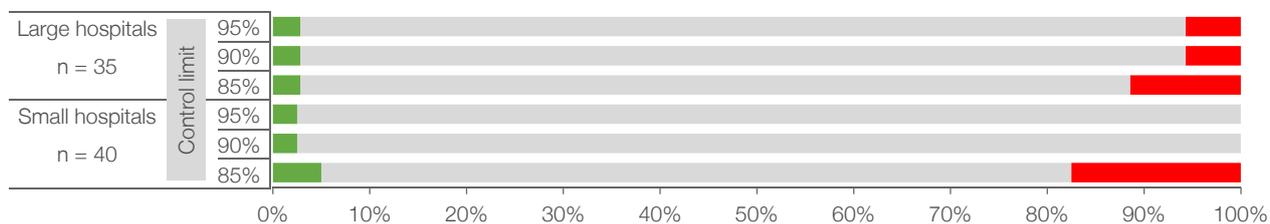
Acute myocardial infarction



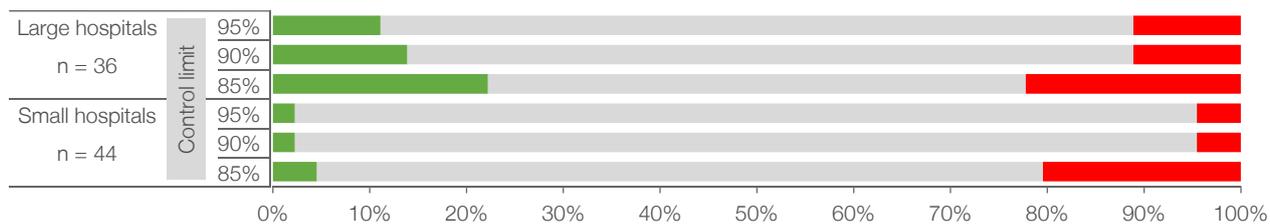
Ischaemic stroke



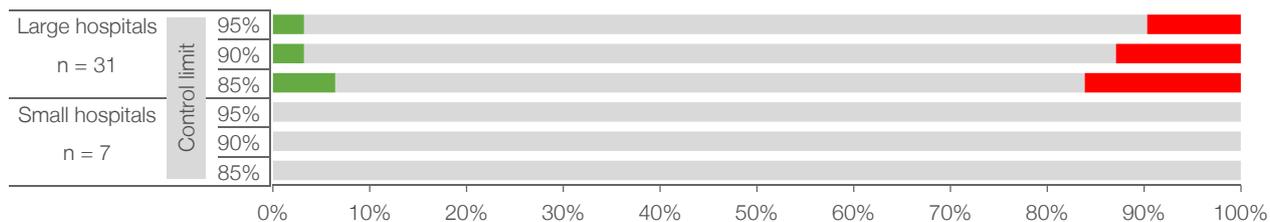
Haemorrhagic stroke



Pneumonia



Hip fracture surgery*



■ Lower than expected ■ No different than expected ■ Higher than expected

*For hip fracture surgery, there are only seven small hospitals with patients compared to 31 large hospitals. The percentage of outliers for small and large hospitals for hip fracture surgery should be interpreted with caution.

Assessing mortality in small hospitals

RSMRs are more variable for smaller hospitals (peer groups C1 and C2) than large hospitals (peer groups A, BM and BNM). Using haemorrhagic stroke to illustrate, the average standard deviation in three-year discrete RSMRs was 0.37 for small hospitals and 0.13 for large hospitals (Figure 16).

Low patient volumes at small hospitals mean that small, possibly random, changes in observed or expected deaths can have a substantial impact on RSMRs. Funnel plots make allowances for random variation that can affect the interpretation of results for small hospitals, making it possible to make fair assessments in any three-year time period.

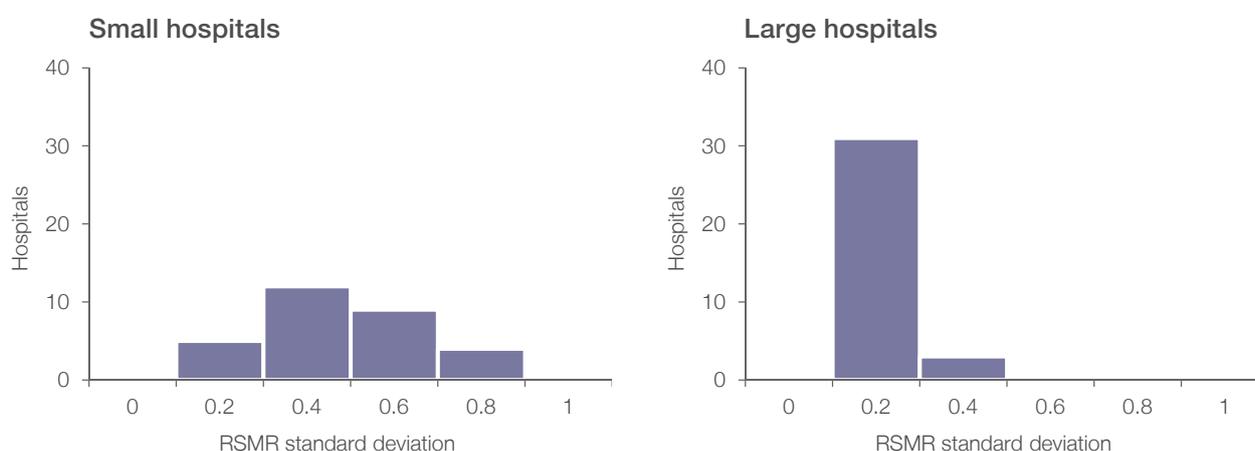
There are concerns that some small hospitals may consistently record high mortality ratios but a low volume of patients in any one period means there is insufficient precision to identify them as outliers. This could be addressed by the use of a longer time period, but with consequences for the timeliness and actionability of results. One option is to flag a hospital that consistently records RSMRs over a pre-defined threshold, even if it fails to reach statistical significance.

This option was explored using discrete three-year haemorrhagic stroke RSMRs for small hospitals for July 2000 – June 2012 (Figure 17). Haemorrhagic stroke was used because of the substantial increase in small hospital outliers at 80% control limits.

Setting the RSMR threshold at 2.0 identified a single hospital, C2-14. In the original analysis, this hospital's result reached statistical significance but the public reporting criterion of at least 50 patients was not met. Lowering the screening threshold, there were 20 RSMR results higher than 1.5, none of which reached statistical significance. No hospital had RSMRs greater than 1.5 for all four time periods. There were however six hospitals with RSMRs that were above 1.5 and not significant in multiple periods. For another eight hospitals, RSMRs fluctuated between above and below average, or they had too few patients in the other time periods to calculate an RSMR.

There are some concerns that small hospitals have reduced capacity to diagnose some conditions and may be disadvantaged in comorbidity risk adjustment. Previous work has shown that there is only a modest trend towards fewer secondary diagnosis codes in smaller hospitals.²

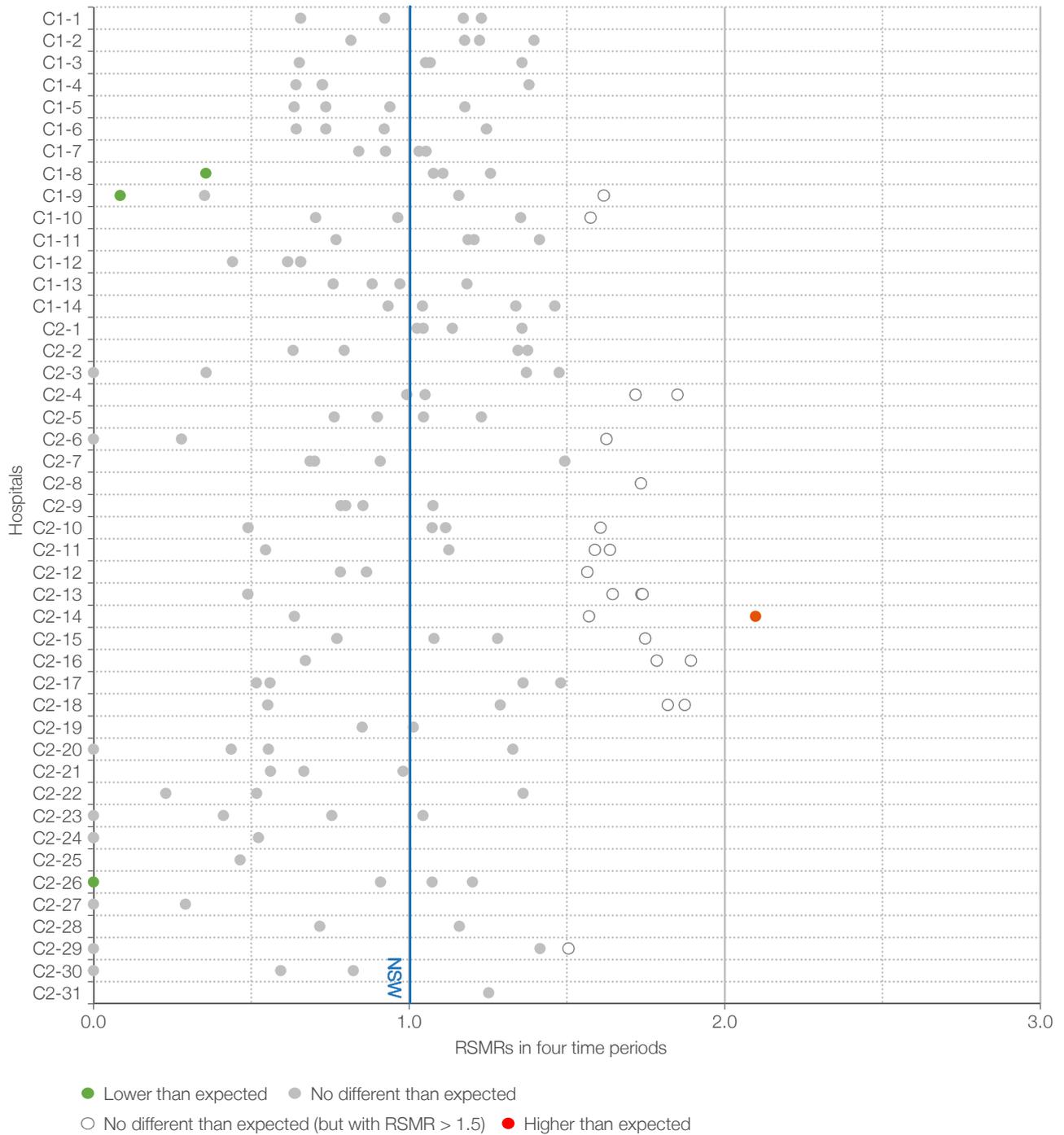
Figure 16 Haemorrhagic stroke standard deviation in discrete three-year RSMRs, by small hospitals (peer groups C1 and C2) and large hospitals (peer groups A, BM and BNM), July 2000 – June 2012



*Hospitals with at least one expected death in every period

*Another option for small hospitals is the use of a Bayesian approach, where known information about other hospitals is used to produce estimates for small hospitals.³² Bayesian analyses were beyond the scope of this report but could be explored in the future

Figure 17 Haemorrhagic stroke discrete three-year RSMRs, small hospitals (peer groups C1 and C2), July 2000 – June 2012



*Data for hospitals with an expected mortality < 1.0 are suppressed.

*Hospitals with RSMR equal to zero had at least one expected death but no observed deaths.

*For Hospital C2-14, the RSMR greater than 2 is statistically significant but would not be publicly reported.

Handling cases with acute myocardial infarction unspecified

An acute myocardial infarction (AMI) can be classified as ST-segment Elevation Myocardial Infarction (STEMI) or non-STEMI based on the electrocardiogram reading. In the July 2009 – June 2012 AMI cohort, most patients were noted in the administrative data as having either a STEMI or a non-STEMI AMI, but about 7% were ‘unspecified’.

Investigation of outcomes in the unspecified group revealed some striking patterns. The 30-day mortality rate for this group was 49 deaths per 100 patients, compared to 10 per 100 patients for STEMI and 6 per 100 patients for non-STEMI patients. Of the patients in the unspecified group who died within 30 days, 57% died on the first day of hospitalisation, compared to 26% for STEMI and 5% for non-STEMI (Figure 18). Overall, the unspecified group accounted for about 32% of AMI deaths. At the hospital level, the proportion of patients classified as AMI unspecified was higher among small hospitals (Figure 19).

These findings suggest that the unspecified group may be a heterogeneous mix of critically unwell patients who died before their AMI could be specified, and patients for whom diagnostic records were less precise.

STEMI status is an important predictor of mortality for AMI patients. A meta-analysis found that STEMI are associated with higher mortality at 30 days compared to non-STEMI (OR = 1.55, 95% CI [1.16 – 2.06]).³³ For peer group A–C hospitals, the

proportion of AMIs that were categorised as STEMI ranged between 4% and 53%. This suggests that risk adjustment should include STEMI status.

However, because the AMI unspecified group comprises a heterogeneous mix of patients, including it in a model that adjusts for STEMI status can have a spurious effect on calculations of expected mortality.

Therefore, in the 2013 BHI report on 30-day mortality, the decision was made to exclude the AMI unspecified group from the analysis. This meant that about a third of AMI deaths and a large proportion of patients at small hospitals were excluded. Therefore some small hospitals may have higher than expected mortality but are not identified because of the AMI unspecified exclusion.

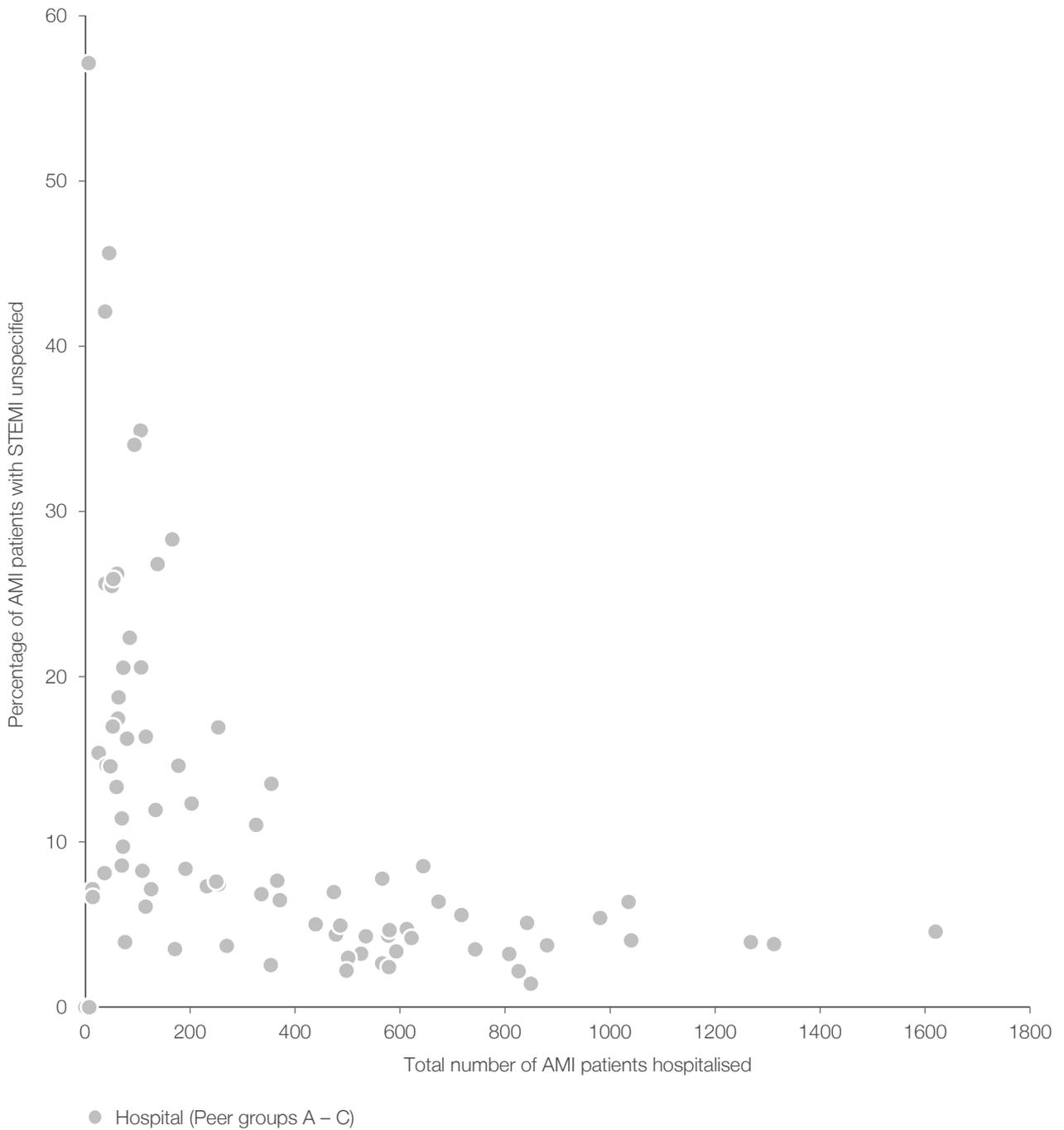
Rather than exclude the entire unspecified group, BHI considered only excluding those patients that died on the first day of hospitalisation. It was thought that this would remove the critically ill patients likely to die, leaving a group that was similar to the combined STEMI and non-STEMI patients. However, the 30-day mortality for this group is still high — 30 deaths per 100 patients, compared to eight for the combined STEMI and non-STEMI group.

The impact of not including STEMI status in the prediction model, and therefore inclusion of the STEMI unspecified group, is investigated on pages 33–34.

Figure 18 Mortality among AMI sub-categories: STEMI, non-STEMI and unspecified, NSW, July 2009 – June 2012

	30-day deaths	Patients	30-day death rate	Percentage of deaths on first day of hospitalisation
STEMI	948	9,257	10%	26%
non-STEMI	1,258	19,966	6%	5%
STEMI unspecified	1,051	2,137	49%	57%

Figure 19 Total number of AMI patients hospitalised and percentage with STEMI unspecified, peer group A–C hospitals, July 2009 – June 2012



Adjusting for severity

Severity of illness on presentation can be considered for inclusion in risk adjustment models. However, robust and sufficiently detailed information on severity is not usually available in hospital administrative datasets. A series of exploratory analyses investigated the effect of disease severity adjustment in the RSMRs.

Acute myocardial infarction

For AMIs, those classified as a ST-segment Elevation Myocardial Infarction or STEMI are associated with higher mortality at 30 days compared to non-STEMIs (OR = 1.55, 95% CI [1.16 – 2.06]).³³ Some AMIs are 'unspecified', that is they are neither classified as STEMI nor non-STEMI. In the July 2009 – June 2012 cohort, about 7% of the cohort were categorised as 'unspecified' AMI (see pages 31–32). The heterogeneity of this group means that the unspecified group cannot be included in a model which adjusts for STEMI status.

In the 2013 BHI report on 30-day mortality, unspecified AMIs were excluded from the analysis (see Figure 20a). However, this decision meant that a large proportion of deaths (32%) and a substantial proportion of patients at small hospitals were not included.

An alternate way to accommodate this issue is to include all patients but not adjust for STEMI status.*

A sensitivity analysis was conducted on the inclusion of STEMI status in the risk adjustment model. RSMRs were produced for the AMI cohort in the 2013 BHI report (i.e. excluding the unspecified group) but this time without STEMI adjustment. The C-statistic decreased but not significantly, from 0.85 to 0.84. There was a change in outliers: one hospital was

no longer high, two hospitals became high and one hospital became low. Nine hospitals remained either high or low. There was no evidence of a systematic effect on RSMRs (Figure 20b). The Spearman rank correlation coefficient for RSMRs with and without STEMI adjustment was 0.96. This means that the hospitals had stable relative positions.

RSMRs were also produced for the full AMI cohort (i.e. including the unspecified group), without STEMI adjustment. The C-statistic was 0.82. There was a substantial change in outliers among small hospitals compared to those reported in the 2013 BHI report, partly because some now had more than one expected death which meant they could be included in the funnel plot. The status of most large hospitals did not change (Figure 20c).

Ischaemic stroke

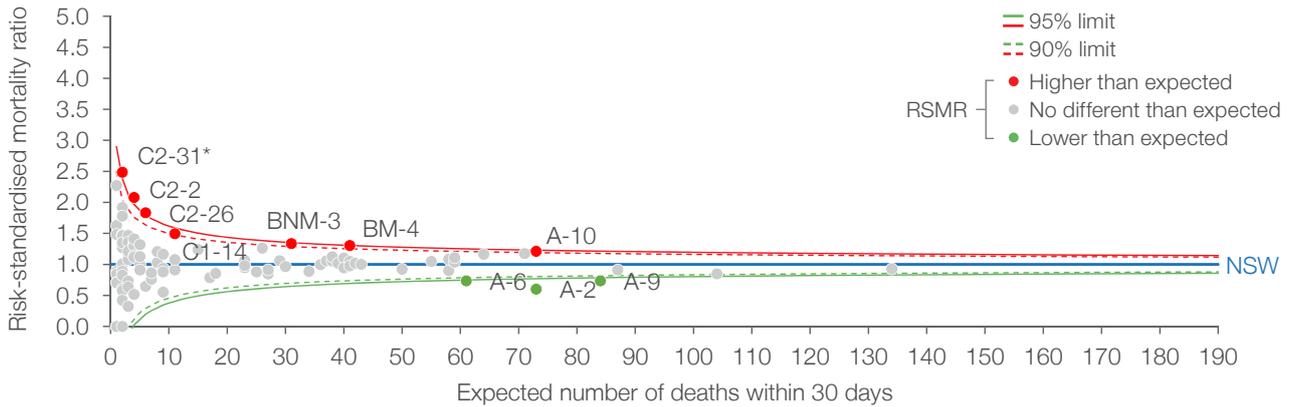
Severity is an important predictor of mortality for ischaemic stroke.³⁴ However there is mixed evidence about the impact of including severity in 30-day mortality models.^{35,36} Stroke RSMRs published in the United States by the Centers for Medicare and Medicaid Services (CMS) do not adjust for severity.⁷

Where available, the National Institutes of Health Stroke Scale (NIHSS) provides a potential risk adjustment, however these data are not available in administrative databases in NSW. Other work in NSW has used Australian Refined Diagnosis Related Group (AR-DRG) codes as a proxy for disease severity in risk adjustment methods.³⁷ However this coding can reflect outcomes (e.g. catastrophic complications, including death) as well as severity of disease on presentation, so is not suitable for use here.

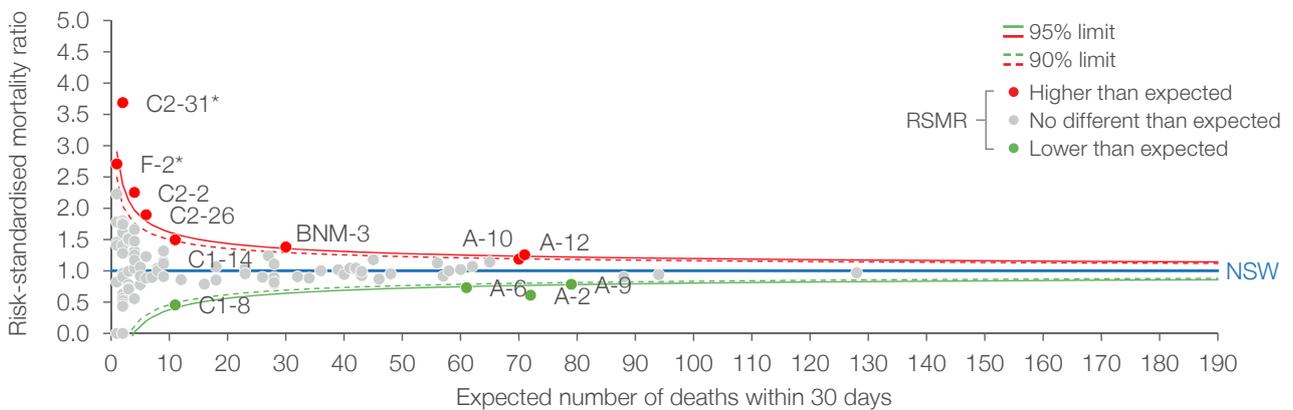
* The Australian Commission on Safety and Quality in Health Care does not include STEMI status in its risk adjustment model for in-hospital AMI mortality.⁴

Figure 20 Acute myocardial infarction (AMI) 30-day risk-standardised mortality ratio, NSW public hospitals, July 2009 - June 2012

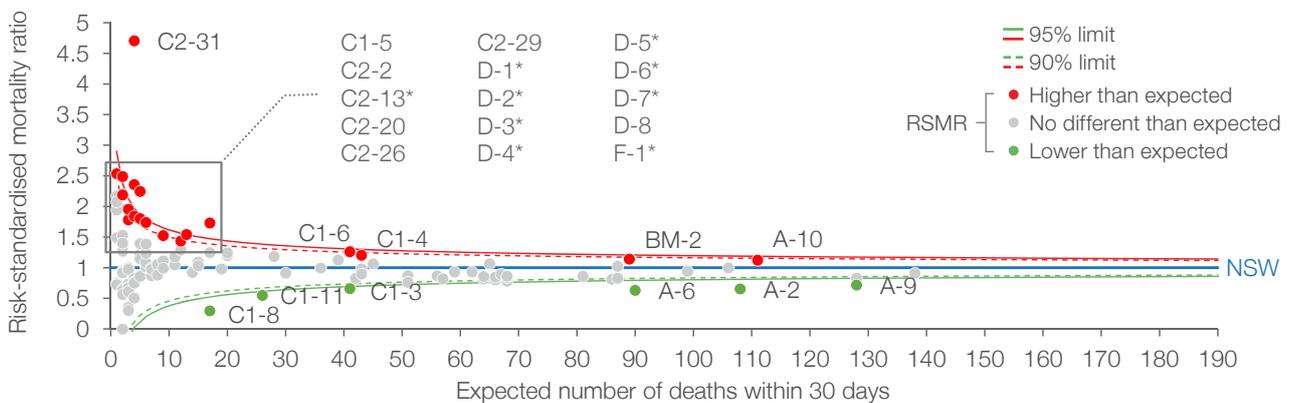
a. AMI unspecified excluded and STEMI adjustment



b. AMI unspecified excluded and no STEMI adjustment



c. AMI unspecified included and no STEMI adjustment



* Hospitals with less than 50 patients. These hospitals would not be publicly reported.

Adjusting for socioeconomic status

The issue of whether to adjust for socioeconomic status (SES) of patients in performance reporting is complex. Decisions about the inclusion of SES variables in statistical models for the assessment of hospital performance go beyond questions of statistical methods. Some argue that risk adjusting for patient SES introduces discrimination in that hospitals with low SES patients would be held to different standards for patient outcomes than hospitals treating higher SES patient populations.³⁸ Others contend that SES is not modifiable by the hospital and holding hospitals accountable, or worse, applying financial penalties, on the basis of unadjusted results is unfair.^{39,40}

In the United States, the Centers for Medicare and Medicaid Services does not adjust for SES when producing RSMRs.⁷ It found that the RSMRs for hospitals serving a high proportion of low SES patients were not consistently higher or lower than the RSMRs for hospitals serving a low proportion of low SES patients.⁴¹ Similarly, in England, the Health and Social Care Information Centre found that

adjusting for SES had little impact on model fit and mortality measures.⁴²

A sensitivity analysis was conducted on the inclusion of SES (based on the patients' postcode of residence) in the risk adjustment models for all five conditions. SES was significantly associated with 30-day mortality for acute myocardial infarction and ischaemic stroke but not for the other three conditions (Figure 21). There were no significant changes in the model C-statistics for any condition.

There was a change in outliers for all conditions (Figure 22). The funnel plots are shown for ischaemic stroke, which had the highest percentage of hospitals change outlier status (Figure 23). However, there was no evidence of a systematic effect on RSMRs. The Spearman rank correlation coefficient was used to assess change in the rank of hospital RSMRs after SES adjustment. It ranged from 0.95 to 0.99 for the five conditions. This means that there was a modest change in the relative position of hospital RSMRs after adjusting for SES.

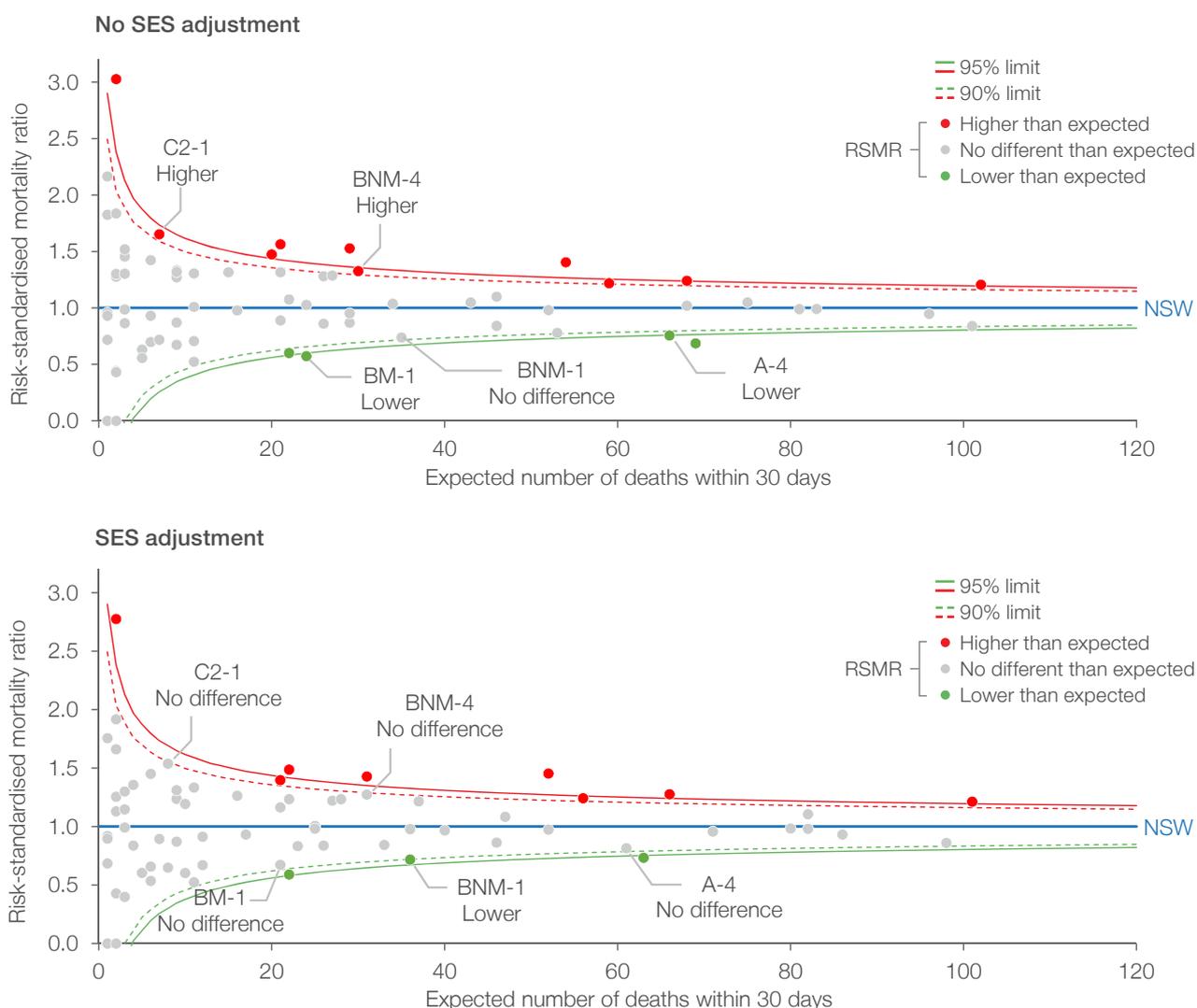
Figure 21 Odds ratio, 95% confidence interval and p-value for socioeconomic status in risk adjustment models, July 2009 – June 2012

	Acute myocardial infarction	Ischaemic stroke	Haemorrhagic stroke	Pneumonia	Hip fracture surgery
1st quintile (most disadvantaged)	1.00	1.00	1.00	1.00	1.00
2nd quintile	1.00 (0.88–1.15)	0.89 (0.77–1.04)	0.99 (0.84–1.17)	0.99 (0.90–1.09)	1.01 (0.84–1.21)
3rd quintile	0.90 (0.78–1.05)	0.87 (0.74–1.03)	1.02 (0.84–1.23)	1.01 (0.91–1.13)	0.87 (0.71–1.06)
4th quintile	0.84 (0.70–1.01)	0.76 (0.63–0.92)	1.18 (0.95–1.46)	0.99 (0.87–1.13)	0.78 (0.61–1.00)
5th quintile (least disadvantaged)	0.73 (0.61–0.87)	0.69 (0.57–0.83)	1.02 (0.82–1.25)	0.86 (0.75–0.98)	0.79 (0.64–0.99)
p-value	0.004	0.003	0.544	0.095	0.087

Figure 22 Effect on outliers when socioeconomic status is in the models, July 2009 – June 2012

Condition	Change in hospital outliers after adjusting for socioeconomic status
Acute myocardial infarction	One hospital is no longer higher than expected, two hospitals are no longer lower than expected
Ischaemic stroke	Two hospitals are no longer higher than expected, two hospitals are no longer lower than expected, one hospital is now lower than expected
Haemorrhagic stroke	One hospital is now lower than expected
Pneumonia	Three hospitals are now higher than expected, two hospitals are now lower than expected
Hip fracture surgery	One hospital is no longer higher than expected

Figure 23 Ischaemic stroke 30-day risk-standardised mortality ratio, NSW public hospitals, July 2009 – June 2012



Exploring partner hospital performance

The NSW healthcare system is becoming increasingly integrated with multiple inter-hospital partnerships, or operational arrangements where different sites specialise in particular aspects of care.[†] This raises questions of attribution — if hospitals are working in partnership, what impact does that have on their individual and combined results?

This analysis illustrates the potential scope for reporting on partner hospitals. The RSMR method is well-suited to the exploration of permutations in organisational arrangements. Calculating a patient-level risk of mortality means that allocating patients to a cluster of hospitals is relatively straightforward.

There are two hospitals in metropolitan Sydney, a peer group BM and a peer group C1 hospital, that operate under one administration and share clinical services across both sites.

In the 2013 BHI report on 30-day mortality, the hospitals were analysed separately. Hospital BM-2 had patients for all five conditions. It had higher than expected mortality for pneumonia and mortality no different than expected for the other four conditions. Hospital C1-7 had patients for all conditions except hip fracture surgery and mortality was no different than expected across those four conditions.

Figure 24 Distribution of patients for Hospital BM-2 and Hospital C1-7, July 2009 – July 2012

Condition	BM-2	C1-7
Acute myocardial infarction	630 (64%)	347 (36%)
Ischaemic stroke	419 (91%)	40 (9%)
Haemorrhagic stroke	130 (79%)	35 (21%)
Pneumonia	962 (66%)	486 (34%)
Hip fracture surgery	321 (100%)	0 (0%)

[†] The number of hospitals working in partnership and the nature of that partnership varies across the conditions of interest

A sensitivity analysis was conducted on the impact of treating BM-2 and C1-7 as a single unit. The majority of patients were admitted to BM-2 (Figure 24). The new RSMRs are essentially a weighted average of the RSMRs for the individual hospitals, with BM-2 carrying more weight (Figure 25). BM-2 had higher than expected mortality for pneumonia and, when combined with C1-7, mortality was still higher than expected. Both hospitals had expected mortality for the other conditions and when combined, mortality was still as expected.

This analysis provides a first step in investigating the impact on hospital partnerships on performance reporting. More detailed sensitivity testing would however be necessary to gauge the effects on reporting performance.

The development of meaningful and actionable reporting units will however be dependent upon accurate and current recording of relevant partnerships across the state.

Figure 25 RSMRs and outlier status for Hospital BM-2 and Hospital C1-7, separate and combined, July 2009 – July 2012

Condition	BM-2	C1-7	Combined
Acute myocardial infarction	1.11	1.07	1.10
Ischaemic stroke	0.98	0.63	0.95
Haemorrhagic stroke	0.99	1.05	1.00
Pneumonia	1.26*	1.09	1.22*
Hip fracture surgery	1.06	NA	1.06

* Higher than expected mortality

3. Actionability and timeliness

Using rolling time periods

Some agencies report rolling RSMRs, whereby measurement periods are not discrete but a series of overlapping periods (see page 10, Figure 4). Rolling RSMRs can be used to increase statistical power and reduce random variation relative to shorter periods while still allowing for frequent reporting. Rolling RSMRs are also more sensitive to short-term variations in hospital performance than discrete measures of the same length. However, unlike discrete measures, temporary but marked fluctuations in performance will continue to influence rolling RSMRs for several periods.

The standard deviations of RSMRs for discrete one-year and rolling two- and three-year periods from July 2000 – June 2012 were compared using the ischaemic stroke dataset. The analysis was restricted to the 48 hospitals with at least one expected death each year. Average standard deviations were 0.44 for one-year periods, 0.30 for rolling two-year periods and 0.23 for rolling three-year periods — a twofold difference in variability.

The number of outlier hospitals for rolling two- and three-year periods was compared to the number of outliers for discrete one-, two- and three-year periods (Figure 26). The analysis was again based

on the 48 hospitals with at least one expected death each year, representing 576 hospital years. There were slightly more hospitals with higher or lower than expected mortality in at least one period when discrete one-year periods are compared to rolling two and three years. However, on average, hospitals were higher or lower for longer periods of time for rolling two and three years compared to discrete one year.

There were more hospitals that were outliers in at least one period for rolling three years compared to discrete three years. For discrete periods, a slightly different set of hospitals may be identified as high or low, depending on the starting point.

One-year and rolling three-year ischaemic stroke RSMRs are plotted for a sample of hospitals from peer groups A–C. The rolling three-year RSMRs stabilise one-year RSMRs but still flag hospitals that are consistently high or low on the one-year RSMR (Figure 27).

For example, Hospital A-3 had one year with a significantly high RSMR flanked by years with high, but not significantly high, RSMRs. The rolling three-year RSMRs were significantly high. There were

Figure 26 Ischaemic stroke, higher or lower than expected mortality for different time periods, July 2000 – June 2012 (48 hospitals with at least one expected death each year)

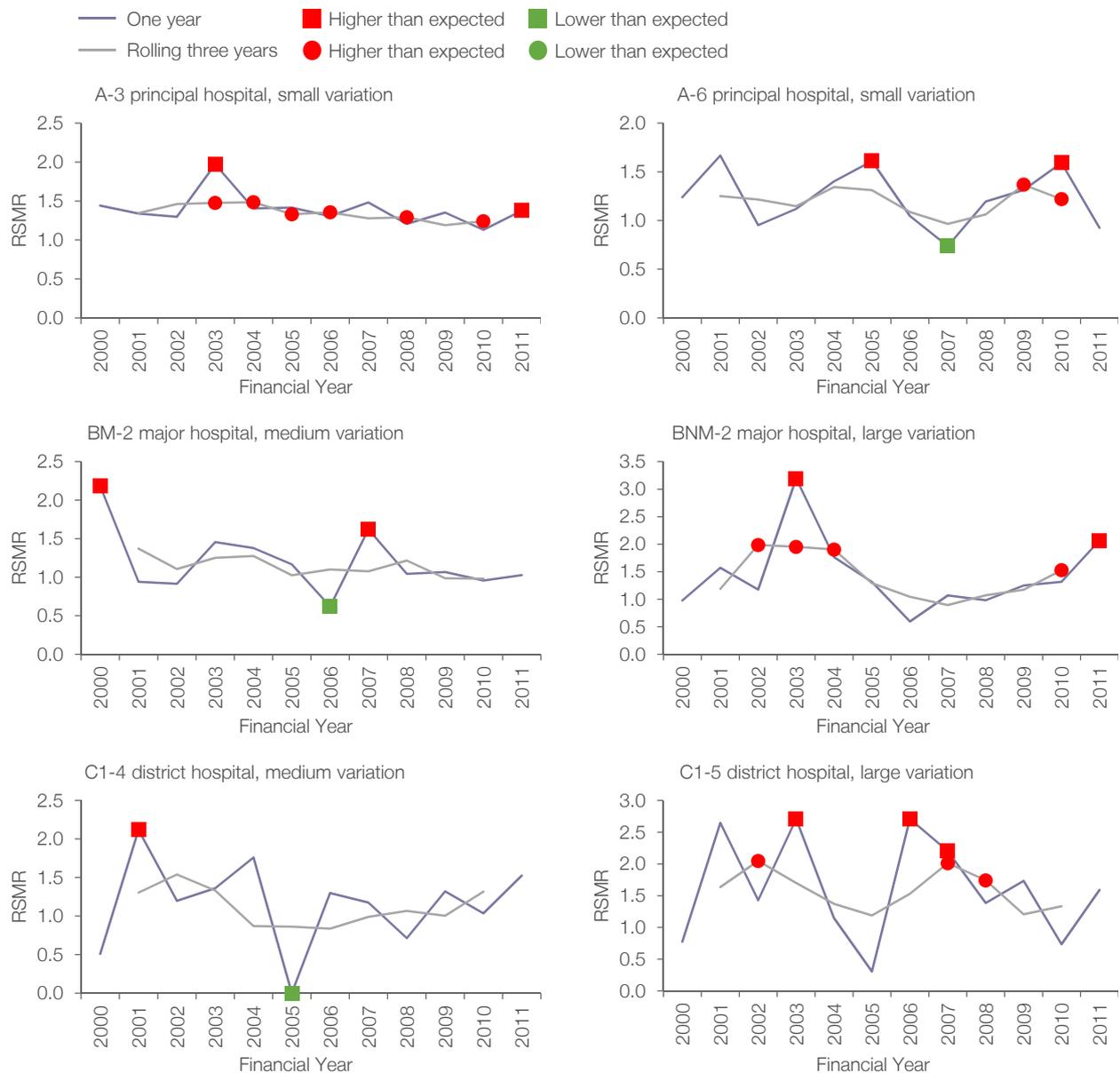
		Discrete one year	Discrete two years	Discrete three years	Rolling two years	Rolling three years
Number of hospitals with:	Higher than expected mortality in at least one period	28	18	16	23	24
	Lower than expected mortality in at least one period	19	10	8	15	15
Number of hospital years with:	Higher than expected mortality	55	64	84	98	114
	Lower than expected mortality	29	34	42	52	51

times when the one-year RSMR was higher than the rolling three-year RSMR but the three-year result reached statistical significance while the one-year result did not. There is more certainty in the three-year RSMRs because they are based on a larger sample of patients.

Hospital BM-2 also had significantly high one-year RSMRs but surrounding years were low and none of the rolling three-year RSMRs were outliers.

Hospital BNM-2 had one year with a significantly high RSMR and this result affected the rolling RSMR three times.

Figure 27 Ischaemic stroke RSMRs for discrete one year and rolling three years, July 2000 – June 2012*



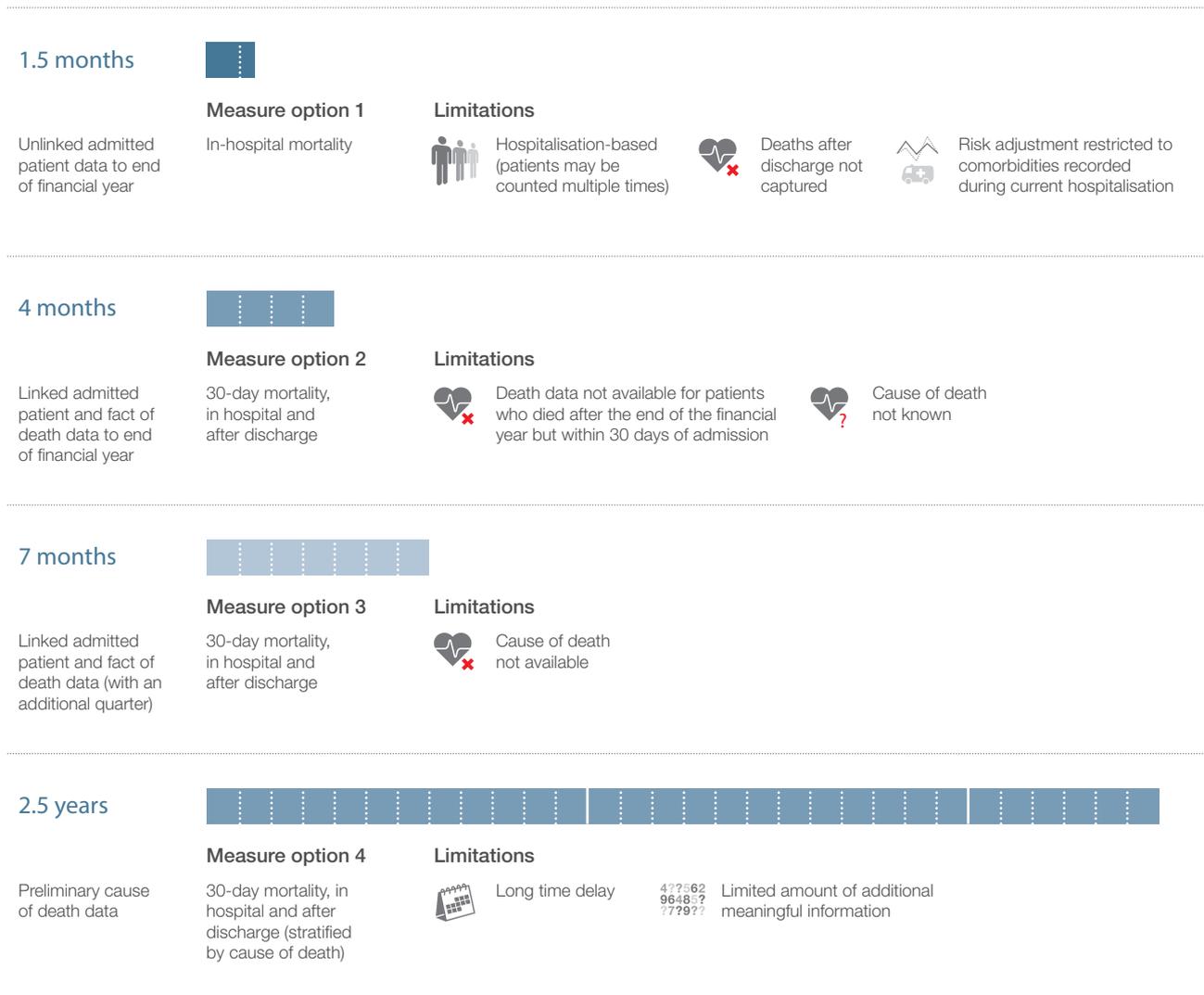
* Note different y-axis scales

Using linked or unlinked data

There is a trade-off between the timeliness of reporting on the one hand and the detail of information that can be provided, and hence the accuracy of the RSMR, on the other. Decisions about how to balance timeliness and completeness are informed by lag times for different levels of detail in patient data. Figure 28 provides a timeline illustrating when admitted patient and death data are available, the measure that can be calculated at each point given the data availability, and key limitations of each measure.

The most timely option uses unlinked admitted patient data. These data are available six weeks after patient discharge, however estimates are based on counts of single 'episodes' or hospitalisations, so patients may be counted multiple times. Deaths after discharge are not captured and only comorbidities recorded during the hospitalisation can be included in risk adjustment. Deaths after transfer are attributed to the hospital in which the patient died, not the first admitting hospital.

Figure 28 Timeline comparing options for data availability and timeliness

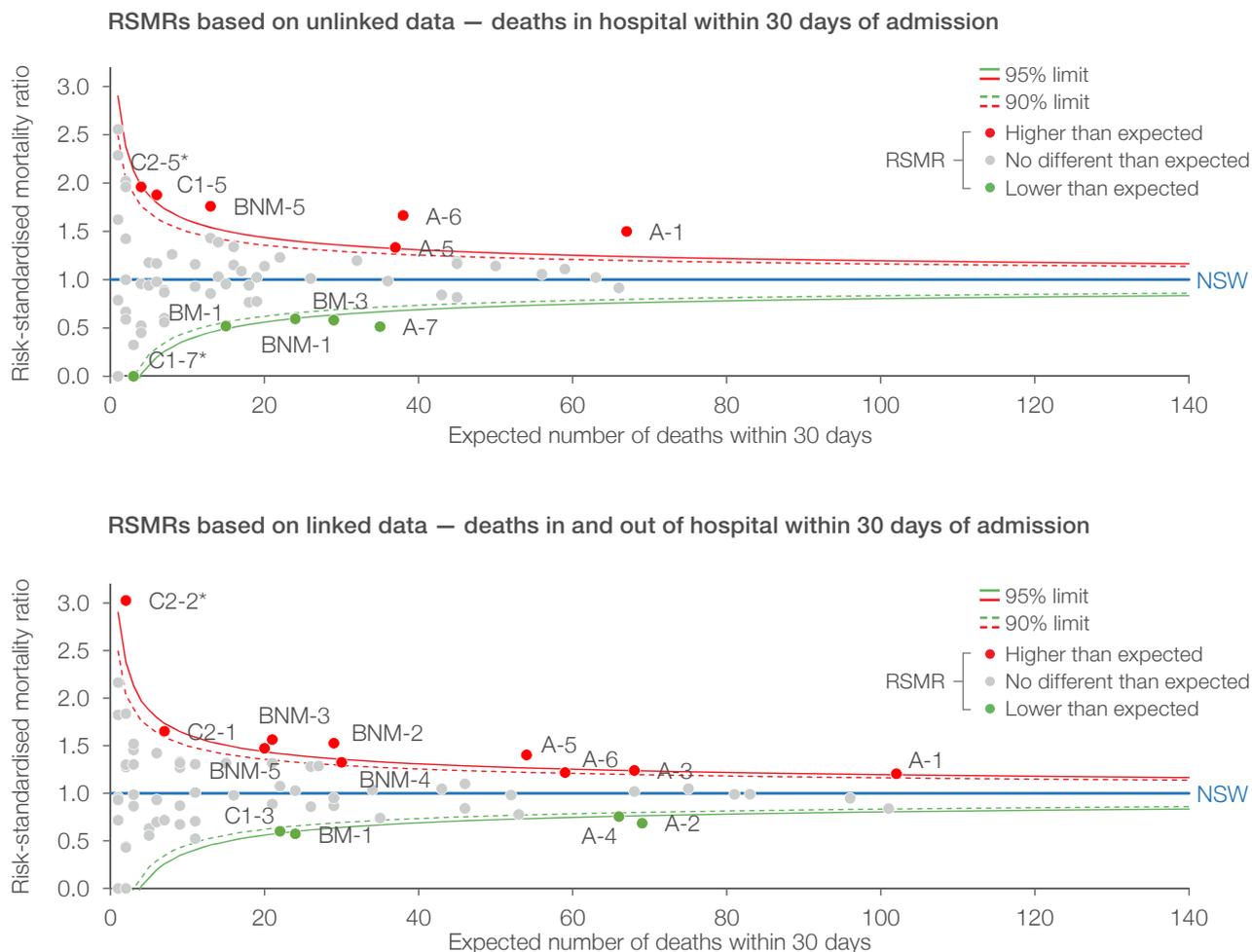


The inability to capture deaths after discharge but within the 30 days following admission is the most compelling shortcoming. Across the five conditions of interest, between 21% and 50% of deaths occurred after discharge (see page 45). Further, the proportion of deaths that occurred after discharge varied across the state's hospitals. Among hospitals with at least 10 deaths within 30 days between July 2009 and June 2012, the percentage ranged between 18%–73% for acute myocardial infarction, 9%–64% for ischaemic stroke, 0%–67% for haemorrhagic stroke, 0%–93% for pneumonia and 24%–83% for hip fracture surgery. This means that

limiting analyses to unlinked data and in-hospital deaths only provides an unbalanced view of performance.

To examine the impact of reporting in-hospital deaths only in the calculation of RSMRs, comparative funnel plots were produced for ischaemic stroke for the period July 2009 – June 2012 using both unlinked and linked data (Figure 29). Out of 71 hospitals, five were outliers with both unlinked and linked data, six were outliers based on unlinked data but not on linked data, and nine were outliers based on linked data but not on unlinked data.

Figure 29 Ischaemic stroke 30-day risk-standardised mortality ratio, NSW public hospitals, July 2009 – June 2012



*Hospitals with less than 50 patients. These hospitals would not be publicly reported.

Relying on ‘fact of death’ or ‘cause of death’ information

The 2013 BHI report defined deaths from any cause within 30 days of admission as the primary outcome. These pages explore the value of using cause of death data to provide additional information on RSMRs.

Preliminary cause of death data are available approximately two and a half years after the end of a financial year. This means that using cause of death information has considerable consequences for the timeliness of reporting. The accuracy of the information has also been called into question.⁴³

An alternative approach to waiting for cause of death data to become available is to restrict analyses to in-hospital mortality, on the assumption that deaths in hospital are more likely to be related to the condition of interest than deaths after discharge. However, if this option were adopted, between a fifth and half of all deaths would be excluded from the analysis, and the predictive power of the model would decrease (Figure 30). Furthermore, the proportion of deaths that occur after discharge varies substantially by hospital. A hospital that discharges patients prematurely may appear to perform better if deaths outside hospital are excluded.

To examine the extra insight generated from using cause of death data, cohorts from the 2013 BHI report were re-analysed using cause of death data.

The underlying cause of death is defined as “the disease or injury which initiated the train of morbid events leading directly to death”⁴⁴. The percentage of patients whose death was attributed to the same ICD-10 chapter for both principal diagnosis and underlying cause of death was only slightly higher among patients who died in hospital than among patients who died after discharge. Across the five conditions, the difference ranged from 9 to 15 percentage points (Figure 30). The leading underlying causes of death in hospital and after discharge for all conditions, July 2009 – June 2012, are shown in Figure 31.

Further analysis on the ischaemic stroke cohort showed that the distribution in cause of death for patients who died in hospital and after discharge was similar when stratified according to days post admission (Figure 32).

These results suggest that the 30-day window reduced the likelihood of including unrelated deaths. Fact of death data appear to be sufficiently specific for use in RSMR measures of hospital performance.

Figure 30 Number of deaths within 30 days and percentage of deaths with the same ICD10 chapter for principal diagnosis and underlying cause of death, July 2009 – June 2012

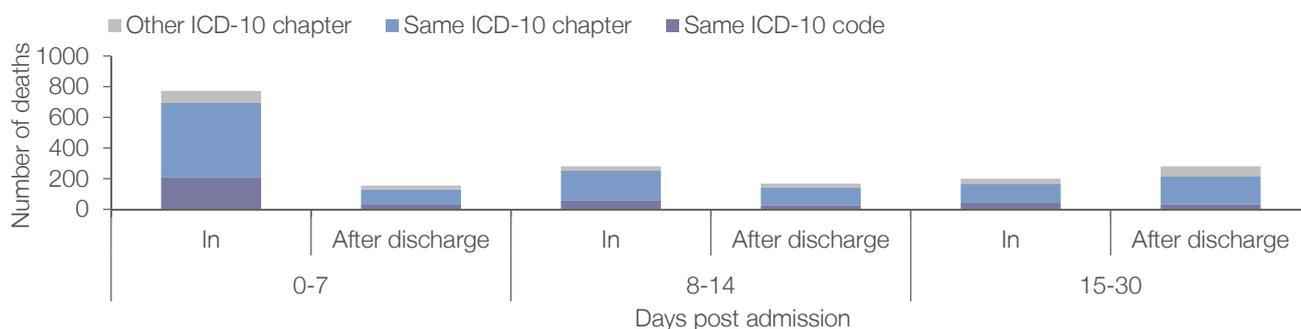
Condition	Deaths within 30 days		Underlying cause of death same ICD10 chapter (%)	
	In hospital	After discharge	In hospital	After discharge
Acute myocardial infarction	1,530	676	81%	68%
Ischaemic stroke	1,307	589	89%	80%
Haemorrhagic stroke	1,513	410	82%	73%
Pneumonia	3,275	1,468	35%	20%
Hip fracture surgery	545	541	34%	22%

Figure 31 Underlying cause of death (ICD-10 block) in hospital and after discharge, July 2009 – June 2012

	Leading cause of death in hospital	%	Leading cause of death out of hospital	%
Acute myocardial infarction	I20-I25 Ischaemic heart diseases	74%	I20-I25 Ischaemic heart diseases	54%
	I30-I52 Other forms of heart disease	4%	C00-C97 Malignant neoplasms	9%
	E10-E14 Diabetes mellitus	3%	I30-I52 Other forms of heart disease	7%
	C00-C97 Malignant neoplasms	3%	I60-I69 Cerebrovascular diseases	6%
	N17-N19 Renal failure	2%	E10-E14 Diabetes mellitus	5%
	Subtotal	86%	Subtotal	80%
Ischaemic stroke	I60-I69 Cerebrovascular diseases	66%	I60-I69 Cerebrovascular diseases	60%
	I30-I52 Other forms of heart disease	13%	I30-I52 Other forms of heart disease	10%
	I20-I25 Ischaemic heart diseases	8%	I20-I25 Ischaemic heart diseases	8%
	C00-C97 Malignant neoplasms	2%	C00-C97 Malignant neoplasms	6%
	E10-E14 Diabetes mellitus	2%	E10-E14 Diabetes mellitus	5%
	Subtotal	91%	Subtotal	90%
Haemorrhagic stroke	I60-I69 Cerebrovascular diseases	75%	I60-I69 Cerebrovascular diseases	64%
	C00-C97 Malignant neoplasms	6%	C00-C97 Malignant neoplasms	10%
	V01-X59 Accidents*	4%	V01-X59 Accidents*	7%
	I30-I52 Other forms of heart disease	3%	I30-I52 Other forms of heart disease	4%
	I20-I25 Ischaemic heart diseases	3%	I20-I25 Ischaemic heart diseases	3%
	Subtotal	91%	Subtotal	89%
Pneumonia	C00-C97 Malignant neoplasms	19%	C00-C97 Malignant neoplasms	31%
	J09-J18 Influenza and pneumonia	18%	I20-I25 Ischaemic heart diseases	9%
	J40-J47 Chronic lower respiratory diseases	11%	F00-F09 Organic mental disorders	9%
	I30-I52 Other forms of heart disease	8%	J40-J47 Chronic lower respiratory diseases	8%
	I20-I25 Ischaemic heart diseases	7%	J09-J18 Influenza and pneumonia	7%
	Subtotal	63%	Subtotal	63%
Hip fracture surgery	V01-X59 Accidents*	32%	V01-X59 Accidents*	21%
	I20-I25 Ischaemic heart diseases	18%	I20-I25 Ischaemic heart diseases	17%
	I30-I52 Other forms of heart disease	7%	F00-F09 Organic mental disorders	10%
	J60-J70 Lung diseases due to external agents	5%	I60-I69 Cerebrovascular diseases	9%
	J40-J47 Chronic lower respiratory diseases	5%	C00-C97 Malignant neoplasms	7%
	Subtotal	67%	Subtotal	64%

*Nearly all haemorrhagic stroke patients and hip fracture patients with accident as cause of death were further classified as fall or exposure to unspecified factor (95% haemorrhagic stroke, 99% hip fracture). ** Deaths within 30 days of admission. Percentages may not add up to subtotal due to rounding.

Figure 32 Ischaemic stroke, cause of death in hospital and after discharge, days post admission, July 2009 – June 2012



Comparing RSMRs and unadjusted mortality rates

There are clear advantages in terms of precision and increased statistical power when analyses are based on three-year reporting periods. However there is a balance to be struck in terms of the frequency of public reports: too infrequent reporting risks not being reflective of current performance; too frequent reporting risks overwhelming the system and not allowing sufficient time between reporting periods for changes to be enacted and for improvements to be discernible.

Although the RSMR is the preferred option for measuring and assessing 30-day mortality following hospitalisation, the analyses on this page considered whether it would be reasonable and informative to supplement RSMRs with more regular calculations of unadjusted observed mortality rates.

Over time, hospitals' observed rates tended to fluctuate more than the expected rates. For ischaemic stroke, the change in the observed rate and expected rate from one rolling three-year period

to the next between July 2000 and June 2012 was calculated. The analysis was restricted to the 48 hospitals with at least one expected death every year. The distributions of changes in the observed rate and expected rate show that the observed rate is more variable — with changes ranging from -8 to +8 percentage points — than the expected rate, with changes ranging from -2 to +4 percentage points. This suggests that the characteristics of patients presenting to each hospital did not vary markedly across measurement periods while observed mortality varied more over time (Figure 33).

Hospitals with higher observed rates tend to have higher RSMRs. Looking across the five conditions of interest, there was generally a good correlation between the RSMR and the observed unadjusted mortality rate. The Pearson correlation coefficient ranged from moderate (0.64) for acute myocardial infarction to strong (0.95) for haemorrhagic stroke (Figure 34). In contrast, there was no evidence of a relationship between expected rates and RSMRs.

Figure 33 Ischaemic stroke, distribution of percentage point change in observed rates and expected rates over rolling three-year periods, July 2000 – June 2012 (48 hospitals with at least one expected death each year)

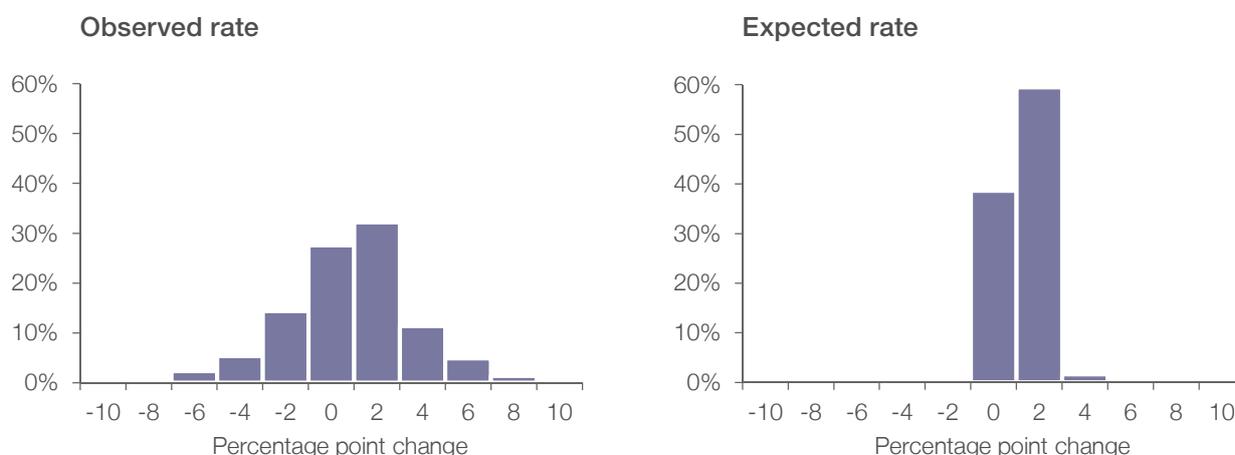
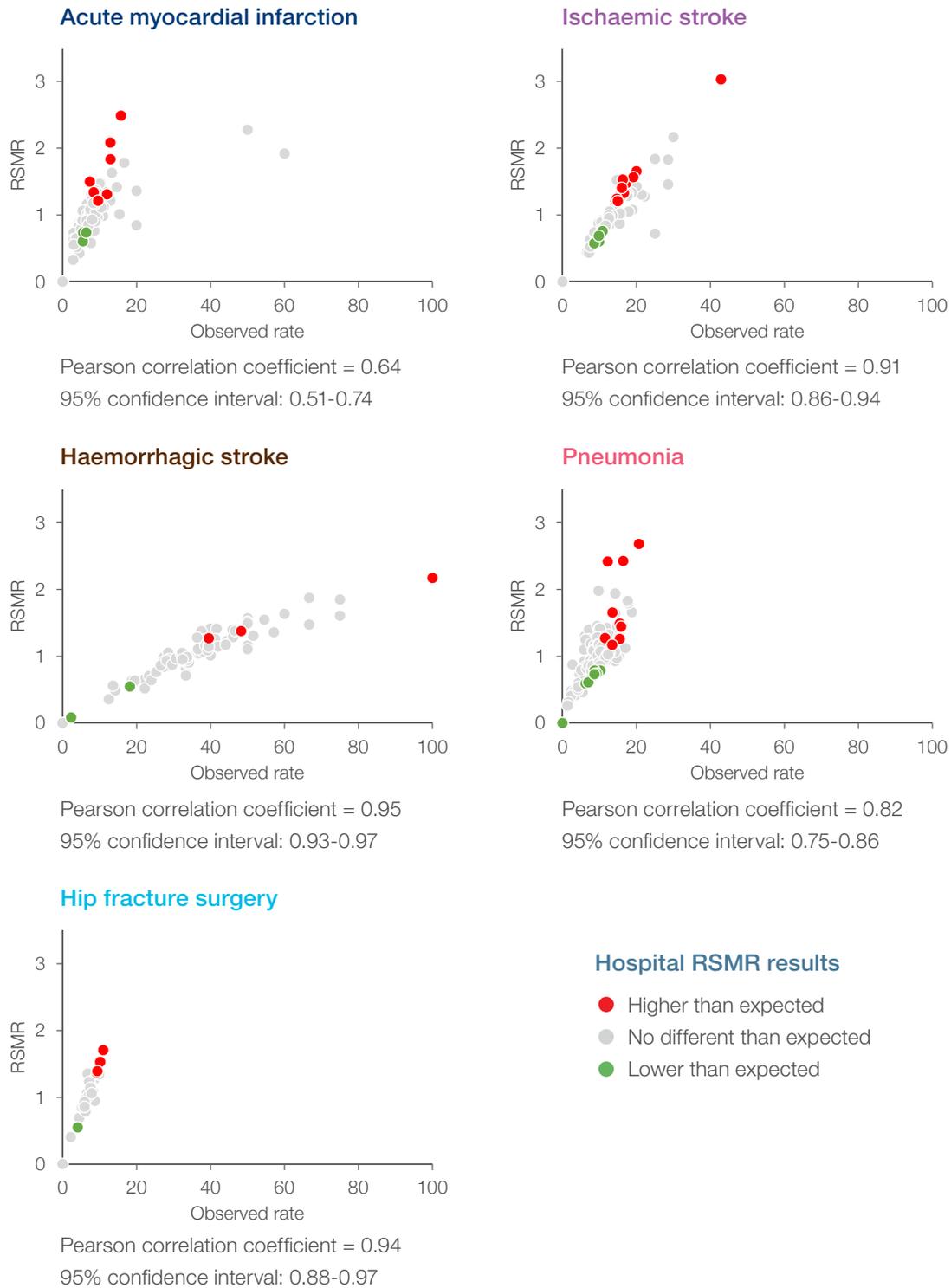


Figure 34 Five conditions, observed mortality rate (%) and risk-standardised mortality ratio, NSW public hospitals, July 2009 – June 2012



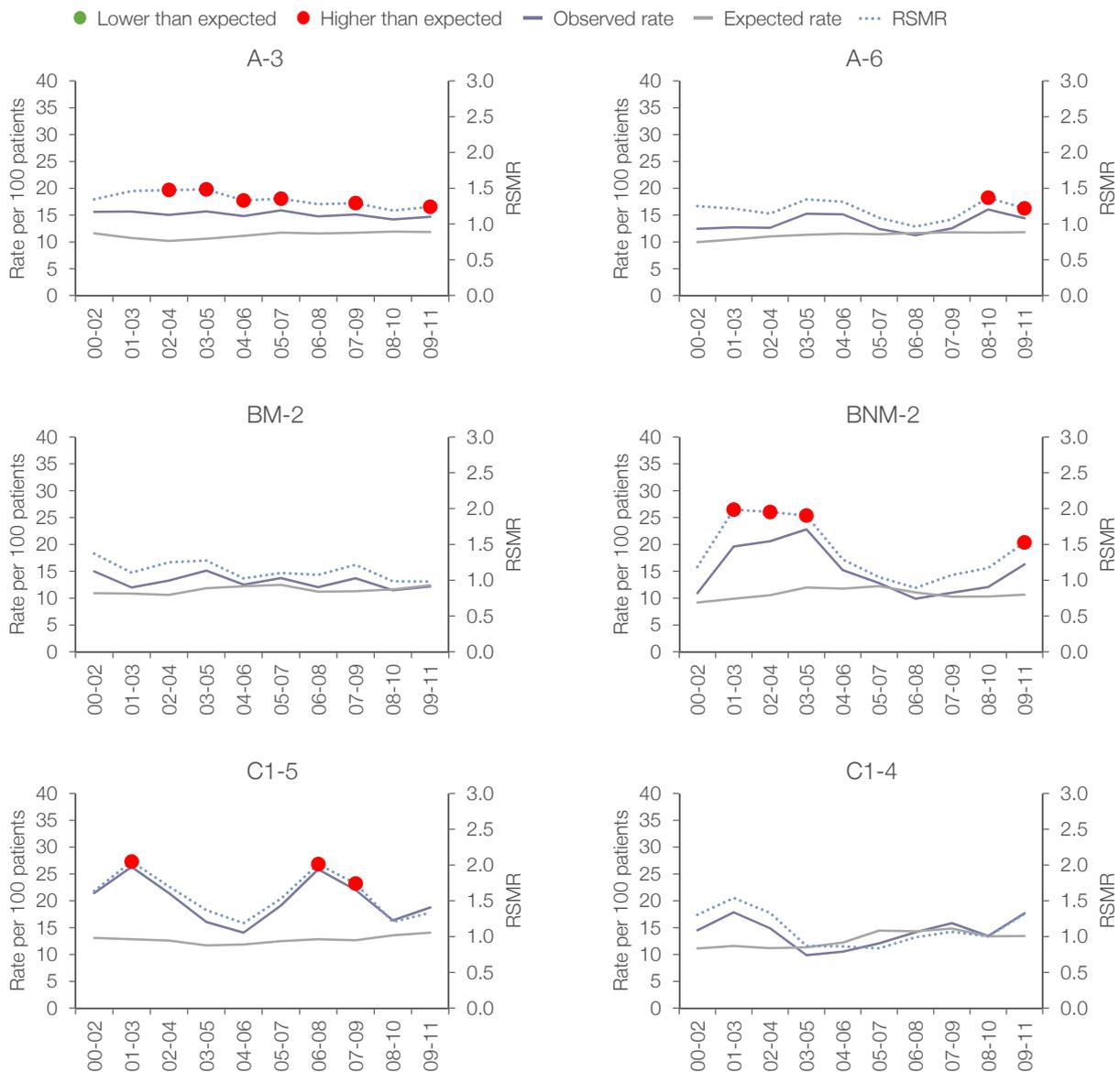
*Data for hospitals with an expected mortality < 1.0 are suppressed.

Hospital results: RSMRs and unadjusted rates

RSMRs are a ratio of ‘observed’ deaths to ‘expected’ deaths. For each hospital, the number of expected deaths is calculated by a statistical model that takes account of its patients’ characteristics. Over time, the observed rate tends to fluctuate more than the expected rate (see page 47, Figure 33). This finding was explored for a sample of hospitals by plotting the rolling three-year observed rate (deaths per 100 patients), expected rate and RSMR (Figure 35).

In these plots, there is a strong association between movements in the observed rate and the RSMR, while the expected rate is relatively stable over time. Therefore, if a hospital’s RSMR changes substantially, it is likely because the observed rate (based on the number of deaths within 30 days), has changed rather than the expected rate (based on the model that accounts for case mix). This means that meaningful information could be provided to hospitals using a mix

Figure 35 Ischaemic stroke, observed rate, expected rate and RSMR for selected hospitals, rolling three years, July 2000 – June 2012

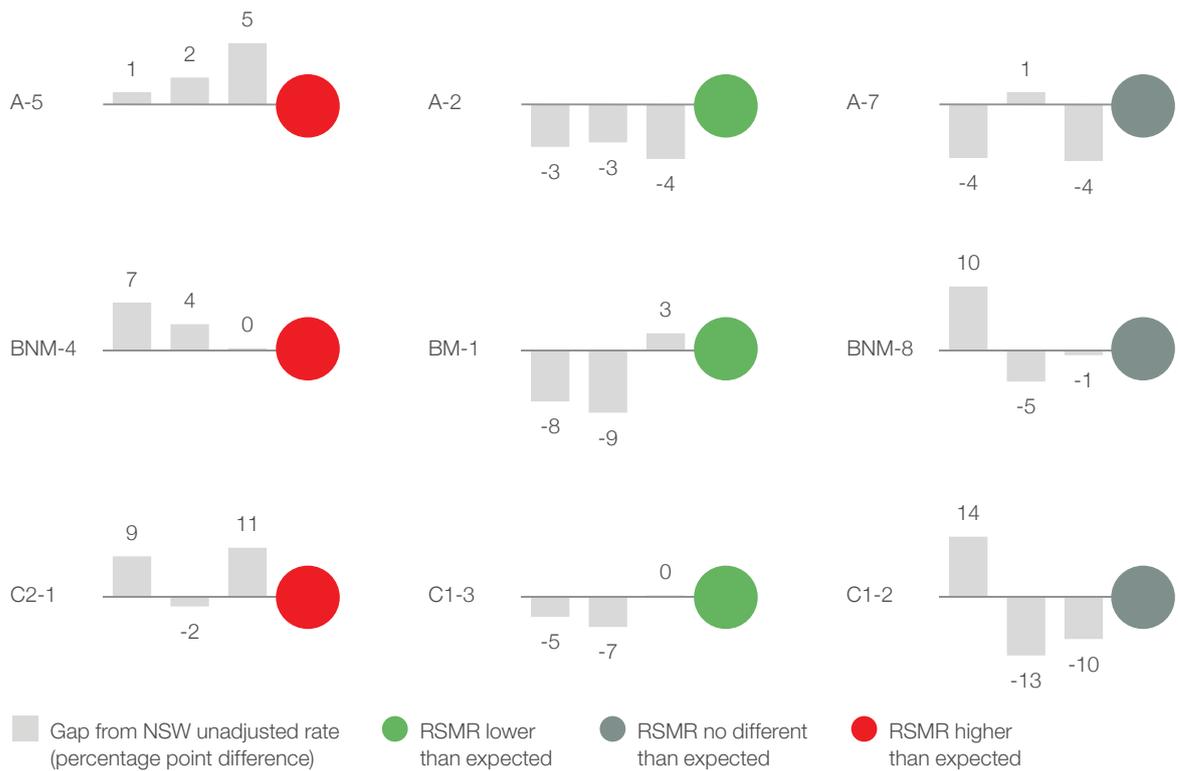


of model-based, risk-adjusted RSMRs, using publicly reported measures; as well as unadjusted observed mortality rates for more frequent updates to support formative assessments locally.

For example, 'key' diagrams could be provided that display unadjusted annual mortality data alongside the three-year RSMR (Figure 36). In these diagrams, the bars represent the difference between a hospital's observed rate and the NSW observed rate for each of the years in the three-year period (Figure 36). The

circle represents the three-year RSMR and is colour-coded according to whether the hospital had higher than expected mortality (red), lower than expected mortality (green), or no different than expected (grey). These diagrams may help inform clinicians and managers about the relative contribution of each year's results in their hospital's three-year RSMR. Unadjusted annual mortality data could also be provided to hospitals as an interim measure while waiting for the next three-year RSMR.*

Figure 36 Ischaemic stroke 'key diagrams', difference in hospital and NSW annual observed mortality rate and three-year RSMR for selected hospitals, July 2009 – June 2012



* While observed rates can provide hospitals with insights into performance, they should not be used to compare hospitals. Not adjusted for case mix or patient volume.

Conclusion

Public reporting of performance information has been shown to have a powerful effect on motivating change and supporting improvement at a hospital and clinician level.^{45,46} In public healthcare systems it is an important mechanism for providing accountability. However, public reporting on hospital performance requires judicious application.

While the frequency of reporting RSMR results is to a large extent shaped by the measurement period used in the analysis, there are other factors to consider in determining reporting schedules. These include the availability of resources to review and respond to RSMRs at a local and system level, and the need to allow sufficient time between reporting periods for any changes put in place to take effect. There is a balance to be struck between providing information on a sufficiently regular basis so as to guide and inform improvement efforts on the one hand, and yet not overwhelm organisations and clinicians with too frequent public releases of information on the other.

Some organisations use a mixed reporting approach to resolve these tensions. England's Health & Social Care Information Centre (HSCIC) publicly reports rolling annual mortality measures every quarter but only highlights those hospitals that are outliers both in the current period and in the same quarter in the previous year.⁹ In this way, hospitals are assessed on two non-overlapping periods, avoiding unfair

criticism of a hospital that continues to be an outlier on quarterly mortality results when they have not had time to improve, or they have improved but the earlier poor performance is still influencing the rolling average. In a NSW context however, given smaller volumes, quarterly reporting is not possible.

A mixed reporting approach is also used by the Australian Bureau of Statistics (ABS), with the release of preliminary death data in a timely way followed by revised and final figures when more complete data and analyses are available.⁴⁷

BHI's public reports that assess hospital performance are rigorous and impartial. As well as descriptive statistics, reports often contain sophisticated statistical analyses that take account of patient characteristics and hospital case mix. This supports summative assessments that are fair and reflect differences in the care provided. Such risk-standardised analyses can however be time consuming.

The results of the analyses in this edition of *Spotlight on Measurement* indicate that unadjusted rates are sufficiently accurate to support formative assessments of performance by local healthcare providers. This means that more timely data can be released to guide improvement, while more robust risk-adjustment processes can be reserved for less frequent public reports.

Appendix 1: Peer groups

NSW hospitals vary in size and in the types and complexity of clinical services that they provide. It is important to compare similar or like hospitals. To do this, BHI uses a NSW Health classification system called 'peer group'.

Group	Name	Description
A	Principal referral	Very large hospitals providing a broad range of services, including specialised units at a state or national level (for this report, ungrouped tertiary hospitals are included in this group)
BM/BNM	Major	Large metropolitan (BM) and non-metropolitan (BNM) hospitals
C1	District group 1	Medium-sized hospitals treating between 5,000–10,000 patients annually
C2	District group 2	Smaller hospitals, typically in rural locations
D-F	Community	Community, nursing home, multipurpose, palliative care and rehabilitation facilities

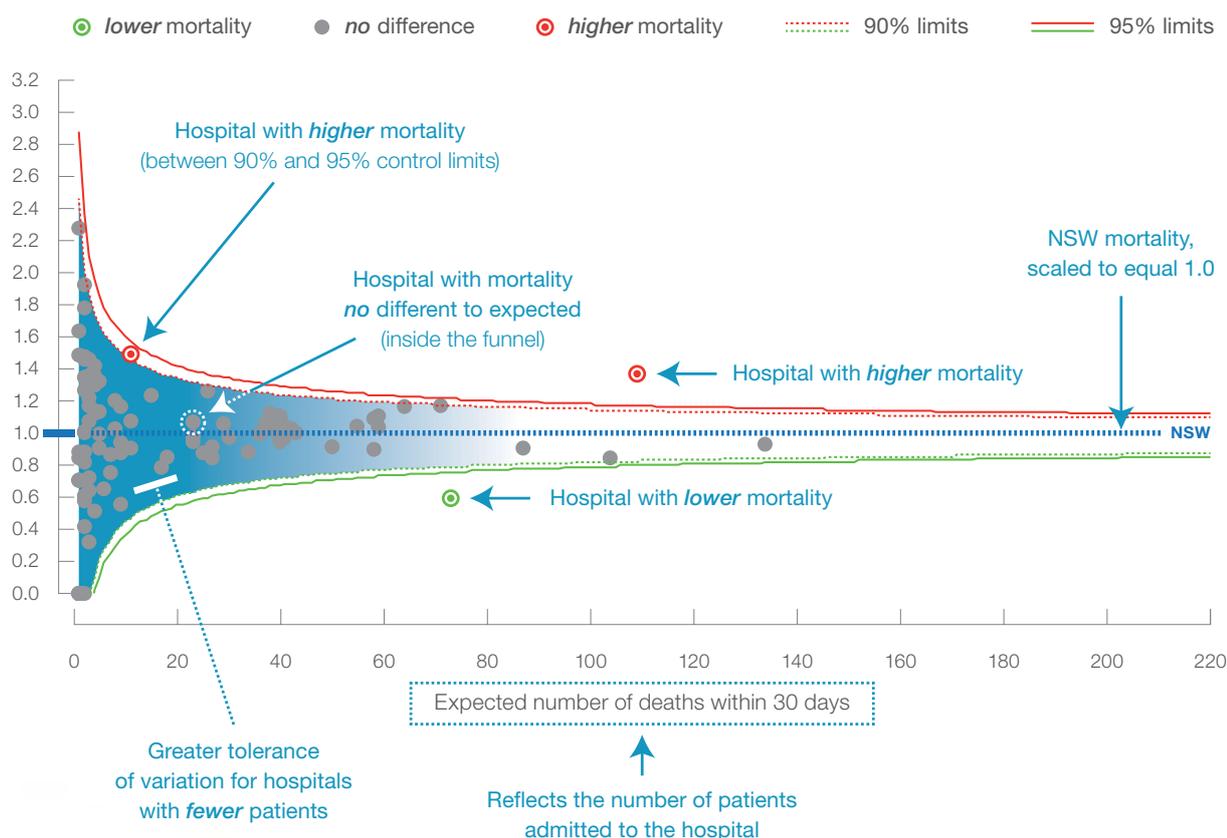
Appendix 2: Funnel plots

How to interpret funnel plots

Mortality is influenced by a wide range of factors that interact in complex ways, meaning there will always be some level of variation in patient outcomes.

The 'funnel' shape that gives the funnel plot its name indicates the tolerance around this variability. Hospitals with fewer patients (those with lower expected number of deaths, and appearing towards the left hand side of the plot) will inevitably display greater variability and fair judgements about performance should take this into account. Therefore the funnel's 90% and 95% limits are wider for hospitals with fewer patients (see example below).

Some hospitals, particularly those with relatively small numbers of patients with a condition, may have high or low ratios simply by chance. Therefore funnel plots have been used to identify those hospitals that individually have a low probability of being high or low simply by chance. Hospitals above the 90% limits of the funnel are considered to have higher than expected mortality; those below the 90% control limits are considered to have lower than expected mortality. For hospitals outside 95% limits, there is greater confidence about their outlier status.



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Glossary

C-statistic – A measure of how well a statistical model predicts patient outcomes. The C-statistic ranges from 0.5 to 1.0, with values higher than 0.7 indicating a reasonable model and values higher than 0.8 a strong model.

Funnel plots – A method of identifying hospitals with outcomes significantly higher or lower than expected that takes into account hospital size and its impact on outcome variability.

Hierarchical logistic regression – A method of modelling patient outcomes that accounts for clustering of patient in hospitals.

Linked data – Data that contains unique patient identifiers, assigned probabilistically on the basis of demographic information such as name, date of birth, gender and address in individual records.

Outliers – Hospitals with significantly higher or lower than expected mortality.

Period of care – The set of contiguous episodes of acute care, including hospital transfers.

Risk adjustment – The process of using statistical methods to adjust hospital outcome rates for differences in patient risk profiles.

Risk-Standardised Mortality Ratio (RSMR) – The ratio of observed deaths to expected deaths, given the hospitals case-mix.

Rolling time periods – A series of time periods that overlap, for example, a series of two year time periods with one year overlap.

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The Bureau of Health Information (BHI) is the main source of information for the people of NSW about the performance of their healthcare system. A NSW board-governed organisation, BHI is led by Chairperson Professor Bruce Armstrong AM and Chief Executive Jean-Frédéric Lévesque MD, PhD.

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About the Bureau of Health Information

The Bureau of Health Information (BHI) is a board-governed organisation that provides independent information about the performance of the NSW public healthcare system.

BHI was established in 2009 to provide system-wide support through transparent reporting.

BHI supports the accountability of the healthcare system by providing regular and detailed information to the community, government and healthcare professionals. This in turn supports quality improvement by highlighting how well the healthcare system is functioning and where there are opportunities to improve.

BHI also manages the NSW Patient Survey Program, gathering information from patients about their experiences in public hospitals and other healthcare facilities.

BHI publishes a range of reports and tools that provide relevant, accurate and impartial information about how the health system is measuring up in terms of:

- Accessibility – healthcare when and where needed
- Appropriateness – the right healthcare, the right way
- Effectiveness – making a difference for patients
- Efficiency – value for money
- Equity – health for all, healthcare that's fair
- Sustainability – caring for the future

BHI's work relies on the efforts of a wide range of healthcare, data and policy experts. All of our assessment efforts leverage the work of hospital coders, analysts, technicians and healthcare providers who gather, codify and report data. Our public reporting of performance information is enabled and enhanced by the infrastructure, expertise and stewardship provided by colleagues from NSW Health and its pillar organisations.

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