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Acute coronary syndrome: validation of the method used to monitor incidence in Australia

A working paper using linked hospitalisation and deaths data from Western Australia and New South Wales

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Authoritative information and statistics to promote better health and wellbeing

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Australian Institute of Health and Welfare
Canberra
CVD 68

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Contents

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Abbreviations

ABS	Australian Bureau of Statistics
ACS	acute coronary syndrome
ACT	Australian Capital Territory
AIHW	Australian Institute of Health and Welfare
AMI	acute myocardial infarction
APDC	Admitted Patient Data Collection
ASGC	Australian Standard Geographical Classification
CHD	coronary heart disease
CHeReL	Centre for Health Record Linkage
CKD	chronic kidney disease
COAG	Council of Australian Governments
COPD	chronic obstructive pulmonary disease
CVD	cardiovascular disease
DLB	Data Linkage Branch
DOHWA	Department of Health Western Australia
ICD-10-AM	International Statistical Classification of Diseases and Related Health Problems, Tenth Revision, Australian Modification
MLK	Master Linkage Key
MONICA	World Health Organization's project to MONItor the trends and determinants of CArdiovascular disease
NHA	National Healthcare Agreement
NHMD	National Hospital Morbidity Database
NMD	National Mortality Database
NSW	New South Wales
NT	Northern Territory
PPN	Project Person Number
Qld	Queensland
SA	South Australia

SCRGSP	Steering Committee for the Review of Government Service Provision
UA	unstable angina
UCOD	Underlying cause of death
WA	Western Australia
WADLS	Western Australian Data Linkage System
WHO	World Health Organization

Summary

Monitoring the incidence of acute coronary events is critical to assess the health and economic burden of coronary heart disease (CHD) on the Australian population and for health service planning. There are currently no reliable national or jurisdictional data on the number of acute coronary events. Hence, the AIHW has developed a proxy measure that combines unlinked hospitalisation data from the AIHW National Hospital Morbidity Database and deaths data from the AIHW National Mortality Database. An algorithm (a problem-solving method) is required to avoid double counting. It makes a number of assumptions about how acute coronary events are recorded in the 2 data sets. For instance, it assumes that acute coronary events ending in death in hospital will have an acute CHD underlying cause of death, and that hospitalisations for acute coronary events ending in transfer have a subsequent episode with an acute myocardial infarction (AMI) or unstable angina (UA) principal diagnosis.

Key findings

This working paper presents the results of a validation study using linked hospitalisation and deaths data from WA and NSW. Analysis of these data sets indicates that the assumptions underlying the method are largely valid and it provides a reasonable measure of the incidence of acute coronary events. Nonetheless, there are some limitations:

- Around 36% and 34% of people in WA and NSW, respectively, who died in hospital with a principal diagnosis of AMI or UA recorded for the hospitalisation did not have a cause of death of acute CHD in the deaths data.
- Around 5% of hospitalisations in WA and 11% of hospitalisations in NSW coded with a separation mode of 'transferred to another acute hospital' did not have a subsequent episode identified in the linked data.
- Following a transfer to another hospital, not all identified subsequent episodes are coded with a principal diagnosis of AMI or UA (4% and 7% of all AMI/UA hospitalisations in WA and NSW, respectively).
- Clinical practices and coding are changing over time. The proportion of deaths in hospital reported as acute CHD in the deaths data is declining and hospital transfer rates are increasing.

A comparison of age-standardised event rates calculated using the linked and unlinked data, suggests that the unlinked data appears to underestimate the rate of acute coronary events (by 6% in WA and 11% in NSW in 2007). The results also suggest that trends over time are comparable within jurisdictions, but, given the difference in the level of underestimation between WA and NSW, comparisons between jurisdictions should not be made.

Conclusion

In the absence of an acute CHD event register or national linked hospitalisation and deaths data, the current methodology for estimating the incidence of acute coronary events is at present the best approach, despite the limitations outlined. This linked data study has broadened our understanding and awareness of key issues influencing the estimation of rates of acute coronary events using unlinked administrative data.

1 Introduction

Coronary heart disease (CHD) is the largest single cause of death in Australia. It contributes to significant illness, disability, poor quality of life and premature mortality, and results in high health-care costs (AIHW 2011a). CHD is common, affecting an estimated 585,900 Australians in 2011–12. It was the underlying cause of 21,513 deaths in 2011 (15% of all deaths). However, CHD is largely preventable, because many of its risk factors are modifiable, including tobacco smoking, high blood pressure, high blood cholesterol, physical inactivity, poor nutrition and obesity (AIHW 2014).

CHD occurs when there is a blockage in the blood vessels that supply blood to the heart muscle. There are 2 major clinical forms of CHD:

- Heart attack—also known as acute myocardial infarction (AMI). An acute life-threatening event where the blood vessel is completely blocked, requiring prompt treatment.
- Angina—a chronic condition where there is a temporary deficiency in the blood supply to the heart.

Heart attacks and the most serious form of angina, known as 'unstable angina', are considered to be part of a continuum of acute coronary heart diseases, described as 'acute coronary syndrome' (ACS). These are sudden, severe life-threatening events.

National monitoring of acute coronary events

Monitoring the number of new cases of acute coronary events each year is critical for assessing the impact of these conditions on the Australian population and will inform health-care policy and service planning, as well as evaluating progress in disease prevention and management. However, there are currently no reliable national and jurisdictional data on the number of new cases of acute coronary events each year. Hence, proxy measures have been developed that combine routinely available unlinked hospital and deaths data to estimate rates of acute coronary events.

The AIHW uses unlinked episode-based hospitalisation data from the AIHW National Hospital Morbidity Database (NHMD) and deaths data from the AIHW National Mortality Database (NMD) to estimate new cases (or incidence) of acute coronary events. This is a reasonable approach because it assumes that all acute coronary events will result either in hospitalisation or death (or both). Because these data are based on unlinked data, an algorithm (a problem-solving method) is required to take into account potential duplicates across the 2 data sets and potential multiple hospitalisation episodes for the single event within the NHMD (see Box 1.1). Currently, in the absence of linked data routinely available for such analyses, there is no alternative means of estimating the incidence of acute coronary events at a national level other than from these unlinked administrative data sets.

In the late 1990s, an algorithm was developed to estimate the incidence of major coronary events (non-fatal AMIs and fatal CHD events), which was validated against the WHO MONICA study (McElduff et al. 2000; Jamrozik et al. 2001). Due to recent changes in clinical and treatment patterns and diagnostics, this algorithm is no longer valid or appropriate to use in estimating acute coronary events (AIHW 2011b; Sanfilippo et al. 2008). Work undertaken by the AIHW in 2010–2012 proposed a revised algorithm for estimating the

incidence of acute coronary events that takes into account these recent changes (see Box 1.1 and Appendix A for more detail).

The revised algorithm focuses on acute CHD and takes into account the broad spectrum of clinical presentations for acute CHD spanning the continuum from AMI through to unstable angina (UA). People with UA are at imminent and very high risk of an AMI, and are therefore included in the definition of acute CHD and ACS.

Box 1.1: Estimating the incidence of acute coronary events

The key assumption underlying the algorithm for estimating the contemporary incidence of acute coronary events is that each acute coronary event will involve hospitalisation or death or both.

Algorithm for estimating acute coronary events

The number of fatal events:

Count the number of deaths where 'acute coronary heart disease' (ICD-10 codes I20–I24) is the underlying cause of death in each calendar year (based on year of registration of death).

Plus the number of non-fatal events:

Count the number of non-fatal hospitalisations where 'acute myocardial infarction' (AMI) (ICD-10-AM I21) or 'unstable angina'(UA) (ICD-10-AM I20.0) is the principal diagnosis, and the episode did not end in death or with the patient being transferred to another acute hospital in each calendar year (based on discharge date from hospital).

Aim of the study

The main objective of this study is to validate the revised algorithm, in particular the central assumptions underlying the algorithm for estimating the incidence of acute coronary events in Australia. This validation study has used linked hospitalisation and deaths data from 2 large states, WA and NSW, to determine how well the algorithm functions. Linked data sets such as the ones used here allow individuals to be followed over time and examine the relationships between consecutive hospitalisations or multiple hospitalisations over time, as well as the association between hospitalisation and death.

Structure of the paper

This working paper presents the results of this validation study. Chapter 2 outlines the methods used to obtain and analyse the linked hospitalisation and deaths data from WA and NSW. The results of the analysis of both unlinked national data and the linked data sets from WA and NSW are described in Chapter 3. Chapter 4 presents the implications for reporting and monitoring, including estimated rates for acute coronary events at the national level. Appendix A contains the timeline of changes made to the algorithm, while Appendixes B-E include further information on the methods, classifications, codes, data from the full linked WA and NSW data sets and supplementary tables from the linked and national unlinked data sets.

2 Methods

2.1 Linked data sources

Western Australia

Linked hospitalisation and deaths data were obtained from the Government of Western Australia Department of Health through the Data Linkage Branch (DLB), which manages the Western Australian Data Linkage System (WADLS).

New South Wales

Linked hospitalisation and deaths data were obtained from the NSW Ministry of Health and NSW Register of Births, Deaths and Marriages through the Centre for Health Record Linkage (CHeReL).

More details about the data linkage methods used by NSW and WA are provided in Appendix B.

2.2 Data requested

All hospitalisation and death records for people within the *population of interest* were obtained by the AIHW. The *population of interest* was defined as:

- people who have at least 1 hospitalisation where the principal or additional diagnosis was cardiovascular disease (CVD), chronic kidney disease (CKD) or diabetes; plus
- people who have died due to any cause of death.

The ICD-10-AM codes used to define CVD, diabetes and CKD hospitalisations are described in Appendix B.

Linked hospitalisation and deaths data were obtained from Data Linkage Western Australia for the period 1 July 1999 to 31 December 2010, following ethical approval by the Department of Health WA Human Research Ethics Committee (project #2012/30). The data were extracted in December 2012.

The same population of interest was used to apply for hospitalisation and deaths data from the CHeReL for NSW. The project was approved by the NSW Population & Health Services Research Ethics Committee (reference HREC/12/CIPHS/84). Given that the population of interest in NSW was larger than in WA and given AIHW budgetary constraints, the data set obtained from NSW was restricted to those people aged 40 and over. Admitted patient hospitalisation data were supplied for the period 1 July 2000 to 31 December 2010; however, the deaths data cover the period 1 July 2000 to 31 December 2007 because more recent data were not available.

The hospitalisation data from both states consists of hospital separation records from both public and private hospitals. From WA, the AIHW obtained a total of 2,333,628 hospitalisation and death records, corresponding to 438,387 people (Table 2.1). From NSW, the AIHW obtained a total of 7,010,122 hospitalisation and death records, which corresponded to 1,496,319 people aged 40 and over (Table 2.1).

Table 2.1: Records received by the AIHW in linked data sets from WA and NSW

	WA[a]		NSW[b]	
Linked data set	**People[c]**	**Episodes**	**People[c]**	**Episodes**
Hospitalised (no death)	330,789	1,384,950	1,172,500	5,238,299
Hospitalised and died	93,234	934,314	233,571	1,681,575
Died but not hospitalised	14,364	. .	90,248	. .
Total	**438,387**	**2,333,628**	**1,496,319**	**7,010,122**

(a) WA data covers the time period 1 July 1999 to 31 December 2010.

(b) NSW hospitalisation data covers the time period 1 July 2000 to 31 December 2010; NSW deaths data covers the time period 1 July 2000 to 31 December 2007.

(c) The count of people consists of 1 individual counted once for all hospitalisations and/or deaths across the entire time period.

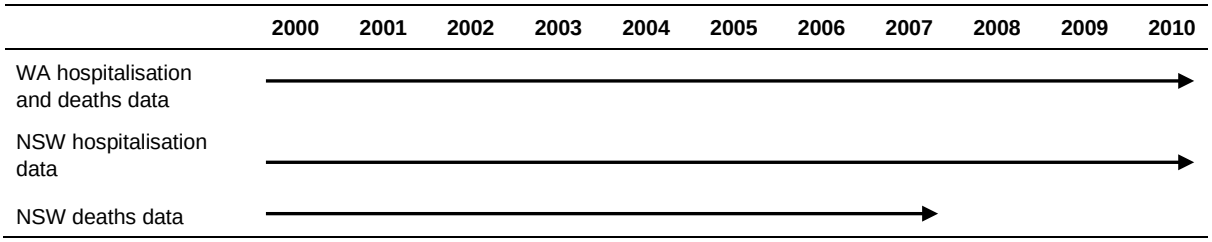
Note: . . Not applicable.

Sources: Government of Western Australia Department of Health and NSW Ministry of Health and NSW Register of Births, Deaths and Marriages.

Time frames

For the purpose of the analyses outlined in this paper, the WA data was restricted to the same age range and time periods as NSW to allow direct comparison where possible (Figure 2.1).

Figure 2.1: Time periods for the WA and NSW data sets



Please note that:

- Data supplied by WA for 1999 and by NSW for 2000 are not full calendar years and start from 1 July.
- Totals reported for these data may differ from that in the NMD and the NHMD due to different dates of supply.
- The data do not include WA or NSW residents who die or are hospitalised interstate or overseas, but include non-residents who may have been hospitalised or died in WA or NSW.
- A variable to identify Aboriginal and Torres Strait Islander people is not included in any of the data sets; therefore the algorithm could not be specifically validated for Indigenous Australians.

The full list of variables provided for the hospitalisation and deaths data for each state is presented in Appendix B.

2.3 Linked data preparation

On receipt of the linked data sets, the AIHW loaded the data into a database and checks were performed to confirm that the population of interest included all the requested disease codes and the data contained all the variables requested.

Data quality checks

The hospitalisation and deaths data sets were each cleaned before combining into 2 final linked data sets (1 for NSW and 1 for WA), containing a unique identification number to identify individuals and their hospitalisation and death records. Data cleaning tasks included:

- Validating the population in scope to ensure that patients hospitalised with principal or additional diagnosis for CVD, CKD or diabetes were on file (for example, missing data for patients with Type 1 diabetes resulted in reissue of linked data from 1 of the data providers). Counts were cross checked with data in the AIHW national hospital and mortality databases and state-based data custodians and researchers were consulted when anomalies arose.
- Checking data consistency between death/hospital reporting, and repairing missing values, to ensure consistency of each linked data record (for example, substituting sex recorded on death as 'Unknown' or 'Not Registered' with the patient's sex reported on hospitalisation record or ensuring consistency of date of birth between death/hospital reporting for individual records).
- When differences between the death and hospital records were found, the death record took precedence.
- Checking date of death for missing and out of range values, and replacing those with valid dates from associated hospitalisation records where the separation mode was 'died in hospital'.
- Removing potential duplicated death records and incomplete duplicates (for example, additional record with missing death record linkage where the full record was already present on the file).
- Checking consistency of hospitalisation records ensuring that last separation date and date of death are in agreement.
- Checking consistency of records with separation mode of 'died in hospital' for linkage to the death record and cleaning apparently unrelated subsequent episodes of hospital admission.

Frequency counts of the complete WA and NSW linked data sets obtained by the AIHW are provided in Appendix C.

2.4 National unlinked data

AIHW National Mortality Database

The AIHW NMD contains information, including cause of death, on all deaths registered in Australia. Mortality data are provided to the AIHW by the Registrars of Births, Deaths and Marriages and National Coronial Information System, and coded by the Australian Bureau of Statistics (ABS).

The NMD includes cause of death information. For each death, only 1 cause can be coded as the underlying cause. However, in each death there can be more than 1 associated cause. Underlying and associated causes of death are defined as follows:

- *Underlying cause of death*—the disease or injury that initiated the train of events leading directly to death, or the circumstances of the accident or violence that produced the fatal injury. For each death, only a single underlying cause is selected from among all the conditions reported. The underlying cause provides a logical point to target public health interventions aimed at preventing the precipitating cause from occurring—that is, by breaking the chain of events or providing a treatment or cure. The underlying cause of death refers to the health condition or event at the beginning of the chain of events leading to death.
- *Associated causes of death*—causes, other than the underlying cause, that were instrumental in causing death. They encompass conditions that intervened or significantly contributed to the death (AIHW 2012a).

The data quality statements for the AIHW National Mortality Database can be found in the following ABS publications:

ABS Quality declaration summary for causes of death, Australia, 2011 (ABS cat. no. 3303.0) <http://www.abs.gov.au/Ausstats/abs@.nsf/0/D4A300EE1E04AA43CA2576E800156A24?OpenDocument> and

ABS Quality declaration summary for deaths, Australia, 2011 (ABS cat. no. 3302.0) <http://www.abs.gov.au/Ausstats/abs@.nsf/0/9FD0E6AAA0BB3388CA25750B000E3CF5?OpenDocument>.

AIHW National Hospital Morbidity Database

Data for the AIHW NHMD are supplied by state and territory health authorities, under the terms of the National Health Information Agreement. The state and territory health authorities received these data from public and private hospitals. States and territories use these data for service planning, monitoring, and internal and public reporting. Hospitals may be required to provide data to states and territories through administrative arrangements, contractual requirements or legislation.

The scope of the NHMD is episodes of care for admitted patients in essentially all hospitals in Australia, including public and private acute and psychiatric hospitals, free-standing day hospital facilities, alcohol and drug treatment hospitals and dental hospitals. Hospitals operated by the Australian Defence Force, corrections authorities and in Australia's offshore territories are not included.

The hospital separations data do not include episodes of non-admitted patient care provided in outpatient clinics or emergency departments.

The NHMD records the reason why a person was admitted to hospital (identified as the principal diagnosis), and the presence of other disease conditions that required hospital treatment (additional diagnoses; these may be multiple) while they were in hospital. Characteristics of the person (such as age and sex), the length of stay in hospital and how it was concluded (discharge to home, transfer to another hospital, death) are also recorded. The data set records only admissions in isolation: it does not identify the repeated hospital admissions that an individual person may experience over time.

There are 2 distinct types of diagnoses recorded in the database—principal and additional:

- The *principal diagnosis* is the one listed in hospital records to describe the problem that was chiefly responsible for the patient's episode of care.
- An *additional diagnosis* is a condition or complaint, either co-existing with the principal diagnosis or that arises during a person's hospital admission that requires the provision of care. Multiple diagnoses may be recorded, but it is recognised that not all additional diagnoses are recorded every time.

Year specific data quality statements for the National Hospital Morbidity Database 2010–11 and 2011–12 can be found at:
<http://meteor.aihw.gov.au/content/index.phtml/itemId/511338> and
<http://meteor.aihw.gov.au/content/index.phtml/itemId/529483>.

3 Analysis and results

This chapter uses linked hospitalisation and deaths data from 2 large states, WA and NSW, to determine how well the revised algorithm functions for estimating the incidence of acute coronary events (see Box 1.1). The algorithm, and the assumptions underlying it, has not been validated nationally or internationally to assess whether it provides a reasonable measure of the incidence of acute coronary events. Linked data sets such as the ones used here allow the method and central assumptions underlying it to be more fully assessed. In this validation study, the linked data provides a means of assessing the consistency and accuracy in disease coding in both hospital and deaths records and in coding of transfers and deaths in hospital. These are key assumptions underlying the algorithm to reduce potential double counting of acute events and ensure that each coronary event is captured only once by the algorithm.

To validate the revised algorithm, several key questions were explored for both fatal and non-fatal events and the findings of the analyses are presented in this chapter.

The following key questions were examined:

Fatal events

- Does the revised algorithm count all deaths in hospital attributable to acute coronary syndrome?
- What effect would including chronic coronary heart disease in the deaths definition have on the number of fatal acute coronary events counted by the algorithm?
- Does the algorithm adequately take account of potential double counting of deaths by excluding deaths in hospital?
- Are changes over time likely to have an impact on trends in estimates based on the algorithm?

Non-fatal events

- How well are transfers coded for acute myocardial infarction and unstable angina hospitalisations?
- Are all related episodes for an acute coronary event following a transfer coded as acute myocardial infarction or unstable angina?
- Do transfer rates differ by jurisdiction and region?
- Do transfer rates and coding change over time and will this have an impact on trends?

3.1 Fatal acute coronary events

The algorithm defines the number of fatal events as the:

Number of deaths where ‘acute coronary heart disease’ (ICD-10 codes I20–I24) is the underlying cause of death in each calendar year (based on year of registration of death).

Does the revised algorithm count all deaths in hospital attributable to acute coronary syndrome?

The revised algorithm only counts hospitalisations that did not end in death. This means that if deaths in hospital from acute coronary events are not coded with an underlying cause of death of acute CHD in the deaths data, the algorithm will underestimate the number of events. It is not possible to determine this from the episode-based, de-identified data in the NHMD. Linked data are needed to determine the accuracy of this association.

Findings from the WA and NSW linked hospitalisation and deaths data sets

By comparing the principal diagnosis and underlying cause of death for those people who died in hospital, some measure of the potential levels of over- and underestimation can be determined from the WA and NSW linked data sets.

From 1 July 2000 to 31 December 2007:

- In WA, 1,956 people had a hospitalisation ending in death where the principal diagnosis was AMI or UA. Of these people, 63.7% had an acute CHD underlying cause of death code, while 36.3% did not.
- In NSW, 9,523 people had a hospitalisation ending in death where the principal diagnosis of AMI or UA. Of these people, 66.2% had an acute CHD underlying cause of death code, while 33.8% did not.

Of the 710 people in WA and 3,219 people in NSW who had a hospital separation ending in death where the principal diagnosis was AMI or UA *without* an acute CHD underlying cause of death code, 206 (29.0%) in WA and 1,168 (36.3%) in NSW had the underlying cause of death recorded as chronic CHD (Table 3.1). The remainder had an underlying cause of death of diabetes, stroke, chronic obstructive pulmonary disease (COPD), renal failure, CKD, pneumonia or aortic valve stenosis.

Table 3.1: People with a principal diagnosis of AMI or UA in their last hospitalisation and who died in hospital, aged 40 and over, WA and NSW, 1 July 2000 to 31 December 2007

	WA			NSW[(a)]		
Underlying cause of death in deaths data	**Number**	**Proportion of total (%)**	**Proportion of non-acute (%)**	**Number**	**Proportion of total (%)**	**Proportion of non-acute (%)**
Acute CHD (ICD-10 I20–I24)	1,246	63.7		6,304	66.2	
Chronic CHD (ICD-10 I25)	206	10.5	29.0	1,168	12.3	36.3
Other	504	25.8	71.0	2,051	21.5	63.7
Diabetes	85	4.3	12.0	308	3.2	9.6
Stroke	35	1.8	4.9	123	1.3	3.8
Total	**1,956**	**100.0**	**100.0**	**9,523**	**100.0**	**100.0**

(a) Deaths in NSW emergency departments are recorded as admitted patient episodes.

Source: AIHW analysis of WA and NSW linked hospitalisation and deaths data sets.

Results presented in Table 3.1 indicate that there are a number of deaths from ACS that are coded as chronic CHD death and, possibly, these should be included in the estimates. However, the analysis of the linked data indicates that there are a substantially higher

number of chronic CHD deaths that probably cannot be attributed to ACS and, therefore, should not be included in the counts (see below).

The coding of some of the acute deaths as chronic CHD may be due to coding or recording errors, but some will be legitimately stating that although ACS may have been the reason for the admission, it may not necessarily have led directly to the death. In these cases, acute CHD could be recorded as an associated cause of death, which would not be picked up by the algorithm. Even if a patient is admitted to hospital with an ACS principal diagnosis, it does not necessarily mean that it was the underlying cause of death.

Between July 2000 and December 2007 in WA and NSW, there were 2,439 and 12,235 people, respectively, who had an underlying cause of death of chronic CHD (I25) and who died in hospital. Of these, 91.6% in WA and 90.5% in NSW *did not* have a principal diagnosis of AMI or UA in their last hospitalisation and are, on that basis, unlikely to have died from an acute coronary event (Table 3.2).

In both states, about half of those deaths had the principal diagnosis of their last hospitalisation reported as heart failure, cardiac arrest, stroke, pneumonia, rehabilitation procedure, kidney disease or diabetes (Table 3.2).

Table 3.2: Deaths in hospital coded with underlying cause of chronic CHD (ICD-10 I25) by principal diagnosis of last hospitalisation, people aged 40 and over, WA and NSW, 1 July 2000 to 31 December 2007

	WA		NSW[(a)]	
Principal diagnosis in last hospitalisation	**Number**	**%**	**Number**	**%**
AMI or UA (I21, I20.0)	206	8.4	1,168	9.5
Other principal diagnosis	2,233	91.6	11,067	90.5
Heart failure (I50)	622	27.9	2,857	25.8
Cardiac arrest (I46)	52	2.3	1,336	12.1
Stroke (I60–64)	120	5.4	559	5.1
Pneumonia, organism unspecified (J18)	104	4.7	482	4.4
Care involving use of rehabilitation procedure, unspecified (Z50.9)	83	3.7	150	1.4
Kidney disease (N17–N19)	65	2.9	269	2.4
Diabetes (E10–E14)	47	2.1	240	2.2
Other	1,140	51.1	5,174	46.8
Total	**2,439**	**100.0**	**12,235**	**100.0**

(a) Deaths in NSW emergency departments are recorded as admitted patient episodes.

Source: AIHW analysis of WA and NSW linked hospitalisation and deaths data sets.

What effect would including chronic coronary heart disease in the deaths definition have on the number of fatal acute coronary events counted by the algorithm?

The number of fatal acute coronary events is estimated from the NMD. To do this, the current algorithm counts all deaths with an underlying cause of death coded as acute CHD (ICD-10 codes I20–I24).

The previous version of the algorithm also included deaths from chronic CHD (ICD-10 code I25) to ensure all acute coronary deaths were counted (see Appendix A). However, including chronic CHD could lead to an overestimation of the number of acute coronary events.

Findings from the National Mortality Database

The exclusion or inclusion of I25 codes for chronic CHD makes a considerable difference to the number of deaths counted, and therefore the incidence estimates. In 2010, for people aged 40 and over there were:

- 10,244 deaths from acute CHD (I20–I24) and 11,341 from chronic CHD (I25).

Thus, the estimates of the number of fatal acute events would be more than doubled by including chronic CHD (I25) deaths in the algorithm. The inclusion of I25 would result in an increase of 15% in the incidence of acute coronary events, increasing from 448 per 100,000 to 516 per 100,000 in 2010.

Findings from the WA and NSW linked hospitalisation and deaths data sets

Similarly, for WA and NSW, the exclusion or inclusion of I25 codes also makes a considerable difference to the number of deaths counted. From July 2000 to December 2007, for people aged 40 and over there were:

- 8,103 deaths from acute CHD (I20–I24) and 6,765 from chronic CHD (I25) in WA
- 33,908 deaths from acute CHD (I20–I24) and 29,405 from chronic CHD (I25) in NSW.

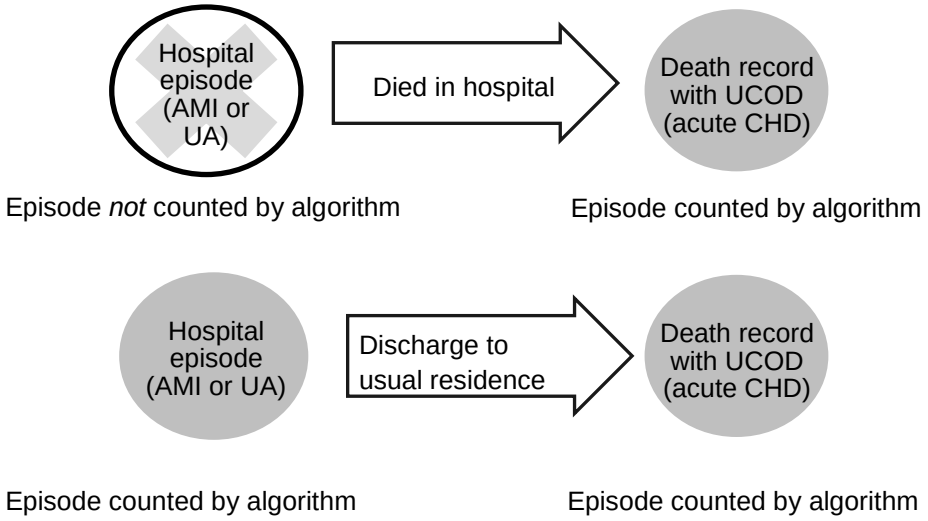
Implications of findings

Analysis of the linked data shows that the last hospitalisation for the vast majority of chronic CHD deaths is for conditions other than AMI or UA, including diagnoses such as heart failure and cardiac arrest, and therefore should not be counted by the algorithm.

By restricting counts to only acute CHD deaths, this is likely to result in an underestimate of acute coronary deaths in the unlinked data, but this is less substantial than the potential overestimation if deaths from chronic CHD were also counted (inclusion of chronic CHD would almost double the number of fatal coronary events).

Does the algorithm adequately take account of potential double counting of deaths by excluding deaths in hospital?

Another issue that is important for the accuracy of the algorithm relates to deaths in hospital from ACS. There is the potential for double counting of deaths because people who die in hospital may also be counted in the deaths data (Figure 3.1). To avoid this, the algorithm excludes hospitalisations in the NHMD with a principal diagnosis of AMI or UA that end in death in hospital under the assumption that these are also coded with an underlying cause of death of acute CHD in the deaths data (and therefore picked up in the NMD). Linked data are needed to determine the validity of this assumption.



Notes

1. The algorithm relies on the consistency of coding between the principal diagnosis in hospital and underlying cause of death recorded on the death certificate
2. Death after discharge to usual residence can occur at any time.

Figure 3.1: Illustration of deaths counted by the algorithm

Findings from the WA and NSW linked hospitalisation and deaths data sets

The accuracy of the algorithm relies on consistency of coding between principal diagnosis in the NHMD and underlying cause of death in the NMD. This is a limitation of the algorithm because it assumes agreement between 2 different concepts: namely the principal diagnosis in hospital and underlying cause of death.

Analysis of the WA and NSW linked data sets showed that, out of the 1,956 people in WA and 9,523 in NSW with a principal diagnosis of AMI or UA in their last hospitalisation, almost two-thirds were coded with an underlying cause of death of acute CHD in the deaths data (1,246 and 6,304, respectively; Table 3.1). However, in WA 36.3% and in NSW 33.8% of AMI and UA hospitalisations ending in death were *not* coded to an underlying cause of acute CHD. These deaths would not be counted by the algorithm, which would result in an undercount of fatal events of 8.8% for WA and 9.5% for NSW.

The proportion of people with a principal diagnosis of AMI or UA who died in hospital and who were coded with an acute CHD underlying cause of death appears to vary by age in

both WA and NSW linked data sets (see Figure D1). Although 63.8% of people in WA who died in hospital had an underlying cause of death of acute CHD, this varied from 56.2% for people aged 60–69 to 67.6% for people aged 40–49. Overall, in NSW 66.3% of people who died in hospital had an underlying cause of death of acute CHD, but this varied from 55.0% for people aged 40–49 to 70.5% for people aged 85+. This suggests that there could be variations in the underestimate of the number of acute coronary events by age and jurisdiction.

Implications of findings

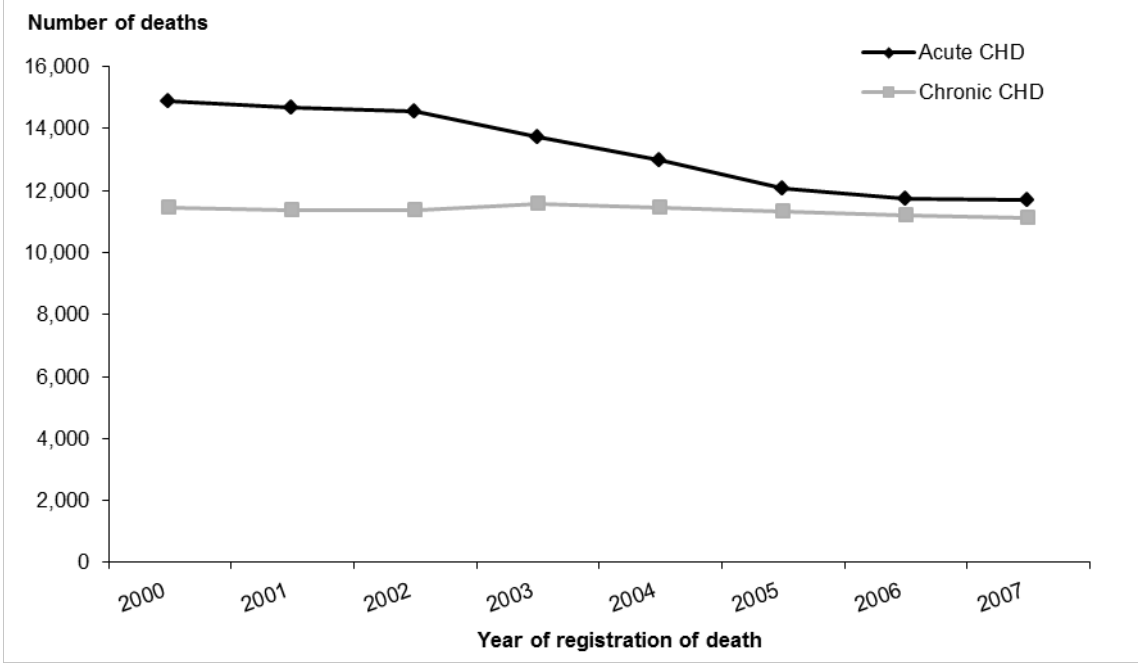
Based on the WA and NSW linked data, around one-third of people who died in hospital with a principal diagnosis of AMI or UA were not coded with an underlying cause of death of acute CHD. This results in an undercount of acute CHD deaths of around 10%.

Are changes over time likely to have an impact on trends in estimates based on the algorithm?

Changes in diagnostic methods, treatment and referral patterns and data recording practices are likely to have an impact on the reliability of the algorithm over time. For instance, the original algorithm, validated in the late 1990s, is no longer valid due to changes in hospital transfer rates and length of hospital stays over time. In addition, the number of fatal events counted by the algorithm was changed from all deaths from CHD to those with an acute CHD underlying cause (AIHW 2011b; Appendix A). This section examines whether changes over time in the number of deaths recorded with an underlying cause of acute CHD could have an impact on estimates determined by the revised algorithm.

Findings from the National Mortality Database

Data from the NMD indicate that the number of acute CHD coded deaths has declined over time, while the number of chronic CHD coded deaths has remained stable (Figure 3.2).

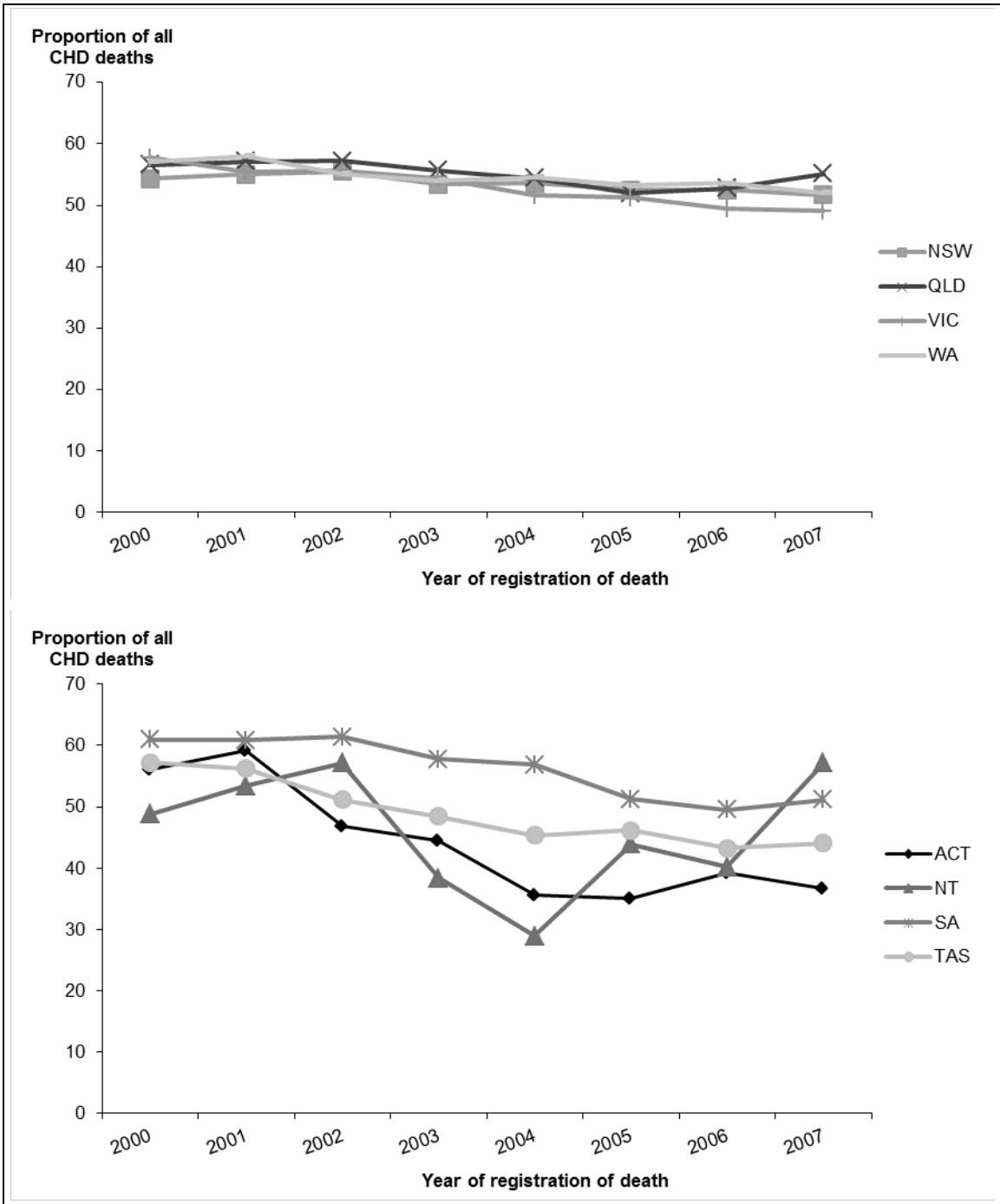


Note: Deaths registered in 2007 and earlier are based on the final version of cause of death data.

Source: AIHW National Mortality Database.

Figure 3.2: Deaths with an underlying cause of acute CHD (I20–I24) or chronic CHD (I25), people aged 40 and over, Australia, 2000–2007

The proportion of all CHD deaths (that is, with an underlying cause of death of I20–I25) that are coded as acute (I20–I24) declined from 56.7% in 2000 to 51.4% in 2007. In general, this trend is found across all jurisdictions, although to different extents and with substantial variability in the smaller states and territories (Figure 3.3).



Note: Deaths registered in 2007 and earlier are based on the final version of cause of death data.

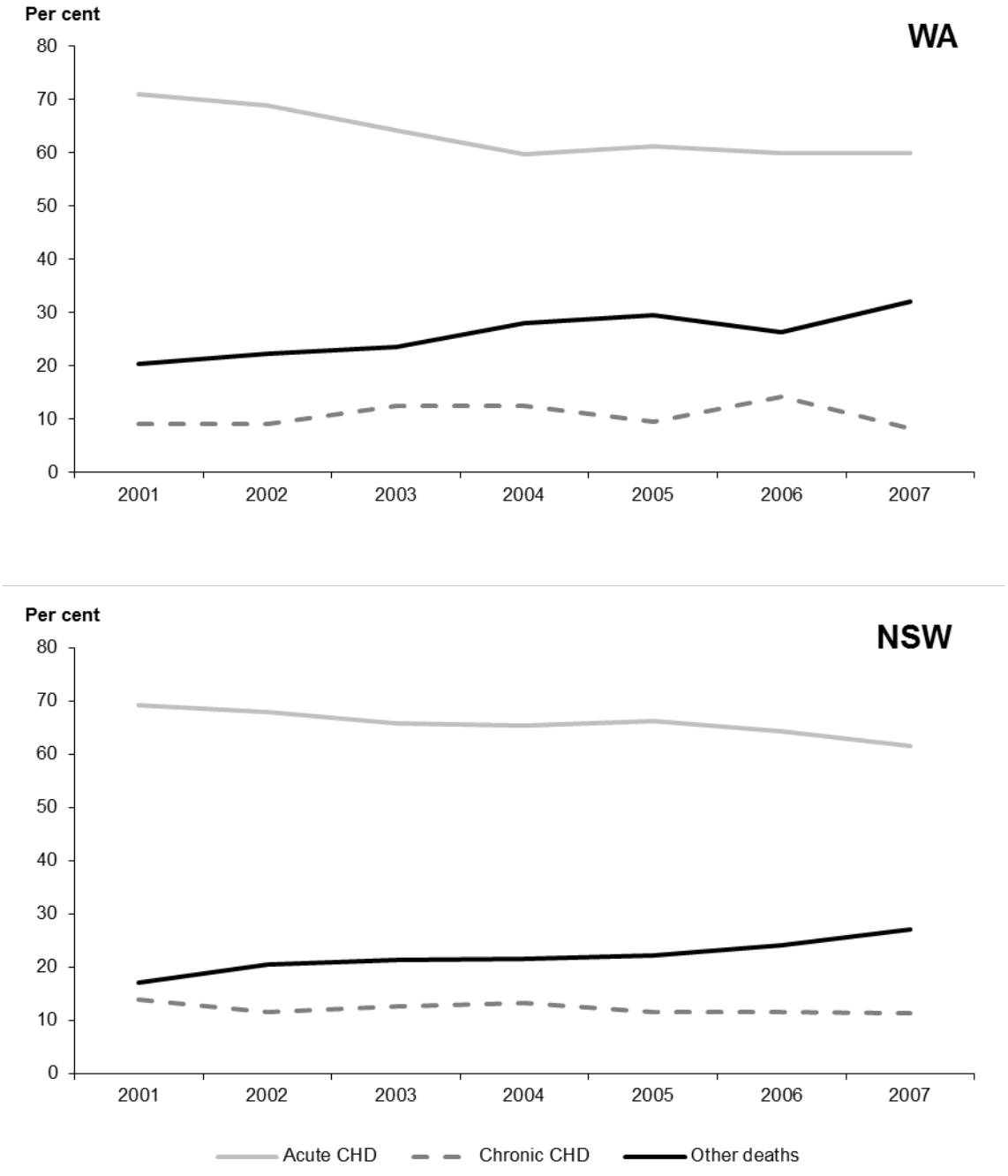
Source: AIHW National Mortality Database.

Figure 3.3: Proportion of deaths with an underlying cause of CHD (I20–I25) that are coded as acute CHD (I20–I24), people aged 40 and over, by state and territory, 2000–2007

Findings from the WA and NSW linked hospitalisation and deaths data sets

Between 2001 and 2007, there has been a declining proportion in WA and NSW of AMI and UA hospitalisations that ended in death in hospital coded with an underlying cause of death of acute CHD (Figure 3.4).

However, this is not due to a shift in coding from acute to chronic CHD, as one may expect. Instead, it appears that a greater proportion of deaths are being coded with an underlying cause of death of other diseases, such as diabetes, stroke, COPD or chronic kidney disease.



Note: Deaths in NSW emergency departments are recorded as admitted patient episodes.

Source: AIHW analysis of WA and NSW linked hospitalisation and deaths data sets.

Figure 3.4: People with a principal diagnosis of AMI or UA in their last hospitalisation and who died in hospital, by underlying cause of death in the deaths data, aged 40 and over, WA and NSW, 2001–2007

Implications of findings

These findings suggest that the level of underestimation in acute CHD deaths appear to be increasing over time, based on the declining proportion of AMI and UA hospital deaths coded with an underlying cause of acute CHD in WA and NSW linked data. This may also be indicative of the pattern in the other jurisdictions, given the declining trend in acute CHD deaths as a proportion of all CHD deaths in the national unlinked data.

3.2 Non-fatal acute coronary events

The algorithm defines non-fatal events as:

Count the number of non-fatal hospitalisations where 'acute myocardial infarction' (AMI) (ICD-10-AM I21) or 'unstable angina'(UA) (ICD-10-AM I20.0) is the principal diagnosis, and the episode did not end in death or with the patient being transferred to another acute hospital in each calendar year (based on discharge date from hospital).

The algorithm uses the NHMD to estimate non-fatal acute coronary events. To capture each event, and to capture it only once, it counts hospitalisations for AMI and UA that do not end in a transfer to another acute hospital—thus consolidating multiple hospitalisation episodes recorded in NHMD to a single event. Similarly, deaths in hospital are not counted by the algorithm, because it is assumed that these deaths are counted in the fatal acute coronary event estimates in the NMD.

Because the treatment of acute coronary events often involves multiple transfers of a patient (for example, from the local hospital of first admission to a specialist cardiac facility or after treatment for long-term post-operative care), each event may have multiple unlinked hospitalisation episodes in the NHMD.

The accuracy of the algorithm in counting non-fatal acute coronary events is dependent on the quality of the data recorded in the NHMD. It assumes that the mode of separation variable is accurately and consistently coded to enable the identification of transfers for ACS events involving multiple hospitalisations for the single event.

Information on admitted patients are compiled when an admitted patient (a patient who undergoes a hospital's formal admission process) completes an episode of admitted patient care and 'separates' from the hospital. This is because most of the data on the use of hospitals by admitted patients are based on information provided at the end of the patients' episodes of care, rather than at the beginning. The length of stay and the procedures carried out are then known and the diagnostic information is more accurate (AIHW 2012b).

How well are transfers coded for acute myocardial infarction and unstable angina hospitalisations?

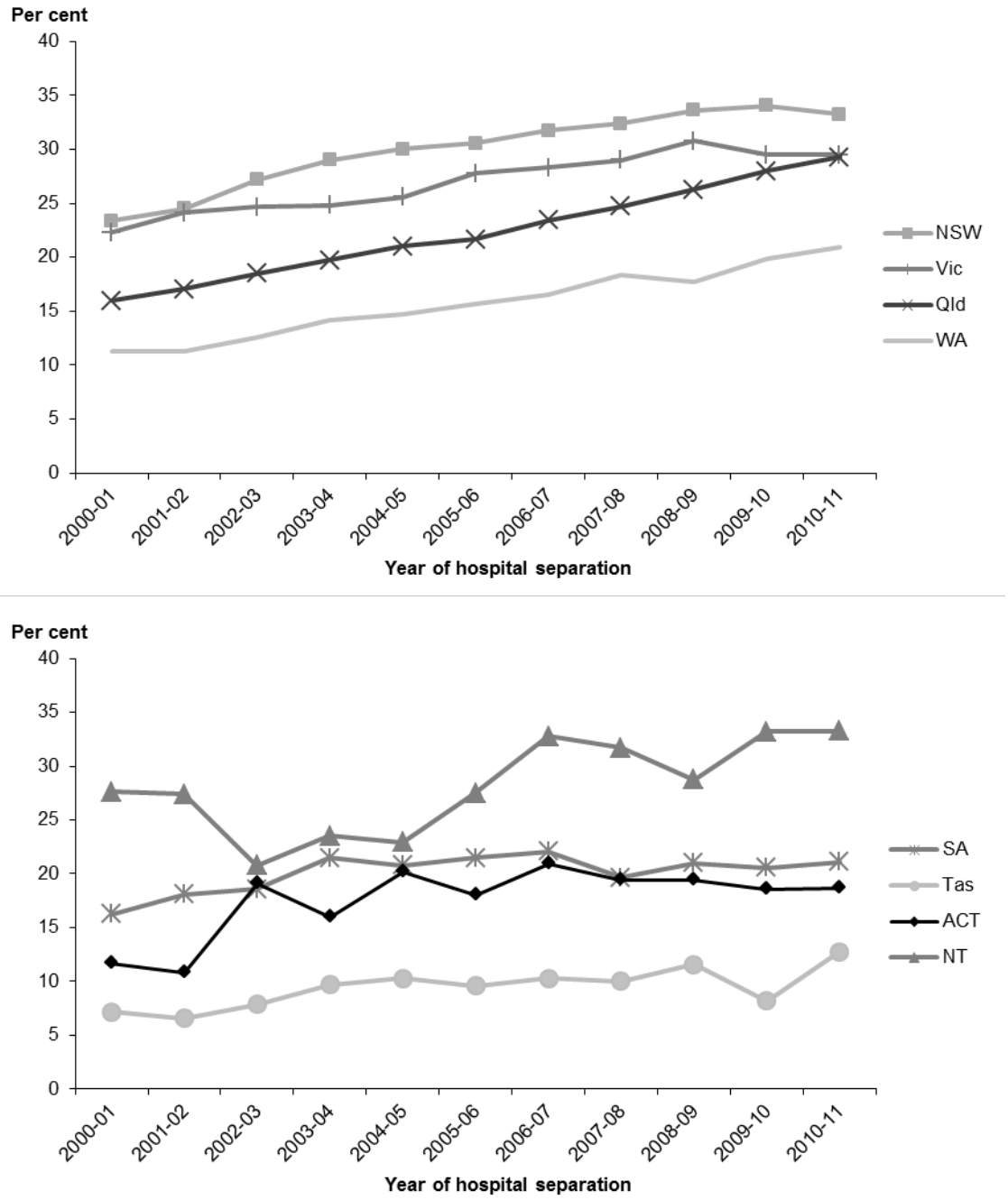
Because individuals are not identified in the NHMD, nor are associated hospitalisations able to be grouped together, the algorithm excludes those hospitalisations for AMI or UA that are coded with a 'separation mode' of 'transferred to another acute hospital'. In this way (in theory) only the 'last' hospitalisation episode for each ACS event is counted, and the initial episodes are excluded by the algorithm.

The 'separation mode' variable was used to exclude transfers because, at the time of developing this algorithm, it was considered more reliable than the 'admission mode' variable, which could be used to exclude admissions that begin with a transfer. The 'admission mode' variable was also not available in the linked data and therefore could not be validated during this analysis. For further information on the development of the algorithm see Table A1.

Findings from the National Hospital Morbidity Database

In 2010–11, 28.8% of non-fatal hospitalisations for AMI or UA among people aged 40 and over, had a mode of separation of 'transferred to another acute hospital'. People from the NSW and NT had the highest transfer rates (33.2%) and people from Tasmania the lowest (12.8%—Appendix D Table D1).

Inter-hospital transfer rates for AMI and UA have increased over time across all jurisdictions, with smaller jurisdictions experiencing greater variability in rates over time (nationally there was an increase of 47% between 2000–01 and 2010–11) (Figure 3.5). The increase in transfer rates reflects the increase in interventions for ACS in recent years and the geographical spread of facilities that can perform the interventions within the different jurisdictions (Clark et al. 2012; Chew et al. 2013).



Source: AIHW National Hospital Morbidity Database.

Figure 3.5: Proportion of hospitalisation episodes with a principal diagnosis of AMI or UA ending in a transfer to another acute hospital (transfer rates), people aged 40 and over, by state or territory of usual residence of patient, 2000–01 to 2010–11

Transfer rates also differ by region, with rates generally increasing with remoteness. For example, in NSW, Qld, WA and SA transfer rates are about twice as high for people living in *Remote* areas than *Major cities* (Table 3.3). This is probably because certain cardiac procedures required for the treatment of acute coronary events are generally performed in large hospitals located in urban areas (Clark et al. 2012).

Table 3.3: Proportion of hospitalisations with a principal diagnosis of AMI or UA ending in a transfer to another acute hospital, people aged 40 and over, by state/territory of hospital and region of usual residence of patient, 2010-11

State/territory of hospital	Major city	Inner regional	Outer regional	Remote	Very remote
NSW	27.2	40.4	45.3	56.4	n.p.
VIC	25.9	33.5	37.9	n.p.	n.p.
Qld	21.5	36.7	28.6	41.3	41.9
WA	15.7	27.1	33.5	34.6	38.3
SA	11.7	32.5	34.5	30.7	25.0
Tas	n.p.	6.3	19.3	n.p.	n.p.
ACT	15.6	9.4	n.p.	n.p.	n.p.
NT	n.p.	n.p.	31.0	40.5	49.3
Total	**23.1**	**34.7**	**34.0**	**39.8**	**41.7**

Note: n.p. — Not published due to small cell sizes. Includes hospitalisations for people from other states/territories; that is, people may be reported as residing in areas not represented in some jurisdictions.

Source: AIHW National Hospital Morbidity Database.

Findings from the WA and NSW linked hospitalisation and deaths data sets

The WA and NSW linked data sets allow us to look at those hospitalisations coded with a principal diagnosis of AMI or UA and a separation mode of 'transferred to another acute hospital' to see whether they do have a subsequent hospitalisation episode. It also allows us to see the principal diagnosis of that subsequent episode. Linked hospitalisation data for WA and NSW for the period 1 July 2000 to 31 December 2010 was used for this analysis.

There were 45,000 people in WA and 176,238 people in NSW hospitalised for an acute coronary event at least once during this period. This accounted for 73,654 and 315,219 hospitalisation episodes, respectively (Table 3.4). Of these, 9,612 people in WA and 69,686 people in NSW had a hospitalisation for ACS where the initial episode was AMI or UA and ended in a transfer to another acute hospital (10,923 and 91,236 hospitalisation episodes, respectively). The majority of those, 88.9% in WA and 76.9% in NSW, had only 1 transfer during this time period, while 1,066 people in WA and 16,522 people in NSW had 2 or more transfers.

Table 3.4: The number of people and hospitalisation episodes with a principal diagnosis of AMI or UA ending in a transfer to another acute hospital, people aged 40 and over, WA and NSW, 1 July 2000 to 31 December 2010

	WA		NSW	
	Number	**%**	**Number**	**%**
Episodes				
Number of hospitalisations	73,654	100.0	315,219	100.0
Number of hospitalisations ending in a transfer	10,923	14.8	91,236	28.9
Number of hospitalisations that *did not* end in a transfer	62,731	85.2	223,983	71.1
People				
Number of people	45,000	100.0	176,238	100.0
Number of people with hospitalisations ending in transfer	9,612	21.4	69,686	39.5
Number of people transferred once	8,546	19.0	53,608	30.4
Number of people transferred multiple times	1,066	2.4	16,078	9.1
Number of people with hospitalisations that *did not* end in a transfer	35,388	78.6	106,552	60.5

Source: AIHW analysis of WA and NSW linked hospitalisation and deaths data sets.

The use of separation mode variable to account for multiple episodes for the single event assumes that where a transfer has occurred to another acute hospital that there will be a subsequent immediate hospitalisation record and, as such, the initial episodes are excluded by the algorithm. However, the linked data from WA and NSW shows that this is not the case for all hospitalisations. Between 1 July 2000 and 31 December 2010, 5.2% of hospitalisations in WA and 10.5% of hospitalisations in NSW coded with a principal diagnosis of AMI or UA and a separation mode of 'transferred to another acute hospital' did not have a subsequent hospitalisation episode identified in the linked data (Table 3.5). Some of these patients could have been transferred to non-acute care facilities or interstate, which would account for the lack of a subsequent episode in the respective state's data, although it is unlikely to account for all missing episodes.

Table 3.5: Hospitalisations with a principal diagnosis of AMI or UA that end in transfer to another acute hospital and the presence/absence of a subsequent episode, people aged 40 and over, WA and NSW, 1 July 2000 to 31 December 2010

	WA		NSW	
	Number	%	Number	%
Number of hospitalisations	73,654	100.0	315,219	100.0
Separation mode = transferred to another acute hospital				
Number of hospitalisations	10,923		91,236	
Number of hospitalisations with any subsequent episode between 1 July 2000 and Dec 2010	10,359	94.8	81,667	89.5
Number of hospitalisations *without* any subsequent episode between 1 July 2000 and Dec 2010[(a)]	564	5.2	9,569	10.5
Separation date and subsequent admission date = +/– 1 day[(b)]				
Number with immediately following episode	9,841	90.1	66,648	73.1
Number *without* an immediately following episode	1,082	9.9	24,588	26.9
Separation date and subsequent admission date = +/– 5 days[(c)]				
Number with immediately following episode	9,902	90.7	69,483	76.2
Number *without* an immediately following episode	1,021	9.3	21,753	23.8

(a) The lack of a subsequent hospitalisation episode following a transfer is possibly due to interstate transfers, transfers to non-acute facilities, cut-off dates for data extraction or coding inconsistencies.

(b) Number of hospitalisations for AMI and UA with a subsequent hospitalisation (with any principal diagnosis) commencing +/– 1 day of separation date.

(c) Number of hospitalisations for AMI and UA with a subsequent hospitalisation (with any principal diagnosis) commencing +/– 5 days of separation date.

Source: AIHW analysis of WA and NSW linked hospitalisation and deaths data sets.

One would expect that the number of AMI and UA hospitalisation episodes with a subsequent episode (within +/– 1 day) would be at least equal to the number of AMI and UA episodes coded with a separation mode of 'transferred to another acute hospital'. However, in both linked data sets this was not the case. In WA 9.9%, and in NSW 26.9%, of AMI and UA hospitalisations coded with a separation mode of 'transferred to another acute hospital' *did not* have a subsequent episode within +/– 1 day. The much higher proportion of the absence of a subsequent episode in NSW may reflect a higher proportion of interstate transfers in NSW. In both NSW and WA, cut-off dates for data extraction, separation mode coding inconsistencies or linkage error may also influence the identification of subsequent episodes. The range of +/– 1 or 5 days was used during the analysis to allow for discrepancies in the dates and to capture as many subsequent episodes as possible.

Although the proportion of hospitalisations without a subsequent episodes are considerable for multi-episode events, when this is placed in the context of all hospitalisations, this shortfall in subsequent episodes of care after transfer affects 1.5% and 7.8% of all AMI or UA hospitalisations in WA and NSW, respectively.

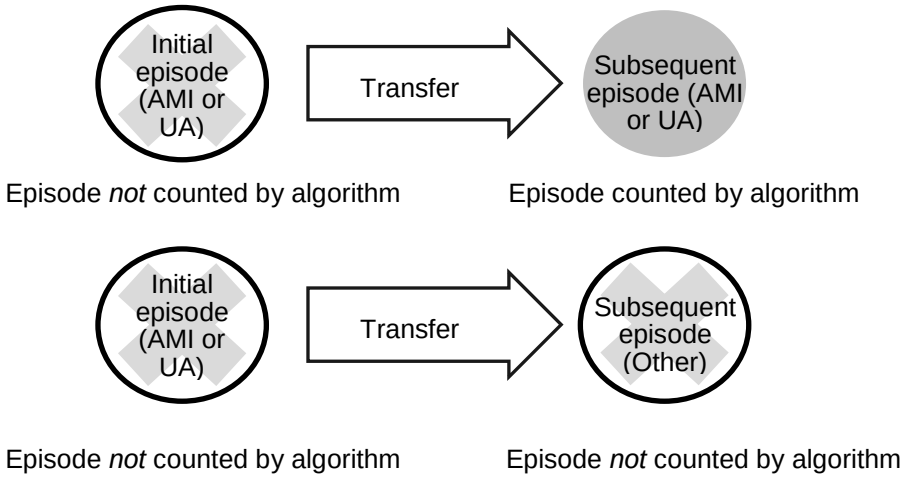
Implications of findings

The absence of a subsequent hospitalisation following transfer to another acute hospital would result in an underestimate of non-fatal acute coronary events in the unlinked data, because the initial hospitalisation episode is not counted in the algorithm. Given that this underestimation varies considerably for NSW and WA (27% and 10%, respectively, did not have a subsequent episode within +/– 1 day) and that transfer rates vary considerably across Australia, the extent of underestimation is expected to vary across Australia.

These differences in transfer rates across jurisdictions, region and time are likely to result in variations in estimates of incidence of acute coronary events if transfers are not being recorded consistently across all jurisdictions.

Are all related episodes for an acute coronary event following a transfer coded as acute myocardial infarction or unstable angina?

For those events that consist of multiple hospitalisation episodes due to transfers to another acute hospital, the algorithm relies not only on the reliable coding of 'separation mode' but also on the consistent coding of principal diagnosis of AMI or UA across all related episodes. Where there has been a transfer, the initial episodes are excluded by the algorithm, despite being coded as AMI or UA (on the assumption that the subsequent episode will be counted). However, the subsequent episode will only be counted if it is coded with a principal diagnosis of AMI or UA (Figure 3.6).



Notes

1. The algorithm relies on the principal diagnosis of AMI or UA in hospital.
2. Transfer refers to hospital separations that end in a transfer to another acute hospital.

Figure 3.6: Illustration of the hospitalisation episodes counted by the algorithm

Findings from the WA and NSW linked hospitalisation and deaths data sets

In WA from 1 July 2000 to 31 December 2010, of the 9,841 hospitalisations with a principal diagnosis of AMI or UA ending in a transfer and with a subsequent episode within +/– 1 day, 73.3% of the subsequent episodes were coded as AMI or UA (Table 3.6). This means that, for WA, 26.7% of acute coronary events that consist of multiple hospitalisation episodes are *not* picked up by the algorithm. The proportion is higher if the initial episode is UA (34.9%) than AMI (21.1%).

In NSW, only 65.9% of the subsequent episode within +/– 1 day were coded as AMI or UA, meaning that 34.1% of acute coronary events consisting of multiple episodes would be missed (Table 3.6). Like WA, the proportion not picked up by the algorithm is higher if the initial hospitalisation is for UA (45.2%).

Table 3.6: Hospitalisations with a principal diagnosis of AMI or UA ending in a transfer, and with a subsequent episode within +/– 1 day, people aged 40 and over, WA and NSW, 1 July 2000 to 31 December 2010

	WA			NSW		
	Number	%	Proportion not counted (%)[(a)]	Number	%	Proportion not counted (%)[(a)]
Hospitalisations with principal diagnosis of **AMI or UA** ending in transfer and with subsequent episode	9,841			66,648		
Subsequent episode = AMI or UA	7,209	73.3	26.7	43,951	65.9	34.1
Hospitalisations with principal diagnosis of **AMI** ending in transfer and with subsequent episode	5,803			41,949		
Subsequent episode = AMI or UA	4,579	78.9	21.1	30,420	72.5	27.5
Hospitalisations with principal diagnosis of **UA** ending in transfer and with subsequent episode	4,038			24,699		
Subsequent episode = AMI or UA	2,630	65.1	34.9	13,531	54.8	45.2

(a) Percentage of hospitalisations ending in transfer and with subsequent episode not counted by the algorithm.

Source: AIHW analysis of WA and NSW linked hospitalisation and deaths data sets.

The higher proportions of the initial episode of UA not picked up by the algorithm may reflect a shift in the diagnosis of acute coronary events over time. Over the last decade, the proportion of subsequent episodes with AMI as a principal diagnosis has increased substantially while the proportion with UA as a principal diagnosis has declined substantially (see Table D2). This increase in AMI diagnoses reflects the increasing reliance on cardiac troponin measurements to diagnose non-ST elevation AMIs. Cases that previously would have been diagnosed as UA would now be classed as an AMI instead,

because troponins are much more sensitive than markers used previously (Goodman et al., 2006).

Although the proportions of subsequent episodes that are not coded as AMI or UA are relatively high for multi-episode events, the vast majority of ACS hospitalisations did not end in a transfer to another acute hospital (85.2% in WA and 71.1% in NSW—Table 3.4). Overall, this shortfall of AMI or UA hospitalisations that do not have a subsequent AMI or UA episode would result in an underestimate of 3.6% and 7.2% of all AMI or UA hospitalisations in WA and NSW, respectively.

If the subsequent episodes are not coded as AMI or UA, then what is their principal diagnosis? From both linked data sets, it is clear that this varies depending on the principal diagnosis of the initial hospitalisation (see Tables D3 and D4 for more detail).

For those with an initial episode of AMI, rehabilitation in WA and atherosclerotic heart disease in NSW accounted for over a quarter of the subsequent episodes not coded as AMI or UA. For UA, 21.4% were coded as chest pain in WA and 29.4% were coded as atherosclerotic heart disease in NSW.

For non-fatal events, it is possible that the anomaly over transfer may relate to post-hoc clinical analysis, where the transfer was initiated for what was thought to be ACS, but which subsequently wasn't confirmed as such, the diagnosis may have then been changed or the transfer was for a purpose other than primarily for ACS. If the diagnosis is changed following the transfer, then this would not represent a 'missed case' by the algorithm. However, if the diagnosis in the initial episode was AMI or UA and the diagnosis following the transfer was for care related to the cardiac event, such as rehabilitation, this would not be counted by the algorithm and could be considered a 'missed case'.

Implications of findings

Because not all subsequent episodes following transfer are coded with a principal diagnosis of AMI or UA (in addition to the initial episode) (27% in WA and 34% in NSW), this may result in an underestimate of non-fatal acute coronary events in the unlinked data.

This level of underestimation is likely to vary over time, both nationally and at a jurisdictional level, due to the increasing number of hospital transfers associated with ACS events, inconsistencies in coding of transfers and apparent changes in coding of ACS.

4 Implications for reporting and monitoring

The AIHW uses unlinked episode-based hospitalisation and deaths data to estimate the incidence of acute coronary events. This is a valid approach to take because it assumes that all acute coronary events will result in either hospitalisation or death (or both). The linked data from WA and NSW provides some insight into how well the algorithm performs for estimating incidence of acute coronary events.

The linked hospitalisation and deaths data analysis for WA and NSW presented in the Chapter 3 aims to assess whether the assumptions underlying the algorithm for estimating the incidence of acute coronary events are largely valid. The findings in Chapter 3 indicate that the algorithm provides a reasonable measure of acute coronary events. However, the linked data analysis highlights that fatal acute coronary events excluded from hospitalisation data by the algorithm are not always counted in the deaths data. This is a limitation of the algorithm because it assumes agreement between the principal diagnosis in hospital and underlying cause of death, which are 2 different concepts. It has also shown that there are issues in identifying multiple-episode events, in particular hospital transfers for AMI or UA.

Age-standardised rates of acute coronary events calculated using unlinked data and linked data were compared, which provides an indication of whether the unlinked data are a good proxy for linked data. Results from Chapter 3 suggest that the algorithm for estimating the incidence of acute coronary events, using unlinked data, may result in an underestimation of acute coronary events.

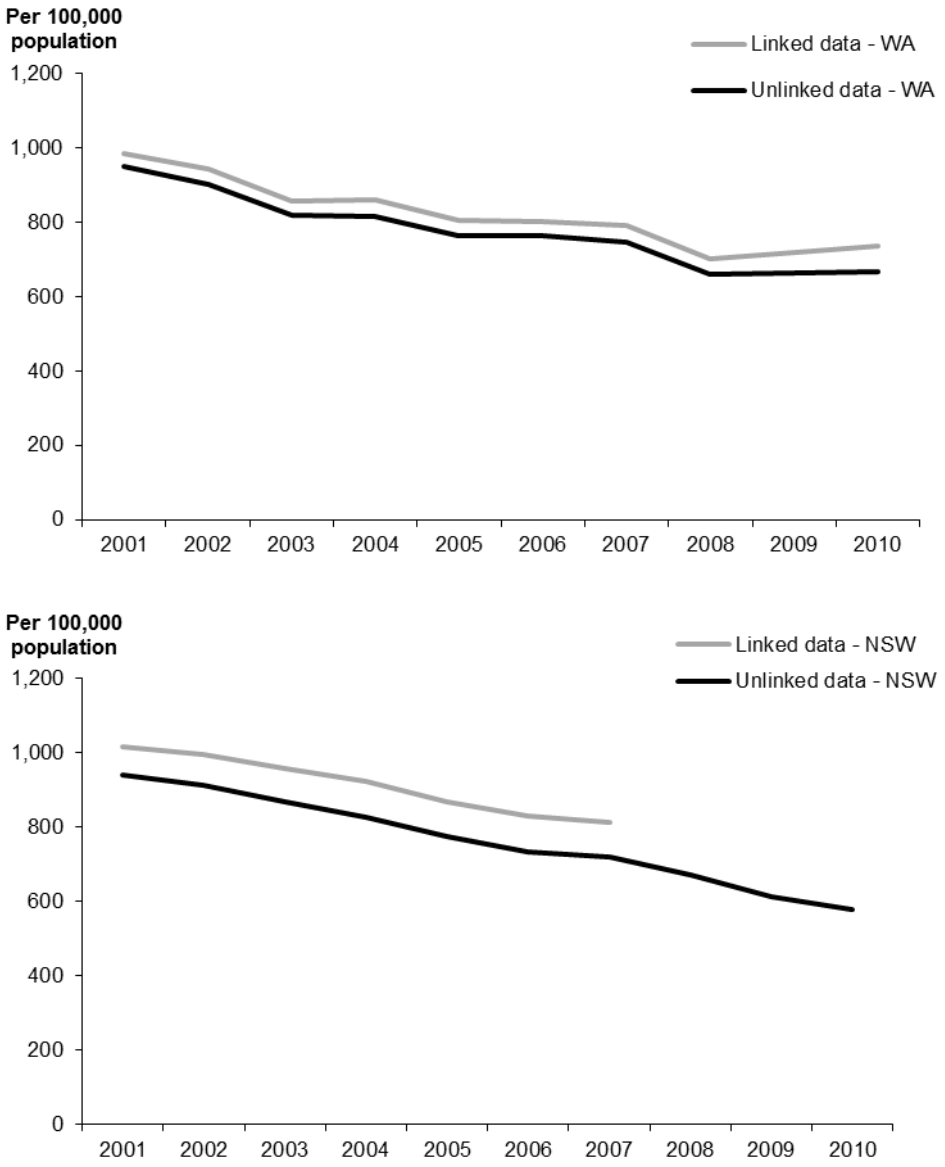
This chapter aims to assess this level of overall underestimation and its impact on age-standardised rates by comparing the acute coronary event rates based on linked and unlinked data. This chapter also presents information on the national reporting of acute coronary events in Australia as part of the Council of Australian Governments (COAG) reporting process.

4.1 Extent of underestimation

The age-standardised rates of the incidence of acute coronary events in WA and NSW among those aged 40 and over were consistently lower in the unlinked data than in the linked data. The rates in 2007 for WA were 6% lower, and for NSW 11% lower, using the unlinked data (Figure 4.1). This shows that the unlinked data underestimates the incidence of acute coronary events compared with the linked data.

The decline in acute coronary event rates over time followed the same pattern for linked and unlinked data. This suggests that changes in the incidence of acute coronary event rates over time are not likely to be influenced by the use of unlinked data.

These results indicate that, despite limitations with the algorithm, using unlinked data to estimate the incidence of acute coronary events produces similar results to that for linked data. This suggests that the unlinked data are a good proxy for linked data and provide a reliable and robust measure for the rate of acute coronary events in Australia.



Notes

1. The NSW linked data set did not contain death records for 2008 and beyond.
2. Directly age-standardised to the 2001 Australian population.
3. In the National Mortality Database, deaths registered in 2009 and earlier are based on the final version of cause of death data; deaths r egistered in 2010 are based on the revised version and are subject to further revision.

Sources: AIHW analysis of WA and NSW linked hospitalisation and deaths data sets; AIHW National Hospital Morbidity Database and National Mortality Database.

Figure 4.1: Age-standardised rate of acute coronary events per 100,000 population using linked and unlinked data, people aged 40 and over, WA and NSW, 2001–2010

The results from this validation study are based on 2 large states, NSW and WA. Although there were some consistent findings between them, it is unclear whether the results can be generalised to other jurisdictions. In the absence of comprehensive linked data from each jurisdiction, it is difficult to ascertain whether variations in the recording of acute events in hospitalisation and deaths data, and varying levels of underestimation seen in WA and

NSW, are indicative of the situation in other jurisdictions. Consequently, this validation study was not able to assess the comparability of event rates across jurisdictions. Jurisdictional comparability is likely to be influenced by variations in under-ascertainment of acute events, as observed in WA and NSW, and also affected by factors such as differing treatment and referral patterns and data recording practices across the jurisdictions.

Implications of findings

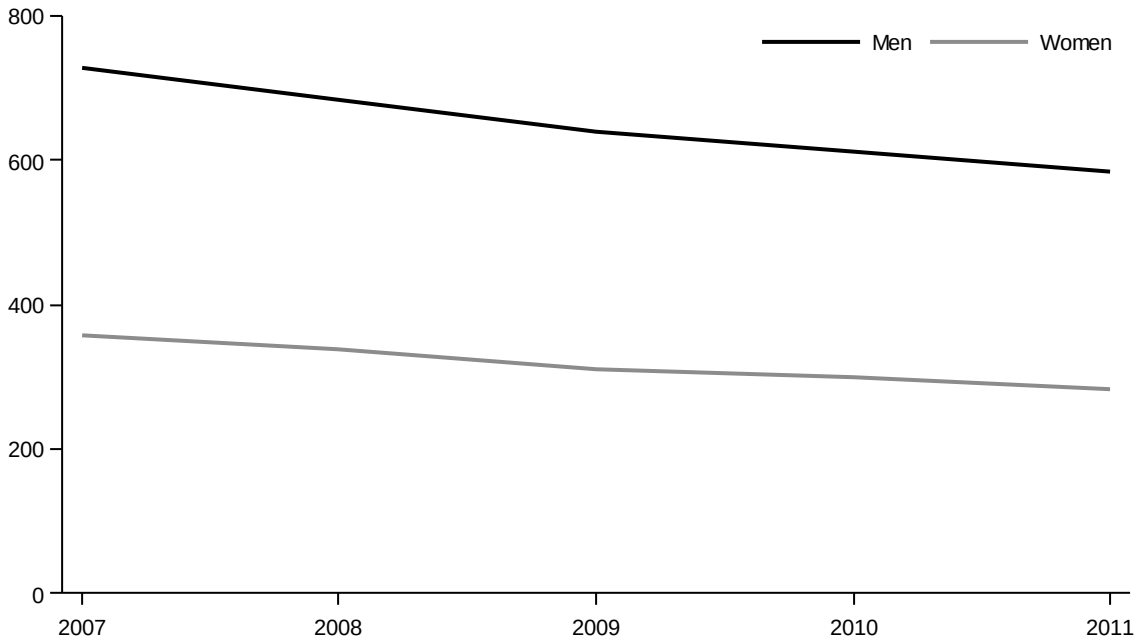
Despite the fact that the algorithm undercounts acute coronary events, the impact on overall age-standardised rates of acute coronary events is relatively small when applied to unlinked data. This suggests that the algorithm provides a reasonable measure of the incidence of acute coronary events and that trends over time are comparable within each jurisdiction. However, event rates should not be compared across jurisdictions due to variations in under-ascertainment of coronary events, as observed in WA and NSW.

The analysis of the linked data sets from WA and NSW has been a very valuable exercise, exposing variations in pathways for clinical care, changes over time and geographical differences. It has provided insights into the assumptions underlying the algorithm and highlighted issues with using unlinked administrative data to report on the incidence of acute coronary events as a population health indicator.

4.2 National reporting using the algorithm

In 2012, the AIHW commenced reporting on the incidence of acute coronary events as part of the National Healthcare Agreement (NHA) 'heart attack' indicator (PI 09) for the 2013 and 2014 COAG reporting rounds (COAG Reform Council 2013). This indicator has been reported on at the national level only and by Aboriginal and Torres Strait Islander status (at the national level based on the 5 jurisdictions where Indigenous identification is of adequate quality across both the hospitalisation and deaths data collections). The term 'heart attack' has been used for this indicator for ease of understanding, but this indicator includes both AMI and UA and estimates the incidence of acute coronary events, using the definition presented in Box 1.1. A link to the data quality statement for the 'heart attack' indicator PI 09 can be found in Appendix E.

In 2011, an estimated 69,900 people aged 25 and over had a heart attack: a rate of 427 per 100,000 population (Table E1). Men account for almost two-thirds (63%) of heart attack events. The incidence of heart attack rates was twice as high in men as women: age-standardised rates for men of 584 per 100,000 population compared with 284 per 100,000 for women (Figure 4.2; Table E1).



Notes

1. Rates have been age standardised to the Australian Estimated Resident Population as at 30 June 2001.
2. Deaths registered in 2009 and earlier are based on the final version of cause of death data; deaths registered in 2010 and 2011 are based on revised and preliminary versions, respectively, and are subject to further revision by the ABS; deaths data for 2010 have not been adjusted for the additional deaths arising from outstanding registrations of deaths in Queensland in 2010.

Sources: AIHW National Hospital Morbidity Database, AIHW National Mortality Database.

Figure 4.2: Trends in age-standardised rates of heart attacks, among people aged 25 and over, Australia, 2007–2011

Since 2007, the age-adjusted incidence rate of heart attack events has fallen by 20%, from 534 per 100,000 to 427 per 100,000 in 2011 (Table E1).

Since 2007, heart attack event rates among Aboriginal and Torres Strait Islander adults have declined, but have remained at least twice as high as among Other Australians (age-standardised rates of 1,077 and 421 per 100,000 population, respectively, in 2011) in the 5 jurisdictions with adequate identification of Indigenous deaths (NSW, Qld, WA, SA and NT only) (Table E2).

As outlined in Chapter 1 and Appendix A the method for calculating rates of heart attack was revised in 2012 to reflect changes in diagnostic techniques and clinical practice. Therefore rates presented in this report are not comparable with previously published rates on heart attacks in Australia.

Appendix A: Revision of the algorithm used to estimate the incidence of acute coronary events

Table A1: Timeline of the development and changes made to the algorithm used to estimate the incidence of acute coronary events

Timeline	Reporting	Definition	Comments/references
2001	Incidence of CHD	Non-fatal AMI hospitalisations with LOS > 2 days + All CHD deaths (underlying COD) Ages: 40–90	Algorithm was developed and validated against the WHO MONICA study data (Jamrozik et al. 2001). ICD codes for all CHD deaths were included in the algorithm because this was determined to be the best way to capture as many acute events as possible.
2002–2012	Major/acute coronary events	As above	Reported at the national level only by age and sex (see AIHW Australia's Health publications).
2011	Acute coronary events	A range of potential algorithms were examined.	A review of the algorithm by the AIHW determined that this algorithm was no longer valid due to changes in clinical and treatment patterns and diagnostics (AIHW 2011b). Note: The potential algorithms explored were not validated against linked hospitalisation and deaths data.
2012	Incidence of heart attacks	Non-fatal AMI and UA hospitalisations not ending in a transfer to another acute hospital + Acute CHD deaths (underlying COD) Ages: 25+	The algorithm was revised for use in the COAG NHA indicator 'Incidence of heart attacks' (PI 09). The revision was based on work by the AIHW and advice provided by the Cardiovascular Disease Monitoring Advisory Committee. To reduce double counting when patients are transferred to other acute hospitals, only the last episode for each multi-episode ACS event is counted. The separation mode variable is used to exclude episodes ending in a transfer because it is more reliable than the admission mode variable in the NHMD (AIHW 2011b). The ICD codes for CHD deaths were restricted to those for acute CHD deaths only.
2013	NHA PI 09: Incidence of heart attacks	As above	Reported at the national level only by age and sex 2007–2010. Also reported by Indigenous status (national level only, including those jurisdictions with the appropriate quality of Indigenous status variable) (COAG Reform Council 2013). Considered an interim measure pending results of validation work using linked hospitalisation and deaths data.
2014	NHA PI 09: Incidence of heart attacks	As above	Reported at the national level only by age and sex 2007–2011. Also reported by Indigenous status (national level only, including those jurisdictions with the appropriate quality of Indigenous status variable) (SCRGSP 2014). Considered an interim measure pending the results of validation work using linked hospitalisation and deaths data.

Current algorithm for estimating acute coronary events

The number of fatal events:

Count the number of deaths where 'acute coronary heart disease' (ICD-10 codes I20–I24) is the underlying cause of death in each calendar year (based on year of registration of death).

Plus the number of non-fatal events:

Count the number of non-fatal hospitalisations where 'acute myocardial infarction' (AMI) (ICD-10-AM I21) or 'unstable angina' (UA) (ICD-10-AM I20.0) are the principal diagnosis, and separation mode is not equal to 'died' or 'transferred to another acute hospital', and care type is not equal to 'new born-unqualified days only' or 'organ procurement–posthumous' or 'hospital boarder' in each calendar year (based on discharge date from hospital).

Appendix B: Methods

This appendix contains further detail about the methods used for data linkage by the data providers (WA and NSW) and the variables obtained by the AIHW. Statistical measures and classifications used in this report are also included in this appendix.

Linked hospitalisation and deaths data

Western Australia

The Department of Health Western Australia (DOHWA) collects and maintains a number of core state-wide data collections such as the Hospital Morbidity Data Collection, which is comprised of around 20,000,000 electronic admitted patient records and includes all hospitals in WA (public and private). Death registrations are also included in the core data sets and consists of all deaths registered in WA, with coded cause of death data updated annually.

Data linkage is a process in which connections are made between different collections of information that are thought to belong to the same person. The Data Linkage Branch (DLB) of DOHWA uses a probabilistic linkage method to identify links and uses demographic information such as name, date of birth, sex and address. The DLB creates, updates, enhances and manages links between the core DOHWA data collections and other administrative data sources. The linkage process produces a set of indexes known as 'linkage keys', which are stored in the Master Links File of the WADLS (Holman et al. 2008) and are kept separate from personal and clinical information. An internal audit in 2002 estimated that the number of chains in the WA Data Linkage System containing 1 or more false positive matches (mismatches) was 0.3% (Rosman et al. 2003). The variables obtained by the AIHW from WA for the analysis are shown in Table B1.

Table B1: Variables obtained from WA for hospitalisation and deaths linked data analysis

Hospitalisations	Deaths
Subset date of birth (MMYYYY)	Subset date of birth (MMYYYY)
Gender	Sex
Care type	Date of death (DDMMYYYY)
Mode of separation	Registration year
Diagnosis codes:	
Principal diagnosis	Cause of death:
Co-diagnosis	Underlying cause
Additional diagnoses (up to 20)	Additional causes (up to 19)
Postcode of residence	Postcode of residence
SLA of residence	SLA of residence
Admission date (DDMMYYYY)	Died in hospital flag
Separation date (DDMMYYYY)	

New South Wales

There were 2 main data sources used for the NSW linked data set: the NSW Admitted Patient Data Collection (APDC) and ABS mortality data. Identifying information such as name, address, date of birth and sex obtained from the NSW APDC are included in the Master Linkage Key (MLK), which was constructed by the CHeReL. No health data are used in this process.

The NSW APDC records were linked using probabilistic record linkage methods and ChoiceMaker software (Goldberg & Borthwick 2004). At the completion of the process, each record in the Master Linkage Key was assigned a record identification number and a Master Linkage Key Person ID to allow linked records for the same individual to be identified and extracted.

The ABS mortality records were deterministically linked to death records from the NSW Registry for Births, Deaths and Marriages held in the MLK, using death registration number and date of birth. This allowed potential matches to hospitalisation records to be found. Once the linkage was finalised, the CHeReL created a Project Person Number (PPN) for each Person ID and assigned the PPN to all records in the linked data sets. The MLK is regularly checked for false positive linkages and in 2012 the false positive rate was 0.3% (CHeReL 2012). The variables obtained by the AIHW from NSW for the analysis are shown in Table B2.

Table B2: Variables obtained from NSW for hospitalisation and deaths linked data analysis

Hospitalisations	Deaths
Subset date of birth (MMYYYY)	Subset date of birth (MMYYYY)
Sex	Sex
Service category (care type)	Date of death (MMYYYY)[(a)]
Mode of separation	Registration year
Diagnosis codes:	Cause of death:
Principal diagnosis	Cause of death
Additional diagnoses (up to 55)	Contributing cause of death
Postcode of residence	State of registration
State of residence	SLA of residence
Admission date	State of usual residence
Separation date	
Transferred from hospital	
Transferred to hospital	
Urgency of admission	
Episode start date	
Episode end date	
Episode sequence number	

(a) Complete date of death was not supplied

Disease codes used to define cardiovascular disease, diabetes and chronic kidney disease

Table B3: Definitions of the ICD-10-AM codes used to define CVD, CKD and diabetes in hospitalisation data

Codes	Definition
Cardiovascular disease	
I00–I99	Diseases of the circulatory system
G45	Transient cerebral ischaemic attacks and related syndromes (TIA)
Chronic kidney disease	
E10.2	Type 1 diabetes mellitus with kidney complication
E11.2	Type 2 diabetes mellitus with kidney complication
E13.2	Other specified diabetes mellitus with kidney complication
E14.2	Unspecified diabetes mellitus with kidney complication
I12	Hypertensive kidney disease
I13	Hypertensive heart and kidney disease
I15.0	Renovascular hypertension
I15.1	Hypertension secondary to other kidney disorders
N00	Acute nephritic syndrome
N01	Rapidly progressive nephritic syndrome
N02	Recurrent and persistent haematuria
N03	Chronic nephritic syndrome
N04	Nephrotic syndrome
N05	Unspecified nephritic syndrome
N06	Isolated proteinuria with specified morphological lesion
N07	Hereditary nephropathy, not elsewhere classified
N08	Glomerular disorders in diseases classified elsewhere
N11	Chronic tubulo-interstitial nephritis
N12	Tubulo-interstitial nephritis, not specified as acute or chronic
N14	Drug- and heavy-metal-induced tubulo-interstitial and tubular conditions
N15	Other renal tubulo-interstitial diseases
N16	Renal tubulo-interstitial disorders in diseases classified elsewhere
N18	Chronic kidney disease
N19	Unspecified kidney failure
N25	Disorders resulting from impaired renal tubular function
N26	Unspecified contracted kidney
N27	Small kidney of unknown cause
N28	Other disorders of kidney and ureter, not elsewhere classified
N39.1	Persistent proteinuria, unspecified

(continued)

Table B3 (continued): Definitions of the ICD-10-AM codes used to define CVD, CKD and diabetes in hospitalisation data

Codes	Definition
N39.2	Orthostatic proteinuria, unspecified
Q60	Renal agenesis and other reduction defects of kidney
Q61	Cystic kidney disease
Q62	Congenital obstructive defects of renal pelvis and congenital malformations of ureter
Q63	Other congenital malformations of kidney
T82.4	Mechanical complication of vascular dialysis catheter
T86.1	Kidney transplant failure and rejection
Z49	Care involving dialysis
Z94.0	Kidney transplant status
Z99.2	Dependence on kidney dialysis
Diabetes	
E10	Type 1 diabetes mellitus
E11	Type 2 diabetes mellitus
E13	Other specified DM
E14	Unspecified DM
O24.0	Pre-existing DM, Type 1, in pregnancy
O24.1	Pre-existing DM, Type 2, in pregnancy
O24.2	Pre-existing DM, other specified type, in pregnancy
O24.3	Pre-existing DM, unspecified, in pregnancy

Note: There is some overlap of the codes between the 3 disease groups.

Age calculations

In the linked data analyses, age was estimated using partial date of birth containing month and year, and full date of separation and/or partial date of death (month and year). All data analyses of the linked records are presented in 5-year age groupings. For the purpose of direct comparison between the WA and NSW linked data sets, age was restricted to 40 and over.

Age-standardised rates

Age-standardised rates were used to assess the extent of underestimation of the incidence of acute coronary events by the algorithm on the unlinked data. Age-standardisation is a technique used to eliminate the effect of differences in population age structures when comparing rates for different periods of time, geographical areas and/or population groups. Definitions are included in the *National health data dictionary* (Health Data Standards AIHW: Health Data Standards Committee 2006).

There are 2 methods of age-standardisation, direct and indirect. The method used in this report is direct age-standardisation.

Population for standardisation

The Australian population as at 30 June 2001 was the standard population.

Geographic classifications

The data presented by state and territory of hospital and region were analysed using the Australian Standard Geographical Classification (ASGC).

The ASGC is a classification system developed by the ABS that groups Australian regions into 6 areas, called remoteness areas, based on their distance from major population centres and services. The 6 remoteness areas are:

- *Major cities*
- *Inner regional*
- *Outer regional*
- *Remote*
- *Very remote*
- *Migratory*

Data from Migratory areas are not analysed in this report. The remoteness areas used in this report are based on the 2006 Census.

Appendix C: Summary tables—WA and NSW linked data sets provided to AIHW

All hospitalisation and death records for people within the *population of interest* were obtained. The *population of interest* was defined as:

- people who have at least 1 hospitalisation where the principal or additional diagnosis was CVD, CKD or diabetes; plus
- people who have died due to any cause of death.

The ICD-10-AM codes used to define CVD, diabetes and CKD hospitalisations are described in Appendix B.

Linked hospitalisation and deaths data were obtained from Data Linkage Western Australia for the period 1 July 1999 to 31 December 2010.

The scope of the NSW data set was those people aged 40 or older. Admitted patient hospitalisation data was supplied for the period 1 July 2000 to 31 December 2010; however, the deaths data covers the period 1 July 2000 to 31 December 2007 because the more recent data was not available.

The following tables summarise the data provided to the AIHW in the linked data sets.

Western Australia

Hospitalisations

Table C1: Total number of hospitalisations by calendar year of separation, WA, 1 July 1999–31 December 2010

Year of separation	Number of hospitalisations
1999[(a)]	76,768
2000	153,123
2001	159,421
2002	169,239
2003	174,470
2004	189,554
2005	206,198
2006	208,647
2007	218,341
2008	222,828
2009	221,355
2010	226,086
Total	**2,226,030**

(a) Data for 1999 are from 1 July to 31 December

Note: Data include multiple hospitalisations for some individuals.

Source: Government of Western Australia Department of Health.

Table C2: Total number of hospitalisations by age and sex, WA, 1 July 1999–31 December 2010

	Sex		
Age at separation (years)	**Male**	**Female**	**Total**
< 1	1,988	1,154	3,142
1–4	2,162	1,560	3,722
5–9	2,478	2,230	4,708
10–14	3,550	3,088	6,638
15–19	7,520	7,337	14,857
20–24	14,877	12,100	26,977
25–29	14,905	20,968	35,873
30–34	34,361	32,056	66,417
35–39	45,944	36,570	82,514
40–44	60,875	55,043	115,918
45–49	75,134	64,572	139,706
50–54	99,736	78,079	177,815
55–59	124,483	80,326	204,809
60–64	122,161	87,573	209,734
65–69	134,814	102,887	237,701
70–74	146,627	103,550	250,177
75–79	150,320	117,442	267,762
80–84	111,512	99,730	211,242
85+	68,941	97,377	166,318
Total	**1,222,388**	**1,003,642**	**2,226,030**

Source: Government of Western Australia Department of Health.

Deaths

Table C3: Total number of deaths by calendar year of death, WA, 1 July 1999–31 December 2010

Year of death	Number of deaths
1999[(a)]	4,099
2000	7,733
2001	8,414
2002	8,800
2003	8,938
2004	8,941
2005	9,307
2006	9,569
2007	10,270
2008	10,413
2009	10,527
2010	10,587
Total	**107,598**

(a) Data for 1999 is from 1 July to 31 December

Note: 482 death records did not contain any cause of death codes.

Source: Government of Western Australia Department of Health.

Table C4: Number of deaths by age and sex, WA, 1 July 1999–31 December 2010

	Sex		
Age at death (years)	**Female**	**Male**	**Total**
< 1	99	124	223
1–4	35	67	102
5–9	23	38	61
10–14	33	41	74
15–19	72	106	178
20–24	94	118	212
25–29	123	183	306
30–34	203	292	495
35–39	295	456	751
40–44	493	774	1,268
45–49	815	1,243	2,058
50–54	1,047	1,811	2,858
55–59	1,395	2,499	3,895
60–64	1,783	3,448	5,231
65–69	2,528	4,811	7,340
70–74	3,955	6,596	10,551
75–79	6,145	9,085	15,230
80–84	9,201	10,061	19,262
85+	23,573	13,866	37,439
Not reported	25	39	64
Total	**51,937**	**55,658**	**107,598**

Note: Total includes deaths where age or sex is unknown.

Source: Government of Western Australia Department of Health.

New South Wales

Hospitalisations

Table C5: Total number of hospitalisations by calendar year of separation, people aged 40 and over, NSW, 1 July 2000–31 December 2010

Year of separation	Number of hospitalisations
2000[(a)]	270,693
2001	540,761
2002	557,460
2003	571,019
2004	637,974
2005	683,189
2006	674,469
2007	710,729
2008	691,787
2009	672,707
2010	675,515
Total	**6,686,303**

(a) Data for 2000 are from 1 July to 31 December

Note: Data include multiple hospitalisations for some individuals.

Source: NSW Ministry of Health.

Table C6: Total number of hospitalisations by age (40 and over) and sex, NSW, 1 July 2000–31 December 2010

	Sex		
Age at separation (years)	Male	Female	Total
40–44	126,028	91,909	217,940
45–49	193,932	136,640	330,574
50–54	259,869	184,018	443,887
55–59	337,955	230,168	568,125
60–64	408,797	285,518	694,316
65–69	449,871	332,023	781,896
70–74	531,848	438,595	970,454
75–79	566,153	484,392	1,050,556
80–84	452,974	425,973	878,951
85+	304,716	444,845	749,577
Total	**3,632,149**	**3,054,083**	**6,686,303**

Note: Total includes 79 records with missing/unknown/not reported age/sex.

Source: NSW Ministry of Health.

Deaths

Table C7: Total number of deaths by calendar year of death, people aged 40 and over, NSW, 1 July 2000–31 December 2007

Year of death	Number of deaths
2000[(a)]	22,749
2001	41,787
2002	43,423
2003	43,287
2004	43,561
2005	42,622
2006	43,656
2007	42,734
Total	**323,819**

(a) Data for 2000 are from 1 July to 31 December

Source: NSW Register of Births, Deaths and Marriages.

Table C8: Number of deaths by age (40 and over) and sex, NSW, 1 July 2000–31 December 2007

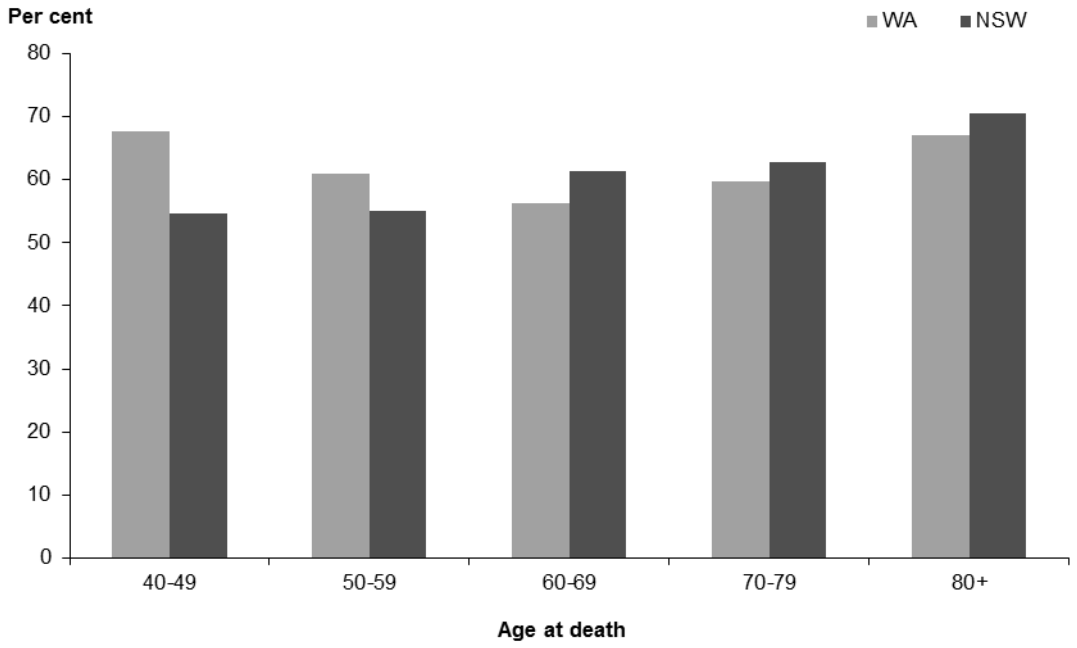
	Sex		
Age at death (years)	Male	Female	Total
40–44	2,696	1,534	4,230
45–49	4,098	2,376	6,474
50–54	5,533	3,389	8,922
55–59	7,787	4,698	12,485
60–64	10,483	6,176	16,659
65–69	13,932	8,350	22,282
70–74	19,858	12,317	32,175
75–79	27,492	19,967	47,459
80–84	30,106	29,064	59,170
85+	40,764	72,511	113,275
Total	**163,161**	**160,658**	**323,819**

Note: Total includes 688 records in which age was not reported.

Source: NSW Register of Births, Deaths and Marriages.

Appendix D: Supplementary results

This appendix provides additional results and data to those presented in Chapter 3 and provides readers with more detailed information and context surrounding the data analysis.



Note: Deaths in NSW emergency departments are recorded as admitted patient episodes.

Source: AIHW analysis of WA and NSW linked hospitalisation and deaths data sets.

Figure D1: Proportion of people with a principal diagnosis of AMI or UA who died in hospital who had an underlying cause of death of acute CHD, aged 40 and over, WA and NSW, 1 July 2000 to 31 Dec 2007

Table D1: Proportion of non-fatal hospitalisations with a principal diagnosis of AMI or UA ending in a transfer to another acute hospital, people aged 40 and over, by state and territory of usual residence, 2000–01 to 2010–11

	2000–01	2001–02	2002–03	2003–04	2004–05	2005–06	2006–07	2007–08	2008–09	2009–10	2010–11	Percentage increase in rates[(a)]
							%					
NSW	23.3	24.4	27.0	29.0	30.0	30.6	31.7	32.3	33.6	34.1	33.2	**42.5**
VIC	22.3	24.1	24.7	24.8	25.5	27.8	28.3	29.0	30.8	29.5	29.5	**32.2**
Qld	15.9	16.9	18.4	19.7	21.0	21.6	23.4	24.7	26.3	28.0	29.3	**83.7**
WA	11.2	11.3	12.5	14.1	14.6	15.6	16.6	18.4	17.7	19.9	20.9	**86.9**
SA	16.2	18.1	18.6	21.5	20.8	21.5	22.1	19.7	21.0	20.6	21.1	**30.3**
Tas	7.1	6.6	7.9	9.7	10.3	9.6	10.3	10.0	11.5	8.2	12.8	**80.9**
ACT	11.8	10.9	19.2	16.0	20.0	18.0	20.9	19.5	19.4	18.5	18.5	**57.8**
NT	27.7	27.4	20.6	23.5	23.0	27.4	32.6	31.6	28.8	33.3	33.2	**19.9**
Total	**19.6**	**20.7**	**22.4**	**23.8**	**24.5**	**25.6**	**26.6**	**27.2**	**28.5**	**28.7**	**28.8**	**47.0**

(a) Percentage increase from 2000–01 to 2010–11.

Source: AIHW National Hospital Morbidity Database.

Table D2: Proportion of hospitalisation episodes with a principal diagnosis of AMI or UA ending in transfer to another acute hospital with subsequent episode coded with a principal diagnosis of AMI or UA, people aged 40 and over, WA and NSW, 2000–01 to 2009–10

	WA			NSW		
Year of separation	**AMI**	**UA**	**AMI or UA**	**AMI**	**UA**	**AMI or UA**
2000–01	38.6	35.7	74.3	34.0	31.1	65.1
2001–02	43.1	28.1	71.3	36.6	27.9	64.5
2002–03	46.1	25.5	71.6	41.5	24.1	65.6
2003–04	49.6	23.6	73.3	44.3	20.8	65.1
2004–05	50.6	23.2	73.8	45.8	17.7	63.5
2005–06	55.6	19.5	75.2	49.9	15.7	65.5
2006–07	53.0	19.9	72.9	50.5	14.2	64.7
2007–08	56.6	16.5	73.1	53.9	13.1	67.0
2008–09	58.0	17.1	75.1	53.3	13.3	66.5
2009–10	57.5	14.3	71.8	55.6	14.2	69.8

Source: AIHW analysis of WA and NSW linked hospitalisation and deaths data sets.

Table D3: Hospitalisations with a principal diagnosis of AMI or UA, ending in transfer and with a subsequent episode +/– 1 day, by principal diagnosis in subsequent episode, people aged 40 and over, WA, 1 July 2000 to 31 December 2010

	Number	%
Principal diagnosis in episode ending in transfer = AMI	5,803	
Subsequent episode principal diagnosis = AMI or UA	4,579	
Subsequent episode principal diagnosis = Other	1,224	100.0
Care involving use of rehabilitation procedure, unspecified	348	28.4
Atherosclerotic heart disease of native coronary artery	73	6.0
Congestive heart failure	72	5.9
Chest pain, unspecified	55	4.5
Angina pectoris, unspecified	48	3.9
Atrial fibrillation and flutter	42	3.4
Other specified surgical follow-up care	38	3.1
Left ventricular failure	36	2.9
Other cardiomyopathies	25	2.0
Other chest pain	18	1.5
Ventricular tachycardia	16	1.3
Convalescence following other treatment	16	1.3
Other	437	35.7
Principal diagnosis in episode ending in transfer = UA	**4,038**	
Subsequent episode principal diagnosis = AMI or UA	2,630	
Subsequent episode principal diagnosis = Other	1,406	100.0
Chest pain, unspecified	301	21.4
Angina pectoris, unspecified	297	21.1
Atherosclerotic heart disease of native coronary artery	134	9.5
Other chest pain	89	6.3
Care involving use of rehabilitation procedure, unspecified	87	6.2
Atrial fibrillation and flutter	52	3.7
Other forms of angina pectoris	47	3.3
Congestive heart failure	33	2.3
Other specified surgical follow-up care	31	2.2
Angina pectoris with documented spasm	17	1.2
Left ventricular failure	17	1.2
Other	301	21.4

Source: AIHW analysis of WA and NSW linked hospitalisation and deaths data sets.

Table D4: Hospitalisations with a principal diagnosis of AMI or UA, ending in transfer and with a subsequent episode +/– 1 day, by principal diagnosis in subsequent episode, people aged 40 and over, NSW, 1 July 2000 to 31 December 2010

	Number	%
Principal diagnosis in episode ending in transfer = AMI	**41,949**	
Subsequent episode principal diagnosis = AMI or UA	30,420	
Subsequent episode principal diagnosis = Other	11,529	100.0
Atherosclerotic heart disease of native coronary artery	2,989	25.9
Other specified surgical follow-up care	2,045	17.7
Care involving use of rehabilitation procedure, unspecified	1,254	10.9
Angina pectoris, unspecified	622	5.4
Chest pain, unspecified	352	3.1
Congestive heart failure	212	1.8
Atrial fibrillation and flutter	173	1.5
Convalescence following other treatment	156	1.4
Left ventricular failure	125	1.1
Ventricular tachycardia	113	1.0
Other	3,488	30.3
Principal diagnosis in episode ending in transfer = UA	**24,699**	
Subsequent episode principal diagnosis = AMI or UA	13,531	
Subsequent episode principal diagnosis = Other	11,168	100.0
Atherosclerotic heart disease of native coronary artery	3,280	29.4
Angina pectoris, unspecified	1,726	15.5
Chest pain, unspecified	1,484	13.3
Other specified surgical follow-up care	1,231	11.0
Care involving use of rehabilitation procedure, unspecified	527	4.7
Other chest pain	309	2.8
Atrial fibrillation and flutter	217	1.9
Atherosclerotic heart disease of unspecified vessel	97	0.9
Atherosclerotic heart disease of autologous bypass graft	97	0.9
Congestive heart failure	83	0.7
Angina pectoris with documented spasm	73	0.7
Aortic (valve) stenosis	72	0.6
Chronic ischaemic heart disease, unspecified	70	0.6
Other	1,902	17

Source: AIHW analysis of WA and NSW linked hospitalisation and deaths data sets.

Appendix E: National Healthcare Agreement indicator PI 09: Incidence of heart attacks

This appendix contains tables with data reported to COAG for the NHA indicator PI 09 'Incidence of heart attacks' (SCRGSP 2014). The 2013 data quality statement for the NHA indicator PI 09 'Incidence of heart attacks' can be found at:

<http://meteor.aihw.gov.au/content/index.phtml/itemId/507359>.

Table E1: Rate of heart attacks, by age and sex, people aged 25 and over, Australia, 2007 to 2011 (rate per 100,000 population)

		Age group							
Year	**Sex**	**25–34**	**35–44**	**45–54**	**55–64**	**65–74**	**75–84**	**85+**	**Total[(a)]**
2011									
	Males	15.8	125.7	416.8	784.4	1,264.7	2,127.3	3,834.8	**584.0**
	Females	6.4	40.6	134.3	274.0	578.3	1,287.7	2,900.5	**283.8**
	Total	11.1	82.8	274.2	527.7	917.7	1,663.8	3,222.4	**427.0**
2010									
	Males	17.3	131.5	437.3	823.6	1,325.5	2,225.0	3,980.0	**611.4**
	Females	5.2	43.3	139.9	283.6	620.5	1,395.3	2,943.8	**299.2**
	Total	11.3	87.0	287.3	552.4	968.0	1,765.3	3,296.5	**447.8**
2009									
	Males	18.4	140.4	438.5	882.3	1,399.8	2,334.5	4,104.6	**639.9**
	Females	5.1	46.3	139.6	296.9	641.1	1,442.7	3,102.1	**310.2**
	Total	11.8	93.0	287.8	588.7	1,014.1	1,838.7	3,439.7	**467.2**
2008									
	Males	18.8	142.0	457.1	907.6	1,556.2	2,519.7	4,408.5	**682.7**
	Females	5.3	40.9	144.0	314.1	721.0	1,599.7	3,402.9	**337.4**
	Total	12.1	91.1	299.2	610.4	1,130.7	2,006.3	3,737.6	**501.7**
2007									
	Males	22.3	149.3	492.7	979.0	1,650.8	2,710.5	4,586.1	**729.0**
	Females	6.4	44.1	148.1	350.7	785.8	1,683.5	3,475.5	**358.2**
	Total	**14.4**	**96.3**	**319.0**	**664.7**	**1,209.3**	**2,135.1**	**3,840.9**	**534.2**

(a) The Australian total is directly age-standardised to the 2001 Australian standard population.

Sources: AIHW National Hospital Morbidity Database; AIHW National Mortality Database; ABS (2012) Australian Demographic Statistics, September 2011, ABS cat. no. 3101.0; ABS (2013) Australian Demographic Statistics, December 2012, ABS cat. no. 3101.0.

Table E2: Age-standardised rate of heart attacks, people aged 25 and over, by Indigenous status, Australia[a], 2007 to 2011 (rate per 100,000 population)[b]

	Year				
	2007	**2008**	**2009**	**2010**	**2011**
Indigenous	1,208.2	1,197.8	1,183.5	1,104.3	1,076.9
Other Australians[c]	521.1	485.6	450.7	435.2	420.8

(a) The Australian estimate is based on 5 jurisdictions where Indigenous identification is considered reasonable in both the NHMD and the NMD (NSW, QLD, WA, SA, and NT).

(b) Directly age-standardised to the 2001 Australian standard population.

(c) Other Australians includes non-Indigenous, not stated and inadequately described.

Sources: AIHW National Hospital Morbidity Database; AIHW National Mortality Database; ABS (2012) Australian Demographic Statistics, September 2011, ABS cat. no. 3101.0; ABS (2009) Experimental Estimates and Projections, Aboriginal and Torres Strait Islander Australians, 1991 to 2021, Series B, ABS cat. no. 3238.0.

Glossary

acute: Coming on sharply and often brief, intense and severe.

acute coronary syndrome (ACS): Describes an **acute myocardial infarction** (**heart attack**) and **unstable angina** when they first present as clinical emergencies with chest pain or other features.

acute myocardial infarction (AMI): Term still commonly used to mean a **heart attack**, but more correctly refers only to those heart attacks that have caused some death of heart muscle.

additional diagnosis: A diagnosis established after study to be a contributing factor to, or affecting, the patient's episode of care in hospital (or attendance at the health-care facility). Compare with **principal diagnosis**.

age-standardisation: A method of removing the influence of age when comparing populations with different age structures. This is usually necessary because the rates of many diseases vary strongly (usually increasing) with age. The age structures of the different populations are converted to the same 'standard' structure, and then the disease rates that would have occurred with that structure are calculated and compared.

algorithm: A process or set of rules to be followed in calculations or other problem-solving operations.

angina: Temporary chest pain or discomfort when the heart's own blood supply is inadequate to meet extra needs, as in exercise. See also **unstable angina** and **cardiovascular disease**.

associated cause(s) of death: Any condition(s), diseases and injuries—other than the underlying cause—considered to contribute to a death. See also **cause of death**.

cardiovascular disease: Any disease of the **circulatory system**, namely the heart (cardio) or blood vessels (vascular). Includes **ACS, angina**, stroke and peripheral vascular disease. Also known as circulatory disease.

cause of death: From information reported on the medical certificate of cause of death, each death is classified by the **underlying cause of death** according to rules and conventions of the 10th revision of the International Classification of Diseases. The underlying cause is defined as the disease that initiated the train of events leading directly to death. Deaths from injury or poisoning are classified according to the circumstances of the fatal injury, rather than to the nature of the injury. See also **associated cause(s) of death**.

chronic: Persistent and long lasting.

chronic diseases: Term applied to a diverse group of diseases, such as heart disease, cancer and arthritis, which tend to be long lasting and persistent in their symptoms or development. Although these features also apply to some communicable diseases (infectious diseases), the term is usually confined to non-communicable diseases.

circulatory disease: Alternative name for **cardiovascular disease**.

circulatory system: The heart along with the blood vessels, comprising the system that circulates blood around the body to supply oxygen and nutrients to all body tissues and to carry away waste products from them. Also known as the cardiovascular system.

condition (health condition): A broad term that can be applied to any health problem, including symptoms, diseases, and various risk factors such as high blood cholesterol, obesity. Often used synonymously with disorder or problem.

coronary heart disease (CHD): Is disease due to blockages in the heart's own (coronary) arteries, expressed as **angina** or a **heart attack**. Also known as **ischaemic heart disease**.

data linkage: The bringing together (linking) of information from 2 or more different data sources that are believed to relate to the same entity, for example, the same individual or the same institution. This can provide more information about the entity and in certain cases provide a time sequence, helping to 'tell a story', show 'pathways' and perhaps unravel cause and effect. The term is used synonymously with 'record linkage' and 'data integration'.

diabetes (diabetes mellitus): A chronic condition in which the body cannot properly use its main energy source, the sugar glucose. This is due to a relative or absolute deficiency in insulin, a hormone that is produced by the pancreas and helps glucose enter the body's cells from the bloodstream and then be processed by them. Diabetes is marked by an abnormal build-up of glucose in the blood, and it can have serious short- and long-term effects.

fatal hospitalisation: A hospitalisation episode that ends in death (that is, where separation mode is recorded as 'died').

heart attack: Life-threatening emergency that occurs when a vessel supplying blood to the heart muscle is suddenly blocked completely by a blood clot. The medical term commonly used for a heart attack is myocardial infarction. See also **cardiovascular disease**.

hospitalisation: Synonymous with admission and separation; that is, an episode of hospital care that starts with the formal admission process and ends with the formal separation process. An episode of care can be completed by the patients being discharged, transferred to another hospital or care facility, or dying, or by a portion of a hospital stay beginning or ending in a change of type of care (for example, from acute to rehabilitation).

incidence: The number of new cases (of an illness, disease or event) occurring during a given period.

indicator: A key statistical measure selected to help describe (indicate) a situation concisely, to track change, progress and performance, and to act as a guide to decision making.

International Statistical Classification of Diseases and Related Health Problems: The World Health Organization's internationally accepted classification of death and disease. The 10th Revision (ICD-10) is currently in use. The 10th revision, Australian modification (ICD-10-AM) is currently in use in Australian hospitals for admitted patients.

ischaemic heart disease: Also h**eart attack** and **angina** (chest pain). Also known as **coronary heart disease.**

length of stay in hospital: Duration of hospital stay, calculated by subtracting the date the patient is admitted from the date of separation. All leave days, including the day the patient went on leave, are excluded. A same-day patient is allocated a length of stay of 1 day.

linkage key: An index that is produced during the **data linkage** process, which is used to enable health records to be joined together for research. The linkage keys are held separately from any personal demographic information.

mode of admission: The mechanism by which a person begins an episode of admitted patient care. In this paper, described by the term 'admission mode'.

mode of separation: Status of a person at separation (discharge/transfer/death) and place to which a person is released (where applicable). In this paper, described by the term 'separation mode'.

mortality: Death.

principal diagnosis: The diagnosis listed in hospital records to describe the problem that was chiefly responsible for **hospitalisation**.

separation: The formal process where a hospital records the completion of an episode of treatment and/or care for an admitted patient. In this paper, described by the term hospitalisation. See **hospitalisation**.

underlying cause of death: The condition, disease or injury initiating the sequence of events leading directly to death; that is, the primary or main cause. Compare **with associated cause(s) of death**.

unstable angina: A form of **angina** that is more dangerous than normal angina but less so than a **heart attack.** It can feature chest pain that occurs at rest; and in someone who already has angina it can be marked by new patterns of onset with exertion or by pain that comes on more easily, more often or for longer than previously.

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Monitoring the incidence of acute coronary events is critical to assess the health and economic burden of coronary heart disease. This working paper uses linked data from Western Australia and New South Wales to assess the central assumptions underlying the proxy measure for estimating the incidence of acute coronary events, in the absence of a heart disease register. This validation study shows that the algorithm may underestimate the incidence of acute coronary events in Australia, but despite this the methodology does provide a reasonable measure of the acute coronary events in Australia.