Bureau of Health Information

Indicator specifications

30-day mortality following hospitalisation, five clinical conditions, NSW, July 2009 – June 2012

Acute myocardial infarction, ischaemic stroke, haemorrhagic stroke, pneumonia and hip fracture surgery

December 2013

30-day mortality (all cause)

Following hospitalisation for AMI (risk-standardised mortality ratio)

The condition

An AMI, or heart attack, occurs when the blood supply to part of the heart is interrupted. The interruption is most commonly due to blockage of the coronary artery following the rupture of an atherosclerotic plaque – which is an unstable collection of lipids (such as cholesterol) and white blood cells in the arterial wall. The disruption to cardiac blood flow results in death of heart cells and if blood supply is not restored quickly, the heart muscle suffers permanent damage.

The indicator

Risk-standardised mortality ratios (RSMRs) can provide important information about healthcare system performance. Variation in mortality, after adjusting for case mix, may reflect differences in hospitals' general environments (such as coordination of care, patient safety policies, and staffing) or variation in care processes.

The cohort for the indicator consists of patients aged 15 years or over who were discharged between 1 July 2009 and 30 June 2012 with an acute, emergency admission for a principal diagnosis of acute myocardial infarction (ICD-10-AM code I21). Each patient is counted once only, based on a probabilistically assigned unique patient identifier, which is generated by statistical linkage with a false positive rate of 3 in 1,000 records (0.3%).

Patients with hospitalisations coded as 'STEMI, not specified' (ICD-10-AM I21.9) were excluded from the base model and analysed separately.

The hospital-specific risk-standardised mortality ratio (RSMR) is calculated as the ratio of 'observed' deaths to 'expected' deaths.

Note

This measure does not have a traditional numerator and denominator. Instead, hierarchical logistic regression modelling is used to calculate a hospital-specific RSMR. The measure is based on the ratio of 'observed' to 'expected' mortality for each hospital.

Conceptually, RSMRs allow for a comparison of a particular hospital's performance given its case mix to an average hospital's performance with the same case mix.

RSMRs take into account a range of patient level factors that have been shown to influence the likelihood of dying. For details, see risk adjustment section.

A ratio less than 1.0 indicates lower-than-expected mortality, and a ratio higher than 1.0 indicates higher-than-expected mortality.

Small deviations from 1.0 are not considered to be meaningful either in clinical or organisational performance terms. Funnel plots with 90% control limits, based on a Poisson distribution, are used to identify outliers.

Data source

Data are drawn from the NSW Ministry of Health's Health Information Exchange (HIE), and probabilistically linked by the Centre for Health Record Linkage (CheReL).

Attribution

Regardless of subsequent transfers to other facilities, patients (and if applicable, their deaths) are attributed to the hospital to which they were initially admitted at the start of an acute period of care.† This admission is the starting point for the 30 day interval of interest. If patients had more than one period of care during the specified financial years, their last period of care was selected.

Risk adjustment

For each (de-identified) patient, demographic information and recorded comorbidities were obtained from the Admitted Patients Data Collection (within HIE) extending 12 months prior to, and including, the hospitalisation under consideration (index admission).

A random intercept logistic regression approach was used to develop a risk adjustment model. The model adjusts for patient level risk factors, as well as allowing for some variation around the population mean due to unknown factors beyond the providers' control.[1] Only those variables that were shown to have a significant impact on mortality ($P<0.05$) were retained in the final model. The clinical relevance of the variables in the final model and their direction of association with the outcome were reviewed by clinicians. The model calculates the expected mortality for each hospital.

The final set of risk-adjustment variables were: age, STEMI/non-STEMI status, dementia, Alzheimers, hypotension, shock, renal failure, heart failure, dysrhythmia, malignancy, hypertension and cerebrovascular disease.

Our approach to risk adjustment is consistent with that deemed appropriate for a publicly reported outcome measure in the research literature.[2]

Limits

RSMRs are displayed in a funnel plot.[3] Results that fall beyond the 90% and 95% control limits are flagged.[4]

Extent of Measure Testing

The model's performance was assessed in terms of discriminant ability using the area under the receiver operating characteristic (ROC) curve (C-statistic) - a summary statistic for assessing model performance. The C-statistic is an indicator of the model's discriminant ability, that is, its ability to correctly classify those who have and have not died within 30 days of hospitalisation. C-statistic values can range from 0.5 (no better than chance) to 1.0 (perfect discrimination). Models are typically considered reasonable when the C-statistic is higher than 0.7 and strong when C exceeds 0.8.[5]

(†) Any hospitalisation that consisted of multiple contiguous episodes, a transfer to another hospital and/ or a type-change separation was rolled up into a single period of care.

The model's C-statistic was 0.85

The model was validated by calculating C-statistics for data from previous financial years (2000-2002, 2003-2005 and 2006-2008), and assessing the change to the estimated parameters. The model's performance was stable over the four sets of financial years; the C-statistic was above 0.83 for all four time periods.

Sensitivity analyses on approaches to risk adjustment took the draft set of variables defined by the Australian Commission on Safety and Quality in Health Care[6] as the base model and compared the Charlson comorbidity index and Elixhauser comorbidity set, by calculating C-statistic, the Akaike's information criterion (AIC) and the Bayesian information criterion (BIC). Only those comorbidities that were significant ($P<0.05$) were retained in our final model. In all, 37 comorbidities were considered (see table 1).

The calculated hospital-specific risk-standardised mortality estimates were compared to directly standardised rates (standardised on the basis of age, sex and Charlson comorbidity score); to odds ratios (comparing the odds of mortality for patients in a specific hospital to their odds of dying at an average hospital); and to a stabilised standardised mortality ratio that replaces the observed number of deaths with smoothed observed number of deaths using the developed state level risk adjustment model.[7]

Table 1

- Congestive heart failure
- Cardiac arrhythmia
- Valvular disease
- Pulmonary circulation disorders
- Renal failure
- Liver disease
- Peptic ulcer disease excluding bleeding
- AIDS/HIV
- STEMI/non-STEMI status
- Cerebrovascular disease
- Peripheral vascular disorders
- Hypertension
- Paralysis
- Lymphoma
- Obesity
- Blood loss anaemia
- Deficiency anaemia
- Alcohol abuse
- Alzheimer's
- Dementia
- Other neurological disorders
- Chronic pulmonary disease
- Diabetes uncomplicated
- Diabetes complicated
- Hypothyroidism
- Weight loss
- Fluid and electrolyte disorders
- Hypotension
- Shock
- Dysrhythmia
- Metastatic cancer
- Solid tumor without metastasis
- Rheumatoid arthritis/ collagen
- Coagulopathy
- Drug abuse
- Psychoses
- Depression

References

1. Jones H. and Spiegelhalter D. 2012 The identification of “unusual” health-care providers from a hierarchical model. The American Statistician.

2. Krumholz HM, Wang Y, Mattera JA, Wang Y, Han LF, Ingber MJ, Roman S, Normand SL. An administrative claims model suitable for profiling hospital performance based on 30-day mortality rates among patients with an acute myocardial infarction. Circulation. 2006 Apr 4;113(13):1683-92.

3. Spiegelhalter D. Funnel plots for comparing institutional performance. Statist. Med. 2005; 24:1185–1202.

4. Care Quality Commission. Methodology and information sources used in CQC's new surveillance model for NHS Acute Trusts. July 2013.

5. Hosmer, D. and Lemeshow. Applied Logistic Regression. New York: Wiley, 2012.

6. Australian Commission on Safety and Quality in Health Care. National core, hospital-based outcome indicator specification. Consultation Draft. Sydney, ACSQHC, 2012.

7. Mohammed MA, Manktelow BN, Hofer TP/Comparison of four methods for deriving hospital standardised mortality ratios from a single hierarchical logistic regression model. Stat Methods Med Res. 2012, Nov 6.

30-day mortality (all cause)

Following hospitalisation for ischaemic stroke (risk-standardised mortality ratio)

The condition

An ischaemic stroke occurs when a blood vessel that carries oxygen and nutrients to the brain is blocked by a clot. As a result, the area of the brain supplied by the blood vessel is damaged or dies. The severity and consequences of stroke can vary from no persistent consequences, to severe disability or death.

The indicator

Risk-standardised mortality ratios (RSMRs) can provide important information about healthcare system performance. Variation in mortality, after adjusting for case mix, may reflect differences in hospitals' general environments (such as coordination of care, patient safety policies, and staffing) or variation in care processes.

The cohort for the indicator consists of patients aged 15 years or over who were discharged between 1 July 2009 and 30 June 2012 with an acute, emergency admission for a principal diagnosis of ischaemic stroke (ICD-10 code I63). Each patient is counted once only, based on a probabilistically assigned unique patient identifier, which is generated by statistical linkage with a false positive rate of 3 in 1,000 records (0.3%).

The hospital-specific risk-standardised mortality ratio (RSMR) is calculated as the ratio of 'observed' deaths to 'expected' deaths.

Note

This measure does not have a traditional numerator and denominator. Instead, hierarchical logistic regression modelling is used to calculate a hospital-specific RSMR. The measure is based on the ratio of 'observed' to 'expected' mortality for each hospital.

Conceptually, RSMRs allow for a comparison of a particular hospital's performance given its case mix to an average hospital's performance with the same case mix.

RSMRs take into account a range of patient level factors that have been shown to influence the likelihood of dying. For details, see risk adjustment section.

A ratio less than 1.0 indicates lower-than-expected mortality, and a ratio higher than 1.0 indicates higher-than-expected mortality.

Small deviations from 1.0 are not considered to be meaningful either in clinical or organisational performance terms. Funnel plots with 90% control limits, based on a Poisson distribution, are used to identify outliers.

Data source

Data are drawn from the NSW Ministry of Health's Health Information Exchange (HIE), and probabilistically linked by the Centre for Health Record Linkage (CheReL).

Attribution

Regardless of subsequent transfers to other facilities, patients (and if applicable, their deaths) are attributed to the hospital to which they were initially admitted at the start of an acute period of care.† This admission is the starting point for the 30 day interval of interest. If patients had more than one period of care during the specified financial years, their last period of care was selected.

Risk adjustment

For each (de-identified) patient, demographic information and recorded comorbidities were obtained from the Admitted Patients Data Collection (within HIE) extending 12 months prior to, and including, the hospitalisation under consideration (index admission).

A random intercept logistic regression approach was used to develop a risk adjustment model. The model adjusts for patient level risk factors, as well as allowing for some variation around the population mean due to unknown factors beyond the providers' control.[1] Only those variables that were shown to have a significant impact on mortality ($P<0.05$) were retained in the final model. The clinical relevance of the variables in the final model and their direction of association with the outcome were reviewed by clinicians. The model calculates the expected mortality for each hospital.

The final set of risk-adjustment variables were: age, sex, renal failure, heart failure, and malignancy.

Our approach to risk adjustment is consistent with that deemed appropriate for a publicly reported outcome measure in the research literature.[2]

Limits

RSMRs are displayed in a funnel plot.[3] Results that fall beyond the 90% and 95% control limits are flagged.[4]

Extent of Measure Testing

The model's performance was assessed in terms of discriminant ability using the area under the receiver operating characteristic (ROC) curve (C-statistic) - a summary statistic for assessing model performance. The C-statistic is an indicator of the model's discriminant ability, that is, its ability to correctly classify those who have and have not died within 30 days of hospitalisation. C-statistic values can range from 0.5 (no better than chance) to 1.0 (perfect discrimination). Models are typically considered reasonable when the C-statistic is higher than 0.7 and strong when C exceeds 0.8.[5]

(†) Any hospitalisation that consisted of multiple contiguous episodes, a transfer to another hospital and/ or a type-change separation was rolled up into a single period of care.

The model's C-statistic was 0.74

The model was validated by calculating C-statistics for data from previous financial years (2000-2002, 2003-2005 and 2006-2008), and assessing the change to the estimated parameters. The model's performance was stable over the four sets of financial years; the C-statistic was above 0.69 for all four time periods.

Sensitivity analyses on approaches to risk adjustment took the draft set of variables defined by the Australian Commission on Safety and Quality in Health Care[6] as the base model and compared the Charlson comorbidity index and Elixhauser comorbidity set, by calculating C-statistic, the Akaike's information criterion (AIC) and the Bayesian information criterion (BIC). Only those comorbidities that were significant ($P<0.05$) were retained in our final model. In all, 37 comorbidities were considered (see table 1).

The calculated hospital-specific risk-standardised mortality estimates were compared to directly standardised rates (standardised on the basis of age, sex and Charlson comorbidity score); to odds ratios (comparing the odds of mortality for patients in a specific hospital to their odds of dying at an average hospital); and to a stabilised standardised mortality ratio that replaces the observed number of deaths with smoothed observed number of deaths using the developed state level risk adjustment model.[7]

Table 1

- Congestive heart failure
- Cardiac arrhythmia
- Valvular disease
- Pulmonary circulation disorders
- Renal failure
- Liver disease
- Peptic ulcer disease excluding bleeding
- AIDS/HIV
- STEMI/non-STEMI status
- Cerebrovascular disease
- Peripheral vascular disorders
- Hypertension
- Paralysis
- Lymphoma
- Obesity
- Blood loss anaemia
- Deficiency anaemia
- Alcohol abuse
- Alzheimer's
- Dementia
- Other neurological disorders
- Chronic pulmonary disease
- Diabetes uncomplicated
- Diabetes complicated
- Hypothyroidism
- Weight loss
- Fluid and electrolyte disorders
- Hypotension
- Shock
- Dysrhythmia
- Metastatic cancer
- Solid tumor without metastasis
- Rheumatoid arthritis/ collagen
- Coagulopathy
- Drug abuse
- Psychoses
- Depression

References

1. Jones H. and Spiegelhalter D. 2012 The identification of “unusual” health-care providers from a hierarchical model. The American Statistician.

2. Krumholz HM, Wang Y, Mattera JA, Wang Y, Han LF, Ingber MJ, Roman S, Normand SL. An administrative claims model suitable for profiling hospital performance based on 30-day mortality rates among patients with an acute myocardial infarction. Circulation. 2006 Apr 4;113(13):1683-92.

3. Spiegelhalter D. Funnel plots for comparing institutional performance. Statist. Med. 2005; 24:1185–1202.

4. Care Quality Commission. Methodology and information sources used in CQC's new surveillance model for NHS Acute Trusts. July 2013.

5. Hosmer, D. and Lemeshow. Applied Logistic Regression. New York: Wiley, 2012.

6. Australian Commission on Safety and Quality in Health Care. National core, hospital-based outcome indicator specification. Consultation Draft. Sydney, ACSQHC, 2012.

7. Mohammed MA, Manktelow BN, Hofer TP/Comparison of four methods for deriving hospital standardised mortality ratios from a single hierarchical logistic regression model. Stat Methods Med Res. 2012, Nov 6.

30-day mortality (all cause)

Following hospitalisation for haemorrhagic stroke (risk-standardised mortality ratio)

The condition

A haemorrhagic stroke occurs when a blood vessel that carries oxygen and nutrients to the brain is ruptured. As a result, the area of the brain supplied by the blood vessel is damaged or dies. The severity and consequences of stroke can vary from no persistent consequences, to severe disability or death.

The indicator

Risk-standardised mortality ratios (RSMRs) can provide important information about healthcare system performance. Variation in mortality, after adjusting for case mix, may reflect differences in hospitals' general environments (such as coordination of care, patient safety policies, and staffing) or variation in care processes.

The cohort for the indicator consists of patients aged 15 years or over who were discharged between 1 July 2009 and 30 June 2012 with an acute, emergency admission for a principal diagnosis of haemorrhagic stroke (ICD-10 code I61, I62). Each patient is counted once only, based on a probabilistically assigned unique patient identifier, which is generated by statistical linkage with a false positive rate of 3 in 1,000 records (0.3%).

The hospital-specific risk-standardised mortality ratio (RSMR) is calculated as the ratio of 'observed' deaths to 'expected' deaths.

Note

This measure does not have a traditional numerator and denominator. Instead, hierarchical logistic regression modelling is used to calculate a hospital-specific RSMR. The measure is based on the ratio of 'observed' to 'expected' mortality for each hospital.

Conceptually, RSMRs allow for a comparison of a particular hospital's performance given its case mix to an average hospital's performance with the same case mix.

RSMRs take into account a range of patient level factors that have been shown to influence the likelihood of dying. For details, see risk adjustment section.

A ratio less than 1.0 indicates lower-than-expected mortality, and a ratio higher than 1.0 indicates higher-than-expected mortality.

Small deviations from 1.0 are not considered to be meaningful either in clinical or organisational performance terms. Funnel plots with 90% control limits, based on a Poisson distribution, are used to identify outliers.

Data source

Data are drawn from the NSW Ministry of Health's Health Information Exchange (HIE), and probabilistically linked by the Centre for Health Record Linkage (CheReL).

Attribution

Regardless of subsequent transfers to other facilities, patients (and if applicable, their deaths) are attributed to the hospital to which they were initially admitted at the start of an acute period of care.† This admission is the starting point for the 30 day interval of interest. If patients had more than one period of care during the specified financial years, their last period of care was selected.

Risk adjustment

For each (de-identified) patient, demographic information and recorded comorbidities were obtained from the Admitted Patients Data Collection (within HIE) extending 12 months prior to, and including, the hospitalisation under consideration (index admission).

A random intercept logistic regression approach was used to develop a risk adjustment model. The model adjusts for patient level risk factors, as well as allowing for some variation around the population mean due to unknown factors beyond the providers' control.[1] Only those variables that were shown to have a significant impact on mortality ($P<0.05$) were retained in the final model. The clinical relevance of the variables in the final model and their direction of association with the outcome were reviewed by clinicians. The model calculates the expected mortality for each hospital.

The final set of risk-adjustment variables were: age, sex, history of haemorrhagic stroke, heart failure, and malignancy.

Our approach to risk adjustment is consistent with that deemed appropriate for a publicly reported outcome measure in the research literature.[2]

Limits

RSMRs are displayed in a funnel plot.[3] Results that fall beyond the 90% and 95% control limits are flagged.[4]

Extent of Measure Testing

The model's performance was assessed in terms of discriminant ability using the area under the receiver operating characteristic (ROC) curve (C-statistic) - a summary statistic for assessing model performance. The C-statistic is an indicator of the model's discriminant ability, that is, its ability to correctly classify those who have and have not died within 30 days of hospitalisation. C-statistic values can range from 0.5 (no better than chance) to 1.0 (perfect discrimination). Models are typically considered reasonable when the C-statistic is higher than 0.7 and strong when C exceeds 0.8.[5]

(†) Any hospitalisation that consisted of multiple contiguous episodes, a transfer to another hospital and/ or a type-change separation was rolled up into a single period of care.

The model's C-statistic was 0.68

The model was validated by calculating C-statistics for data from previous financial years (2000-2002, 2003-2005 and 2006-2008), and assessing the change to the estimated parameters. The model's performance was stable over the four sets of financial years; the C-statistic was above 0.65 for all four time periods.

Sensitivity analyses on approaches to risk adjustment took the draft set of variables defined by the Australian Commission on Safety and Quality in Health Care[6] as the base model and compared the Charlson comorbidity index and Elixhauser comorbidity set, by calculating C-statistic, the Akaike's information criterion (AIC) and the Bayesian information criterion (BIC). Only those comorbidities that were significant ($P<0.05$) were retained in our final model. In all, 37 comorbidities were considered (see table 1).

The calculated hospital-specific risk-standardised mortality estimates were compared to directly standardised rates (standardised on the basis of age, sex and Charlson comorbidity score); to odds ratios (comparing the odds of mortality for patients in a specific hospital to their odds of dying at an average hospital); and to a stabilised standardised mortality ratio that replaces the observed number of deaths with smoothed observed number of deaths using the developed state level risk adjustment model.[7]

Table 1

- Congestive heart failure
- Cardiac arrhythmia
- Valvular disease
- Pulmonary circulation disorders
- Renal failure
- Liver disease
- Peptic ulcer disease excluding bleeding
- AIDS/HIV
- STEMI/non-STEMI status
- Cerebrovascular disease
- Peripheral vascular disorders
- Hypertension
- Paralysis
- Lymphoma
- Obesity
- Blood loss anaemia
- Deficiency anaemia
- Alcohol abuse
- Alzheimer's
- Dementia
- Other neurological disorders
- Chronic pulmonary disease
- Diabetes uncomplicated
- Diabetes complicated
- Hypothyroidism
- Weight loss
- Fluid and electrolyte disorders
- Hypotension
- Shock
- Dysrhythmia
- Metastatic cancer
- Solid tumor without metastasis
- Rheumatoid arthritis/ collagen
- Coagulopathy
- Drug abuse
- Psychoses
- Depression

References

1. Jones H. and Spiegelhalter D. 2012 The identification of “unusual” health-care providers from a hierarchical model. The American Statistician.

2. Krumholz HM, Wang Y, Mattera JA, Wang Y, Han LF, Ingber MJ, Roman S, Normand SL. An administrative claims model suitable for profiling hospital performance based on 30-day mortality rates among patients with an acute myocardial infarction. Circulation. 2006 Apr 4;113(13):1683-92.

3. Spiegelhalter D. Funnel plots for comparing institutional performance. Statist. Med. 2005; 24:1185–1202.

4. Care Quality Commission. Methodology and information sources used in CQC's new surveillance model for NHS Acute Trusts. July 2013.

5. Hosmer, D. and Lemeshow. Applied Logistic Regression. New York: Wiley, 2012.

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7. Mohammed MA, Manktelow BN, Hofer TP/Comparison of four methods for deriving hospital standardised mortality ratios from a single hierarchical logistic regression model. Stat Methods Med Res. 2012, Nov 6.

30-day mortality (all cause)

Following hospitalisation for pneumonia (risk-standardised mortality ratio)

The condition

Pneumonia is an inflammatory condition of one or both lungs, usually due to infection. Symptoms may include fever, chills, cough with sputum production, chest pain, and shortness of breath.

The indicator

Risk-standardised mortality ratios (RSMRs) can provide important information about healthcare system performance. Variation in mortality, after adjusting for case mix, may reflect differences in hospitals' general environments (such as coordination of care, patient safety policies, and staffing) or variation in care processes.

The cohort for the indicator consists of patients aged 18 years or over who were discharged between 1 July 2009 and 30 June 2012 with an emergency type of admission for a principal diagnosis of pneumonia (ICD-10 codes J13, J14, J15, J16, J18). Each patient is counted once only, based on a probabilistically assigned unique patient identifier, which is generated by statistical linkage with a false positive rate of 3 in 1,000 records (0.3%).

The hospital-specific risk-standardised mortality ratio (RSMR) is calculated as the ratio of 'observed' deaths to 'expected' deaths.

Note

This measure does not have a traditional numerator and denominator. Instead, hierarchical logistic regression modelling is used to calculate a hospital-specific RSMR. The measure is based on the ratio of 'observed' to 'expected' mortality for each hospital.

Conceptually, RSMRs allow for a comparison of a particular hospital's performance given its case mix to an average hospital's performance with the same case mix.

RSMRs take into account a range of patient level factors that have been shown to influence the likelihood of dying. For details, see risk adjustment section.

A ratio less than 1.0 indicates lower-than-expected mortality, and a ratio higher than 1.0 indicates higher-than-expected mortality.

Small deviations from 1.0 are not considered to be meaningful either in clinical or organisational performance terms. Funnel plots with 90% control limits, based on a Poisson distribution, are used to identify outliers.

Data source

Data are drawn from the NSW Ministry of Health's Health Information Exchange (HIE), and probabilistically linked by the Centre for Health Record Linkage (CheReL).

Attribution

Regardless of subsequent transfers to other facilities, patients (and if applicable, their deaths) are attributed to the hospital to which they were initially admitted at the start of an acute period of care.† This admission is the starting point for the 30 day interval of interest. If patients had more than one period of care during the specified financial years, their last period of care was selected.

Risk adjustment

For each (de-identified) patient, demographic information and recorded comorbidities were obtained from the Admitted Patients Data Collection (within HIE) extending 12 months prior to, and including, the hospitalisation under consideration (index admission).

A random intercept logistic regression approach was used to develop a risk adjustment model. The model adjusts for patient level risk factors, as well as allowing for some variation around the population mean due to unknown factors beyond the providers' control.[1] Only those variables that were shown to have a significant impact on mortality ($P<0.05$) were retained in the final model. The clinical relevance of the variables in the final model and their direction of association with the outcome were reviewed by clinicians. The model calculates the expected mortality for each hospital.

The final set of risk-adjustment variables were: age, dementia, hypotension, shock, renal failure, other chronic obstructive pulmonary disease, heart failure, dysrhythmia, malignancy, liver disease, hypertension, cerebrovascular disease and Parkinson's disease.

Our approach to risk adjustment is consistent with that deemed appropriate for a publicly reported outcome measure in the research literature.[2]

Limits

RSMRs are displayed in a funnel plot.[3] Results that fall beyond the 90% and 95% control limits are flagged.[4]

Extent of Measure Testing

The model's performance was assessed in terms of discriminant ability using the area under the receiver operating characteristic (ROC) curve (C-statistic) - a summary statistic for assessing model performance. The C-statistic is an indicator of the model's discriminant ability, that is, its ability to correctly classify those who have and have not died within 30 days of hospitalisation. C-statistic values can range from 0.5 (no better than chance) to 1.0 (perfect discrimination). Models are typically considered reasonable when the C-statistic is higher than 0.7 and strong when C exceeds 0.8.[5]

(†) Any hospitalisation that consisted of multiple contiguous episodes, a transfer to another hospital and/ or a type-change separation was rolled up into a single period of care.

The model's C-statistic was 0.83

The model was validated by calculating C-statistics for data from previous financial years (2000-2002, 2003-2005 and 2006-2008), and assessing the change to the estimated parameters. The model's performance was stable over the four sets of financial years; the C-statistic was above 0.80 for all four time periods.

Sensitivity analyses on approaches to risk adjustment took the draft set of variables defined by the Australian Commission on Safety and Quality in Health Care[6] as the base model and compared the Charlson comorbidity index and Elixhauser comorbidity set, by calculating C-statistic, the Akaike's information criterion (AIC) and the Bayesian information criterion (BIC). Only those comorbidities that were significant ($P<0.05$) were retained in our final model. In all, 37 comorbidities were considered (see table 1).

The calculated hospital-specific risk-standardised mortality estimates were compared to directly standardised rates (standardised on the basis of age, sex and Charlson comorbidity score); to odds ratios (comparing the odds of mortality for patients in a specific hospital to their odds of dying at an average hospital); and to a stabilised standardised mortality ratio that replaces the observed number of deaths with smoothed observed number of deaths using the developed state level risk adjustment model.[7]

Table 1

- Congestive heart failure
- Cardiac arrhythmia
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- Paralysis
- Lymphoma
- Obesity
- Blood loss anaemia
- Deficiency anaemia
- Alcohol abuse
- Alzheimer's
- Dementia
- Other neurological disorders
- Chronic pulmonary disease
- Diabetes uncomplicated
- Diabetes complicated
- Hypothyroidism
- Weight loss
- Fluid and electrolyte disorders
- Hypotension
- Shock
- Dysrhythmia
- Metastatic cancer
- Solid tumor without metastasis
- Rheumatoid arthritis/ collagen
- Coagulopathy
- Drug abuse
- Psychoses
- Depression

References

1. Jones H. and Spiegelhalter D. 2012 The identification of “unusual” health-care providers from a hierarchical model. The American Statistician.

2. Krumholz HM, Wang Y, Mattera JA, Wang Y, Han LF, Ingber MJ, Roman S, Normand SL. An administrative claims model suitable for profiling hospital performance based on 30-day mortality rates among patients with an acute myocardial infarction. Circulation. 2006 Apr 4;113(13):1683-92.

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6. Australian Commission on Safety and Quality in Health Care. National core, hospital-based outcome indicator specification. Consultation Draft. Sydney, ACSQHC, 2012.

7. Mohammed MA, Manktelow BN, Hofer TP/Comparison of four methods for deriving hospital standardised mortality ratios from a single hierarchical logistic regression model. Stat Methods Med Res. 2012, Nov 6.

30-day mortality (all cause)

Following hospitalisation for hip fracture (risk-standardised mortality ratio)

The condition

Hip fracture refers to a fracture of the femur within 5 cm of the distal (lower) part of the lesser trochanter. Numerous subdivisions and classification methods exist for these fractures. Hip fractures may occur at any age but are most common in elderly people. There are two main risk factors, both associated with ageing: increased risk of falling, and loss of skeletal strength from osteoporosis.[1]

The indicator

Risk-standardised mortality ratios (RSMRs) can provide important information about healthcare system performance. Variation in mortality, after adjusting for case mix, may reflect differences in hospitals' general environments (such as coordination of care, patient safety policies, and staffing) or variation in care processes.

Risk-standardised mortality ratios (RSMRs) can provide important information about healthcare system performance. Variation in mortality, after adjusting for case mix, may reflect differences in hospitals' general environments (such as coordination of care, patient safety policies, and staffing) or variation in care processes. The cohort for the indicator consists of patients aged 50 years or over who were discharged between 1 July 2009 and 30 June 2012 with an emergency type of admission for a principal diagnosis of hip fracture (ICD-10 codes S72.0, S72.1, S72.2), and the following procedure codes (procedure block): 47519-00 (1479) - Internal fixation of # of trochanteric or subcapital femur; 47522-00 (1489) - Hemiarthoplasty of femur; 47528-01 (1486) - Open reduction of fracture of femur; 47531-00 (1486) - Closed reduction of fracture of femur with internal fixation 49315-00 (1489) - Partial arthroplasty of hip; *49318-00 (1489)-Total arthroplasty of hip; *49319-00 (1489)- Total arthroplasty of hip bilateral ;* these procedures are only included if combined with one of the following Uastalian Diagnostic Related Groups(AR_DRGs) : 'I03B' , 'I08B' , 'I78B' , 'I08A' ,, 'I03A' , 'I78A , 'I73A' , 'Z63A'.

Only patients with fall related fracture i.e. External cause fall (W00-W19) or Tendency to fall (R29.6) are included. Each patient is counted once only, based on a probabilistically assigned unique patient identifier, which is generated by statistical linkage with a false positive rate of 3 in 1,000 records (0.3%).

The hospital-specific risk-standardised mortality ratio (RSMR) is calculated as the ratio of ‘observed’ deaths to ‘expected’ deaths.

Data source

Data are drawn from the NSW Ministry of Health's Health Information Exchange (HIE), and probabilistically linked by the Centre for Health Record Linkage (CheReL).

Attribution

Regardless of subsequent transfers to other facilities, patients (and if applicable, their deaths) are attributed to the hospital to which they were initially admitted at the start of an acute period of care.† This admission is the starting point for the 30 day interval of interest. If patients had more than one period of care during the specified financial years, their last period of care was selected.

Note

This measure does not have a traditional numerator and denominator. Instead, hierarchical logistic regression modelling is used to calculate a hospital-specific RSMR. The measure is based on the ratio of 'observed' to 'expected' mortality for each hospital.

Conceptually, RSMRs allow for a comparison of a particular hospital's performance given its case mix to an average hospital's performance with the same case mix.

RSMRs take into account a range of patient level factors that have been shown to influence the likelihood of dying. For details, see risk adjustment section.

A ratio less than 1.0 indicates lower-than-expected mortality, and a ratio higher than 1.0 indicates higher-than-expected mortality.

Small deviations from 1.0 are not considered to be meaningful either in clinical or organisational performance terms. Funnel plots with 90% control limits, based on a Poisson distribution, are used to identify outliers.

(†) Any hospitalisation that consisted of multiple contiguous episodes, a transfer to another hospital and/ or a type-change separation was rolled up into a single period of care.

Risk adjustment

For each (de-identified) patient, demographic information and recorded comorbidities were obtained from the Admitted Patients Data Collection (within HIE) extending 12 months prior to, and including, the hospitalisation under consideration (index admission).

A random intercept logistic regression approach was used to develop a risk adjustment model. The model adjusts for patient level risk factors, as well as allowing for some variation around the population mean due to unknown factors beyond the providers' control.[2] Only those variables that were shown to have a significant impact on mortality ($P<0.05$) were retained in the final model. The clinical relevance of the variables in the final model and their direction of association with the outcome were reviewed by clinicians. The model calculates the expected mortality for each hospital.

The final set of risk-adjustment variables were: age, sex, ischaemic heart disease, dysrhythmia, congestive heart failure, acute respiratory tract infection, renal failure, dementia, malignancy.

Our approach to risk adjustment is consistent with that deemed appropriate for a publicly reported outcome measure in the research literature.[3]

Limits

RSMRs are displayed in a funnel plot.[4] Results that fall beyond the 90% and 95% control limits are flagged.[5]

Extent of Measure Testing

The model's performance was assessed in terms of discriminant ability using the area under the receiver operating characteristic (ROC) curve (C-statistic) - a summary statistic for assessing model performance. The C-statistic is an indicator of the model's discriminant ability, that is, its ability to correctly classify those who have and have not died within 30 days of hospitalisation. C-statistic values can range from 0.5 (no better than chance) to 1.0 (perfect discrimination). Models are typically considered reasonable when the C-statistic is higher than 0.7 and strong when C exceeds 0.8.[6]

The model's C-statistic was 0.77

The model was validated by calculating C-statistics for data from previous financial years (2000-2002, 2003-2005 and 2006-2008), and assessing the change to the estimated parameters. The model's performance was stable over the four sets of financial years; the C-statistic was above 0.75 for all four time periods.

Sensitivity analyses on approaches to risk adjustment took the draft set of variables defined by the Australian Commission on Safety and Quality in Health Care[7] as the base model and compared the Charlson comorbidity index and Elixhauser comorbidity set, by calculating C-statistic, the Akaike's information criterion (AIC) and the Bayesian information criterion (BIC). Only those comorbidities that were significant ($P<0.05$) were retained in our final model. In all, 37 comorbidities were considered (see table 1).

The calculated hospital-specific risk-standardised mortality estimates were compared to directly standardised rates (standardised on the basis of age, sex and Charlson comorbidity score); to odds ratios (comparing the odds of mortality for patients in a specific hospital to their odds of dying at an average hospital); and to a stabilised standardised mortality ratio that replaces the observed number of deaths with smoothed observed number of deaths using the developed state level risk adjustment model.[8]

Table 1

- Congestive heart failure
- Cardiac arrhythmia
- Valvular disease
- Pulmonary circulation disorders
- Renal failure
- Liver disease
- Peptic ulcer disease excluding bleeding
- AIDS/HIV
- STEMI/non-STEMI status
- Cerebrovascular disease
- Peripheral vascular disorders
- Hypertension
- Paralysis
- Lymphoma
- Obesity
- Blood loss anaemia
- Deficiency anaemia
- Alcohol abuse
- Alzheimer's
- Dementia
- Other neurological disorders
- Chronic pulmonary disease
- Diabetes uncomplicated
- Diabetes complicated
- Hypothyroidism
- Weight loss
- Fluid and electrolyte disorders
- Hypotension
- Shock
- Dysrhythmia
- Metastatic cancer
- Solid tumor without metastasis
- Rheumatoid arthritis/ collagen
- Coagulopathy
- Drug abuse
- Psychoses
- Depression

References

1. Gillespie W (2001) Hip fracture BMJ. 2001 April 21; 322(7292): 968–975.
2. Jones H. and Spiegelhalter D. 2012 The identification of “unusual” health-care providers from a hierarchical model. The American Statistician.
3. Krumholz HM, Wang Y, Mattera JA, Wang Y, Han LF, Ingber MJ, Roman S, Normand SL. An administrative claims model suitable for profiling hospital performance based on 30-day mortality rates among patients with an acute myocardial infarction. Circulation. 2006 Apr 4;113(13):1683-92.
4. Spiegelhalter D. Funnel plots for comparing institutional performance. Statist. Med. 2005; 24:1185–1202.
5. Care Quality Commission. Methodology and information sources used in CQC's new surveillance model for NHS Acute Trusts. July 2013.
6. Hosmer, D. and Lemeshow. Applied Logistic Regression. New York: Wiley, 2012.
7. Australian Commission on Safety and Quality in Health Care. National core, hospital-based outcome indicator specification. Consultation Draft. Sydney, ACSQHC, 2012.
8. Mohammed MA, Manktelow BN, Hofer TP/Comparison of four methods for deriving hospital standardised mortality ratios from a single hierarchical logistic regression model. Stat Methods Med Res. 2012, Nov 6.

About the Bureau

The Bureau of Health Information provides the community, healthcare professionals and the NSW Parliament with timely, accurate and comparable information on the performance of the NSW public health system in ways that enhance the system's accountability and inform efforts to increase its beneficial impact on the health and wellbeing of the people of NSW.

The Bureau is an independent, board-governed statutory health corporation. The conclusions in this report are those of the Bureau and no official endorsement by the NSW Minister for Health, the NSW Ministry of Health or any other NSW statutory health corporation is intended or should be inferred.

To contact the Bureau of Health Information

Telephone: +61 2 8644 2100
Fax: +61 2 8644 2119
Email: enquiries@bhi.nsw.gov.au
Postal address:
PO Box 1770, Chatswood
New South Wales 2057, Australia
Web: **www.bhi.nsw.gov.au**