bureau of health information

Spotlight on Measurement

Return to acute care following hospitalisation

Spotlight on readmissions

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State Health Publication Number: (BHI)150404
ISBN: 978-1-76000-237-4
ISSN: 2204-1958

Suggested citation:
Bureau of Health Information. *Spotlight on Measurement: Return to acute care following hospitalisation, Spotlight on Readmissions*
Sydney (NSW); BHI; 2015.

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Published June 2015

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Summary

Why measure and report on variation in hospital readmissions?

Hospital readmissions are an important performance measure that can be used as an indicator in both clinical practice and health service management. Unplanned readmissions have been used to identify areas for improvement in hospital care, in primary care, and in transitions between the two.

Generic rates of readmission following an acute hospitalisation, the main reason for that hospitalisation, have been reported previously in NSW. Such generic measures provide some broad information about performance. Clinical relevance and actionability are however, greatly enhanced with more specific or focused measures such as the risk standardised readmission ratio (RSRR) described in this report. RSRRs provide specificity by assessing separately the results for patients with a particular condition, or who are undergoing a certain procedure. They provide a focus on the clinically relevant acute phase of patient care – measuring and reporting readmissions in terms of patient 'returns to acute care'.

What is a readmission? What is a return to acute care?

The readmission metric developed in this report uses returns to acute care as the outcome of interest. It measures hospitalisations to acute care that occur shortly after discharge from an 'index hospitalisation'. For precision, this report and the accompanying edition of *The Insights Series* refer to the measure as 'return to acute care'. For patients whose acute index hospitalisation ends with discharge home, a return to acute care involves readmission to hospital; while for patients whose acute index hospitalisation ends with a 'discharge' to non-acute care, a return involves a move back into an acute care setting.

The return to acute care analyses in this report differ slightly on the basis of whether they focus on clinical conditions or on elective surgical procedures. For returns to acute care following hospitalisation for one of five clinical conditions (acute myocardial infarction, ischaemic stroke, congestive heart failure, pneumonia and hip fracture surgery), the follow-up period is 30 days. For returns to acute care following hospitalisation for two elective surgical procedures (total hip or total knee replacement) the follow-up period is 60 days.

The work that underpins this report is based on linked patient data and so the analyses capture returns to acute care that occur either to the same hospital as the index hospitalisation or to a different hospital.

The measure is concerned with 'unplanned' returns to acute care, that is, those that would not generally be expected to occur in the course of a patient's recovery following hospitalisation. The return to acute care is attributed to the hospital that discharged the patient from the acute index hospitalisation, either home or to a non-acute care setting.

How to measure returns to acute care in a fair and balanced way?

Simple counts of the proportion of hospital discharges that are followed by a readmission within 30 days are not sensitive to the complex mix of patient-level factors or case mix that influence the likelihood of a patient returning to acute care. As such, they are not generally regarded to be fair measures of hospital performance.

Internationally, there is growing use of risk-standardised readmission ratios (RSRRs). This is an approach that focuses on variation in readmission patterns across hospitals, after taking into account case mix and patient-level factors. The RSRR, initially developed in the USA, has been adapted by BHI for use in a NSW context, and focuses on returns to acute care.

The RSRR method calculates the expected number of returns to acute care for each hospital in light of its particular case mix, and compares that to

the observed number of returns to acute care. Results are interpreted using a funnel plot with 95% and 99.8% control limits, so as not to over-interpret random variation that can occur with small volumes of patients. RSRRs cannot be used to directly compare performance between hospitals. Conceptually, the RSRR method supports comparisons between a particular hospital's results, given its case mix, and a NSW 'average' hospital's results with the same case mix.

The RSRR method provides a means to highlight differences that are the result of different local practices such as models of care, clinical decision-making and the extent of integration across healthcare providers. In the NSW context, it is designed to be a screening tool – identifying areas of excellence and providing opportunities for learning as well as areas for further investigation and potential improvement.

Key concepts and definitions in the RSRR method adapted for use in NSW

Index hospitalisation: the starting point for analysing repeat hospital visits. The principal diagnosis recorded in the hospital record is used to identify patients admitted with the condition of interest.

Period of care: an acute hospitalisation event as experienced by a patient. It concatenates all acute, contiguous hospitalisations, clustering transfers into a single unit of analysis.

Unplanned hospitalisations: RSRRs are a measure of 'unplanned' readmissions to acute care. In administrative urgency categories, an 'emergency' hospitalisation generally refers to an unplanned admission. Emergency hospitalisations are for patients who, in the opinion of the treating clinician, require care or treatment within 24 hours.*

Return to acute care: an unplanned or emergency acute hospitalisation (in the same or a different hospital) within the 30-day (or for some surgical hospitalisations within the 60-day) period following discharge from an index acute hospitalisation. In many jurisdictions returns to acute care are referred to as unplanned readmissions. Return to acute care is a more precise term.

Attribution: outcomes are attributed to the hospital that discharges patients from acute care.

Reasons for return to acute care: categorisation of the principal diagnoses for the return to acute care episode, stratified as:

- the same as the index hospitalisation
- related to that of the index hospitalisation
- potentially related to hospital care (i.e. complications and adverse events) using various time horizons
- other.

Same-day returns to acute care: patients who, according to the administrative records, return to acute care on the same-day that they were discharged from an index hospitalisation are considered to be transfers and are included in the index hospitalisation's period of care. This follows extensive investigation of records in NSW, which showed that administrative records were not accurately capturing patient dispositions in the case of transfers to other hospitals or to services like hospital in the home.

* On the advice of clinicians and following sensitivity testing, returns to acute care following elective procedures included non-emergency readmissions. This enabled the RSRR to capture hospitalisations related to orthopaedic complications such as joint manipulation and wound debridement, which are often categorised as non-emergency (i.e., they do not require treatment within 24 hours). Non-emergency hospitalisations for common, scheduled procedures such as haemodialysis, chemotherapy and cataract surgery were however excluded.

About the *Spotlight on Measurement* series

Spotlight on Measurement is a series of reports that reflects on methodological developments made in the course of BHI analyses.

Reports in this series generally provide two key types of background information. First, they outline the rationale for use of a candidate indicator in healthcare performance reporting, discussing its relative strengths and weaknesses. Second, they describe the analytic steps taken to validate the indicator and explore its sensitivity, specificity and application in a NSW context.

The series represents the main vehicle for BHI to share these important developments with academic and governmental institutions and provides an opportunity to explore, in a transparent way, the relative strengths and limitations of measures used to report on various aspects of performance.

This edition focuses on the use of risk standardised readmission ratios (RSRRs) to measure variation in performance across NSW public hospitals for five clinical conditions and two elective surgical procedures. It is published alongside an edition of *The Insights Series* which applies the developed measure to report state and hospital level results.

Why measure readmissions?

Why are readmissions important in performance measurement and reporting?

What approaches are available to measure readmissions?

What indicator has been developed for use in BHI's analyses?

Introduction

Context and background

Across healthcare systems internationally, rates of unplanned readmission are increasingly used to measure and report on healthcare performance and quality.[1-3]

The justifications for using readmissions as a performance measure are multiple. First, from a patient perspective, returning to hospital soon after discharge is disruptive and stressful – and so minimising the need for readmission is a patient-centred goal. Second, from a hospital perspective, readmission rates can highlight areas where there are opportunities to improve care – in discharge planning, coordinating care, reducing complication rates, or in integrating care with providers outside the hospital setting. Third, from a system perspective, readmissions can be costly and unpredictable – affecting work flows, bed occupancy and availability, productivity and efficiency.

Conceptually meaningful, readmission rates appear to be obvious candidates for performance reporting and comparison efforts. However, while readmissions may seem to be straightforward to measure, they require considerable care both in analytic approach and in interpretation of results if they are to provide a fair picture of performance.

Simple counts of the proportion of hospital discharges followed by a readmission within 30 days are not sensitive to the complex mix of factors that shape readmission rates. These include patient-associated factors such as age, health status, social support arrangements, health literacy and disease progression; as well as healthcare-associated factors such as hospital treatment and discharge processes, availability of alternative outpatient models of care, and integration of services across community and hospital settings (Figure 1).

While there is a convincing case for minimising unnecessary unplanned readmissions – from a patient, a hospital and a system perspective – it is important to acknowledge that not all readmissions are avoidable. Many are necessary for high-quality care.

Measuring and comparing unplanned readmission rates in a fair and balanced way in light of this complexity is challenging. Measurement efforts that seek to compare hospital performance should focus on variation, taking into account case mix and patient-level factors known to be associated with readmission.

This edition of *Spotlight on Measurement* describes the development and evaluation of statistical methods in preparation for the public reporting of a specific measure of readmissions - emergency returns to acute care to NSW public hospitals.

The methods described in this report calculate, for each hospital, the expected number of returns to acute care – after taking account of important patient characteristics known to affect the rate of return – and compares that figure to the observed number of returns to acute care, expressed as a risk standardised readmission ratio (RSRR).

The development of an RSRR methodology for use in NSW provides an important hospital-based outcome measure. A preventable, emergency return to acute care may result from a variety of healthcare factors, including premature hospital discharge, inadequate preparation of the patient or their family for discharge, complications that manifest after discharge, or poor care transitions back to community settings.

While the RSRR has many advantages, it should be used judiciously. No single measure can entirely capture performance. Its interpretation should be informed by complementary measures of performance, including other outcome indicators (e.g. mortality); activity measures (e.g. length of stay); and process measures (e.g. compliance with guideline recommended care).

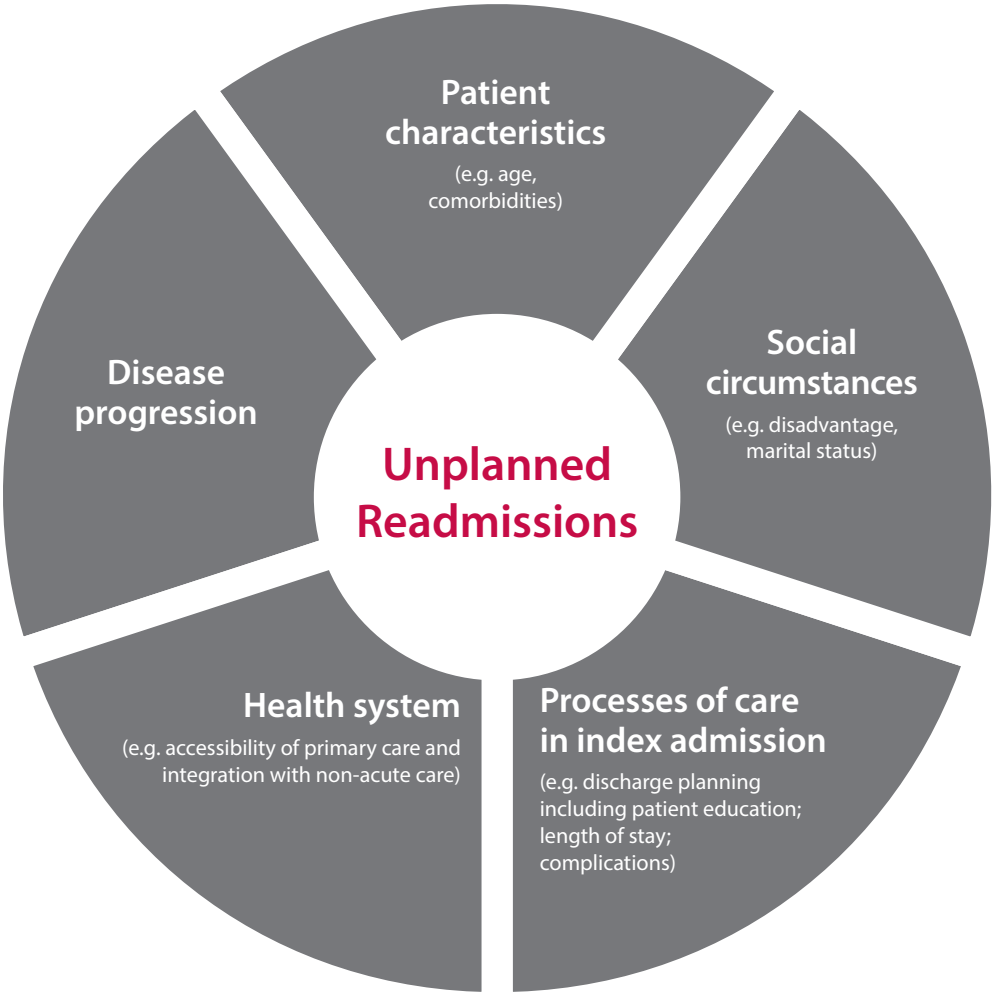
Seven sets of analyses: five clinical conditions and two elective surgical procedures

The measures described in this report focus on five clinical conditions (acute myocardial infarction, ischaemic stroke, congestive heart failure, pneumonia and hip fracture surgery) and two surgical procedures (total hip or total knee replacements). The clinical conditions are usually acute unplanned hospitalisations while total hip or total knee replacements are elective surgical hospitalisations. These conditions and surgical procedures are important and prevalent causes of hospitalisation, and together resulted in 15,400 returns to acute care – or around 13% of all acute, overnight, emergency returns to acute care among patients aged 15 years or over who were discharged from NSW public hospitals between July 2009 and June 2012.

The conditions included in the report provide insights into many different elements of healthcare in NSW and span differences in patient characteristics, acuity and prognosis; different care pathways and patient trajectories; and various settings and care types.

Reporting return to acute care data for specific conditions or procedures can inform local review processes, and help identify opportunities for improvement.

Figure 1 Factors influencing unplanned readmissions



Developing a measure of readmissions – return to acute care – for use in NSW

Readmission measurement approaches in other healthcare systems

Recognising the potential benefits that can flow from using readmissions as an outcome indicator, BHI sought to develop a measure appropriate for use in a NSW context.

Seven criteria were used to guide the selection and development of a measure of readmissions for public reporting purposes in NSW: relevance, actionability, appropriateness, specificity, sensitivity, synergy with other performance measures, and timeliness (Figure 2).

Healthcare systems have seen a heightened and sustained interest in measuring and reporting hospital-level variation in unplanned readmissions.[1-3] The measures in use vary in terms of definitions and reporting regimes (Figure 3).[4-7]

In December 2013 BHI published a report on 30-day mortality following hospitalisation for five clinical conditions (acute myocardial infarction, ischaemic stroke, haemorrhagic stroke, pneumonia and hip fracture surgery), based on risk standardised mortality ratios (RSMRs). Drawing on research undertaken by a team at Yale University in the US on behalf of the Centers for Medicare & Medicaid Services (CMS), RSMRs express for each hospital a ratio of the 'observed' number of deaths to the 'expected' number of deaths.

Researchers at Yale University used a similar method for use in assessing readmissions – a risk-standardised readmission ratio (RSRR).

This formed the starting point for the BHI development work. BHI adapted the RSRR measure for application in a NSW context, informed by the wider research literature and advice from local clinical and improvement experts. This report details the steps taken in the development of the RSRR for NSW.

Figure 2 Selection criteria for indicators for public reporting purposes

Criteria	Details
Relevance: measures an element of performance that is meaningful clinically, has implications for the organisation or efficiency of care, and makes a difference to patients	Unplanned readmissions are widely used to reflect on a meaningful element of healthcare performance.
Actionability: informs improvement locally	Clinically focused single condition-based measures are more meaningful and help guide change locally. Single condition measures are generally preferred to aggregate readmission indicators.
Appropriateness: makes comparisons to the NSW state-wide cohort, rather than an absolute measure of readmission rate	Use of an indirect standardisation approach, where each hospital's results are reported relative to that of the state as a whole, is preferred over approaches that encourage direct comparisons between hospitals and league tables.
Specificity: minimises 'noise', random variation or false positive results	Risk standardisation, based on patient characteristics are required. Seek methods that are compatible with use of funnel plot or similar approach to take account of different volumes.
Sensitivity: the ability to capture meaningful variation across different sized hospitals (sensitive)	Use of a method able to discriminate relatively good and poor performance at a hospital level, in light of patient mix and volume differences. A 'screening tool' method is preferred that highlights potential issues for investigation at a local level.
Synergy with other performance measures: makes a contribution to a broader set of indicators that together provide insights into performance	Compatible and coherent with other performance measures, such as 30-day mortality, length of stay, patient survey data.
Timeliness: provides timely information to clinicians and managers	Measure can be calculated with minimal delays.

Figure 3 **Specifications for public reported readmission measures across international jurisdictions (risk standardised and contiguous hospitalisations)**

Agency	USA Centers for Medicare & Medicaid Services[6,7]	Canadian Institute for Health Information[5]	England Health & Social Care Information Centre[4]
Measure	Risk standardised readmission rate (RSRR)	Risk adjusted rate (RAR)	Risk standardised percentage rate (ISR) per 100,000 registered patients
Definition	30-day all cause unplanned readmission, as measured from the date of discharge of the index admission to a non-acute care setting	The rate of urgent readmissions within 28-90 days of discharge (general vs. condition-specific)	Emergency admissions within 30 days of discharge from hospital
Diagnoses	• acute myocardial infarction • ischaemic stroke • congestive heart failure • pneumonia • elective hip and knee replacement • chronic obstructive pulmonary disease • hospital wide readmission	• overall • surgical • medical • obstetric • 19 years and younger • acute myocardial infarction • stroke • elective knee replacement • elective hip replacement	All within selected surgical and medical groups (except cancer and obstetrics)
Care type	Acute	Acute (exception stroke: which includes contiguous rehabilitation stay)	All hospital episodes (all continuous consultant episodes)
Cohort inclusions	65+ year olds enrolled in Medicare. Veterans Affairs beneficiaries also included for AMI, heart failure and pneumonia	29 days+, participating hospitals	All
Cohort exclusions	Deaths in-hospital, discharges against medical advice, patients without at least 30 days of follow-up, admissions within 30 days are considered as readmissions only and are excluded from the index cohort	Deaths in-hospital, discharges against medical advice	Day cases, spells with a discharge coded as death, maternity spells (based on specialty, episode type, diagnosis), and those with mention of a diagnosis of cancer or chemotherapy for cancer anywhere in the spell are excluded. Patients with mention of a diagnosis of cancer or chemotherapy for cancer anywhere in the 365 days prior to admission are excluded
Unit of analysis	Contiguous acute hospitalisations	Contiguous acute hospitalisations	Contiguous hospitalisations
Transfer rule	The second hospital admission must occur on the same-day or the next calendar day following discharge from the first hospital, with the same principal diagnosis	Admission occurs within 6 hours of discharge from another acute facility regardless of whether institution codes the transfer, or admission occurs within 6-12 hours of discharge from another acute facility and at least one of the institutions codes the transfer	All continuous consultant episodes included (no specific time period)
Risk adjustment	Age, sex and comorbidity	Age, sex and comorbidity	Age, sex, method of admission and diagnosis/procedure
Measurement period	One year and rolling three years	Quarter year and year to date	Rolling one year
Reporting frequency	Annual	Annual	Annual
Results	RSRR with 95% interval estimate	Risk adjusted rate with 95% confidence intervals	ISR with 95% confidence interval
Suppression rule	Suppress results for hospitals with fewer than 25 cases	Suppress results for hospitals with fewer than 5 cases in the numerator	Suppress results for hospitals with fewer than 5 cases in the numerator

Measurement of readmissions in NSW: introducing 'returns to acute care'

Readmission is a generic term. There is currently no agreed definition of what constitutes an unplanned readmission.[8] Historically, readmissions have been measured in NSW on the basis of patient stays; expressed as the proportion of discharged patients who were readmitted to the same hospital within 28 days of physically leaving the hospital. This approach poses a number of problems – as noted by the recent report from the Auditor-General of NSW (see Box).[9]

First, it is a non-specific indicator that measures total readmissions. This makes it difficult to disentangle relative performance and to inform efforts to improve in the treatment of particular diseases or the provision of different surgical procedures.

Second, its interpretation is difficult given the range of different arrangements hospitals have in place for non-acute care. For example, hospitals without on-site facilities for non-acute care are obliged to transfer patients who need such care to another hospital, 'starting the clock' for follow-up in readmission measures. Hospitals with on-site capacity can move a patient to a non-acute setting without the patient ever physically leaving the hospital, and as a consequence only 'start the clock' when patients subsequently leave non-acute care to go home. From the non-acute setting, a patient who deteriorates and returns to acute care is considered by non-specific indicators to have been readmitted in the first case but not in the second.

Therefore, a fairer way to measure readmission is to formulate it as a measure of 'return to acute care'. Conceptually, this is the approach used in the United States and Canada.[1,3] It is more sensitive to variation in clinical practice and patient care, and provides a more homogeneous unit of analysis by which to assess performance. To differentiate the approach described in this report from that in use elsewhere in NSW, the BHI measure is referred to as a 'return to acute care'.

A 'return to acute care' includes:

- a readmission to any hospital (same or different) to receive acute care for patients who, at the end of their index hospitalisations, were discharged home
- a transfer into hospital to receive acute care for patients who, at the end of their index hospitalisations, were transferred to another hospital for non-acute care
- a return to acute care for patients who did not physically leave the site of their index hospitalisation but who had been moved to a non-acute setting within that hospital.

In April 2015 a report released by the Auditor-General of NSW recommended that limitations in existing specifications for measuring unplanned readmissions be addressed. In particular it identified the need for:

- use of linked data to capture readmissions to any hospital, rather than only to the same hospital from which a patient was initially discharged
- the ability to differentiate the reasons for readmission
- use of different follow-up periods according to reasons for the initial hospitalisation (such as longer follow-up periods for hip replacements)
- local health district and hospital-level analysis and reporting of length of stay and unplanned readmissions.

The measures developed in this report address these recommendations and represent an important advance in the measurement and reporting of performance in NSW public hospitals

http://www.audit.nsw.gov.au/news/managing-length-of-stay-and-unplanned-readmissions-in-nsw-public-hospitals

Data and analytic software

BHI analyses used admitted patient data drawn from the NSW Ministry of Health's Health Information Exchange (HIE) and fact of death data drawn from the NSW Registry of Births, Deaths and Marriages. These data were probabilistically linked by the NSW Ministry of Health's Centre for Health Record Linkage (CHeReL) by assigning a Project Person Number to each record using record linkage software.[10] The linked data were accessed via the SAPHaRI data warehouse, administered by the Centre for Epidemiology and Evidence, NSW Ministry of Health.[11] The analysis was conducted using Stata SE v12, SAS/BASE and SAS/STAT software.[12-13]

The potential value of measures of return to acute care is increased by the ability to report on variation across hospitals.

Using linked data allows for the identification of emergency returns to acute care to any NSW hospital within 30 days of discharge. The benefits of using linked data are considerable.[14] Altogether 5,214 additional returns to acute care were identified across the seven different datasets (Figure 4).

Additionally, the linked data made it possible for the competing risk of death to be taken into account in the estimation of expected volumes of returns to acute care and allowed for better capture of patient comorbidities using a 1-year lookback period (see pages 24 and 25).

NSW data in the *Insights* report are contextualised where possible using international data. While there are considerable similarities in indicators used in different jurisdictions, important differences mean that it is difficult to draw direct comparisons (Figure 3).

Figure 4 Proportion of returns to acute care that were returns to the discharging hospital, July 2009 – June 2012

Condition	Percentage of returns to the discharging hospital	Number of extra returns captured by linked data
Acute myocardial infarction	68%	1,411
Ischaemic stroke	77%	299
Congestive heart failure	82%	1,242
Pneumonia	80%	1,089
Hip fracture surgery	74%	360

Surgical procedure	Percentage of returns to the discharging hospital	Number of extra returns captured by linked data
Total hip replacement	60%	277
Total knee replacement	65%	536

Categorising hospital admissions

The NSW admitted patient data were drawn from the Admitted Patient Data Collection (APDC) which contains information from all NSW health facilities with admitted patients. Information is recorded using 'episodes of care' as the counting unit and the database contains 150 different data elements that categorise those episodes.[11]

Cohorts for healthcare performance measurement are often defined in terms of two criteria: urgency of admission and service category (Figures 5 and 6). Urgency of admission coding was used to identify emergency admissions and service category coding was used to identify episodes of acute care.

Appropriate use of hospital administrative data and clinical coding enables uniform, low cost and objective measurement across NSW hospitals. The data are available for all NSW hospitals, can be linked to capture transferred patients and can generate performance measures adjusted for case mix and other relevant variables. Coding of principal diagnosis (i.e. the diagnosis 'chiefly responsible' for the patient's care) has been found to be accurate with positive prediction values consistently over 95% among NSW hospitals.[15-17] Measures developed from this data are likely to be fairer and more accurate than those derived from more limited sources (e.g. clinical databases).[18-19]

Figure 5 Urgency of admission categories used in the NSW Admitted Patient Data Collection

Urgency	Description
1 = Emergency	An admission of a patient who has a condition that requires treatment within 24 hours at the time of diagnosis.
2 = Non-Emergency/Planned	An admission of a patient for care or treatment that, in the opinion of the treating clinician, can be delayed for at least 24 hours at the time of diagnosis.
3 = Urgency Not Assigned	An admission of a patient who is transferred from another hospital for non-emergency care, including transfers of newborns and inter-hospital transfers.
4 = Maternity/Newborn	An admission that begins with the birth of the patient, or begins shortly after the birth of the patient (e.g. in the case of deliveries prior to arrival), where there has been at least 37 weeks gestation or more and the mother had no obvious complications at the time of presentation; or an obstetrics admission for delivery, at term (i.e. at least 37 weeks gestation or more), without obvious complications at the time of presentation regardless or whether or not the patient delivered the baby; or an admission for foetal monitoring, or maternity blood pressure monitoring.
5 = Regular same-day planned admissions	Admissions that are intended regular and planned same-day admissions for an ongoing phase of treatment, such as renal dialysis or chemotherapy.

Figure 6 Service categories used in the NSW Admitted Patient Data Collection

Service category	Principal clinical intent
1 = Acute Care	Cure illness or provide definitive treatment of injury Perform surgery Relieve symptoms of illness or injury (excluding palliative care) Reduce severity of an illness or injury Perform diagnostic or therapeutic procedures Protect against exacerbation and/or complication of an illness and/or injury which could threaten life or normal function Manage labour (obstetric)
2 = Rehabilitation Care	Improve the functional status of a patient with an impairment, disability or handicap.
3 = Palliative Care	Provide relief of suffering and enhancement of quality of life for a patient with an active, progressive disease and for whom there is little or no prospect of cure.
4 = Maintenance Care	Prevent deterioration in the functional and current health status of a patient with a disability or severe level of functional impairment. Includes care provided to a patient who would normally receive care in another setting, for example, at home, or in a nursing home, that is unavailable in the short term.
5 = Newborn Care	Provide care and/or accommodation to a patient born in the hospital or who is nine days old or less at the time of admission.
6 = Other Care	Non-admitted activity reported via a patient administration system. May include community residential care, and residential aged care covered by Commonwealth Block funding.
7 = Geriatric Evaluation and Management	Maximise health status and/or optimise the living arrangements for a patient (usually elderly) with multi-dimensional medical conditions associated with disabilities and psychosocial problems.
8 = Psychogeriatric Care	Patients (almost always elderly) with either an age-related organic brain impairment with significant behavioural disturbance, or late onset psychiatric disturbance, or a physical condition accompanied by severe psychiatric or behavioural disturbance, and for whom the primary treatment goal is improvement in health, modification of symptoms and enhancement in functional behaviour or quality of life.
9 = Organ Procurement – Posthumous	Procurement of human tissue for the purpose of transplantation from a donor who has been declared brain dead.
0 = Hospital Boarder	A person receiving food and/or accommodation from the hospital but for whom there is no principal clinical intent (e.g. a carer of a patient who stays overnight with the patient). A newborn aged 10 days old or more who does not require clinical care but remains in hospital with the mother (who remains an admitted patient). A patient receiving non-admitted patient care where there is no local requirement to record clinical activity. This may include patients accommodated in Commonwealth Block funded residential aged care beds, and community residential care beds.

How to measure returns to acute care

How is the measure defined and calculated?

Defining cohorts, index admissions

An index admission is a hospitalisation used in calculating RSRRs for the condition of interest. The Index admissions form the 'cohort' for assessing returns to acute care. Discharge from an index hospitalisation starts the 30-day return to acute care clock. The 'event of interest' is an unplanned, or as referred to in this report, an emergency return to acute care within that 30 day period (further defined on page 14).

Constructing the set of index admissions involves identifying relevant records in the administrative data. Key steps and considerations in defining the cohort and identifying index admissions are depicted schematically in Figure 7 and described in Figure 8.

Seven sets of cohorts were constructed: one for each of the conditions and procedures of interest (acute myocardial infarction, ischaemic stroke, congestive heart failure, pneumonia, hip fracture surgery, total hip replacement and total knee replacement).

For transferred patients, the index admissions and any qualifying returns to acute care were attributed to the 'last' hospital – that is, the facility that ultimately discharged the patient to a non-acute care setting.

One patient can be counted multiple times – both for multiple index admissions for the same condition and for different conditions.

While similar, the return to acute care cohorts differed from the corresponding groups for the risk standardised mortality ratio (RSMR) analysis. For example, in the RSMR analysis, in cases where patients were transferred, outcomes were attributed to the 'first' or initial admitting hospital. Patients that experienced multiple hospitalisations for the condition of interest were included once only for RSMRs, using the last hospitalisation during the study period.

Figure 7 Schematic of approach used: step 1

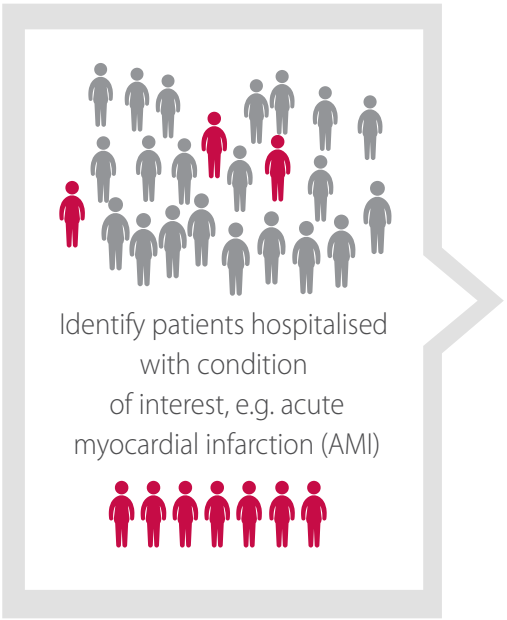


Figure 8 **Defining cohorts and index admissions: key steps**

Approach	Rationale & notes
Identify acute admissions with a principal diagnosis of interest (e.g. for AMI, ICD-10AM codes I21 and I22)	Data drawn from SAPHaRI[11]; linkage key provided by CHeReL[10] ICD-10AM codes for the analyses are listed in Appendices 1–7
Build periods of care, joining up all acute contiguous episodes, including transfers between hospitals. Identify the 'last' hospital that discharged the patient to a non-acute care setting	RSRR evaluates hospitalisations for patients discharged to non-acute care setting. A period of care reflects the hospitalisation as experienced by the patient, starting with admission and ending with leaving acute care (considering ward changes and hospital transfers as part of the same continuous hospitalisation). However, for joint replacement RSRRs any hospitalisation for which patients were transferred as part of the period of care was excluded. This is to ensure outcomes were attributed to a hospital within which the surgery occurred and from which the patient was discharged. For hip/knee replacements, in case of transfers, the period of care was excluded and no attribution was made. See flowcharts in Appendices 6 and 7 for details of other exclusions.
For the AMI cohort only, exclude periods of care that were discharged alive and started and ended on the same-day	The Yale CMS specifications assert that a same-day hospitalisation for AMI for which a patient is discharged alive is unlikely to be caused by a clinically significant AMI, and the hospitalisation should be excluded from the analysis.[6] A sensitivity analysis undertaken with NSW data found that results did not change substantively when this exclusion was relaxed.
Exclude index admissions that were coded as "discharged at own risk"	In cases where patients left hospital against medical advice, the hospital did not have the opportunity to deliver full care and prepare the patient for discharge. It is noted however that leaving against medical advice may be a reflection of performance in terms of responsiveness to patients' cultural and emotional needs.[20]
Admissions within 30 days of a prior index admission cannot be categorised as an index admission	Using the CMS/Yale methodology, hospitalisations cannot be both an index admission and a return to acute care. However, because the cohorts for the RSRRs are determined independently of each other, a return to acute care in one clinical condition may qualify as an index admission in another RSRR cohort.
Exclude index admissions with the separation mode of "transfer to palliative care unit/hospital"	Patients receiving palliative care could be expected to have a different propensity for a return to acute care than other patients. Patients receiving palliative care are usually less likely to return. Excluding them makes comparisons with hospitals that do not have have access to palliative care more fair.
Exclude index hospitalisations with an in-hospital death	Patients who die in hospital during the index admission are at zero risk of a return to acute care and are excluded from the modelling for RSRR. However there are some concerns that in-hospital deaths in index admissions represent a confounder in the context of measuring hospital performance. That is, a hypothetical facility with a high in-hospital mortality could discharge relatively healthy patients that are less likely to return to acute care compared to those discharged from a facility that manages to keep sicker patients alive. Higher in-hospital mortality (poor performance) could result in lower rates of return to acute care (apparent strong performance). See page 28 for more details.
Exclude hospitalisations in private hospitals	Private hospital patients differ from public hospital patients in ways that administrative data are not always able to capture. Additionally, there are different patterns of care provided to private hospital patients and different coding practices. To make fair comparisons performance was compared across public hospitals only.

Identifying returns to acute care

Returns to acute care were included in the analysis if they met the following criteria:

- Acute hospitalisations
- Emergency admission to any NSW hospital (public or private) within 30 days of the separation date of the index admission (for acute myocardial infarction, ischaemic stroke, congestive heart failure, pneumonia and hip fracture surgery)
- Admission to any NSW hospital (public or private) within 60 days of separation date of the index admission (for total hip replacement and total knee replacement surgery).

Key steps and considerations in identifying returns to acute care are depicted in Figure 9 and described in Figure 10.

All returns to acute care were included, regardless of the principal diagnosis for the return to acute care. However, additional and valuable information is provided by describing the reasons for returns to acute care.

The methods used to classify the reasons for returns to acute care are described on page 36.

Figure 9 Schematic of the approach used: step 2

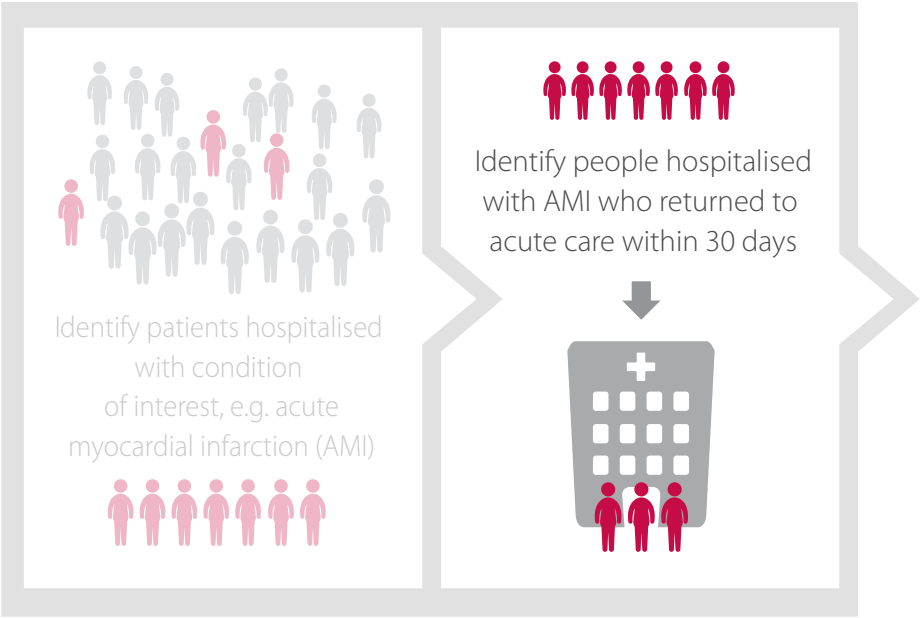


Figure 10 **Identifying returns to acute care: key steps**

Approach	Rationale & notes
Identify all acute and emergency hospitalisations within 30 days of index admission discharge	The measure includes all acute clinical events requiring urgent rehospitalisation and will contain some unavoidable returns to acute care.
For AMI, ischaemic stroke, pneumonia, hip fracture surgery and congestive heart failure, the measures assess acute emergency returns to acute care within a 30 day period from the date of discharge from an index admission	This standard time period is necessary so that the outcome for each patient is measured uniformly. The measures use a 30 day time frame because outcomes occurring within 30 days of discharge can be influenced by hospital care by the early transition period to an outpatient setting. The use of the 30 day time frame is a clinically meaningful period for hospitals to collaborate with their communities in an effort to reduce returns to acute care.[6,19]

Elective surgery	Differences from main approach
For total hip replacement and total knee replacement analyses, set the time period to 60 days rather than 30 days	The Australian Commission on Quality and Safety in Health care has developed draft indicator specifications for hip and knee replacement readmissions and specify a 60 day window.[21] Similarly, according to the Canadian Institute for Health Information (CIHI), clinical experts advise that certain conditions such as mechanical complications, infections and inflammatory reactions are more likely to occur beyond the 30 days after discharge. To capture these cases, the readmission time frame was extended to 90 days in Canadian reporting.[5]
60-day returns to acute care following hospitalisation for total hip replacement and total knee replacement included acute hospitalisations (excluding haemodialysis, chemotherapy, radiotherapy and cataract surgery)	Non-emergency returns to acute care, which are generally not a signal of quality of care, are not counted in the RSRRs for AMI, stroke, pneumonia, congestive heart failure or hip fracture surgery. However on clinical advice, non-emergency returns to acute care were included for the total hip replacement and total knee replacement cohorts. This was to capture hospitalisations for procedures required as a consequence of the index admission, such as wound debridement (see page 17 for details). Regular day only, non-emergency admissions were excluded.

Attribution and patient flows

Emergency returns to acute care are attributed to the discharging hospital – on the basis that it is the responsibility of staff in that hospital to ensure that their patients are well enough to leave acute care.

A series of analyses informed additional attribution decisions. For example, reasons for non-emergency returns to acute care were explored in order to inform the decision regarding attribution, focusing on whether these episodes represented an opportunity to substantively influence patient trajectories or whether they could be interpreted as outcomes.

For acute myocardial infarction, stroke, pneumonia, and hip fracture surgery, non-emergency hospitalisations that occurred in the interval between the index hospitalisation and an emergency return to acute care were dominated by admissions for haemodialysis which were primarily same-day admissions. Therefore, non-emergency day-only hospitalsations were ignored.

For joint replacements however, non-emergency hospitalisations were often a consequence of the index admission, with principal diagnoses such as wound debridement.

Therefore non-emergency hospitalisations in the 60 days post discharge from an acute hospitalisation with a principal procedure of total hip replacement or total knee replacement were considered to be a return to acute care (although regular day only non-emergency admissions such as haemodialysis, chemotherapy, radiotherapy and cataract surgery were still excluded).

Other attribution decisions were:

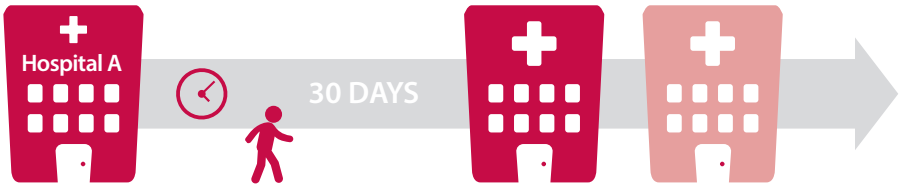
- In the case of patient transfers, index hospitalisations and emergency returns to acute care are attributed to the last hospital that discharged the patient to a non-acute care setting
- Hospitalisations cannot be categorised as both an index admission and a return to acute care. Admissions within 30 days of a prior index admission are not categorised as an index admission. If two returns to acute care occur within 30 days of an index admission, the first return is attributed to the index hospitalisation. The subsequent return is neither attributed to the index admission nor is it deemed a new index admission
- Non-emergency day only hospitalisations in the 30 days following discharge from an index admission, and preceding an emergency return to acute care, are ignored
- For the five clinical conditions, when there was a non-emergency overnight acute rehospitalisation in the 30 days following discharge from the index admission, and preceding an emergency return to acute care, no return to acute care was assigned to that index admission.

Figure 11 Schematic of attribution decisions

In cases of patient transfers, returns to acute care are attributed to the hospital from which the index case was discharged.

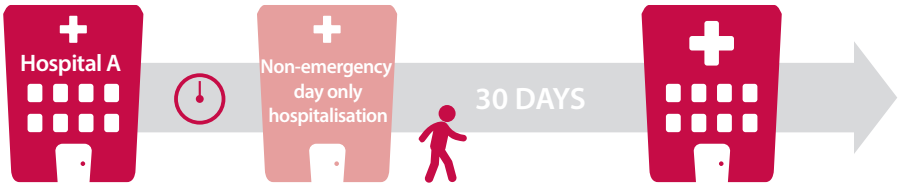
Attribution to **HOSPITAL B**

In cases where two returns to acute care occur within 30 days of an index admission, the first return is attributed to the index hospitalisation. The subsequent return is neither attributed to the index admission nor does it constitute a new index admission.



Attribution to **HOSPITAL A**

In cases where there is a non-emergency day only hospitalisation in the 30 days following discharge from the index admission, and preceding the first return to acute care, the return is attributed to the index hospitalisation, and the non-emergency day only hospitalisation is ignored.



Attribution to **HOSPITAL A**

In cases where there is a non-emergency overnight acute hospitalisation within 30 days of discharge from the index admission and preceding the first return to acute care, no outcome is assigned to that index admission.

No attribution

Attribution decisions for the elective procedures differed from the above:

- a 60 day time period is considered
- if there are hospital transfers during the index admission, the admission is excluded from analysis
- all acute non-emergency hospitalisations in the 60 days following discharge from the index admission are considered to be a return to acute care (excluding haemodialysis, chemotherapy, radiotherapy and cataract surgery).

Statistical modelling

Statistical modelling approaches such as building multivariable regression models to estimate associations between patient factors (e.g. age and comorbidities) and an event of interest (e.g. readmission or death) for a population of patients can help inform assessments of hospital performance.

Models can determine the expected number of events for a particular hospital based on the case mix of patients treated there. Insights into performance are revealed when this expected number is compared with the actual number of events that occurred. Hospitals for which the number of events is significantly higher or lower than expected can be identified.

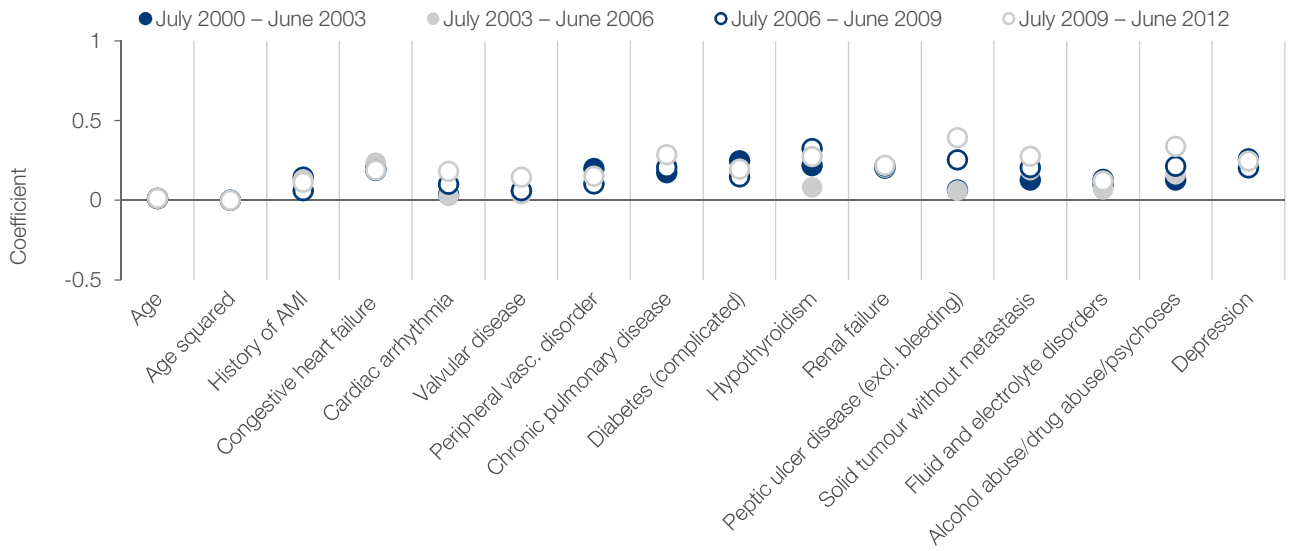
Conceptually, the statistical modelling work in this project is a survival analysis. Standard survival analysis is concerned to capture the time to an event of interest (e.g. an emergency return to acute care). A patient who has not experienced the event at the end of the study period is said to be censored. In censoring, the event of interest may still occur, however its occurrence is beyond the time period of study. To determine the risk of an emergency return to acute care having occurred by a certain time, a fundamental assumption is that such censoring is not associated with an altered chance of the event occurring at any given moment. If a patient dies however, the censoring assumption is violated (the chance of an emergency return to acute care is now zero). Any event which causes censoring and is associated with an altered chance of the event of interest occurring has to be treated as a competing event. Deaths are obvious competing events in this analysis. In order to take account of the competing risk of death, Fine and Gray competing risks regression models were used.[22] The standard errors were adjusted for within hospital correlations.

Building the models

Variables that were significant at 20 percent level ($p<0.20$) were included in the initial analysis. Only variables with a 2-sided p-value <0.05 in the multivariable model were retained in the final model.

Final prediction models for the conditions of interest, with subhazard ratios and confidence intervals, are shown in Appendices 1–7. The prediction ability of the

Figure 12 Acute myocardial infarction: stability of the predictive model coefficients, four time periods, July 2000 – June 2012



Dealing with competing risks in statistical analyses

Competing risks are events that prevent an event of interest from occurring. Not taking into account the competing risk of death can cause an overestimation of cumulative incidence. The cumulative incidence function is the probability that the event of interest occurs before a given time. The calculated incidences are conditional on the competing risk not occurring at each time point.

The Fine and Gray model computes subhazard ratios (SHR). Covariates affect the subhazard proportionally.[22]

final models which were developed using July 2009 – June 2012 data was evaluated using c-statistics. In order to ensure that the prediction models perform comparably in samples other than the sample from which they were derived, the prediction ability of the models in previous years were assessed using c-statistics. This was done by applying the estimated coefficients from the July 2009 – June 2012 to data from previous periods and also by re-estimating the coefficients in each period.

The stability and consistency of the parameter estimates were assessed over time using the re-estimated coefficients in previous periods (Figure 12 for AMI). Validation results for all of the final models are shown in Appendices 1–7.

The c-statistic (area under the Receiver Operating Characteristics or ROC) is a measure of the discriminant ability of a regression model. The statistics for the BHI final models were similar to those developed by Yale University[6,7] (used in the US by the Centers for Medicare and Medicaid Services) and Imperial College, England[23] (Figure 13).

Figure 13 Comparison of c-statistics for final predictive models using the BHI, Yale and Imperial College methods

Condition	BHI (NSW)	Yale (US)	Imperial College (England)
Acute myocardial infarction	0.63	0.64	0.64
Ischaemic stroke	0.59	0.59	0.62
Congestive heart failure	0.60	0.61	0.62
Pneumonia	0.67	0.64	0.66
Total hip replacement	0.61	0.65	0.61
Total knee replacement	0.56	0.65	0.61

How to make fair comparisons

How are potential confounders identified?

How are they taken into account in the analyses?

Public and private hospital patients

The proportion of hospitalisations that occur in private hospitals varies across the conditions and procedures included in this report (Figure 15).

The RSRR analysis focuses on NSW public hospitals only. This is because private hospital patients are widely considered to be different from public hospital patients in ways that are not perfectly observable, rendering available risk adjustment approaches inadequate.[24]

Further, for some of the RSRR cohorts (particularly those for elective surgical procedures), a considerable proportion of patients are treated in private hospitals. Inclusion of private hospital patients in the NSW totals would dominate the analyses, preventing an adequate assessment of performance within the public sector.

Sensitivity analyses found that excluding private hospital patients changed the overall outlier status among public hospitals for three of the seven conditions and procedures. In general, the exclusion of private hospital patients had a dampening effect on the RSRRs for public hospitals, with fewer high outliers and more low outliers (Figure 16).

To illustrate this effect, Figure 17 compares the funnel plots for total hip replacement when private hospital patients are included in the modelling (A) and excluded from the modelling (B). Neither plot shows individual private hospital results. Across NSW public hospitals, there were seven hospitals that had higher than expected RSRRs when private hospital patients were included in the predictive model; while only five had higher than expected RSRRs when private hospital patients were excluded.

Figure 15 Percentage of index hospitalisations that occurred in public and private hospitals July 2009 – June 2012

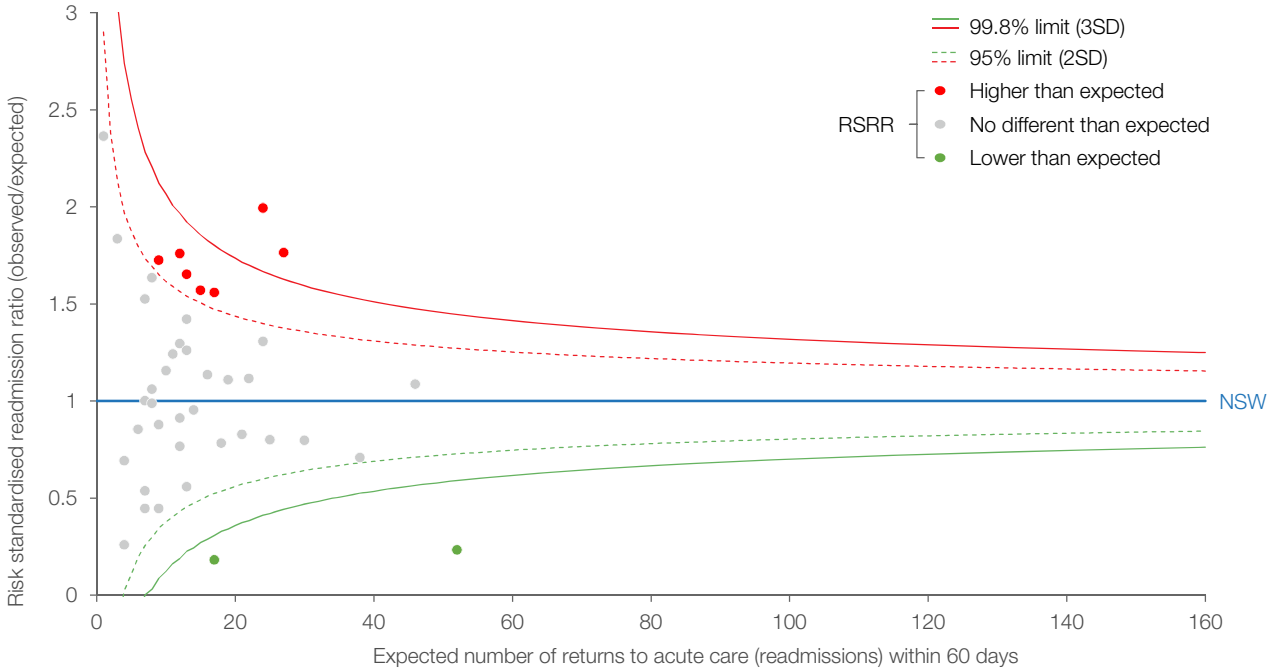
Condition / Procedure	Public hospitals	Private hospitals
Acute myocardial infarction	84%	16%
Ischaemic stroke	94%	6%
Congestive heart failure	87%	13%
Pneumonia	91%	9%
Hip fracture surgery	88%	12%
Total hip replacement	38%	62%
Total knee replacement	40%	60%

Figure 16 Changes to hospitals with RSRRs greater than or less than expected when patients receiving care in private hospitals are removed from the models

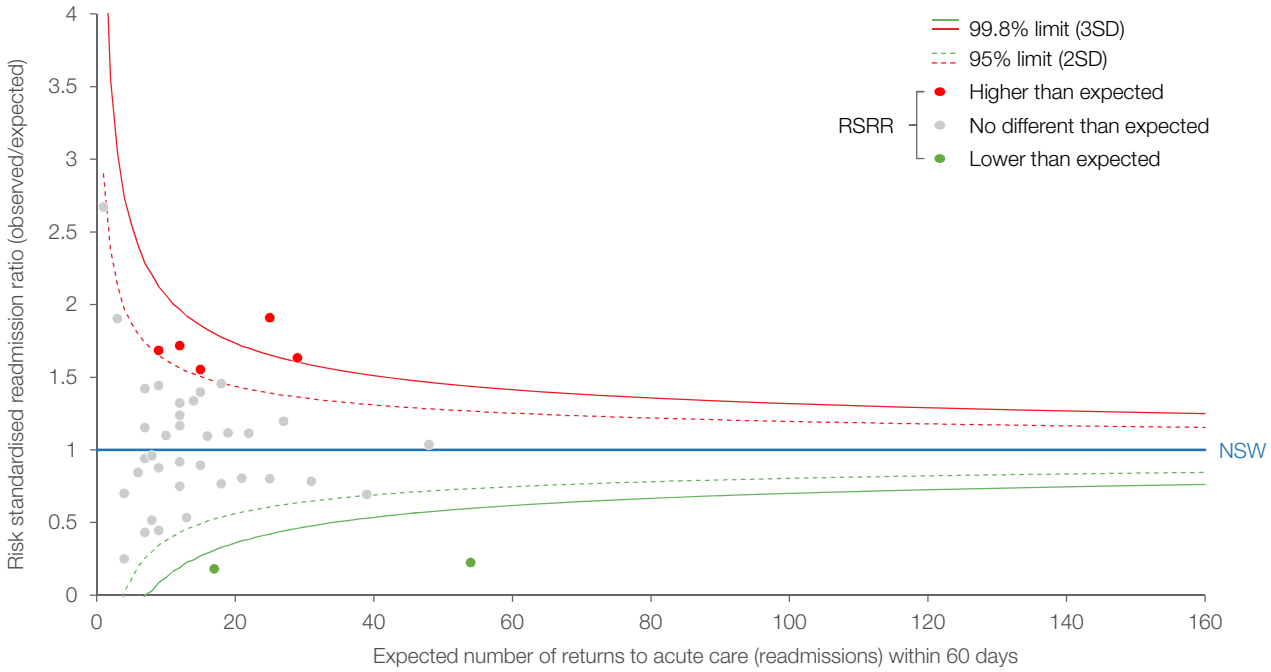
Condition	Changes in outliers when private patients not included in the model (among hospitals with at least 50 cases)
Acute myocardial infarction	One hospital no longer has significantly lower than expected RSRR, and one hospital no longer has higher than expected RSRR
Ischaemic stroke	No hospitals changed outlier status
Congestive heart failure	One hospital no longer has significantly higher than expected RSRR, and two additional hospitals have lower than expected RSRRs
Pneumonia	No hospitals changed outlier status
Hip fracture surgery	No hospitals changed outlier status
Total hip replacement	Two hospitals no longer have significantly higher than expected RSRRs
Total knee replacement	No hospitals changed outlier status

Figure 17 Impact on public hospital reporting by including private hospital patients in the predictive model of return to acute care following total hip replacement

A. Total hip replacement: RSRRs, NSW public and private hospital patients, July 2009 – June 2012*



B. Total hip replacement: RSRRs, NSW public hospital patients only, July 2009 – June 2012



* Individual private hospital results are not shown in the figure.

Risk adjustment

Risk adjustment helps make comparisons across hospitals fairer by accounting for comorbidities and other patient level factors that would make returns to acute care more or less likely, regardless of quality of care in the index admission. Hospitals that treat sicker patients are not expected to achieve the same rate of returns to acute care as hospitals that treat relatively less sick patients.

The competing risk model computes the risk of a return to acute care within 30 days of discharge from an index admission (or 60 days, in the case of joint replacements), based on patient characteristics such as age, sex and comorbidities.

There are different methods available to measure comorbidities, such as the Charlson[25] or Elixhauser[26] indices. A recent systematic review found that the Elixhauser index outperforms other risk adjustment indices.[27] The Elixhauser Index comprises a list of 30 comorbidities that affect patient outcomes (Figure 18).

The Elixhauser comorbidity set was used and was applied with a one-year lookback. The one-year lookback captures recorded comorbidities for all admissions to any NSW hospital prior to and including the date of the index admission.

Based on clinical advice, dementia and a history of the index condition were considered with the Elixhauser comorbidities for inclusion in each of the models.[23, 28]

A separate model was developed for each of the five conditions and two procedures. This model identified, at a state level, patient level factors significantly associated with increased risk of return to acute care. This model was used to calculate the risks for each hospital's patients, which were summed and expressed as an 'expected' number of returns to acute care (E) to be compared with the actual number of returns (O) using the risk-standardised readmission ratio (O/E) for each hospital.

The impact of this risk adjustment on the range of hospital RSRR results for the five conditions and two surgical procedures was modest (Figure 19).

Details of the final models for each of the conditions and procedures are shown in Appendices 1–7.

Figure 18 Elixhauser comorbidities

Congestive heart failure	Diabetes (complicated)	Obesity
Cardiac arrhythmia	Hypothyroidism	Weight loss
Valvular disease	Renal failure	Fluid and electrolyte disorders
Pulmonary circulation disorders	Liver disease	Blood loss anaemia
Peripheral vascular disorders	Peptic ulcer disease (excluding bleeding)	Deficiency anaemia
Hypertension (uncomplicated)	AIDS/HIV	Alcohol abuse
Hypertension (complicated)	Lymphoma	Drug abuse
Paralysis	Metastatic cancer	Psychoses
Other neurological disorders	Solid tumour without metastasis	Depression
Chronic pulmonary disease	Rheumatoid arthritis/collagen	
Diabetes (uncomplicated)	Coagulopathy	

Figure 19 The effect of statistical adjustment on measures of return to acute care, NSW public hospitals, July 2009 – June 2012

Condition procedure	Unadjusted ratios (range)	Age and sex standardised ratios (range)	Risk standardised readmission ratios (range)
30-day RSRRs			
Acute myocardial infarction	0.55 to 1.77	0.48 to 1.68	0.47 to 1.52
Ischaemic stroke	0.54 to 2.28	0.56 to 2.19	0.58 to 2.01
Congestive heart failure	0.65 to 1.46	0.66 to 1.46	0.69 to 1.63
Pneumonia	0.22 to 1.81	0.25 to 2.03	0.24 to 2.25
Hip fracture surgery	0.29 to 1.77	0.31 to 1.80	0.30 to 1.72
60-day RSRRs			
Total hip replacement	0.19 to 1.92	0.19 to 1.95	0.18 to 1.91
Total knee replacement	0.48 to 1.89	0.48 to 1.86	0.50 to 1.86

Exploring the effect of socioeconomic status

The question of whether to adjust for socio-economic status of patients in performance reporting is a difficult one. Evidence about the impact of socioeconomic status (SES) is mixed, with many studies suggesting that lower income or SES is associated with increased risk of readmission.[29-31]

In the US, readmission results show that many hospitals with a high percentage of patients with high levels of socioeconomic disadvantage have low risk standardised readmission rates.[32] Similarly, CMS reports that hospitals serving the fewest Medicaid or minority patients (low SES) had distributions of performance nearly identical to those of hospitals serving the most Medicaid or minority patients, indicating that both groups of hospitals can perform well on the measures. It notes however that for some measures, such as congestive heart failure readmission, median rates are higher for hospitals with the highest proportion of Medicaid or minority patients.[33]

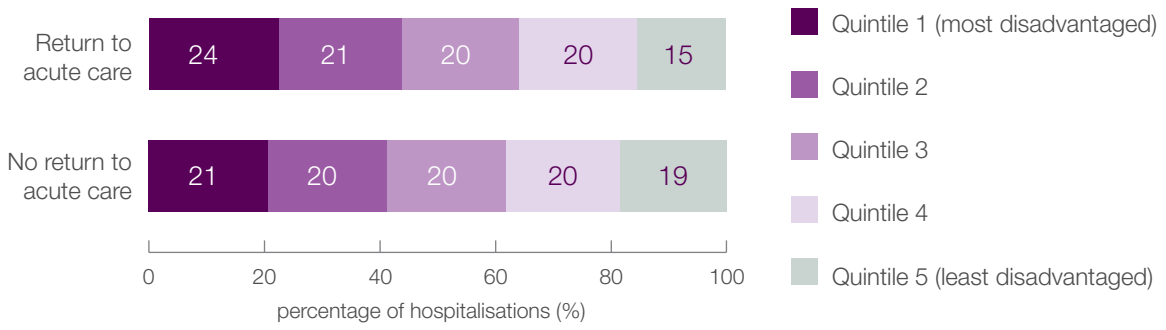
There is a fundamental conceptual question regarding the inclusion of SES variables in statistical models that seek to assess hospital performance which go beyond questions of statistical methods.

Some argue that risk adjusting for patient SES suggests that hospitals with low SES patients should be held to different standards for patient outcomes than hospitals treating higher SES patient populations[19]. Others contend that SES is not modifiable by the hospital. Therefore holding hospitals accountable, or worse, applying financial penalties, on the basis of readmission rates is unfair.[29,34]

The results shown here compare hospitalisations that were and were not followed by a return to acute care, in terms of patients' SES (as determined by postcode of residence).* A larger percentage of hospitalisations that were followed by a return to acute care were for patients living in the most disadvantaged postcodes compared to hospitalisations with no subsequent return to acute care (Figure 20).

Sensitivity analyses that included socioeconomic status in the models found there was no significant improvement in discriminatory power. In the case of ischaemic stroke, the c-statistic for the model without inclusion of SES was 0.593 (0.578-0.610); inclusion of SES resulted in a c-statistic of 0.600 (0.583-0.616). There were some changes in hospital-level results but there was no clear evidence of a systematic effect on results (Figure 23). In light of these findings, SES was not adjusted for in the models used to generate RSRRs in the *Insights* report.

Figure 20 **Ischaemic stroke: distribution of socioeconomic status quintiles among index hospitalisations by whether or not they were followed by a return to acute care, July 2009 – June 2012**



* Patients' socioeconomic status is identified by assigning them to quintiles of the index of relative socioeconomic disadvantage (IRSD) based on postcode of residence. The IRSD is part of the Australian Bureau of Statistics' Socioeconomic Indices for Areas (SEIFA).[51]

Figure 21 Ischaemic stroke: comparing models for returns to acute care, with and without SES adjustment

	No SES adjustment			SES adjustment		
Condition	SHR*	95% CI		SHR*	95% CI	
Cardiac arrhythmia	1.21	1.04	1.40	1.21	1.05	1.41
Chronic pulmonary disease	1.60	1.25	2.03	1.56	1.22	2
Renal failure	1.52	1.27	1.81	1.49	1.24	1.78
AIDS/HIV	5.29	1.55	18.00	5.51	1.68	18.1
Metastatic cancer diseases	1.74	1.17	2.58	1.73	1.16	2.57
Weight loss	1.29	1.02	1.64	1.29	1.02	1.64
Fluid & electrolyte disorders	1.40	1.19	1.65	1.42	1.2	1.67
Dementia	1.31	1.07	1.60	1.3	1.06	1.58

Figure 22 Subhazard ratio and 95% confidence interval for SES, when included in the model

	Acute myocardial infarction	Ischaemic stroke	Congestive heart failure	Pneumonia	Hip fracture surgery	Total hip replacement	Total knee replacement
Most disadvantaged	1.00	1.00	1.00	1.00	1.00	1.00	1.00
2nd quintile	0.98 (0.91-1.06)	0.92 (0.73-1.17)	0.97 (0.89-1.04)	0.91 (0.84-0.99)	0.89 (0.72-1.10)	1.08 (0.87-1.35)	1.14 (0.99-1.30)
3rd quintile	0.89 (0.82-0.97)	0.86 (0.70-1.05)	0.89 (0.79-0.99)	0.95 (0.86-1.06)	1.05 (0.88-1.26)	1.23 (1.01-1.50)	0.90 (0.76-1.08)
4th quintile	0.85 (0.76-0.95)	0.89 (0.71-1.10)	0.87 (0.79-0.97)	0.83 (0.75-0.91)	1.00 (0.86-1.16)	0.86 (0.63-1.17)	0.87 (0.68-1.10)
Least disadvantaged	0.81 (0.71-0.92)	0.70 (0.56-0.89)	0.83 (0.76-0.91)	0.77 (0.68-0.87)	0.97 (0.83-1.13)	0.92 (0.63-1.34)	0.85 (0.65-1.10)

Figure 23 Summary of changes to outlier status when SES is included in the predictive model, July 2009 – June 2012

Condition	Outliers changed after adjusting for SES
Acute myocardial infarction	Two hospitals no longer green
Ischaemic stroke	One hospital no longer red
Congestive heart failure	Two hospitals no longer red, one hospital no longer green; one hospital became green
Pneumonia	Three hospitals no longer green; one hospital became green
Hip fracture surgery	One hospital no longer red
Total hip replacement	No change
Total knee replacement	Two hospitals became red

* SHR = Subhazard ratio

Deaths in the index hospitalisation

The BHI analysis excludes patients who died during the index admission. The return to acute care 'clock' starts with a patient's discharge from an acute care setting.

While the RSRR method developed by BHI accounts for the competing risk of death once the 'return to acute care' clock starts (see page 18), it does not account for death during the index hospitalisation.

Clearly, a patient who dies during the index episode of care can never return to acute care. However patients who die in hospital may have been at higher risk of a return had they survived their first admission compared with patients who survive. Therefore, if a hospital has a lower mortality rate, a greater proportion of its patients may be frail and unstable and at higher risk of returning to acute care. Therefore to some extent, a higher rate of return to acute care may be a consequence of successful or life-extending care.[24]

Given this, it is interesting to examine hospitals' RSRRs alongside the corresponding risk standardised mortality ratio (RSMR) results.

There are four conditions that have results for both RSRRs and RSMRs, acute myocardial infarction, ischaemic stroke, pneumonia and hip fracture surgery. Across the four conditions, most hospitals (62–77%) were 'no different than expected' for both RSRRs and RSMRs. Within each condition, a smaller proportion of hospitals (18–39%) were outliers in one of the two measures; and very few were higher than expected for both measures (0–2%) or lower than expected for both measures (0–4%). Only one hospital, for hip fracture surgery, was a high outlier for one measure and a low outlier for the other (Figure 24).

Figure 24 Patterns of RSRR and RSMR results for four clinical conditions, NSW public hospitals, July 2009 – June 2012

		Acute myocardial infarction		Ischaemic stroke		Pneumonia		Hip fracture surgery	
RSRR	RSMR	Number	Percentage	Number	Percentage	Number	Percentage	Number	Percentage
		2	4%	0	0%	1	1%	0	0%
		1	2%	4	9%	5	6%	1	2%
		0	0%	1	2%	2	3%	2	5%
		41	77%	29	62%	57	73%	31	74%
		1	2%	0	0%	0	0%	0	0%
		4	8%	9	19%	5	6%	3	7%
		4	8%	4	9%	8	10%	4	10%
		0	0%	0	0%	0	0%	1	2%
		0	0%	0	0%	0	0%	0	0%

Higher than expected No different than expected Lower than expected

Relationship between RSRR and RSMR

Existing studies have explored patterns in RSRR and RSMR within and across clinical conditions addressing two key questions.

1. Do hospitals with lower mortality rates have higher rates of return to acute care?

Such a relationship would suggest that interventions that improve mortality might also increase rates of return to acute care by resulting in a higher risk group being discharged from the hospital.

Krumholz and colleagues[19] investigated the relationship between hospital-level 30-day RSMRs and RSRRs for Medicare fee-for-service beneficiaries hospitalised with AMI, CHF, or pneumonia and found no association for either AMI or pneumonia and only a weak association for CHF. The study found no evidence that a hospital's performance for 30-day RSMR is strongly associated with its performance on 30-day RSRR. At all levels of performance on the mortality measures, there were both high and low performers on the readmission measures.

Tsai and colleagues[35] in a study of surgical readmissions reported that hospitals with the lowest surgical mortality rates had a significantly lower readmission rate than hospitals with the highest mortality rates although the absolute difference was small (13.3% vs. 14.2%, P<0.001).

2. Do hospitals with lower rates (mortality or returns to acute care) for one condition have lower rates for other conditions?

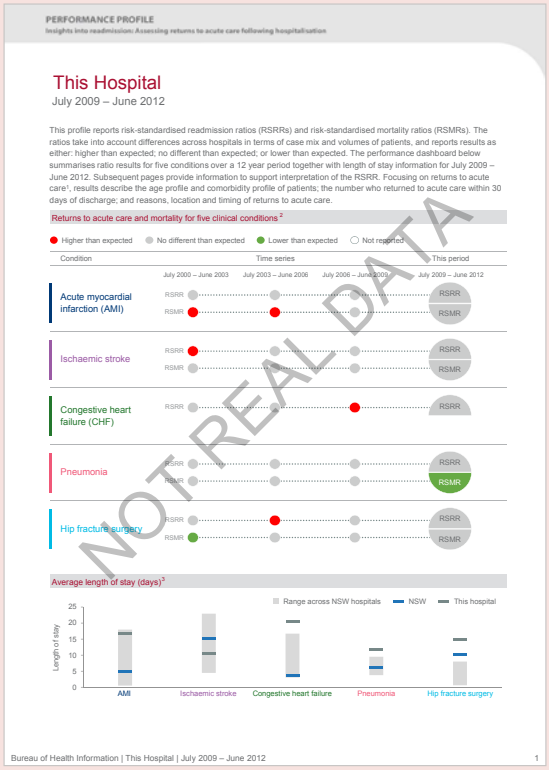
Here, correlation among measures within the same hospital would indicate common hospital-wide quality factors (e.g. discharge planning) which have an effect on outcomes, regardless of principal diagnosis or reason for hospitalisation.

Horwitz and colleagues[36] conducted a cross-sectional study of US hospital results to assess the correlation between pairs of risk standardised mortality rates and pairs of risk standardised readmission rates for AMI, HF, and pneumonia. It found that every mortality measure was significantly correlated with every other mortality measure and every readmission measure was significantly correlated with every other readmission measure – suggesting that hospital-wide factors do affect hospital outcomes across a range of conditions.

The hospital performance profiles that accompany the release of the *Insights* report illustrate for each hospital the patterns in RSRRs and RSMRs across conditions and procedures (see Box).

Hospital performance profiles

Performance profiles with detailed information including mortality (July 2009 – June 2012), tailored to each of the 78 hospitals meeting inclusion criteria are available.



Sensitivity analyses – stroke severity

Risk standardised modelling approaches that include patient level demographic and comorbidity information have generally been considered to be sufficiently discriminating for public reporting purposes.[1-5,23,37] This is despite not adjusting for indicators of disease severity, laboratory test results, or diagnostic studies at the time of presentation.

There are some studies that have found for ischaemic stroke in particular, measures of severity such as the National Institutes of Health Stroke Scale (NIHSS), are predictive of in-hospital and 30-day mortality[38], although others have found the impact of NIHSS on RSMRs to be limited.[39]

In a NSW context, severity has not been shown to be a predictor in multivariable models of hospital readmissions following admission with ischaemic stroke.[40]

To investigate the impact of including available information on severity in the multivariable modelling for the stroke cohort, AR-DRG[41,42] coding for severity in index hospitalisations was included in a sensitivity analysis.

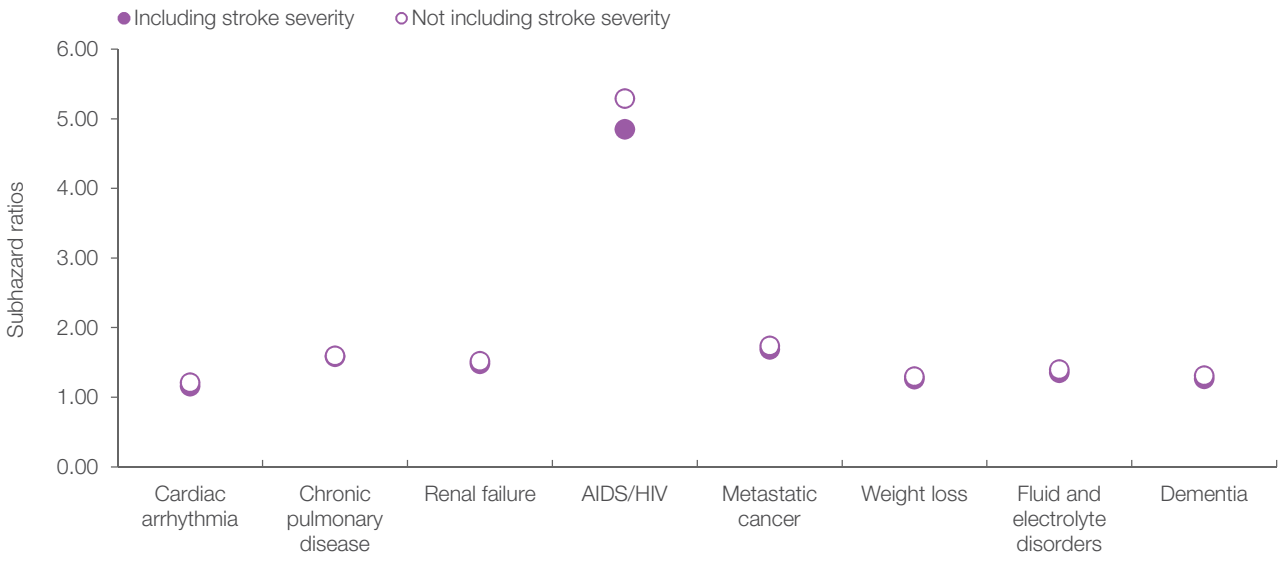
Of the ischaemic stroke hospitalisations included in the analysis, 61% were coded as severe (serious or catastrophic comorbidities and/or complications). Descriptive data show that 12% of ischaemic stroke admissions coded as severe were followed by an emergency return to acute care, compared to 8% of those not coded as severe.

Sensitivity analysis using the AR-DRG data in the predictive models showed that including severity information had little effect on the discriminatory power of the model (Figures 25 and 26). The c-statistic went from 0.593 to 0.597 when the severity data were included.

Figure 25 Ischaemic stroke: predictive model comparison, with and without inclusion of severity codes, NSW public hospitals, July 2009 – June 2012

	Not including stroke severity		Including stroke severity	
	SHR*	(95%CI)	SHR*	(95%CI)
Not severe vs. severe			0.80	(0.70-0.91)
Others vs. severe			1.06	(0.66-1.70)
Cardiac arrhythmia	1.21	(1.04-1.40)	1.16	(1.01-1.33)
Chronic pulmonary disease	1.60	(1.25-2.03)	1.58	(1.24-2.02)
Renal failure	1.52	(1.27-1.81)	1.48	(1.24-1.77)
AIDS/HIV	5.29	(1.55-18.00)	4.85	(1.43-16.48)
Metastatic cancer	1.74	(1.17-2.58)	1.69	(1.14-2.50)
Weight loss	1.29	(1.02-1.64)	1.26	(1.00-1.58)
Fluid and electrolyte disorders	1.40	(1.19-1.65)	1.35	(1.15-1.59)
Dementia	1.31	(1.07-1.60)	1.26	(1.04-1.54)

Figure 26 Ischaemic stroke: sensitivity analysis for inclusion of severity codes in the predictive model, NSW public hospitals, July 2009 – June 2012



* SHR = sub-hazard ratio
CI = confidence interval

How to interpret the results

How do we identify meaningful variation?

Why do patients return to acute care?

Using RSRRs to assess hospital variation

Rates of return to acute care can be influenced by a range of factors relating to the quality of care, discharge practices and community services. However, not all returns to acute care are preventable. Wide variations in returns that persist after adjusting for patient-level factors can be used to guide efforts to investigate and improve care. The steps used in the analysis to calculate, for each hospital, a risk-standardised readmission ratio given its case mix is summarised in Figure 27.

Figure 27 Assessing hospital variation: key steps

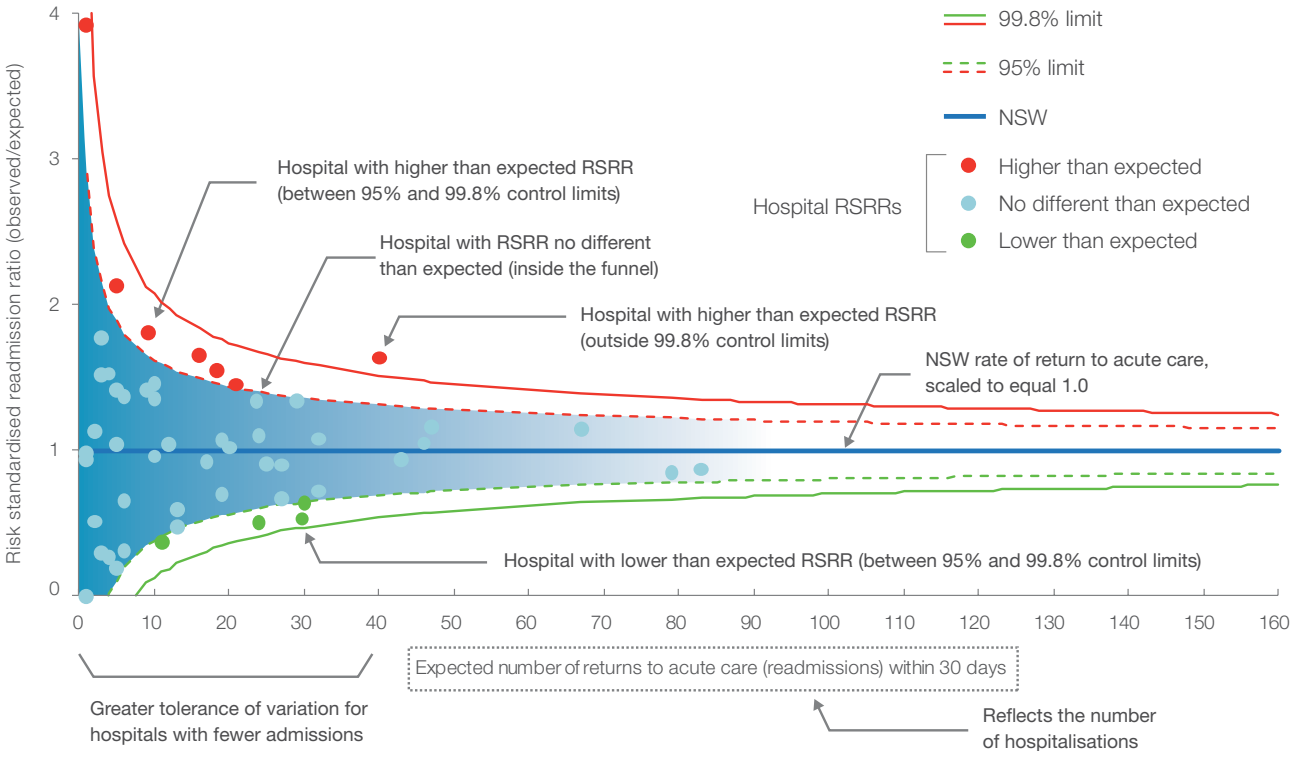
Approach	Rationale & notes
Identify index admissions with a principal diagnosis of interest e.g. for AMI, ICD-10AM codes I21 and I22	See page 12 for details (cohort spread)
Identify hospitalisations of patients who met the criteria for a return to acute care	See page 14 for details (numerator spread)
Assign each emergency return to acute care to the appropriate discharging hospital	See page 16 for details (attribution spread)
Build a competing risk model to identify significant associations between measured patient-level factors and returns to acute care	Fine and Gray[22] competing risks regression models were used to find predictors of unplanned returns to acute care within 30 days or 60 days of discharge. The analysis had to account for 'competing risk' of death – people who die within the 30 (or 60) days following discharge from hospital are no longer at risk of a return to acute care. Variables included in the multivariable model development were: • Age at index admission • Gender • Comorbidities The prediction ability of the model was tested using data from previous financial years. The final multivariable models are shown in Appendices 1–7
Use the competing risk model to compute for each patient the probability of return to acute care, based on a number of characteristics. For each hospital an expected number of emergency returns to acute care (or for the 60-day joint replacement indicator, all returns) is estimated by summing all of the probabilities for the patients discharged	For details on the modelling approach, validation and risk adjustment see pages 18-19. Sensitivity analyses are described on pages 26-30.
Calculate a RSRR of observed/expected returns to acute care	Each hospital's observed or actual number of returns to acute care is compared to the expected number generated from the statistical model
Present results using a funnel plot to take account of different patient volumes	Hospitals with relatively small numbers of patients with a condition may have high or low ratios simply by chance. In order to account for small numbers, funnel plots were used to identify those hospitals that were outliers – those that for which there is 95% confidence that the result is not high or low by chance.[43]

A hospital-specific RSRR is a measure that allows adjustment for patient-level factors (or case mix). RSRRs report the ratio of the 'observed' number of returns to acute care to the 'expected' number of returns (O/E). The expected number is generated by a statistical model which adjusts for patient-level factors that have been shown to affect the risk of return to acute care (see Figure 28). Ratios greater than 1.0 are higher than expected and ratios less than 1.0 are lower than expected. Small deviations from 1.0 are not considered meaningful however.

Funnel plots provide a way to interpret RSRRs. The line at 1.0 represents the NSW rate of return to acute care. Hospitals are plotted according to their RSRR and to their volume of index hospitalisations (expressed as expected returns to acute care). The funnel shape that gives the plot its name depicts greater tolerance for variability in results based on small numbers of patients.[43]

In the RSRR analyses, the funnel's control limits are set at 95% and 99.8%. Hospitals above the upper 95% limits of the funnel are considered to have a significantly higher than expected result; those below the lower 95% control limits are considered to have a significantly lower than expected result. For hospitals outside 99.8% limits, there is greater confidence about their outlier status (Figure 28).

Figure 28 How to interpret a funnel plot



Characterising reasons for return to acute care

While there have been some studies that explore the reasons for readmission in particular patient groups[44] and to identify codes that represent complications of care or adverse events[45], system level readmission measures do not generally capture the reasons for patients returning to hospital. This makes it difficult to determine the extent to which a readmission is related to the index hospitalisation.

There has however been some work conducted by the Australian Institute for Health and Welfare (AIHW) to classify readmissions that are potentially related to hospital care following discharge for acute myocardial infarction and surgical procedures.[21,46]

Drawing on the AIHW list, the ICD-10AM codes for each of the conditions for 30-day returns to acute care were sorted into six categories:

1. Same as index admission principal diagnosis
2. Condition related to index admission principal diagnosis
3. Potentially related to hospital care (relevant at any time)
4. Potentially related to hospital care (time sensitive, ≤ 7 days post discharge)
5. Potentially related to hospital care (time sensitive, 8–30 days post discharge)
6. Other (Figures 29 and 30).

The 'potentially related to hospital care' categories contain diagnoses that differ according to how likely they are to have been a result of care provided in the index hospitalisation.

Category 3 diagnoses are potentially attributable to hospital care, regardless of when the return to acute care occurred within the 30-day follow-up period. They include diagnoses such as pulmonary embolism and adverse drug events.

Category 4 diagnoses are most attributable to the index hospitalisation when they occur within seven days of discharge from acute care. They include diagnoses such as urinary tract infection, pneumonitis, or an exacerbation of a comorbidity such as diabetes.

Category 5 diagnoses are the same as those in category 4, but occur beyond the 7 day time period. This means there is a lower likelihood that the reason for return was a result of care in the index hospitalisation.

From the same AIHW list, five categories were defined for the analysis of 60-day returns to acute care following elective procedures:

1. Orthopaedic complications (within time specified)
2. Orthopaedic complications (outside time specified)
3. Potentially related to hospital care (within time specified)
4. Potentially related to hospital care (outside time specified)
5. Other.

Calculating length of stay

In calculating average length of stay, index admissions that were transferred in from, or out to, another acute care hospital were excluded.

In order to avoid the effect of patients with unreasonably long length of stay, results were trimmed to third quartile plus 1.5x the interquartile range for the DRG group.

Figure 29 Schematic of approach used: step 3

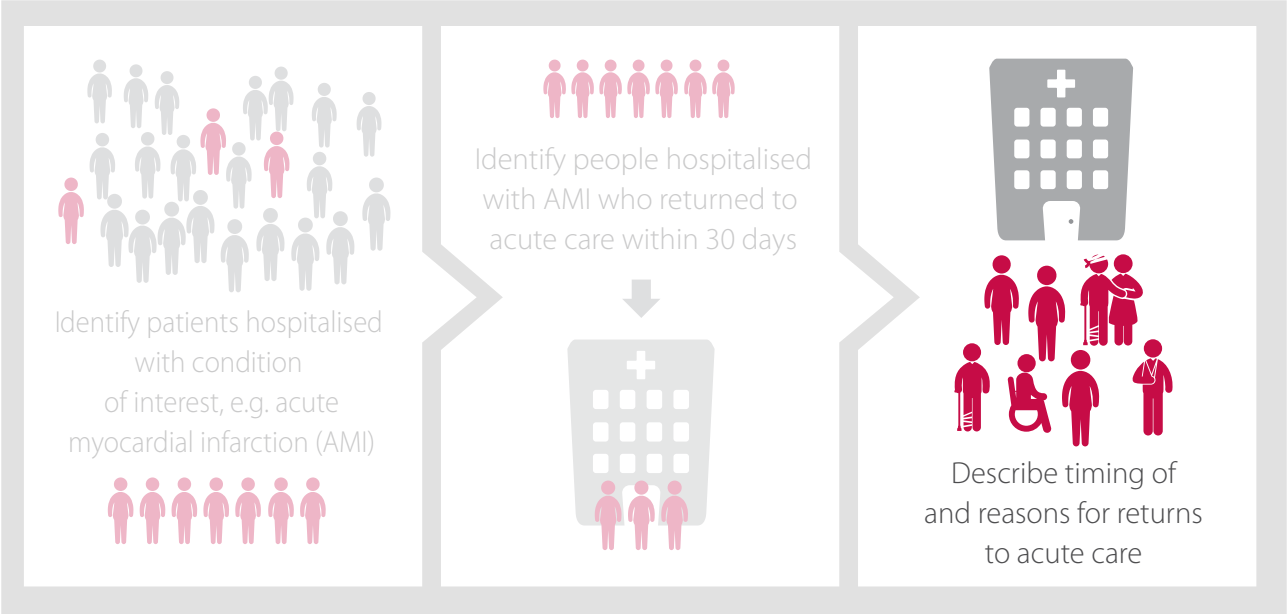


Figure 30 Stratification of principal diagnoses for returns to acute care within 30 days of discharge or transfer to a non-acute care setting following hospitalisation for acute myocardial infarction

Category	Stratification of principal diagnoses	Examples
1	Same principal diagnosis as the index hospitalisation	Acute myocardial infarction
2	Related to the index hospitalisation principal diagnosis	Angina
		Atrial fibrillation
		Ischaemic cardiomyopathy
		Congestive heart failure
3	Potentially related to hospital care (not time sensitive)	Enterocolitis due to Clostridium difficile
		Haemorrhagic disorder due to circulating agents
		Hypotension due to drugs
		Peptic ulcer, acute with haemorrhage
		Phlebitis and thrombophlebitis of deep vesssels of lower extremities
		Pulmonary embolism
		Mechanical complication of cardiac electronic device
4	Potentially related to hospital care (if occurring on days 1-7)	Decubitus ulcer
		Urinary tract infection
		Sepsis
		Fracture of neck of femur
		Hypokalemia
		Fluid overload
		Acute kidney failure
		Complication of procedure
		Diabetes
5	Potentially related to hospital care (if occurring on days 8-30)	Same as category 4*
6	Other	Malignant neoplasm
		Laceration of liver
		Calculus in urethra

* These conditions are considered more likely to be related to the index hospitalisation if they occur within 7 days of discharge, but remain potentially related for the 30 day follow-up period.

How to apply the measure in a NSW context?

What NSW-specific data limitations and contextual caveats should be considered?

Investigating same-day returns to acute care

In most jurisdictions, the clock for 30 day readmissions start at the point a patient is discharged – identified in administrative records using the 'mode of separation'.

For the BHI analysis between July 2009 and June 2012, there were 1,250 cases in which patients 'returned to acute care' on the same-day as they were discharged. The proportion of index admissions deemed to be a same-day return to acute care ranged across the clinical cohorts from 0.5% for hip fracture surgery to 1.2% for acute myocardial infarction (AMI) (Figure 31).

This prompted further investigation which found inconsistencies in mode of separation coding across NSW hospitals.

One key area of inconsistency is the use and recording of 'Hospital in the Home' (HITH) admissions. HITH 'delivers multidisciplinary acute care to suitable, consenting patients at their home or clinic setting as an alternative to inpatient hospital care'.[47] In some hospitals, patients transferred for acute care to HITH were coded as a discharge from the index hospital and therefore identified as a same-day return to acute care in a HITH setting. In other hospitals, patients transferred for acute care to HITH were coded as a return to acute care back to the same hospital. Both of these scenarios resulted in spurious return to acute care flags.

A second source of inconsistency involves patients who were transferred to another facility for further treatment, or acute post-interventional care. For example, there were 30 same-day returns to acute care for patients hospitalised for AMI at Hospital X (a peer group A metropolitan hospital) during the study period. Patients returned to Hospital X (four patients), to private hospitals (three patients), HITH (three patients) and regional NSW hospitals (20 patients). Investigation found that approximately half (47%) of these hospitalisations were coded as a discharge by Hospital X and a 'transfer from Hospital X' by the accepting

Figure 31 Percentage of same-day returns to acute care within the cohort of index cases and within the unadjusted returns to acute care, July 2009 – June 2012

Condition	Proportion of index cohort coded in the APDC as a same-day return to acute care	Proportion of returns to acute care no longer deemed returns following reclassification
Acute myocardial infarction	1.2%	7.2%
Ischaemic stroke	0.8%	7.0%
Congestive heart failure	0.7%	3.1%
Pneumonia	0.9%	6.6%
Hip fracture surgery	0.5%	5.1%
Total hip replacement	1.0%	10.1%
Total knee replacement	0.6%	5.2%
TOTAL	0.8%	5.6%

hospital. This resulted in spurious same-day return to acute care flags.

Given these inconsistencies, the analytic data set was rebuilt with a new definition of 'period of care'. The new definition reclassified all same-day returns to acute care as either a transfer (if the patient moved to a different acute care facility) or an extension of the index period of care (if the patient record indicated that the patient had returned to the same hospital).

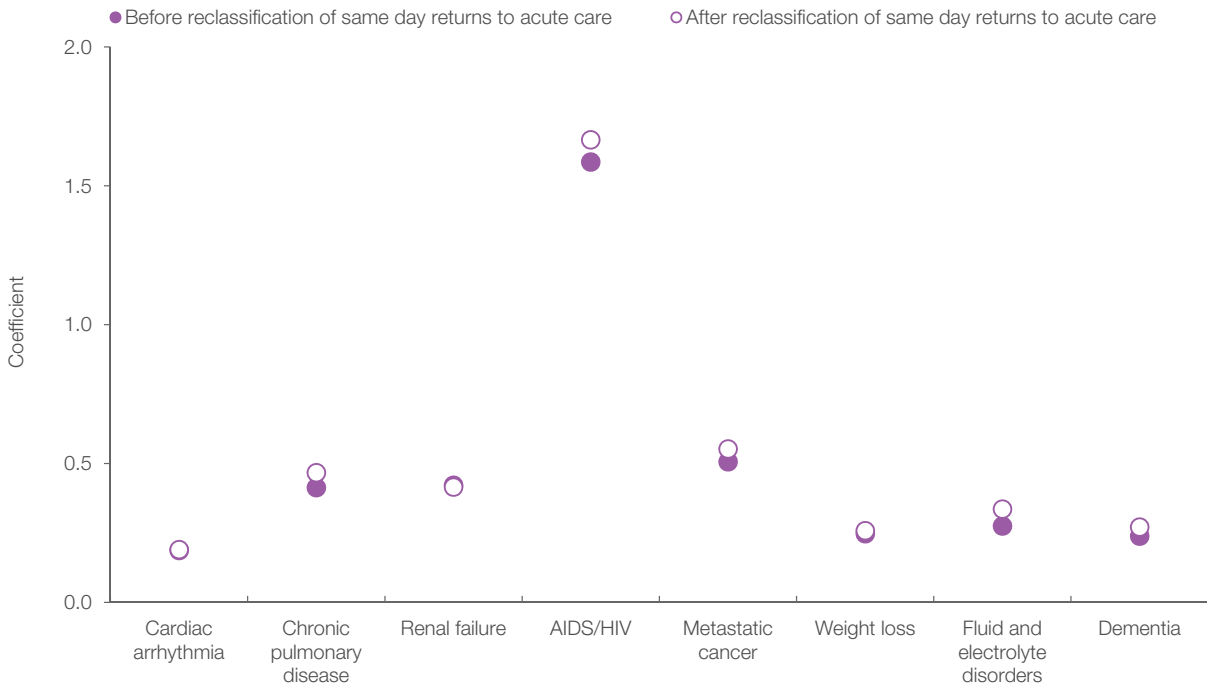
Following this change to the definition of the 'period of care' all the statistical models were re-run. The impact of this change on the c-statistics of the models was modest (Figure 32). The impact on the model coefficients was also modest (see, for example, ischaemic stroke in Figure 33).

This approach favours specificity over sensitivity – that is to say there may be actual cases of same-day returns to acute care that are now missed. However, the results are less likely to mistakenly flag a hospital as having a higher than expected RSRR.

Figure 32 C-statistics before and after reclassification of same-day returns to acute care, July 2009 – June 2012

Condition	Before	After
Acute myocardial infarction	0.63	0.63
Ischaemic stroke	0.58	0.59
Congestive heart failure	0.60	0.60
Pneumonia	0.66	0.67
Hip fracture surgery	0.60	0.60
Total hip replacement	0.61	0.61
Total knee replacement	0.56	0.56

Figure 33 Ischaemic stroke: impact of including same-day returns to acute care following hospitalisation in the predictive modelling for return to acute care within 30 days, July 2009 – June 2012



Impact of reclassifying same-day returns to acute care

Reclassifying same-day returns to acute are as either a transfer (if the patient moved to a different acute care facility) or an extension of the index period of care (if the patient was admitted to the same hospital) had a negligible impact on the statistical models (see pages 40-41).

The effects of the definitional change on the cohorts and on results for the five clinical conditions and two elective surgical procedures are summarised in Figure 34. The change to the funnel plot for ischaemic stroke is shown in Figures 35 and 36.

Figure 34 Effects of definitional change on cohorts and results, July 2009 – June 2012

	Acute myocardial infarction		Ischaemic stroke		Congestive heart failure		Pneumonia		Hip fracture surgery		Total hip replacement		Total knee replacement	
	Old	New	Old	New	Old	New	Old	New	Old	New	Old	New	Old	New
Index cases	27,579	27,325	12,817	12,776	29,320	29,961	42,950	42,777	14,087	14,035	7,834	7,773	13,913	13,870
Returns to acute care	4636	4453	1396	1321	6819	6848	5676	5412	1444	1377	774	698	1614	1533
Unadjusted rate	16.8	16.3	10.9	10.3	23.3	22.9	13.2	12.6	10.3	9.9	9.9	9.0	11.6	11.1
Unadjusted rate after exclusions*	17.1	16.6	11.2	10.6	23.9	23.4	13.5	13.0	10.5	10.2	10.0	9.1	11.9	11.4
Hospitals with high RSRR	6	5	5	4	6	5	9	8	4	4	4	5	7	6
Hospitals with low RSRR	4	2	2	1	2	3	6	3	3	3	3	2	3	3
Hospitals unaffected	161	-	143	-	187	-	185	-	141	-	41	-	43	-
Changes in high RSRR	3	-	3	-	1	-	3	-	2	-	3	-	1	-
Changes in low RSRR	2	-	1	-	1	-	5	-	0	-	1	-	0	-

*After excluding index cases without at least 30 days of information (60 days for total hip replacement and total knee replacement

Figure 35 Ischaemic stroke pre-reclassification, 30-day RSRR, NSW public hospitals, July 2009 – June 2012

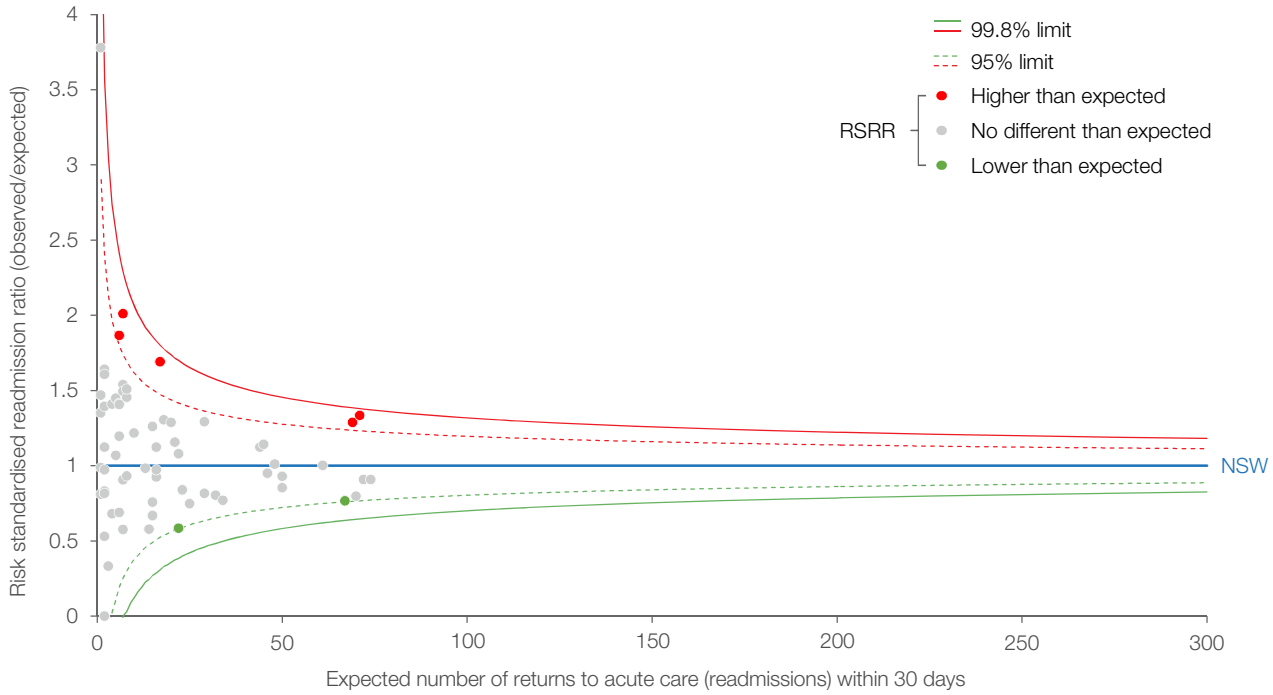
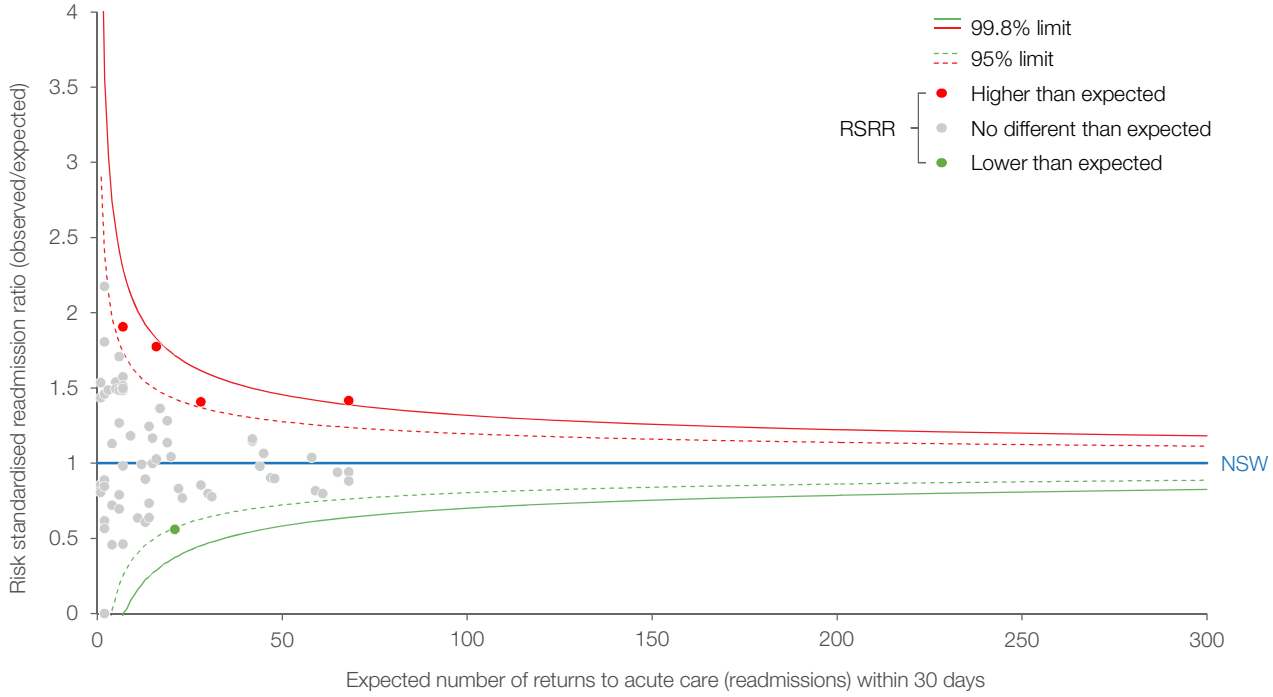


Figure 36 Ischaemic stroke post-reclassification, 30-day RSRR, NSW public hospitals, July 2009 – June 2012



How to handle type change separations

In line with specifications published internationally[5-7] (e.g. CMS in the US) and elsewhere in Australia,[49] the BHI analysis considers only acute episodes in the construction of index periods of care (see page 31).

Periods of care concatenate all acute, contiguous hospitalisations, collapsing transfers into a single unit of analysis. A return to acute care is attributed to the hospital that ultimately discharged the patient to a non-acute care setting. This means that in some hospitals, and for some conditions, there are returns that involve patients whose care type changed from acute to subacute care (thereby starting the 30-day return to acute care 'clock') with a subsequent type change back to acute care flagged as a return to acute care. They have 'returned to acute care' without ever physically leaving the hospital.

This approach has strong clinical justifications. Timing of discharge from acute care is an important clinical decision that impacts on quality of care and patient flow. Premature discharge from acute care to an environment that is less well equipped to meet patients' needs can lead to adverse outcomes.

While the BHI approach is consistent with that used in many other jurisdictions, analyses conducted elsewhere in NSW have at times used indicator specifications that exclude patient with a type change (see box); or focus on 'stays' which consider contiguous periods in hospital regardless of service category or care type.

Excluding index admissions with a type change separation would lead to a 13,997 fewer cases across all analyses reported here. There would be a particularly marked effect on ischaemic stroke (28.5% of cases excluded) and hip fracture surgery (31.1% of cases excluded) (Figure 37).

Unplanned hospital readmissions within 28 days[48]

Numerator: The total number of unplanned admissions with an admission date within the reference period, and patient previously discharged from the same facility in previous 28 days for any other purpose than mental health, chemotherapy or dialysis.

Denominator: The total number of admissions within the reference period, excluding mental health, chemotherapy or dialysis.

Patients with change of care type, patients who are transfers from other hospitals, and patients in small hospitals (facilities with peer groups below D2) are also excluded.

Centre for Epidemiology and Evidence. 2012. The health of Aboriginal people of NSW: Report of the Chief Health Officer, 2012. Sydney: NSW Ministry of Health.

The implications of adopting an approach that considers hospital stays were also investigated. The decision to type change a patient or to transfer to a non-acute setting is affected by availability of resources. To a certain extent, the two are substitutive – hospitals with no non-acute facilities will transfer patients for non-acute care.

An analysis was undertaken to explore patterns of patient transitions from an acute to a subacute setting (i.e. patients were either type changed or transferred to another hospital for non-acute care). The proportion of cases for which acute care ended in patients transitioning to non-acute setting (i.e a type change separation or a transfer to a non-acute setting) ranged from 6.1% of pneumonia cases to 40.0% of ischaemic stroke and 51.4% of hip fracture surgery cases (Figure 37).

Figure 37 Numbers of index hospitalisations ending with type change or transfer to non-acute hospital, NSW public hospitals, July 2009 – June 2012

	Total index hospitalisations	Index hospitalisation ending with type change		Index hospitalisation ending with transfer to sub-acute hospital*		Index hospitalisation ending with type change OR transfer to non-acute	
	Number	Number	% of index admissions	Number	% of index admissions	Number	% of index admissions
Acute myocardial infarction	27,325	789	2.9	449	1.6	1,238	4.5
Ischaemic stroke	12,776	3,639	28.5	1,466	11.5	5,105	40.0
Congestive heart failure	29,961	1,575	5.3	583	1.9	2,158	7.2
Pneumonia	42,777	1,881	4.4	723	1.7	2,604	6.1
Fractured hip surgery	14,035	4,358	31.1	2,862	20.4	7,220	51.4
Total hip replacement	7,773	607	7.8	397	5.1	1004	12.9
Total knee replacement	13,870	1,148	8.3	675	4.9	1823	13.1

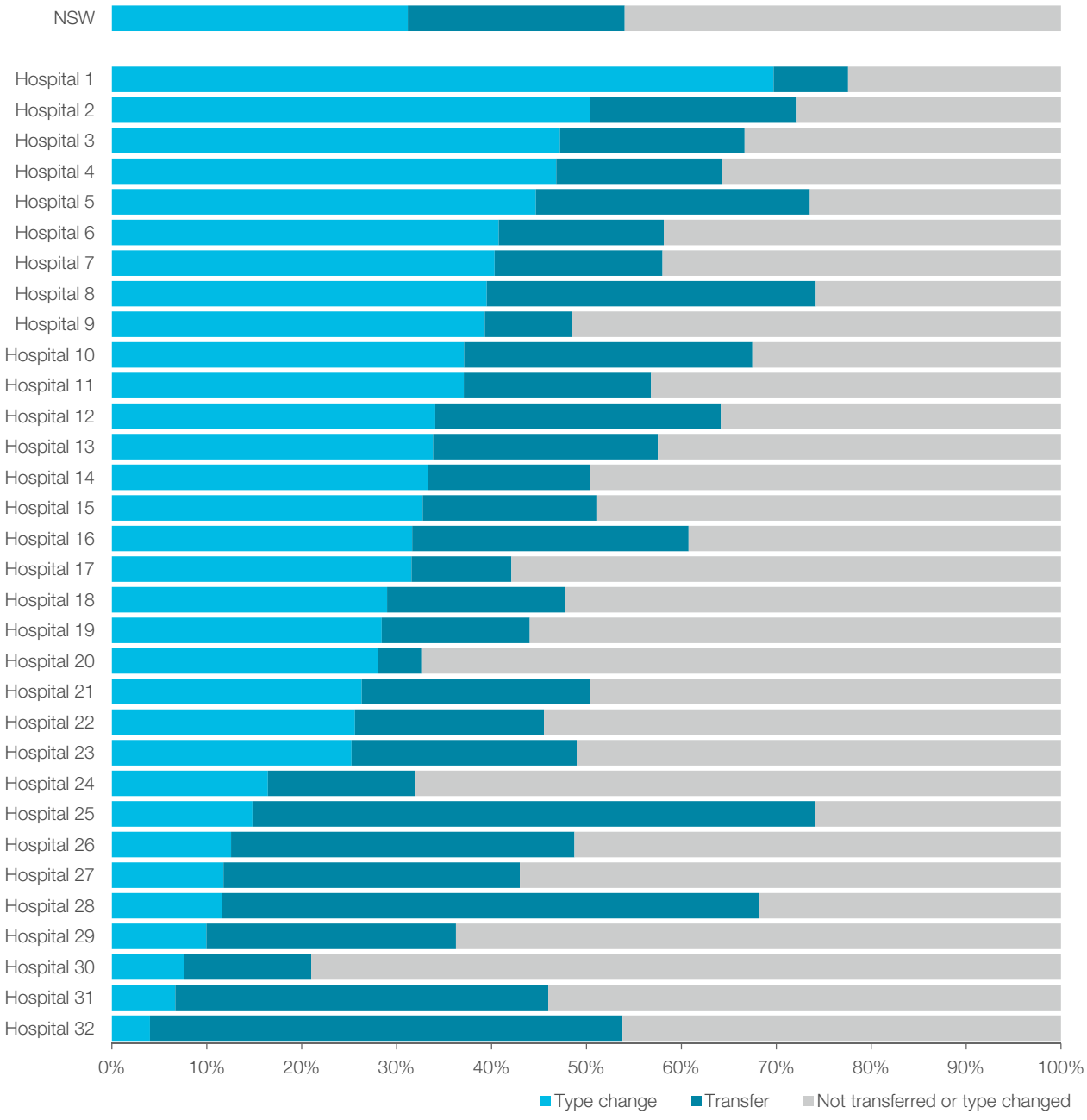
* Agency for Clinical Innovation identified inconsistent approaches to classifying and 'type changing' patients from acute to subacutecare across hospitals.[50]

Transitioning from acute care

The transition from acute care is an important part of patients' journeys, particularly for conditions such as stroke which often require rehabilitation care. There is variation across the state's hospitals in arrangements for non-acute care on-site.[50] To quantify the extent of this variation, index admissions were stratified by mode of separation.

There was a high proportion of index admissions that ended with a transfer to non-acute care in the ischaemic stroke cohort (42% of index admissions) and hip fracture surgery cohort (54% of index admissions). Figures 38 and 39 illustrate, for these

Figure 38 **Hip fracture surgery: distribution of index admissions by mode of separation, NSW hospitals, July 2009 – June 2012***

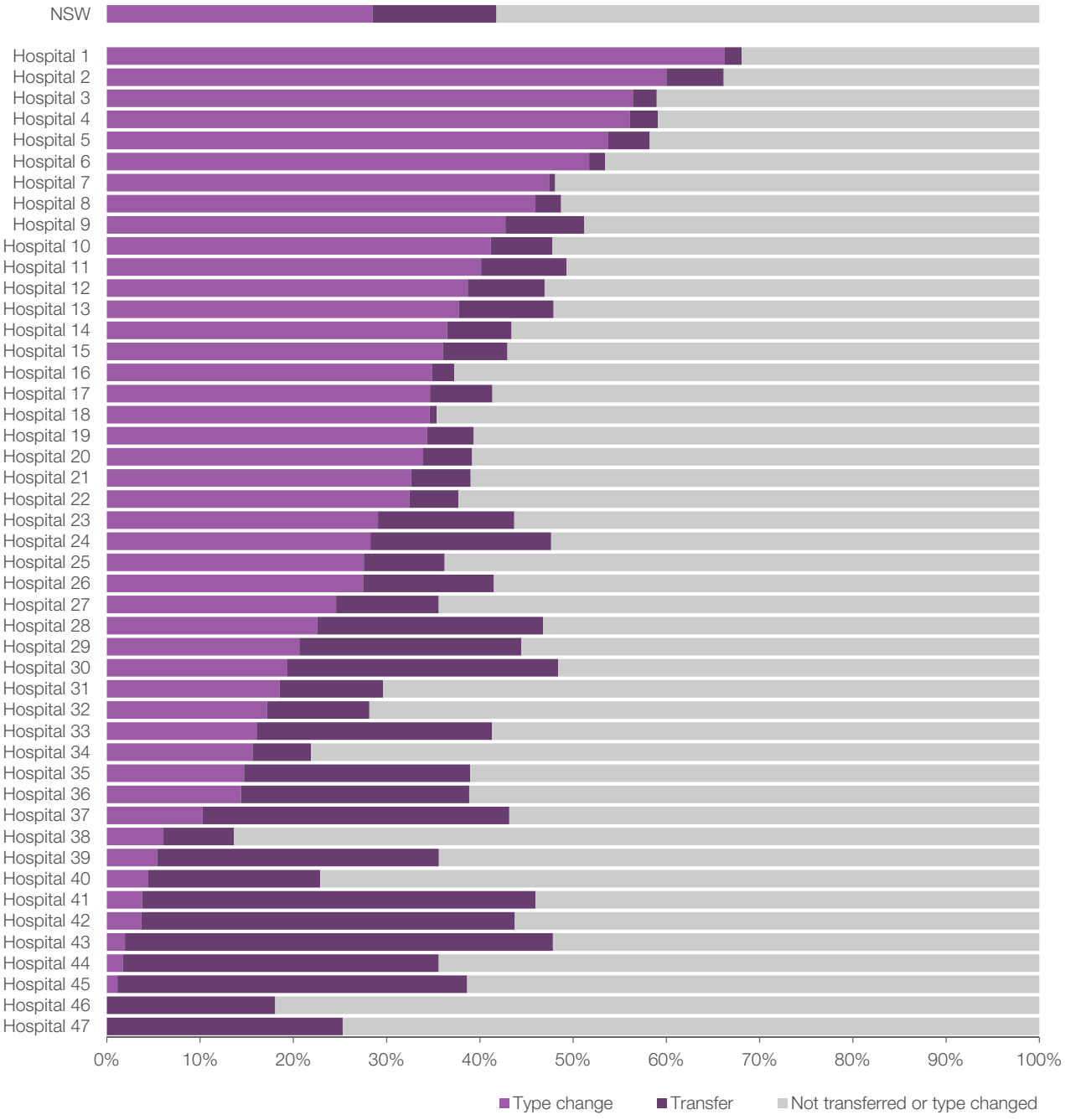


* Index admissions with less than 30 days follow-up have been excluded.

conditions, variation across the state's hospitals in the extent to which their patients' acute care episodes end in a type change to non-acute care within the hospital, or in a transfer to a non-acute setting.

Looking at the ischaemic stroke results, Hospital 1 type changed 66% of its patients and transferred 2%, while Hospital 47 type change 0% of its patients and transferred 25% (Figure 39).

Figure 39 Ischaemic stroke: distribution of index admissions by mode of separation, NSW hospitals, July 2009 – June 2012*



* Index admissions with less than 30 days follow-up have been excluded.

A focus on acute care: Homogeneity and fair comparisons

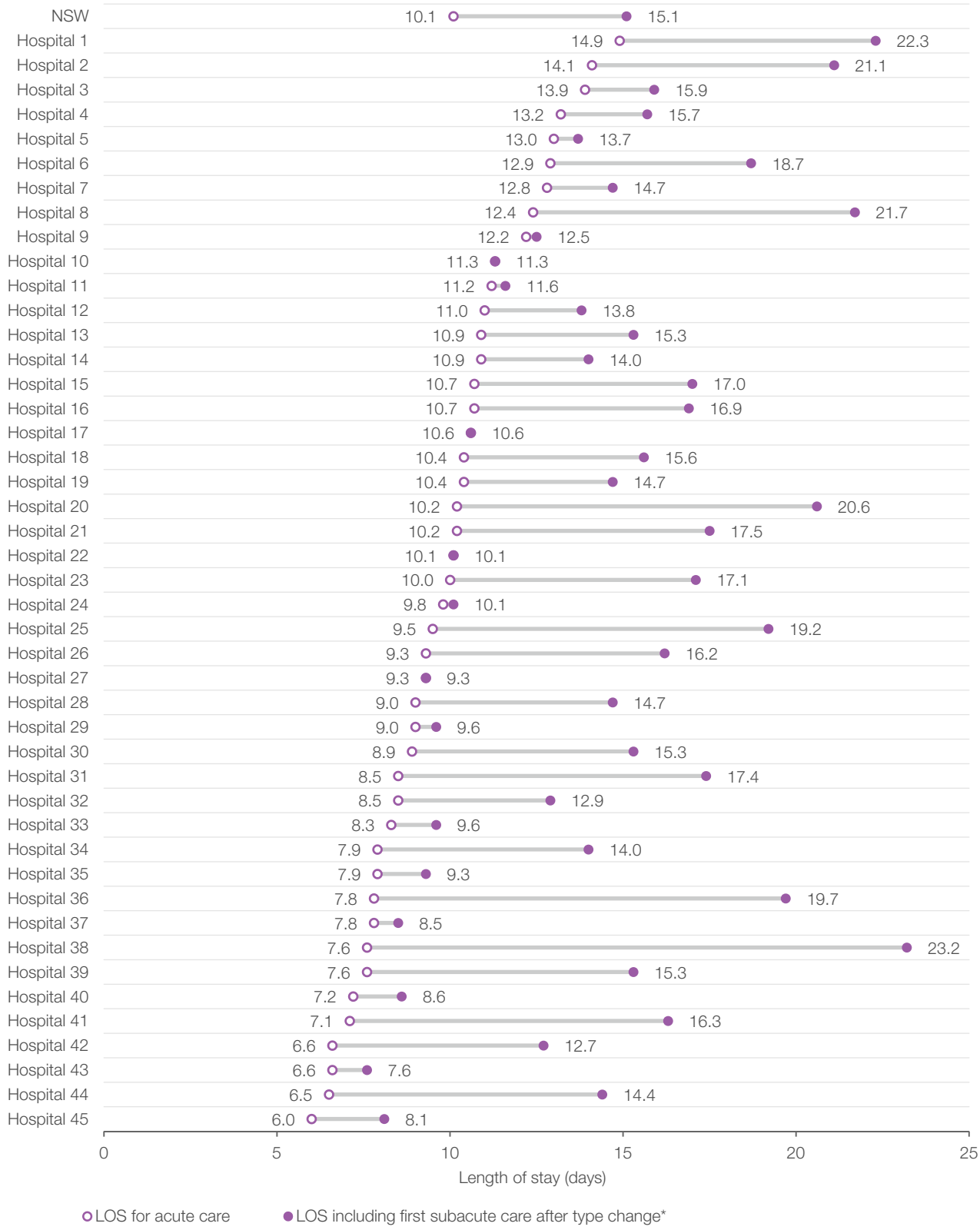
The BHI version of the RSRR measure focuses on returns to acute care. It considers the point at which patients are discharged from acute care to be the start of the follow-up period, regardless of whether they were discharged home, were transferred to another hospital for non-acute care, or were transferred to non-acute care in the same hospital (type changed).

To explore the effect of considering index admissions to be contiguous periods in hospital, regardless of service category or care type, an analysis of patients' length of stay (LOS) was undertaken. Given the variation in the use and availability of non-acute care within hospitals (see pages 46 - 47), defining index admissions as contiguous 'all-care type' stays would be prone to misinterpretation because of heterogeneity. For example, among patients who require non-acute care at the end of their acute episode, those who are cared for in a hospital with on-site capacity to provide non-acute care usually remain in that hospital until they are ready to go home. In contrast, patients who are cared for in a hospital wth no capacity for providing non-acute care, physically leave the hospital at an earlier point in their recovery. In other words, the return to acute care 'clock' woiuld start at a different stage in patients' recovery depending on whether the hospital has access to on-site non-acute care – introducing a bias in the analysis.

Length of stay was used to assess the extent of heterogeneity across the two approaches to defining index hospitalisations. For each hospital stay in the ischaemic stroke analysis, the length of stay for the acute care period was compared to the length of stay for the entire patient hospitalisation, regardless of stay type (Figure 40). For each hospital, the same group of patients is included and the two points represent the two definitions of an index admission.

The analysis reveals that while there is some variation in the length of acute stays (as might be expected), a considerable amount of heterogeneity is introduced when the entire hospitalisation length of stay is considered. This suggests that it is fairer and more meaningful to base readmission analyses on returns to acute care.

Figure 40 Ischaemic stroke: length of stay, acute care versus contiguous 'all care type', NSW public hospitals, July 2009 – June 2012*



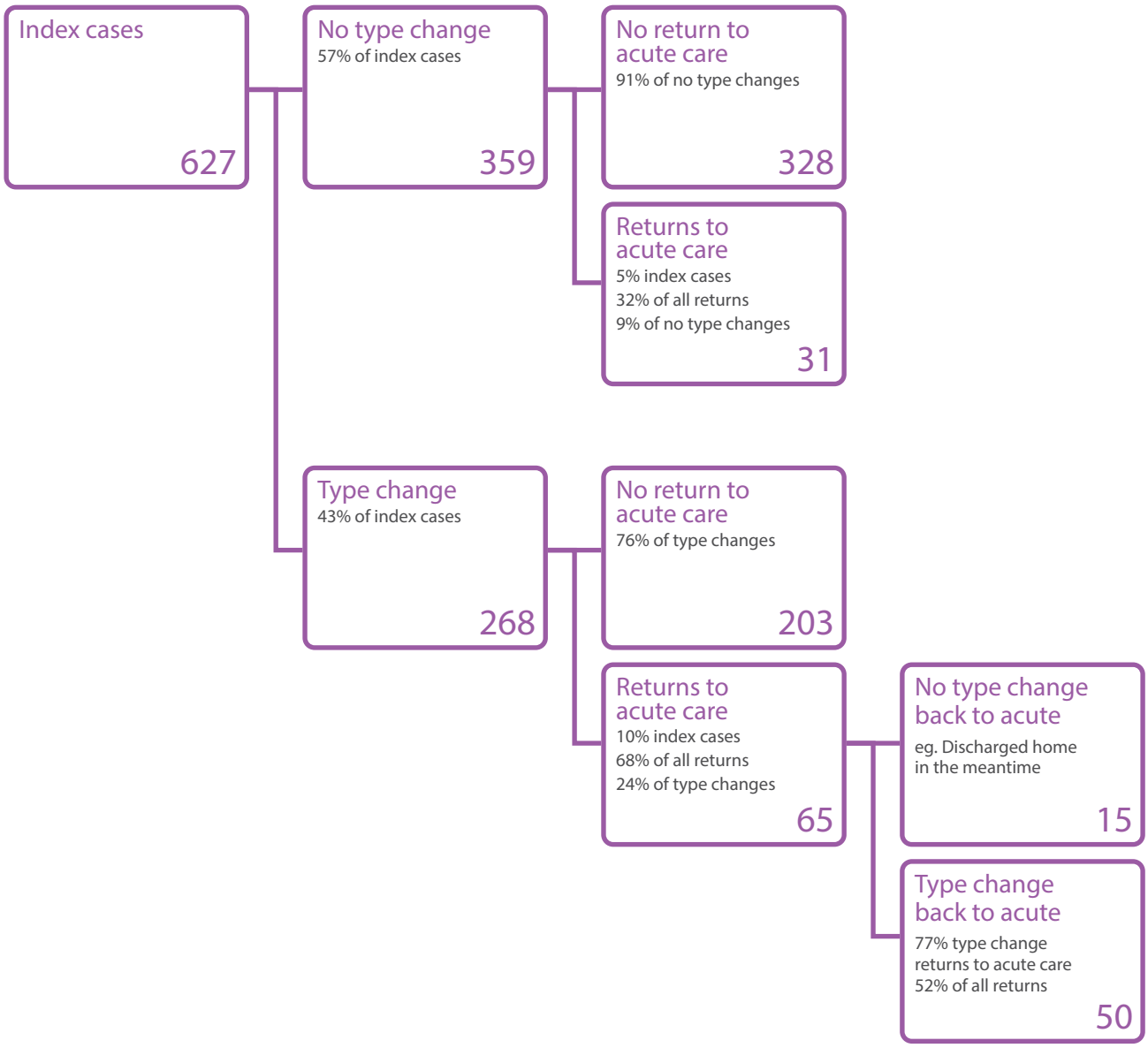
* Length of stay (LOS) of contiguous 'all care types' were calculated by summing length of stay for acute care with length of stay for first subacute care episode following type change

Relationship between mode of separation and returns to acute care

To further explore the implications of the decision to limit index cases to acute periods of care only, analyses were conducted to ascertain whether patients who were type changed at the end of acute care were more or less likely to return to an acute care setting than those patients who were transferred to another hospital for non-acute care, or discharged home.

For NSW overall, unadjusted rates of return to acute care were broadly similar across the different modes of separation, particularly for acute myocardial infarction and pneumonia. For ischaemic stroke and hip fracture surgery, unadjusted rates of return to acute care were lower for patients transferred to another hospital for non-acute care and higher for patients that left acute care with a type change. However hospitals with high use of type change separations did not always have higher than expected RSRRs.

Figure 41 Ischaemic stroke: schematic of returns to acute care according to type change separations, Hospital Z, July 2009 – June 2012



Compared with statewide results, there is much more variation at a hospital level – suggesting that local practices may affect rates of return back to an acute care setting. For example, in the ischaemic stroke cohort, there was one hospital (Hospital Z) within which 43% of index cases ended in a type change. Admissions ending in a type change accounted for 68% of all Hospital Z's returns to acute care (compared to 31% for NSW as a whole) (Figures 41 and 42).

Variation in unadjusted rates of return to acute care by mode of separation at a hospital level across all seven patient cohorts was illustrated in Figures 43 - 49.

Overall, these results suggest that 'starting the clock' at the point at which patients leave an acute care setting is the most meaningful point at which to compare hospital performance to the state overall.

Figure 42 Ischaemic stroke: schematic of returns to acute care according to type change separations, NSW, July 2009 – June 2012

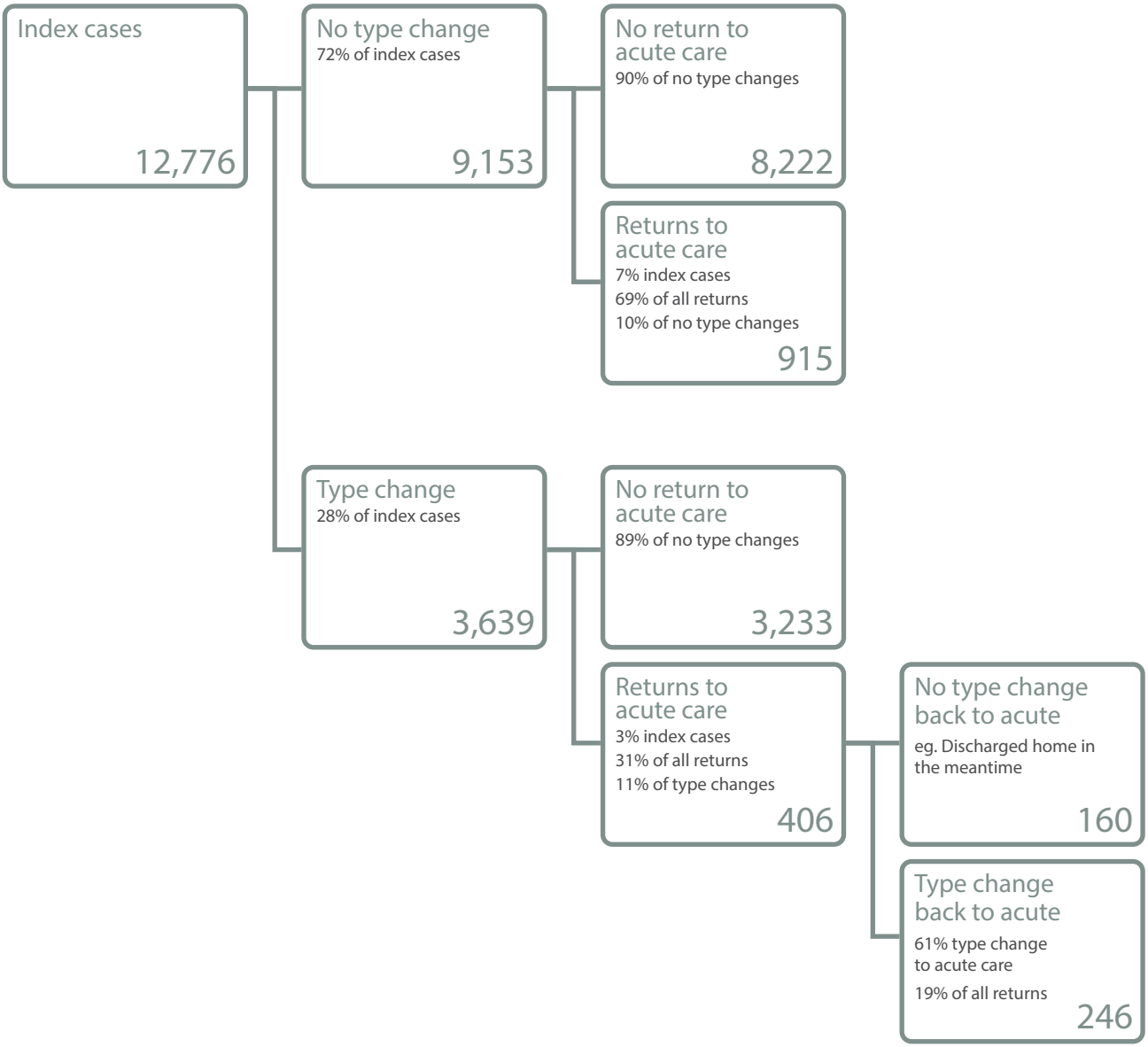


Figure 43 Acute myocardial infarction: unadjusted rate of return to acute care following hospitalisation by hospital and index case separation mode, NSW public hospitals, July 2009 – June 2012*

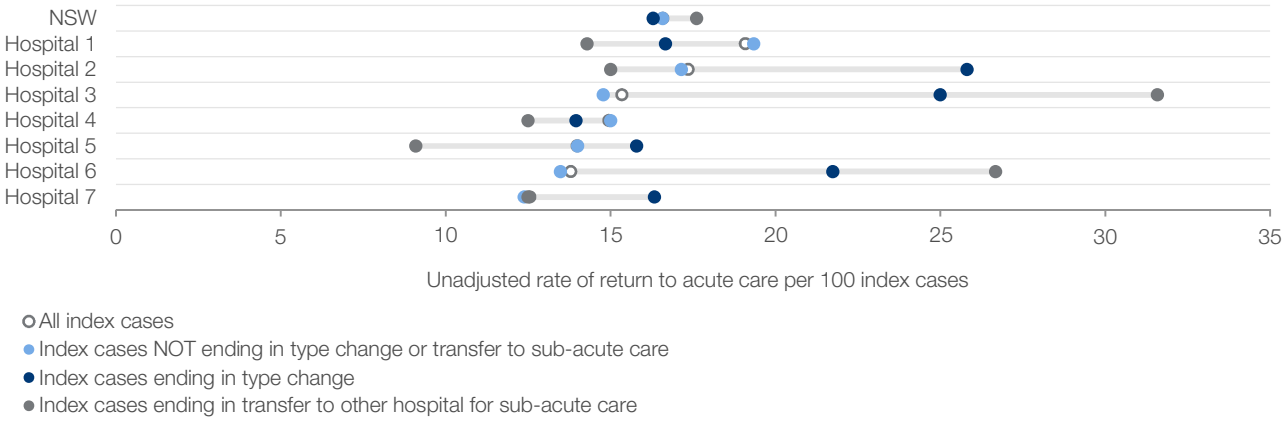
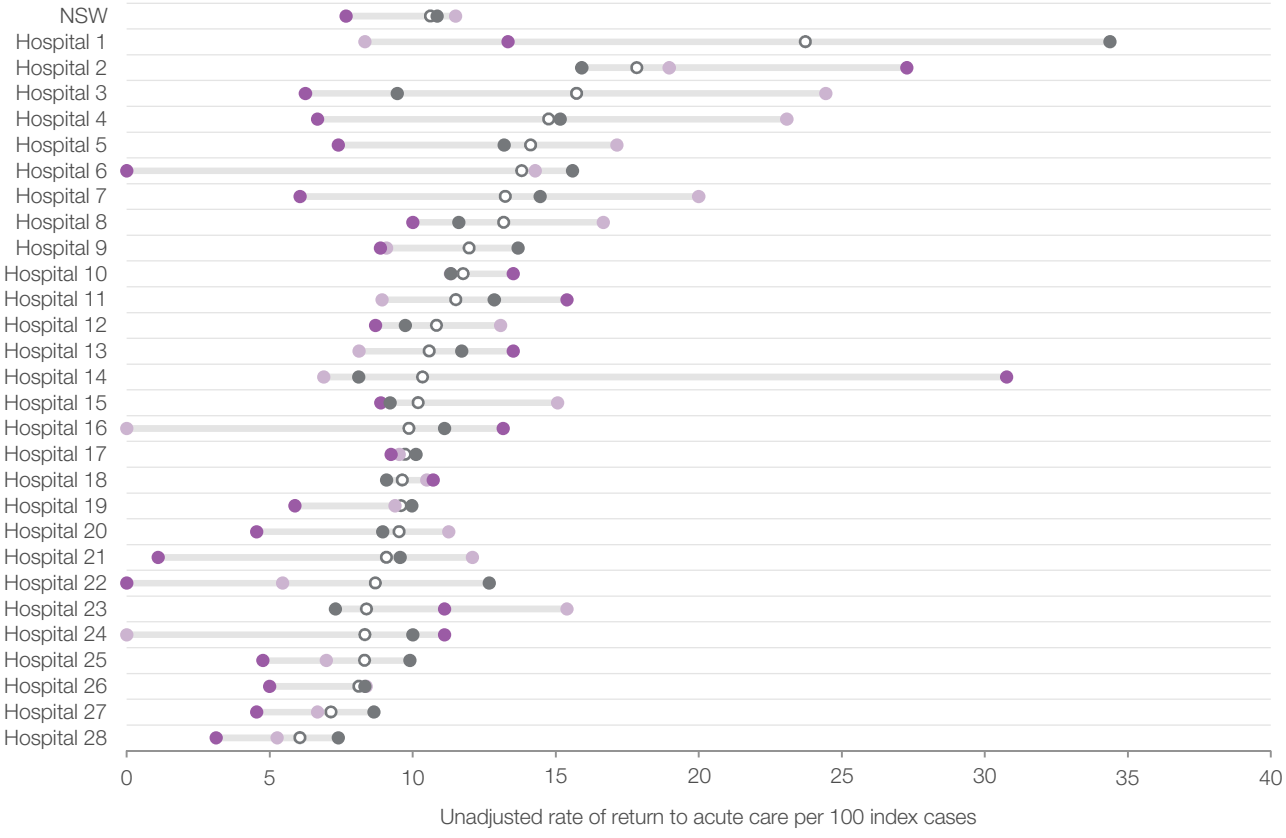


Figure 44 Ischaemic stroke: unadjusted rate of return to acute care following hospitalisation by hospital and index case separation mode, NSW public hospitals, July 2009 – June 2012*



* Includes A-C peer group hospitals with more than 50 index cases overall, and at least 10 index cases in all four categories (index cases without at least 30 days of information are excluded)

Figure 45 Congestive heart failure: unadjusted rate of return to acute care following hospitalisation by hospital and index case separation mode, NSW public hospitals, July 2009 – June 2012*

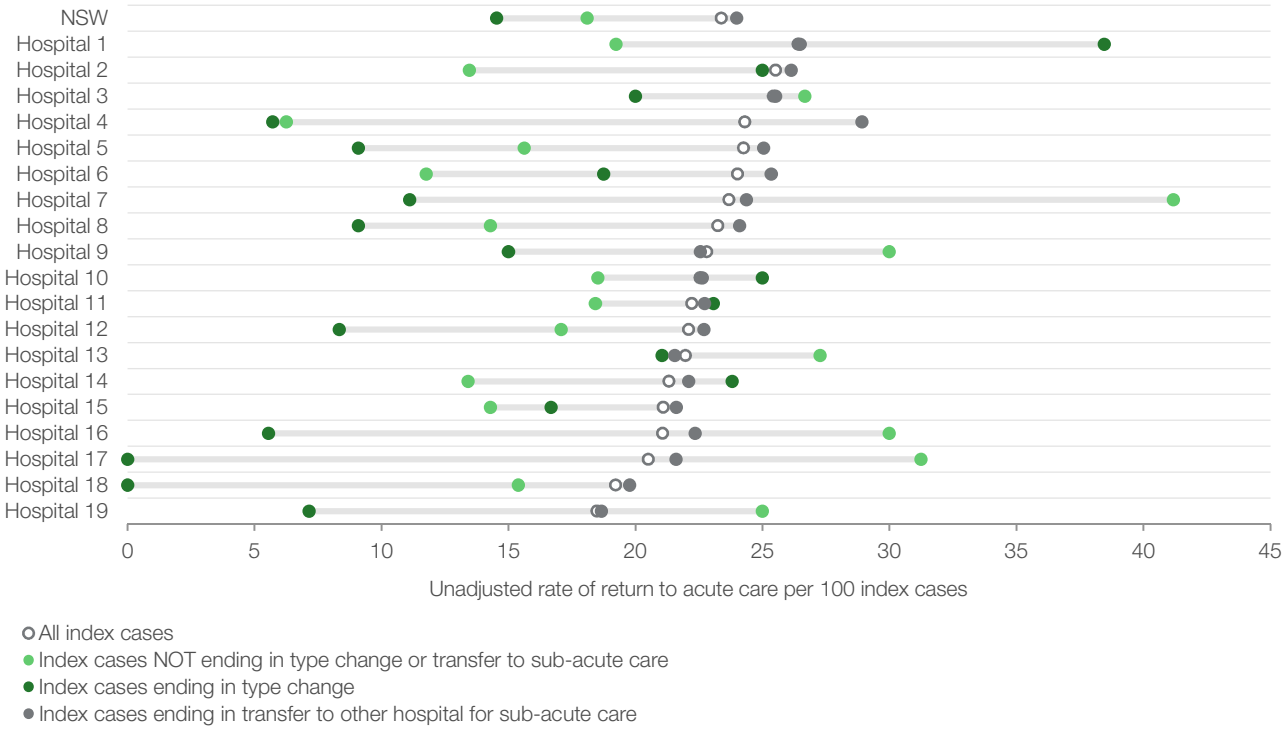
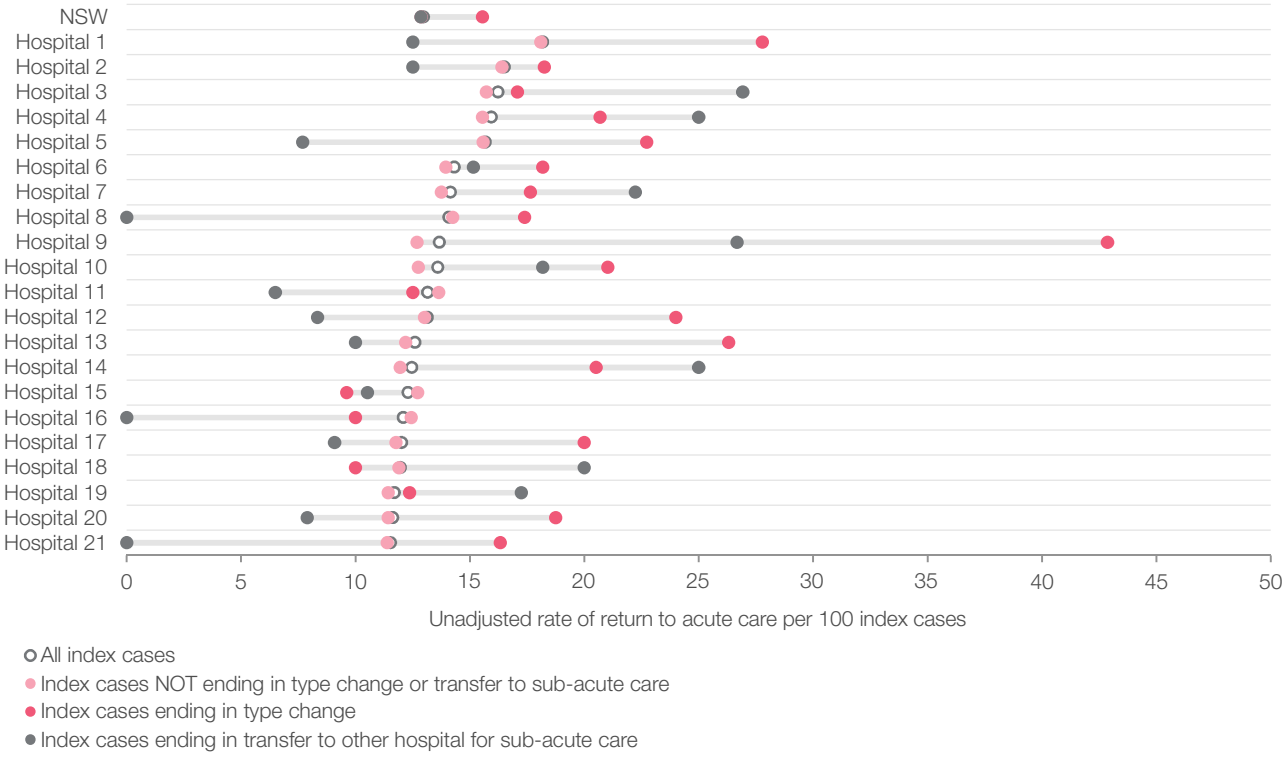
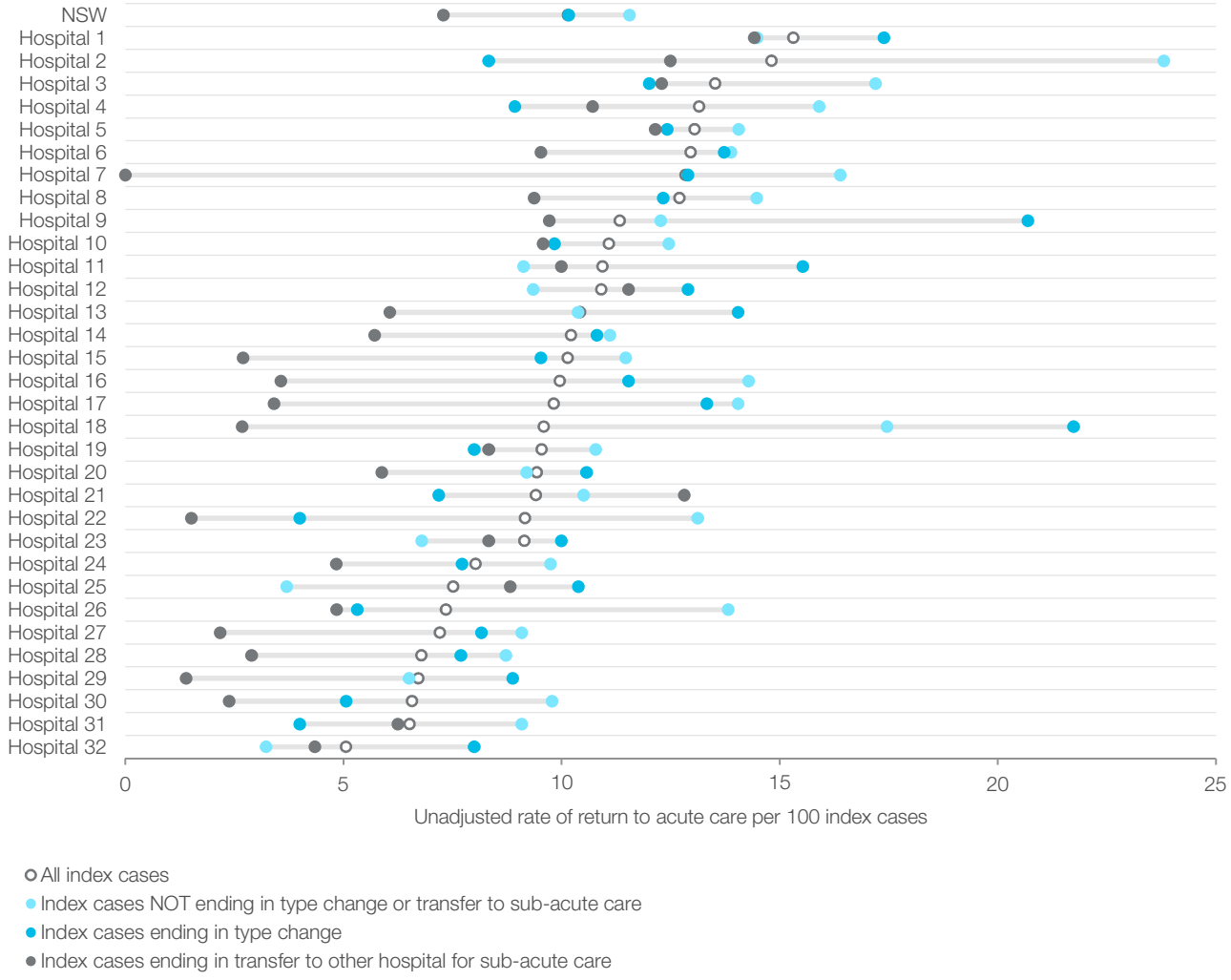


Figure 46 Pneumonia: unadjusted rate of return to acute care following hospitalisation by hospital and index case separation mode, NSW public hospitals, July 2009 – June 2012*



* Includes A-C peer group hospitals with more than 50 index cases overall, and at least 10 index cases in all four categories (index cases without at least 30 days of information are excluded)

Figure 47 Hip fracture surgery: unadjusted rate of return to acute care following hospitalisation by hospital and index case separation mode, NSW public hospitals, July 2009 – June 2012*



* Includes A-C peer group hospitals with more than 50 index cases overall, and at least 10 index cases in all four categories (index cases without at least 30 days of information are excluded)

Figure 48 **Total hip replacement: unadjusted rate of return to acute care following hospitalisation by hospital and index case separation mode, NSW public hospitals, July 2009 – June 2012***

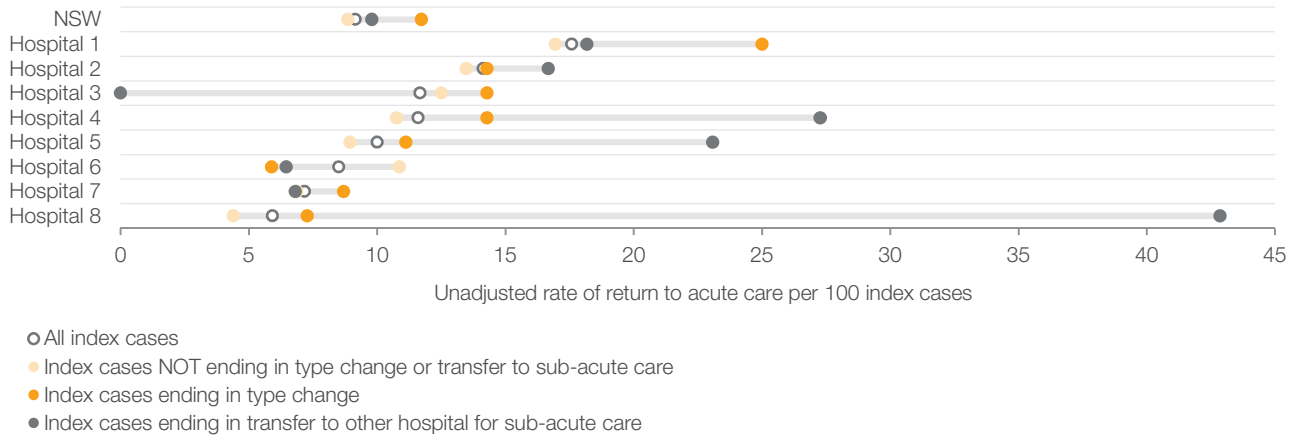
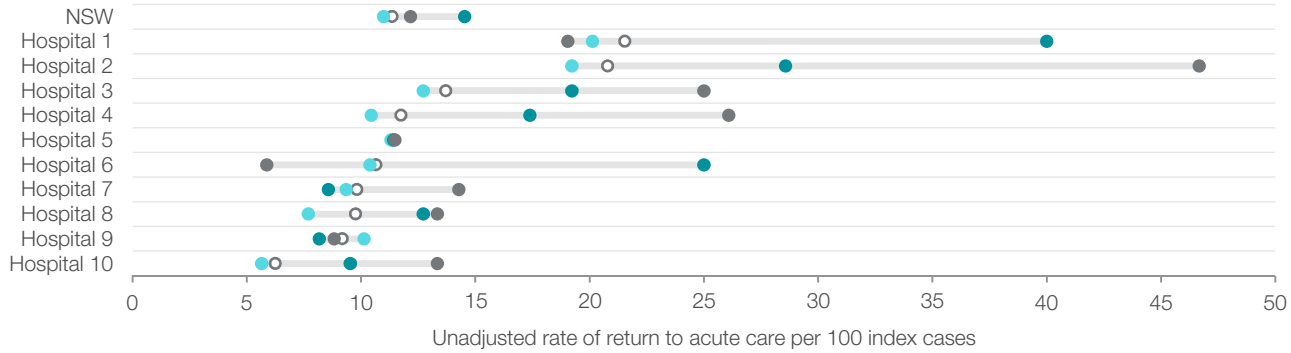


Figure 49 **Total knee replacement: unadjusted rate of return to acute care following hospitalisation by hospital and index case separation mode, NSW public hospitals, July 2009 – June 2012***



* Includes A-C peer group hospitals with more than 50 index cases overall, and at least 10 index cases in all four categories (index cases without at least 30 days of information are excluded)

Appendices

- RSRR indicator specifications
- cohorts
- prediction models

Appendix 1

Acute myocardial infarction: RSRR indicator specification, cohort and prediction model

RSRR Indicator specification

The condition

An acute myocardial infarction (AMI), or heart attack, occurs when the blood supply to part of the heart is interrupted, resulting in death of heart cells. If blood supply is not restored quickly, the heart muscle suffers permanent damage.

The indicator

The risk standardised readmission ratio (RSRR) provides a fair comparison of a particular hospital's results in returns to acute care given its case mix with an average NSW hospital with the same case mix[1].

Data source

Data are drawn from the NSW Ministry of Health's Health Information Exchange (HIE) and the NSW Registry of Births, Deaths and Marriages, and probabilistically linked by the Centre for Health Record Linkage (CheReL). Data are accessed via SAPHaRI, Centre for Epidemiology and Evidence, NSW Ministry of Health.

Calculation

The ratio of the observed number of emergency returns to acute care (numerator) to the expected number of emergency returns to acute care (denominator) within 30 days following discharge from AMI index admissions at a given hospital.

Cohort index admissions

An index admission is the hospitalisation included in calculating RSRRs for the condition of interest. The index admissions form the 'cohort' for assessing returns to acute care.

Inclusions

- Principal diagnosis of AMI (I21, I22)
- Aged 15 years or over
- Admissions to acute care
- Discharged between 1 July 2009 and 30 June 2012.

Exclusions

- Admissions that started and ended on the same day, as they are unlikely to be a clinically significant AMI
- Index admissions with mode of separation 'Discharged at own risk', as the hospital would not be able to complete treatment or discharge planning
- Index admissions within 30 days of a prior index admission (any admission within 30 days following discharge from an index admission is considered a readmission)
- Discharges from NSW hospitals administered by agencies external to NSW
- Index admissions with mode of separation 'Transferred to palliative care'
- Index admissions ending with an in-hospital death
- Discharges from a private hospital.

Period of care and transfers

Multiple acute, contiguous hospitalisations are considered as a single, acute period of care. Acute admissions on the same day of separation from another acute hospitalisation are included in the same acute period of care, regardless of the mode of separation at the previous hospitalisation. If an acute admission is coded as ending in a transfer, and there is another acute admission within one day of that transfer, the second admission is concatenated into the same period of care.

Numerator

Observed number of hospital-level emergency returns to acute care, where an emergency return to acute care meets the following criteria:

- All-cause hospitalisations within 30 days following discharge from an AMI index admission
- Acute and emergency hospitalisations
- Admitted to any NSW hospital (public or private).

In cases where more than one emergency return to acute care occurs within 30 days of an index admission, only the first return is counted.

Denominator

Expected number of emergency returns to acute care at a given hospital, on the basis of an average NSW hospital's performance with the same case mix, calculated as the sum of the estimated probabilities of emergency returns to acute care using a NSW-level prediction model.

Attributions of index admissions and emergency returns to acute care

- In cases of patient transfers, index admissions and emergency returns to acute care are attributed to the last hospital that discharged the patient to a non-acute care setting
- When there is a non-emergency overnight acute rehospitalisation in the 30 days following discharge from the index admission, and preceding the first emergency return to acute care, no return is assigned to that index admission.

Transfers to non-acute care

Periods of care include acute hospitalisations only. A transfer from acute to non-acute care, within the same or to a different hospital, is considered to be a discharge. Should the patient then be transferred from non-acute care to acute care within 30 days of this discharge, it will be considered as a return to acute care. The return to acute care will be attributed to the hospital which discharged the patient from acute to non-acute care.

Development and validation of the prediction model

The NSW-level prediction model is developed using Fine & Gray competing risks regression models adjusting for patient-level risk factors, and taking into account the competing risk of death.[2] The standard errors are adjusted for within hospital correlations. A backward modelling approach is used to build the multivariable regression models. Variables significant at 20 percent level in the univariate analysis are considered for inclusion in multivariable models. Only variables with a 2-sided p-value of less than 0.05 in the multivariable models are retained in the final model.

The prediction ability of the model is assessed using c-statistics in data from previous financial years. The stability of the coefficients in previous financial years is also tested. The clinical relevance of the variables in the final model and their direction of association with the outcome are reviewed by clinicians.

Risk adjustment variables

The following variables are included in the development of the prediction models:

- Age at index admission
- Sex
- Elixhauser comorbidities[3], dementia and history of AMI with a one-year look back period.

Index admissions with less than 30 days of follow-up information

Calculation of unadjusted rates of return to acute care and hospital RSRRs excludes index cases that occurred less than 30 days from the end of the study period (30 Jun 2012) to avoid introducing bias with a truncated follow-up period. However, as competing risk regression models take into account different follow-up periods, index admissions without a full 30 days of follow-up information are included to build the NSW prediction models.

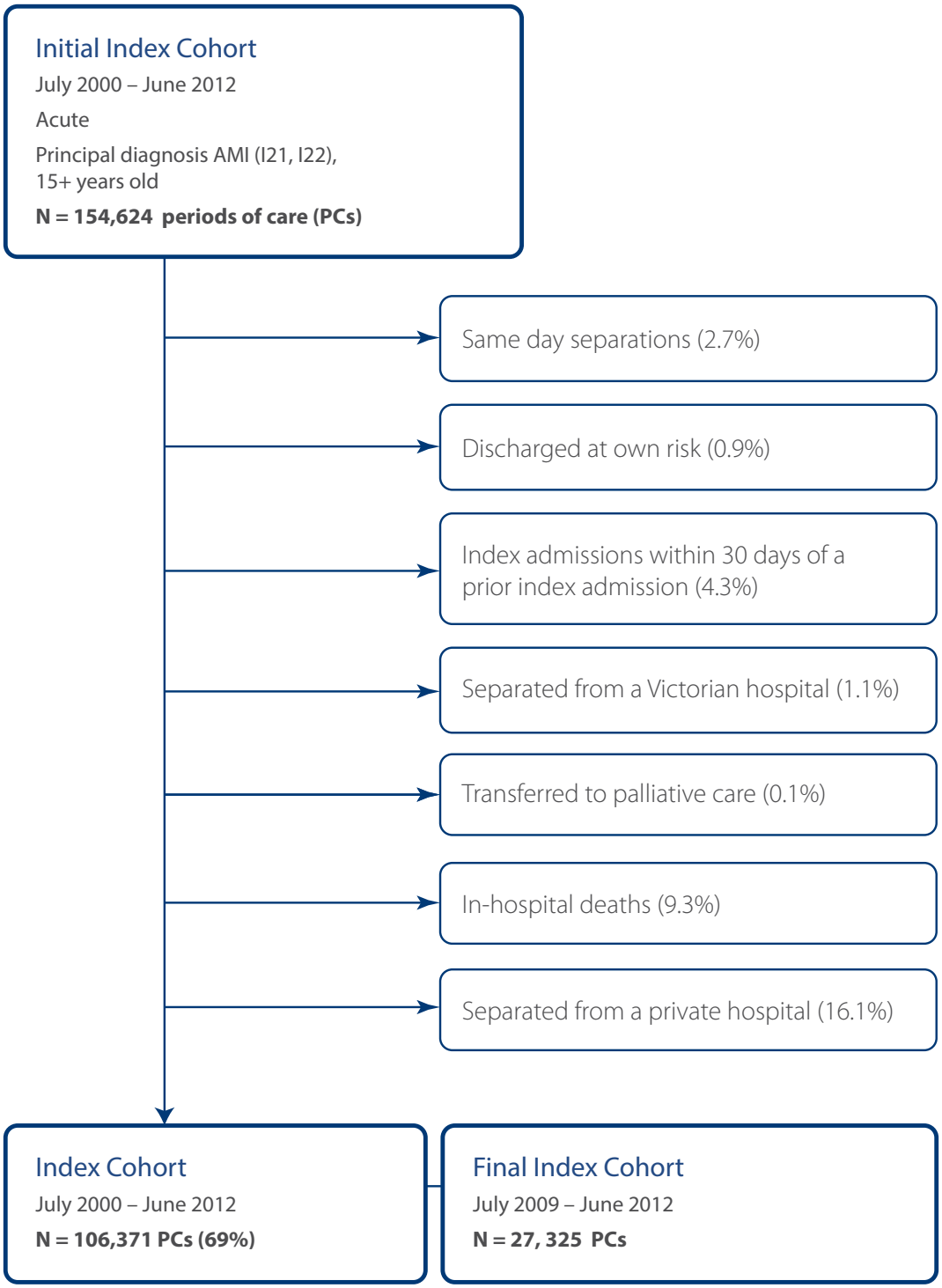
Presentation

Results are presented in a funnel plot. Hospitals with an RSRR that falls beyond the 95% and 99.8% control limits are flagged. Control limits are calculated based on a Poisson distribution.[4]

References

1. Centers for Medicare & Medicaid Services CMS 2014 Measures Updates and Specifications Report: Hospital-Level 30-Day Risk-Standardized Readmission Measures for Acute Myocardial Infarction (Version 7), Heart Failure (Version 7), Pneumonia (Version 7), Chronic obstructive pulmonary disease (Version 3), Stroke (Version 3) Yale New Haven Health Services Corporation/Center for Outcomes Research & Evaluation (YNHHSC/CORE); 2014
2. Fine JP, Gray RJ. A proportional hazards model for the subdistribution of a competing risk. Journal of the American Statistical Association 1999; 94: 496–509
3. Elixhauser A, Steiner C, Harris DR, Coffey RM: Comorbidity measures for use with administrative data. Med Care 1998, 36:8-27
4. Spiegelhalter D. Funnel plots for comparing institutional performance. Statistics in Medicine 2005; 24: 1185-1202.

Figure A1.1 Cohort



Exclusions are not mutually exclusive.

Prediction model

Figure A1.2 Acute myocardial infarction: predictors of return to acute care within 30 days of discharge using competing risk model, July 2000 – June 2012

Predictors	Subhazard ratio	P-value	(95% Conf. Interval)
Age* (per 1 year increase)	1.01	<0.001	(1.01-1.02)
Age^2	1.00	0.002	(1.00-1.00)
History of AMI	1.12	0.032	(1.01-1.24)
Congestive heart failure	1.21	<0.001	(1.13-1.29)
Cardiac arrhythmia	1.20	<0.001	(1.12-1.28)
Valvular disease	1.16	0.004	(1.05-1.28)
Peripheral vascular disorders	1.16	0.002	(1.06-1.28)
Chronic pulmonary disease	1.33	<0.001	(1.22-1.46)
Diabetes (complicated)	1.22	<0.001	(1.12-1.32)
Hypothyroidism	1.31	0.018	(1.05-1.65)
Renal failure	1.25	<0.001	(1.13-1.38)
Peptic ulcer disease (excluding bleeding)	1.48	0.017	(1.07-2.05)
Solid tumour without metastasis	1.32	<0.001	(1.14-1.52)
Fluid and electrolyte disorders	1.13	0.01	(1.03-1.24)
Alcohol abuse/drug abuse/psychoses	1.40	<0.001	(1.19-1.65)
Depression	1.28	0.005	(1.08-1.51)

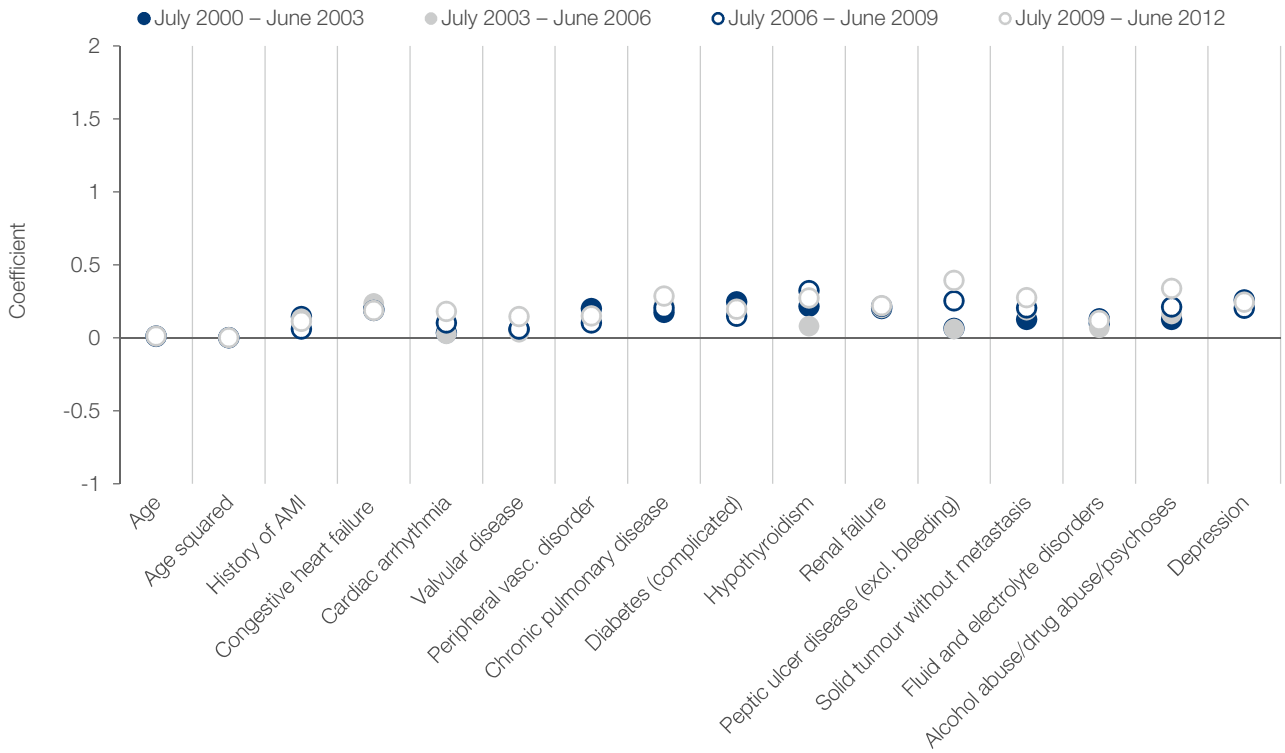
* age is centred around mean

Figure 51 Model performance (c-statistics) over different time periods

Reference period	c-statistic	
July 2009 – June 2012	0.63	
Validation period	**Method 1**	**Method 2**
July 2006 – June 2009	0.62	0.62
July 2003 – June 2006	0.62	0.62
July 2000 – June 2003	0.61	0.61

Method 1: using July 2009 – June 2012 coefficients Method 2: using recalibrated coefficients

Figure A1.3 Acute myocardial infarction: stability of the predictive model coefficients, four time periods, July 2000 – June 2012



Appendix 2

Ischaemic stroke: RSRR indicator specification, cohort and prediction model

RSRR Indicator specification

The condition

Ischaemic stroke occurs when a blood vessel is blocked, depriving the brain of oxygen and nutrients. Consequently, the area of the brain affected is damaged.

The indicator

The risk standardised readmission ratio (RSRR), provides a fair comparison of a particular hospital's results in returns to acute care given its case mix with an average NSW hospital with the same case mix[1].

Data source

Data are drawn from the NSW Ministry of Health's Health Information Exchange (HIE) and NSW Registry of Births, Deaths and Marriages, and probabilistically linked by the Centre for Health Record Linkage (CheReL). Data are accessed via SAPHaRI, Centre for Epidemiology and Evidence, NSW Ministry of Health.

Calculation

The ratio of observed number of emergency returns to acute care (numerator) to expected number of emergency returns to acute care (denominator) within 30 days following discharge from ischaemic stroke index admissions at a given hospital.

Cohort index admissions

An index admission is the hospitalisation included in calculating RSRRs for the condition of interest. The index admissions form the 'cohort' for assessing returns to acute care.

Inclusions

- Principal diagnosis of ischaemic stroke (I63)
- Aged 15 years or over
- Admissions to acute care
- Discharged between 1 July 2009 and 30 June 2012.

Exclusions

- Index admissions with mode of separation 'Discharged at own risk', as the hospital would not be able to complete treatment or discharge planning
- Index admissions within 30 days of a prior index admission (any admission within 30 days following discharge from an index admission is considered a readmission)
- Discharges from NSW hospitals administered by agencies external to NSW
- Index admissions with mode of separation 'Transferred to palliative care'
- Index admissions ending with an in-hospital death
- Discharges from a private hospital.

Period of care and transfers

Multiple acute, contiguous hospitalisations are considered as a single, acute period of care. Acute admissions on the same day of separation from another acute hospitalisation are included in the same acute period of care, regardless of the mode of separation at the previous hospitalisation. If an acute admission is coded as ending in a transfer, and there is another acute admission within one day of that transfer, the second admission is concatenated into the same period of care.

Numerator

Observed number of hospital-level emergency returns to acute care, where an unplanned readmission meets the following criteria:

- All-cause hospitalisations within 30 days following discharge from an ischaemic stroke index admission
- Acute and emergency hospitalisations
- Admitted to any NSW hospital (public or private).

In case where more than one emergency return to acute care occurs within 30 days of an index admission, only the first return is counted.

Denominator

Expected number of emergency returns to acute care at a given hospital, on the basis of an average NSW hospital's performance with the same case mix, calculated as the sum of the estimated probabilities of unplanned readmissions using a NSW-level prediction model.

Attributions of index admissions and emergency returns to acute care

- In cases of patient transfers, index admissions and emergency returns to acute care are attributed to the last hospital that discharged the patient to a non-acute care setting
- When there is a non-emergency overnight acute readmission in the 30 days following discharge from the index admission, and preceding the first emergency return to acute care, no return is assigned to that index admission.

Transfers to non-acute care

Periods of care include acute hospitalisations only. A transfer from acute to non-acute care, within the same or to a different hospital, is considered to be a discharge. Should the patient then be transferred from non-acute care to acute care within 30 days of discharge, it will be considered as a return to acute care. This return to acute care will be attributed to the hospital which discharged the patient from acute to non-acute care.

Development and validation of the prediction model

The NSW-level prediction model is developed using Fine & Gray competing risks regression models adjusting for patient-level risk factors, and taking into account the competing risk of death.[2] The standard errors are adjusted for within hospital correlations. A backward modelling approach is used to build the multivariable regression models. Variables significant at 20 percent level in the univariate analysis are considered for inclusion in multivariable models. Only variables with a 2-sided p-value of less than 0.05 in the multivariable models are retained in the final model.

The prediction ability of the model is assessed using c-statistics in data from previous financial years. The stability of the coefficients in previous financial years is also tested. The clinical relevance of the variables in the final model and their direction of association with the outcome are reviewed by clinicians.

Risk adjustment variables

The following variables are included in the development of the prediction models:

- Age at index admission
- Sex
- Elixhauser comorbidities[3], dementia and history of ischaemic stroke with a one year look-back period.

Index admissions with less than 30 days of follow-up information

Calculation of unadjusted rates of return to acute care and hospital RSRRs excludes index cases that occurred less than 30 days from the end of the study period (30 Jun 2012) to avoid introducing bias with a truncated follow-up period. However, as competing risk regression models take into account different follow-up periods, index admissions without a full 30 days of follow-up information are included to build the NSW prediction models.

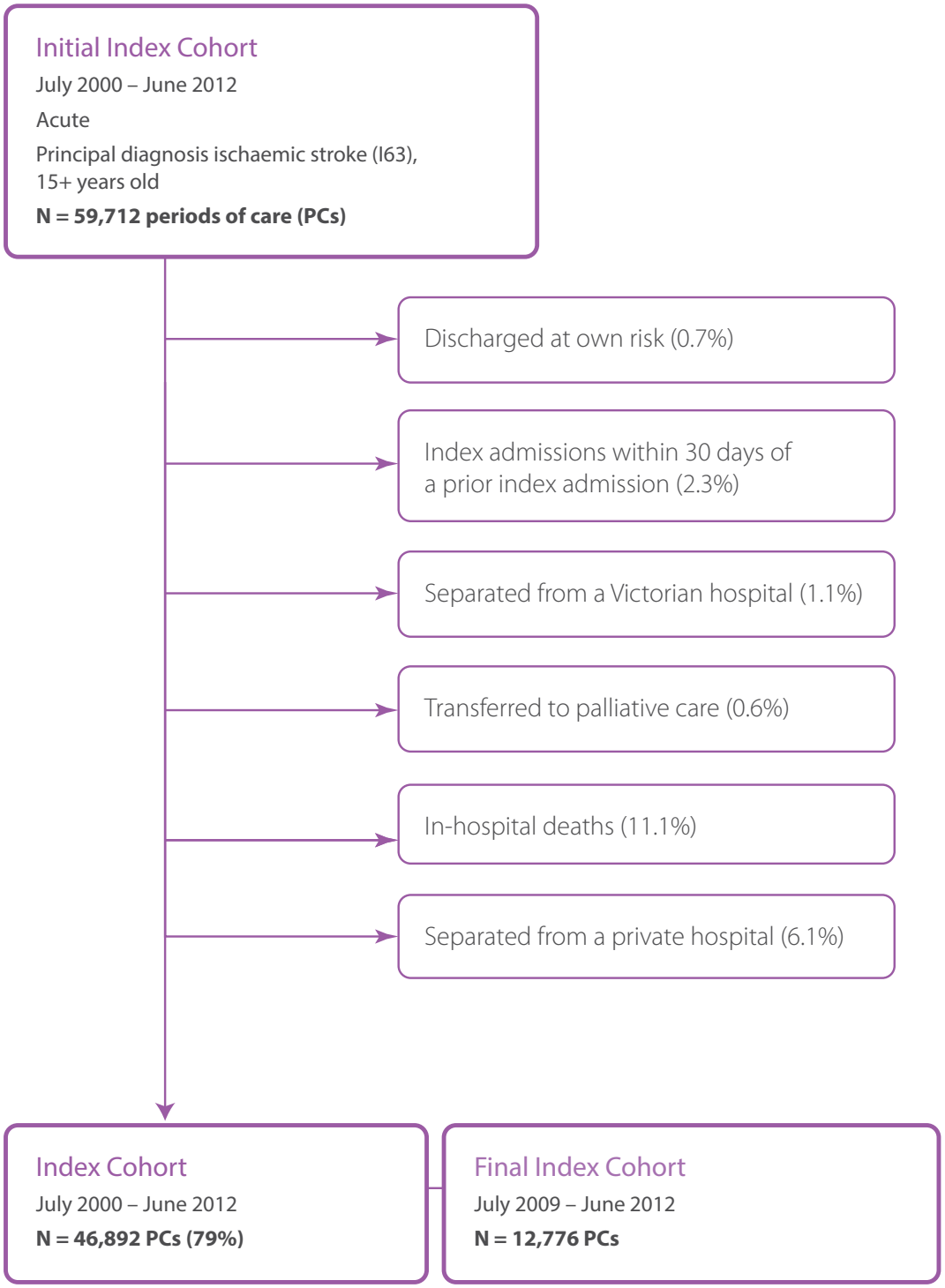
Presentation

Results are presented in a funnel plot. Hospitals with an RSRR that falls beyond the 95% and 99.8% control limits are flagged. Control limits are calculated based on a Poisson distribution.[4]

References

1. Centers for Medicare & Medicaid Services CMS 2014 Measures Updates and Specifications Report: Hospital-Level 30-Day Risk-Standardized Readmission Measures for Acute Myocardial Infarction (Version 7), Heart Failure (Version 7), Pneumonia (Version 7), Chronic obstructive pulmonary disease (Version 3), Stroke (Version 3) Yale New Haven Health Services Corporation/Center for Outcomes Research & Evaluation (YNHHSC/CORE); 2014
2. Fine JP, Gray RJ. A proportional hazards model for the subdistribution of a competing risk. Journal of the American Statistical Association 1999; 94: 496–509
3. Elixhauser A, Steiner C, Harris DR, Coffey RM: Comorbidity measures for use with administrative data. Med Care 1998, 36:8-27
4. Spiegelhalter D. Funnel plots for comparing institutional performance. Statistics in Medicine 2005; 24: 1185-1202.

Figure A2.1 Cohort



Exclusions are not mutually exclusive.

Prediction model

Figure A2.2 Ischaemic stroke: predictors of return to acute care within 30 days of discharge using competing risk model, July 2000 – June 2012.

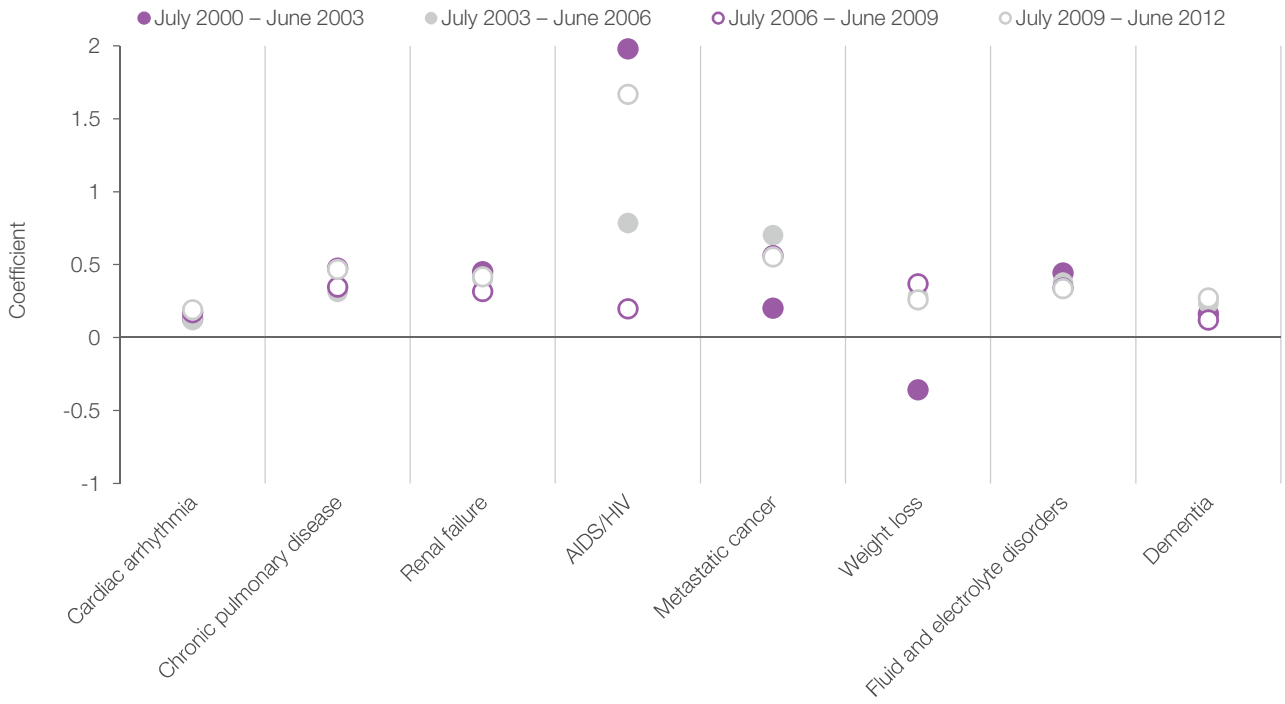
Predictors	Subhazard ratio	P-value	(95% Conf. Interval)
Cardiac arrhythmia	1.21	0.011	(1.04-1.40)
Chronic pulmonary disease	1.60	<0.001	(1.25-2.03)
Renal failure	1.52	<0.001	(1.27-1.81)
AIDS/HIV	5.29	0.008	(1.55-18.00)
Metastatic cancer diseases	1.74	0.006	(1.17-2.58)
Weight loss	1.29	0.033	(1.02-1.64)
Fluid and electrolyte disorders	1.40	<0.001	(1.19-1.65)
Dementia	1.31	0.008	(1.07-1.60)

Figure A2.3 Model performance (c-statistics) over different time periods

Reference period	c-statistic	
July 2009 – June 2012	0.59	
Validation period	**Method 1**	**Method 2**
July 2006 – June 2009	0.57	0.57
July 2003 – June 2006	0.58	0.58
July 2000 – June 2003	0.58	0.58

Method 1: using July 2009 – June 2011 coefficients Method 2: using recalibrated coefficients

Figure A2.4 **Ischaemic stroke: stability of the predictive model coefficients, four time periods, July 2000 – June 2012**



Appendix 3

Congestive heart failure: RSRR indicator specification, cohort and prediction model

RSRR Indicator specification

The condition

Congestive heart failure (CHF) is a complex syndrome that can result from structural or functional disease involving either or both sides of the heart. It is a progressive condition in which the heart is unable to pump blood effectively enough to meet the body's needs.

The indicator

The risk standardised readmission ratio (RSRR) provides a fair comparison of a particular hospital's results in returns to acute care given its case mix with an average NSW hospital with the same case mix[1].

Data source

Data are drawn from the NSW Ministry of Health's Health Information Exchange (HIE) and NSW Registry of Births, Deaths and Marriages, and probabilistically linked by the Centre for Health Record Linkage (CheReL). Data are accessed via SAPHaRI, Centre for Epidemiology and Evidence, NSW Ministry of Health.

Calculation

The ratio of the observed number of emergency returns to acute care (numerator) to the expected number of emergency returns to acute care (denominator) within 30 days following discharge from CHF index admissions at a given hospital.

Cohort index admissions

An index admission is the hospitalisation included in calculating RSRRs for the condition of interest. The index admissions form the 'cohort' for assessing returns to acute care.

Inclusions

- Principal diagnosis of CHF (I11.0, I13.0, I13.2, I50.0, I50.1, I50.9)
- Aged 15 years or over
- Admissions to acute care
- Discharged between 1 July 2009 and 30 June 2012.

Exclusions

- Index admissions with mode of separation 'Discharged at own risk', as the hospital would not be able to complete treatment or discharge planning
- Index admissions within 30 days of a prior index admission (any admission within 30 days following discharge from an index admission is considered a readmission)
- Discharges from NSW hospitals administered by agencies external to NSW
- Index admissions with mode of separation 'Transferred to palliative care'
- Index admissions ending with an in-hospital death
- Discharges from a private hospital.

Period of care and transfers

Multiple acute, contiguous hospitalisations are considered as a single, acute period of care. Acute admissions on the same day of separation from another acute hospitalisation are included in the same acute period of care, regardless of the mode of separation at the previous hospitalisation. If an acute admission is coded as ending in a transfer, and there is another acute admission within one day of that transfer, the second admission is concatenated into the same period of care.

Numerator

Observed number of hospital-level emergency returns to acute care, where an emergency return to acute care meets the following criteria:

- All-cause hospitalisations within 30 days following discharge from a CHF index admission

- Acute and emergency hospitalisations
- Admitted to any NSW hospital (public or private).

In cases where more than one emergency return to acute care occurs within 30 days of an index admission, only the first return is counted.

Denominator

Expected number of emergency returns to acute care at a given hospital, on the basis of an average NSW hospital's performance with the same case mix, calculated as the sum of the estimated probabilities of emergency returns to acute care using a NSW-level prediction model.

Attributions of index admissions and emergency returns to acute care

- In case of patient transfers index admissions and emergency returns to acute care are attributed to the last hospital that discharged the patient to a non-acute care setting
- When there is a non-emergency overnight acute rehospitalisation in the 30 days following discharge from the index admission, and preceding the first emergency return to acute care, no return is assigned to that index admission.

Transfers to non-acute care

Periods of care include acute hospitalisations only. A transfer from acute to non-acute care, within the same or to a different hospital, is considered to be a discharge. Should the patient then be transferred from non-acute care to acute care within 30 days of discharge, it will be considered as a return to acute care. This return to acute care will be attributed to the hospital which discharged the patient from acute to non-acute care.

Development and validation of the prediction model

The NSW-level prediction model is developed using Fine & Gray competing risks regression models adjusting for patient-level risk factors, and taking into account the competing risk of death.[2] The standard errors are adjusted for within hospital correlations. A backward modelling approach is used to build the multivariable regression models. Variables significant at 20 percent level in the univariate analysis are considered for inclusion in multivariable models. Only variables with a 2-sided p-value of less than 0.05 in the multivariable models are retained in the final model.

The prediction ability of the model is assessed using c-statistics in data from previous financial years. The stability of the coefficients in previous financial years is also tested. The clinical relevance of the variables in the final model and their direction of association with the outcome are reviewed by clinicians.

Risk adjustment variables

The following variables are included in the development of the prediction models:

- Age at index admission
- Sex
- Elixhauser comorbidities[3], dementia and history of CHF with a one year look-back period.

Index admissions with less than 30 days of follow-up information

Calculation of unadjusted rates of return to acute care and hospital RSRRs excludes index cases that occurred less than 30 days from the end of the study period (30 Jun 2012) to avoid introducing bias with a truncated follow-up period. However, as competing risk regression models take into account different follow-up periods, index admissions without a full 30 days of follow-up information are included to build the NSW prediction models.

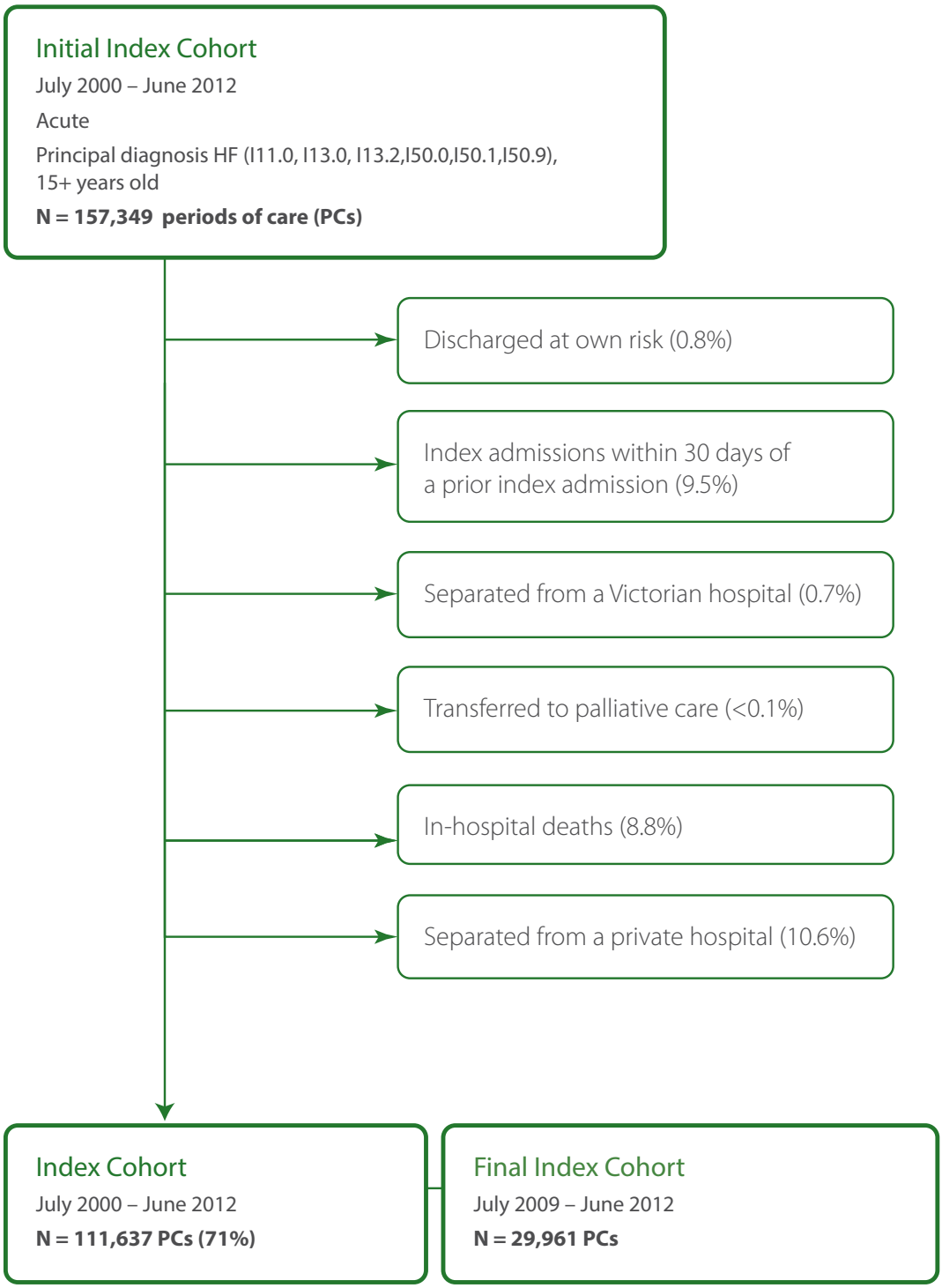
Presentation

Results are presented in a funnel plot. Hospitals with an RSRR that falls beyond the 95% and 99.8% control limits are flagged. Control limits are calculated based on a Poisson distribution.[4]

References

1. Centers for Medicare & Medicaid Services CMS 2014 Measures Updates and Specifications Report: Hospital-Level 30-Day Risk-Standardized Readmission Measures for Acute Myocardial Infarction (Version 7), Heart Failure (Version 7), Pneumonia (Version 7), Chronic obstructive pulmonary disease (Version 3), Stroke (Version 3) Yale New Haven Health Services Corporation/Center for Outcomes Research & Evaluation (YNHHSC/CORE); 2014
2. Fine JP, Gray RJ. A proportional hazards model for the subdistribution of a competing risk. Journal of the American Statistical Association 1999; 94: 496–509
3. Elixhauser A, Steiner C, Harris DR, Coffey RM: Comorbidity measures for use with administrative data. Med Care 1998, 36:8-27
4. Spiegelhalter D. Funnel plots for comparing institutional performance. Statistics in Medicine 2005; 24: 1185-1202.

Figure A3.1 Cohort



Exclusions are not mutually exclusive.

Prediction model

Figure A3.2 Congestive heart failure: predictors of return to acute care within 30 days of discharge, using competing risk model, July 2000 – June 2012

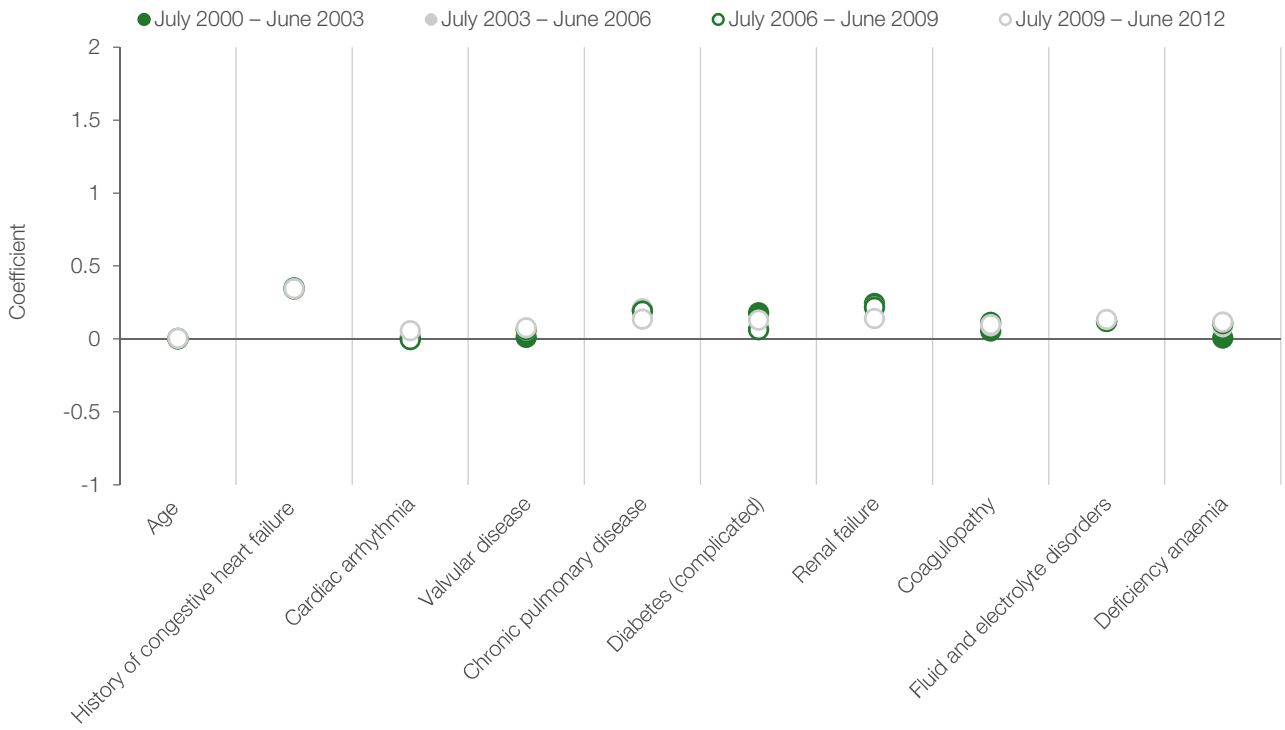
Predictors	Subhazard ratio	P-value	(95% Conf. Interval)
Age (per 1 year increase)	1.00	<0.001	(1.00-1.01)
History of HF	1.41	<0.001	(1.35-1.48)
Cardiac arrhythmia	1.06	0.01	(1.01-1.11)
Valvular disease	1.08	0.014	(1.02-1.15)
Chronic pulmonary disease	1.15	<0.001	(1.08-1.22)
Diabetes (complicated)	1.14	<0.001	(1.07-1.21)
Renal failure	1.15	<0.001	(1.09-1.21)
Coagulopathy	1.10	0.051	(1.00-1.22)
Fluid and electrolyte disorders	1.14	<0.001	(1.09-1.20)
Deficiency anaemia	1.12	0.002	(1.04-1.21)

Figure A3.3 Model performance (c-statistics) over different time periods

Reference period	c-statistic	
July 2009 – June 2012	0.60	
Validation years	**Method 1**	**Method 2**
July 2006 – June 2009	0.60	0.60
July 2003 – June 2006	0.60	0.56
July 2000 – June 2003	0.59	0.59

Method 1: using July 2009 – June 2012 coefficients Method 2: using recalibrated coefficients

Figure A3.4 Congestive heart failure: stability of the predictive model coefficients, four time periods, July 2000 – June 2012



Appendix 4

Pneumonia: RSRR indicator specification, cohort and prediction model

RSRR Indicator specification

The condition

Pneumonia is an inflammatory condition of one or both lungs, usually due to infection by bacteria or a virus.

The indicator

The risk standardised readmission ratio (RSRR) provides a fair comparison of a particular hospital's results in returns to acute care given its case mix with an average NSW hospital with the same case mix[1].

Data source

Data are drawn from the NSW Ministry of Health's Health Information Exchange (HIE) and NSW Registry of Births, Deaths and Marriages, and probabilistically linked by the Centre for Health Record Linkage (CheReL). Data are accessed via SAPHaRI, Centre for Epidemiology and Evidence, NSW Ministry of Health.

Calculation

The ratio of the observed number of emergency returns to acute care (numerator) to the expected number of emergency returns to acute care (denominator) within 30 days following discharge from pneumonia index admissions at a given hospital.

Cohort index admissions

An index admission is the hospitalisation included in calculating RSRRs for the condition of interest. The index admissions form the 'cohort' for assessing returns to acute care.

Inclusions

- Principal diagnosis of pneumonia (J13, J14, J15, J16, J18)
- Aged 18 years or over
- Admissions to acute care
- Discharged between 1 July 2009 and 30 June 2012.

Exclusions

- Index admissions with mode of separation 'Discharged at own risk', as the hospital would not be able to complete treatment or discharge planning
- Index admissions within 30 days of a prior index admission (any admission within 30 days following discharge from an index admission is considered a readmission)
- Discharges from NSW hospitals administered by agencies external to NSW
- Index admissions with mode of separation 'Transferred to palliative care'
- Index admissions ending with an in-hospital death
- Discharges from a private hospital.

Period of care and transfers

Multiple acute, contiguous hospitalisations are considered as a single, acute period of care. Acute admissions on the same day of separation from another acute hospitalisation are included in the same acute period of care, regardless of the mode of separation at the previous hospitalisation. If an acute admission is coded as ending in a transfer, and there is another acute admission within one day of that transfer, the second admission is concatenated into the same period of care.

Numerator

Observed number of hospital-level returns to acute care, where an emergency return to acute care meets the following criteria:

- All-cause hospitalisations within 30 days following discharge from a pneumonia index admission
- Acute and emergency hospitalisations
- Admitted to any NSW hospital (public or private).

In cases where more than one emergency return to acute care occurs within 30 days of an index admission, only the first readmission is counted.

Denominator

Expected number of emergency returns to acute care at a given hospital, on the basis of an average NSW hospital's performance with the same case mix, calculated as the sum of the estimated probabilities of emergency returns to acute care using a NSW-level prediction model.

Attributions of index admissions and emergency returns to acute care

- In case of patient transfers, index admissions and emergency returns to acute care are attributed to the last hospital that discharged the patient to a non-acute care setting
- When there is a non-emergency overnight acute rehospitalisation in the 30 days following discharge from the index admission, and preceding the first emergency return to acute care, no return is assigned to that index admission.

Transfers to non-acute care

Periods of care include acute hospitalisations only. A transfer from acute to non-acute care, within the same or to a different hospital, is considered to be a discharge. Should the patient then be transferred from non-acute care as an acute, emergency return to acute care within 30 days of discharge, it will be considered as a return to acute care. The return to acute care will be attributed to the hospital which discharged the patient from acute to non-acute care.

Development and validation of the prediction model

The NSW-level prediction model is developed using Fine & Gray competing risks regression models adjusting for patient-level risk factors, and taking into account the competing risk of death.[2] The standard errors are adjusted for within hospital correlations.

A backward modelling approach is used to build the multivariable regression models. Variables significant at 20 percent level in the univariate analysis are considered for inclusion in multivariable models. Only variables with a 2-sided p-value of less than 0.05 in the multivariable models are retained in the final model.

The prediction ability of the model is assessed using c-statistics in data from previous financial years. The stability of the coefficients in previous financial years is also tested. The clinical relevance of the variables in the final model and their direction of association with the outcome are reviewed by clinicians.

Risk adjustment variables

The following variables are included in the development of the prediction models:

- Age at index admission
- Sex
- Elixhauser comorbidities[3], dementia and history of pneumonia with a one year look-back period.

Index admissions with less than 30 days of follow-up information

Calculation of unadjusted rates of return to acute care and hospital RSRRs excludes index cases that occurred less than 30 days from the end of the study period (30 Jun 2012) to avoid introducing bias with a truncated follow-up period. However, as competing risk regression models take into account different follow-up periods, index admissions without a full 30 days of follow-up information are included to build the NSW prediction models.

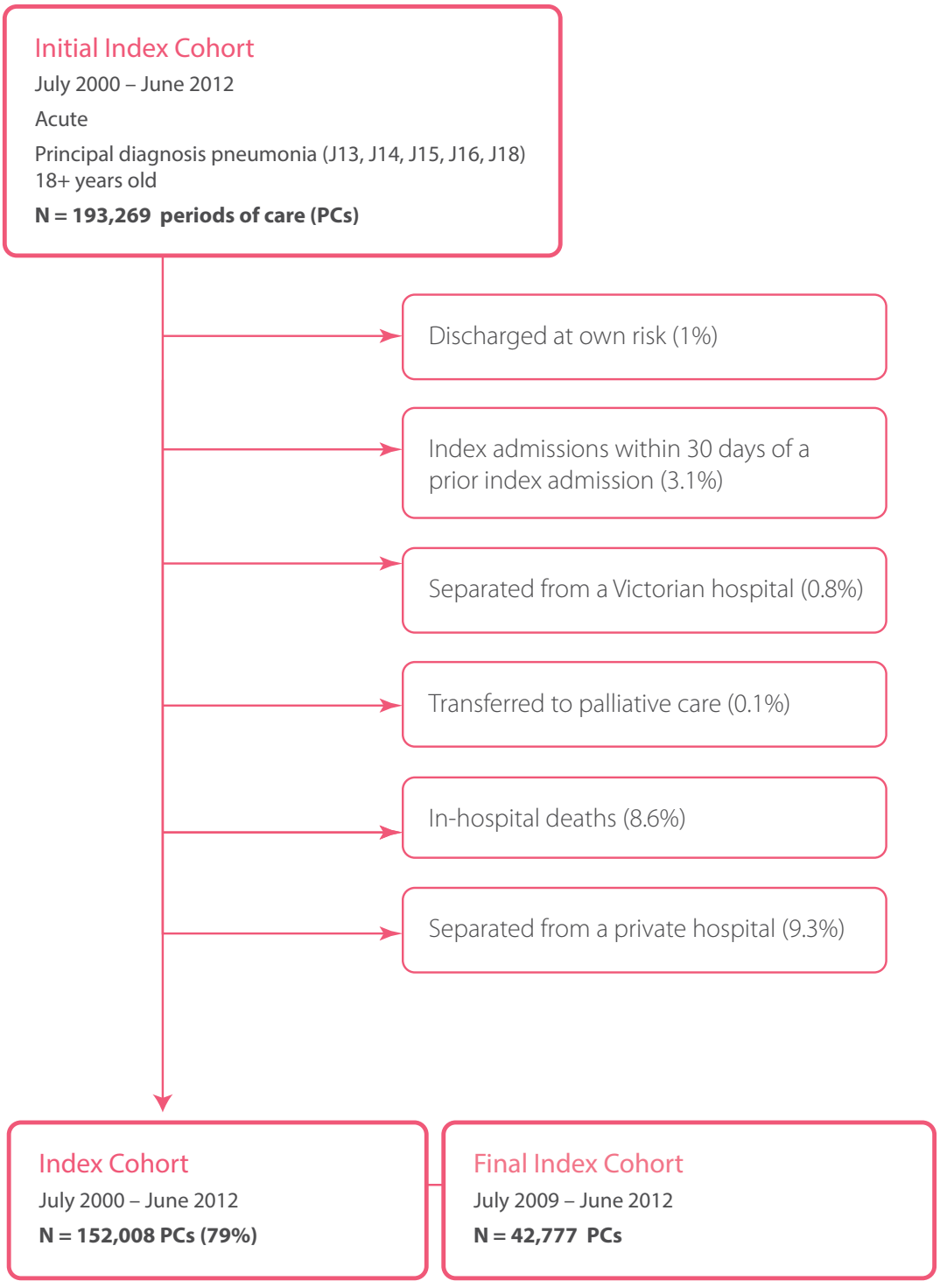
Presentation

Results are presented in a funnel plot. Hospitals with an RSRR that falls beyond the 95% and 99.8% control limits are flagged. Control limits are calculated based on a Poisson distribution.[4]

References

1. Centers for Medicare & Medicaid Services CMS 2014 Measures Updates and Specifications Report: Hospital-Level 30-Day Risk-Standardized Readmission Measures for Acute Myocardial Infarction (Version 7), Heart Failure (Version 7), Pneumonia (Version 7), Chronic obstructive pulmonary disease (Version 3), Stroke (Version 3) Yale New Haven Health Services Corporation/Center for Outcomes Research & Evaluation (YNHHSC/CORE); 2014
2. Fine JP, Gray RJ. A proportional hazards model for the subdistribution of a competing risk. Journal of the American Statistical Association 1999; 94: 496–509
3. Elixhauser A, Steiner C, Harris DR, Coffey RM: Comorbidity measures for use with administrative data. Med Care 1998, 36:8-27
4. Spiegelhalter D. Funnel plots for comparing institutional performance. Statistics in Medicine 2005; 24: 1185-1202.

Figure A4.1 Cohort



Exclusions are not mutually exclusive.

Prediction model

Figure A4.2 Pneumonia: predictors of return to acute care within 30 days of discharge using competing risk model, July 2000 – June 2012

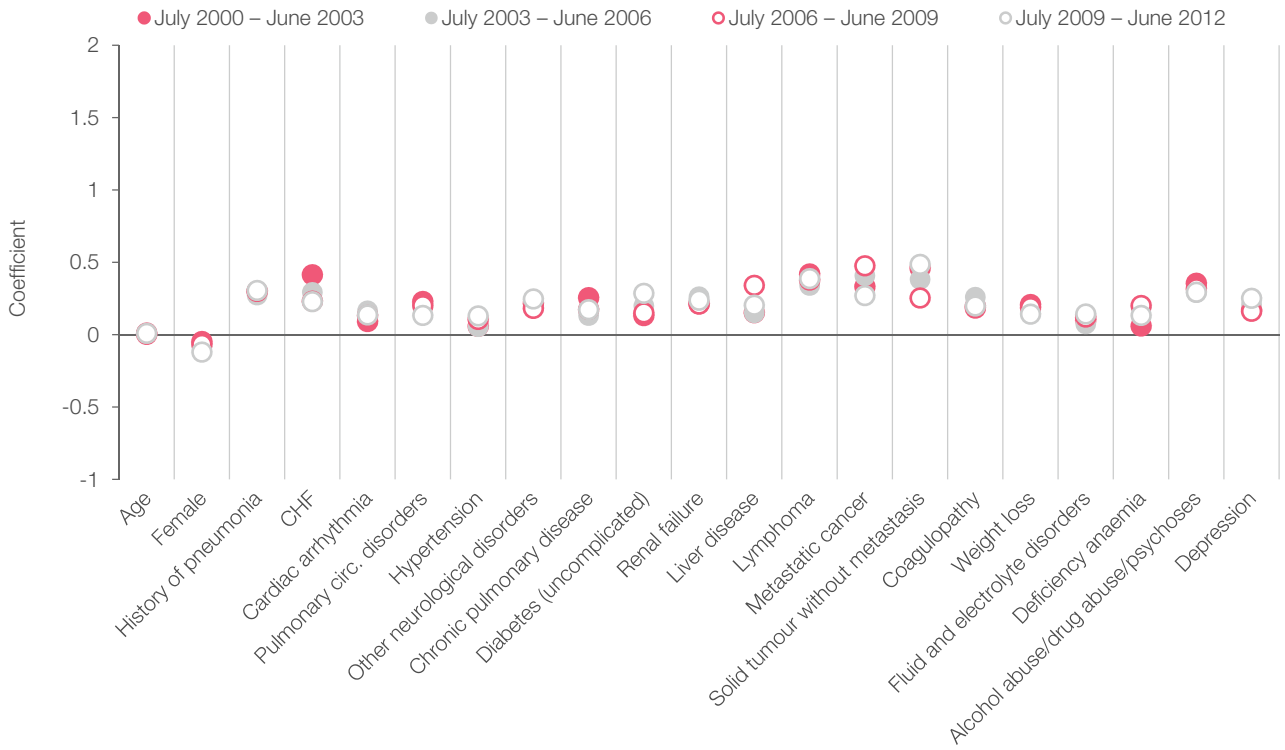
Predictors	Subhazard ratio	P-value	(95% Conf. Interval)
Age (per 1 year increase)	1.01	<0.001	(1.01-1.01)
Female	0.89	<0.001	(0.84-0.94)
History of pneumonia	1.36	<0.001	(1.27-1.45)
Congestive heart failure	1.26	<0.001	(1.17-1.35)
Cardiac arrhythmia	1.15	<0.001	(1.08-1.22)
Pulmonary circulation disorders	1.14	0.048	(1.00-1.30)
Hypertension	1.14	<0.001	(1.06-1.22)
Other neurological disorders	1.28	<0.001	(1.14-1.44)
Chronic pulmonary disease	1.19	<0.001	(1.12-1.26)
Diabetes (uncomplicated)	1.33	<0.001	(1.16-1.53)
Renal failure	1.27	<0.001	(1.15-1.40)
Liver disease	1.23	0.021	(1.03-1.46)
Lymphoma	1.47	<0.001	(1.28-1.69)
Metastatic cancer	1.31	<0.001	(1.15-1.50)
Solid tumour (without metastasis)	1.63	<0.001	(1.45-1.82)
Coagulopathy	1.22	0.002	(1.08-1.38)
Weight loss	1.15	0.004	(1.05-1.27)
Fluid and electrolyte disorders	1.15	<0.001	(1.09-1.22)
Deficiency anaemia	1.14	0.041	(1.01-1.30)
Alcohol abuse/drug abuse/psychoses	1.34	<0.001	(1.17-1.53)
Depression	1.29	<0.001	(1.15-1.43)

Figure A4.3 Model performance (c-statistics) over different time periods

Reference period	c-statistic	
July 2009 – June 2012	0.67	
Validation period	**Method 1**	**Method 2**
July 2006 – June 2009	0.66	0.66
July 2003 – June 2006	0.66	0.66
July 2000 – June 2003	0.65	0.66

Method 1: using July 2009 – June 2012 coefficients Method 2: using recalibrated coefficients

Figure A4.4 **Pneumonia: stability of the predictive model coefficients, four time periods, July 2000 – June 2012**



Appendix 5

Hip fracture surgery: RSRR indicator specification, cohort and prediction model

RSRR Indicator specification

The condition

Hip fracture refers to fracture of the femur (thigh bone) within 5cm of the distal (lower) part of the lesser trochanter (part of the hip). Hip fractures can occur at any age but are most common in older adults.

The indicator

The risk standardised readmission ratio (RSRR) provides a fair comparison of a particular hospital's results in returns to acute care given its case mix with an average NSW hospital with the same case mix.[1]

Data source

Data are drawn from the NSW Ministry of Health's Health Information Exchange (HIE) and NSW Registry of Births, Deaths and Marriages, and probabilistically linked by the Centre for Health Record Linkage (CheReL). Data are accessed via SAPHaRI, Centre for Epidemiology and Evidence, NSW Ministry of Health.

Calculation

The ratio of observed number of emergency returns to acute care (numerator) to the expected number of emergency returns to acute care (denominator) within 30 days following discharge from hip fracture surgery index admissions at a given hospital.

Cohort index admissions

An index admission is the hospitalisation included in calculating RSRRs for the condition of interest. The index admissions form the 'cohort' for assessing returns to acute care.

Inclusions

- Patients aged 50 years or over
- Discharges between 1 July 2009 and 30 June 2012
- Admissions to acute care:
    - With a principal diagnosis of hip fracture (ICD-10-AM codes: S72.0, S72.1, S72.2)
    - With an additional diagnosis indicating the hip fracture was related to a fall (ICD-10-AM codes: W00–W99, R29.6)
    - With a principal procedure code from the following list, indicating that the patient was admitted for surgery: 47519-00, 47522-00, 47528-01, 47531-00, 49315-00, 49318-00*, 49319-00* (Patients with admission records with procedure codes marked with* are only included if one of the following Australian Diagnostic Related Groups (DRG) codes was also recorded on the admission record: I03B, I08B, I78B, I08A, I03A, I78A, I73A, Z63A).

Exclusions

- Index admissions with mode of separation 'Discharged at own risk', as the hospital would not be able to complete treatment or discharge planning
- Index admissions within 30 days of a prior index admission (any admission within 30 days following discharge from an index admission is considered a readmission)
- Discharges from NSW hospitals administered by agencies external to NSW
- Index admissions with mode of separation 'Transferred to palliative care'
- Index admissions ending with an in-hospital death
- Discharges from a private hospital.

Period of care and transfers

Multiple acute, contiguous hospitalisations are considered as a single, acute period of care. Acute admissions on the same day of separation from another acute hospitalisation are included in the same acute period of care, regardless of the mode of separation at the previous hospitalisation. If an acute admission is coded as ending in a transfer, and there is another acute admission within one day of that transfer, the second admission is concatenated into the same period of care.

Numerator

Observed number of hospital-level emergency returns to acute care, where an emergency return to acute care meets the following criteria:

- All-cause hospitalisations within 30 days following discharge from a hip fracture surgery index admission
- Acute and emergency hospitalisations
- Admitted to any NSW hospital (public or private).

In cases where more than one emergency return to acute care occurs within 30 days of an index admission, only the first return is counted.

Denominator

Expected number of emergency returns to acute care at a given hospital, on the basis of an average NSW hospital's performance with the same case mix, calculated as the sum of the estimated probabilities of emergency returns to acute care using a NSW-level prediction model.

Attribution of index admissions and emergency returns to acute care

- In case of patient transfers index admissions and emergency returns to acute care are attributed to the last hospital that discharged the patient to a non-acute care setting
- When there is a non-emergency overnight acute rehospitalisation in the 30 days following discharge from the index admission, and preceding the first emergency return to acute care, no return is assigned to that index admission.

Transfers to non-acute care

Periods of care include acute hospitalisations only. A transfer from acute care to non-acute care, within the same or to a different hospital, is considered to be a discharge. Should the patient then be transferred from non-acute care to acute care within 30 days of discharge, it will be considered as a return to acute care. This return to acute care will be attributed to the hospital which discharged the patient from acute to non-acute care.

Development and validation of the prediction model

The NSW-level prediction model is developed using Fine & Gray competing risks regression models adjusting for patient-level risk factors, and taking into account the competing risk of death.[2] The standard errors are adjusted for within hospital correlations. A backward modelling approach is used to build the multivariable regression models. Variables significant at 20 percent level in the univariate analysis are considered for inclusion in multivariable models. Only variables with a 2-sided p-value of less than 0.05 in the multivariable models are retained in the final model.

The prediction ability of the model is assessed using c-statistics in data from previous financial years. The stability of the coefficients in previous financial years is also tested. The clinical relevance of the variables in the final model and their direction of association with the outcome are reviewed by clinicians.

Risk adjustment variables

The following variables are included in development of the prediction models:

- Age at index admission
- Sex
- Elixhauser comorbidities[3] and dementia with a one year look-back period.

Index admissions with less than 30 days of follow-up information

Calculation of unadjusted rates of return to acute care and hospital RSRRs excludes index cases that occurred less than 30 days from the end of the study period (30 June 2012) to avoid introducing bias with a truncated follow-up period. However, as competing risk regression models take into account different follow-up periods, index admissions without a full 30 days of follow-up information are included to build the NSW prediction models.

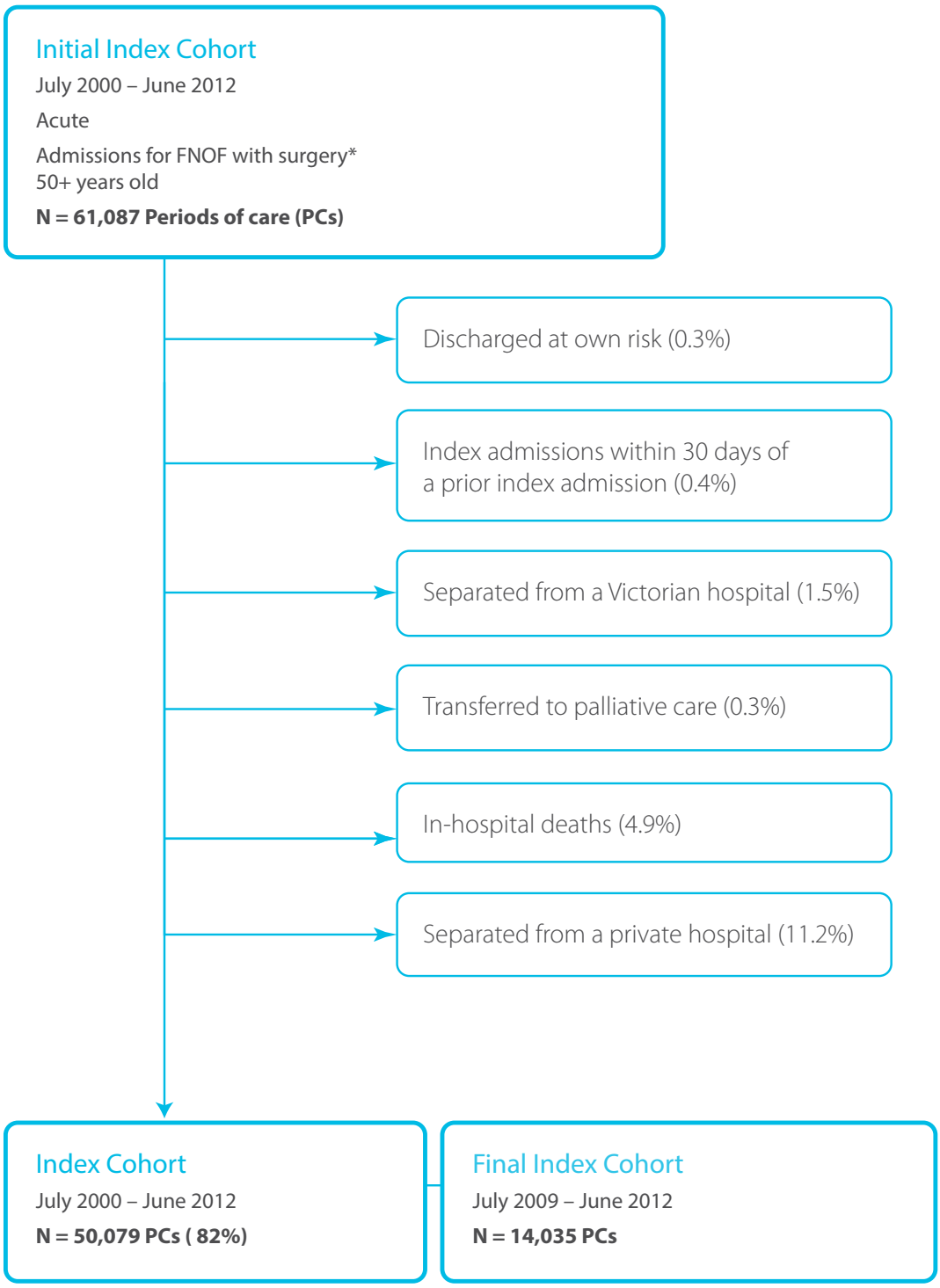
Presentation

Results are presented in a funnel plot. Hospitals with an RSRR that falls beyond the 95% and 99.8% control limits are flagged. Control limits are calculated based on a Poisson distribution.[4]

References

1. Centers for Medicare & Medicaid Services CMS 2014 Measures Updates and Specifications Report: Hospital-Level 30-Day Risk-Standardized Readmission Measures for Acute Myocardial Infarction (Version 7), Heart Failure (Version 7), Pneumonia (Version 7), Chronic obstructive pulmonary disease (Version 3), Stroke (Version 3) Yale New Haven Health Services Corporation/Center for Outcomes Research & Evaluation (YNHHSC/CORE); 2014
2. Fine JP, Gray RJ. A proportional hazards model for the subdistribution of a competing risk. Journal of the American Statistical Association 1999; 94: 496–509
3. Elixhauser A, Steiner C, Harris DR, Coffey RM: Comorbidity measures for use with administrative data. Med Care 1998, 36:8-27
4. Spiegelhalter D. Funnel plots for comparing institutional performance. Statistics in Medicine 2005; 24: 1185-1202.

Figure A5.1 Cohort



Exclusions are not mutually exclusive.

* Refer to page 82 for specific details of identifying patients admitted for hip fracture surgery.

Prediction model

Figure A5.2 Hip fracture surgery: predictors of return to acute care within 30 days of discharge using competing risk model, July 2000 – June 2012

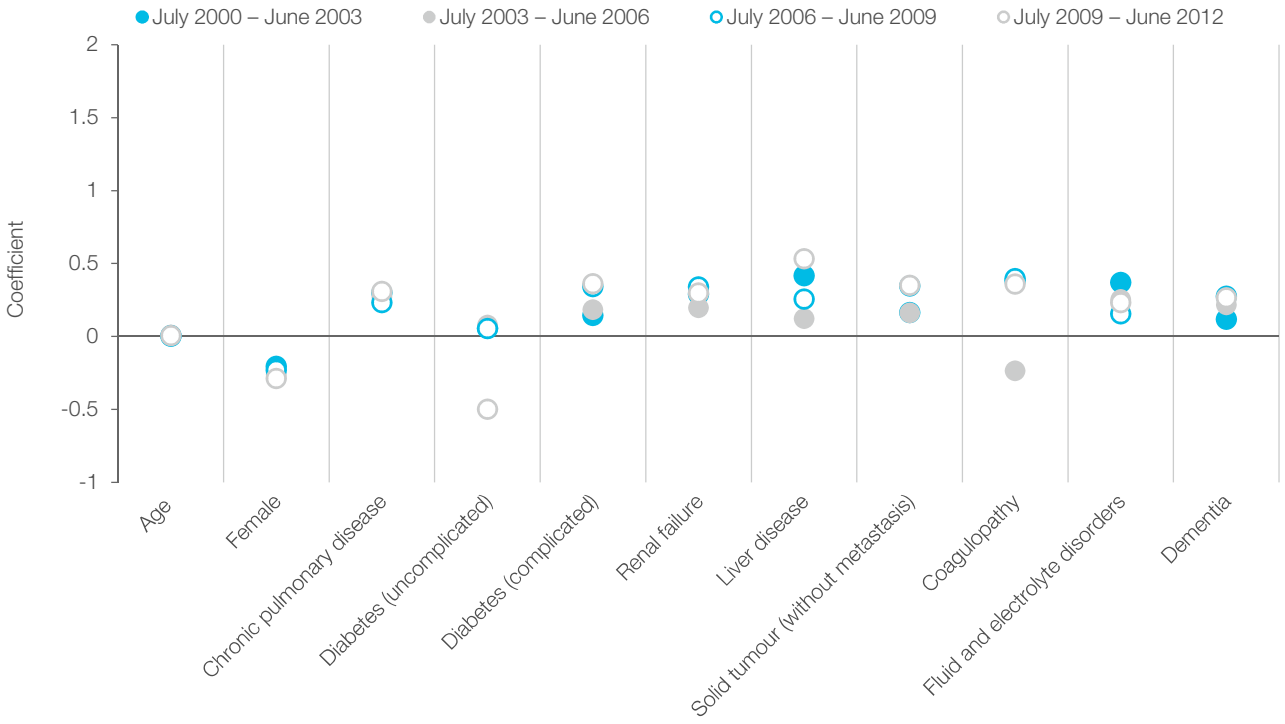
Predictors	Subhazard ratio	P-value	(95% Conf. Interval)
Age (per 1 year increase)	1.01	0.036	(1.00-1.01)
Female	0.75	<0.001	(0.67-0.84)
Chronic pulmonary disease	1.36	0.003	(1.11-1.67)
Diabetes (uncomplicated)	0.61	0.017	(0.40-0.91)
Diabetes (complicated)	1.44	<0.001	(1.18-1.75)
Renal failure	1.35	<0.001	(1.14-1.60)
Liver disease	1.70	0.010	(1.13-2.56)
Solid tumour (without metastasis)	1.42	<0.001	(1.18-1.72)
Coagulopathy	1.43	0.001	(1.17-1.76)
Fluid and electrolyte disorders	1.26	<0.001	(1.13-1.41)
Dementia	1.30	<0.001	(1.17-1.45)

Figure A5.3 Model performance (c-statistics) over different time periods

Reference period	c-statistic	
July 2009 – June 2012	0.60	
Validation period	**Method 1**	**Method 2**
July 2006 – June 2009	0.59	0.60
July 2003 – June 2006	0.58	0.59
July 2000 – June 2003	0.57	0.58

Method 1: using July 2000 – June 2012 coefficients Method 2: using recalibrated coefficients

Figure A5.4 Hip fracture surgery: stability of the predictive model coefficients, four time periods, July 2000 – June 2012



Appendix 6

Total hip replacement: RSRR indicator specification, cohort and prediction model

RSRR Indicator specification

The procedure

A total hip replacement removes a hip joint that has been damaged, usually by arthritis, replacing it with an artificial joint. The procedure alleviates pain, stiffness and muscle weakness.

The indicator

The risk standardised readmission ratio (RSRR) provides a fair comparison of a particular hospital's results in returns to acute care given its case mix with an average NSW hospital with the same case mix[1].

Data source

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

Calculation

The ratio of observed number of returns to acute care (numerator) to the expected number of returns to acute care (denominator) within 60 days following discharge from total hip replacement surgery index admissions at a given hospital.

Cohort index admissions

An index admission is the hospitalisation included in calculating RSRRs for the condition of interest. The index admissions form the 'cohort' for assessing returns to acute care.

Inclusions

- Patients aged 18 years or over
- Discharged between 1 July 2009 and 30 June 2012
- Admitted to acute care with a procedure code for total hip replacement (ACHI codes: 49318-00 or 49319-00) recorded as a primary or secondary procedure.

Exclusions

- Index admissions meeting one or more of the diagnosis and procedure code exclusions listed in Appendix Table 1
- Hospitalisations beginning with a transfer in from another facility
- Hospitalisations ending with a transfer to another facility to acute care
- Index admissions with mode of separation 'Discharged at own risk', as the hospital would not be able to complete treatment or discharge planning
- Index admissions within 60 days of a prior index admission (any admission within 60 days following discharge from an index admission is considered a readmission)
- Discharges from NSW hospitals administered by agencies external to NSW
- Index admissions with mode of separation 'Transferred to palliative care'
- Index admissions ending with an in-hospital death
- Discharges from a private hospital.

Period of care and transfers

Multiple acute, contiguous hospitalisations are considered as a single, acute period of care. Acute admissions on the same day of separation from another acute hospitalisation are included in the same acute period of care, regardless of the mode of separation at the previous hospitalisation. If an acute admission is coded as ending in a transfer, and there is another acute admission within one day of that transfer, the second admission is concatenated into the same period of care. See 'Exclusions' section above.

Numerator

Observed number of hospital-level returns to acute care, where a returns to acute care meets the following criteria:

- All-cause hospitalisations within 60 days following discharge from a total hip replacement index admission
- Acute hospitalisations (excluding hospitalisations for haemodialysis, chemotherapy, radiotherapy or cataract surgery)
- Admitted to any NSW hospital (public or private).

In cases where more than one return to acute care occurs within 60 days of an index admission, only the first return is counted.

Denominator

Expected number of returns to acute care at a given hospital, on the basis of an average NSW hospital's performance with the same case mix, calculated as the sum of the estimated probabilities of returns to acute care using a NSW-level prediction model.

Attributions of index admissions and returns to acute care

Index admissions and returns to acute care are attributed to the hospital that performed the elective procedure.

Transfers to non-acute care

Periods of care include acute hospitalisations only. A transfer from acute care to non-acute care, within the same or to a different hospital, is considered to be a discharge. Should the patient then be transferred from non-acute care as an acute readmission within 60 days of discharge, it will be considered as a return to acute care. This return to acute care will be attributed to the hospital which discharged the patient from acute to non-acute care.

Development and validation of the prediction model

The NSW-level prediction model is developed using Fine & Gray competing risks regression models adjusting for patient-level risk factors, and taking into account the competing risk of death.[2] The standard errors are adjusted for within hospital correlations. A backward modelling approach is used to build the multivariable regression models. Variables significant at 20 percent level in the univariate analysis are considered for inclusion in multivariable models. Only variables with a 2-sided p-value of less than 0.05 in the multivariable models are retained in the final model.

The prediction ability of the model is assessed using c-statistics in data from previous financial years. The stability of the coefficients in previous financial years is also tested. The clinical relevance of the variables in the final model and their direction of association with the outcome are reviewed by clinicians.

Risk adjustment variables

The following variables are included in the development of the prediction models:

- Age at index admission
- Sex
- Elixhauser comorbidities[3] and dementia with a one year look-back period.

Index admissions with less than 60 days of follow-up information

Calculation of unadjusted rates of return to acute care and hospital RSRRs excludes index cases that occurred less than 60 days from the end of the study period (30 Jun 2012) to avoid introducing bias with a truncated follow-up period. However, as competing risk regression models take into account different follow-up periods, index admissions without a full 60 days of follow-up information are included to build the NSW prediction models.

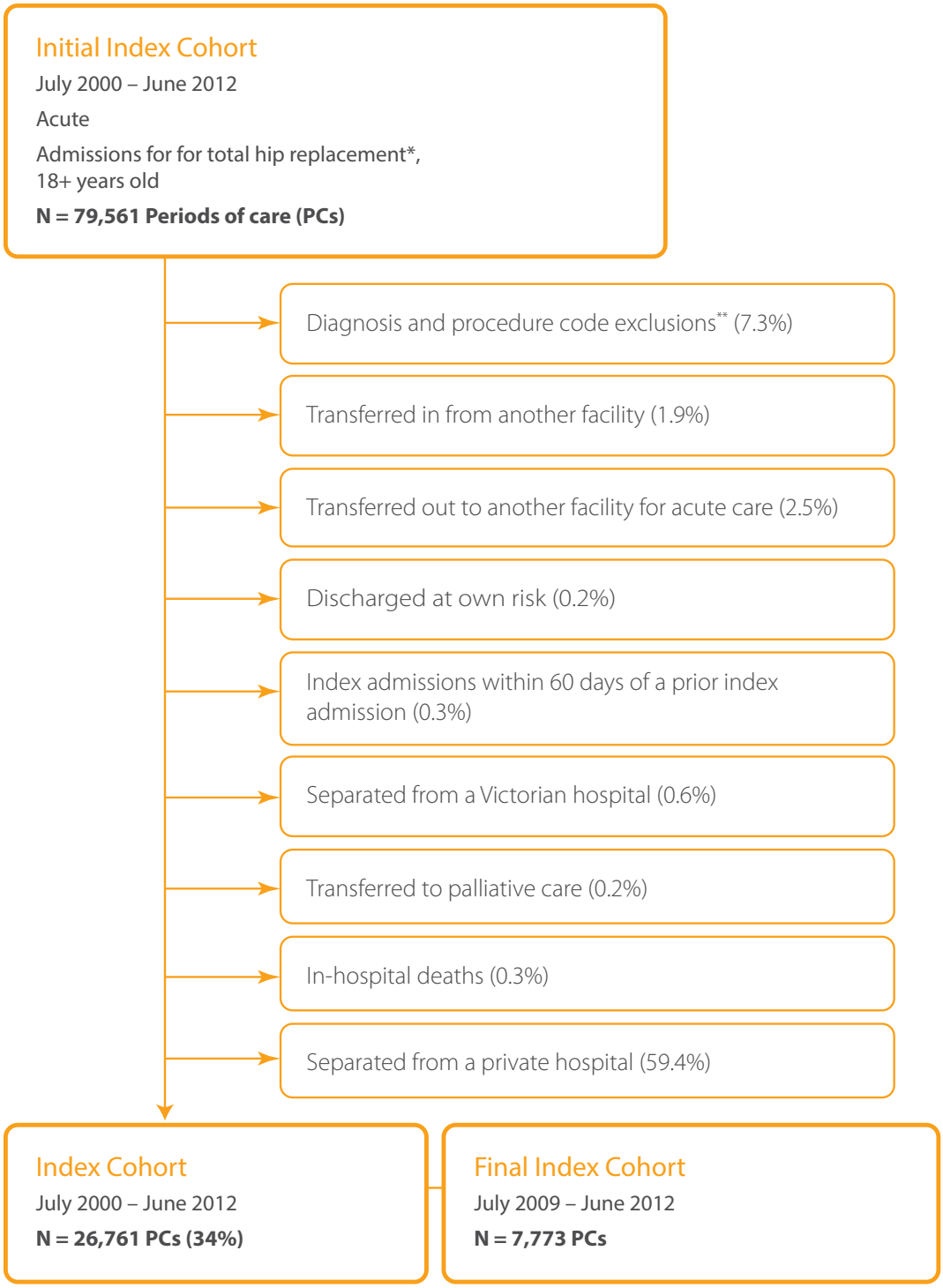
Presentation

Results are presented in a funnel plot. Hospitals with an RSRR that falls beyond the 95% and 99.8% control limits are flagged. Control limits are calculated based on a Poisson distribution[4].

References

1. Centers for Medicare & Medicaid Services CMS 2014 Measures Updates and Specifications Report: Hospital-Level 30-Day Risk-Standardized Readmission Measures for Acute Myocardial Infarction (Version 7), Heart Failure (Version 7), Pneumonia (Version 7), Chronic obstructive pulmonary disease (Version 3), Stroke (Version 3) Yale New Haven Health Services Corporation/Center for Outcomes Research & Evaluation (YNHHSC/CORE); 2014
2. Fine JP, Gray RJ. A proportional hazards model for the subdistribution of a competing risk. Journal of the American Statistical Association 1999; 94: 496–509
3. Elixhauser A, Steiner C, Harris DR, Coffey RM: Comorbidity measures for use with administrative data. Med Care 1998, 36:8-27
4. Spiegelhalter D. Funnel plots for comparing institutional performance. Statistics in Medicine 2005; 24: 1185-1202.

Figure A6.1 Cohort



Exclusions are not mutually exclusive.

* Total hip replacements are identified by procedures codes 49318-00 and 49319-00 recorded as a primary or secondary procedure.

**Diagnosis and procedure code exclusions are presented in Figure A6.2

Figure A6.2 Total hip replacement: Counts and prevalences of exclusions based on recorded diagnoses and procedures

Periods of care with the following ICD-10AM codes in principal or secondary diagnoses/procedures on discharge from index admission	# periods of care excluded	% prevalence (of 79,561 periods of care)
Fracture of femur (S72)	3922	4.9%
Fracture of lumbar spine and pelvis (S32)	201	0.3%
Pathological fracture (M80.0, M80.1, M80.2, M80.3, M80.4, M80.5, M80.8, M80.9, M84.4)	387	0.5%
Stress fracture (M84.3)	27	<0.1%
Malunion of fracture (M84.0)	75	0.1%
Nonunion of fracture (M84.1)	358	0.4%
Mechanical complications of prosthesis (T84.0 – T84.4)	664	0.8%
Excision arthroplasty of hip (49312-00)	21	<0.1%
Partial arthroplasty of hip (49315-00)	0	0.0%
Resurfacing of hip (unilateral) (90607-00)	3	<0.1%
Revision arthroplasty of hip (49346-00, 49324-00, 49327-00, 49330-00, 49333-00, 49339-00, 49342-00, 49345-00, 47525-00, 47525-01)	38	<0.1%

Periods of care with the following ICD-10AM codes in principal diagnosis field on discharge from index admission	# periods of care excluded	% prevalence (of 79,561 periods of care)
Malignant neoplasm of:		
Pelvis, sacrum, coccyx (C41.4)	0	0.0%
Long bones of lower limbs (C40.2)	18	<0.1%
Bone (C41.9)	0	0.0%
Pelvis (C76.3)	0	0.0%
Lower limb (C76.5)	0	0.0%
Secondary malignant neoplasm of bone/bone marrow (C79.5)	524	0.7%
Disseminated malignant neoplasm (C80.0)	0	0.0%

Prediction model

Figure A6.3 Total hip replacement: predictors of return to actute care within 60 days of discharge using competing risk model, July 2009 – June 2012

Predictors	Subhazard ratio	P-value	(95% Conf. Interval)
Age* (per 1 year increase)	1.02	<0.001	1.02-1.03
Age squared	1.00	0.002	1.00-1.00
Female	0.88	0.029	0.78-0.99
Congestive heart failure	2.09	0.001	1.33-3.28
Pulmonary circulatory disorders	1.95	0.021	1.11-3.43
Peripheral vascular disorders	2.16	0.011	1.20-3.89
Hypertension	1.36	0.015	1.06-1.74
Chronic pulmonary disease	2.05	<0.001	1.44-2.90
Diabetes (uncomplicated)	1.96	<0.001	1.35-2.85
Solid tumour (without metastasis)	2.04	0.004	1.25-3.32
Rheumatoid arthritis/collagen	1.82	0.006	1.19-2.80
Alcohol abuse/drug abuse/psychoses	1.50	0.022	1.06-2.13

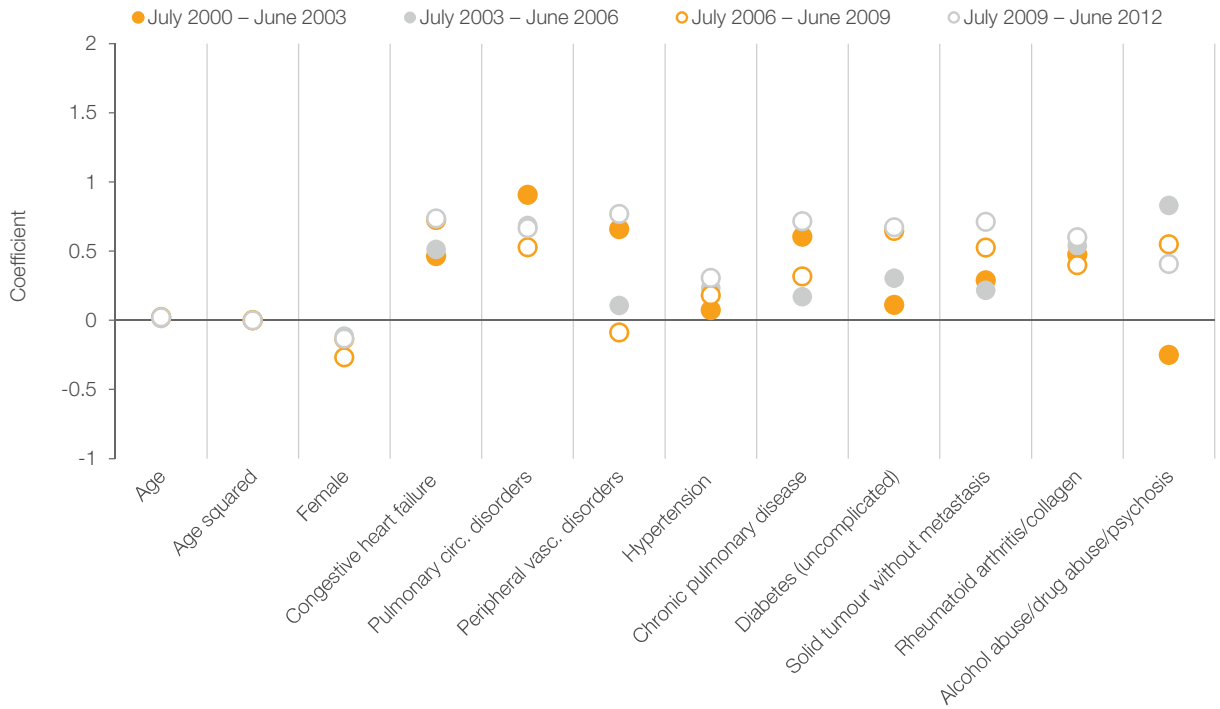
* age is centred around the mean

Figure A6.4 Model performance (c-statistics) over different time periods

Reference period	c-statistic	
July 2009 – June 2012	0.61	
Validation period	**Method 1**	**Method 2**
July 2006 – June 2009	0.62	0.63
July 2003 – June 2006	0.60	0.61
July 2000 – June 2003	0.59	0.61

Method 1: using July 2009 – June 2012 coefficients Method 2: using recalibrated coefficients

Figure A6.5 Total hip replacement: stability of the predictive model coefficients, four time periods, July 2000 – June 2012



Appendix 7

Total knee replacement: RSRR indicator specification, cohort and prediction model

RSRR Indicator specification

The procedure

A total knee replacement removes a knee joint that has been damaged, usually by arthritis, replacing it with an artificial joint. The procedure alleviates pain, stiffness and muscle weakness.

The indicator

The risk standardised readmission ratio (RSRR) provides a fair comparison of a particular hospital's results in returns to acute care given its case mix with an average NSW hospital with the same case mix[1].

Data source

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

Calculation

The ratio of the observed number of returns to acute care (numerator) to the expected number of returns to acute care (denominator) within 60 days following discharge from total knee replacement surgery index admissions at a given hospital.

Cohort index admissions

An index admission is the hospitalisation included in calculating RSRRs for the condition of interest. The index admissions form the 'cohort' for assessing returns to acute care.

Inclusions

- Patients aged 18 years or over
- Discharged between 1 July 2009 and 30 June 2012
- Admitted to acute care with a procedure code for total knee replacement (ACHI codes: 49518-00, 49519-00, 49521-00, 49521-01, 49521-02, 49521-03, 49524-00, 49524-01) recorded as a primary or secondary procedure.

Exclusions

- Index admissions meeting one or more of the diagnosis and procedure code exclusions listed in Appendix Table 1
- Index admissions beginning with a transfer in from another facility
- Index admissions ending with a transfer to another facility to acute care
- Index admissions with mode of separation 'Discharged at own risk', as the hospital would not be able to complete treatment or discharge planning
- Index admissions within 60 days of a prior index admission (any admission within 60 days following discharge from an index admission is considered a readmission)
- Discharges from NSW hospitals administered by agencies external to NSW
- Index admissions with mode of separation 'Transferred to palliative care'
- Index admissions ending with an in-hospital death
- Discharges from a private hospital.

Period of care and transfers

Multiple acute, contiguous hospitalisations are considered as a single, acute period of care. Acute admissions on the same day of separation from another acute hospitalisation are included in the same acute period of care, regardless of the mode of separation at the previous hospitalisation. If an acute admission is coded as ending in a transfer, and there is another acute admission within one day of that transfer, the second admission is concatenated into the same period of care. See 'Exclusions' section above.

Numerator

Observed number of hospital-level returns to acute care, where a return to acute care meets the following criteria:

- All-cause hospitalisations within 60 days following discharge from a total knee replacement index admission
- Acute hospitalisations (excluding hospitalisations for haemodialysis, chemotherapy, radiotherapy or cataract surgery)
- Admitted to any NSW hospital (public or private).

In cases where more than one return to acute care occurs within 60 days of an index admission, only the first return is counted.

Denominator

Expected number of returns to acute care at a given hospital, on the basis of an average NSW hospital's performance with the same case mix, calculated as the sum of the estimated probabilities of returns to acute care using a NSW-level prediction model.

Attributions of index admissions and returns to acute care

Index admissions and returns to acute care are attributed to the hospital that performed the elective procedure.

Transfers to non-acute care

Periods of care include acute hospitalisations only. A transfer from acute to non-acute care, within the same or to a different hospital, is considered to be a discharge. Should the patient then be transferred from non-acute care to acute care within 60 days of discharge, it will be considered as a return to acute care. This return to acute care will be attributed to the hospital which discharged the patient from acute to non-acute care.

Development and validation of the prediction model

The NSW-level prediction model is developed using Fine & Gray competing risks regression models adjusting for patient-level risk factors, and taking into account the competing risk of death.[2] The standard errors are adjusted for within hospital correlations. A backward modelling approach is used to build the multivariable regression models. Variables significant at 20 percent level in the univariate analysis are considered for inclusion in multivariable models. Only variables with a 2-sided p-value of less than 0.05 in the multivariable models are retained in the final model.

The prediction ability of the model is assessed using c-statistics in data from previous financial years. The stability of the coefficients in previous financial years is also tested. The clinical relevance of the variables in the final model and their direction of association with the outcome are reviewed by clinicians.

Risk adjustment variables

The following variables are included in the development of the prediction models:

- Age at index admission
- Sex
- Elixhauser comorbidities[3] and dementia using one year look-back period.

Index admissions with less than 60 days of follow-up information

Calculation of unadjusted rates of return to acute care and hospital RSRRs excludes index cases that occurred less than 60 days from the end of the study period (30 Jun 2012) to avoid introducing bias with a truncated follow-up period. However, as competing risk regression models take into account different follow-up periods, index admissions without a full 60 days of follow-up information are included to build the NSW prediction models.

Presentation

Results are presented in a funnel plot. Hospitals with an RSRR that falls beyond the 95% and 99.8% control limits are flagged. Control limits are calculated based on a Poisson distribution.[4]

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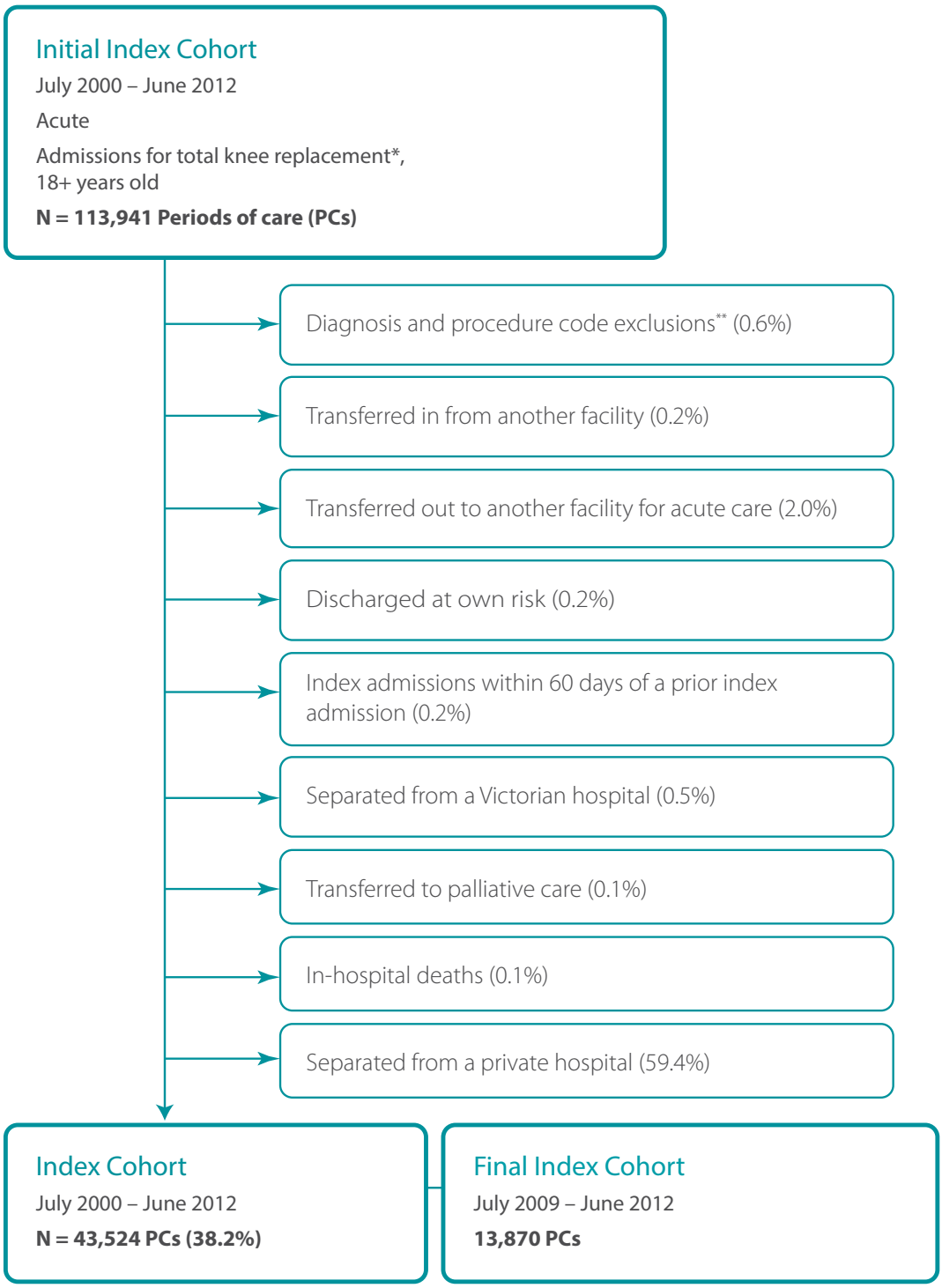
Figure A7.1 Cohort



Exclusions are not mutually exclusive.

* Total knee replacements are identified by procedures codes 49518-00, 49519-00, 49521-00, 49521-01, 49521-02, 49521-03, 49524-00, 49524-01 recorded as a primary or secondary procedure.

**Diagnosis and procedure code exclusions are presented in Figure A7.2

Table A7.2 Total knee replacement: counts and prevalences of exclusions based on recorded diagnoses and procedures in order to ensure that only patients undergoing primary, elective joint replacements are included

Periods of care with the following ICD-10AM codes in principal or secondary diagnoses/procedures on discharge from index admission	# periods of care excluded	% prevalence (of 113,941 periods of care)
Fracture of femur (S72)	98	0.1%
Fracture of lumbar spine and pelvis (S32)	11	<0.1%
Pathological fracture (M80.0, M80.1, M80.2, M80.3, M80.4, M80.5, M80.8, M80.9, M84.4)	69	0.1%
Stress fracture (M84.3)	17	<0.1%
Malunion of fracture (M84.0)	44	<0.1%
Nonunion of fracture (M84.1)	48	<0.1%
Mechanical complications of prosthesis (T84.0 – T84.4)	362	0.3%
Removal of knee prothesis (49515-00)	43	<0.1%
Hemiarthroscopy of knee (49517-00)	15	<0.1%
Resurfacing of knee (49534-01, 90562-00)	7	<0.1%
Revision arthroplasty of knee (49530-00, 49530-01, 49533-00, 49554-00, 49545-00, 49548-00, 49551-00, 49527-00)	0	0.0%

Periods of care with the following ICD-10AM codes in principal diagnosis field on discharge from index admission	# periods of care excluded	% prevalence (of 113,941 periods of care)
Malignant neoplasm of:		
Pelvis, sacrum, coccyx (C41.4)	0	0.0%
Long bones of lower limbs (C40.2)	7	<0.1%
Bone (C41.9)	0	0.0%
Pelvis (C76.3)	0	0.0%
Lower limb (C76.5)	0	0.0%
Secondary malignant neoplasm of bone/bone marrow (C79.5)	11	<0.1%
Disseminated malignant neoplasm (C80.0)	0	0.0%

Prediction model

Figure A7.3 Total knee replacement: predictors of return to acute care within 60 days of discharge, using competing risk model, July 2000 – June 2012

Predictors	Subhazard ratio	P-value	(95% Conf. Interval)
Age* (per 1 year increase)	1.01	0.001	(1.00-1.01)
Age squared	1.00	0.033	(1.00-1.00)
Female	0.84	<0.001	(0.77-0.92)
Congestive heart failure	1.59	0.016	(1.09-2.33)
Pulmonary circulatory disorders	1.69	0.005	(1.17-2.44)
Paralysis	2.46	<0.001	(1.75-3.47)
Chronic pulmonary disease	1.66	0.005	(1.16-2.36)
Diabetes (complicated)	1.52	0.002	(1.17-1.98)
Renal failure	1.60	<0.001	(1.25-2.03)
Fluid and electrolyte disorders	1.25	0.014	(1.05-1.50)
Alcohol abuse/drug abuse/psychoses	2.25	0.038	(1.05-4.86)
Depression	1.73	0.022	(1.08-2.78)

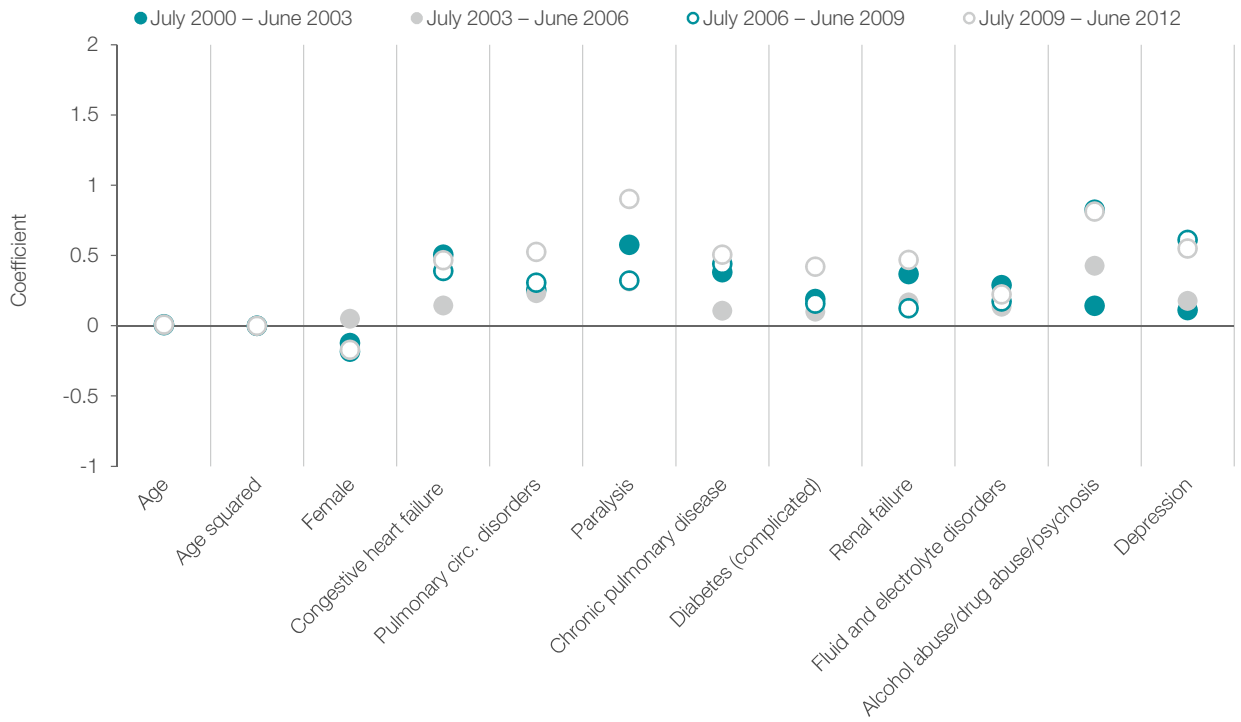
* age is centred around the mean

Figure A7.4 Model performance (c-statistics) over different time periods

Reference period	c-statistic	
July 2009 – June 2012	0.56	
Validation period	**Method 1**	**Method 2**
July 2006 – June 2009	0.56	0.56
July 2003 – June 2006	0.55	0.57
July 2000 – June 2003	0.56	0.56

Method 1: using July 2009 – June 2012 coefficients Method 2: using recalibrated coefficients

Figure A7.5 Total knee replacement: stability of the predictive model coefficients, four time periods, July 2000 – June 2012



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Acknowledgements

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

We would like to thank our expert advisors, reviewers and staff who contributed to the report.

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bureau of health information

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The Bureau of Health Information (BHI) is a board-governed organisation that provides independent reports 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 is turn supports quality improvement by highlighting how well the healthcare system is functioning and where there are opportunities to improve.

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:

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- 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
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