4 Hospital mortality

Key points

- Mortality rates are often used as a partial indicator of the safety and quality of practice within hospitals. They can also be used as a measure of the effectiveness of a hospital's services. Mortality is straight forward to measure, but does not necessarily capture quality differences unrelated to patient death.
- When comparing mortality across hospitals, it is necessary to adjust for differences in the characteristics of the patients treated and the services offered by different hospitals to ensure an accurate comparison across hospitals.
- A hospital-standardised mortality ratio (HSMR) is the ratio of observed mortality to the level of mortality that is predicted on the basis of hospital and patient characteristics. The ratio may be used as an indicator of a hospital's underlying quality of service.
- A hospital's predicted mortality involves a process of risk adjustment that takes into account the patient characteristics and other aspects of the hospital's operations.
- Using hospital-level data, the Commission's risk-adjustment process shows that the key patient characteristics that influence in-hospital mortality include the relative number of older patients, particularly aged 70 plus, the relative number of highly co-morbid patients, the average length of stay, the principal diagnosis, and the socioeconomic status of the patient.
- The key hospital characteristics affecting mortality include the degree to which a hospital specialised in surgical procedures, its size, the extent to which it specialises in a narrow range of activities, and whether the hospital had a palliative care unit.
- The Commission found that HSMRs vary according to the hospital owner, the size of the hospital and where it is located.
  - Overall, private hospitals tend to have lower HSMRs than public hospitals, although there is no significant difference between very large public and private hospitals.
  - As the size of hospitals decreases, HSMRs for public hospitals tend to increase, while the HSMRs for private hospitals decrease.
- Even though the Commission sought to account for both specialisation and the effects of size, the wide dispersion of HSMRs for smaller private and public hospitals suggests that such patterns may still be present in the HSMRs.

When assessing the efficiency of a hospital, the quality of the care provided needs to be taken into account to ensure an accurate comparison of hospital outputs. As discussed in chapter 2, hospital mortality is used in this study as an indicator of hospital quality.

This chapter outlines the Commission's approach to estimating hospital-standardised mortality ratios (HSMRs). HSMRs are used in two ways in this study. First, they permit a partial comparison of the quality of hospital services. Second, they provide a necessary variable to account for differences in hospital quality in the subsequent analysis of technical and cost efficiency.

An overview of the calculation of HSMRs is given in section 4.1, with the factors that are likely to affect the mortality rate of a hospital outlined in section 4.2. Results from the process of risk-adjusting mortality rates are presented in section 4.3. HSMRs for both public and private hospitals across Australia are presented in section 4.4. While individual HSMRs for Australian public hospitals have been previously published (Ben-Tovim, Woodman, Harrison et al. 2009), this is the first time a comparison of public and private HSMRs has been undertaken using a common method and dataset. Section 4.5 outlines how HSMRs may be improved for future use as a measure of hospital quality.

4.1 Hospital-standardised mortality ratios

The incidence of mortality is used in this study as a measure of the quality and patient safety of a hospital's health care as well as a measure of the effectiveness of a hospital's service provision (chapter 2). For brevity, 'hospital quality' is used hereafter to refer to both quality and effectiveness. As a measure of safety and quality, mortality is useful because hospital deaths are a well-defined and generally accurately reported outcome, and HSMR scores are regarded as a reasonable indicator of hospital performance (Ben-Tovim, Woodman, Harrison et al. 2009). An attraction of HSMRs is that they are based on routinely collected administrative data which may be as good at predicting risk as more expensive and less-accessible clinical databases (Aylin, Bottle and Majeed 2007; Miyata et al. 2008).

Unadjusted mortality rates are not readily comparable between different hospitals for two main reasons. First, the incidence can vary between hospitals for reasons that are beyond their control, including the type of patients presenting. For example, some hospitals may specialise in treating higher or lower-risk patients, a factor that is likely to impact on observed mortality rates. Second, mortality rates are likely to vary according to the range of services provided by different hospitals — the services offered determine to a large extent the types of patients that are admitted. Hospitals that provide palliative care facilities, for example, are expected to report higher mortality rates.

In order to use mortality statistics as a comparative measure of hospital safety and quality, it is therefore necessary to control for differences in the characteristics of patients treated and the activities of hospitals through a process of risk adjustment (ACSQHC 2009).

Comparing risk-adjusted in-hospital mortality rates involves two steps. First, a predicted mortality rate is derived for each hospital. This is either done via direct standardisation or, as is more common at present, by using patient-level logistic regression as a means of predicting the likelihood of mortality (Heijink et al. 2008). The second step involves calculating a HSMR from both the observed and predicted mortality rates (see box 4.1).

Box 4.1 **What is a hospital-standardised mortality ratio?**

The hospital-standardised mortality ratio (HSMR) is an indicator that compares the number of observed deaths in a given hospital with the number of deaths that would have been expected, after adjusting for factors that affect the likelihood of in-hospital death.

That is, for any hospital:

$$HSMR = \frac{Number\ of\ deaths\ observed}{Number\ of\ deaths\ expected}\ x\,100$$

A ratio greater than 100 indicates that a hospital's mortality rate is greater than expected on the basis of the risks associated with its patients and services. The expected number of deaths for a given hospital is determined by firstly estimating the determinants of in-hospital mortality using a form of regression. Regression parameters are then used to predict the total number of expected deaths for each hospital, given patient and hospital characteristics. This number of expected deaths is then used as the denominator for the HSMR.

Source: Shojania and Forster 2008; CIHI 2009.

HSMRs as an indicator of hospital quality

Even though HSMRs are a potentially useful measure of hospital quality, their use as an indicator of quality has been subject to wide discussion, particularly in both Canada and the United Kingdom, where HSMRs are routinely reported (CIHI 2009; Dr. Foster Health 2010). Mortality is a useful indicator of hospital quality both because of its intrinsic nature and its relationship with other quality measures. A sustained increase in HSMRs or a persistence of HSMRs above 100 is recognised as a useful trigger for further investigation into hospital practices that may affect mortality (Zahn et al. 2008).

A number of studies have demonstrated that lower HSMRs are associated with better performance in quality indicators. For example, HSMRs are shown to have an inverse relationship with adherence to processes of care across a range of conditions, although this effect is often relatively small (Jha et al. 2007; Werner and Bradlow 2006).

Other authors, however, have cautioned that HSMRs are limited in their ability to reflect hospital quality (Brien and Ghali 2008) because HSMRs:

- are too broad to readily identify the source of any problems within a facility
- do not directly account for variations in care between hospitals such as differences in admission and discharge strategies
- do not take into consideration differences in the underlying morbidity rates within the population
- do not provide direct evidence on other aspects of hospital quality, such as the incidence of unplanned readmissions
- are of little use as a measure of adverse events or unexpected death (Penfold et al. 2008)
- are of little value if variation in mortality is largely random.

Mohammed et al. (2009) also raised the possibility that HSMRs might be biased because risk-adjustment processes are premised on the assumption that risk factors are constant across hospitals, when this may not actually be the case. This is referred to as the 'constant risk fallacy', and could arise if coding practices differed across hospitals.

These criticisms can be addressed if HSMRs are estimated and interpreted appropriately. For example:

- while they are broad indicators, HSMRs can provide a suggestion of whether or not there is a problem of quality of care to be investigated by the hospital
- concerns regarding underlying morbidity rates can be addressed through an appropriate risk-adjustment process
- HSMRs are not intended to be used to measure adverse events or unexpected deaths (Wen et al. 2008)

- risk adjustment provides an acceptable level of discrimination so that the residual variation between hospitals has 'a substantial systematic element' that justifies the use of HSMRs (Ben-Tovim, Woodman, Harrison et al. 2009).

Ben-Tovim, Woodman, Hakendorf and Harrison (2009) tested the constant-risk hypothesis for Australian public hospitals using a procedure similar to that used by Mohammed et al. (2009). They concluded that it is generally valid to assume constant risk across hospitals for many factors. However, the authors did find that the risk associated with being an emergency patient or being admitted from another hospital did vary across hospitals, and it was not clear as to whether risk was constant across diagnostic coding categories.

4.2 Factors affecting hospital mortality

The premise of risk adjustment is that rates of in-hospital mortality are systematically influenced by the characteristics of patients presenting and the services offered at each hospital. Ben-Tovim, Woodman, Harrison et al. (2009) provide a review of recent literature covering the risk-adjustment of mortality rates, and note that age, sex, clinical diagnosis, and any comorbidities noted upon admission need to be considered.

Additional information about the admission can also indicate the possible risk associated with a patient, including arrival and discharge dates, whether or not the admission was an emergency or planned, and the nature of discharge (CIHI 2010). Length of stay is also used as a possible indicator of severity of illness (Jarman et al. 1999; Heijink et al. 2008; CIHI 2010). Information about whether or not the patient was transferred from an acute institution can also provide information about risk of mortality (CIHI 2010). Examining mortality from a hospital level necessitates the use of averages across the patient population for these variables.

Risk adjustment may often take into account the characteristics of the institution at which a patient is being treated (Jarman et al. 1999; Heijink et al. 2008; Shahian and Normand 2008). This entails including information about hospital type and size, the services provided by the hospitals, and teaching status, on the grounds that this affects the quality of treating personnel and the types of patients attracted by the institution. Other hospital characteristics considered include staffing levels and discharge procedures (Heijink et al. 2008; Jarman et al. 1999). Hospital staffing levels were not taken into account in risk adjusting the mortality rates presented here, as they are explicitly considered as a hospital input in the estimation of efficiency in the following chapters.

Patient characteristics and hospital treatment

Drawing on recent studies estimating the determinants of within-hospital mortality (Ben-Tovim, Woodman, Harrison et al. 2009; Heijink et al. 2008), the following variables were used to estimate the likelihood of patient mortality:

- *Age* — the percentage of patients who are in youngest and oldest age groups, with the default category being those aged 20–59.
- *Gender* — the percentage of patients who are female.
- *Indigenous status* — the percentage of patients who identify as Indigenous.
- *Comorbidity* — the percentage of patients with a Charlson index of comorbidity in different ranges. The share of patients with a score below two is the default category.
- *Average length of stay* — the average length of stay (ALOS) for medical, surgical or otherwise categorised patients (CIHI 2010).
- *Socioeconomic status* — the percentage of patients who reside in areas of the highest quintiles of socioeconomic disadvantage, as measured by the Socio-economic index for Areas — Index of Relative Disadvantage and Advantage (SEIFA) (ABS 2008b). The percentage of patients in the highest quintile (most advantaged) was treated as the default.
- *Major Diagnostic Category* — the percentage of casemix-adjusted separations in each Major Diagnostic Category (MDC) (see chapter 3). The percentage of patients with diseases and disorders of the central nervous system were treated as the default category.
- *Transfers* — the percentage of admissions that were transfers from other hospitals (Wen et al. 2008). Similarly, the percentage of separations that concluded with a transfer to another acute hospital was also included.

In addition to the variables above, a number of nonlinear and interactive terms were also considered. For example, the transfer variable was interacted with hospital size variables, to account for the possibility that transfers are made between hospitals for different reasons (Wen et al. 2008). Severely-ill patients — with a higher likelihood of death — may be transferred from smaller to larger hospitals for treatment in specialised facilities, such as intensive care units. Conversely, patients recovering from severe illness, and at a lower risk of mortality, may be transferred to smaller hospitals. However, the Commission found that these variables did not significantly impact on mortality and did not improve the fit of the model, so they were not included in the final model specification.

Remoteness of residence was also considered as a factor likely to affect mortality. However, this was found not to improve the fit of the model, given the inclusion of the SEIFA variables. Remoteness was therefore not included in the final model specification.

Hospital characteristics

A number of hospital characteristics were also included to account for the fact that not all individual patient-risk characteristics are observable, but hospital characteristics are known. Hospital characteristics used in estimating expected mortality include:

- *Hospital services* — binary indicators as to whether or not a hospital operates neonatal intensive care, obstetric, level-III intensive care, coronary care, palliative care, rehabilitation, and domiciliary care units were included so as to provide further information about the types and severity of illnesses treated.
- *Teaching status* — included as an indicator of the potential complexity of cases treated in a given hospital.
- *Admissions from an emergency department* — the ratio of emergency department visits to inpatient admissions as a proxy for the share of patients admitted as emergency patients.
- *Hospital size* — variables reflecting hospital size were included.
- *Specialisation* — the percentage of total separations accounted for by the five most common MDCs was included as an indicator of the degree of specialisation of treatment. The percentage of total separations that are non-medical (classified as 'surgical' or 'other') was also included as an indicator of specialisation.

The relative complexity of work undertaken by hospitals was also taken into account by including an Evans and Walker information index in the regression (Evans and Walker 1972). The index is a measure of the complexity of hospital work that takes into account differences in hospital size. This means that, while larger hospitals generally treat more complex cases than smaller hospitals, due to their size, they are also expected to treat more complex cases, due to a higher degree of capacity (see chapter 3).

Time variables were also included so as to account for national variations in mortality over time.

Other factors affecting in-hospital mortality

It is important to note that a number of factors likely to impact on the mortality rate of a hospital were not able to be taken into consideration. For example, access to both general practitioners (Heijink et al. 2008) and other forms of primary care (Jarman et al. 1999) are likely to effect levels of within-hospital mortality. Similarly the level of access to hospitals themselves is likely to influence mortality rates. It has been demonstrated that, in an urban environment in the United Kingdom, a 10 km increase in the distance from the hospital is associated with a one per cent increase in mortality (Nicholl et al. 2007). It is likely that a patient's proximity to hospital care could impact significantly on the mortality rates observed in regional and remote hospitals in Australia.

4.3 Risk adjusting hospital mortality rates

As the number of deaths observed in a hospital over a given time period is by definition a non-negative integer, it is appropriate to apply a statistical model that takes these restrictions into account. A negative binomial regression was used to predict the expected number of deaths for a given hospital within a given time frame (see appendix C). This is a similar approach to that taken by Korda et al. (2007) in modelling the effect of health care on avoidable mortality rates in Australia.

The negative binomial is based on the assumption that there is an underlying mortality rate within a population that can be multiplied by an 'exposure' to determine the expected number of deaths for that population. A characteristic of the negative binomial is that in the instance of small exposures, the probability of observing more than one death will be small compared with the size of the exposure. The number of deaths for each hospital in each year is regressed over a vector of independent variables, with the number of casemix-adjusted separations used as the 'exposure' variable.

It is worth noting that, by necessity, this approach to risk adjustment is different to that used in other studies (see for example, Ben-Tovim, Woodman, Harrison et al. 2009; CIHI 2007, 2010; Heijink et al. 2008). Normally, the expected mortality of a hospital is predicted from a logistic regression using patient-level data. This was not possible because patient-level data were not available for this study.

The Commission compared the HSMRs resulting from the negative binomial approach with a logistic regression using hospital-level data. The hospital-level data were used to create a pseudo patient-level dataset, with each individual separation for each hospital being ascribed the average patient characteristics for the hospital in which they were treated. The rank correlation between the HSMRs derived from the pseudo patient-level dataset and those produced using the negative binomial approach was in excess of 0.9, suggesting that both approaches produce very similar HSMRs. However, the lack of within-hospital variation inherent in the pseudo patient-level data means that the logistic regression results overstate the statistical significance of mortality determinants. It is for this reason that the negative binomial approach was preferred.

In order to closely adhere to established practice, a range of model specifications were tested, following the patient-level studies of Ben-Tovim, Woodman, Harrison et al. (2009), CIHI (2007) and Heijink et al. (2008). The coefficients were generally of the expected sign. Results from the specification which had the greatest explanatory power are presented as incidence rate ratios — the effect on the mortality rate of an incremental change in the explanatory variable. Estimates from the preferred specification are also the basis for the summary statistics and the HSMR indicator that is used in the following chapters.[1]

Incidence rate ratios

Results from the preferred regression of hospital mortality can be presented as incidence rate ratios (IRRs) for the individual factors that affect in-hospital mortality (table 4.1) Negative binomial regressions model mortality levels as a rate that is subject to a level of exposure — in this case, the number of total separations. The IRR represents the percentage increase in the incidence of mortality given a one-unit increase in the independent variable.[2] For example, an IRR of 1.10 indicates that a one unit increase in the independent variable would lead to a 10 per cent increase in the mortality rate. An IRR of 0.90 indicates that a one-unit increase in the independent variable leads to a 10 per cent decline in the mortality rate.

The interpretation of categorical 'share' variables requires care. These are categorical variables that represent the share of patients, as a percentage, that

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1 The preferred model was the specification with the greatest log-likelihood and the lowest Akaike Information Criterion score (Hilbe 2007). Coefficients for both the preferred model, as well as an alternative specification that included only variable groups that resulted in a significant increase in the log-likelihood, are presented in appendix D.

2 That is, the incidence rate ratio (IRR) for hospital i for a binary variable x_i that affects mortality rate y_i can be expressed as:

$$IRR_i = \frac{E(y_i \mid x_i = 1)}{E(y_i \mid x_i = 0)}.$$

correspond to that category. As with other regressions, any marginal effect of an increase in a categorical variable is relative to the default category for that group of variables.

For example, the IRR for the share of patients aged over 70 is the ratio of expected mortality following a one percentage point increase in the share of those aged over 70 to the level of expected mortality without that increase. It is important to remember that a one percentage point increase in the share of those aged over 70 is relative to the default age category, and therefore simultaneously corresponds to a decrease in the share of those aged between 20 and 59.

As expected, a higher proportion of younger patients is generally associated with a lower expected mortality rate. That is, hospitals that treat a greater number of older patients are likely to experience higher levels of mortality, all else being equal. This is consistent with patient-level studies that demonstrate that the likelihood of mortality increases with age (Ben-Tovim, Woodman, Harrison et al. 2009).

ALOS is associated with increased mortality for medical procedures. In contrast, for surgical procedures the likelihood of death decreases as ALOS increases. This suggests that the relationship between mortality risk and length of stay is not linear, as shown by Ben-Tovim, Woodman, Harrison et al. (2009).

Differences in the effect of ALOS variables on mortality also reflect the different risks associated with medical and surgical procedures. The strength of this effect is reinforced by the significance and magnitude of the specialisation variables. Hospitals with a higher concentration of separations in the five diagnostic categories in which they perform the most separations have a noticeably lower IRR. Importantly, this effect is contingent on size, and is no longer significant when the sample is restricted to large and very large hospitals (appendix D).

Contrary to expectations, an increase in the proportion of admitted patients who were transferred from another hospital is associated with a significant reduction in mortality. This is in contrast to the findings of Ben-Tovim, Woodman, Harrison et al. (2009). A possible explanation for this is that transfers between hospitals of different sizes and capacities occur for different reasons. To examine this explanation, the share of transferred admissions was interacted with the hospital size variables, with the result being that the share of admitted patients was no longer significantly related to mortality for all hospital sizes.

Table 4.1 **Effects of patient and hospital characteristics on mortality**

Incidence rate ratios

Variable	*IRR*	*Variable*	*IRR*
Age (%)		**Major Diagnostic Category (cont.)**	
Age <1 yr	0.992	Mental diseases and disorders	1.015**
Age 1–4	1.006	Drug and alcohol related diseases	0.952*
Age 5–19	0.969***	Injuries, poisoning and effects of drugs	0.998
Age 60–69	0.990	Burns	1.032
Age ≥70	1.014***	Factors influencing health status	1.008
Female (%)	0.999	**Patient's socioeconomic status (%)**	
Indigenous status (%)	0.994***	SEIFA 1	1.005***
Charlson score (%)		SEIFA 2	1.004***
2 ≤ Charlson < 3	1.000	SEIFA 3	1.005***
3 ≤ Charlson < 4	1.003	SEIFA 4	1.005***
4 ≤ Charlson < 5	0.994	**Other**	
5 ≤ Charlson < 6	1.003	Surgery/other (% of seps.)	0.978***
Charlson ≥ 6	1.131***	Ratio of emerg. visits to seps.	1.000
Average length of stay		Transfers from other hospital (% of admissions)	0.976***
ALOS (medical)	1.156***	Transfers to other hospital (% seps.)	1.006
ALOS (surgical)	0.989*	Sameday (% of seps.)	1.003
ALOS (other)	1.000	Top five MDCs (% of seps.)	0.977***
Major Diagnostic Category (%)		**Hospital characteristics**	
Eye diseases and disorders	1.013**	Recognised teaching hospital	0.990
Ear, nose, mouth and throat diseases and disorders	1.003	Neonatal intensive care unit	1.048
Respiratory diseases and disorders	1.038***	Obstetric unit	0.920
Circulatory diseases and disorders	1.023***	Intensive care unit	1.053
Digestive diseases and disorders	1.049***	Coronary care unit	1.010
Hepatobiliary and pancreatic diseases and disorders	1.017	Palliative care unit	1.253***
Musculoskeletal and connective tissue diseases and disorders	1.023***	Domiciliary care unit	0.997
Skin, subcutaneous tissue and breast diseases and disorders	1.009	Rehabilitation unit	0.924**
Endocrine, nutritional and metabolic diseases and disorders	0.993	Evans & Walker 2 (x 100)	1.002
Kidney and urinary tract diseases and disorders	1.009	Large hospital	1.181***
Male reproductive diseases and disorders	0.996	Medium hospital	1.221**
Female reproductive diseases and disorders	1.027***	Small or very small hospital	1.638***
Pregnancy, childbirth and the puerperium	1.014**	**Time**	
Newborns and other neonates	1.017	2005	0.967*
Diseases and disorders of blood, blood forming organs, immunological disorders	0.989	2006	0.961*
Neoplastic disorders	1.017**	2007	0.958*
Infectious and parasitic diseases	1.014		

*** p<0.01, ** p<0.05, and * p<0.1

Source: Productivity Commission estimates.

4.4 Comparing HSMRs across public and private hospitals

The HSMRs for different sub-groups of hospitals are summarised in table 4.2. It is useful to consider both the mean and median HSMR scores as aggregate quality indicators. Mean HSMR scores are prone to influence by outliers, as is evidenced by the high mean relative to the median score for public contract hospitals. However, relying solely on the median scores does not acknowledge the persistence of a number of very low HSMR scores for private hospitals.

Table 4.2 **Hospital-standardised mortality ratios summary statistics, 2003-04 to 2006-07[a,b]**

	Mean	*Standard deviation*	*Median*	*5th Percentile*	*95th Percentile*	*Number of observations*
All hospitals	100.2	44.9	96.3	36.4	177.5	1806
Owner						
Public	102.5	39.2	98.1	48.4	168.9	1354
Private	90.8	58.8	85.9	13.2	197.4	389
For-profit	92.7	62.2	85.2	16.0	202.2	295
Not-for-profit	85.0	46.6	90.2	8.1	197.2	94
Public contract	109.2	53.6	88.5	65.0	199.0	63
Location						
Major city	97.1	49.5	91.9	29.7	186.2	699
Inner regional	102.8	40.9	99.1	50.8	170.4	566
Outer regional	102.8	38.1	100.6	41.0	162.4	379
Remote	94.1	45.2	87.1	39.8	197.0	78
Very remote	103.2	56.5	93.1	29.9	206.5	84
Size						
Very large	103.8	48.3	99.2	38.7	179.4	356
Large	95.8	43.5	93.0	32.0	157.6	279
Medium	99.1	51.3	92.2	22.1	207.4	295
Small	99.1	46.7	93.9	34.4	196.0	295
Very small	100.1	30.9	97.5	53.4	145.5	581

a Hospital-standardised mortality ratio is equal to the actual (observed) mortality rate divided by the predicted mortality rate multiplied by 100.

Source: Unpublished ABS and AIHW data; Productivity Commission estimates.

Over all hospitals, the mean HSMR score for private hospitals is lower than for public hospitals by around 12 percentage points, averaged over 2003-04 to 2006-07. The difference in mortality between public and private hospitals was shown to be significant at the aggregate level by including binary variables indicating management type in a specification of the mortality equation (appendix D).

However, when disaggregated by size, there is little difference between the HSMRs for very large public and private hospitals (table 4.3). If the sample is restricted to include only large and very large hospitals, there is no significant difference between the HSMRs for public and private hospitals (appendix D).

Table 4.3 **Hospital-standardised mortality ratios, by owner and hospital size, 2003-04 to 2006-07[a]**

	Very large[b]	*Large*[c]	*Medium*[d]	*Very small and small*[e]
Public hospitals				
Mean	101.10	106.64	99.21	102.88
Standard deviation	25.22	45.77	39.45	41.32
Median	99.36	97.23	91.92	99.21
5th percentile	59.41	62.69	39.95	44.42
95th percentile	142.16	195.47	188.58	169.22
Number of observations	252	155	167	780
Private hospitals				
Mean	100.30	81.78	98.54	79.70
Standard deviation	44.17	47.18	64.35	69.64
Median	96.85	76.55	91.99	72.33
5th percentile	34.28	12.13	16.02	9.54
95th percentile	180.25	169.58	221.34	182.84
Number of observations	87	85	125	92
Public contract hospitals				
Mean	83.29	106.55	np	np
Standard deviation	21.53	40.19	np	np
Median	77.78	96.77	np	np
5th percentile	60.27	62.13	np	np
95th percentile	142.75	202.66	np	np
Number of observations	17	39	np	np

a The hospital-standardised mortality ratio is equal to the actual (observed) mortality rate divided by the predicted mortality rate, multiplied by 100. **b** *Very large* hospitals report more than 20 000 separations per year. **c** *Large* hospitals are report between 10 001 and 20 000 separations per year. **d** *Medium* hospitals are those reporting 5001 and 10 000 separations per year. **e** *Very small and small hospitals* reporting less than 5000 separations per year. **np** Not published due to ABS confidentiality concerns. **..** Not applicable.

Source: Unpublished ABS and AIHW data; Productivity Commission estimates.

The gap between public and private HSMRs appears to widen as hospitals get smaller — with the exception of medium-sized hospitals. The difference in means for small and very small hospitals is around 23 percentage points. However, the dispersion of HSMRs for smaller private hospitals is significantly larger than that for public hospitals, suggesting that the difference in means may be substantially influenced by very low outliers — the HSMR score at the 5th percentile is just under 10 for private hospitals, compared to around 44 for public hospitals.

Even though the Commission sought to measure the effect of size and specialisation, it is unlikely that this is fully taken into account, given the wide dispersion of HSMRs for smaller hospitals and the number of smaller private hospitals with very low HSMRs. Given the larger proportion of smaller public hospitals that are located in remote and regional areas, smaller public hospitals are unlikely to be able to specialise to the same extent as private hospitals of a similar size.

Furthermore, it is possible that the if the availability of primary care is an important determinant of in-hospital mortality (Heijink et al. 2008; Jarman et al. 1999), then the HSMRs of smaller public hospitals may also reflect the relative absence of primary care in more remote communities.

Variation in HSMRs across time

The Commission also examined the relative position of each hospital over time by undertaking Spearman rank correlation test of hospital HSMRs for each year (table 4.4). Large changes in mortality ratios could either indicate large shifts in the quality of care provided or indicate random variation. The correlations for 2004 gradually declined from 0.688 to 0.564, suggesting a decline in consistency over time. However, the correlations between 2004 and 2005 (0.688), 2005 and 2006 (0.718) and 2006 and 2007 (0.743) have increased, suggesting that that possible random variation has been declining over time.

Table 4.4 **HSMR rank correlation over time**[a]

	2004	*2005*	*2006*	*2007*
2004	1.000			
2005	0.688*	1.000		
2006	0.636*	0.718*	1.000	
2007	0.564*	0.692*	0.743*	1.000

a Spearman's rank correlation coefficients. * p<0.01

Source: Productivity Commission estimates.

More broadly, variation in HSMRs can be examined by classifying hospitals into high, intermediate and low mortality groups, as per CIHI (2007). Hospitals classed as being high mortality refers to those with HSMRs and confidence intervals in excess of 100, while low mortality hospitals were estimated to have HSMRs and confidence intervals below 100. Hospitals with HSMRs and confidence intervals that intersected 100 were classed as intermediate.

Of the 163 large and very large hospitals included in the sample for all four years, around 15 per cent were low for all four years, 11.7 per cent were high for all four years and 11 per cent were intermediate. Around 35 per cent moved between having intermediate and low HSMRs, and the remaining 28 per cent moved between having intermediate and high HSMRs. Variation was much larger for the medium, small and very small hospitals, with only around 4.5 per cent classed as low for all four years, and 3.8 per cent remaining as high over this time. This is in part attributable to the increasing impact of individual deaths on mortality rates as the number of separations decrease.

Caterpillar plots

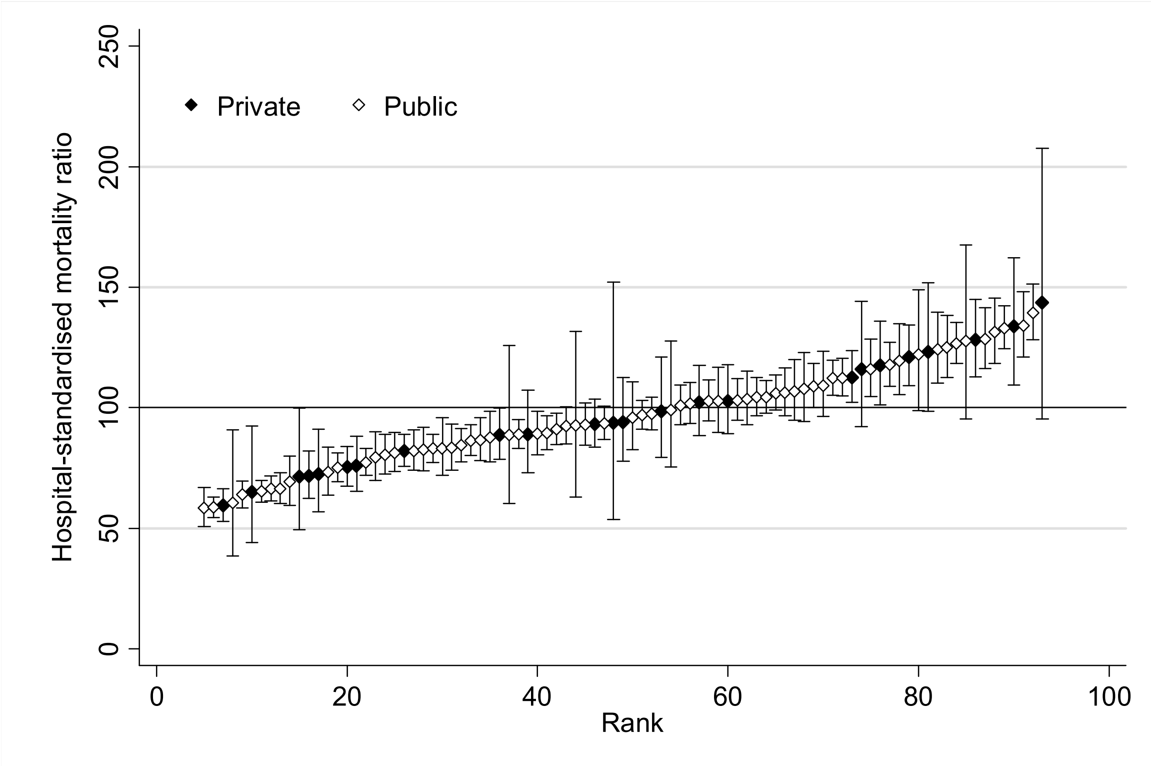
Ben-Tovim, Woodman, Harrison et al. (2009) present HSMRs graphically, with hospitals ranked by HSMRs on the *x*-axis and HSMRs on the *y*-axis. These plots provide a readily accessible means of displaying the distribution of HSMRs across a hospital sub-sample, along with confidence intervals that provide an indication of the reliability of the estimates (see appendix C).

The HSMRs for very large, large and medium-sized public and private hospitals across Australia in 2006-07 are presented in figures 4.1, 4.2, and 4.3. As is evident across these figures, the size of the confidence intervals increases as the size of hospitals diminish.[3] It is for this reason that plots for the numerous small and very small hospitals have not been presented.

The confidence intervals are calculated using an approximation method that is contingent on the number of deaths observed in each hospital. Given that, within each hospital size grouping, public hospitals are generally larger than privately-run hospitals, the confidence intervals are often wider for private hospitals. This means that it is more likely that the private hospital confidence intervals will cross an HSMR score of 100.

3 Technically, the size of the confidence intervals increase as the number of deaths observed in a hospital decreases.

Figure 4.1 Hospital-standardised mortality ratios for very large hospitals, 2007[a,b,c,d]

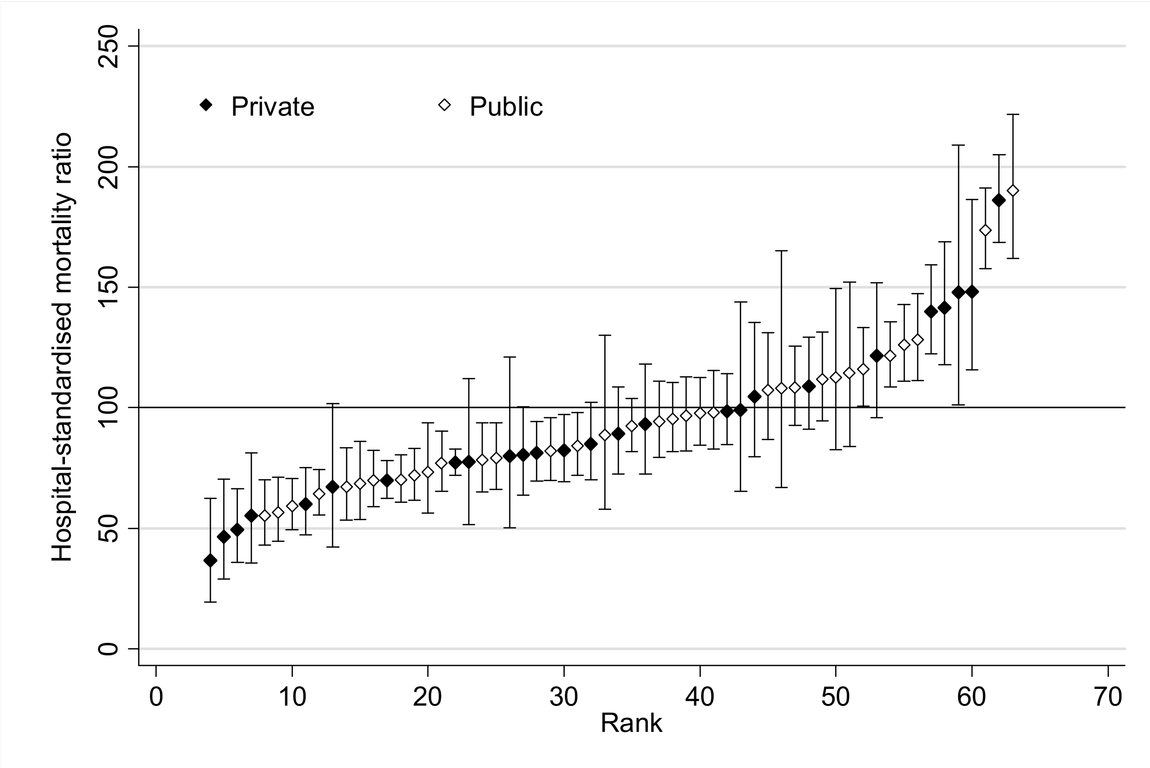


a Very large hospitals are those reporting more than 20 000 separations per year. **b** Confidence intervals indicate precision of the HSMR estimates, and are contingent on the size of hospital and the number of observed deaths. They are calculated using Byar's approximation, as set out in CIHI (2007) and appendix C. **c** Private hospitals awarded public contracts are not identified separately due to confidentiality requirements. They are classified as private hospitals in this figure. **d** The 5 per cent lowest and highest HSMR estimates for very large hospitals are not published due to ABS confidentially concerns.

Source: Productivity Commission estimates.

Taking into account the confidence intervals, this demonstrates the broad similarity of HSMR outcomes for the very large public and private hospitals. Around 23 per cent of very large public hospitals have HSMRs above 100, taking into account the confidence interval. For private hospitals of the same size, around 21 per cent have HSMRs in excess of 100. Around 41 per cent of very large public hospitals have HSMRs below 100, while this figure is around 43 per cent for very large private hospitals.

Figure 4.2 **Hospital-standardised mortality ratios for large hospitals, 2007[a,b,c,d]**



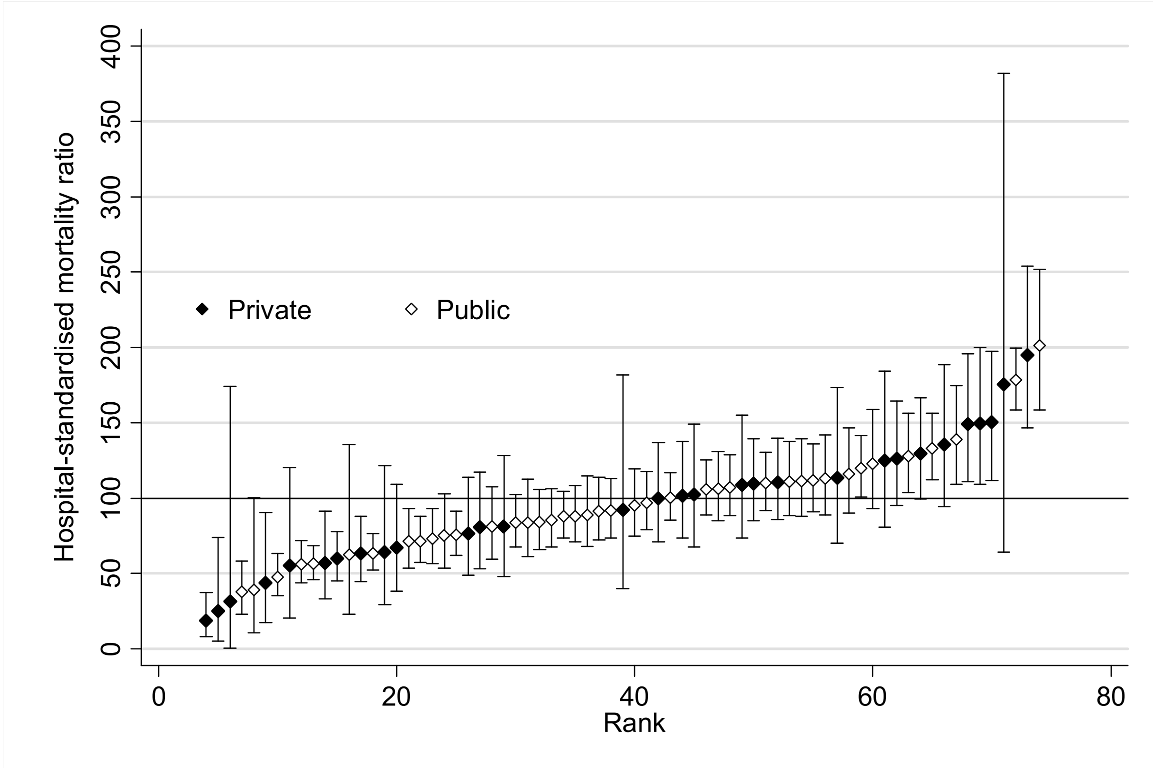
[a] Large hospitals are those reporting between 10 000 and 20 000 separations per year. [b] Confidence intervals indicate precision of the HSMR estimates, and are contingent on the size of hospital and the number of observed deaths. They are calculated using Byar's approximation, as set out in CIHI (2008) and appendix C. [c] Private hospitals awarded public contracts are not identified separately due to confidentiality requirements. They are classified as private hospitals in this figure. [d] The 5 per cent lowest and highest HSMR estimates for large hospitals are not published due to ABS confidentially concerns.

Source: Productivity Commission estimates.

Around 39 per cent of large public hospitals have HSMRs are below 100, in comparison to around 37 per cent of large private hospitals. For medium-sized hospitals, the difference is reversed with around 24 per cent of public hospitals and 29 per cent of private hospitals are shown with HSMRs below 100.

The difference between public and private hospitals becomes more pronounced for the smaller hospitals. Around 10 per cent of very small, small and medium public hospitals have HSMRs above 100, while this is about 25 per cent for comparable private hospitals. About 45 per cent of these private hospitals have an adjusted mortality ratio that is below 100, but for comparable public hospitals, the number is notably lower, at around 10 per cent.

Figure 4.3 **Hospital-standardised mortality ratios for medium hospitals, 2007[a,b,c,d]**



[a] Medium hospitals are those reporting 5000 and 10 000 separations per year. [b] Confidence intervals indicate precision of the HSMR estimates, and are contingent on the size of hospital and the number of observed deaths. They are calculated using Byar's approximation, as set out in CIHI (2007) in appendix C. [c] Private hospitals awarded public contracts are not identified separately due to confidentiality requirements. They are classified as private hospitals in this figure. [d] The 5 per cent lowest and highest HSMR estimates for medium hospitals are not published due to ABS confidentially concerns.

Source: Productivity Commission estimates.

4.5 Improving HSMRs as a measure of hospital quality

There are opportunities to improve the modelling of HSMRs in the future. First, estimating mortality rates at the hospital level with a negative binomial regression does not take into account the wide range of variation in mortality risks associated with individual patients. While the negative binomial is an acceptable approach for modelling mortality at a hospital level, adjusting mortality risk at the patient level requires logistic regression and patient-level data — as demonstrated by Ben-Tovim, Woodman, Harrison et al. (2009) and Heijink et al. (2008). This is a preferred approach because risk is taken into account at the patient level, rather than on the basis of hospital-wide averages.

Second, information about the context of a hospital within the health system is likely to improve the validity of HSMRs as an indicator of in-hospital quality of care. This is due to the fact that access to health services — in addition to those provided by hospitals — is likely to have a notable impact on hospital mortality. Heijink et al. (2008) show that the number of general practitioners in the surrounding areas has a significant effect on in-hospital mortality, something that was not able to be taken into account in this study. Jarman et al. (1999) point out that access to other health services is also likely to affect mortality levels in a more direct manner. Hospitals faced with a greater availability of aged care services are more able to discharge patients to these services, and any subsequent deaths are not in a hospital.

Related to this, is that the time taken to travel to a hospital may be a useful measure of the accessibility of hospital services.

Third, HSMRs could be improved by access to more detailed information about the nature and severity of patient diagnoses. Risk adjustment in the HSMRs presented in this chapter involves taking into account the primary diagnosis of patients, as well as the emergency ratio and average length of stay. However, as noted by Shojania and Forster (2008), in some instances administrative data may be inadequate to account for influential differences in casemix.

While Ben-Tovim, Woodman, Harrison et al. (2009) use the same approach, this is a broad categorisation of diagnosis, and encompasses a broad range of acuity, severity and complexity of cases. Systematic differences between public and private hospitals in the mortality risk associated with patients within a primary diagnosis group will not be accounted for in the risk-adjustment process as it has been implemented. More detailed diagnostic information would substantially improve the risk-adjustment process.