

Readmission and returns to acute care following hospitalisation for eight clinical conditions

Technical Supplement

July 2015 – June 2018

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Please note there is the potential for minor revisions of data in this report.

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The conclusions in this report are those of BHI and no official endorsement by the NSW Minister for Health, the NSW Ministry of Health or any other NSW public health organisation is intended or should be inferred.

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Introduction

This technical supplement expands on the existing Bureau of Health Information (BHI) methodological report, *Spotlight on Measurement: Measuring return to acute care following discharge from hospital, 2nd edition*¹, published in 2017.

Together, this technical supplement and the *Spotlight on Measurement* outline the methodology used to prepare the report released in April 2020, *Readmission and returns to acute care following hospitalisation for eight clinical conditions, July 2015 – June 2018*.

The *Spotlight on Measurement* was developed to explain the principal methods used to inform the BHI readmission and returns to acute care report released in 2017, which remain relevant to the April 2020 report. It includes how, in developing the report, BHI has:

- defined cohorts, readmission and returns to acute care
- conducted statistical modelling
- risk-adjusted results
- conducted sensitivity analysis for socioeconomic status and stroke severity
- interpreted results
- determined, where there are multiple reasons for a return to acute care, which one was identified and used in the analysis.

This technical supplement outlines methods, additional to those in the *Spotlight on Measurement*, that were used to develop *Readmission and returns to acute care following hospitalisation for eight clinical conditions, July 2015 – June 2018*. It includes:

- methods for excluding emergency department (ED) only patients
- sensitivity analysis for residence in an aged-care facility
- description of methods used for depth of secondary diagnoses and comorbidity coding

- condition-specific indicator specifications
- cohort and outcome definitions based on new inclusion and exclusion criteria.

Report measures

Measures that assess how healthcare affects health outcomes make an important contribution to efforts to support transparency, strengthen accountability and inform local efforts to improve care for patients in NSW.

Readmission and returns to acute care following hospitalisation for eight clinical conditions, July 2015 – June 2018 provides the community and health professionals with information about the performance of 74 public hospitals for eight clinical conditions, including three surgical procedures. The patient journey from an acute care admission to readmission is tracked in two ways:

1. **Readmissions following discharge:** discharge from hospital following an acute care admission, then readmission to the same hospital, or a different hospital, within 30 days (60 days for specified surgical procedures).
2. **Returns to acute care:** a change in care type or transfer to non-acute care within the same or different hospital, then a return to acute care within 30 days (60 days for specified surgical procedures).

Indicators of readmission often only include patients who return to hospital following discharge. However, the value of including readmission following discharge (patients returning to hospital) and returns to acute care (patients returning to acute care from non-acute care, such as rehabilitation) is that both provide insights into the quality and effectiveness of transitions of care. **Therefore, the readmission indicators used throughout the report include both readmissions following discharge and returns to acute care.**

Excluding emergency department-only patients

In June 2017, NSW Health released a new patient admission policy stating that a patient treated in and discharged from an ED only is not, and should not be recorded as, an admitted patient.² ED-only patients are defined under the policy as having been treated solely within the ED.

Prior to the introduction of this policy, BHI included all ED-only episodes within the index admission cohort for previous readmission and returns to acute care reports.

The introduction of the policy required some changes to the reporting methodology in *Readmission and returns to acute care following hospitalisation for eight clinical conditions, July 2015 – June 2018*, as compared with earlier reports.

In particular, there were implications for which patient episodes were included in the report, and subsequently in the relevant cohorts. The cohorts are:

- The **index admission cohort** is comprised of all episodes of care involving a patient admitted to hospital for one of the eight clinical conditions in the report.
- The **readmission cohort** is a subset of the index admission cohort, including readmissions following discharge and returns to acute care as defined on page 1 of this technical supplement.

To comply with the policy, BHI has applied the following exclusion criteria for each cohort:

- Index admission cohort – patients attending the ED, but not admitted, are excluded.
- Readmission cohort – patients within the index cohort attending the ED following initial discharge, but not admitted, are excluded.

BHI conducted sensitivity analyses on the data in its previous readmission and returns to acute care report (2012–2015) to investigate the effect of the new policy, and resulting changes in reporting methodology, on results. This demonstrated that ED-only episodes accounted for a small proportion of patients (Table 1). Proportions varied by condition, with acute myocardial infarction (AMI) having the highest proportion of ED-only patients. These analyses indicated that the policy change will have the most impact on clinicians who seek to understand temporal trends in relation to AMI patients.

These sensitivity analyses demonstrated that excluding ED-only patients had little effect on rates of readmission (Table 2).

The sensitivity analyses for the 2012–2015 period showed a small change in the number of outlier hospitals for all conditions following exclusion of ED-only patients, mainly among hospitals that had previously been located close to the control limits (Table 3).

Due to the shift in cohort definition, comparisons of hospital-level results in this report with previous readmission and returns to acute care reports should be made with caution. This change in policy period is flagged and explained in hospital-level profiles. For NSW-level results, a uniform cohort was constructed for all patients, followed by standardisation work by BHI which allows for comparisons over time.

Table 1

Number and percentage of index admissions and readmissions affected by, and the prevalence and impact of, ED-only patients, by clinical cohort, July 2012 – June 2015

Condition	Index admissions			Readmissions		
	Total index admissions including ED-only patients	ED-only patients at first hospital*	ED-only patients excluded with new inclusion criteria** (%)	Total readmissions, including ED-only patients	Return to ED, not admitted to the hospital ward***	ED-only patients excluded with new inclusion criteria** (%)
Acute myocardial infarction	28,047	8.4%	590 (2.1%)	4,568	11.8%	416 (9.1%)
Ischaemic stroke	14,466	2.7%	174 (1.2%)	1,563	9.0%	126 (8.1%)
Congestive (chronic) heart failure	33,472	4.0%	1,005 (3.0%)	7,754	7.7%	554 (7.1%)
Pneumonia	46,409	5.1%	1,607 (3.5%)	6,596	8.2%	536 (8.1%)
Chronic obstructive pulmonary disease	47,434	5.5%	1,591 (3.4%)	10,484	8.7%	821 (7.8%)
Hip fracture surgery	14,564	0.0%	0 (0.0%)	1,503	6.2%	75 (5.0%)
Total hip replacement	8,254	0.0%	0 (0.0%)	815	8.8%	40 (4.9%)
Total knee replacement	14,933	0.0%	0 (0.0%)	1,775	9.4%	90 (5.1%)

Notes: *Index admissions coded as ED-only at first hospital. ** Since some patients are transferred between EDs before being admitted to a hospital ward and some have more than one readmission following an index admission, the number of ED-only patients excluded based on new inclusion and exclusion criteria for index admissions and readmissions is slightly lower. ***First return within 30 days of discharge, or 60 days for total hip replacement and total knee replacement.

Table 2

Readmission rates per 100 acute hospitalisations based on historic and new methodology, by inclusion and exclusion criteria and clinical cohort, NSW public hospitals, July 2012 – June 2015

Condition	Historic methodology (ED-only patients in index admissions and readmissions)	New methodology (ED-only patients excluded from index admissions and readmissions)
Acute myocardial infarction	16.3	15.1
Ischaemic stroke	10.8	10.1
Congestive (chronic) heart failure	23.2	22.2
Pneumonia	14.2	13.5
Chronic obstructive pulmonary disease	22.1	21.1
Hip fracture surgery	10.3	9.8
Total hip replacement	9.9	9.4
Total knee replacement	11.9	11.3

Table 3

Effect of new relative to historic methodology on the number of hospitals identified as outliers on the basis of risk-standardised readmission ratios, by clinical cohort, NSW public hospitals, July 2012 – June 2015*

Condition	Change in hospital outliers after excluding ED-only episodes
Acute myocardial infarction	One hospital was no longer higher than expected. One hospital was no longer lower than expected and one hospital became lower than expected
Ischaemic stroke	Two hospitals were no longer higher than expected and two hospitals were no longer lower than expected
Congestive (chronic) heart failure	Two hospitals were no longer higher than expected and one hospital became higher than expected. One hospital was no longer lower than expected
Pneumonia	One hospital was no longer higher than expected and one hospital became higher than expected. Two hospitals were no longer lower than expected
Chronic obstructive pulmonary disease	Three hospitals were no longer higher than expected. Two hospitals became lower than expected
Hip fracture surgery	One hospital became lower than expected
Total hip replacement	Three hospitals became higher than expected and one hospital was no longer higher than expected. One hospital was no longer lower than expected and one hospital became lower than expected
Total knee replacement	One hospital was no longer lower than expected

* Some of the observed changes may be attributable to updates in the data, which were accessed and downloaded on 28 May 2019. These data was used for identifying the outliers excluding ED-only patients.

Adjusting for residence in an aged care facility

Frail patients have been shown to have an increased risk of readmission and returns to acute care.³ However, as frailty is not an indexed or tabular term listed in the ICD-10-AM classification, it is difficult to accurately identify these patients using the NSW Admitted Patient Data Collection (APDC). A sensitivity analysis was conducted on the inclusion of ‘residence in an aged care facility’ in the development of the prediction models for the 2015–18 cohorts to see whether it improves the predictive accuracy of the existing statistical models, beyond age and the comorbidities.

As a starting point, the classification ‘patients that were referred from a residential aged care facility or transferred to a nursing home or any admission to residential aged care facilities’ was used to identify frail patients. A one-year lookback checked whether ‘residence in an aged care facility’ was noted in the patient’s index admission and in any other admissions in that period.

‘Residence in an aged care facility’ was associated with a lower risk of 30-day readmission among congestive (chronic) heart failure (CHF) and chronic obstructive pulmonary disease (COPD) cohorts, and a higher risk of readmission among the hip fracture surgery cohort after taking into account other patient-level risk factors in the multivariable models ($p < 0.05$). However its inclusion did not improve the predictive ability of the models and the C-statistics remained the same (Table 4). Its inclusion caused a change in the

significant variables in the hip fracture surgery and COPD prediction models (i.e. dementia which had the same direction of association and a similar effect size as ‘residence in an aged care facility’ was no longer associated with readmission and was therefore removed from these two models).

Risk-standardised readmission ratios (RSRRs) were reproduced and outliers were identified for these three conditions (CHF, COPD and hip fracture surgery) based on the new prediction models (including aged care residence). Among peer group A–C hospitals, there was a change in hospital outlier status for COPD but not for the other two conditions. Figures 1 and 2 show the funnel plots for COPD, which after adjusting for ‘residence in an aged care facility’ had one hospital that became higher than expected (i.e. an outlier). The RSRR for this hospital did not change substantially – it was close to the control limits and a small change was sufficient to change its status.

‘Residence in an aged care facility’ was not associated with readmission for the other five conditions, after taking into account other patient-level risk factors including age, sex and comorbidities.

Given these results, and the difficulty in accurately identifying frail patients in the APDC, the 2015–18 analyses retained the standardisation approach used for 2009–12, and 2012–15 (i.e. ‘residence in an aged care facility’ was not included in the development of risk-adjustment models).

Table 4 Effect sizes and model fit statistics for residence in an aged care facility in risk adjusted models, by clinical condition, NSW, July 2015 – June 2018

Condition	Effect size		Model fit statistics	
	Sub-hazard ratio	(95% confidence interval)	C-statistics with adjustment	C-statistics without adjustment
Congestive (chronic) heart failure	0.84	(0.76–0.93)	0.60	0.60
Chronic obstructive pulmonary disease	0.90	(0.83–0.98)	0.64	0.64
Hip fracture surgery	1.29	(1.10–1.52)	0.61	0.61

Figure 1 Risk-standardised readmission ratios 'without' a residential aged care predictor for COPD, NSW public hospitals, July 2015 – June 2018

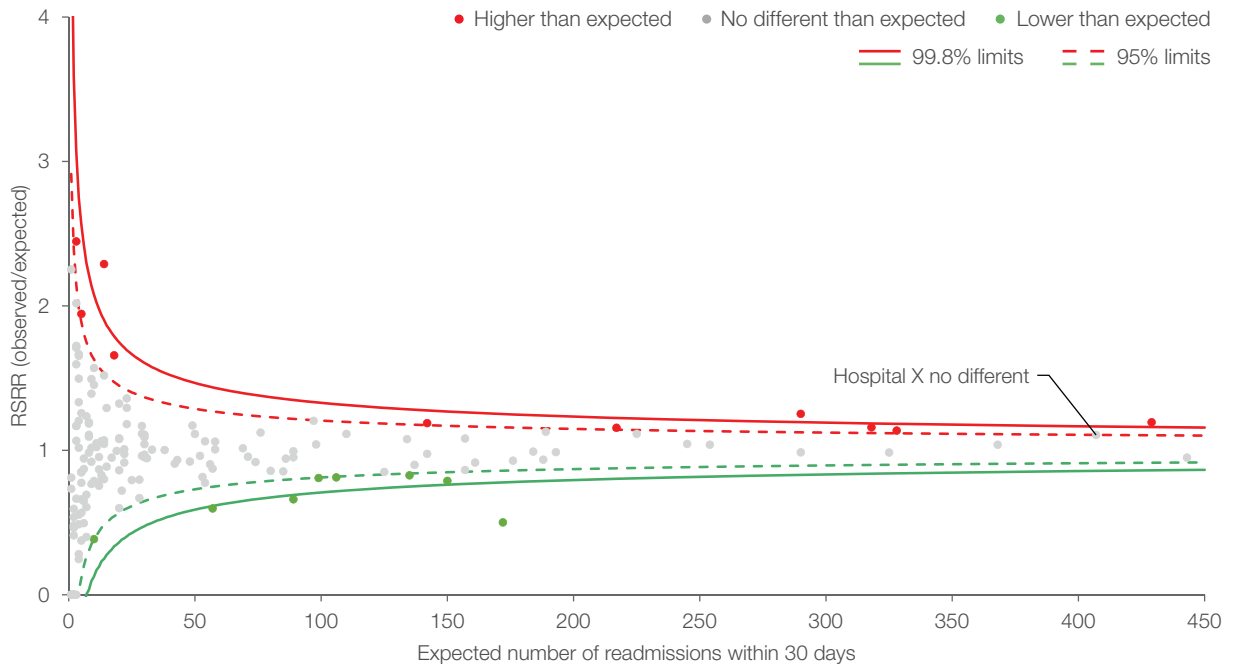
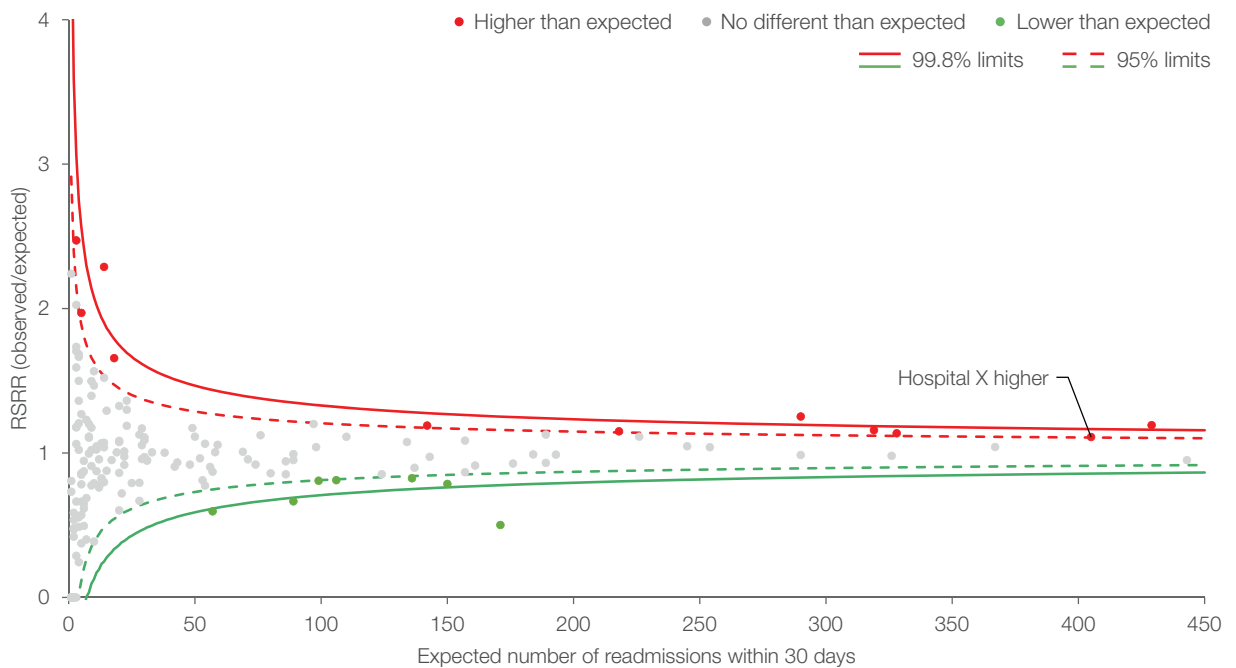


Figure 2 Risk-standardised readmission ratios 'with' a residential aged care predictor for COPD, NSW public hospitals, July 2015-June 2018



Depth of secondary diagnoses and comorbidity coding

Indicators of readmission and returns to acute care may depend on hospital coding practices, as the extent to which comorbidities are coded in the patient record may affect risk standardisation.

Depth of coding is defined as the average number of secondary diagnoses or significant comorbidities coded for index cases. An assessment of depth of coding was conducted, comparing hospitals and changes over time.

The average number of secondary diagnoses has increased over time for all conditions but most

markedly for hip fracture surgery. During July 2012 – June 2015, the average depth of coding was 9.2 diagnoses and during July 2015 – June 2018, it was 11.4 diagnoses among the hip fracture surgery cohort (Table 5).

The average number of secondary diagnoses that were predictors in the model has not increased over time (Table 6).

The one-year lookback method used for risk adjustment to some extent accounts for possible lower depth of coding in some hospitals.

Table 5 Average number of any secondary diagnoses, eight conditions, NSW and hospital range, July 2012 – June 2015 and July 2015 – June 2018

Condition	July 2012 – June 2015	July 2015 – June 2018
Acute myocardial infarction	5.6 (3.3–9.4)	6.4 (2.8–10.6)
Ischaemic stroke	7.0 (3.7–9.4)	8.1 (4.7–10.9)
Congestive (chronic) heart failure	5.9 (1.9–8.9)	7.8 (3.3–11.7)
Pneumonia	4.8 (1.0–8.4)	6.2 (1.6–10.2)
Chronic obstructive pulmonary disease	4.1 (1.2–8.2)	5.5 (1.5–10.4)
Hip fracture surgery	9.2 (6.0–12.5)	11.4 (7.1–15.7)
Total hip replacement	2.6 (1.1–5.6)	3.5 (2.0–7.3)
Total knee replacement	2.4 (1.0–4.5)	3.5 (1.8–7.7)

Table 6 Average number of secondary diagnoses that were predictors in the model, eight conditions, NSW and hospital range, July 2012 – June 2015 and July 2015 – June 2018

Condition	July 2012 – June 2015	July 2015 – June 2018
Acute myocardial infarction	1.1 (0.5–2.2)	1.3 (0.5–2.2)
Ischaemic stroke	0.9 (0.3–1.4)	1.2 (0.7–1.8)
Congestive (chronic) heart failure	1.7 (0.7–2.4)	1.7 (0.6–2.8)
Pneumonia	1.6 (0.4–2.4)	1.5 (0.2–2.4)
Chronic obstructive pulmonary disease	0.9 (0.2–1.7)	1.1 (0.3–2.0)
Hip fracture surgery	1.1 (0.4–1.6)	1.0 (0.4–1.5)
Total hip replacement	0.3 (0.1–0.8)	0.3 (0.2–0.8)
Total knee replacement	0.3 (0.0–0.9)	0.3 (0.1–0.9)

Appendix 1:

Acute myocardial infarction indicator specification

Risk-standardised readmission ratio (RSRR) indicator specification, cohort and prediction model

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 readmissions results given its case mix with an average NSW hospital with the same case mix.⁴

Data source

Data are drawn from the Hospital Performance Dataset, NSW Ministry of Health Secure Analytics for Population Health Research and Intelligence. Record linkage was carried out by the Centre for Health Record Linkage.

Calculation

The ratio of the observed number of acute, emergency readmissions (numerator) to the expected number of acute, emergency readmissions (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 readmissions.

Inclusions

- principal diagnosis of AMI (I21, I22)
- aged 15 + years
- admissions to acute care
- discharged between 1 July 2015 and 30 June 2018.

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 readmissions, where a readmission 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 acute, emergency readmission occurs within 30 days of an index admission, only the first readmission is counted.

Denominator

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

Attributions of index admissions and acute, emergency readmissions

- In cases of patient transfers, index admissions with an emergency readmission 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 readmission, no readmission 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 is considered to be a readmission.

The readmission 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 was developed using Fine and Gray competing risks regression models adjusting for patient-level risk factors, and taking into account the competing risk of death.⁵ The standard errors were adjusted for within hospital correlations. A backward modelling approach was used to build the multivariable regression models. Variables significant at 20 percent level in the univariate analysis were

considered for inclusion in multivariable models. Only variables with a 2-sided p-value of less than 0.05 in the multivariable models were retained in the final model.

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

Risk adjustment variables

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

- age at index admission
- sex
- Elixhauser comorbidities⁶, dementia and history of AMI with a one-year lookback period.

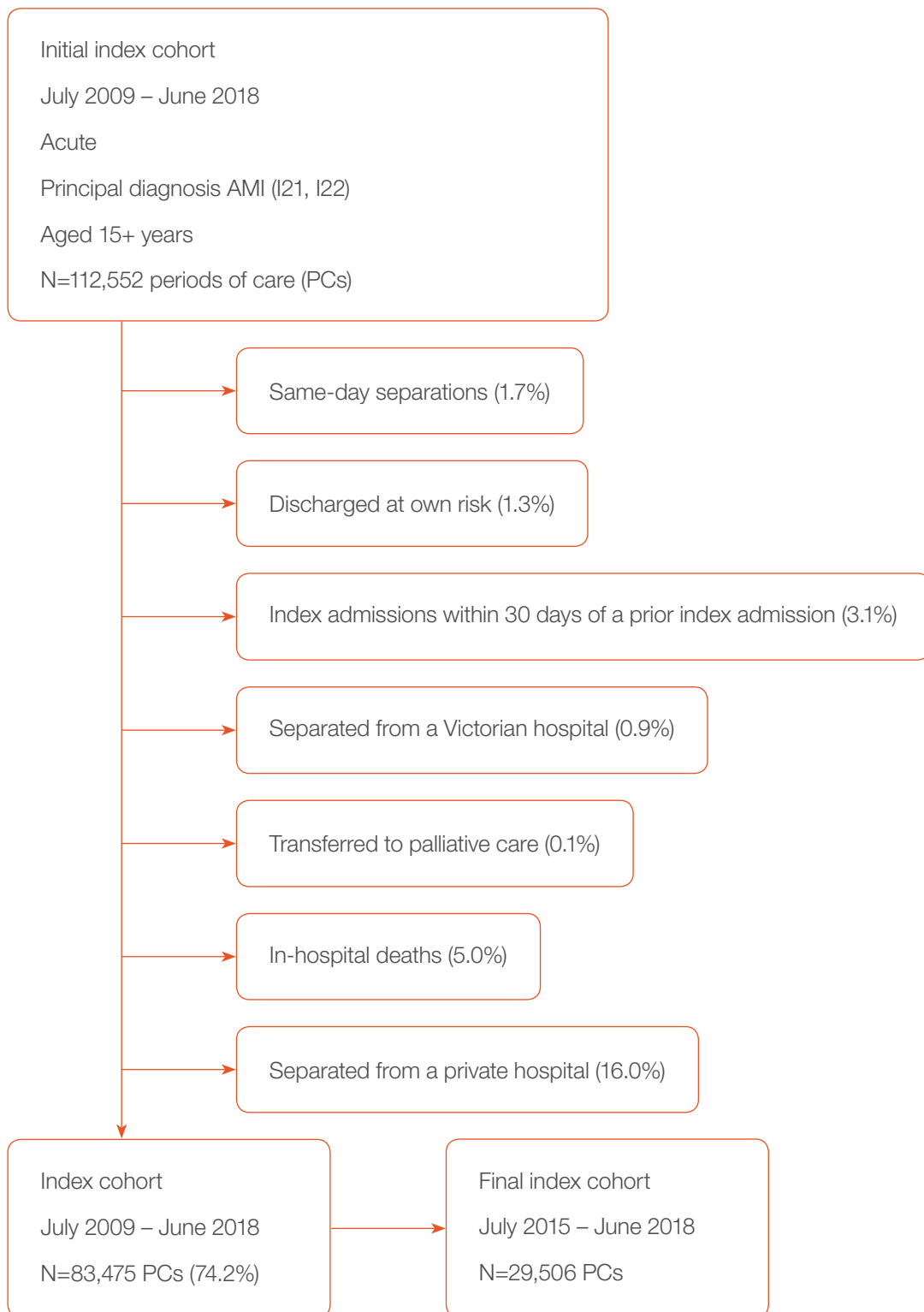
Index admissions with fewer than 30 days of follow-up information

Calculation of unadjusted rates of readmission and hospital RSRRs excluded index cases that occurred fewer than 30 days from the end of the study period (30 June 2018) 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 were 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.⁷

Figure 3 Acute myocardial infarction, cohort



Note: Exclusions are not mutually exclusive

Prediction model

Figure 4 Acute myocardial infarction: Predictors of readmission within 30 days of discharge using competing risk model, July 2015 – June 2018

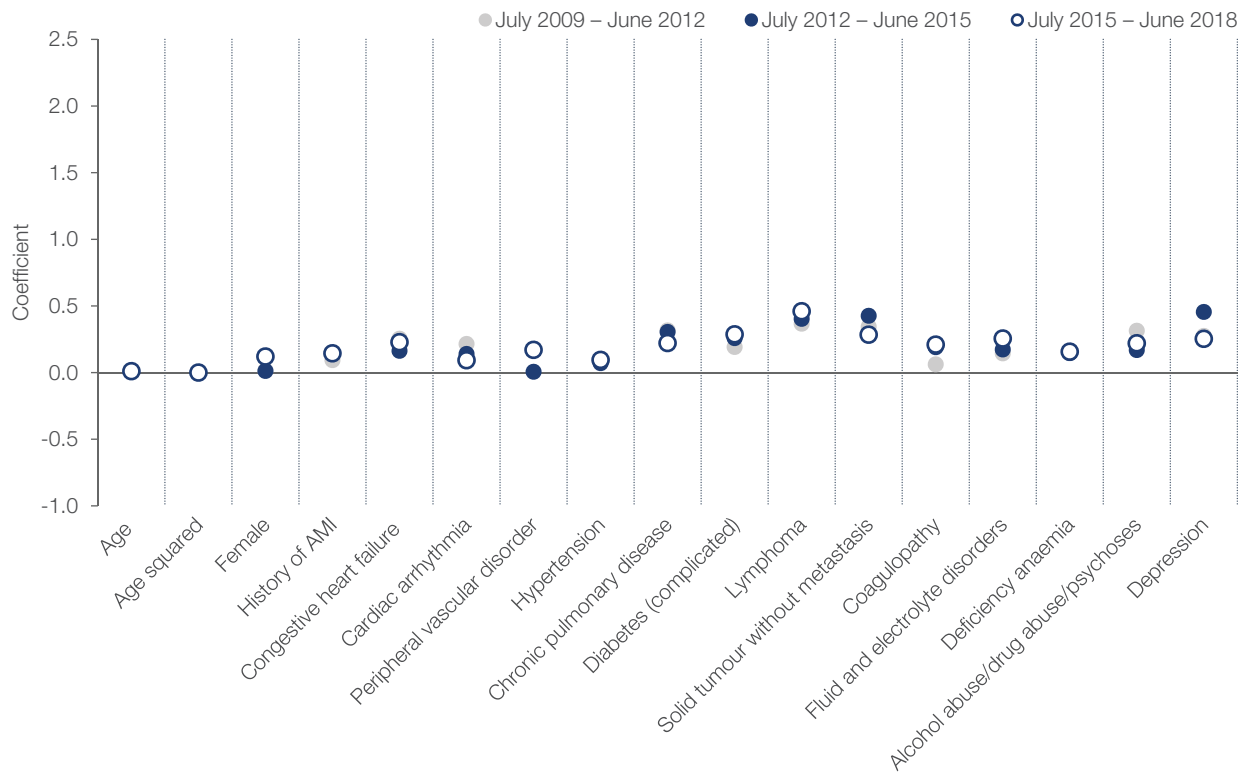
Predictors	Subhazard ratio	P-value	[95% confidence interval]
Age* (per one-year increase)	1.01	<0.001	(1.01–1.01)
Age squared	1.00	0.013	(1.00–1.00)
Female	1.13	<0.001	(1.06–1.20)
History of AMI	1.16	<0.001	(1.07–1.25)
Congestive heart failure	1.26	<0.001	(1.16–1.36)
Cardiac arrhythmia	1.10	0.001	(1.04–1.16)
Peripheral vascular disorder	1.19	0.004	(1.06–1.33)
Hypertension	1.10	0.005	(1.03–1.18)
Chronic pulmonary disease	1.25	<0.001	(1.13–1.37)
Diabetes (complicated)	1.33	<0.001	(1.24–1.44)
Lymphoma	1.58	0.011	(1.11–2.26)
Solid tumour without metastasis	1.33	0.001	(1.12–1.58)
Coagulopathy	1.23	<0.001	(1.10–1.38)
Fluid and electrolyte disorders	1.29	<0.001	(1.19–1.40)
Deficiency anaemia	1.17	0.003	(1.05–1.30)
Alcohol abuse/drug abuse/psychoses	1.25	0.001	(1.09–1.42)
Depression	1.29	0.021	(1.04–1.60)

*Age is centred around the mean

Figure 5 Model performance (C-statistics) over different time periods

Reference period	C-statistic
July 2015 – June 2018	0.63
Validation periods	
July 2012 – June 2015	0.63
July 2009 – June 2012	0.64

Figure 6 Acute myocardial infarction: Predictive model coefficients, three time periods, July 2009 – June 2018



Appendix 2:

Ischaemic stroke indicator specification

Risk-standardised readmission ratio (RSRR) indicator specification, cohort and prediction model

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

The indicator

The risk-standardised readmission ratio (RSRR) provides a fair comparison of a particular hospital's readmission results given its case mix with an average NSW hospital with the same case mix.⁴

Data source

Data are drawn from the Hospital Performance Dataset, NSW Ministry of Health Secure Analytics for Population Health Research and Intelligence. Record linkage was carried out by the Centre for Health Record Linkage.

Calculation

The ratio of observed number of acute, emergency readmissions (numerator) to expected number of acute, emergency readmissions (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 readmissions.

Inclusions

- principal diagnosis of ischaemic stroke (I63)
- aged 15 + years
- admissions to acute care
- discharged between 1 July 2015 and 30 June 2018.

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 readmissions, where a 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 cases where more than one acute, emergency readmission occurs within 30 days of an index admission, only the first readmission is counted.

Denominator

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

Attributions of index admissions and acute, emergency readmissions

- In cases of patient transfers, index admissions with an emergency readmission 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 readmission, no readmission 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 is considered to be a readmission.

The readmission 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 was developed using Fine and Gray competing risks regression models adjusting for patient-level risk factors, and taking into account the competing risk of death.⁵ The standard errors were adjusted for within hospital correlations. A backward modelling approach was used to build the multivariable regression models. Variables significant

at 20 percent level in the univariate analysis were considered for inclusion in multivariable models. Only variables with a 2-sided p-value of less than 0.05 in the multivariable models were retained in the final model.

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

Risk adjustment variables

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

- age at index admission
- sex
- Elixhauser comorbidities⁶, dementia and history of ischaemic stroke with a one-year lookback period.

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

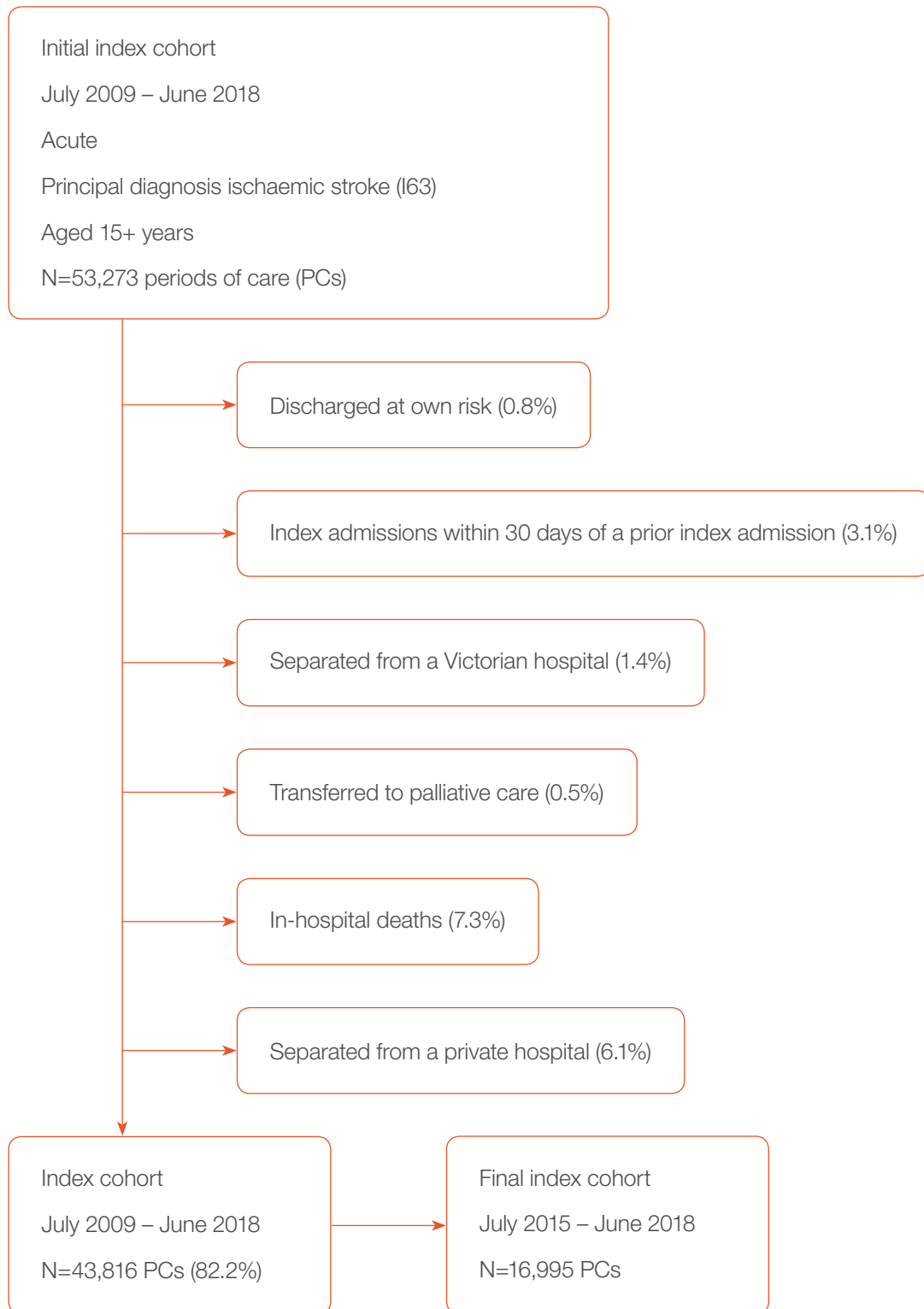
Calculation of unadjusted rates of readmission and hospital RSRRs excludes index cases that occurred fewer than 30 days from the end of the study period (30 June 2018) to avoid introducing bias with a truncated follow-up period. However, as competing risk regression models take into account different follow-up periods, index admissions without a full 30 days of follow-up information were 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.⁷

Figure 7

Ischaemic stroke, cohort



Note: Exclusions are not mutually exclusive.

Prediction model

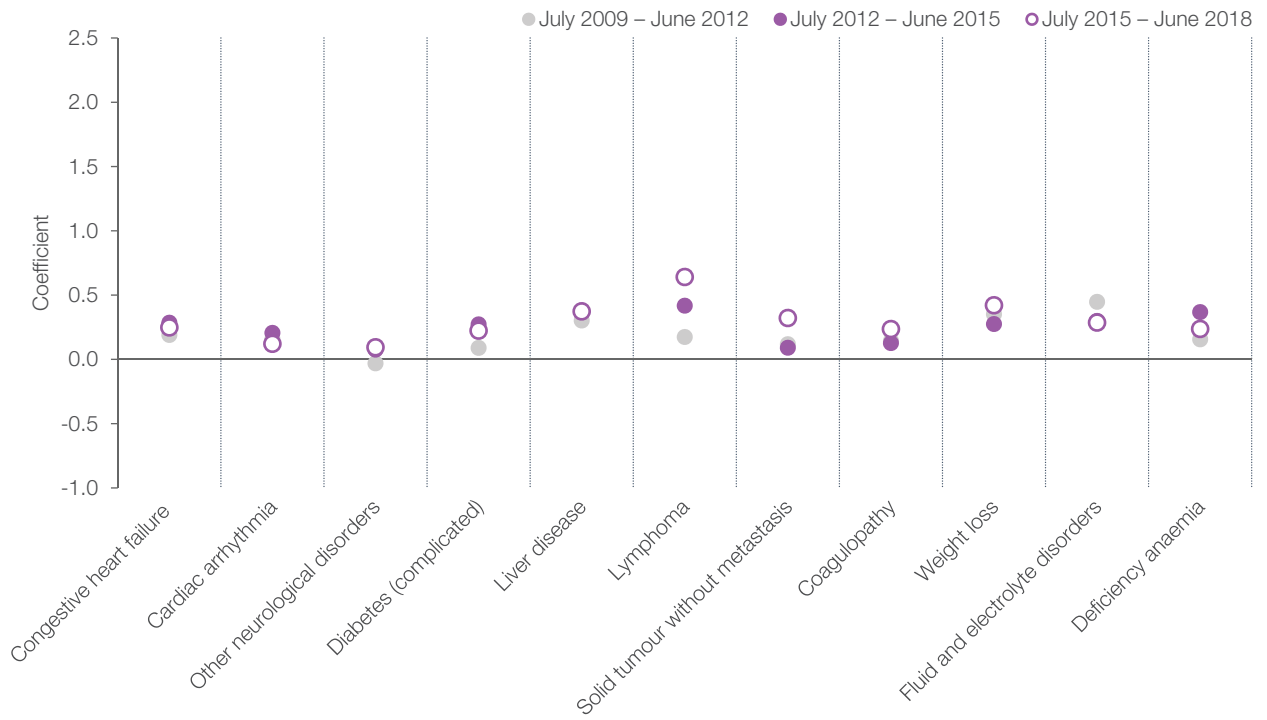
Figure 8 Ischaemic stroke: Predictors of readmission within 30 days of discharge using competing risk model, July 2015 – June 2018

Predictors	Subhazard ratio	P-value	[95% confidence interval]
Congestive heart failure	1.28	0.012	(1.06–1.56)
Cardiac arrhythmia	1.13	0.005	(1.04–1.23)
Other neurological disorders	1.10	0.029	(1.01–1.20)
Diabetes (complicated)	1.25	0.001	(1.10–1.42)
Liver disease	1.45	0.009	(1.10–1.92)
Lymphoma	1.90	0.018	(1.12–3.22)
Solid tumour without metastasis	1.38	<0.001	(1.19–1.60)
Coagulopathy	1.27	0.034	(1.02–1.57)
Weight loss	1.52	<0.001	(1.33–1.75)
Fluid and electrolyte disorders	1.33	<0.001	(1.18–1.50)
Deficiency anaemia	1.27	0.020	(1.04–1.55)

Figure 9 Model performance (C-statistics) over different time periods

Reference period	C-statistic
July 2015 – June 2018	0.60
Validation periods	
July 2012 – June 2015	0.59
July 2009 – June 2012	0.58

Figure 10 Ischaemic stroke: Predictive model coefficients, three time periods, July 2009 – June 2018



Appendix 3:

Congestive heart failure indicator specification

Risk-standardised readmission ratio (RSRR) indicator specification, cohort and prediction model

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 readmission results to acute care given its case mix with an average NSW hospital with the same case mix.⁴

Data source

Data are drawn from the Hospital Performance Dataset, NSW Ministry of Health Secure Analytics for Population Health Research and Intelligence. Record linkage was carried out by the Centre for Health Record Linkage.

Calculation

The ratio of the observed number of acute, emergency readmissions (numerator) to the expected number of acute, emergency readmissions (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 readmissions.

Inclusions

- principal diagnosis of CHF (I11.0, I13.0, I13.2, I50.0, I50.1, I50.9)
- aged 15+ years

- admissions to acute care
- discharged between 1 July 2015 and 30 June 2018.

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 readmissions, where a readmission 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 acute, emergency readmission occurs within 30 days of an index admission, only the first readmission is counted.

Denominator

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

Attributions of index admissions and acute, emergency readmissions

- In case of patient transfers index admissions with an emergency readmission 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 readmission, no readmission 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 is considered to be a readmission.

The readmission 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 was developed using Fine and Gray competing risks regression models adjusting for patient-level risk factors, and taking into account the competing risk of death.⁵ The standard errors were adjusted for within hospital correlations. A backward modelling approach was used to build the multivariable regression models. Variables significant

at 20 percent level in the univariate analysis were considered for inclusion in multivariable models. Only variables with a 2-sided p-value of less than 0.05 in the multivariable models were retained in the final model.

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

Risk adjustment variables

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

- age at index admission
- sex
- Elixhauser comorbidities⁶, dementia and history of CHF with a one-year lookback period.

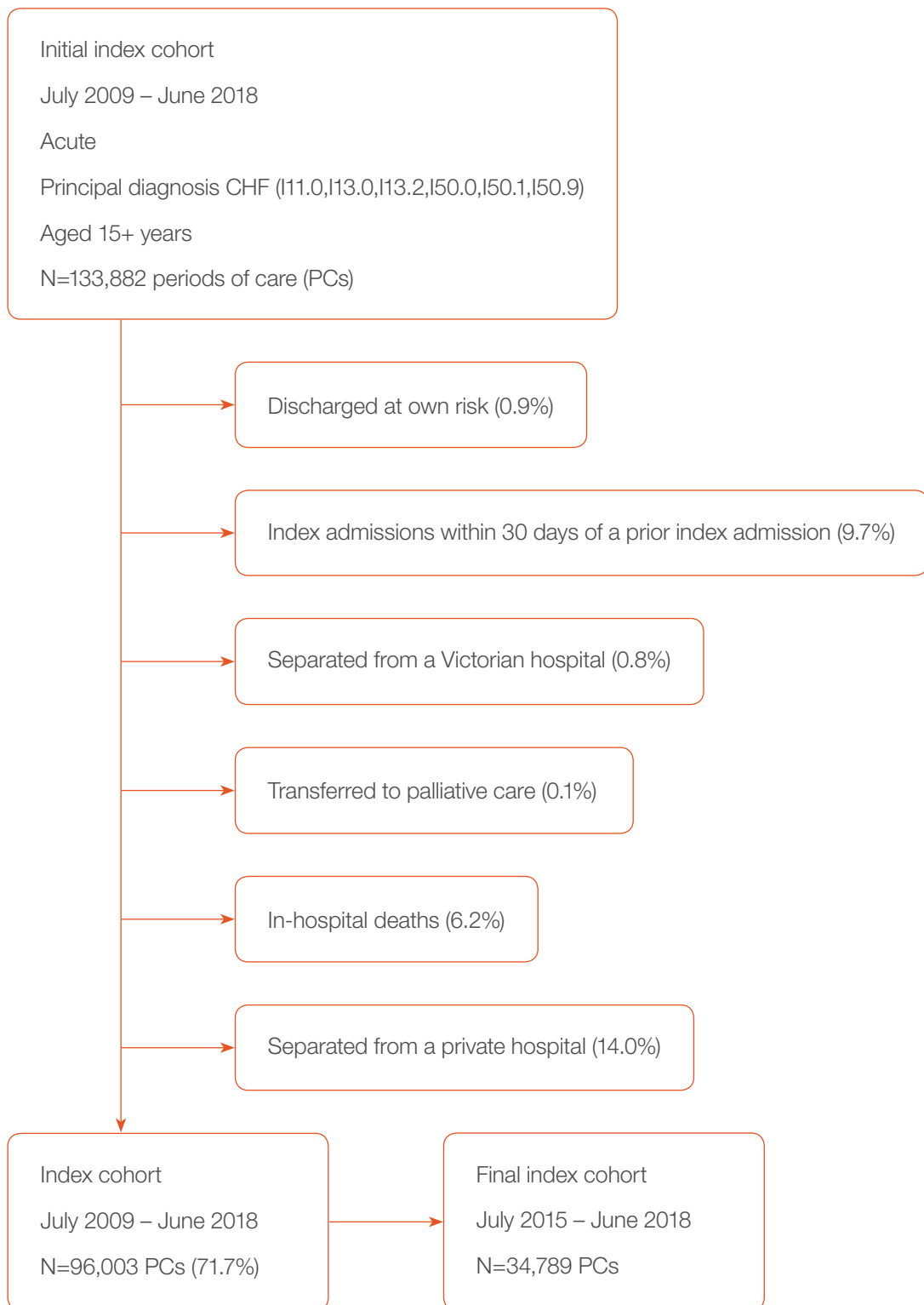
Index admissions with fewer than 30 days of follow-up information

Calculation of unadjusted rates of readmission and hospital RSRRs excludes index cases that occurred fewer than 30 days from the end of the study period (30 June 2018) 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.⁷

Figure 11 Congestive heart failure, cohort



Note: Exclusions are not mutually exclusive.

Prediction model

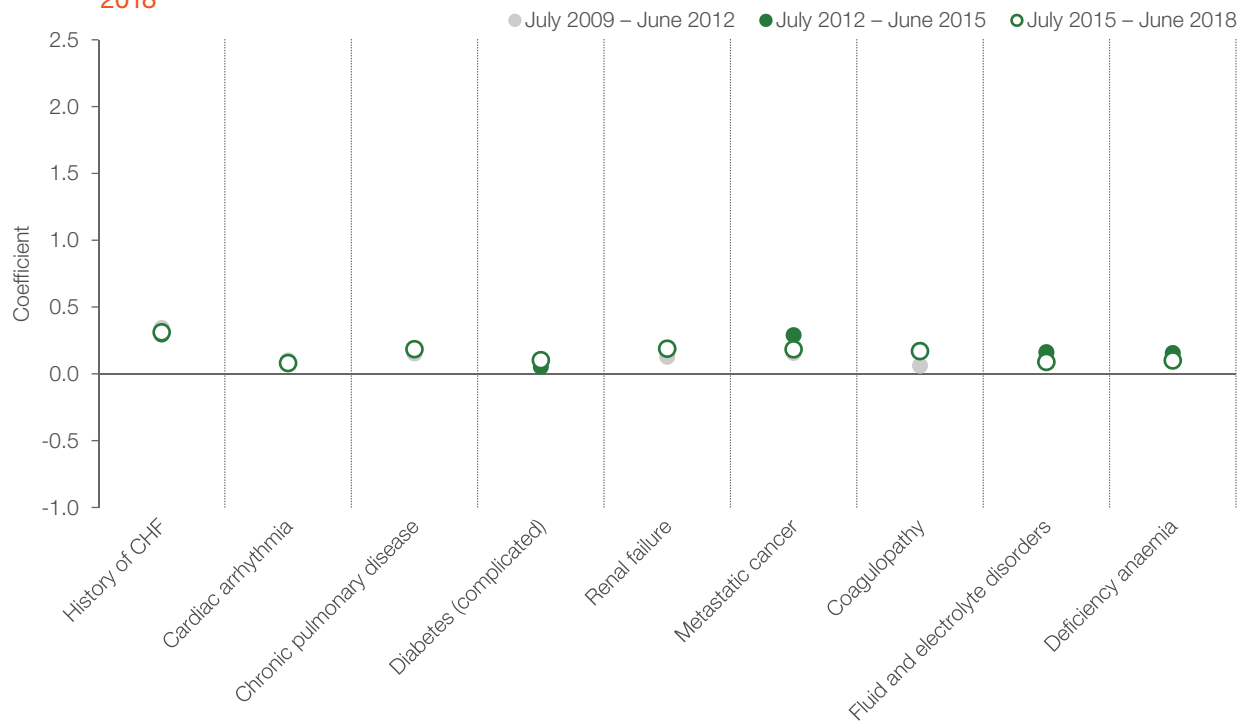
Figure 12 Congestive heart failure: Predictors of readmission within 30 days of discharge, using competing risk model, July 2015 – June 2018

Predictors	Subhazard ratio	P-value	[95% confidence interval]
History of CHF	1.37	<0.001	(1.31–1.43)
Cardiac arrhythmia	1.08	0.001	(1.03–1.14)
Chronic pulmonary disease	1.20	<0.001	(1.14–1.27)
Diabetes (complicated)	1.11	<0.001	(1.06–1.15)
Renal failure	1.21	<0.001	(1.13–1.29)
Metastatic cancer	1.20	0.038	(1.01–1.42)
Coagulopathy	1.18	<0.001	(1.11–1.26)
Fluid and electrolyte disorders	1.09	<0.001	(1.05–1.14)
Deficiency anaemia	1.10	0.007	(1.03–1.19)

Figure 13 Model performance (C-statistics) over different time periods

Reference period	C-statistic
July 2015 – June 2018	0.60
Validation periods	
July 2012 – June 2015	0.60
July 2009 – June 2012	0.59

Figure 14 Congestive heart failure: Predictive model coefficients, three time periods, July 2009 – June 2018



Appendix 4:

Pneumonia indicator specification

Risk-standardised readmission ratio (RSRR) indicator specification, cohort and prediction model

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 readmission results given its case mix with an average NSW hospital with the same case mix.⁴

Data source

Data are drawn from the Hospital Performance Dataset, NSW Ministry of Health Secure Analytics for Population Health Research and Intelligence. Record linkage was carried out by the Centre for Health Record Linkage.

Calculation

The ratio of the observed number of acute, emergency readmissions (numerator) to the expected number of acute, emergency readmissions (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 readmissions.

Inclusions

- principal diagnosis of pneumonia (J13, J14, J15, J16, J18)
- aged 18+ years
- admissions to acute care
- discharged between 1 July 2015 and 30 June 2018.

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 readmissions, where a readmission 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 acute, emergency readmission occurs within 30 days of an index admission, only the first readmission is counted.

Denominator

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

Attributions of index admissions and acute, emergency readmissions

- In cases of patient transfers, index admissions with an emergency readmission 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 readmission, no readmission 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 is considered to be a readmission.

The readmission 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 was developed using Fine and Gray competing risks regression models adjusting for patient-level risk factors, and taking into account the competing risk of death.⁵ The standard errors were adjusted for within hospital correlations.

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

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

Risk adjustment variables

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

- age at index admission
- sex
- Elixhauser comorbidities⁶, dementia and history of pneumonia with a one-year lookback period.

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

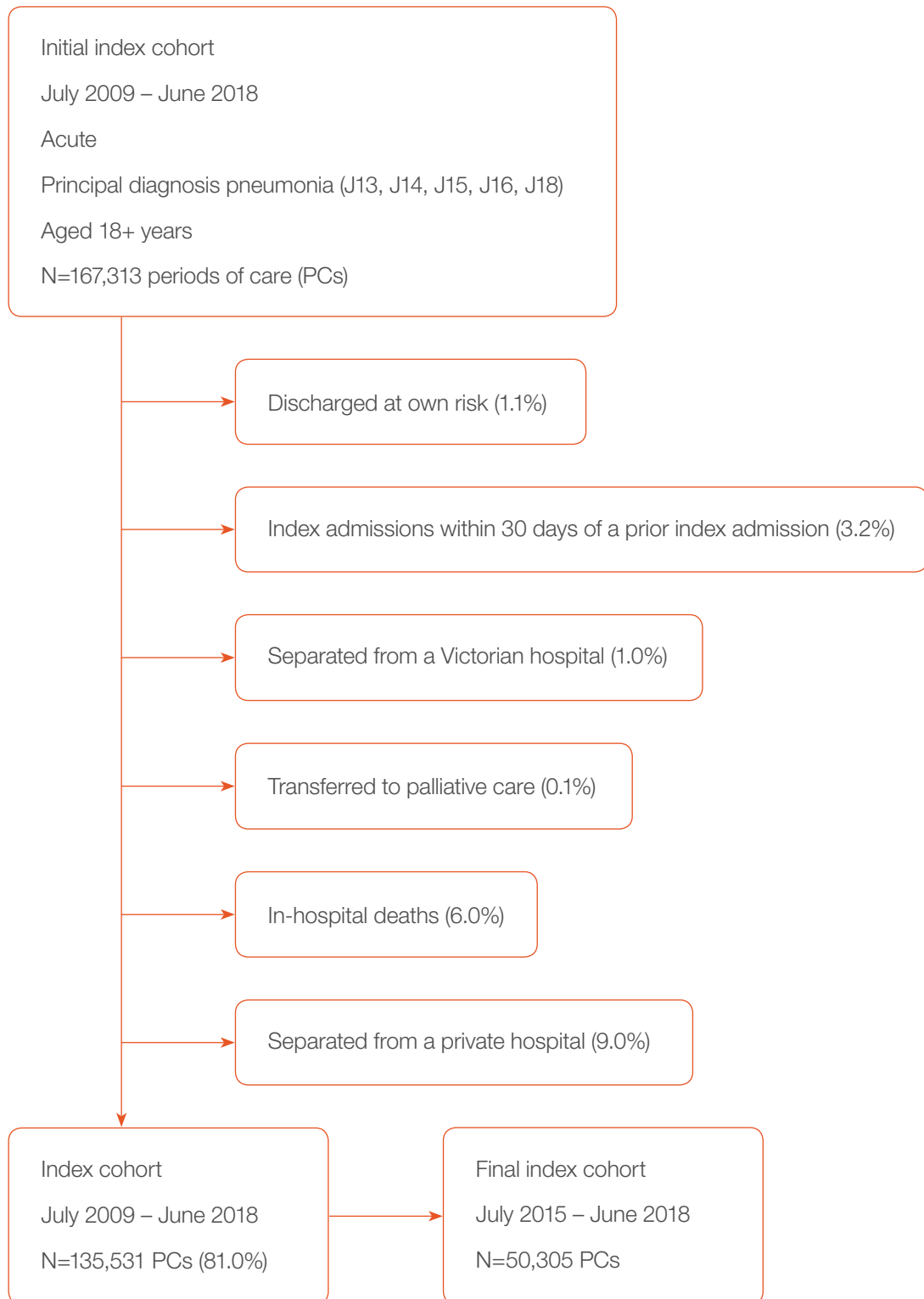
Calculation of unadjusted rates of readmission and hospital RSRRs excludes index cases that occurred fewer than 30 days from the end of the study period (30 June 2018) to avoid introducing bias with a truncated follow-up period. However, as competing risk regression models take into account different 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.⁷

Figure 15

Pneumonia, cohort



Note: Exclusions are not mutually exclusive.

Prediction model

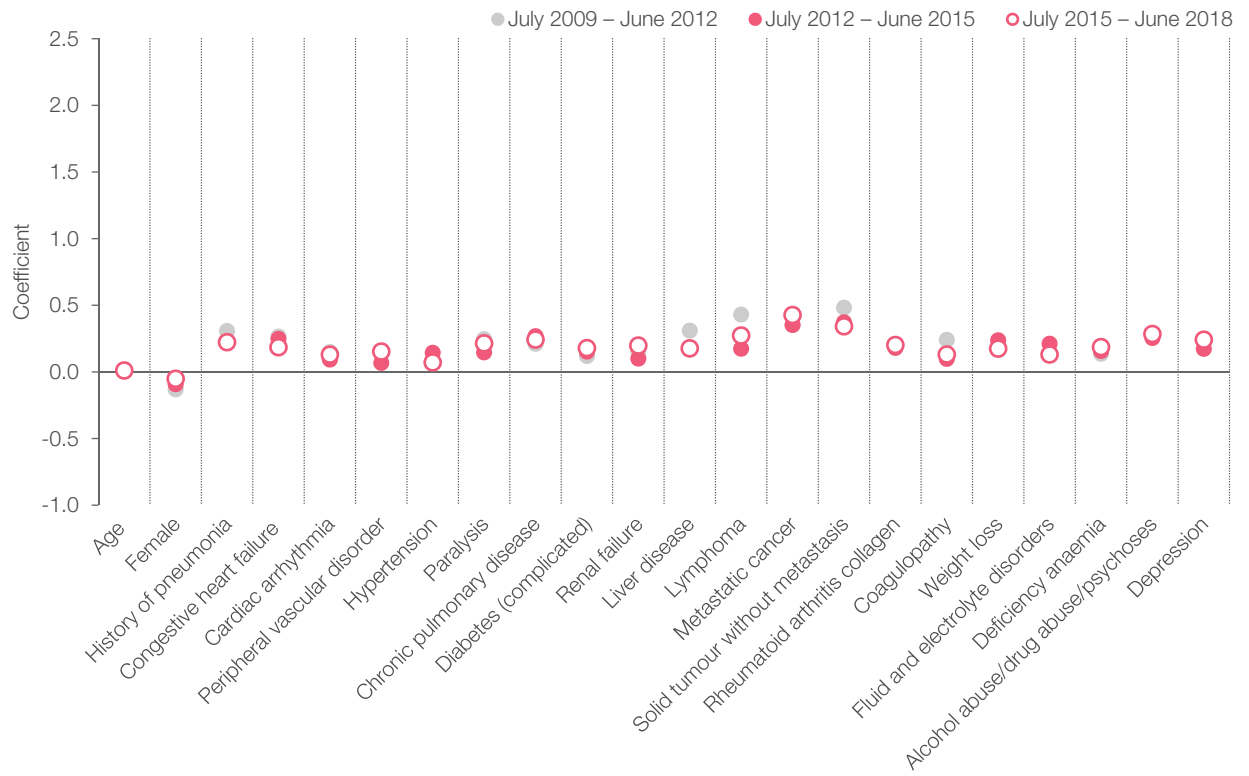
Figure 16 Pneumonia: Predictors of readmission within 30 days of discharge using competing risk model, July 2015 – June 2018

Predictors	Subhazard ratio	p-value	[95% confidence interval]
Age (per one-year increase)	1.01	<0.001	(1.01–1.01)
Female	0.95	0.004	(0.92–0.98)
History of pneumonia	1.25	<0.001	(1.18–1.33)
Congestive heart failure	1.20	<0.001	(1.13–1.28)
Cardiac arrhythmia	1.14	<0.001	(1.06–1.22)
Peripheral vascular disorder	1.16	0.008	(1.04–1.30)
Hypertension	1.07	0.032	(1.01–1.15)
Paralysis	1.24	0.01	(1.05–1.46)
Chronic pulmonary disease	1.27	<0.001	(1.21–1.34)
Diabetes (complicated)	1.20	<0.001	(1.13–1.27)
Renal failure	1.22	<0.001	(1.13–1.31)
Liver disease	1.19	0.004	(1.06–1.35)
Lymphoma	1.31	0.003	(1.10–1.57)
Metastatic cancer	1.53	<0.001	(1.36–1.73)
Solid tumour without metastasis	1.41	<0.001	(1.22–1.62)
Rheumatoid arthritis collagen	1.22	0.005	(1.06–1.41)
Coagulopathy	1.14	<0.001	(1.06–1.23)
Weight loss	1.19	<0.001	(1.10–1.29)
Fluid and electrolyte disorders	1.14	<0.001	(1.07–1.21)
Deficiency anaemia	1.20	<0.001	(1.10–1.31)
Alcohol abuse/drug abuse/psychoses	1.33	<0.001	(1.21–1.46)
Depression	1.27	<0.001	(1.15–1.41)

Figure 17 Model performance (C-statistics) over different time periods

Reference period	C-statistic
July 2015 – June 2018	0.66
Validation periods	
July 2012 – June 2015	0.66
July 2009 – June 2012	0.67

Figure 18 Pneumonia: Predictive model coefficients, three time periods, July 2009 – June 2018



Appendix 5:

Chronic obstructive pulmonary disease indicator specification

Risk-standardised readmission ratio (RSRR) indicator specification, cohort and prediction model

The condition

Chronic obstructive pulmonary disease (COPD) is a long-term lung disease, associated with prolonged exposure to tobacco smoke. While there is no cure, COPD, can be effectively managed outside the hospital setting with appropriate and timely care.

The indicator

The risk-standardised readmission ratio (RSRR) provides a fair comparison of a particular hospital's readmission results given its case mix, with an average NSW hospital with the same case mix.⁴

Data source

Data are drawn from the Hospital Performance Dataset, NSW Ministry of Health Secure Analytics for Population Health Research and Intelligence. Record linkage was carried out by the Centre for Health Record Linkage.

Calculation

The ratio of the observed number of acute, emergency readmissions (numerator) to the expected number of acute, emergency readmissions (denominator) within 30 days following discharge from COPD 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 readmissions.

Inclusions

- principal diagnosis of COPD: J20*, J40*, J41, J42, J43, J44, J47 (*only if accompanied by secondary diagnosis of J41–J44, J47)
- aged 45+ years

- admissions to acute care
- discharged between 1 July 2015 and 30 June 2018.

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 readmissions, where a readmission meets the following criteria:

- all-cause hospitalisations within 30 days following discharge from a COPD index admission
- acute and emergency hospitalisations
- admitted to any NSW hospital (public or private).

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

Denominator

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

Attributions of index admissions and acute, emergency readmissions

- In cases of patient transfers, index admissions with an emergency readmission 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 readmission, no readmission 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 is considered to be a readmission.

The readmission 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 was developed using Fine and Gray competing risks regression models adjusting for patient-level risk factors, and taking into account the competing risk of death.⁵ The standard errors were adjusted for within hospital correlations.

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

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

Risk adjustment variables

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

- age at index admission
- sex
- Elixhauser comorbidities⁶, dementia and history of COPD with a one-year lookback period.

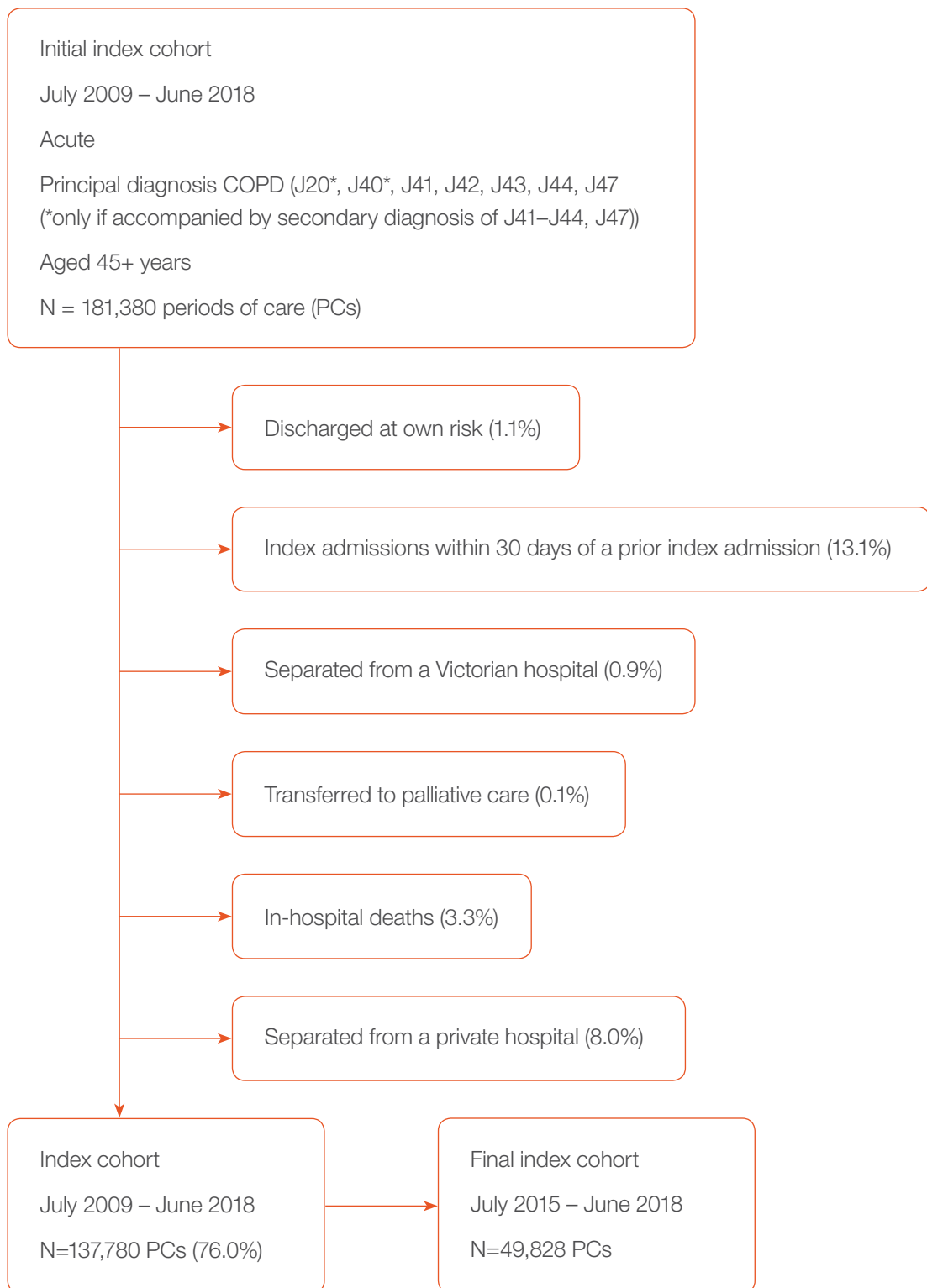
Index admissions with fewer than 30 days of follow-up information

Calculation of unadjusted rates of readmission and hospital RSRRs excludes index cases that occurred fewer than 30 days from the end of the study period (30 June 2018) 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.⁷

Figure 19 Chronic obstructive pulmonary disease, cohort



Note: Exclusions are not mutually exclusive.

Prediction model

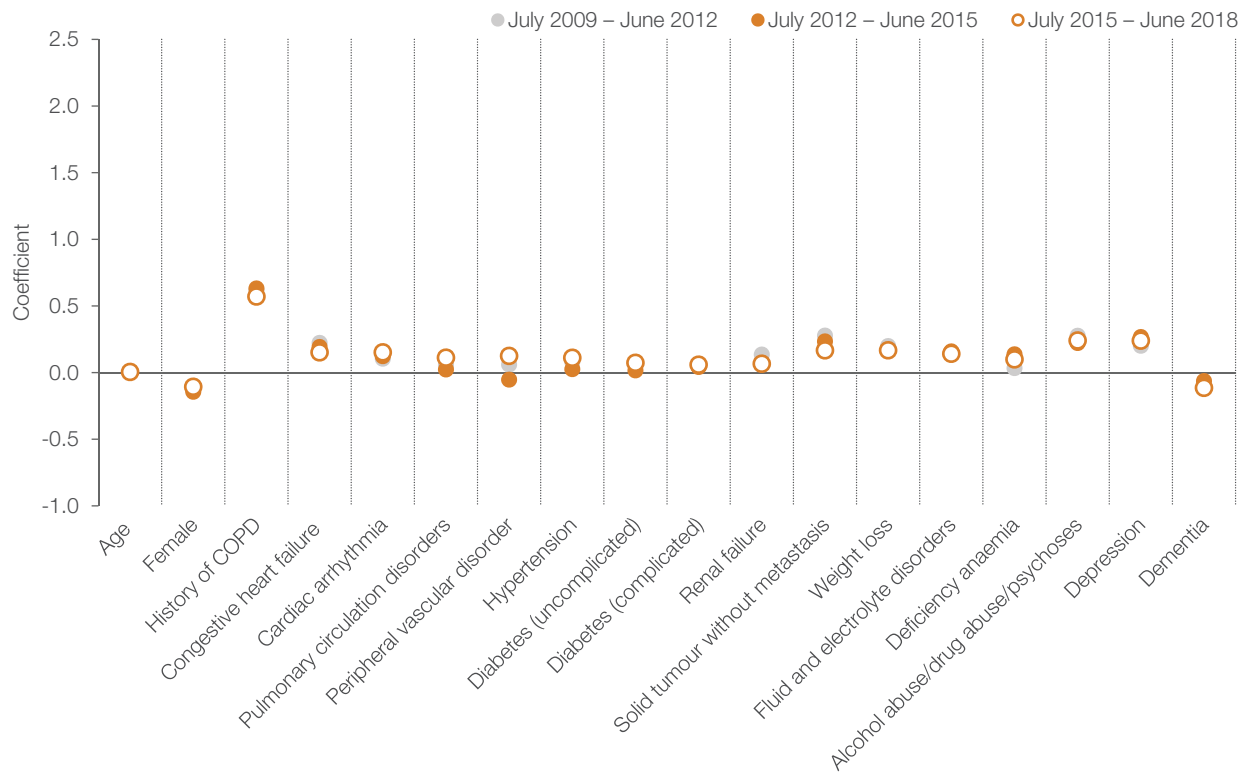
Figure 20 Chronic obstructive pulmonary disease: Predictors of readmission within 30 days of discharge using competing risk model, July 2015 – June 2018

Predictors	Subhazard ratio	p-value	[95% confidence interval]
Age (per one-year increase)	1.00	<0.001	(1.00–1.01)
Female	0.90	<0.001	(0.87–0.93)
History of COPD	1.77	<0.001	(1.70–1.84)
Congestive heart failure	1.16	<0.001	(1.12–1.21)
Cardiac arrhythmia	1.16	<0.001	(1.11–1.22)
Pulmonary circulation disorders	1.12	0.008	(1.03–1.22)
Peripheral vascular disorder	1.13	0.049	(1.00–1.28)
Hypertension	1.12	<0.001	(1.06–1.18)
Diabetes (uncomplicated)	1.08	0.019	(1.01–1.14)
Diabetes (complicated)	1.06	0.038	(1.00–1.12)
Renal failure	1.07	0.043	(1.00–1.14)
Solid tumour without metastasis	1.18	0.001	(1.07–1.30)
Weight loss	1.18	<0.001	(1.12–1.25)
Fluid and electrolyte disorders	1.15	<0.001	(1.10–1.20)
Deficiency anaemia	1.10	0.032	(1.01–1.21)
Alcohol abuse/drug abuse/psychoses	1.27	<0.001	(1.17–1.38)
Depression	1.27	<0.001	(1.13–1.43)
Dementia	0.89	0.028	(0.81–0.99)

Figure 21 Model performance (C-statistics) over different time periods

Reference period	C-statistic
July 2015 – June 2018	0.64
Validation periods	
July 2012 – June 2015	0.65
July 2009 – June 2012	0.65

Figure 22 Chronic obstructive pulmonary disease: Predictive model coefficients, three time periods, July 2009 – June 2018



Appendix 6:

Hip fracture surgery indicator specification

Risk-standardised readmission ratio (RSRR) indicator specification, cohort and prediction model

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 readmission results given its case mix with an average NSW hospital with the same case mix.⁴

Data source

Data are drawn from the Hospital Performance Dataset, NSW Ministry of Health Secure Analytics for Population Health Research and Intelligence. Record linkage was carried out by the Centre for Health Record Linkage.

Calculation

The ratio of observed number of acute, emergency readmissions (numerator) to the expected number of acute, emergency readmissions (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 readmissions.

Inclusions

- patients aged 50+ years
- discharges between 1 July 2015 and 30 June 2018

- 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–W19, R29.6)
 - with a 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 an asterisk (*) 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 readmissions, where a readmission 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 acute, emergency readmission occurs within 30 days of an index admission, only the first readmission is counted.

Denominator

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

Attribution of index admissions and acute, emergency readmissions

- In cases of patient transfers, index admissions and emergency readmissions 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 readmission, no readmission 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 is considered to be a readmission.

The readmission 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 was developed using Fine and Gray competing risks regression models adjusting for patient-level risk factors, and taking into account the competing risk of death.⁵ The standard errors were adjusted for within hospital correlations.

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

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

Risk adjustment variables

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

- age at index admission
- sex
- Elixhauser comorbidities⁶, and dementia with a one-year lookback period.

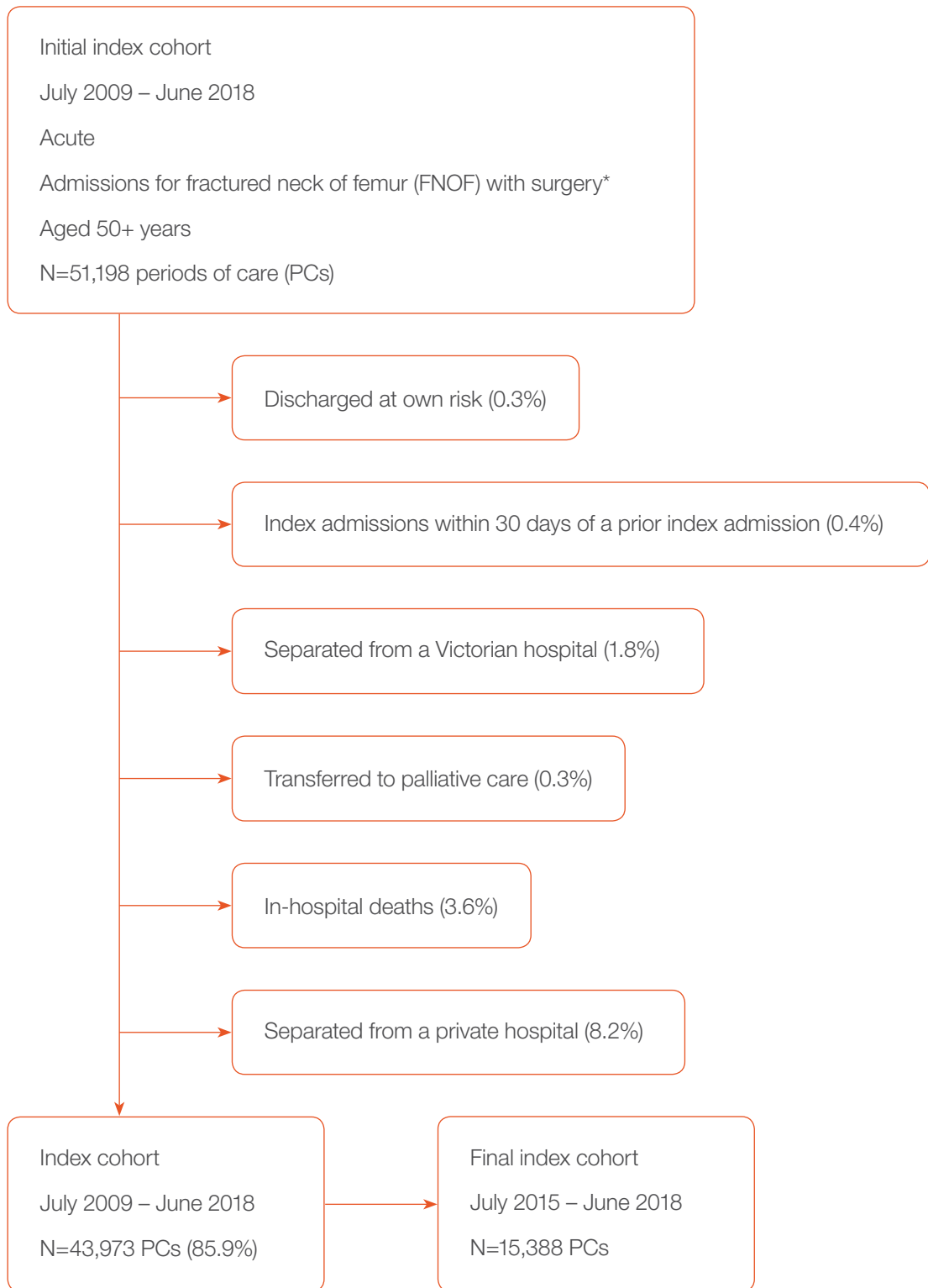
Index admissions with fewer than 30 days of follow-up information

Calculation of unadjusted rates of readmission and hospital RSRRs excludes index cases that occurred fewer than 30 days from the end of the study period (30 June 2018) 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.⁷

Figure 23 Hip fracture surgery, cohort



Note: Exclusions are not mutually exclusive.

*Refer to page 33 for specific details of identifying patients admitted for hip fracture surgery.

Prediction model

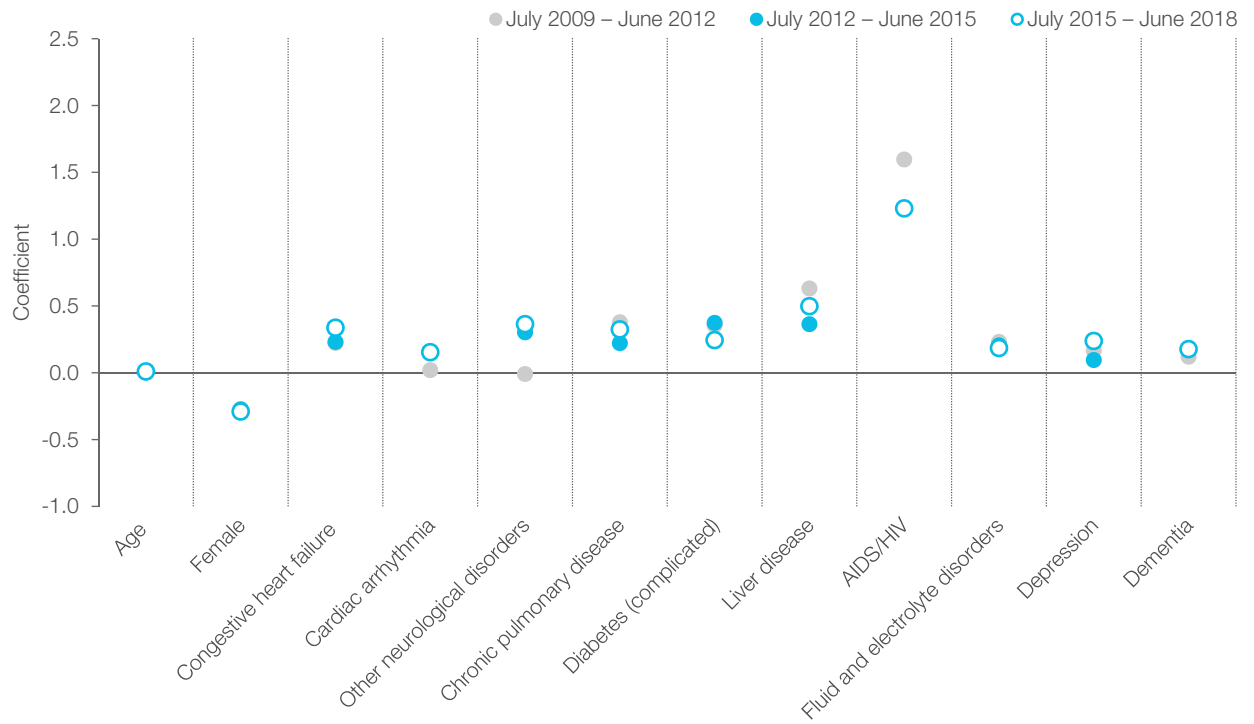
Figure 24 Hip fracture surgery: Predictors of readmission within 30 days of discharge using competing risk model, July 2015 – June 2018

Predictors	Subhazard ratio	P-value	[95% confidence interval]
Age (per one-year increase)	1.01	<0.001	(1.00–1.01)
Female	0.75	<0.001	(0.66–0.85)
Congestive heart failure	1.40	<0.001	(1.17–1.67)
Cardiac arrhythmia	1.17	0.002	(1.06–1.29)
Other neurological disorders	1.44	<0.001	(1.20–1.73)
Chronic pulmonary disease	1.38	<0.001	(1.20–1.60)
Diabetes (complicated)	1.28	<0.001	(1.16–1.41)
Liver disease	1.65	0.001	(1.23–2.19)
AIDS/HIV	3.42	0.009	(1.36–8.60)
Fluid and electrolyte disorders	1.20	<0.001	(1.10–1.32)
Depression	1.27	0.022	(1.04–1.55)
Dementia	1.19	0.009	(1.05–1.36)

Figure 25 Model performance (C-statistics) over different time periods

Reference period	C-statistic
July 2015 – June 2018	0.61
Validation periods	
July 2012 – June 2015	0.60
July 2009 – June 2012	0.59

Figure 26 Hip fracture surgery: Predictive model coefficients, three time periods, July 2009 – June 2018



Appendix 7:

Total hip replacement indicator specification

Risk-standardised readmission ratio (RSRR) indicator specification, cohort and prediction model

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 readmission results given its case mix with an average NSW hospital with the same case mix.⁴

Data source

Data are drawn from the Hospital Performance Dataset, NSW Ministry of Health Secure Analytics for Population Health Research and Intelligence. Record linkage was carried out by the Centre for Health Record Linkage.

Calculation

The ratio of observed number of acute readmissions (numerator) to the expected number of acute readmissions (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 readmissions.

Inclusions

- aged 18+ years
- discharged between 1 July 2015 and 30 June 2018

- 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 28
- 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 the 'Exclusions' section above.

Numerator

Observed number of hospital-level readmissions, where a readmission 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 acute readmission occurs within 60 days of an index admission, only the first readmission is counted.

Denominator

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

Attributions of index admissions and readmissions

Index admissions and readmissions 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 this discharge, it is considered to be a readmission.

The readmission 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 was developed using Fine and Gray competing risks regression models adjusting for patient-level risk factors, and taking into account the competing risk of death.⁵ The standard errors were adjusted for within hospital correlations. A backward modelling approach was used to build the

multivariable regression models. Variables significant at 20 percent level in the univariate analysis were considered for inclusion in multivariable models. Only variables with a 2-sided p-value of less than 0.05 in the multivariable models were retained in the final model.

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

Risk adjustment variables

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

- age at index admission
- sex
- Elixhauser comorbidities⁶, and dementia with a one-year lookback period.

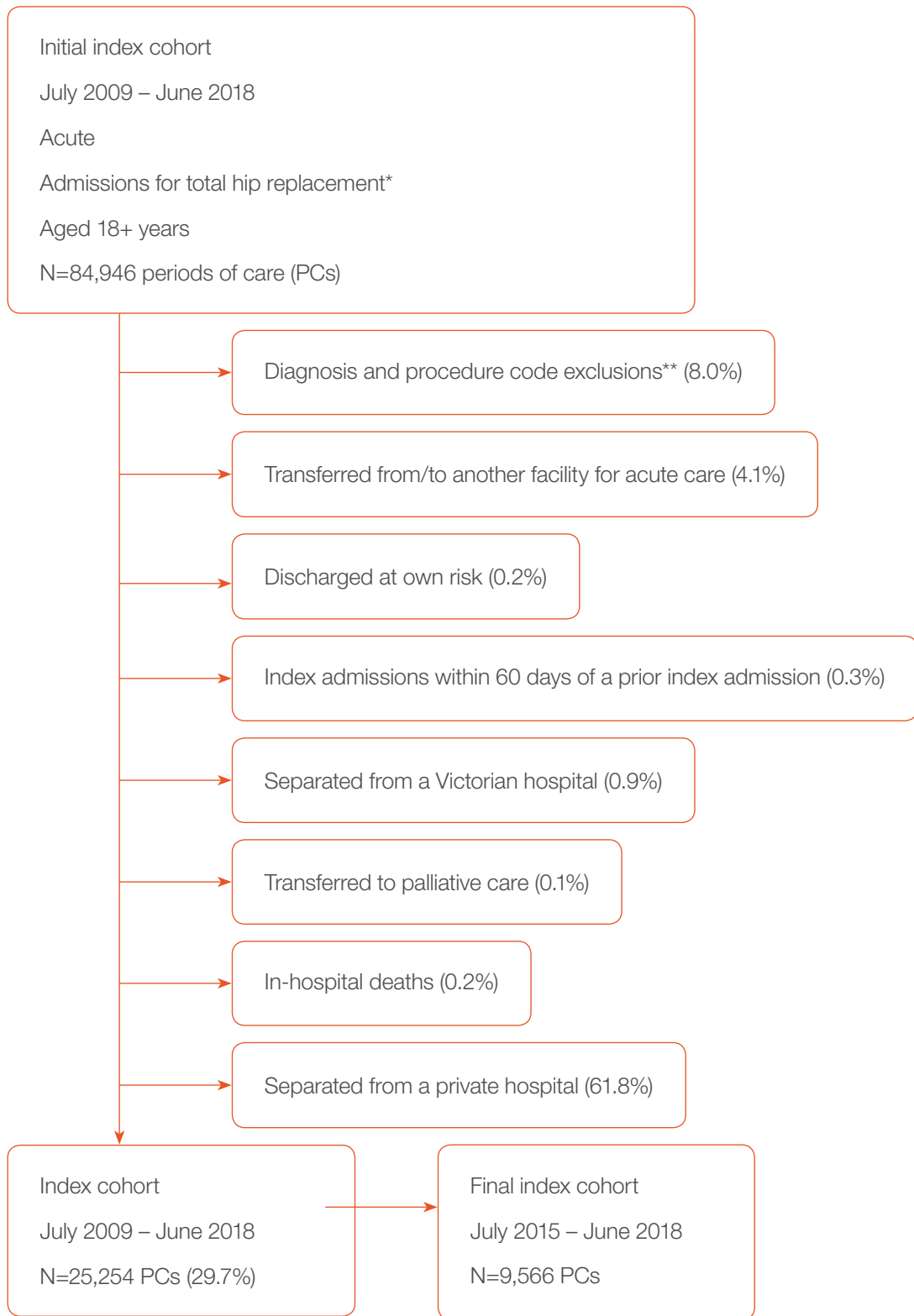
Index admissions with fewer than 60 days of follow-up information

Calculation of unadjusted rates of readmission and hospital RSRRs excludes index cases that occurred fewer than 60 days from the end of the study period (30 June 2018) 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.⁷

Figure 27 Total hip replacement, cohort



Note: Exclusions are not mutually exclusive.

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

**Diagnosis and procedure code exclusions are presented in Figure 28

Figure 28

Total hip replacement: Counts and prevalences of exclusions based on recorded diagnoses and procedures

Periods of care with the following ICD-10-AM codes in principal or secondary diagnoses/procedures on discharge from index admission	# periods of care excluded	% prevalence (of 84,946 periods of care)
Fracture of femur (S72)	5062	6.0
Fracture of lumbar spine and pelvis (S32)	259	0.3
Pathological fracture (M80.0, M80.1, M80.2, M80.3, M80.4, M80.5, M80.8, M80.9, M84.4)	300	0.4
Stress fracture (M84.3)	51	0.1
Malunion of fracture (M84.0)	79	0.1
Nonunion of fracture (M84.1)	310	0.4
Mechanical complications of prosthesis (T84.0 – T84.4)	551	0.7
Excision arthroplasty of hip (49312-00)	35	<0.1
Partial arthroplasty of hip (49315-00)	2	<0.1
Resurfacing of hip (unilateral) (90607-00)	32	<0.1
Revision arthroplasty of hip (49346-00, 49324-00, 49327-00, 49330-00, 49333-00, 49339-00, 49342-00, 49345-00, 49525-00, 49525-01)	279	0.3

Periods of care with the following ICD-10AM codes in principal diagnosis field on discharge from index admission	# periods of care excluded	% prevalence (of 84,946 periods of care)
Malignant neoplasm of:		
Pelvis, sacrum, coccyx (C41.4)	16	<0.1
Long bones of lower limbs (C40.2)	4	<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)	281	0.3
Disseminated malignant neoplasm (C80.0)	1	<0.1

Prediction model

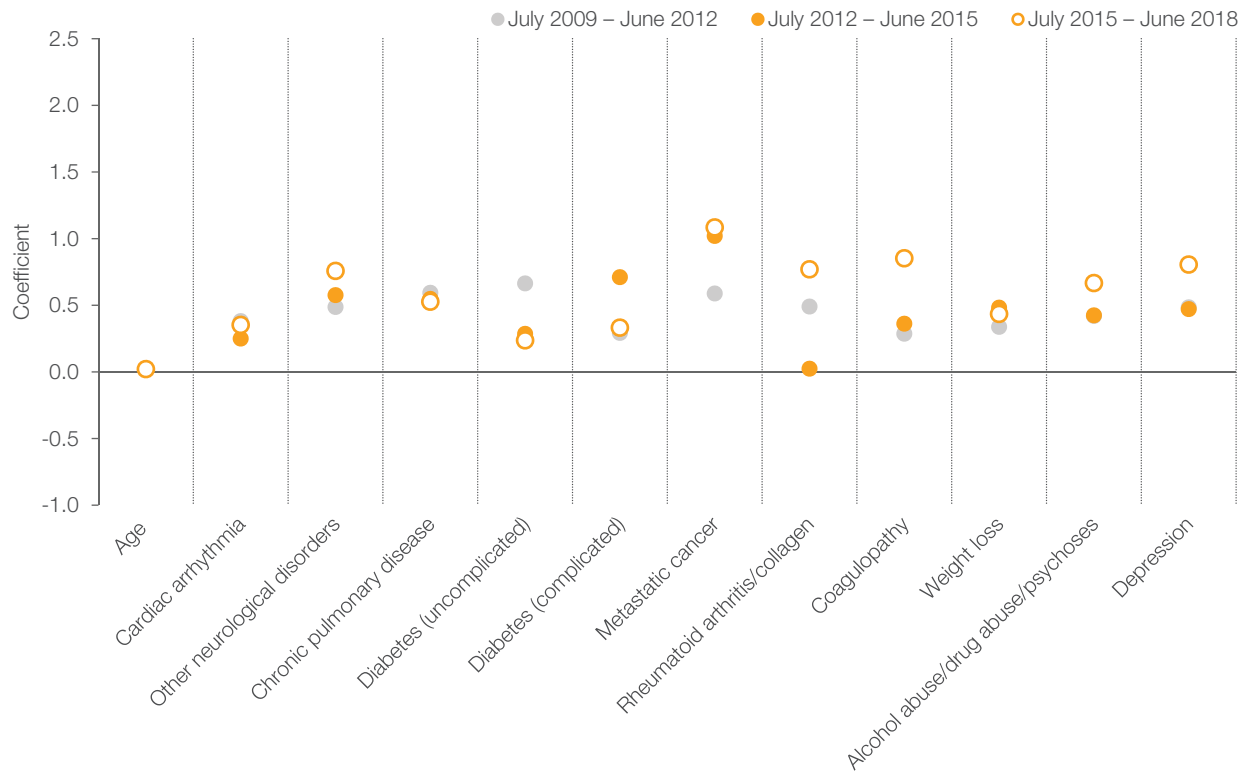
Figure 29 Total hip replacement: Predictors of readmission within 60 days of discharge using competing risk model, July 2015 – June 2018

Predictors	Subhazard ratio	P-value	[95% confidence interval]
Age (per one-year increase)	1.02	<0.001	(1.02–1.03)
Cardiac arrhythmia	1.42	<0.001	(1.18–1.72)
Other neurological disorders	2.13	0.002	(1.31–3.47)
Chronic pulmonary disease	1.69	0.003	(1.20–2.38)
Diabetes (uncomplicated)	1.27	0.028	(1.03–1.56)
Diabetes (complicated)	1.39	0.001	(1.15–1.69)
Metastatic cancer	2.96	<0.001	(1.90–4.60)
Rheumatoid arthritis/collagen	2.16	<0.001	(1.42–3.29)
Coagulopathy	2.35	<0.001	(1.71–3.22)
Weight loss	1.54	0.005	(1.14–2.10)
Alcohol abuse/drug abuse/psychoses	1.95	<0.001	(1.54–2.47)
Depression	2.24	0.001	(1.39–3.59)

Figure 30 Model performance (C-statistics) over different time periods

Reference period	C-statistic
July 2015 – June 2018	0.65
Validation periods	
July 2012 – June 2015	0.63
July 2009 – June 2012	0.60

Figure 31 Total hip replacement: Predictive model coefficients, three time periods, July 2009 – June 2018



Appendix 8:

Total knee replacement indicator specification

Risk-standardised readmission ratio (RSRR) indicator specification, cohort and prediction model

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 readmission results given its case mix with an average NSW hospital with the same case mix.⁴

Data source

Data are drawn from the Hospital Performance Dataset, NSW Ministry of Health Secure Analytics for Population Health Research and Intelligence. Record linkage was carried out by the Centre for Health Record Linkage.

Calculation

The ratio of the observed number of acute readmissions (numerator) to the expected number of acute readmissions (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 readmissions.

Inclusions

- aged 18+ years
- discharged between 1 July 2015 and 30 June 2018

- 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 33
- 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 the 'Exclusions' section above.

Numerator

Observed number of hospital-level readmissions, where a readmission 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 acute readmission occurs within 60 days of an index admission, only the first readmission is counted.

Denominator

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

Attributions of index admissions and acute readmissions

Index admissions and readmissions 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 this discharge, it is considered to be a readmission.

The readmission 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 was developed using Fine and Gray competing risks regression models adjusting for patient-level risk factors, and taking into account the competing risk of death.⁵ The standard errors were adjusted for within hospital correlations.

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

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

Risk adjustment variables

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

- age at index admission
- sex
- Elixhauser comorbidities⁶, and dementia using a one-year lookback period.

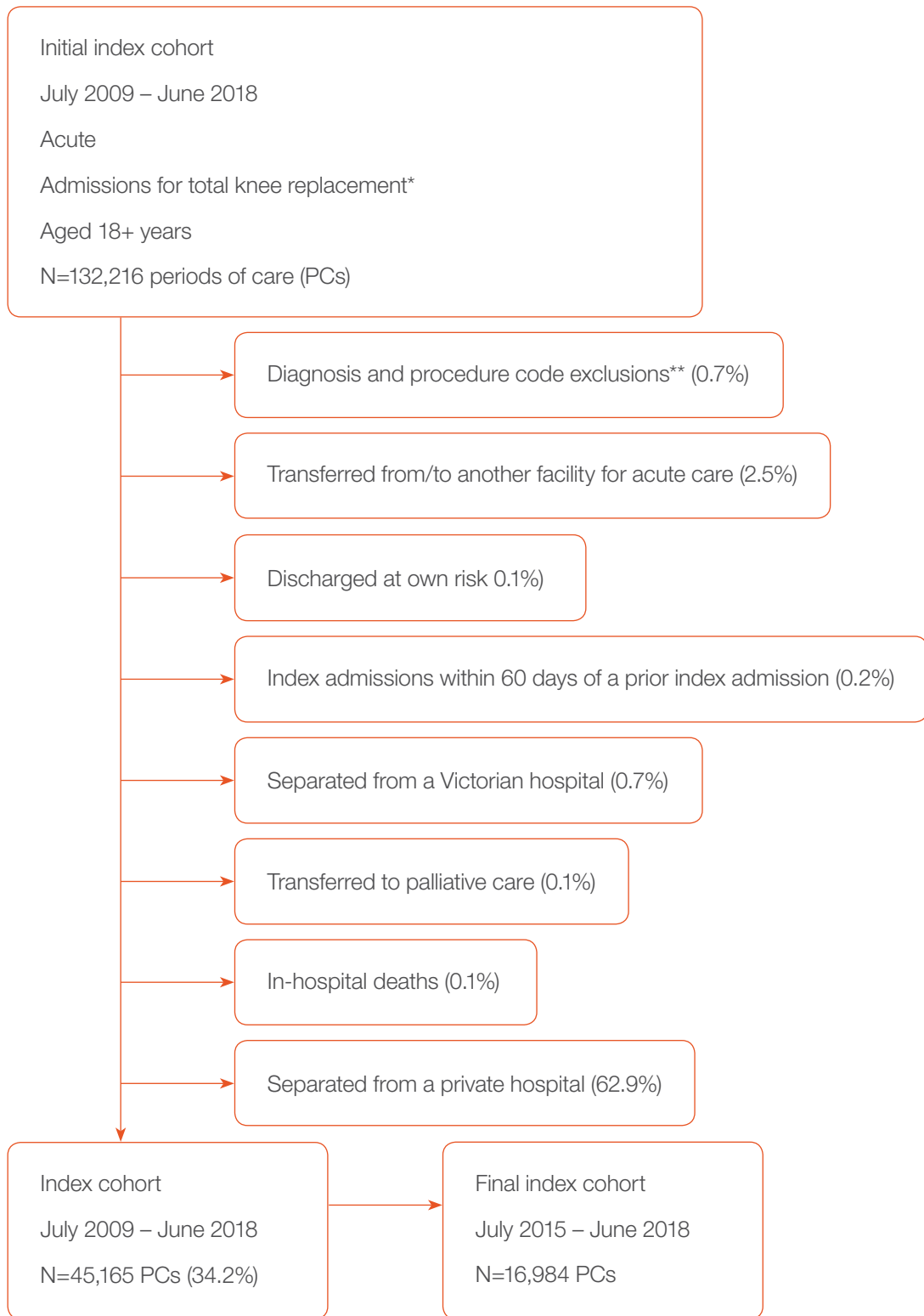
Index admissions with fewer than 60 days of follow-up information

Calculation of unadjusted rates of readmission and hospital RSRRs excludes index cases that occurred fewer than 60 days from the end of the study period (30 June 2018) 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.⁷

Figure 32 Total knee replacement, cohort



Note: Exclusions are not mutually exclusive.

*Total knee replacements are identified by procedure 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 33

Figure 33

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-10-AM codes in principal or secondary diagnoses/procedures on discharge from index admission	# periods of care excluded	% prevalence (of 132,216 periods of care)
Fracture of femur (S72)	138	0.1
Fracture of lumbar spine and pelvis (S32)	12	<0.1
Pathological fracture (M80.0, M80.1, M80.2, M80.3, M80.4, M80.5, M80.8, M80.9, M84.4)	50	<0.1
Stress fracture (M84.3)	17	<0.1
Malunion of fracture (M84.0)	44	<0.1
Nonunion of fracture (M84.1)	41	<0.1
Mechanical complications of prosthesis (T84.0 – T84.4)	262	0.2
Removal of knee prosthesis (49515-00)	135	0.1
Hemiarthroscopy of knee (49517-00)	58	<0.1
Resurfacing of knee (49534-00, 49534-01, 90562-00)	100	0.1
"Revision arthroplasty of knee (49530-00, 49530-01, 49533-00, 49554-00, 49545-00, 49548-00, 49551-00, 49527-00)"	210	0.2

Periods of care with the following ICD-10AM codes in principal diagnosis field on discharge from index admission	# periods of care excluded	% prevalence (of 132,216 periods of care)
Malignant neoplasm of:		
Pelvis, sacrum, coccyx (C41.4)	1	<0.1
Long bones of lower limbs (C40.2)	1	<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)	10	<0.1
Disseminated malignant neoplasm (C80.0)	0	0.0

Prediction model

Figure 34 Total knee replacement: Predictors of readmission within 60 days of discharge, using competing risk model, July 2015 – June 2018

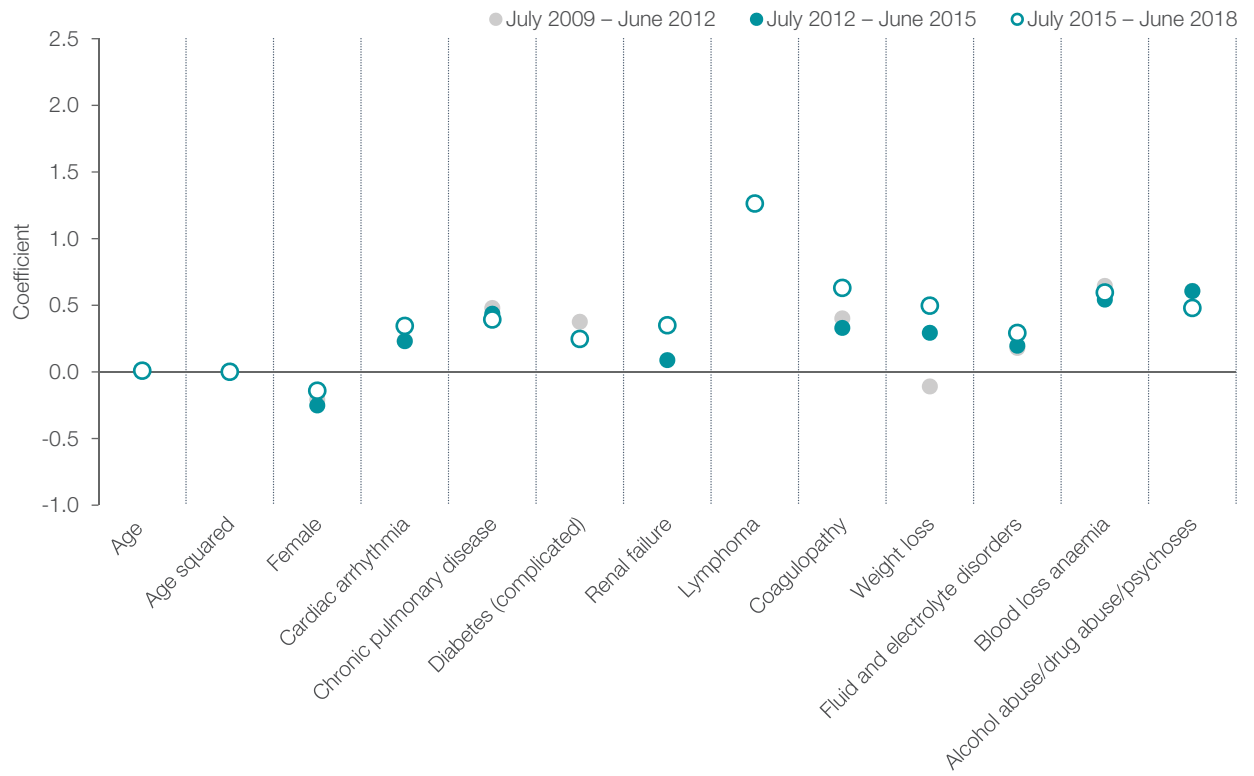
Predictors	Subhazard ratio	P-value	[95% confidence interval]
Age* (per one-year increase)	1.01	0.002	(1.00–1.02)
Age squared	1.00	<0.001	(1.00–1.00)
Female	0.87	0.006	(0.79–0.96)
Cardiac arrhythmia	1.41	<0.001	(1.25–1.60)
Chronic pulmonary disease	1.48	0.001	(1.17–1.87)
Diabetes (complicated)	1.28	0.002	(1.10–1.49)
Renal failure	1.42	0.011	(1.08–1.86)
Lymphoma	3.54	<0.001	(1.93–6.49)
Coagulopathy	1.88	<0.001	(1.32–2.67)
Weight loss	1.64	0.006	(1.15–2.34)
Fluid and electrolyte disorders	1.34	<0.001	(1.17–1.54)
Blood loss anaemia	1.81	0.002	(1.24–2.66)
Alcohol abuse/drug abuse/psychoses	1.62	0.003	(1.18–2.22)

*Age is centred around the mean

Figure 35 Model performance (C-statistics) over different time periods

Reference period	C-statistic
July 2015 – June 2018	0.59
Validation periods	
July 2012 – June 2015	0.58
July 2009 – June 2012	0.56

Figure 36 Total knee replacement: Predictive model coefficients, three time periods, July 2009 – June 2018



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About the Bureau of Health Information

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

BHI was established in 2009 and supports the accountability of the healthcare system by providing regular and detailed information to the community, government and healthcare professionals. This in turn supports quality improvement by highlighting how well the healthcare system is functioning and where there are opportunities to improve.

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

BHI publishes a range of reports and information products, including interactive tools, that provide objective, accurate and meaningful information about how the health system is performing.

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

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