Monitoring the incidence of cardiovascular disease in Australia

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CARDIOVASCULAR DISEASE SERIES
Number 17

Monitoring the incidence of cardiovascular disease in Australia

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June 2001

Australian Institute of Health and Welfare
Canberra

AIHW cat. no. CVD 16

This publication is part of the Australian Institute of Health and Welfare's Cardiovascular Disease Series. A complete list of the Institute's publications is available from the Publications Unit, Australian Institute of Health and Welfare, GPO Box 570, Canberra ACT 2601, or via the Institute's web site (http://www.aihw.gov.au).

ISSN 1323-9236
ISBN 1 74024 122 3

Suggested citation

Jamrozik K, Dobson A, Hobbs M, McElduff P, Ring I, D'Este K & Crome M 2001. Monitoring the incidence of cardiovascular disease in Australia. AIHW Cat. No. CVD 16. Canberra: Australian Institute of Health and Welfare (Cardiovascular Disease Series No. 17).

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Published by Australian Institute of Health and Welfare

Printed by Elect Printing

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Preface

Despite successes in the fight against heart, stroke and vascular diseases in Australia in recent decades, these diseases continue to have considerable impact on the health of Australians and on the health care system. This has been recognised by Australian Health Ministers who made cardiovascular disease one of six National Health Priority Areas. This initiative involves various levels of government and non-government organisations, and its primary cardiovascular goal is to reduce the incidence and impact of heart, stroke and vascular disease in Australia.

In order to monitor progress towards this goal it is necessary to have a valid, reliable and sustainable method of measuring the incidence of cardiovascular disease over time. This task is complex and costly at a national level and has only been attempted at the local level through event registers. This report *Monitoring the Incidence of Cardiovascular Disease in Australia* examines the feasibility of monitoring the incidence of selected cardiovascular diseases using existing national datasets.

The report was commissioned by the National Centre for Monitoring Cardiovascular Disease at the Australian Institute of Health and Welfare. The Centre funded a consortium of researchers at The University of Newcastle, The University of Western Australia and Queensland Health to develop feasible methods for monitoring the national incidence of coronary heart disease, stroke, unstable angina pectoris and congestive heart failure. It was envisaged that the methods developed would use existing national data collections, possibly with periodic supplementation by parameters estimated from sentinel disease registers.

The report, which is available on the AIHW website, will be particularly relevant to health professionals and researchers concerned with health policy, planning and monitoring.

Richard Madden
Director
Australian Institute of Health and Welfare

Acknowledgments

We would like to thank the principal investigators, researchers and nurses of the Perth Community Stroke Study, Darren Starmer who collected, coded and analysed data from the medical records of patients with cardiac failure and Brendan Bertuola and Steve Ridout who assisted with data analysis. Similarly, we would like to thank the researchers and nurses who assisted with the Queensland Heart Attack Morbidity and Mortality Study, the Newcastle MONICA Study and the New South Wales Acute Cardiac Care Study. We are grateful to Julia Lowe and Paula Candlish for providing us with information from the heart failure study at the John Hunter Hospital.

Special thanks to those who assisted with the validation study: Carole Spencer for coding the ECGs, Emma Hollis for coding and entering the data, and to the study nurses, Sue Forbes and Lynn Schofield from Perth, Carol Male from Queensland, and Julie Hanson and Kirsty Allan from Newcastle.

The authors gratefully acknowledge comment, advice, and assistance from Dr Stan Bennett, Ms Joanne Davies and Ms Sushma Mathur (Australian Institute of Health and Welfare).

The report was refereed by Professor Terry Dwyer (Menzies Centre for Population Health Research, Tasmania).

The project was funded by the National Centre for Monitoring Cardiovascular Disease at the Australian Institute of Health and Welfare. The National Centre is funded by the Commonwealth Department of Health and Aged Care.

List of abbreviations

ACCS	Acute Cardiac Care Study (New South Wales)
ACE	angiotensin-converting enzyme
AIHW	Australian Institute of Health and Welfare
AMI	acute myocardial infarction
AST	aspartate transaminase
CABG	coronary artery bypass grafting
CCF	congestive cardiac failure
CeVD	cerebrovascular disease
CHD	coronary heart disease (ischaemic heart disease)
CI	confidence interval
CPK	creatinine phosphokinase
CVD	cardiovascular disease
CXR	chest X-ray
ECG	electrocardiograph
HMD	hospital morbidity data
HMDS	hospital morbidity data system (Western Australia)
ICD	International Classification of Diseases (ICD-9 = Ninth Revision; ICD-9-CM = Ninth Revision Clinical Modification; ICD-10 = Tenth Revision etc.)
JHH	John Hunter Hospital (Newcastle)
JVP	jugular venous pressure
LOS	length of stay
LDH	lactic dehydrogenase
LVEDP	left ventricular end diastolic pressure
MONICA	World Health Organization's project to MONItor the trends and determinants of CArdiovascular disease
PCSS	Perth Community Stroke Study (Western Australia)
PPV	positive predictive value
PTCA	percutaneous transluminal coronary angioplasty
QHAMMS	Queensland Heart Attack and Morbidity and Mortality Study
SBP	systolic blood pressure
TIA	transient cerebral ischaemic attack
UAP	unstable angina pectoris
WHO	World Health Organization

Summary

The purpose of this project is to recommend methods that can be used to monitor the incidence of cardiovascular disease using routinely collected data. Various special data collections were used to examine the validity and reliability of routinely collected data, during the period when International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM) was used for classification of disease. With the recent introduction of ICD-10-AM (International Statistical Classification of Diseases and Related Health Problems, Tenth Revision, Australian Modification) additional validation studies will be needed to examine the concordance between the two classifications and to re-estimate the adjustment factors. This report outlines the methodology that can be used.

This report focuses on the components of cardiovascular disease described below.

CHD is a generic term describing disease that results from insufficient blood flow to the heart caused by the narrowing of the coronary arteries due to atherosclerosis. AMI is the most severe form of CHD and occurs when the heart muscle is damaged as a result of a sustained blockage in a coronary artery. Unstable angina or preinfarction angina is part of the same biological process but may not progress to AMI if the blockage is cleared before the lack of oxygen causes permanent damage to the heart (Crea et al. 1997; Kristensen et al. 1997).

Cerebrovascular disease (stroke) comprises several disorders which results from a deficient blood supply to the brain due to the formation of a blood clot (most common type) or where an artery leaks blood into the brain.

Congestive cardiac failure occurs when the heart is unable to pump enough blood to meet the needs of the body's other organs, which often leads to a build up of fluid, either in the lungs or in other parts of the body.

Acute myocardial infarction

For monitoring incidence of coronary heart disease (CHD) it is recommended that:

1. The rate of coronary events should be calculated as the sum of the rate of coronary deaths estimated from death certificates and the rate of non-fatal acute myocardial infarctions (AMIs) estimated from hospital separations.
2. For fatal coronary events, deaths with (ICD-9) codes 410–414 should be used with adjustment factors to account for underestimation. The single ICD-9-CM code of 410 is not adequate.
3. For non-fatal AMI, hospital separations should be used where the patient is discharged alive, the primary diagnosis is coded 410 using ICD-9-CM and the length of stay is greater than two days. Adjustment factors should be used to account for overestimation due to hospital transfers, readmissions and other effects.
4. Further studies are needed on the use of more detailed hospital information, such as additional ICD coding and whether a hospital admission was unplanned to improve the validity of data on non-fatal AMIs. Also the occurring of routinely collected data for people aged over 65 years requires further investigation.
5. Separate validation studies are needed for fatal and non-fatal events as the data sources and diagnostic criteria differ.

Investigations and procedures

For monitoring numbers of coronary investigations and procedures, booked admissions coded 413 to 414 should be subdivided into:

1. admissions with percutaneous transluminal coronary angioplasty (PTCA) and coronary artery bypass grafts (CABG); and
2. admissions without PTCA or CABG.

The admission rates for each of these categories (separately) should be monitored, without any adjustments, as they are essentially indicators of health services rather than disease incidence.

Angina pectoris

For monitoring incidence of angina pectoris it is recommended that:

1. The rate of angina pectoris can be obtained by counting all patients who had an unbooked (emergency) admission to hospital and who were given a primary discharge diagnosis coded 411 or 413 according to ICD-9-CM.
2. Primary discharge codes of 411 and 413 should be considered together for validation studies of angina pectoris. There is insufficient information in medical records to distinguish between cases of unstable angina pectoris and stable angina pectoris.

Stroke

For monitoring incidence of stroke it is recommended that:

1. At present, hospital morbidity data (HMD) should not be used to measure past trends in attack rates for acute stroke because of rapidly changing proportions of non-fatal cases admitted to hospital. If the relatively large proportion of cases admitted to hospital in Perth in 1995–96 (particularly in patients under 75 years of age) is confirmed in further studies, it should be possible to use HMD to monitor trends in hospitalised cases of stroke from 1995 onwards.
2. HMD may be used for obtaining improved estimates of rates of admission to hospital in a particular year for acute stroke and in hospital case fatality using the following selection algorithms. Total acute stroke is the sum of non-fatal stroke and fatal stroke where non-fatal stroke is defined as:
   - main diagnosis coded as acute stroke (430, 431, 434 or 436), OR acute stroke is coded in another diagnostic field for an admission of at least three days' duration that is unbooked,

   and fatal stroke is defined as:
   - fatal cases where length of stay <29 days AND EITHER the main diagnosis was coded as acute stroke (430, 431, 434, 436), OR acute stroke was coded in another diagnostic field and the admission was unbooked.
3. Validation studies are needed for the coding of deaths from stroke which occur out of hospital.

   Further studies should be undertaken in different geographical areas or health regions (or at least involving more than one major hospital catchment area) to test the algorithms described above and to determine the proportions of non-fatal cases admitted to hospital.

4. The present study should be repeated using HMD and death records that have first been linked to provide episodes of fixed length to remove the effects of multiple admissions relating to the same person. Similar methods should be used to determine 'first' events, defined in terms of no previous admission because of acute stroke within a defined period (for example, five years).

Congestive cardiac failure

There are severe limitations to monitoring trends in congestive cardiac failure using hospital admissions. This is because

- signs and symptoms are poorly recorded in medical records
- diagnostic criteria vary and are not used uniformly
- large changes in rates can be caused by changes in coding practice

As the incidence of congestive cardiac failure is believed to be increasing due to changes in the treatment of cardiovascular disease it is necessary to improve data quality. At present little credence can be given to available data.

Validation of hospital data on cardiac conditions

Based on a pilot study of validation methodology for cardiac conditions (but not stroke) using hospital data it is suggested that:

1. Diagnosis of AMI can be validated through retrospective review of hospital records as the necessary information is usually available;
2. Information in hospital records is insufficient to distinguish between unstable angina; angina pectoris and chest pain, but if a broader category of angina is used then validation is possible;
3. For congestive cardiac failure, lack of universally accepted diagnostic criteria or evidence from a definitive test and inadequacies in hospital records make validation from retrospective review of records unfeasible. Only prospective data collection for patients admitted for a broad range of conditions could produce adequate information.

1 Introduction

1.1 Background and purpose

CHD is a generic term describing disease that results from insufficient blood flow to the heart caused by the narrowing of the coronary arteries due to atherosclerosis. AMI is the most severe form of CHD and occurs when the heart muscle is damaged as a result of a sustained blockage in a coronary artery. Unstable angina or preinfarction angina is part of the same biological process but may not progress to AMI if the blockage is cleared before the lack of oxygen causes permanent damage to the heart (Crea et al. 1997; Kristensen et al. 1997).

Cerebrovascular disease (stroke) comprises several disorders which results from a deficient blood supply to the brain due to the formation of a blood clot (most common type) or where an artery leaks blood into the brain.

Congestive cardiac failure occurs when the heart is unable to pump enough blood to meet the needs of the body's other organs, which often leads to a build up of fluid, either in the lungs or in other parts of the body.

The purpose of this project is to recommend methods which can be used by the Australian Institute of Health and Welfare (AIHW) (and other agencies) to monitor the incidence of cardiovascular disease (CVD) using routinely collected data. For some components, such as coronary deaths and definite acute myocardial infarctions (AMI), the goal is to produce valid estimates of time trends (or differences between subgroups) in CVD in the population. For other components, such as investigations and procedures, the goal is only to monitor trends and document differences in levels of service. Interpretation of trends needs to take into account that criteria may vary over time (or between population subgroups).

The project recommends methods for estimating incidence of coronary heart disease (CHD), stroke, angina pectoris and congestive heart failure. Routinely collected data are available to AIHW from death certificates and hospital separations but the diagnostic criteria may vary and numbers of cardiovascular events may be double-counted. For example, patients transferred between hospitals during the same clinical 'episode' would not usually be identified unless it is possible to link records. Also, deaths in hospital would be counted both from death certificates and hospital records. Thus methods are needed to avoid, as far as possible, double-counting of cardiovascular events.

The results from several Australian studies on the accuracy of routinely collected data provide the basis for the recommendations in this report. Studies of the validity of hospital data for non-fatal AMI and other acute episodes of CHD have been conducted in Newcastle and Perth as part of the World Health Organization's (WHO) MONICA Project (to MONItor the trends and determinants of CArdiovascular disease) and in Queensland as part of the Queensland Heart Attack and Morbidity and Mortality Study (QHAMMS). Similar studies on the validity of death certificates for CHD were also conducted as part of the WHO MONICA Project. Data from other health areas are available through the New South Wales Acute Cardiac Care Study (ACCS)—a study that examined the management of patients with acute cardiac ischaemia in over 30 hospitals in New South Wales. The

validity of hospital data for stroke has been assessed by the Perth Community Stroke Study (PCSS), Western Australia.

1.1.1 Change in coding from ICD-9-CM to ICD-10-AM

Various special data collections were used to examine the validity and reliability of routinely collected data, during the period when the International Classification of Diseases, Ninth Revision, Clinical Modification (ICD-9-CM) was used for classification of disease. With the recent introduction of ICD-10-AM (International Classification of Diseases and Related Health Problems Tenth Revision, Australian Modification) additional validation studies will be needed to examine the concordance between the two classifications and to re-estimate the adjustment factors. This report outlines the methodology that can be used.

1.1.2 Structure of this report

In this report, data from a number of studies conducted in Australia are used to assess the validity of hospital separation data and national mortality data to determine the extent to which this routinely collected data can be used to monitor the incidence of cardiovascular disease. In Chapter 2, a system for monitoring the incidence of AMI is outlined and a detailed discussion on how the information available in hospital separation data can be used is given. In Chapters 3, 4 and 5, the way in which hospital separation data can be used for monitoring the incidence of angina, stroke and congestive cardiac failure (CCF) are discussed and methods for monitoring each disease are outlined. The results of a pilot validation study are presented in Chapter 6. This study was undertaken to establish a methodology to determine whether a diagnosis of CVD could be validated from hospital medical records.

1.2 Definitions

There are several possible sources of error inherent in routinely collected hospital separation data, particularly for the specific forms of CHD where the outcomes are often not well-defined or clear cut. If these data are to be used as the main source of information on CHD, it is important to assess their reliability and accuracy. This can be done by comparison with a 'gold standard' to determine the sensitivity and positive predictive value (PPV) of the hospital separation data. This is illustrated below for non-fatal AMI

		'True' diagnosis		
		Non-fatal definite AMI	Other	
Hospital primary diagnosis	ICD-9-CM code 410	a	b	a+b
	Other	c	d	

sensitivity = a/(a+c)

positive predictive value (PPV) = a/(a+b)

(ICD-9-CM code 410). The sensitivity is the proportion of cases of 'true' non-fatal AMI detected by the morbidity data, or a/(a+c). The PPV is the proportion of the non-fatal AMIs determined from the morbidity data which are true AMIs according to the 'gold standard' or a/(a+b).

The true number of non-fatal AMIs can be estimated from the sensitivity and the PPV. In the diagram above the true number of non-fatal definite AMIs is given by (a+c). The number of non-fatal AMIs according to hospital separation data is (a+b). The number (a+c) can be obtained by multiplying the number of non-fatal episodes coded ICD-9-CM 410 by the PPV divided by the sensitivity in the following way:

$$(a+c) = (a+b) \times (a+c)/(a+b)$$
$$= (a+b) \times \text{PPV/sensitivity}$$

1.3 Sources of data

1.3.1 MONICA Project

The MONICA Project was a WHO study MONItoring trends and determinants of CArdiovascular disease. Forty well-defined populations from 25 countries were involved in the study from the mid-1980s to the mid-1990s. Australia participated in the project with two centres, one in Perth, Western Australia, and the other in Newcastle, New South Wales.

The population defined for the MONICA Study in Perth was persons aged 25–64 years who were usual residents of the Perth Statistical Division, effectively the Perth Metropolitan Area. Coronary events were registered for ten full years from 1984–93 using the 'cold pursuit' method in which non-fatal events were ascertained by surveillance of routinely collected statistics compiled from diagnoses recorded at discharge from hospital. These cases were identified from records bearing ICD-9-CM codes for AMI or subacute CHD (ICD-9-CM codes 410 and 411 respectively). Additionally, three times during the year, computerised hospital separation records for all hospitals in Western Australia were searched systematically for mention of these codes in records of persons usually resident in the Perth Statistical Division and this resulted in a small number of additional cases being registered. Information about deaths from CHD (ICD-9 codes 410–414) in Perth was obtained either by notification from the Coroner's Pathologist or by regular searches of death registrations. Supplementary information was obtained from hospitals and coroner's records and from medical practitioners involved in the management of the cases.

The population for the MONICA Project in Newcastle was residents aged 25–69 years of the five local government areas of Newcastle, Lake Macquarie, Port Stephens, Maitland and Cessnock. Registration of coronary events began in Newcastle in August 1984 and continued until March 1994. The 'hot pursuit' method was used to identify patients, that is, study nurses monitored all hospitals in the area and registered every patient likely to meet the study criteria. Patients were interviewed while they were in hospital and information was extracted from their medical records at that time (rather than retrospectively). Fatal events were ascertained by continuous surveillance of all death certificates and details of fatal cases were obtained from death certificates, postmortem records and from doctors, relatives or other informants.

1.3.2 Queensland Heart Attack Morbidity and Mortality Study

The QHAMMS was a validation study that explored the practicalities of providing an estimate of the incidence of AMI based on the 1992 Queensland Hospital Morbidity Collection. The study was based on MONICA methods using a 'cold pursuit' (see Section 1.3.1 above) approach to surveillance. The validation study reviewed the primary discharge diagnosis in the hospital records at 10 hospitals ranging from teaching hospitals to a small 40-bed rural hospital. The findings of the project indicated important limitations with respect to availability of key data items, particularly data on electrocardiographs and cardiac enzymes in non-teaching hospitals.

1.3.3 Perth Community Stroke Study

The PCSS attempted to register every stroke that occurred in a study area defined by the Swan River to the south and east, Wanneroo Road (the nominal boundary of the catchment area for Royal Perth Hospital) to the west, and the edge of the metropolitan area to the north but excludes postcode area 6060. The area incorporates eight postcode areas, with a total population of 138,000. The availability of hospital morbidity data means that the analyses undertaken for the present report were confined to events occurring before the end of 1995.

The PCSS employed multiple sources of ascertainment to identify every stroke or transient-cerebral ischaemic attack (TIA) affecting a resident of the study area. Cases of TIA were included because if symptoms persisted beyond 24 hours the episode would satisfy the internationally accepted definition for a stroke (assuming that other explanations for the symptoms had been excluded). Patients were seen and assessed by an experienced medical registrar as soon as possible after the event came to the notice of the PCSS. Information was also collected for every fatality involving a resident of the study area where cerebrovascular disease (stroke) was mentioned anywhere on the death certificate. A final diagnosis of stroke in the PCSS Register required that the episode satisfied the WHO criteria originally developed by Hatano (1980).

1.3.4 Record linkage in Western Australia

Since 1971, all hospitals in Western Australia have contributed information to the computerised Hospital Morbidity Data System (HMDS) maintained by the Health Department of Western Australia. Each inpatient separation is represented by an individual record that includes the following variables: first and family names, sex, date of birth and partial address of the patient; the dates of admission to and separation from hospital; a code for the hospital; whether the admission was an emergency or an elective one; the vital status and disposition of the patient at discharge; up to nineteen diagnostic codes covering the principal condition treated, other conditions present, and principal and other complications arising during the stay in hospital; and up to ten fields for procedures undertaken while the patient was in hospital. Since 1988, both diagnoses and procedures have been coded using the Clinical Modification of the International Classification of Diseases, Ninth Revision (ICD-9-CM), whereas from 1979 until 1988 diagnoses were coded using ICD-9-CM and procedures were coded using the International Classification for Procedures in Medicine. Coding staff use information from the discharge summary sheet completed by a member of the junior medical staff in a teaching hospital, from the discharge letter to the patient's referring or usual doctor and directly from the medical record itself.

It is possible to select sub-sets of records from the HMDS based on any combination of fields and values within those fields. In addition, electronic record linkage can be used to link records of successive admissions for a given individual, and to link records from the HMDS to other name-identified collections such as unit mortality records compiled by the Registrar-General for Births, Marriages and Deaths for Western Australia.

1.3.5 New South Wales Acute Cardiac Care Study

The ACSS was funded by the New South Wales Department of Health to examine the management of patients with acute cardiac ischaemia in New South Wales. In particular, the objective was to determine whether patients with acute cardiac ischaemia received appropriate treatment (especially thrombolysis) and whether there were systematic differences in the use of treatments between hospitals. This study included sampling from a wide range of hospitals across the State and the methodology became the basis for the protocol for the validation study described later in this report.

A stratified random sample of patients with a primary discharge diagnosis coded to one of the ICD-9-CM codes of 410 (AMI), 411.1, 411.8, 413 (angina) and 786.5 (chest pain) was selected for inclusion in the acute care study. The sample was stratified according to hospital type as determined by the 1994–95 New South Wales Public Hospital Classification. It was considered important to try to maximise the number of hospitals sampled so that between-hospital variation could be analysed. All hospitals in the first three groups—Principal Referral
(n = 8), Major Metropolitan Referral (n = 5) and Major Non-Metropolitan Referral (n = 6) were included in the study. A random sample of District hospitals was taken, requiring 6 of 21 District Metropolitan hospitals, 6 of 12 Large District Non-Metropolitan hospitals and 16 of 31 Small District Non-Metropolitan hospitals.

The study ran from February–June 1996. All patients admitted to Major Non-Metropolitan Referral, District Metropolitan, Large District Non-Metropolitan and Small District Non-Metropolitan Hospitals with an admission diagnosis of AMI or angina were included in the sampling frame. A random sample of 50 patients who were admitted to each Principal Referral Hospital and 80 patients admitted to each Major Metropolitan Referral hospital within each of the AMI and angina diagnoses were included. For each type of hospital, records of 50 patients with a discharge diagnosis of chest pain were also selected. In total, medical records for 4,668 admissions were selected for this study. Numbers of hospitals and records were selected to provide a total sample of about 1,500 for each condition.

1.3.6 Data on congestive cardiac failure from the John Hunter Hospital

From 1 May 1993 to 30 November 1993 all patients aged 60 years or older who were admitted to the John Hunter Hospital in Newcastle with an admission diagnosis of CCF but without AMI were registered for this prospective cohort study (Lowe et al. 1998). Research nurses searched the hospital's computerised admission notes on a daily basis to identify potential subjects, that is, all patients presenting with the symptom of dyspnoea. Medical records for each of these patients were assessed for agreement between the admitting resident medical officer and the consultant in charge of the patient that the admission of the patient had been for management of CCF. Patients who satisfied the above criteria were included in the study if they also satisfied the Framingham criteria for diagnosis of CCF (McKee et al. 1971).

For each patient who satisfied the inclusion criteria, research nurses extracted data from medical records and carried out a structured interview to obtain information about the current admission and medical history.

2 Acute myocardial infarction

2.1 Introduction

The number of episodes of AMI that occur each year in Australia is estimated from routinely collected data. Fatal events are estimated from death certificates and non-fatal events are estimated from hospital separation data. It was the experience of the MONICA centres in Perth and Newcastle that using the ICD-9-CM code 410 resulted in biased estimates of the true number of AMIs in the population. In this chapter methods are presented which will enable more accurate estimates of the number of AMIs to be calculated. In addition, there is a detailed discussion on what information is available in hospital separation data and how this information could be used to provide better estimates of AMI in the future.

2.2 Monitoring incidence of coronary heart disease

2.2.1 Age and sex categories

For the purpose of monitoring incidence, at this stage only data for three age groups, 35–44, 45–54 and 55–64 years, for each sex should be used. The reasons are:

- coronary events are rare below this age range;
- for older people, for example those aged over 80 years, diagnosis may be less reliable and comorbidity is more likely to affect outcomes; and
- at present we do not have adequate validation information outside this age range.

Further studies are needed to assess the validity and reliability of routinely available data on AMI and CHD in people aged 65 years and over. Fewer than 50% of coronary events occur in people below the age of 65 years, yet the validation studies refer mainly to this age range. Data for this younger age group are likely to be a sensitive marker of changes in incidence due to improvements in levels of risk factors and medical treatment. However, for national monitoring of trends it is highly desirable that a wider age range should be used in order to assess the burden of illness (and costs) due to CHD.

2.2.2 Total events

The total number of coronary 'events' should be calculated as:

Total coronary events = total coronary deaths + total non-fatal AMIs.

These should then be divided by appropriate population data to obtain incidence rates which can be monitored over time (or compared between population subgroups).

The reason for this recommendation is that the sources of data for coronary deaths and non-fatal AMIs differ. Also, the methods needed to obtain valid estimates from the two

sources differ. Therefore, it is necessary to obtain estimates for the two types of events separately and then add these to obtain an overall estimate.

2.2.3 Non-fatal acute myocardial infarction

To monitor non-fatal AMI, hospital separations should be used only where the patient is discharged alive, the primary diagnosis is coded 410 according to the ICD-9-CM and the length of stay (LOS) is greater than two days should be used. The accuracy of counts of patients admitted to hospital for AMI (and related diagnoses) depends on:

- clinical diagnosis and quality of medical records
- coding of diagnoses
- local admission and discharge policies and practices
- transfers between hospitals
- readmissions for investigations and procedures
- characteristics of the patient such as age, sex and previous medical history.

The reasons for the recommendation are as follows:

1. patients with AMI are likely to have their primary diagnosis coded to ICD-9-CM 410 (i.e. the sensitivity is high);
2. as readmissions within 56 days for investigations and procedures are also likely to be coded to ICD-9-CM 410 but not as the primary diagnosis, using only the primary diagnosis code reduces multiple counting of the same coronary 'event'. The ICD-9-CM eight-week coding rule automatically discounts readmissions within 56 days of the initial admission;
3. the fifth digit extension of the ICD-9-CM code 410 is increasingly used to distinguish between the initial admission for an AMI and follow-up admissions for the same episode. It is not used sufficiently in all jurisdictions to be useful for monitoring incidence;
4. as only a small proportion of patients who have a clinically recognised AMI are discharged alive from hospital within two days, use of this criterion will reduce counting of mild episodes and the effects of coding errors (i.e. the specificity will be improved); and
5. transfers between hospitals are an important potential source of multiple counting of patients—omitting hospital stays of two days or less reduces errors from this source.

In Section 1.2 it was shown how the accuracy of routinely collected hospital separation data can be assessed by comparing hospital data and a 'true' diagnosis obtained using rigorous, standardised methods. The MONICA criteria for non-fatal definite AMI are based on definite electrocardiograph (ECG) charges (development of Q wave or sustained ST elevation), abnormal enzyme levels and typical or atypical symptoms. Any episode meeting these criteria would be very likely to be regarded clinically as an AMI, though many milder cases of clinical AMI may not meet the MONICA criteria for non-fatal definite AMI (McElduff et al. 2000; Tunstall-Pedoe et al. 1994).

Figures 2.1, 2.2 and 2.3 show values for sensitivity, PPV and PPV/sensitivity (see Section 1.2 for further detail) for non-fatal definite AMI (according to the MONICA criteria) compared with hospital separations with the primary diagnosis coded 410 and length of stay greater than two days, by age, sex and centre (i.e. QHAMMS, Perth MONICA or

Newcastle MONICA). The data from Queensland are combined for both sexes and all ages, due to small numbers of episodes studied.

The values vary with age and sex. They also vary with the patient's history of CHD (results not shown) but as this information is not routinely available it cannot be used here. Values are also likely to vary with hospital size, facilities for investigation and treatment, and geographical location. Validation studies are therefore needed in a range of different settings.

It is recommended that the number of hospital admissions with primary diagnosis coded 410 using ICD-9-CM and length of stay greater than two days should be multiplied by the age- and sex-specific adjustment factors PPV/sensitivity shown in the last three rows of Table 2.1 to estimate the total number of non-fatal AMIs.

Reasons:

1. The adjustment factors shown in the last three rows of Table 2.1 were calculated using weighted averages for PPV/sensitivity (shown in Figure 2.3) with weights proportional to the estimated variances, using age- and sex-specific data from all three centres. They represent the best available information on the accuracy of hospital data for estimating AMI.
2. They show that the routinely available hospital data tend to overestimate the numbers of non-fatal AMIs so that downward adjustments are required. This effect is more pronounced for younger patients than older ones and for men than women.
3. The effects of diagnostic coding, transfers and readmissions have also been examined using MONICA and QHAMMS data and record linkage and this recommendation has been found to produce the most accurate results.

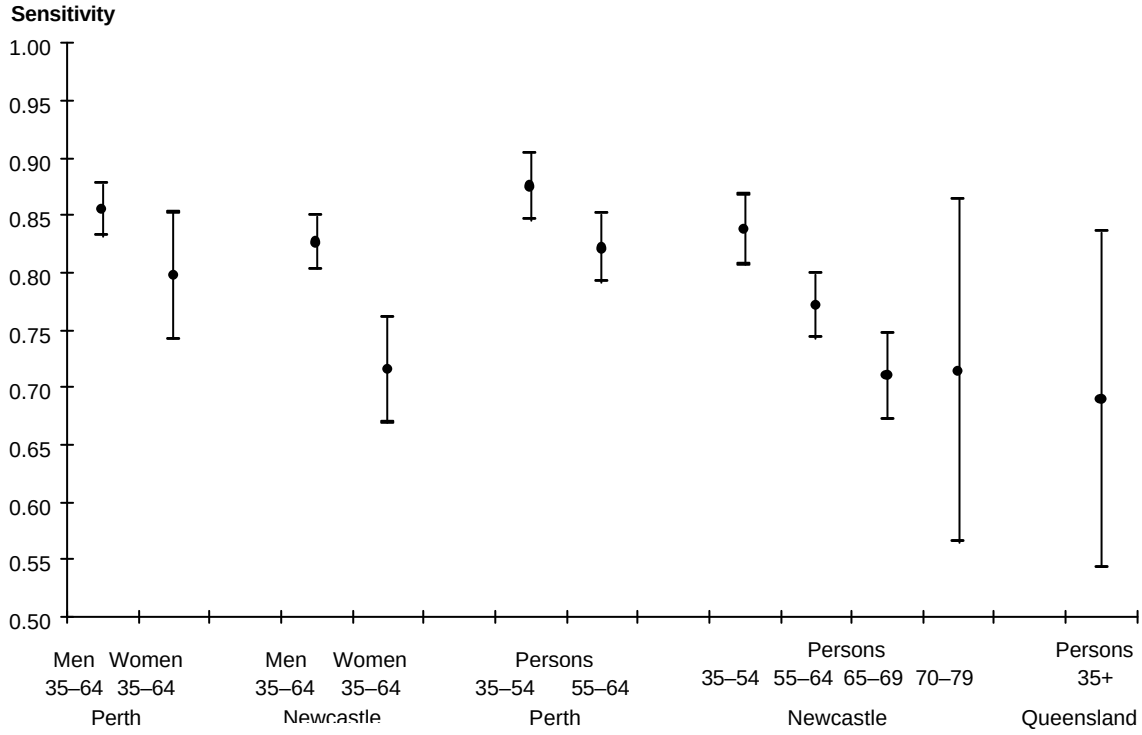


Figure 2.1: Sensitivity analysis for non-fatal events with principal discharge diagnosis 410 and hospital stay greater than 2 days, using MONICA definite acute myocardial infarction as the 'gold standard'

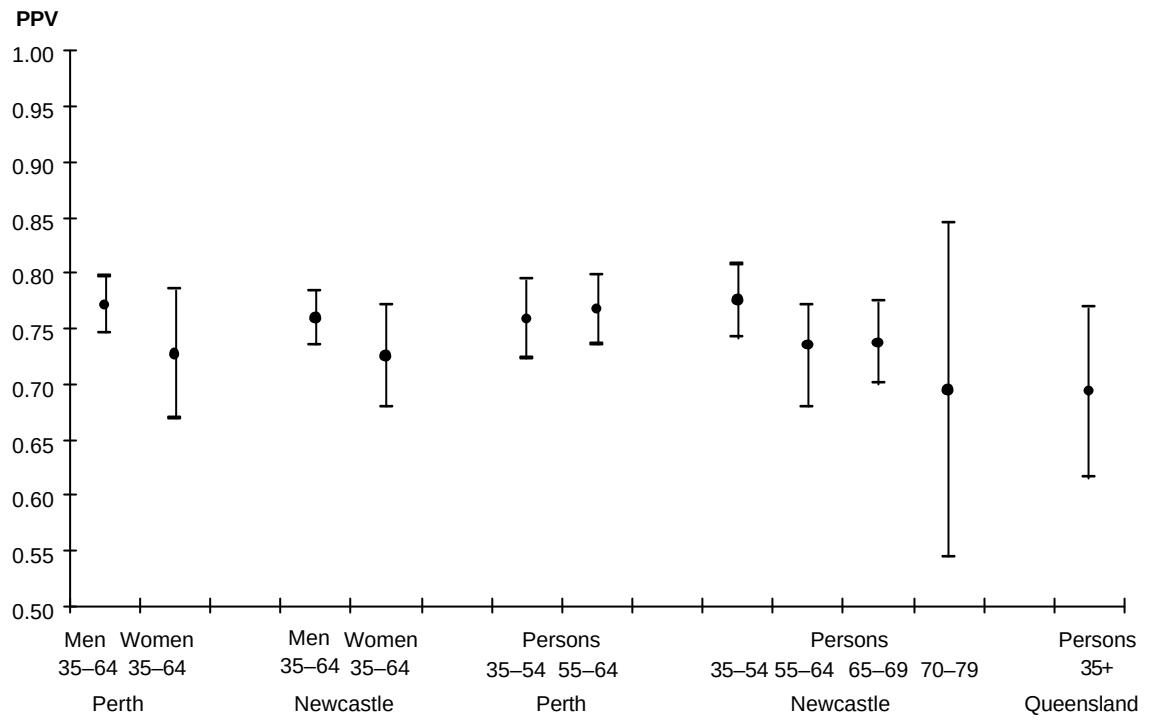
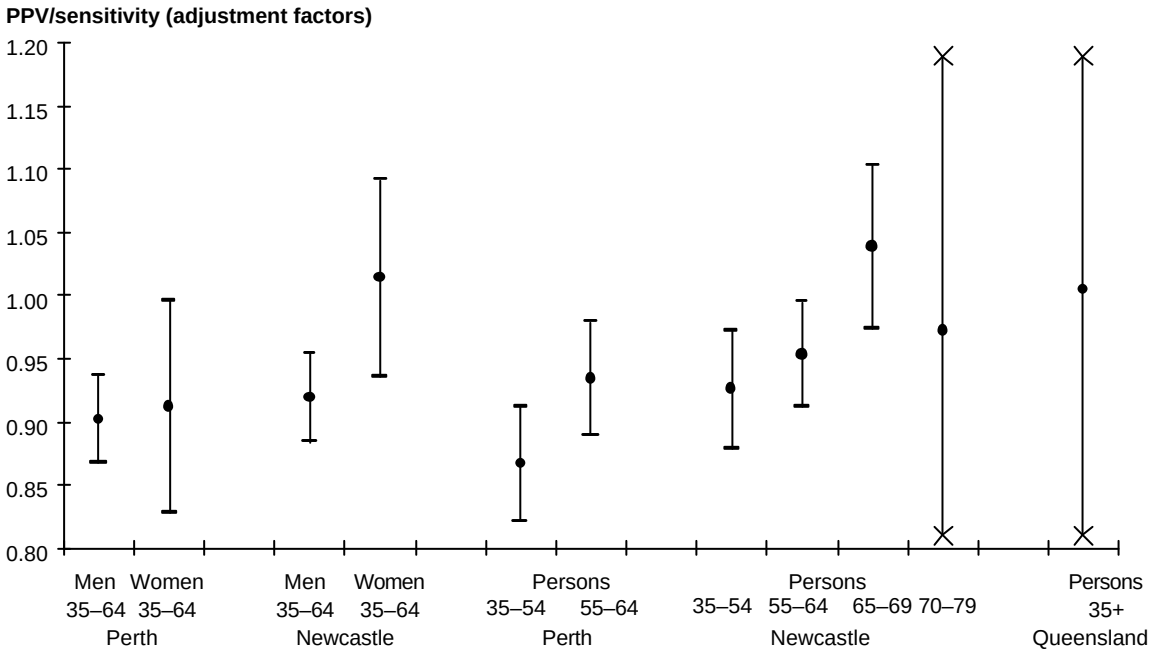


Figure 2.2: Positive predictive value (PPV) for non-fatal events with principal discharge diagnosis 410 and hospital stay greater than 2 days, using MONICA definite acute myocardial infarction as the 'gold standard'



X = confidence interval is beyond the parameters of the graph.

Figure 2.3: Positive predictive value (PPV)/sensitivity analysis for non-fatal events with principal discharge diagnosis 410 and hospital stay greater than 2 days, using MONICA definite acute myocardial infarction as the 'gold standard'

Table 2.1: Adjustment factors for estimating numbers of non-fatal definite acute myocardial infarction

Centre	Age group (years)	Men	Women	Men and women
		Adjustment factors (95% confidence intervals)		
Perth	35–54	0.88 (0.83, 0.92)	0.80 (0.66, 0.94)	
	55–64	0.93 (0.88, 0.98)	0.96 (0.86, 1.07)	
Newcastle	35–54	0.91 (0.86, 0.96)	1.01 (0.87, 1.15)	
	55–64	0.93 (0.88, 0.98)	1.02 (0.92, 1.11)	
	65–69	0.99 (0.92, 1.06)	1.14 (1.00, 1.28)	
Queensland	35–80+	—	—	1.01 (0.35, 1.66)
Combined[(a)]	35–54	0.89 (0.86, 0.93)	0.91 (0.81, 1.01)	
	55–64	0.93 (0.89, 0.96)	0.99 (0.92, 1.06)	
	65–69	0.99 (0.92, 1.06)	1.14 (1.00, 1.27)	

(a) Weighted average of the three centres with weights inversely proportional to the number of events.

2.2.4 Coronary deaths

The total number of coronary deaths should be estimated only from death certificate data as about 60–70% of coronary deaths occur out of hospital and the only available source of information for these deaths is death certificates. The remaining deaths occur in hospital and therefore are recorded in both the death certificate data and hospital records. The recommendation therefore eliminates double-counting and ensures more uniform data on deaths which occur in or out of hospital.

For coronary deaths all records with ICD-9 codes 410–414 (CHD) should be counted. Table 2.2 shows a comparison of ICD codes for causes of death and the WHO MONICA Project criteria for deaths due to definite AMI (based on diagnostic tests for patients who died in hospital, or from autopsy reports), possible AMI (mainly based on a history of CHD and no evidence of any other cause of death) or coronary deaths with insufficient information for further categorisation (based on information from the death certificate, relatives, certifying doctor or other informants). The sensitivity and specificity for the code 410 (AMI) depends on whether the patient dies out of hospital, reaches hospital alive and has diagnostic tests or has an autopsy. The broader category of codes (ICD-9 410–414) corresponds best to the combined MONICA categories of definite or possible AMI or coronary deaths with insufficient information for further classification. The value of PPV/sensitivity was slightly higher for women than men in both Perth and Newcastle (Figures 2.4–2.6). In Newcastle, the values of sensitivity, PPV, and PPV/sensitivity do not vary greatly with age but in Perth the value of PPV/sensitivity was higher for the older age group.

The numbers of deaths with ICD-9 codes 410–414 should be multiplied by the age- and sex-specific adjustment factors PPV/sensitivity shown in the last three rows of Table 2.3, to monitor mortality rates for CHD. Validation studies from the WHO MONICA Project suggest that the numbers of deaths from CHD are underestimated, especially for younger women, if only death certificate diagnoses coded 410–414 are used. This is because some CHD deaths are coded to other diagnostic categories (e.g. diabetes).

Validation studies of death certificate coding should be carried out periodically to identify effects of changing levels of information on the classification of cause of death. Table 2.4

shows evidence of a consistent trend towards increasing underestimation of numbers of coronary deaths over time in Perth. The effect of this and future changes (due to multiple cause coding, changes to the ICD and so on) may be to exaggerate the decline in coronary mortality rates.

Table 2.2: Cross-tabulation of MONICA diagnosis and death certificate cause of death

	MONICA diagnosis of AMI			
Death certificate cause of death	**Definite**	**Possible**	**Insufficient data**	**Not AMI**
Perth men and women 1991–93				
410	138	201	37	15
411–414	24	257	7	43
Other	27	131	57	25
		PPV	**Sensitivity**	**PPV/sensitivity**
410 vs (definite + possible)		86.7	43.6	199.0
410 vs (definite + possible + insufficient)		96.2	42.8	224.8
410–414 vs (definite + possible)		85.9	79.7	107.8
410–414 vs (definite + possible + insufficient)		92.0	75.5	121.7
Newcastle men and women 1986–91				
410	313	597	300	24
411–414	46	191	88	40
Other	34	73	66	51
		PPV	**Sensitivity**	**PPV/sensitivity**
410 vs (definite + possible)		73.7	72.6	101.6
410 vs (definite + possible + insufficient[(a)])		98.1	70.8	138.4
410–414 vs (definite + possible)		71.7	91.5	78.4
410–414 vs (definite + possible + insufficient)		96.0	89.9	106.8

AMI = acute myocardial infarction; PPV = positive predictive value.

(a) Coronary deaths with insufficient information to permit further classification.

Table 2.3: Adjustment factors for estimating numbers of deaths from coronary heart disease

Centre	**Age group (years)**	**Men**	**Women**
		Adjustment factors (95% confidence interval)	
Perth	35–54	1.06 (0.99, 1.13)	1.29 (0.88, 1.69)
	55–64	1.24 (1.17, 1.31)	1.45 (1.28, 1.61)
Newcastle	35–54	1.08 (1.03, 1.13)	1.17 (0.98, 1.37)
	55–64	1.06 (1.03, 1.10)	1.10 (1.04, 1.17)
	65–69	1.05 (1.02, 1.09)	1.05 (1.00, 1.10)
Combined	35–54	1.07 (1.03, 1.12)	1.20 (1.02, 1.37)
	55–64	1.10 (1.07, 1.13)	1.15 (1.09, 1.21)
	65–69	1.05 (1.02, 1.09)	1.05 (1.00, 1.10)

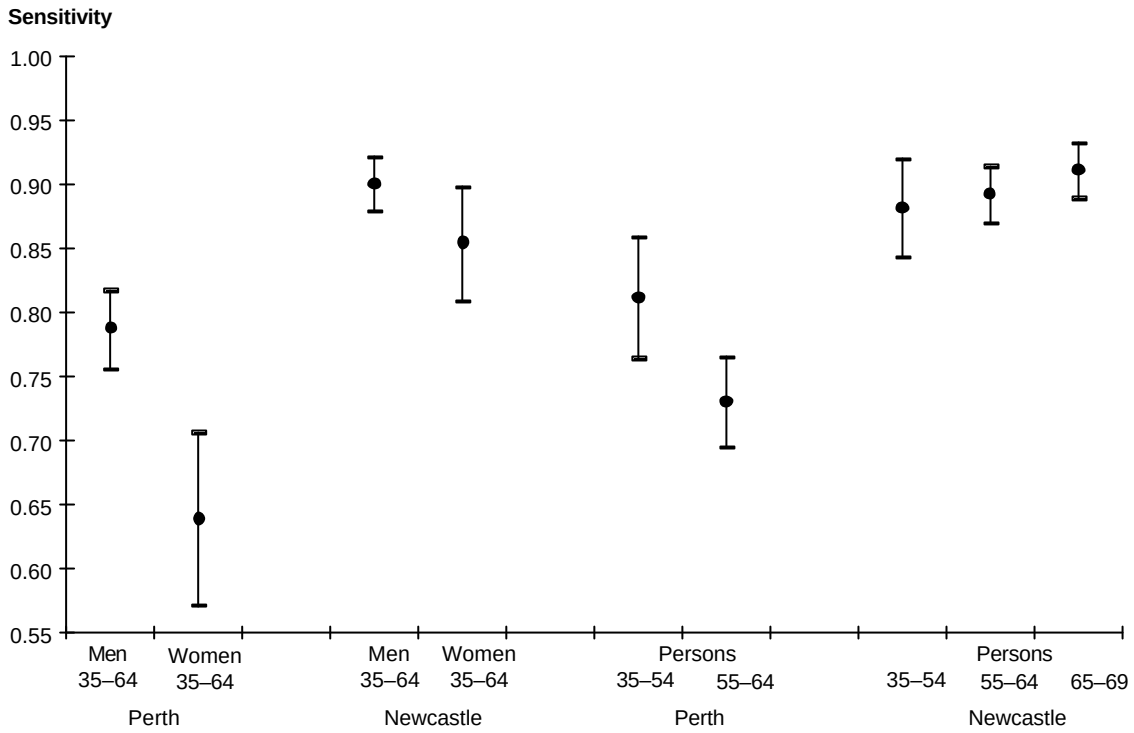


Figure 2.4: Sensitivity analysis for fatal events coded 410–414, using MONICA coronary death as the 'gold standard'

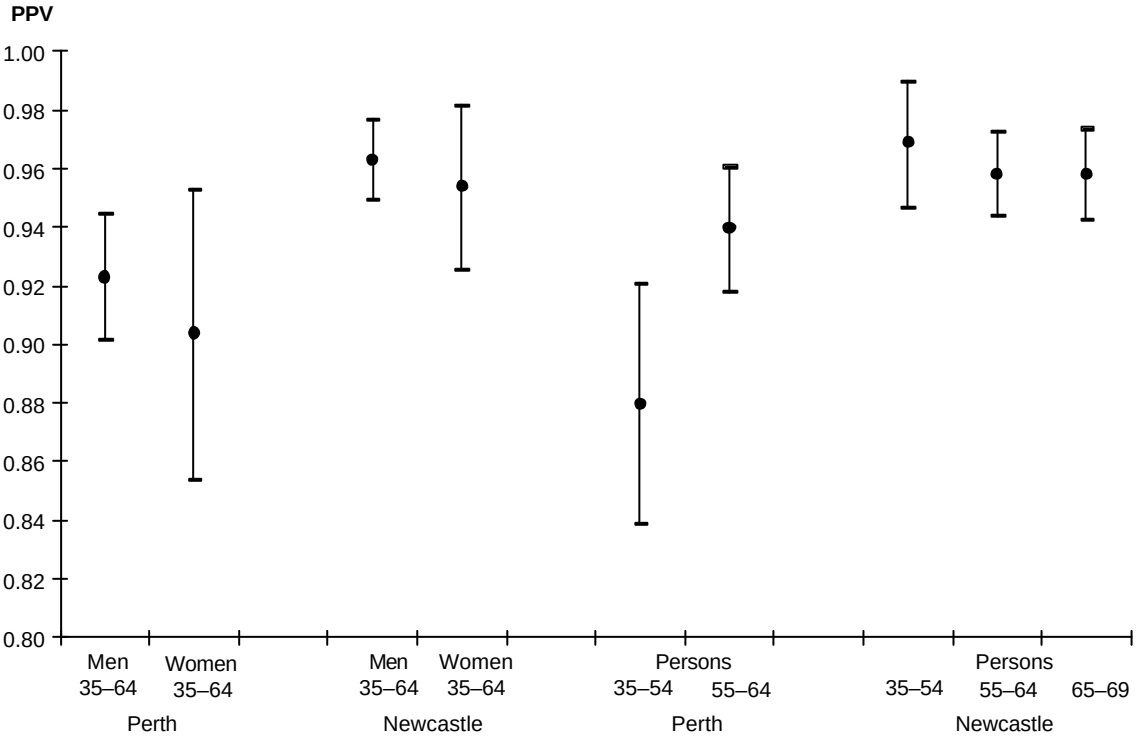


Figure 2.5: Positive predictive value (PPV) for fatal events coded 410–414, using MONICA coronary death as the 'gold standard'

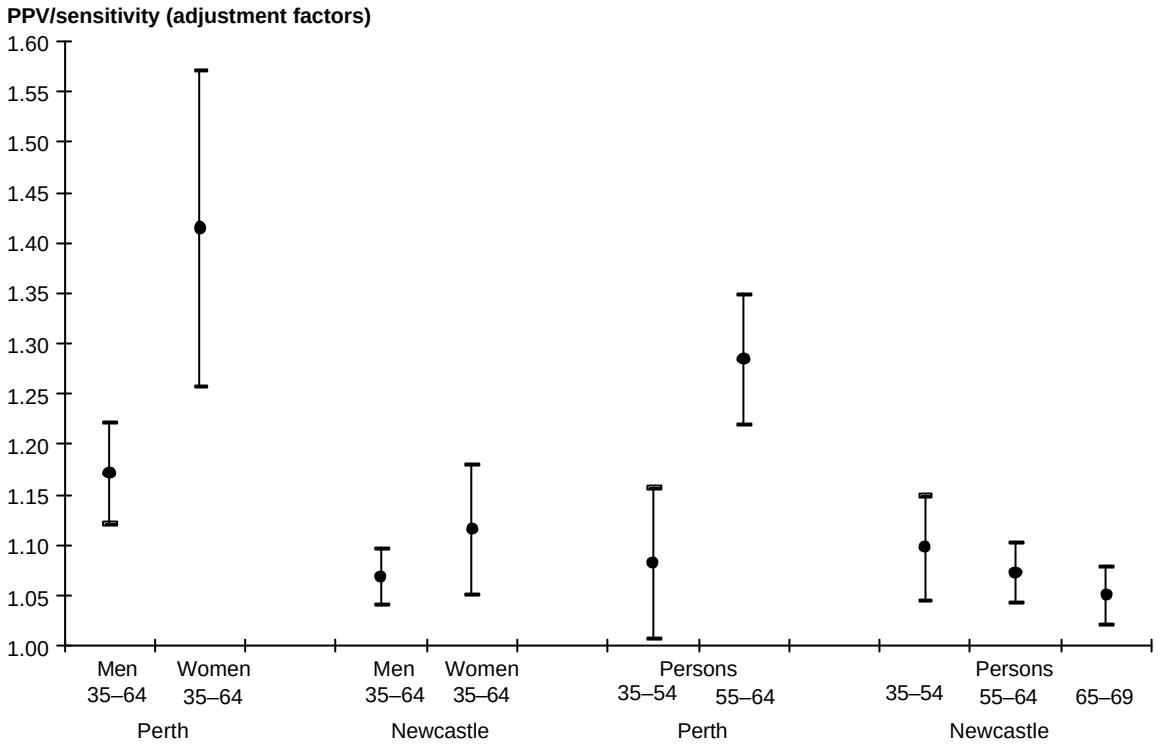


Figure 2.6: Positive predictive value (PPV)/sensitivity analysis for fatal events coded 410–414, using MONICA coronary death as the 'gold standard'

2.2.5 Data issues

The data on which these recommendations are based were mainly collected during the late 1980s and early 1990s. To keep the recommendations up to date regular validation studies will be needed (see Chapter 6).

Case fatality, the ratio of deaths to the total of deaths and non-fatal events, calculated from the estimates recommended here will be considerably higher than expected by clinicians because deaths in the community are included.

To obtain accurate data for monitoring CHD, record linkage is desirable to identify events (hospital admission, transfers, readmissions, and death) which occur for the same person during the same clinically recognised 'episode'. Such linkage is not feasible at present in most settings due to lack of unique identifying information, confidentiality restrictions and technical difficulties. It is, however, available in Western Australia and it was used for the detailed analysis in the next section.

Table 2.4: Comparison of sensitivity analysis for fatal events in Perth 1984–87 to 1991–93

	MONICA diagnosis of AMI			
Death certificate cause of death	**Definite**	**Possible**	**Insufficient data**	**Not AMI**
Men and women 1984–87				
410	289	493	81	26
411–414	41	264	9	57
Other	26	96	63	16
		PPV	**Sensitivity**	**PPV/sensitivity**
410 vs (definite + possible)		88.0	64.7	136.0
410 vs (definite + possible + insufficient[a])		97.1	63.4	153.2
410–414 vs (definite + possible)		86.3	89.9	96.0
410–414 vs (definite + possible + insufficient)		93.4	86.4	108.1
Men and women 1988–90	**Definite**	**Possible**	**Insufficient data**	**Not AMI**
410	156	312	55	16
411–414	19	236	7	36
Other	27	98	65	14
		PPV	**Sensitivity**	**PPV/sensitivity**
410 vs (definite + possible)		86.8	55.2	157.3
410 vs (definite + possible + insufficient)		97.0	53.6	180.9
410–414 vs (definite + possible)		86.4	85.3	101.3
410–414 vs (definite + possible + insufficient)		93.8	80.5	116.5
Men and women 1991–93	**Definite**	**Possible**	**Insufficient data**	**Not AMI**
410	138	201	37	15
411–414	24	257	7	43
Other	27	131	57	25
		PPV	**Sensitivity**	**PPV/sensitivity**
410 vs (definite + possible)		86.7	43.6	199.0
410 vs (definite + possible + insufficient)		96.2	42.8	224.8
410–414 vs (definite + possible)		85.9	79.7	107.8
410–414 vs (definite + possible + insufficient)		92.0	75.5	121.7

AMI = acute myocardial infarction; PPV = positive predictive value (defined in Section 1.2).

(a) Coronary deaths with insufficient information to permit further classification.

2.3 Methods to reduce inflation due to elective readmissions

The value of Hospital Morbidity Data (HMD) for comparative studies of non-fatal AMI depends on two factors:

1. the accuracy of coding of AMI against previously agreed diagnostic criteria; and
2. the extent of inflation of records because of multiple admissions to hospital related to the same episode of AMI.

Section 2.2 described the sensitivity and PPVs of coding non-fatal AMI in HMD in relation to definite AMI as defined by the MONICA diagnostic criteria. While both sensitivity and PPV will be affected by errors in coding, the latter may also be affected by inflation of records due to multiple admissions to hospital related to the same acute event, even when codes have been correctly assigned. This is due partly to transfers between hospitals during the management of the acute episode, but more frequently to elective readmissions for angiography and subsequent revascularisation procedures within eight weeks. Under ICD-9-CM coding rules these further admissions are assigned the code 410. As elective readmissions increased progressively during the 1990s, their inclusion in counts of admissions for AMI diminishes the apparent downward trends in rates of AMI. Elective coronary artery procedures are also more likely to be performed in younger subjects and residents of capital cities compared with smaller towns and rural areas and are thus a potential source of systematic bias in regional studies of AMI.

This section examines possible methods for removing bias due to inflation of hospital admissions with two main purposes in mind:

1. provision of the best estimate of the true level of non-fatal AMI for health service planning and for measuring case fatality; and
2. reducing systematic bias in cross-sectional comparisons and analysis of trends in non-fatal AMI.

2.3.1 Options for reducing inflation of HMD records of AMI

There are two possible approaches to dealing with inflation of HMD records of AMI due to readmissions other than recurrent AMI:

1. the use of record linkage to define episodes of fixed length that will automatically discount elective readmissions within the specified time interval;
2. the use of variables generally included in HMD which, alone or in combination, might distinguish between initial admissions and readmissions;

Candidate variables include:

- whether the code for AMI appears as the main diagnosis or in another diagnostic field;
- a fifth digit extension of the code for AMI (410.x) to distinguish between initial and subsequent hospital admissions (but not transfers) for the same episode of AMI, which was introduced in at least some Australian States in 1990. This will be referred to as the 'modified code 410';

- admission type—booked (elective) or unbooked (emergency); and
- length of stay.

Record linkage

Record linkage may be used to create episodes of fixed duration so that readmissions within the specific time interval can be automatically discounted. This interval might, for example, be of 28 days' duration as in the WHO MONICA Project (which has wide international acceptance), or of 56 days which would be consistent with the ICD 8-week coding rule. Western Australia is at present the only Australian State where record linkage is possible, but record linkage should nevertheless be kept in mind as a future option elsewhere. We have compared the effectiveness of record linkage in reducing inflation due to readmissions with that of alternative methods of record selection for AMI in unlinked data.

Diagnostic field

In Western Australia, the code for AMI appears not as the main diagnosis but in another diagnostic field in approximately 30% of records. In most instances admissions are for elective procedures or complications. Whether inclusion of these cases in studies of AMI based on HMD improves estimates or simply adds unnecessary 'noise' needs to be determined.

Use of the fifth digit extension of the ICD-9-CM code for AMI

In recognition of the problem created by the coding instructions for AMI described above, a fifth digit extension of the code 410.x to distinguish between the initial admission of a new AMI event (code = 1) and follow-up admissions for AMI (code = 2) was introduced in some Australian States in 1990. In Western Australia, a large proportion of cases were coded as 'unspecified' (code = 0) in 1990, but this improved greatly from 1991 onwards. The situation in other States varied but it is likely that the modified code 410 will improve estimates of trends since 1991. For longer term trends, other selection algorithms will be required.

Admission code

In States in which an admission code is included in HMD to distinguish between booked and unbooked admissions, readmissions for elective procedures following AMI will often be coded as booked admissions. This code, alone or in combination with length of stay, should help to eliminate readmissions coded to 410 that are not for new episodes of AMI.

Restricted length of hospital stay

In the Perth MONICA Study, less than 2% of cases of non-fatal definite AMI and 8% of cases of possible AMI had length of stay less than 3 days. In contrast, admissions to hospital for elective angiography or PTCA are generally of shorter duration. Restriction of selection on the basis of length of stay therefore offers one method for discriminating between initial admissions for AMI and related readmissions. For the purpose of this study we have adopted length of stay of three or more days as a selection variable. However, the optimum restriction based on length of stay will vary with local clinical practice and may also change over time.

2.3.2 Methodology

Linked hospital morbidity database (Western Australia)

As part of a wider study of trends in hospital admissions for CVD, we have established a linked database for all hospital admissions and deaths for CHD in Western Australia in the period
1980–95. Probabilistic linkage methods were used to generate a personal identifying number for each individual contained in the file; this was then added to the individual records. By this means, records relating to the same person were aggregated to create episodes of care of fixed length of both 28 and 56-days. The records of the Perth MONICA Study, which validated all hospital admissions for AMI in persons aged 35–64 years for the period
1984–93, were cross-linked to this file.

MONICA registration procedures in Perth

Identification of cases for inclusion in the MONICA register was through retrospective examination of records of cases admitted to hospital for suspected AMI (known within the MONICA Project as 'cold pursuit'). Cases for potential inclusion were principally those in which the code for AMI (ICD-9-CM code 410) was present in any of 19 diagnostic fields. The research nurses responsible for data collection automatically discarded records for readmissions within 28-days from the onset of symptoms, but were also permitted to use their discretion not to register admissions after this period which were clearly not due to a new episode of AMI. It follows that not every hospital admission coded to 410 would generate a record in the MONICA register. It is these unregistered cases particularly that have the potential to lead to substantial overestimates of cases of AMI compared with those defined by MONICA diagnostic criteria.

For the present study we selected all non-fatal cases included in the MONICA register which also had a hospital discharge code of 410 and HMD records with a code of 410 in any diagnostic field for residents of Perth aged 35–64 years for 1991–93 inclusive. This period includes the first three years of complete use of the fifth digit modification of the ICD-9-CM code for AMI and the last three years of the MONICA Study. From cross-linkage, we determined the PPV and sensitivity of hospital records coded to 410 for MONICA definite or (definite + possible) cases using different selection algorithms as described below. Overestimation of AMI as a percentage of MONICA definite or (definite + possible) AMI was determined from (sensitivity/PPV – 1) x 100. As this did not take into account cases of MONICA definite AMI that were coded to diagnoses other than 410 (estimated as up to 15%), a corrected estimate of the level of overestimation was made from
((sensitivity x 0.85)/PPV – 1) x 100.

Separate comparisons were made for unlinked HMD records, for episodes of AMI of 28-days and 56-days based on record linkage, and for various sub-sets of HMD records defined by:

- the presence of the code 410 in the main or other diagnostic field;
- modified code 410;
- type of admission (unbooked or booked);
- length of stay (<3 days or ≥3 days); and
- all combinations of the above.

Estimation of trends in AMI based on MONICA definite AMI and alternative selection methods

In addition to comparing methods of selection of records for estimates of AMI in 1991–93, we tested the comparability of trends in AMI based on MONICA definite AMI with trends based on HMD using linked and unlinked data and the alternative selection algorithms. Change in rates for each year relative to 1984 and the average annual decline were estimated by Poisson regression. The year-to-year consistency of the ratio of cases of AMI in HMD using different selection algorithms to MONICA definite AMI was also examined.

2.3.3 Results

Comparison of cases included in the HMD and those included in the MONICA Register

A detailed analysis of the MONICA registration status of HMD records and MONICA diagnostic categories, where relevant, is given for unlinked data, 28-day episodes and 56-day episodes in Tables A1–A3 (Appendix 1). These show variation in the numbers of unregistered cases by linkage category and in sub-sets of HMD records selected through various combinations of diagnostic field, modified code 410, type of admission and length of stay. They provide the basis for all of the estimates of PPV and sensitivity in the summary tables presented below.

The effects of record linkage on MONICA registration status

As explained in the methodology on page 18, the MONICA register did not include all admissions to hospital with a diagnostic code of AMI (410). This applies particularly to readmissions within the 28-day period of a MONICA event and to admissions up to 56 days for further investigations or revascularisation procedures. A smaller number of cases may not have been registered because they did not meet the MONICA inclusion criteria (for example, usual residential address outside the Perth Metropolitan Area). The principal effects of record linkage on the total number of events and the proportion of these that were not registered by the MONICA Project are shown in Table 2.5.

Table 2.5: The principal effects of record linkage on the total number of events and the proportion of these that were not registered by the Perth MONICA Project

Linkage status	Total events	Registered events	Unregistered events	Proportion of unregistered events (%)
Unlinked hospital admissions	2,782	1,873	909	32.7
28-day episodes	2,296	1,837	459	20.0
56-day episodes	2,069	1,821	248	12.0

In total there were 2,782 separate hospital admission records with a code of 410 in any of up to nineteen diagnostic fields of which 909 (33%) were not registered by the MONICA Study. When record linkage was used to create 28-day and 56-day events the number of total events fell to 2,296 and 2,069 and the proportions of these that were unregistered to 20% and 12% respectively. There was a slight diminution in the number of 28-day and 56-day episodes that linked to a MONICA registered event which were by definition of 28-days' duration. This latter discrepancy is likely to be due to failure of our linkage process to

recreate exactly the same 28-day episodes recorded by MONICA. For example, because MONICA events are estimated from the date of onset of symptoms rather that date of admission to hospital, it would be possible for a single 28-day event based on date of admission to include two MONICA events.

The effect of restricting selection using different combinations of selection criteria on the proportions of unregistered cases is shown in Table 2.6. For example, when only cases with 410 coded as the main diagnosis are considered, the number of unregistered cases falls to 13% in unlinked data and to 8% in 28-day and 56-day events. With the addition of further selection criteria there is progressive reduction of unregistered cases in all linkage categories, but the differences narrow. Thus when all selection criteria are applied unregistered cases fall to 6% in unlinked data and 4% in linked data. There are, moreover, only modest improvements in linked data with the use of main diagnosis and one other variable compared with unlinked data using all selection criteria.

Effects of record linkage and different selection criteria on PPV and sensitivity

While record linkage and the use of additional selection criteria will improve the PPV of HMD for MONICA registered cases, as demonstrated in Tables 2.5 and 2.6, the extent to which sensitivity is also affected is critically important. In Table 2.7 we summarise the effects of record linkage and use of different selection criteria on PPV and sensitivity and, from this, the extent to which AMI will be overestimated compared with MONICA definite AMI.

Table 2.7 shows first that with linkage into 28-day and 56-day episodes there is improvement in PPV from 49% to 58% and 64% respectively, but no change in sensitivity. As a consequence, levels of overestimation decline. As selection is restricted by the use of different selection criteria alone or in various combinations, PPV for MONICA definite AMI improves progressively in unlinked and linked data, but proportionately more in the former as the number of variables in combination is increased. Sensitivity, on the other hand, declines evenly in unlinked and linked data—to approximately 93% when all selection criteria are applied. As the result of this, there are no differences (between linked and unlinked data) in levels of overestimation (approximately 29%) when all restrictions are applied and only marginal differences when selection is made on the basis of main diagnosis and any one or two of the remaining variables.

Of the individual selection criteria, main diagnosis produces the greatest improvement in overestimation (down to 45% from 106% in unlinked data), followed by modified code 410 (down to 49%), unbooked admissions (down to 59%) and length of stay 3+ (down to 65%). Full implementation of modified code 410 therefore has the potential to provide unbiased estimates of trends in the incidence of AMI. When main diagnosis is selected in combination with any one of the remaining variables in unlinked data, overestimation ranged from 33% to 36%, and with any two, from 27% to 30%. At this level there was no difference between the results for unlinked and linked data.

In Table 2.8 the same analysis is shown when the performances of the selection criteria are matched against the combined MONICA non-fatal diagnostic categories (definite + possible). The levels of overestimation of cases of AMI in HMD are obviously much less, but the patterns of overestimation are much the same as in Table 2.7. For example, when selection is restricted to the main diagnosis field and one other variable, the level of overestimation ranges from 4% to 6%, while sensitivity is maintained at 0.90–0.92. As the number of restrictions on selection is further increased, overestimation is virtually eliminated.

Table 2.6: Total events and proportion of events not registered by the Perth MONICA Study by linkage status and various selection algorithms

No. of restrictions	Selection criteria				Unlinked data			28-day episode			56-day episode		
						Unregistered			Unregistered			Unregistered	
	Diag field	5th digit	Atype	LOS	Total	Number	Per cent	Total	Number	Per cent	Total	Number	Per cent
0	Any	Any	Any	Any	**2,782**	909	33	**2,296**	456	20	**2,069**	256	12
1	Any	Any	Any	3+	**2,229**	419	19	**1,962**	184	9	**1,883**	132	7
1	Any	Any	Unbooked	Any	**2,149**	377	18	**1,904**	162	9	**1,839**	121	7
1	Any	1	Any	Any	**2,007**	209	10	**1,944**	151	8	**1,936**	145	7
1	Main	Any	Any	Any	**1,960**	261	13	**1,825**	153	8	**1,810**	139	8
2	Any	Any	Unbooked	3+	**2,010**	295	15	**1,813**	128	7	**1,762**	101	6
2	Any	1	Any	3+	**1,900**	161	8	**1,840**	107	6	**1,836**	107	6
2	Any	1	Unbooked	Any	**1,862**	151	8	**1,812**	106	6	**1,811**	107	6
2	Main	Any	Any	3+	**1,794**	153	9	**1,705**	90	5	**1,702**	88	5
2	Main	Any	Unbooked	Any	**1,795**	144	8	**1,718**	91	5	**1,715**	89	5
2	Main	1	Any	Any	**1,832**	157	9	**1,783**	116	7	**1,779**	113	6
3	Any	1	Unbooked	3+	**1,786**	130	7	**1,741**	91	5	**1,740**	92	5
3	Main	Any	Unbooked	3+	**1,716**	119	7	**1,649**	76	5	**1,646**	74	4
3	Main	1	Any	3+	**1,740**	121	7	**1,693**	83	5	**1,692**	83	5
3	Main	1	Unbooked	Any	**1,751**	120	7	**1,711**	87	5	**1,710**	87	5
4	Main	1	Unbooked	Any	**1,678**	100	6	**1,642**	72	4	**1,641**	72	4

Atype = type of admission—booked or unbooked; Diag = diagnostic; LOS = length of stay.

Table 2.7: PPV, sensitivity and overestimate of AMI from HMD compared with the MONICA diagnostic category of *definite* AMI

	Selection criteria				Unlinked data			28-day episode			56-day episode		
Number of restrictions	Diag field	5th digit	Atype	LOS	PPV	Sens	Overestimate (%)	PPV	Sens	Overestimate (%)	PPV	Sens	Overestimate (%)
0	Any	Any	Any	Any	0.49	1.00	106	0.58	1.00	72	0.64	1.00	56
1	Any	Any	Any	3+	0.59	0.98	65	0.67	0.98	47	0.69	0.98	42
1	Any	Any	Unbooked	Any	0.61	0.97	59	0.68	0.97	43	0.70	0.97	39
1	Any	1	Any	Any	0.66	0.98	49	0.68	0.99	46	0.68	1.00	46
1	Main	Any	Any	Any	0.66	0.95	45	0.69	0.95	37	0.70	0.96	37
2	Any	Any	Unbooked	3+	0.64	0.95	49	0.70	0.95	36	0.71	0.95	33
2	Any	1	Any	3+	0.68	0.96	41	0.70	0.97	38	0.70	0.98	39
2	Any	1	Unbooked	Any	0.68	0.95	38	0.71	0.96	36	0.71	0.97	37
2	Main	Any	Any	3+	0.70	0.93	33	0.73	0.93	28	0.73	0.94	29
2	Main	Any	Unbooked	Any	0.70	0.93	33	0.72	0.93	29	0.72	0.93	30
2	Main	1	Any	Any	0.69	0.94	36	0.71	0.95	34	0.71	0.96	34
3	Any	1	Unbooked	3+	0.70	0.93	32	0.72	0.94	31	0.72	0.95	32
3	Main	Any	Unbooked	3+	0.72	0.91	27	0.74	0.91	24	0.74	0.92	24
3	Main	1	Any	3+	0.72	0.92	29	0.73	0.93	27	0.73	0.94	28
3	Main	1	Unbooked	Any	0.71	0.92	30	0.72	0.93	29	0.72	0.93	29
4	Main	1	Unbooked	Any	0.71	0.92	30	0.72	0.93	29	0.72	0.93	29

AMI = acute myocardial infarction; Atype = type of admission—booked or unbooked; Diag = diagnostic; HMD = hospital morbidity data; LOS = length of stay; PPV = positive predictive value; Sens = sensitivity.

Table 2.8: PPV, sensitivity and overestimate of AMI from HMD compared with MONICA diagnostic categories of *definite and possible* AMI

	Selection criteria				Unlinked data			28-day episode			56-day episode		
Number of restrictions	Diag field	5th digit	Atype	LOS	PPV	Sens	Overestimate (%)	PPV	Sens	Overestimate (%)	PPV	Sens	Overestimate (%)
0	Any	Any	Any	Any	0.62	1.00	61	0.74	1.00	35	0.81	1.00	23
1	Any	Any	Any	3+	0.75	0.97	29	0.84	0.97	16	0.86	0.97	12
1	Any	Any	Unbooked	Any	0.77	0.96	24	0.86	0.96	12	0.88	0.96	10
1	Any	1	Any	Any	0.83	0.97	16	0.86	0.98	14	0.86	0.99	15
1	Main	Any	Any	Any	0.82	0.93	13	0.87	0.93	7	0.87	0.94	8
2	Any	Any	Unbooked	3+	0.80	0.93	16	0.87	0.93	7	0.89	0.93	5
2	Any	1	Any	3+	0.85	0.93	10	0.87	0.95	8	0.87	0.96	10
2	Any	1	Unbooked	Any	0.86	0.93	8	0.89	0.94	7	0.89	0.96	8
2	Main	Any	Any	3+	0.87	0.90	4	0.90	0.90	0	0.90	0.91	1
2	Main	Any	Unbooked	Any	0.87	0.91	4	0.90	0.91	1	0.90	0.92	2
2	Main	1	Any	Any	0.87	0.92	6	0.89	0.93	5	0.89	0.94	6
3	Any	1	Unbooked	3+	0.87	0.90	3	0.89	0.91	3	0.89	0.92	4
3	Main	Any	Unbooked	3+	0.89	0.88	–1	0.91	0.88	–3	0.91	0.89	–2
3	Main	1	Any	3+	0.88	0.89	1	0.90	0.90	0	0.90	0.91	1
3	Main	1	Unbooked	Any	0.89	0.90	1	0.90	0.91	1	0.90	0.92	2
4	Main	1	Unbooked	Any	0.90	0.87	–3	0.91	0.88	–3	0.91	0.89	–2

AMI = acute myocardial infarction; Atype = type of admission—booked or unbooked; Diag = diagnostic; HMD = hospital morbidity data; LOS = length of stay; PPV = positive predictive value; Sens = sensitivity.

Table 2.9: Overestimates of AMI compared with MONICA *definite* AMI adjusted for MONICA cases not coded to 410 in HMD (per cent)

	Selection criteria				Unlinked data		28-day episode		56-day episode	
Number of restrictions	Diag field	5th digit	Atype	LOS	From Table 2.7	Adjusted	From Table 2.7	Adjusted	From Table 2.7	Adjusted
0	Any	Any	Any	Any	106	75	72	47	56	33
1	Any	Any	Any	3+	65	40	47	25	42	21
1	Any	Any	Unbooked	Any	59	35	43	22	39	18
1	Any	1	Any	Any	49	26	46	24	46	24
1	Main	Any	Any	Any	45	23	37	16	37	16
2	Any	Any	Unbooked	3+	49	26	36	16	33	13
2	Any	1	Any	3+	41	20	38	17	39	18
2	Any	1	Unbooked	Any	38	17	36	16	37	16
2	Main	Any	Any	3+	33	13	28	9	29	10
2	Main	Any	Unbooked	Any	33	13	29	10	30	11
2	Main	1	Any	Any	36	155	34	14	34	14
3	Any	1	Unbooked	3+	32	12	31	11	32	12
3	Main	Any	Unbooked	3+	27	8	24	5	24	5
3	Main	1	Any	3+	29	9	27	8	28	9
3	Main	1	Unbooked	Any	30	10	29	9	29	10
4	Main	1	Unbooked	Any	30	10	29	9	29	5

AMI = acute myocardial infarction; Atype = type of admission—booked or unbooked; Diag = diagnostic; HMD = hospital morbidity data; LOS = length of stay.

Table 2.10: Non-fatal MONICA *definite* AMI and cases of AMI from hospital morbidity data using record linkage or other selection algorithms—annual age-standardised rates relative to 1984 and average annual decline

	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993	Average annual decline (95% confidence interval)
Males											
MONICA non-fatal definite and HMD = 410	100.0	104.2	97.5	93.6	92.7	85.3	88.7	86.3	79.0	75.2	3.2 (2.2, 4.2)
HMD linked 410	100.0	103.5	104.4	95.7	95.7	91.2	94.9	90.1	76.3	82.0	2.7 (1.8, 3.6)
HMD linked 410 (56-day)	100.0	101.9	102.1	94.2	93.4	89.2	92.1	89.8	80.5	83.0	2.4 (1.5, 3.3)
HMD unlinked any 410	100.0	104.0	103.3	99.4	110.5	107.3	109.8	108.9	95.8	100.3	0.1 (–0.7, 0.9)
HMD unlinked main 410	100.0	106.3	107.7	99.3	97.3	96.1	97.3	91.8	77.9	81.6	2.9 (2.1, 3.8)
HMD unlinked 410, LOS 3+ days	100.0	103.7	103.2	93.1	93.6	87.2	91.1	89.0	77.3	80.9	2.9 (2.0, 3.8)
HMD unlinked 410, unbooked	100.0	104.9	109.1	106.6	102.9	95.9	94.9	83.6	83.9	86.3	2.5 (1.6, 3.4)
HMD unlinked 410. LOS 3+ days, unbooked	100.0	106.1	107.4	96.2	97.9	90.8	94.7	93.2	81.7	85.2	2.5 (1.5, 3.4)
Females											
MONICA non-fatal definite and HMD = 410	100.0	77.6	78.4	83.8	84.1	94.7	97.4	75.1	73.5	66.0	2.3 (–0.1, 4.5)
HMD linked 410	100.0	76.6	91.1	92.6	81.7	92.7	97.4	82.5	73.6	61.1	2.9 (1.0, 4.7)
HMD linked 410 (56-day)	100.0	77.6	88.3	91.3	80.1	92.8	93.9	82.6	74.7	62.5	2.7 (0.8, 4.5)
HMD unlinked any 410	100.0	74.6	93.3	92.4	90.5	98.2	103.9	91.4	84.5	82.5	0.4 (–1.3, 2.0)
HMD unlinked main 410	100.0	76.2	92.5	95.7	85.4	94.2	97.9	85.4	72.8	59.1	3.0 (1.2, 4.8)
HMD unlinked 410, LOS 3+ days	100.0	82.1	89.3	95.6	81.3	98.9	100.1	83.0	78.0	65.4	2.5 (0.5, 4.4)
HMD unlinked 410, unbooked	100.0	77.8	93.1	96.8	88.2	98.8	94.6	91.1	73.8	62.5	3.1 (1.2, 4.9)
HMD unlinked 410. LOS 3+ days, unbooked	100.0	83.7	92.2	94.3	83.9	101.1	99.4	81.4	78.4	67.9	2.5 (0.5, 4.4)

AMI = acute myocardial infarction; HMD = hospital morbidity data; LOS = length of stay.

Adjustment for cases of AMI coded to diagnoses other than 410

The levels of overestimation of AMI compared with MONICA diagnostic categories shown in Tables 2.7 and 2.8 do not take into account the extent to which MONICA definite and possible AMI are assigned to codes other than 410—for example, to 411.1 (unstable angina) or 413 (other angina). In Perth, the sensitivity of code 410 for detection of cases of definite AMI was 0.87 for persons aged 35–54 years and 0.82 for persons aged 55–64 years (Figure 2.1). If a value of 0.85 is assumed to apply to all ages, the overestimation of AMI in Table 2.7 would be reduced accordingly. The effect of this additional adjustment is shown in Table 2.9. It shows, for example, that when selection from unlinked data is restricted using all variables, the degree of overestimation of AMI would fall from 30% to only 10%.

The sensitivity with which code 410 identifies cases of MONICA definite + possible AMI has not been determined but is known to be less than for definite AMI alone. Adjustment for cases coded to other diagnoses would thus reduce the level of overestimation even more than illustrated in Table 2.9.

Comparison of time trends in AMI based on different selection algorithms with MONICA definite AMI

From the previous tables, it appears that either the use of main diagnosis or the use of modified code 410, alone or in combination with other selection criteria, provide the best estimate of trends of AMI since 1991. The disadvantage of using main diagnosis is that it may be unstable over time. However, in States in which modified code 410 is not used, selection algorithms based on main diagnosis may be the most appropriate. To illustrate how these might perform in practice, we have compared trends in AMI based on HMD using selected algorithms from Table 2.6 with the trend in MONICA definite AMI in the period 1984–93. Numbers of such cases by year are shown in Appendix Table A4.

The age-adjusted ratio of rates of AMI for each year relative to 1984, determined from Poisson regression, and the average annual decline in rates of AMI for each of the groups are shown in Table 2.10. In males, the average annual decline in MONICA definite AMI was 3.2% (95% confidence interval (CI): 2.2–4.2%) and in the remaining groups in which AMI was the main diagnosis ranged from 2.5% to 2.9%. Thus while trends based on HMD were consistently less than for MONICA definite AMI, they were not significantly different. In females the average annual decline in MONICA definite AMI was 2.3% (95% CI:0.1–4.5%) while the declines in rates based on HMD were higher, ranging from 2.5% to 3.1%.

The apparent rates of decline based on incidence calculated from cases with a code for AMI in any diagnostic field stand out from the remaining groups in showing no decline in males and a much lower decline in females. Because of the overlap in confidence intervals, the results in Table 2.10 do not help us to identify an optimum method for determining trends in AMI without case validation. However, consistency is obviously important, as marked year-to-year variation could greatly affect trends over shorter time periods. To assess this, the ratio of MONICA definite AMI to cases of AMI determined from HMD using different selection methods is shown in Figure 2.7.

For unlinked cases in which a code for AMI occurred in any diagnostic field, this ratio increased progressively from 165% to 220% in males and 198% to 247% in females and clearly diverged from that for the remaining groups in which 410 was assigned as the main diagnosis. For the remaining groups, the ratios increased only marginally in males and fell slightly in females. It thus appears that while there was a marked increase in readmissions coded to 410 in this period, in such cases the code was increasingly assigned

to a field other than main diagnosis. This volatility suggests that main diagnosis only should be used in routine tabulations of AMI.

While there were only slight overall increases in the ratio of HMD to MONICA cases in the groups with 410 as main diagnosis, this tended to obscure larger intermediate rises in all unlinked and unbooked cases. With the exception of 1993, the most consistent ratio of HMD to MONICA cases occurred in 56-day events and cases with length of stay 3+ days.

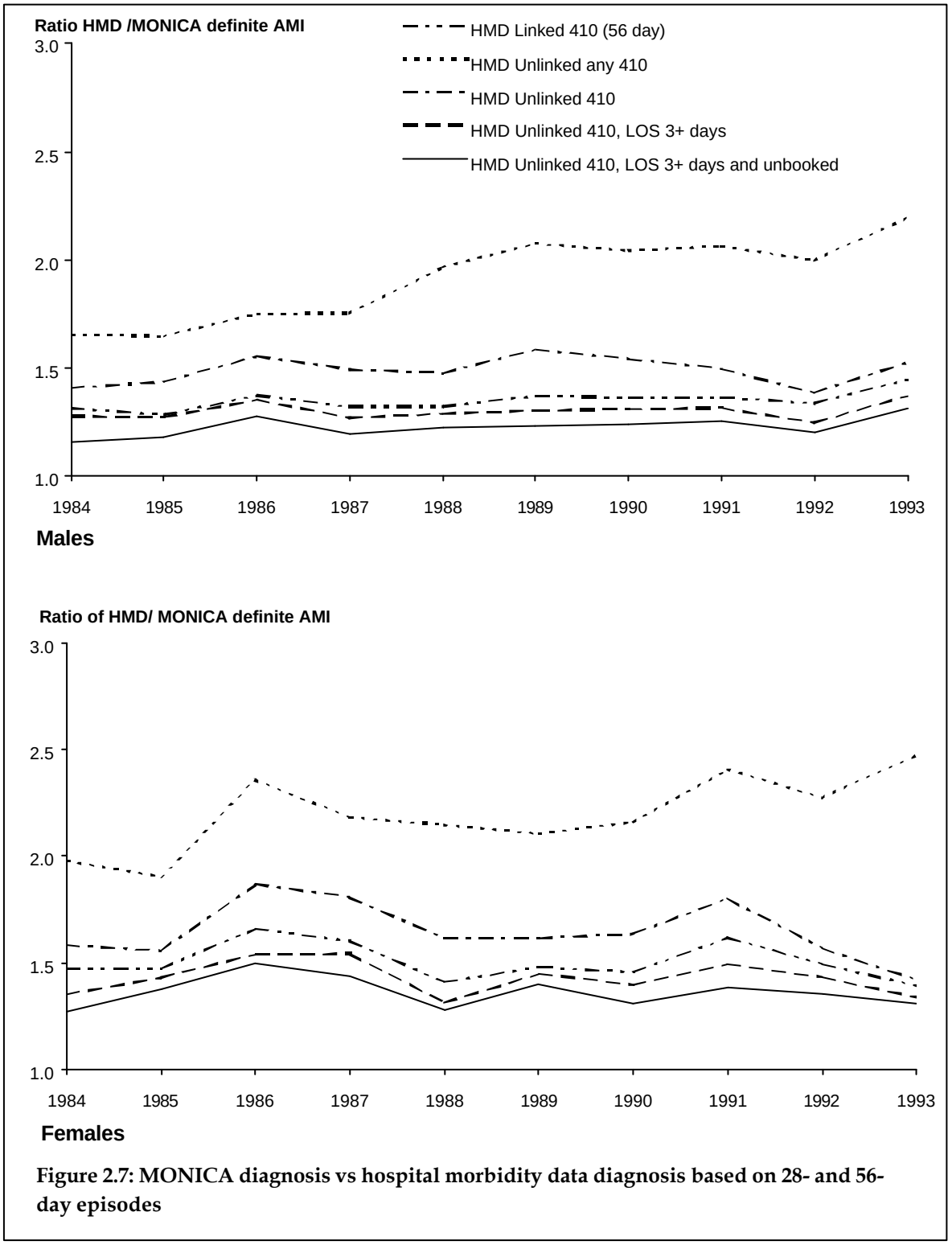


Figure 2.7: MONICA diagnosis vs hospital morbidity data diagnosis based on 28- and 56-day episodes

2.3.4 Discussion

The effects of record linkage on case selection

This record linkage analysis has demonstrated large discrepancies between the number of hospital admissions and the number of cases registered by a formal CHD register. The differences were greatest when a code of AMI in any diagnostic field was considered but even when main diagnosis was considered a large excess of unregistered cases remained. Linkage to create 28-day events (corresponding to the MONICA definition of an event) or 56-day events (which is consistent with ICD coding rules) reduced the excess of unregistered cases from 33% in unlinked data to 20% and 12%, respectively, with little loss of cases of MONICA definite AMI from the remaining records. This is consistent with the proposition that a large proportion of the redundant admissions are readmissions for further investigation or coronary revascularisation procedures.

Record linkage is unfortunately possible only in Western Australia and can therefore not be used for assessing national trends. The study has nevertheless shown that the effects of record linkage can be replicated in unlinked data using selection algorithms based on combinations of main diagnosis, the fifth digit qualification of the ICD-9-CM diagnostic code 410, type of admission and length of stay. It was found, for example, that when all of the selection variables were used, the residual levels of overestimation of AMI in linked and unlinked data were almost identical. It was also apparent that as additional selection variables were introduced, incremental improvements became less. This suggests a high degree of association between the variables with regard to their effects on selection. Thus while it would appear to be preferable to use all selection variables, the results may not be greatly inferior if the use of only three or even two is possible. In selecting other combinations of variables it is useful to understand their individual effects on selection of cases.

Effects of individual variables

Diagnostic field

Given that it may not be possible to use all selection variables described in this study in all circumstances, we need to consider the separate performance of each. From Table 2.6 it was seen that in unlinked data, the greatest individual effects on levels of overestimation were from restriction of diagnostic field and modified code 410, followed by unbooked admission and length of stay three or more days. Scrutiny of cases with a code of 410 in any diagnostic field is important for case identification. Records in which the diagnosis of 410 was not in the main diagnosis field yielded about 5% of cases of definite AMI registered by the Perth MONICA Study. The results of the present analyses, however, indicate quite clearly that inclusion of these cases add too much 'noise' to be used in routine tabulations. We therefore recommend that only cases with a main diagnosis of 410 should be considered for this purpose.

Fifth digit modification of ICD-9-CM code 410

The fifth digit modification of ICD-9-CM code 410 seems to have partly served the purpose for which it was introduced in Western Australia but disappointingly does not completely discriminate between new cases of AMI and related readmissions. It is not intended to identify transfers between hospitals during the acute phase of care, and in regions where

this is a common occurrence we would not expect it to perform so well. Examination of its use in a sample of readmissions in Newcastle also raises doubts about its accuracy and consistency of use. As a recent study in Melbourne showed, one advantage of the modified code, if it were applied consistently, is that it can be used directly to determine case fatality in cases of AMI managed in hospital (O'Hara & McDonald 1997). Further work is therefore required to assess the accuracy of the modified code outside Western Australia and the extent to which it has been adopted in other States.

The New South Wales ACCS was conducted approximately six years after the fifth digit code was introduced. The fifth digit code was unspecified or incorrectly specified (i.e. coded to a value other than 1 or 2) in 22% of patients who were discharged alive with a primary diagnosis of 410. This shows that the fifth digit code is still not used sufficiently well in New South Wales for it to be useful for reducing inflation due to elective readmission. The fifth digit was more widely used in the major city hospitals but even in principal referral hospitals it was unspecified in 16% of records.

Type of admission—booked and unbooked admissions

The code for booked or unbooked admissions used in the Western Australian HMD only partly distinguishes between initial admissions and subsequent readmissions, with a reduction in level of overestimation marginally better than the use of length of stay three days or more. When combined with main diagnosis, however, performance was similar to that resulting from the combination of main diagnosis and length of stay 3+. On the other hand, the combination of main diagnosis, unbooked admission and length of stay 3+ provides better results than any other combination of three variables.

We have assumed that an admission code similar to that used in Western Australia is used in HMD in other States but have not attempted to verify this or to determine whether the definitions of booked and unbooked cases are the same.

Length of stay

Restriction of selection on the basis of a short length of stay is universally possible and operationally simple. One concern with the use of an arbitrary cut-point for length of stay is that as the duration of hospital stays continues to decline, bias in favour of declining rates could be introduced as an increasing proportion of true cases of AMI are excluded. This did not seem to be a problem during the period of the present study as less than 2% of the events meeting the criteria of non-fatal MONICA definite AMI had stays of less than three days. On the other hand, 8% of cases of possible AMI had length of stay less than three days. While this is likely to be less for cases of possible AMI that meet the Finnish definition of probable AMI (Salomaa et al. 1997), any further decline in length of stay in these cases means that the balance between definite and possible (or probable) cases included in the selection will change over time. A method therefore needs to be developed to test for the possible effects of declining length of stay on case selection.

Choosing selection algorithms

The choice of other variables to use in combination with the main diagnosis will vary with different circumstances and according to the objectives of a particular study. For example, if the main concern is to produce the best absolute estimate of AMI or to determine case fatality, selection using all of the available selection variables would be preferred. On the other hand, if the objective is to measure trends, fewer variables may be adequate. In any case, as the modified code 410 was introduced only in 1990 and may not have been fully

effective until later, it is of no value for examining long-term trends commencing before this date.

The effects of different selection algorithms on trends in AMI

The ultimate test of a selection algorithm for monitoring AMI using HMD is whether it produces the same results as for trends measured in validated cases. This study has shown that compared with trends based on MONICA definite AMI the average annual decline in persons 35–64 years over the period from 1984–93 in HMD using various selection algorithms was slightly less in males and more in females. While these differences were not statistically significant, the possible reasons for discrepancies in the results in males at least (which are based on much larger numbers than females), need to be considered. First, the lower rate of decline shown in the HMD could be due to failure of the algorithms to consistently remove records that were not for a new AMI. We found for example that there was considerable year-to-year variability in the ratios of MONICA cases to HMD records selected by different methods, even though the overall trends were closely similar. The results may therefore have been different if we had examined trends over different time intervals, for example, the first or last five years of the decade covered by the MONICA Project. Given this variability, combinations of several variables may give more consistent results than only one or two.

Alternatively, the lower rate of decline in trends based on HMD could be due to a change in the proportions of definite and possible cases of AMI among cases diagnosed clinically as AMI, as was in fact the case in last three years of the Perth MONICA Study. In this situation trends based on HMD may replicate better trends based on MONICA definite and possible cases combined. If the primary purpose of monitoring is to monitor incidence, then the lower rate of decline shown in HMD would be of concern. On the other hand, if it is to determine whether the caseload of AMI is changing, trends based on selected HMD could be more relevant.

Developing selection algorithms for use in older age groups

As the MONICA Study in Perth was restricted to registration of cases in persons under 65 years of age, we have no 'gold standard' to assess the best selection methods for older cases. However, if we assume that 56-day linkage provides the best single method for eliminating records related to readmissions not due to a new AMI, this could be used in older age groups to test the effectiveness of different algorithms in unlinked data.

The effect of using 'probable' AMI as well as 'definite' AMI to test the accuracy of HMD for monitoring AMI

As the diagnostic criteria for MONICA definite AMI are more conservative than those generally used in clinical practice, rates based on definite AMI alone underestimate cases of AMI treated by clinicians. On the other hand, since the category non-fatal possible AMI includes cases that have typical symptoms of AMI (prolonged chest pain) with no confirmatory clinical evidence of AMI, the combination of definite and possible AMI overestimates the true number of cases of AMI treated in hospital. Members of the Finnish MONICA Study have divided MONICA possible cases into 'probable' in which ECG and/or enzyme abnormalities are present, and 'prolonged chest pain' in those with normal enzymes and ECGs. The Newcastle MONICA Study used the 'hot pursuit' method for case finding and therefore were able to investigate the usefulness of using 'probable' AMI as well as 'definite' AMI to test the accuracy of HMD for monitoring AMI. Results from the Newcastle Study indicated that the inclusion of 'probable' AMI led to a decrease

in sensitivity, possibly due to a reliance on ECG abnormalities rather than ECG changes, and therefore 'probable' AMI should not be used for monitoring AMI.

2.3.5 Further studies

While the algorithms described previously would almost certainly result in improved estimates of trends in AMI in national data, there are a number of areas where further work is required. These are as follows:

- linkage methods should be used in Western Australia to determine the best selection algorithms for estimating rates of AMI in persons 65 years and over;
- information needs to be obtained from other States on the availability of information on booked and unbooked admissions and the extent of use of the fifth digit modification of code 410; and
- sensitivity analyses should be conducted on differences in trends using different selection algorithms over a wide range of populations in national data—for example for individual States and capital cities, larger cities and rural populations. These might be conducted directly by AIHW or in Perth or Newcastle using data supplied by AIHW.

2.4 Investigations and procedures

Admissions coded ICD-9-CM 413–414 include acute admissions as well as admissions for investigations and procedures. Therefore they should be subdivided into:

- unbooked admissions;
- booked admissions with percutaneous transluminal coronary angioplasty (PTCA) and coronary artery bypass grafting (CABG);
- booked admissions without PTCA or CABG.

The reason for this recommendation is that these admissions are strongly determined by local policies and availability of services.

Admission rates for each of these categories (separately) should be monitored without any adjustments because issues such as the validity of coding are less crucial than the levels of service delivery shown by the data.

2.5 Conclusion

For monitoring incidence of CHD it is recommended that:

1. The rate of coronary events should be calculated as the sum of the rate of coronary deaths estimated from death certificates and the rate of non-fatal AMIs estimated from hospital separations.
2. For fatal coronary events, deaths with (ICD-9) codes 410–414 should be used with adjustment factors to account for underestimation. The single ICD-9 code of 410 is not adequate.
3. For non-fatal AMI, hospital separations should be used where the patient is discharged alive, the primary diagnosis is coded 410 using ICD-9-CM and the length

of stay is greater than two days. Adjustment factors should be used to account for overestimation due to hospital transfers, readmissions and other effects.

4. Further studies are needed on the use of more detailed hospital information, such as additional ICD coding and whether a hospital admission was unplanned to improve the validity of data on non-fatal AMIs. Also the occurring of routinely collected data for people aged over 65 years requires further investigation.
5. Separate validation studies are needed for fatal and non-fatal events as the data sources and diagnostic criteria differ.

3 Angina

3.1 Introduction

Angina is a symptom of CHD and people who are admitted to hospital with symptomatic angina will undergo a series of tests to exclude AMI. The most commonly used tests are ECG and measurement of cardiac enzymes, generally creatinine phosphokinase (CPK) and aspartate transaminase (AST). For those whose ECGs and enzyme levels exclude them from the category of AMI, their recent medical history and any ECG changes or raised enzyme levels insufficient to categorise them as having AMI are used in making a diagnosis of unstable angina, angina pectoris (ICD-9-CM code 413) or chest pain (ICD-9-CM code 786.5). Patients with changes in ECGs or changes in levels of cardiac enzymes that are not sufficient to satisfy the definition of definite AMI are the most likely to receive a final diagnosis of unstable angina pectoris. For other patients, chest pain that is deemed to be ischaemic in origin should be coded as angina pectoris (413) and chest pain that is not deemed to be ischaemic in origin should be coded as chest pain (786.5). Patients who have unstable angina should have their primary discharge diagnosis coded to the ICD-9-CM code 411 but if the unstable angina progresses to AMI, the primary discharge diagnosis should be coded to 410 with no mention of 411 in any secondary diagnostic field.

Angina is classically described in relation to its characteristic location, radiation, precipitating and relieving factors. In clinical practice however, patients rarely present with all the classical features of angina and the final assessment is often a qualitative one based on how closely the patients subjective experience resembles the classical picture of angina. Therefore the selection of a primary discharge diagnosis for patients admitted with angina is likely to vary from clinician to clinician and between geographic areas. In addition, a diagnosis of unstable angina is sometimes applied to patients who develop recurrent bouts of angina having previously been free of such symptoms, and other times it is applied to those who develop anginal pain predictably in certain circumstances but whose pain has become more frequent, more prolonged, more severe or more easily provoked.

This chapter looks at the available information to determine if hospital morbidity data (HMD) can be used to monitor trends in angina pectoris and to determine if there is sufficient evidence in the medical records to validate a discharge diagnosis of angina pectoris.

3.2 Methodology

The extent to which HMD could be used to monitor trends in angina pectoris is assessed using Newcastle MONICA data for the full calendar years from 1987–91. For this period, MONICA events were cross-referenced with all hospital separations in the Lower Hunter Region, the same area as was monitored by the MONICA Study in Newcastle. The linked records are used to compare MONICA diagnostic categories of non-fatal definite AMI, non-fatal probable AMI and prolonged chest pain with the primary discharge diagnoses

recorded in the HMD. As described in Chapter 2 the presenting symptoms, ECG changes and cardiac enzyme levels determine the MONICA diagnostic categories.

The MONICA definition of definite AMI is strict and excludes cases that some clinicians would consider AMI. However, a well-defined criterion is more suitable for monitoring AMI because a clinical assessment of AMI is likely to vary over time and between areas. Those cases that some clinicians would consider AMI but that would not satisfy the MONICA criteria for definite AMI were monitored by collecting information on all patients who were admitted to hospital with an initial diagnosis of suspected AMI. Patients who did not satisfy the MONICA criteria for definite AMI but who had chest pain that lasted longer that 20 minutes without any other cause established were categorised as having possible AMIs. Cases of MONICA possible AMI were later categorised as either probable AMI or cases of prolonged chest pain (Salomaa et al. 1997). A classification of probable AMI requires typical symptoms and some ECG or enzyme changes and these cases would be similar to clinically defined unstable angina. Cases of MONICA possible AMI that did not satisfy the criteria of probable AMI were categorised as 'prolonged chest pain'—these patients would be similar to patients recognised clinically as having angina pectoris.

Data from the New South Wales Acute Cardiac Care Study (ACCS) are used to assess whether the amount of information available in hospital medical records is sufficient to validate a diagnosis of angina pectoris and therefore to determine if a discharge diagnosis of angina pectoris can be validated by a retrospective review of medical records.

3.3 Results

3.3.1 MONICA records linked with HMD records

The cross tabulation of MONICA records with HMD for the period from 1987–91 is shown in Table 3.1. As was stated in Chapter 2, over 80% of patients discharged from hospital alive with a primary discharge diagnosis of AMI satisfied the MONICA criteria of definite or probable AMI. In contrast, only 61% of patients who were given a primary discharge diagnosis of unstable angina satisfied the MONICA criteria for a coronary event (i.e. definite or probable AMI or prolonged chest pain) and even fewer of the patients who were given a primary discharge diagnosis of angina pectoris satisfied the MONICA criteria for a coronary event (42%). Although it appears that patients who satisfied the MONICA criteria for a more severe event did tend to be given a primary discharge diagnosis for a more severe event, the association is not strong except in the case of definite AMI. For example, of the 1,662 patients who satisfied the MONICA criteria for probable AMI, 21% were given a primary diagnosis of AMI, 25% were given a primary diagnosis of unstable angina, 22% were given a primary diagnosis of angina pectoris, 11% were given a primary diagnosis of chest pain, and the remaining 20% were given some other primary diagnosis. These data also show that only 23% of patients who were given a primary diagnosis of chest pain at discharge had chest pain that was cardiac in origin.

Table 3.1: Number (row percentage) of hospital separations between 1987 and 1991 by MONICA diagnostic category and primary discharge diagnosis

Primary discharge diagnosis (ICD-9-CM code)	MONICA diagnostic category			
	Definite AMI	Probable AMI	Prolonged chest pain	Other
	Number (row percentage)			
AMI (410)	1,517 (66)	351 (15)	25 (1)	413 (18)
UAP (411)	124 (10)	415 (34)	211 (17)	471 (39)
Angina (413)	94 (6)	373 (24)	195 (13)	898 (58)
Chest pain (786.5)	29 (2)	184 (11)	168 (10)	1,355 (78)
Other	169 (2)	339 (4)	231 (3)	8,199 (92)

AMI = acute myocardial infarction; UAP = unstable angina pectoris.

Table 3.2 shows the annual level of age-standardised rates of AMI, unstable angina, angina and chest pain as defined by primary discharge diagnosis. The HMD show that there were sudden reductions in angina and chest pain between 1987 and 1988 and a rise in unstable angina over the same period. After 1988, the level of unstable angina continued to rise whereas the level of angina and chest pain remained relatively constant. This illustrates that trends in HMD can fluctuate arbitrarily if, as occurred in this case, there are changes in the coding rules.

Table 3.2: Age-standardised rates (per 100,000 population) of various primary discharge diagnoses between 1987 and 1991 for men and women aged 35–69 years

Primary discharge diagnosis (ICD-9-CM code)	Year				
	1987	1988	1989	1990	1991
AMI (410)	265	195	207	225	200
UAP (411)	55	88	99	112	113
Angina (413)	125	72	90	80	81
Chest pain (786.5)	92	70	62	64	62

AMI = acute myocardial infarction; UAP = unstable angina pectoris.

3.3.2 Acute Cardiac Care Study

In the ACCS, cases were categorised by the primary discharge diagnosis of AMI, unstable angina pectoris (UAP), angina, and other. For the purpose of this section it will be assumed that the severity of the event decreases across the spectrum of CHD from AMI to UAP to angina to other.

For all these patients the most common principal symptom precipitating admission to hospital was chest pain (Table 3.3). This occurred in 80% of patients with AMI and 88% of patients with UAP. The frequency of most other signs and symptoms of relevance decreased with decreasing severity of disease. Patients with a primary discharge diagnosis of AMI were more likely to: stay in hospital for three or more days; be admitted to a high dependency ward; have ST-elevation and ST-depression at admission to hospital; have raised enzymes; have a high first recorded pulse and high maximum pulse rate in the first 24 hours; and have low systolic blood pressure. Patients with a diagnosis of UAP or other angina were more likely to have a history of CHD.

The two main features that distinguished those with a discharge diagnosis of AMI from those with other discharge diagnoses were CPK enzyme changes and ST-elevation at admission to hospital. In this study, other ECG abnormalities (in particular Q-wave changes) were not recorded because, being slow to evolve, they were not relevant to the purpose of the study (i.e. identification of patients appropriate for thrombolysis). If they had been recorded, it is likely that the pattern of ECG abnormalities would also have demonstrated a clear difference between patients discharged with a primary diagnosis of AMI and patients discharged with the other diagnoses, as both ECGs and enzymes are routinely used by clinicians to diagnose AMI. CPK enzymes are a good marker of AMI, as it has previously been shown that an accurate estimate of the number of non-fatal AMIs treated in hospital can be obtained by linking computerised pathology data for cardiac enzymes with discharge diagnoses (D'Este 1985). It is possible that linking enzyme data and discharge diagnoses would provide a better method of estimating the number of non-fatal AMIs in the future than does use of HMD alone.

Although the indicators of severity of the event decreased from patients discharged with UAP to patients discharged with other angina, there were no signs or symptoms in these data that clearly separated the two groups.

3.3.3 Booked admissions

Further complications in understanding trends in primary discharge diagnoses occur when one considers allocation of primary discharge diagnoses to people who are admitted to hospital for coronary procedures. According to the Health Department of Western Australia, patients who are admitted to hospital for a cardiac procedure (i.e. a booked admission), in particular cardiac catheterisation, should be given a primary discharge diagnosis of coronary atherosclerosis (414) and a secondary diagnosis of AMI, UAP or angina pectoris depending on the nature of the episode which preceded the admission for the procedure. This protocol is not the one followed in all New South Wales hospitals and the extent of adherence elsewhere is uncertain. For example, Table 3.4 shows the primary discharge diagnoses of patients with booked admissions between 1995 and 1998 to the two hospitals in the Lower Hunter Region that perform cardiac catheterisation. Clearly the two hospitals code these patients differently. In fact, Lake Macquarie Private Hospital codes nearly all these patients to the discharge diagnosis of angina.

The implication of these results is that to monitor trends in angina it is necessary to filter out those cases admitted to hospital in order to receive some investigation or procedure. This could be done by considering only emergency (unbooked) admissions.

3.4 Discussion

Using MONICA data we have previously shown that the rate of non-fatal definite AMI fell substantially between 1985 and 1993 in the Lower Hunter Region, the rate of non-fatal probable AMI remained fairly steady and the rate of prolonged chest pain increased sharply (Dobson et al. 1999). The data in Table 3.2 are for a shorter period and reflect the trends that would be seen in HMD but the table does not accurately demonstrate the trends that occurred during the period 1985–93. Table 3.2 shows that there was a reduction in AMI, which is similar to the MONICA trend in definite AMI. However, Table 3.2 also shows there were reductions in rates of admissions for angina pectoris and chest pain and an increase in that for unstable angina. This is in contrast to the MONICA findings. Data from the MONICA Project, which validated diagnoses, show a sharp

increase in admissions for prolonged chest pain, a category that is similar to clinically defined angina pectoris, and no trend in probable AMI which is similar to clinically defined unstable angina.

Data from the ACCS indicate that there are no obvious clinical indicators which distinguish patients discharged with UAP and patients discharged with other angina. This implies that retrospective review of the medical records would not provide enough information to separate the two groups, nor permit validation of diagnoses of angina pectoris or unstable angina. In addition, in studying trends in unstable angina pectoris and other angina, these two categories should be considered together because there appears to be substantial overlap between the two groups and the extent of this overlap is likely to vary over time. Therefore the primary discharge codes 411 and 413 should be considered together.

Booked (non-emergency) admissions for angina should not be considered because these are most likely to be for investigations and procedures and coding of diagnoses for these cases is unreliable.

Table 3.3: Distribution of factors associated with coronary heart disease in each discharge diagnostic category, 1996

	Primary discharge diagnosis			
	AMI	**UAP**	**Other angina**	**Other**
Number of patients	1,451	1,864	475	563
			Per cent	
LOS ≥3 days	85	70	47	40
Principal symptom precipitating admission				
Chest pain	80	88	86	79
High dependency ward				
Coronary care	59	40	21	20
Intensive care	11	9	8	7
Other	11	10	15	11
None	19	31	56	62
ECG				
ST-elevation	57	9	6	7
ST-depression	61	33	29	20
Left bundle branch block	6	8	7	5
Enzymes				
CPK>200% of ULN	79	11	8	15
LDH>200% of ULN	51	20	22	19
CPK of LDH>200% of ULN	84	27	27	28
History of coronary heart disease	41	76	71	43
First recorded pulse rate				
>100 beats per minute	21	17	17	15
First recorded SBP				
<100 mmHg	7	2	2	3
Maximum pulse rate in first 24 hrs				
>100 beats per minute	39	24	23	20

AMI = acute myocardial infarction, CPK = creatinine phosphokinase; LDH = lactic dehydrogenase; SBP = systolic blood pressure; UAP = unstable angina pectoris; ULN = upper limit of normal in the laboratory performing the test; LOS = length of stay.

Source: New South Wales Acute Cardiac Care Study.

Table 3.4: Comparison of allocation of primary discharge diagnoses for patients admitted to hospital for cardiac catheterisation, 1995–98

Primary discharge diagnosis	John Hunter Hospital	Lake Macquarie Private Hospital
	Number (per cent)	
413 (Angina)	402 (28)	1,980 (96)
414 (Coronary atherosclerosis)	1,016 (72)	77 (4)
Total	**1,418 (100)**	**2,057 (100)**

3.5 Conclusion

The most accurate estimates of angina can be obtained by counting all patients who are emergency admissions to hospital and who are given a primary discharge diagnosis of 411 or 413. Retrospective review of medical records can not distinguish between cases of unstable and stable angina and therefore primary discharge codes 411 and 413 should be considered together.

4 Stroke

4.1 Introduction

While mortality rates from cerebrovascular disease (CeVD) or stroke have been declining for over 50 years, little is known about trends in the incidence of stroke or its non-fatal component. Routinely collected hospital statistical data (hospital morbidity data or HMD) have the potential to contribute such knowledge but have seldom been used for this purpose because of many potential difficulties in interpretation of HMD as they relate to stroke. For example:

- not all persons suffering from stroke are admitted to hospital, particularly if the episode is mild or the subject is already residing in a nursing home.
- persons suffering from stroke may have multiple admissions to hospital for the same episode or for other reasons. In the latter instance, residual disability may lead to the recording of stroke in subsidiary diagnostic fields (i.e. other than the main diagnosis).
- clinical practice relating to the acute and long-term management of stroke may change over time, leading to higher or lower rates of admission to hospital. For example, new methods of diagnostic imaging and the introduction of special stroke units are both likely to have led to an increase in rates of admission to hospital.
- for the same reasons, the accuracy of both clinical diagnosis and diagnostic coding may also have improved, resulting in bias in trends based on HMD.
- these considerations are of even more concern in relation to the relative frequency of sub-types of stroke and in distinguishing between admissions for established stroke and those with diagnoses of other forms of CeVD.

For these reasons, it is generally considered that the incidence of stroke can be measured accurately only through stroke registers. These are expensive to maintain, however, and often do not cover whole populations. Changes in case fatality and hospital admission rates for stroke are, nevertheless, topics of major concern for clinicians and health service administrators alike. HMD have at least the potential to provide information relating to these questions. It is therefore important to determine whether, and with what qualifications, HMD can be used to monitor trends in the incidence of stroke or to provide insight into the burden of stroke.

There are three separate issues to be considered:

1. whether the proportion of non-fatal strokes admitted to hospital has remained stable over time, and if not, the rate and direction of change;
2. the consistency with which fatal and non-fatal stroke are identified and coded in HMD; and
3. the extent of inflation of HMD due to readmissions or transfers between hospitals relating to the same clinical event.

The answers to these questions require comparison of HMD records coded as stroke with cases identified through the systematic registration and validation of cases using all

available sources of data. This has been possible in Perth because of the Perth Community Stroke Study (PCSS), which registered all cases of stroke occurring in a defined sub-population within the Perth Statistical Division for 18 months in 1989–90 and 13 months in 1995–96, and the existence of the Western Australia Health Services Research Linked Database. The latter provides the capacity to link HMD and death records relating to the same individual and to cross-link these to other data sets.

The present study was undertaken with the following objectives:

1. to determine the completeness and accuracy of HMD as a source of case-finding for cases of stroke compared with the PCSS;
2. to determine the PPV and sensitivity of HMD for stroke when compared with the PCSS; and
3. to develop selection algorithms and weighting factors to improve the accuracy of HMD for monitoring the incidence of hospital treatment of stroke.

4.2 Methodology

The study is based on the linkage of the registers compiled by the Perth Community Stroke Study in 1989–90 and 1995–96 to HMD records for the same time-periods and catchment area. HMD records with a code for any form of cerebrovascular disease (CeVD) in any one of 19 diagnostic fields were selected from a linked file of records of all hospital admissions of persons ever admitted to hospital for cardiovascular disease (CVD) in the period 1980–96, inclusive. This broad selection of records gave us the option of examining the extent to which cases included in the PCSS registers may have been admitted to hospital other than in the registration periods or with addresses of normal residence outside the PCSS area. However, the HMD records were eventually restricted to those admitted to hospital in the exact PCSS registration periods.

The PCSS attempted to register every stroke that occurred in a study area defined by the Swan River to the south and east, Wanneroo Road (the nominal boundary of the catchment area for Royal Perth Hospital) to the west, and the edge of the metropolitan area to the north. The area incorporates eight postcode areas, with a total population of 138,000. One postcode which lies predominantly outside the PCSS area (6060) was excluded for the purposes of the present study.

The PCSS employed multiple sources of ascertainment to identify every stroke or transient cerebral ischaemic attack (TIA) affecting a resident of the study area. TIAs were sought because persistence of symptoms beyond 24 hours would mean that such events would satisfy the internationally accepted definition for a stroke, assuming that other explanations for the presentation had been excluded. Patients were seen and assessed by an experienced medical registrar as soon as possible after the event came to the notice of the PCSS. Information was also collected for every fatality involving a resident of the study area where CeVD was mentioned anywhere on the death certificate. A final diagnosis of stroke in the PCSS Register required that the episode satisfied the WHO criteria originally developed by Hatano. The median age of patients with stroke registered in 1989–90 was 76 years. In
1995–96, this had increased to 79 years.

Classification of stroke in HMD

HMD records were divided into 'stroke' and other cerebrovascular disease (CeVD) on the basis of the diagnostic codes shown in Table 4.1. The principal change to occur within the study period was the introduction in July 1995 of a fifth digit extension of codes 433 (conditions due to disease of precerebral arteries) and 434 (conditions due to diseases of the cerebral arteries) to indicate the presence of associated cerebral infarction. The change to code 433 was particularly relevant because it enabled the distinction between admissions for stroke due to precerebral arterial disease and admissions for investigations or surgical treatment (endarterectomy) of stenosis of carotid arteries.

Table 4.1: ICD-9-CM codes used to define stroke and other cerebrovascular disease (CeVD)

	ICD-9-CM codes
Stroke	
Subarachnoid haemorrhage	430
Intracerebral haemorrhage	431
Occlusion and stenosis of precerebral arteries with mention of cerebral infarction (from 1st July 1995)	433.x1
Occlusion of cerebral arteries	434
Acute, but ill-defined, cerebrovascular disease	436
Other CeVD	
Hemiplegia and hemiparesis	342
Other and unspecified intracranial haemorrhage	432
Occlusion and stenosis of precerebral arteries (except as above from 1 July 1995)	433.x1
Transient-cerebral ischaemia	435
Other and ill-defined cerebrovascular disease	437
Late effects of cerebrovascular disease	438

Record linkage

Linkage between the data sets was achieved by the use of name information and other identifiers, such as date of birth, date of admission to hospital and postcode of normal residence, included in both sets of records. The initial linkage was performed using probabilistic methods as provided by the software package Automatch.

Linkage to HMD enabled us to characterise PCSS cases in terms of diagnosis and other variables such as diagnostic field, survival, admission type (booked or unbooked) and length of hospital stay (LOS) present in HMD. From this we were able to determine the PPV and sensitivity of HMD for cases accepted by the PCSS as stroke in sub-sets of hospital records defined in terms of these variables.

Elimination of multiple admissions due to transfers

Reduction of inflation of the number of HMD records coded as stroke due to transfers between hospitals for the same event can be achieved using record linkage. This option is not generally available outside Western Australia, but we nevertheless used linkage to create 28-day episodes in keeping with the definition of a stroke event used by the PCSS in order to determine the level of inflation in unlinked data.

4.3 Results

Linkage of PCSS records to HMD

In this section we examine both the outcome of linkage between HMD and PCSS records and the extent to which cases of non-fatal stroke identified by the PCSS were admitted to hospital. Table 4.2 shows the results of the linkage between PCSS records and HMD for each of the 1989–90 and 1995–96 Registers, for fatal, non-fatal and total cases. In 1989–90, the PCSS registered 502 cases of confirmed stroke of which 79% were coded as admitted to hospital. Of the 398 cases admitted to hospital, 354 were linked to an HMD record containing a diagnosis of CeVD in the main or other diagnostic field, 24 were linked to an HMD without such a diagnosis and 20 (5% of all admitted cases) could not be linked. There were however 16 cases coded by the PCSS as 'not admitted' to hospital that did link to an 'in scope' HMD record, 13 of which had an HMD diagnosis of CeVD. The total number of PCSS cases admitted is thus assumed to be 411 (total admitted cases + 13 additional cases) or 82% of all PCSS cases. Marginally fewer (78%) fatal cases were admitted compared with non-fatal cases (83%).

In 1995–96 the PCSS registered a total of 275 confirmed cases, of which 251 (91%) were admitted to hospital. There was an increase in the percentage of both fatal and non-fatal cases admitted to hospital compared with 1989–90 (78% compared with 82% and 83% compared with 94% respectively). This increase occurred in persons of all ages but to a greater extent in those over 75 years (from 77% to 89%) compared with those under 75 years which increased from 87% to 95% (Table 4.3). It is notable that there was also a substantial shift in the age distribution of cases, with the percentage of cases over 75 years of age increasing from 53% in 1989–90 to 64% in 1995–96. The magnitude of the increase in cases admitted to hospital, particularly in those over 75 years is likely to partially obscure any true decline or exaggerate any true increase in the incidence of non-fatal stroke.

One explanation for the apparent increase in the proportion of cases admitted to hospital is that non-hospitalised cases were less well identified in the 1995–96 PCSS Register. If this were the case we might expect a smaller relative increase in the fraction of elderly patients admitted to hospital, given that many older patients may have already been resident in nursing homes. As shown above the reverse was true. An alternative explanation is that the opening of an acute stroke unit at the principal general hospital serving the PCSS catchment area may have led to the admission of a higher proportion of cases.

Table 4.2: Linkage of PCSS Registers to HMD—results according to hospital admission code in PCSS and any diagnosis[(a)] of CeVD in HMD

PCSS	HMD status[(a)]	1989–90 register			1995–96 register		
		Non-fatal	Fatal	All	Non-fatal	Fatal	All
				Number			
Admitted	CeVD	266	88	354	177	46	223
	Other	21	3	24	9	4	13
	Not linked	17	3	20	3	3	6
	Subtotal	304	94	398	189	53	242
Not admitted	CeVD	11	2	13	6	3	9
	Other	3	0	3	1	0	1
	Not linked	61	27	88	11	12	23
	Subtotal	75	29	104	18	15	33
Total	**CeVD**	**277**	**90**	**367**	**183**	**49**	**232**
	Other	**24**	**3**	**27**	**10**	**4**	**14**
	Not linked	**78**	**30**	**108**	**14**	**15**	**29**
	Subtotal	**379**	**123**	**502**	**207**	**68**	**275**
All PCSS admitted[(b)]		**315**	**96**	**411**	**195**	**56**	**251**
				Per cent			
Admitted	CeVD	70	72	71	86	68	81
	Other	6	2	5	4	6	5
	Not linked	4	2	4	1	4	2
	Subtotal	80	76	79	91	78	88
Not admitted	CeVD	3	2	3	3	4	3
	Other	1	0	1	0	0	0
	Not linked	16	22	18	5	18	8
	Subtotal	20	24	21	9	22	12
Total	**CeVD**	**73**	**73**	**73**	**88**	**72**	**84**
	Other	**6**	**2**	**5**	**5**	**6**	**5**
	Not linked	**21**	**24**	**22**	**7**	**22**	**11**
	Subtotal	**100**	**100**	**100**	**100**	**100**	**100**
All PCSS admitted[(b)]		**83**	**78**	**82**	**94**	**82**	**91**

CeVD = cerebrovascular disease; HMD = hospital morbidity data; PCSS = Perth Community Stroke Study.

(a) Diagnosis of CeVD in any diagnostic field.

(b) All PCSS admitted includes those who were registered by the PCSS as being admitted to hospital plus those who were registered by the PCSS as not being admitted to hospital but who did link to HMD with a HMD diagnosis of CeVD (13 cases in 1989–90 and 9 cases in 1995–96).

Table 4.3: The proportion of cases of stroke admitted to hospital

Age (years)	1989–90 register			1995–96 register			Increase in % admitted
	Number	% of cases	% admitted [(a)]	Number	% of cases	% admitted [(a)]	
<75	237	47.2	87	99	36.0	95	8.0
75+	265	52.8	77	176	64.0	89	11.8
All	502	100.0	82	275	100.0	91	9.4

(a) Percentage admitted includes those who were registered by the PCSS as being admitted to hospital plus those who were registered by the PCSS as not being admitted to hospital but who did link to HMD with a HMD diagnosis of CeVD.

Accuracy of coding of stroke in HMD

In this section we examine the sensitivity and positive predictive value (PPV) of HMD for cases of stroke admitted to hospital. For the purpose of this analysis we have included HMD records in which there was a coded diagnosis of any CeVD (as opposed to specific codes for stroke only) in any diagnostic field.

The positive predicted value and sensitivity of HMD for validated cases of stroke

Table 4.4 summarises an extensive exploration of combinations of individual CeVD codes and other variables such as diagnostic field, type of admission and LOS that might maximise PPV and sensitivity of HMD for cases of stroke as registered by the PCSS. The selection algorithms shown are those which are likely to have the greatest practical use in analyses of trends in admissions to hospital for stroke.

In Table 4.4 we show the PPV and sensitivity of HMD for stroke in various sub-sets of records selected on the basis of diagnostic group, diagnostic field, type of admission and LOS. The data are for fatal and non-fatal cases combined and include all admissions in which a diagnosis of CeVD was present in any diagnostic field.

The key figure in Table 4.4 is the ratio of PPV/sensitivity as this reflects the extent to which selection of a particular subgroup of HMD records would over or underestimate the number of true cases of stroke admitted to hospital. For example, in 1989–90, if the estimate of the number of true admissions for stroke was based on Sub-Group I, it would be necessary to multiply the number of HMD records (407) by 1.01 (=411).

Examining first the results for the 1989–90 registration period, Group A shows that there were 1,212 HMD records with a diagnosis of CeVD in any diagnostic field and that this included 367 of the 411 PCSS cases admitted to hospital. The sensitivity was thus 0.89 and the PPV, 0.38. The ratio of PPV/sensitivity was 0.34. Group B, which is selected on the basis of a diagnosis of stroke in the main diagnostic field without further qualification, includes 263 PCSS cases (sensitivity 0.64) and 355 HMD records, most of which would be true cases of stroke (PPV 0.74). The ratio of PPV/sensitivity (1.16) indicates that this sub-set of HMD records would underestimate the true number of cases of stroke admitted to hospital by nearly 16%. Group C includes remaining cases in which the admission was unbooked and a diagnosis of stroke was present in a diagnostic field other than the main diagnosis. This includes a further 29 PCSS cases (sensitivity 0.07) and 52 HMD records (PPV 0.56). Group D is derived from the residual cases in which there was a diagnosis of other CeVD in the main diagnostic field, the admission was unbooked and length of stay (LOS) was at least 3 days. This sub-group contains a further 28 PCSS cases (sensitivity 0.07) but there are many more false positives (PPV 0.35) than in the preceding sub-groups.

All remaining cases are shown in the bottom row of Table 4.4. This row includes 22% of the PCCS (sensitivity 0.22) and more than half of the HMD cases so that the PPV is accordingly low (0.13).

The selection criteria used to define stroke in HMD should attempt to maximise both the positive predictive value and sensitivity for true cases of stroke. The possible options lie between the use of Row B (main diagnosis coded as stroke), Sub-Group I (main diagnosis coded as stroke OR unbooked cases in which a diagnosis of stroke is coded in another diagnostic field), or Sub-Group II (comprised of Sub-Group I, plus unbooked admissions cases of at least 3 days duration in which the main diagnosis was other CeVD). The first of these options would underestimate the number of true cases of stroke by about 16% in the period of the 1989–90 register and 18% in 1995–96, whereas Sub-Group I provides a close estimate of the true numbers of stroke in both periods. Using Sub-Group II, the number of cases would be overestimated by between 16% and 21%. In the 1995–96 registration period, there was an improvement in the values for PPV and sensitivity in each of the main groups of records (Row B and Sub-Groups I and II) suggesting improvement in standards of coding. It is notable that about 30% PCSS cases did not have a main diagnosis of stroke in HMD. The values for the ratio PPV/sensitivity in the main subgroups were however similar, suggesting that reasonably valid trend estimates of total events are possible.

Table 4.4: The positive predictive value (PPV) and sensitivity[(a)] of HMD codes for CeVD (fatal and non-fatal) for validated cases of stroke registered by the PCSS using different selection criteria

					1989–90 register					1995–96 register				
Group	Field	Atype	LOS	Diagnosis	PCSS	HMD	PPV	Sens	PPV/ Sens	PCSS	HMD	PPV	Sens	PPV/ Sens
A	Any	Any	Any	CeVD	367	1,212	0.30	0.89	0.34	232	901	0.26	0.92	0.28
B	Main	Any	Any	Stroke	263	355	0.74	0.64	1.16	180	213	0.85	0.72	1.18
C	Other	Unbooked	Any	Stroke	29	52	0.56	0.07	7.90	21	52	0.40	0.08	4.83
D	Main	Unbooked	3+	Other CeVD	28	80	0.35	0.07	5.14	19	54	0.35	0.08	4.65
B+C	**Sub-Group I**				292	407	0.72	0.71	1.01	201	265	0.76	0.80	0.95
B+C+D	**Sub-Group II**				320	487	0.66	0.78	0.84	220	319	0.69	0.88	0.79
A–(B:D)	Residual—all remaining cases from A				47	725	0.06	0.11	0.57	12	582	0.02	0.05	0.43

(a) Sensitivity based on all PCSS cases admitted to hospital.

Atype = type of admission—booked or unbooked; HMD = hospital morbidity data; LOS = length of stay; Other CeVD = 342, 432, 433, 437, 438; PPV = positive predictive value; Sens = sensitivity; Stroke = ICD-9-CM codes 430, 431, 434, 436.

Variation in identification of stroke in HMD with age stratification

Table 4.5 summarises the PPV/sensitivity ratios for fatal and non-fatal stroke stratified by age using Sub-Group I as the basis for selections of cases. While there is consistency within the 1989–90 period between the ratios for each age stratum and total cases (all being close to unity), the results for 1995–96 are anomalous, with the ratios in persons under 75 years significantly lower than in older subjects. While Sub-Group I appears to provide reasonable estimates of the overall number of true strokes, the possibility that this may not be the case in stratified data must be kept in mind.

Table 4.5: The ratio of PPV/sensitivity of HMD for stroke by age and calendar period (fatal and non-fatal)

	1989–90 register		1995–96 register		Combined registers	
Age (years)	**Ratio**	**95% CI**	**Ratio**	**95% CI**	**Ratio**	**95% CI**
Sub-Group I						
<75	1.04	(0.93, 1.15)	0.80	(0.69, 0.91)	0.95	(0.87, 1.03)
75+	0.98	(0.88, 1.08)	1.06	(0.95, 1.17)	1.01	(0.94, 1.09)
All	1.01	(0.94, 1.08)	0.95	(0.87, 1.02)	0.99	(0.93, 1.04)
Sub-Group II						
<75	0.85	(0.77, 0.94)	0.69	(0.59, 0.78)	0.79	(0.73, 0.86)
75+	0.83	(0.75, 0.92)	0.86	(0.78, 0.94)	0.85	(0.79, 0.91)
All	0.84	(0.78, 0.90)	0.79	(0.72, 0.85)	0.82	(0.78, 0.86)

CI = confidence interval; HMD = hospital morbidity data; PPV = positive predictive value.

The effect of different selection criteria on case fatality

In Table 4.6, case fatality in each Sub-Group is compared with that for cases registered in the PCSS in the two registration periods. In 1989–90 case fatality in Sub-Group I (24.1%) is closer to that based on the PCSS (23.4%) than either of the other two groups, both of which are lower. In 1995–96 there was little difference between case fatalities in Group B and Sub-Group I, but both were marginally lower than in the PCSS cases. In the combined data, case fatality in Sub-Group I (22%) again gave the best approximation to the PCSS cases (23%). Substantial overlap is present in the 95% confidence intervals of all of the estimates, but Table 4.6 tends to confirm the finding from Table 4.4 that Sub-Group I is the preferred option for providing estimates of stroke incidence in HMD.

Table 4.6: Case fatality (%) by selection algorithm compared with PCSS hospital cases by registration period

	1989 register			1995 register			Combined registers		
Selection	**Deaths**	**CF (%)**	**95% CI**	**Deaths**	**CF (%)**	**95% CI**	**Deaths**	**CF (%)**	**95% CI**
Group B (Main Diag = Stroke)	78	22.0	(17.7, 26.3)	42	19.7	(14.4, 25.1)	120	21.1	(17.8, 24.5)
Sub-Group I	98	24.1	(19.9, 28.2)	51	19.2	(14.5, 24.0)	149	22.2	(19.0, 25.3)
Sub-Group II	100	20.5	(16.9, 24.1)	53	16.6	(12.5, 20.7)	153	19.0	(16.3, 21.7)
All PCSS admitted	96	23.4	(19.3, 27.4)	56	22.3	(17.2, 27.5)	152	23.0	(19.8, 26.2)

CI = confidence interval; CF = case fatality; PCSS = Perth Community Stroke Study.

Sub-Group I = main diagnosis coded as stroke OR unbooked cases in which diagnosis of stroke is coded in another diagnostic field.

Sub-Group II = comprised of Sub-Group I plus unbooked admissions of at least 3 days duration in the which the main diagnosis was other CeVD.

Inflation of estimates of stroke due to multiple admissions in the acute event

Table 4.7 compares the number of unlinked HMD records and 28-day events based on record linkage in the diagnostic sub-groups used in Table 4.4. The ratio of unlinked records/28-day events is a measure of the inflation of records due to multiple admissions during the same acute event. In 1989–90, multiple admissions added 8% to each of the numbers in Group B, Sub-Group I and Sub-Group II. In 1995–96 the respective figures were 5%, 12% and 12%. The striking difference between the periods is the much higher ratio in 1995–96 (1.58) in Group C (unbooked cases with a diagnosis of stroke present in a diagnostic field other than the main diagnosis) compared with the 1989–90 (1.11) suggesting that there may have been a change in coding policy relating to readmissions in 1995–96.

Table 4.7 shows that all the possible selection algorithms for stroke cases are sensitive to the frequency of transfers which may vary over time and between different locations. As an alternative to the use of linkage to provide information on 28-day events, we explored the possible use of 'Transfer' codes to eliminate at least one of each pair of records in which an inter-hospital transfer occurred. This did not provide consistent results, partly due to the fact that a stroke diagnosis was not always present in both records and partly because a 'Transfer' code was not always present in the first of each pair of records. Nevertheless, if 28-day linkage cannot be achieved, monitoring the frequency of 'Transfer' codes may provide some indications of variation in multiple admissions between localities or over time.

Table 4.7: Ratio of unlinked HMD records to 28-day events for CeVD

					1989–90 register			1995–96 register		
Group	Field	Atype	LOS	Diagnosis	28-day episodes	Un-linked HMD	Ratio unlinked/ 28 day	28-day episodes	Un-linked HMD	Ratio unlinked/ 28 day
A	Any	Any	Any	CeVD	1,072	1,212	1.13	744	901	1.21
B	Main	Any	Any	Stroke	330	355	1.08	203	213	1.05
C	Other	Unbooked	Any	Stroke	47	52	1.11	33	52	1.58
D	Main	Unbooked	3+	Other CeVD	72	80	1.11	50	54	1.08
B+C	**Sub-Group I**				377	407	1.08	236	265	1.12
B+C+D	**Sub-Group II**				449	487	1.08	286	319	1.12
A–(B:D)	Residual—all remaining cases from A				623	725	1.16	458	582	1.27

Atype = type of admission—booked or unbooked; HMD = hospital morbidity data; LOS = length of stay; Other CeVD = 342, 432, 433, 437, 438; Stroke = ICD-9-CM codes 430, 431, 434, 436.

4.4 Discussion

This study has demonstrated three major problems in using HMD for monitoring trends in the incidence of stroke:

- The proportion of all cases of stroke admitted to hospital is likely to change over time;
- There are errors in the coded diagnosis of stroke compared with the validated diagnosis in the PCSS Registers;
- Estimates of the true number of stroke events are inflated by multiple admissions and inter-hospital transfers.

There were in addition a number of other limitations to our study:

1. It proved impossible to establish links for some PCSS cases admitted to hospital while others linked to HMD records with no diagnosis of CeVD. Conversely we found HMD records for a small number of PCSS coded as not admitted to hospital. These errors were probably related to both technical failure in linkage (for example, in 1989–90, name identifying information was missing from records from one particular hospital) and errors may have been introduced in trying to match up records for the study area on the basis of postcodes in HMD data. Failure to link PCSS records to an HMD record thus does not necessarily mean that there is no equivalent record in the HMD system for the same event. Failure to establish linkage may have therefore led us to underestimate the sensitivity of HMD for PCSS cases. However, adjustment of the sensitivity assuming full linkage of all unlinked PCSS cases admitted to hospital did not materially affect the ratios of PPV/sensitivity.
2. The PCSS area lies within the inner catchment area of a single tertiary hospital which therefore receives most of the admissions from the PCSS population. Coding of the HMD records used in this study may thus vary from those in other parts of the Perth Metropolitan Area or other localities. Further work is required to determine the comparability of coding in cases admitted to other hospitals.
3. The PCSS demonstrated a substantial decline between 1989–90 and 1995–96 in the proportion of cases of stroke treated out of hospital. It is likely that this trend is related to the development of an acute stroke unit in the tertiary referral hospital located in the PCSS area which offers the prospects of improved outcomes both in terms of reduced case fatality and better access to rehabilitation. The extent to which this development applies in other areas is uncertain although it is likely that there will be a general trend towards increased hospital referral because of improvement in diagnostic procedures for stroke. This will have the effect of underestimating the extent of a true decline in the incidence of stroke or exaggerating an increase in incidence.
4. This study has revealed major problems in the way that stroke is coded in HMD. In both 1989–90 and 1995–96 over 30% of hospital cases registered by the PCSS had a principal diagnosis other than stroke. To some extent this is inevitable because of the occurrence of stroke during admission to hospital for other conditions. In such cases it may be correct to assign a diagnosis of stroke to a subsidiary diagnostic field. On the other hand, nearly 30% of PCSS cases in 1989–90 and 20% in 1995–96 linked to HMD records with a code for other variants of CeVD in the main or a subsidiary diagnostic field. We have found it difficult to develop a satisfactory way of identifying cases of true stroke among these but the inclusion of all of this mixed group of records in the selection algorithm would lead to a gross overestimation of stroke cases.
5. The standard of coding of stroke in 1995–96 was higher than in 1989–90 as demonstrated by PPV and sensitivity for PCSS cases in all of the sub-groups of HMD records that we considered for the preferred selection algorithm. Fortuitously the ratios of PPV/sensitivity in the two registration periods were similar, but not surprisingly inconsistencies were apparent when the data were stratified by age and vital status. The improvement in coding in 1995–96 may be partly related to modifications of some ICD codes in mid 1995 which enabled the distinction between admissions for pre-cerebral vascular with cerebral infarction to be distinguished from cases admitted for corotid artery investigation or endarterectomy. It is likely that an increase in the number of trained coders associated with the move to casemix funding of hospitals has also contributed to general improvements in standards of diagnostic coding in HMD. This improvement, together with the diminishing

proportion of cases treated out of hospital, suggests that the reliability of HMD for monitoring the incidence of stroke will have improved since 1995.

6. Comparison of the number of cases of stroke admissions in unlinked data with the number of 28-day events established through record linkage shows that the recommended selection algorithm for stroke is sensitive to the frequency of transfers between hospitals during the acute stroke episode. Attempts to find a simple method for correcting this inflation based on the number of cases of stroke with a separation code for transfer were unsuccessful. As the need for transfers will vary with the way that hospital services are provided and organised in different areas, we believe that there will be no general answer to the problem and that the extent of inter-hospital transfers will need to be determined in each major jurisdiction. This is best dealt with by linkage of records into 28-day events. Further studies should be undertaken to determine the feasibility of achieving this without name identifiers. For example, as the number of stroke admissions from the catchment area of any one hospital is not great, it may prove to be feasible to develop an algorithm to identify pairs of records relating to the same stroke event within a 28-day time window event using simple linkage keys based on date of birth, gender, postcode, proximity of dates of admission and discharge and separation codes for transfers. If this is not possible, the frequency of transfers as indicated in unlinked data should be monitored.

4.5 Conclusions

1. Selection of cases of stroke on the basis of a code for stroke in the main diagnostic field is likely to underestimate the true frequency of stroke admissions by nearly 16% in 1989–90 and 18% in 1995–96. The preferred selection algorithm for estimating true cases of stroke from HMD abstracts is:

   STROKE = admissions with a code for stroke as main diagnosis + (remaining) unbooked admissions with a code of stroke in another diagnostic field.

2. The recommended selection algorithm gave estimates of case fatality that were consistent with the PCSS registers. However, stratification by age produced inconsistent results. This should be borne in mind when interpreting results based on the recommended algorithm.

3. Trends in incidence of stroke based on hospital admissions are likely to be biased because of the declining frequency of cases treated outside hospital. This will have the effect of underestimating the extent of a true decline in the incidence of stroke or exaggerating an increase in incidence.

4. Comparison of HMD coding with the PCCS Registers suggests that the standard of coding of stroke in 1995–96 was higher than in 1989–90. This may be partly related to modifications of some ICD codes in mid 1995 but also to general improvement of standards of diagnostic coding. This, together with the diminishing proportion of cases treated out of hospital, suggests that the reliability of HMD for monitoring the incidence of stroke will have improved since 1995.

5. The recommended selection algorithm for stroke is sensitive to the frequency of transfers between hospitals during the acute stroke episode. The extent of this problem should be determined by linkage of records into 28-day events. Further studies should be undertaken to determine the feasibility of achieving this without name identifiers. If this is not possible, the frequency of transfers as indicated in unlinked data should be monitored.

5 Congestive cardiac failure

5.1 Perth

5.1.1 Background

Cardiac failure ICD-9-CM code 428 appears far more frequently as a primary reason for admission to hospital than it does as the single underlying cause of death in official mortality statistics. Indirect evidence for this comes from HMD for Western Australia for 1995 where unbooked admissions with a main diagnosis of cardiac failure in patients who were alive 28-days later outnumber those where the patient died by almost ten to one (Table 5.1). Even so, an unbooked admission for cardiac failure is twice as likely to have a fatal outcome as emergency admissions for other cardiac complaints. This reflects the fact that Table 5.1 includes patients of all ages, including elderly patients with 'end stage cardiac failure'.

Table 5.1: Booked and unbooked admissions coded to cardiac failure and other non-rheumatic cardiac conditions, Western Australia, 1995

ICD-9-CM	Booked cases	Length of stay (days) for unbooked, non-fatal cases					Deaths	Deaths as % of unbooked total
		£2	£3	£4	>4	*Subtotal*		
428[(a)]	387	234	384	546	916	*1,462*	151	9.4
410–414, 426,427, 429,786.5[(b)]	4,182	2,022	2,757	3,383	2,473	*5,856*	288	4.7
Total	**4,569**	**2,256**	**3,141**	**3,929**	**3,389**	***7,318***	**439**	**5.7**
Per cent 428	8.5	10.4	12.2	13.9	27.0	*20.0*	34.4	

ICD-9-CM = International Classification of Diseases (Ninth Revision) Clinical Modification.

(a) 428 = cardiac failure, 429 = other heart disease, 786.5 = chest pain.

(b) 410–414 = ischaemic heart disease, 426 = heart block, 427 = dysrhythmias.

Table 5.1 also shows that unbooked admissions for cardiac failure tend to be longer than those for other cardiac conditions. Cardiac failure accounts for almost one in seven of admissions to hospital lasting up to four days, but for more than one in four of longer cardiac stays.

Surprisingly, one in every twelve booked admissions is ascribed to cardiac failure. Anecdotal evidence from clinical colleagues is that a large proportion of such booked cases are patients with well-established CCF who have a subacute exacerbation and are placed on a waiting list for a few days until a bed can be found to admit them for reassessment and restabilisation of their condition. Other categories within this broad group might include:

1. booked admissions for assessment prior to some invasive cardiac procedure such as CABG;

2. booked admissions for a noncardiac problem where development or recurrence of CCF as a complication comes to dominate the stay in hospital;
3. admissions for renal dialysis where the patient is in CCF because of fluid overload; or
4. coding errors in the booked/unbooked field.

Overall, CCF poses an important problem for the health system. As will be seen below, the problem is a growing one, the costs of management of cardiac failure are increasing, and the incidence of the condition may partly reflect other changes in the management of CHD and especially AMI.

5.1.2 Trends in admissions for cardiac failure

Admissions to hospital with cardiac failure ICD-9-CM code 428 as the primary diagnosis are increasing in both absolute terms and when measured as rates. A similar trend is apparent when one considers mention of cardiac failure in any field relating to diagnoses or complications pertaining to a given admission (Figures 5.1 and 5.2).

These longitudinal trends in admissions for cardiac failure stand in stark contrast to the fall in incidence of AMI and mortality from CHD that has continued throughout the period from 1980 onwards (Beaglehole et al. 1997; Thompson et al. 1988). The trends in cardiac failure are unlikely to be due to changes in coding systems per se. There was little discontinuity with regard to cardiac failure between the Eighth and the Ninth Revisions of the ICD, the latter being adopted in 1979 (Table 5.2). Moreover, there is exact correspondence in the coding of cardiac failure between ICD-9 and the Clinical Modification of ICD-9 (ICD-9-CM), which replaced it in 1988 in Western Australia. Thus, this second change in coding systems is unlikely to explain the upturn in absolute numbers of admissions seen in 1988 in Figures 5.1 and 5.2.

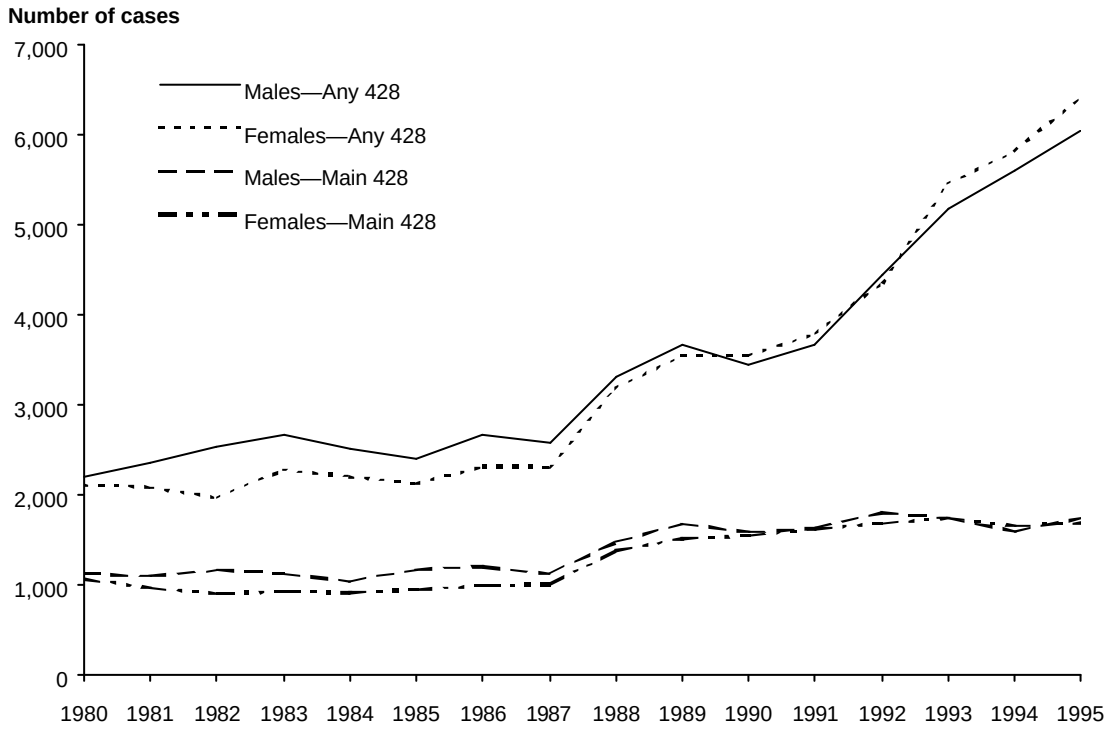


Figure 5.1: Trends in numbers of admissions to hospital with a primary or any diagnosis of cardiac failure ICD-9-CM 428, Western Australia, 1980–95

Table 5.2: Comparison of coding rubrics for cardiac failure in ICD-8, ICD-9 and ICD-9-CM

Code	ICD-8 description	Code	ICD-9 and ICD-9-CM description
427.0	Congestive cardiac failure	428.0	Congestive cardiac failure
427.1	Left ventricular failure	428.1	Left ventricular failure
		428.9	Cardiac failure NOS
514	Pulmonary congestion and hypostasis	514	Pulmonary congestion and hypostasis
519.1	Acute pulmonary oedema NOS	518.4	Acute pulmonary oedema NOS
782.4	Acute heart failure undefined		
783.2	Orthopnoea	786.0	Orthopnoea

NOS = not otherwise specified.

On the other hand, local advice is that there were potentially important changes in numbers and training of coding clerks in Western Australia and in their standing instructions during the period under review. The move to funding based on casemix profiles and DRGs has provided an 'incentive' for hospitals to take more care in recording complications affecting the patients that they admit, as more complicated cases are more expensive to manage. This hypothesis might also explain why admissions with any mention of cardiac failure among the discharge diagnoses more than tripled, while those with CCF listed as the principal condition treated did not quite double between 1987 and 1995 (Figure 5.1). Indeed, age-standardised rates of admissions in which CCF is given as the main diagnosis show no major change over the sixteen years beginning in 1980, but rates of admissions with any mention of CCF have doubled over recent years (Figure 5.2).

5.1.3 Exploring changes in cardiac failure admissions

Changes in coding practice

In preparation for the introduction of ICD-9-CM, coders of medical records in Western Australia were given new coding guidelines set down by the American authors of the system, some of which had the potential to change coding practices. One of these relates to the sequencing of the codes for heart failure and underlying conditions when the former was the main reason for admission to hospital (as opposed to CCF as a complication). In this situation, 428 would be coded as the main diagnosis. Another relates to the specific coding for hypertensive cardiac failure. Prior to ICD 9-CM, it was the practice in Western Australia to code this condition to hypertensive heart disease 402.3 (or to 404 in the case of combined hypertensive heart and renal disease).

We undertook a detailed analysis of changes in the coding of CCF and associated conditions between 1987 and 1988 to see if it is possible to identify transference between CCF and specific cardiac diagnoses. If the reason for the sudden increase in CCF as a main diagnosis could be explained in this way, it might then be reasonable to aggregate cases coded to specific conditions with cases coded as CCF to reestablish temporal continuity.

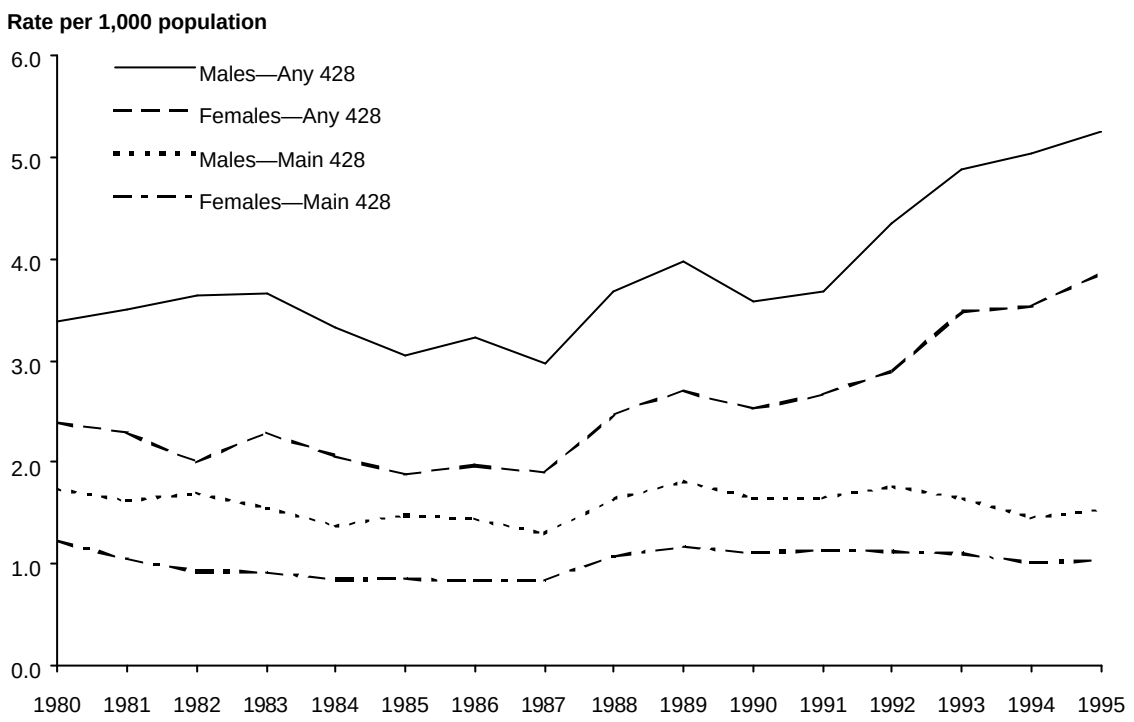


Figure 5.2: Trends in rates of admissions to hospital with a primary or any diagnosis of cardiac failure ICD-9-CM 428, Western Australia, 1980–95

Tables 5.3–5.6 show changes between 1987 and 1988 in numbers of cases in which CCF was coded as a secondary diagnosis following particular conditions and where CCF was coded as the main diagnosis followed by the same condition. They also present the difference and relative change in cases with CCF and in the totals of the associated conditions irrespective of CCF. Finally we have shown the cases with CCF as the main, other or any diagnosis as a percentage of total cases in each year. The four tables cover most of the individual codes within the 'Cardiac' section of the ICD, but we have not looked in detail at changes in coding of CCF in association with non-cardiac conditions.

As may be seen from Table 5.3, the total number of admissions for cardiac conditions increased only marginally (by 6%) between 1987 and 1988. In contrast, CCF, whether as the primary or a secondary diagnosis, increased by about 33% (from 4,877 cases in 1987 to 6,491 cases in 1988). However, the increase occurred only in association with cardiac disease (74% increase) while CCF associated with other conditions (or possibly no conditions) fell slightly. Within the cardiac group, CCF as the main diagnosis increased by 77% compared with 68% when the code for CCF followed another condition. The proportion of all cardiac cases in which CCF was mentioned increased from 16% to 26%.

Table 5.3: Cases of congestive cardiac failure (CCF) occurring in main or other diagnostic fields in 1987 and 1988 in association with other diagnoses

	Diagnostic field		Cases with CCF				All cardiac cases				Per cent of all cases with CCF	
Diagnostic sequence	**Main**	**Other**	**1987**	**1988**	**Diff**	**Ratio 1988/1987**	**1987**	**1988**	**Diff**	**Ratio 1988/1987**	**1987**	**1988**
Total cardiac except CCF + CCF	390–427,429	428	846	1,425	579	1.68	14,221	15,050	829	1.06	5.9	9.5
CCF + all other cardiac	428	390–427,429	1,433	2,530	1,097	1.77					10.1	16.8
Any cardiac with CCF	*Subtotal*	*Subtotal*	*2,279*	*3,955*	*1,676*	*1.74*					*16.0*	*26.3*
Not cardiac[(a)] + CCF	Not 390–427,429	428	1,906	2,210	304	1.16	NR				13.4	14.7
CCF + non-cardiac[(b)]	428	Not 390–427,429	692	326	–366	0.47					4.9	2.2
Any not-cardiac with CCF	*Subtotal*	*Subtotal*	*2,598*	*2,536*	*–62*	*0.98*					*18.3*	*16.9*
All diags + CCF	All codes	428	2,752	3,635	883	1.32	NR				19.4	24.2
CCF + all diags	428	All codes	2,125	2,856	731	1.34					14.9	19.0
Any with CCF	**Total**	**Total**	**4,877**	**6,491**	**1,614**	**1.33**					**34.3**	**43.1**

Diff = difference; NR = not relevant (no totals are included here as we only have records in the vascular file of persons who had at least one record with vascular disease).

(a) Diagnoses other than rheumatic heart disease, hypertension, ischaemic heart disease, non-rheumatic valvular disease, cardiomyopathy, heart block, dysrhythmia or ill-defined cardiac conditions.

(b) Could include CCF with no other diagnosis.

Table 5.4: Cases of congestive cardiac failure (CCF) occurring in main or other diagnostic fields in 1987 and 1988 in association with hypertension

	Diagnostic field		Cases with heart failure				All cases (with or without CCF)				Per cent of all cases with CCF	
Diagnostic sequence	**Main**	**Other**	**1987**	**1988**	**Diff**	**Ratio 1988/1987**	**1987**	**1988**	**Diff**	**Ratio 1988/1987**	**1987**	**1988**
Essential hypertension	401	428	2	18	16	9.00	1,028	955	–73	0.93	0.2	1.9
Essential hypertension	428	401	43	343	300	7.98					4.2	35.9
All essential hypertension + CCF	*Subtotal*	*Subtotal*	*45*	*361*	*316*	*8.02*					*4.4*	*37.8*
Hypertensive heart disease + CCF	402	428	0	1	1	—	391	58	–333	0.15	0.0	1.7
CCF + hypertensive heart disease	428	402	0	4	4	—					0.0	6.9
All hyp. heart disease + CCF	*Subtotal*	*Subtotal*	*0*	*5*	*5*	—					*0.0*	*8.6*
CCF + hypertensive renal disease	403	428	1	14	13	14.00	3,801	137	–3,664	0.04	0.0	10.2
Hypertensive renal disease + CCF	428	403	5	49	44	9.80					0.1	35.8
All hypertensive renal disease + CCF	*Subtotal*	*Subtotal*	*6*	*63*	*57*	*10.50*					*0.2*	*46.0*
Hypertensive heart and renal dis. + CCF	404	428	0	1	1	—	105	18	–87	0.17	0.0	5.6
CCF + hypertensive heart and renal dis.	428	404	1	2	1	2.00					1.0	11.1
All hypertensive heart + renal dis. + CCF	*Subtotal*	*Subtotal*	*1*	*3*	*2*	*3.00*					*1.0*	*16.7*
Hypertensive except renal dis. + CCF[(a)]	401, 402, 404	428	2	20	18	10.00	1,524	1,031	–493	0.68	0.1	1.9
CCF + hypertensive except renal dis.	428	401, 402, 404	44	349	305	7.93					2.9	33.9
All hypertensive except renal dis. with CCF	*Subtotal*	*Subtotal*	*46*	*369*	*323*	*8.02*					*3.0*	*35.8*
Any hypertensive + CCF	401–404	428	3	34	31	11.33	5,325	1,168	–4,157	0.22	0.1	2.9
CCF + any hypertensive	428	401–404	49	398	349	8.12					0.9	34.1
All hypertensive + CCF	**Total**	**Total**	**52**	**432**	**380**	**8.31**					**1.0**	**37.0**

(a) Hypertension with chronic renal disease excluded because most of these cases were coded to chronic renal failure in 1988.

Table 5.5: Cases of congestive cardiac failure (CCF) occurring in main or other diagnostic fields in 1987 and 1988 in association with specific cardiac conditions

	Diagnostic field		Cases with heart failure				All cases (with or without CCF)				Per cent of all cases with CCF	
Diagnostic sequence	**Main**	**Other**	**1987**	**1988**	**Diff**	**Ratio 1988/1987**	**1987**	**1988**	**Diff**	**Ratio 1988/1987**	**1987**	**1988**
Rheumatic HD + CCF	390–399	428	20	25	5	1.25	174	189	15	1.09	11.5	13.2
CCF + rheumatic HD	428	390–399	56	57	1	1.02					32.2	30.2
All + rheumatic HD with CCF	*Subtotal*	*Subtotal*	*76*	*82*	*6*	*1.08*					*43.7*	*43.4*
CHD +CCF	410–414	428	555	890	335	1.60	7726	8271	545	1.07	7.2	10.8
CCF + CHD	428	410–414	705	1229	524	1.74					9.1	14.9
All CHD +CCF	Subtotal	Subtotal	1260	2119	859	1.68					16.3	25.6
Pulmonary HD + CCF	415–417	428	15	30	15	2.00	292	304	12	1.04	5.1	9.9
CCF + pulmonary HD	428	415–417	23	30	7	1.30					7.9	9.9
All pulmonary HD	*Subtotal*	*Subtotal*	*38*	*60*	*22*	*1.58*					*13.0*	*19.7*
Valvular HD + CCF	424	428	31	34	3	1.10	232	196	–36	0.84	13.4	17.3
CCF + valvular HD	428	424	108	125	17	1.16					46.6	63.8
All valvular HD	*Subtotal*	*Subtotal*	*139*	*159*	*20*	*1.14*					*59.9*	*81.1*
Cardiomyopathy + CCF	425	428	48	43	–5	0.90	127	143	16	1.13	37.8	30.1
CCF + cardiomyopathy	428	425	88	159	71	1.81					69.3	111
All cardiomyopathy + CCF	*Subtotal*	*Subtotal*	*136*	*202*	*66*	*1.49*					*107*	*141*
All of the above except CHD												
CCF + selected cardiac	390–399, 415–417, 424, 425	428	191	223	32	1.17	593	636	43	1.07	32.2	35.1
All selected cardiac with CCF	428	390–399, 415–417, 424, 425	306	405	99	1.32					51.6	63.7
Selected cardiac + CCF	*Subtotal*	*Subtotal*	*250*	*344*	*94*	*1.38*					*42.2*	*54.1*

Table 5.6: Cases of congestive cardiac failure (CCF) occurring in main or other diagnostic fields in 1987 and 1988 in association with conduction disorders or dysrhythmias

	Diagnostic field		Cases with heart failure				All cases (with or without CCF)				Per cent of all cases that had CCF	
Diagnostic sequence	Main	Other	1987	1988	Diff	Ratio 1988/1987	1987	1988	Diff	Ratio 1988/1987	1987	1988
Conduction disorders + CCF	426	428	15	20	5	1.33	194	215	21	1.11	7.7	9.3
CCF + conduction disorders	428	426	62	83	21	1.34					32.0	38.6
All conduction disorders	*Subtotal*	*Subtotal*	*77*	*103*	*26*	*1.34*					*39.7*	*47.9*
Atrial fibrillation + CCF	427.3	428	136	11	–125	0.08	699	735	36	1.05	19.5	1.5
CCF + atrial fibrillation	428	427.3	11	289	278	26.27					1.6	39.3
All atrial fibrillation	*Subtotal*	*Subtotal*	*147*	*300*	*153*	*2.04*					*21.0*	*40.8*
Other dysrhythmias + CCF	0ther 427	428	9	143	134	15.89	742	750	8	1.01	1.2	19.1
CCF + other dysrhythmias	428	Other 427	264	128	–136	0.48					35.6	17.1
All other dysrhythmias	*Subtotal*	*Subtotal*	*273*	*271*	*–2*	*0.99*					*36.8*	*36.1*
All dysrhythmias + CCF	427	428	145	154	9	1.06	1,441	1,485	44	1.03	10.1	10.4
CCF + all dysrhythmias	428	427	275	417	142	1.52					19.1	28.1
All dysrhythmias + CCF	*Subtotal*	*Subtotal*	*420*	*571*	*151*	*1.36*					*29.1*	*38.5*
Ill-defined cardiac + CCF	429	428	3	6	3	2.00	86	72	–14	0.84	3.5	8.3
CCF + ill-defined cardiac	428	429	37	27	–10	0.73					43.0	37.5
All ill-defined cardiac + CCF	**Total**	**Total**	**40**	**33**	**–7**	**0.83**					**46.5**	**45.8**

Table 5.4 is concerned specifically with changes in the coding of hypertensive disease. Marked decreases occurred for each of the individual codes 402, 403 and 404, but cases coded to 401 (essential hypertension) also fell. The most dramatic change was the loss of cases coded to 403 (hypertensive renal disease) which, it appears from examining other rubrics, were subsequently coded to chronic renal failure. We suspect that many of these admissions relate to day-case stays by patients undergoing renal dialysis. In aggregate, total cases coded to 402 and 404 fell by 420, while cases coded to 428 followed by 401, 402 or 403 increased by 348. These figures are consistent with transfer between diagnoses for equivalent cases. They account for nearly half of the increase of cases in which CCF was the main diagnosis. Thus, in examining longitudinal trends, it would be reasonable to add codes 402 and 404 to cases of heart failure to compensate for the increase in the latter that occurred as the result of changes in coding hypertensive heart failure.

Coding of specific cardiac conditions likely to be associated with heart failure is examined in Table 5.5. Valvular disorders and cardiomyopathy are of the greatest interest because of the high proportions of all admissions that were associated with CCF. The total number of admissions of valvular disorders declined whereas the number of admissions coded to CCF followed by valvular disorders increased. Thus, there is a suggestion here of transference, but the numbers are small compared with the increase in cases coded to CCF as the main diagnosis. Cases of cardiomyopathy followed by CCF declined slightly while CCF followed by cardiomyopathy increased substantially. However, the total number of cases in which cardiomyopathy was the main diagnosis also increased, perhaps through growing use of the term 'dilated cardiomyopathy' for which coding staff are instructed to use code 425.4 (other cardiomyopathy) even if the patient's condition actually reflects advanced CHD. Thus, adding admissions with a primary diagnosis of cardiomyopathy to cases coded as heart failure will not compensate for the additional cases with a primary diagnosis of CCF.

Table 5.6 examines heart failure in association with conduction disorders, dysrhythmias or ill-defined cardiac conditions. All of these conditions are associated with relatively high proportions of admissions that also have a code for heart failure. As there is instability between atrial fibrillation and other conditions coded to 427, it is best to consider the data for all dysrhythmias together. There was certainly an increase in cases coded as CCF followed by any code within the rubric 427, but the overall numbers of cases coded to 427 did not change much. There would therefore be little point in adding these cases to 428 (particularly in view of the relatively large numbers of admissions with any code for dysrhythmia compared with the numbers coded to 428).

In summary, with the exception of hypertension, the increase of coding of CCF as the primary diagnosis is as much due to a general increase in cases coded as CCF as to transference. Adding admissions with the relevant codes for hypertensive disease to those coded CCF would reduce the discontinuity in the longitudinal data by about half, but there are no other adjustments that could be made. The residual artefact significantly impedes analysis of longitudinal trends in admissions for CCF in Western Australia and this may also be the case in the national data if the changes in coding of hypertensive heart failure that occurred in Western Australia also occurred in other States and Territories.

Other factors that may contribute to the problem include increasing numbers and better training of coding staff, along with a new standing instruction to them that they should independently examine the medical record before allocating codes and not work only from what has been written on the coding sheet or mentioned in discharge letters by medical staff. The foreshadowing, in 1992, of the introduction of funding based for hospitals on casemix provided a strong incentive to search for and code potentially significant comorbidity and would explain the second inflections seen in Figures 5.1 and 5.2. Further

evidence to support this interpretation comes from the coding of diabetes mellitus, a condition for which the prevalence should not have changed sharply (Figure 5.3).

Evolution of pharmacological management of cardiac failure

A further important phenomenon related to cardiac failure is changes in pharmacological management. For many years, the mainstays of drug treatment for cardiac failure were digitalis and diuretic agents. Being well established, both classes of drug are off-patent and therefore relatively inexpensive. From at least the late 1970s, an additional approach was to use long-acting nitrate agents to reduce arterial tone and cardiac afterload. Again, these drugs are old and not expensive. However, the introduction from the mid-1980s (Thompson et al. 1992) of a new class of agents, the angiotensin-converting enzyme inhibitors (ACE inhibitors), has substantially increased costs of medical management of cardiac failure as these drugs are approximately ten times more expensive than those they supplanted. At the same time, because these drugs are now also widely used for the management of hypertension, prescription of an ACE inhibitor cannot be used as a marker of clinically recognised cardiac failure.

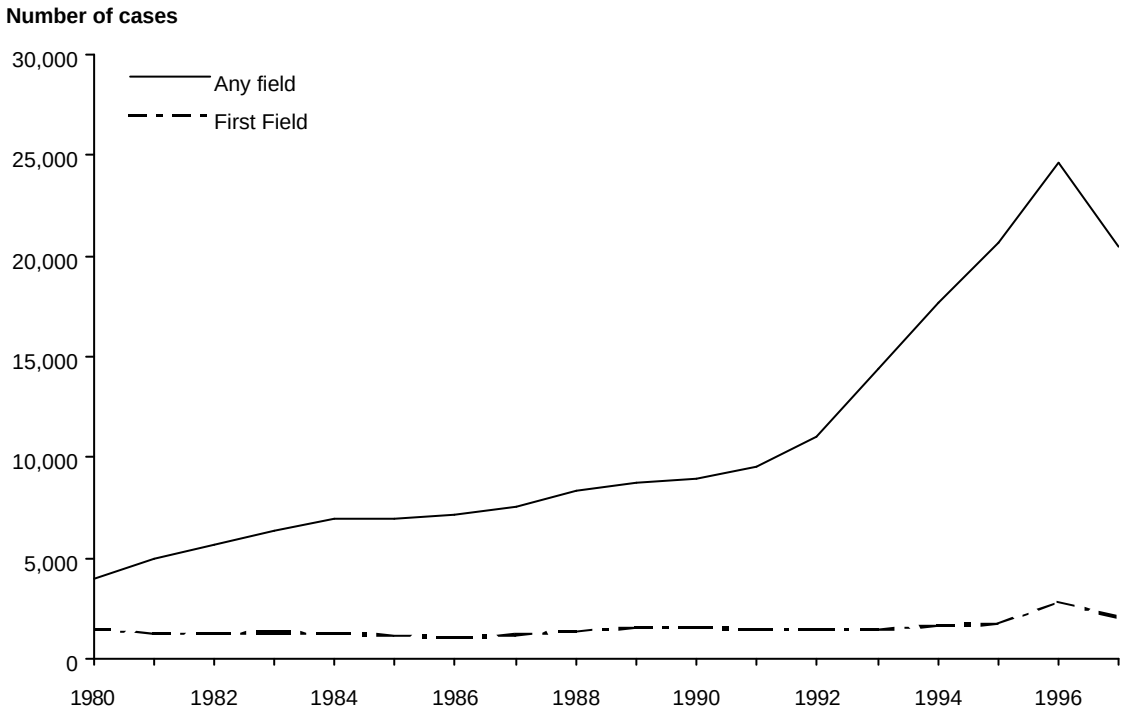


Figure 5.3: Trends in numbers of admissions to hospital with a primary or any diagnosis of diabetes mellitus ICD-9-CM 250, Western Australia, 1980–97

Is cardiac failure becoming more common as a sequel to AMI?

After changes in coding and the introduction of ACE inhibitors, a third issue surrounding trends in cardiac failure relates to another change in the treatment of heart disease that occurred during the 1980s, namely, the adoption of fibrinolytic therapy as the accepted acute treatment for suspected acute myocardial infarction. Two large randomised controlled trials demonstrating the effectiveness of fibrinolysis in lowering the short-term case fatality of AMI were published during that decade, GISSI-1 in 1986 (GISSI investigators 1986) and ISIS-2 in 1988 (ISIS-2 Collaborative Group 1988). However, Australian data from the MONICA Project reveal a steady adoption of fibrinolysis from 1984 onwards (Thompson et al. 1992). Thus, some 2% of patients with AMI in Perth who reached hospital alive in 1984 received a fibrinolytic agent, with this proportion rising progressively to reach almost 50% in 1993. While survival after AMI also improved, one must also ask whether these patients made a full recovery. If fibrinolytic therapy only reduced the extent of myocardial damage to a level compatible with survival, it might be that the residual impairment of cardiac function was so great as to leave these patients at greater risk of CCF.

Some evidence to support the hypothesis that the level of cardiac function in survivors of AMI deteriorated over the decade from 1984 is apparent from Figure 5.4. During this period, the proportion of survivors of AMI who were readmitted to hospital at least once with a main diagnosis of cardiac failure within one year of the initial infarction increased. However, any change in coding practice of the type mentioned earlier would have contributed to the apparent increase in readmissions. Determining whether there has been a real increase in readmissions for CCF and assessing any contribution due to changes in coding practice requires validation of diagnoses of cardiac failure in hospital morbidity data.

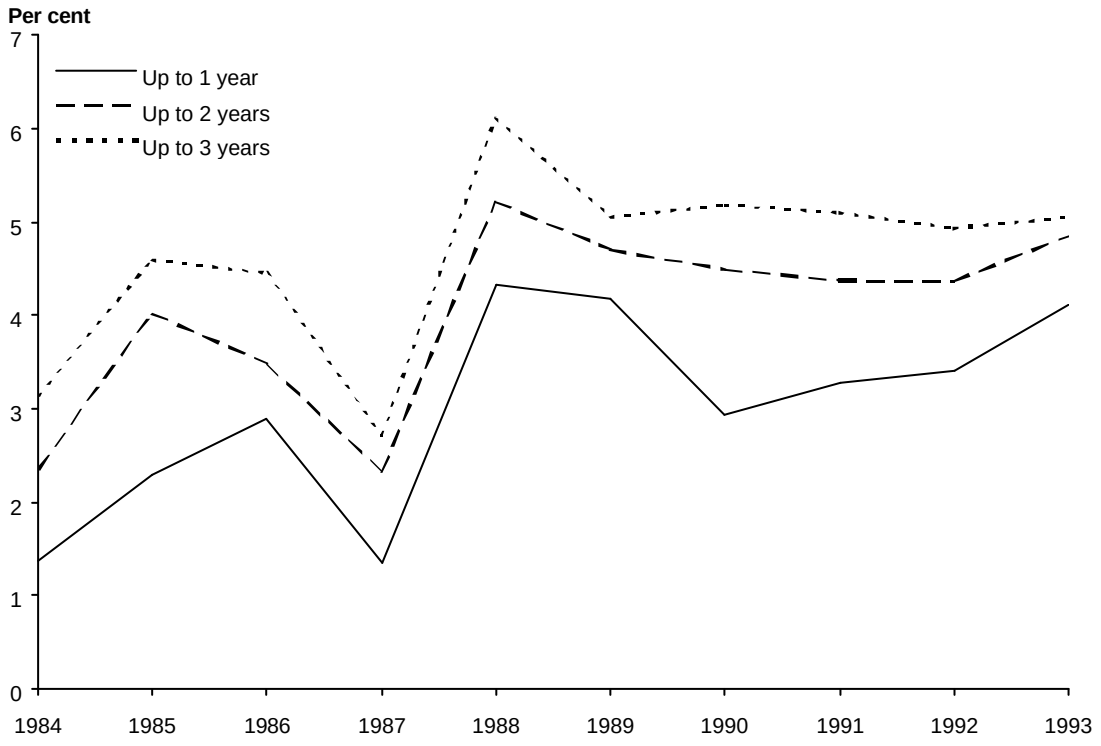


Figure 5.4: Readmissions for cardiac failure after acute myocardial infarction, 1984–93

Relationship of cardiac failure to other diagnoses

The validation of diagnoses of cardiac failure might be approached indirectly by examining trends in 'competing' diagnoses, such as rubrics other than 428 listed in Tables 5.2–5.6, but caution is required in drawing inferences that any reciprocal trends observed were actually explanatory of each other. This caution stems from other data showing that all of the incidence of AMI, its management and the treatment of cardiac failure have also changed over recent years. With multiple elements in the equation and many of them not stable over time, it is very difficult to be confident about which changes are secondary to others occurring during the same period. Ultimately one is left with little option but to review the circumstances of individual cases against some fixed external reference, or 'gold standard', to see if the frequency of admissions to hospital with cardiac failure has truly changed.

Medical records for admissions to hospital with cardiac failure

Work undertaken in Perth during 1997 and 1998 indicates that admissions with a diagnosis of cardiac failure can be sorted into five principal groups based on easily distinguishable clinical presentations. These groups are:

a Patients with a first-ever admission for cardiac failure as the principal presenting problem for that admission;

b Repeat admissions for (exacerbations of) well-established, chronic cardiac failure;

c Patients with cardiac failure complicating AMI;

d Patients with well-controlled CCF who are admitted for unrelated problems;

e Booked admissions with a primary diagnosis of CCF.

As a generalisation, not only are these five presentations quite different clinically, but the quality of the entries pertaining to the symptoms and signs of cardiac failure in the relevant medical records also contrast sharply. The differences in medical documentation, summarised below in Table 5.7, have obvious implications for retrospective validation of the presence and severity of cardiac failure.

Table 5.7: Levels of documentation for different types of admissions for cardiac failure

Type	Description	Quality of medical records
a	Patients with a first-ever admission for cardiac failure as the principal presenting problem for that admission	Best records of presenting history and physical examination.
b	Repeat admissions for well-established, chronic cardiac failure	Very poorly documented with notes of the kind, 'Patient with longstanding CCF, well known to this unit; recent exacerbation'.
c	Patients with cardiac failure complicating AMI	Evidence for the diagnosis of cardiac failure is often very incompletely recorded but the onset of CCF that is deemed clinically significant is reflected in changes in pharmacological management of the patient.
d	Patients with well-controlled CCF who are admitted for unrelated problems	The extent to which CCF-as-comorbidity is systematically recorded in the HMDS is not easily measured and the documentation of evidence for the diagnosis is likely to be poor unless there is an acute exacerbation during the admission.
e	Booked admissions with a primary diagnosis of CCF	Poorly documented with notes of the kind, 'Patient with longstanding CCF, well known to this unit; recent exacerbation'.

Choice of a 'gold standard' for validation of diagnoses of CCF

From first principles of pathophysiology, the cardinal feature of cardiac failure is an increase in left ventricular end diastolic pressure (LVEDP). Since measurement of this variable requires invasive techniques, LVEDP is only likely to be available when a patient has had a cardiac catheterisation for some other reason. Measures of left ventricular function such as the ejection fraction or fractional shortening of the ventricular muscle are good proxy indicators of LVEDP and can be captured non-invasively via techniques such as gated nuclear heart scans and echocardiography. However, neither of these labour-intensive and expensive techniques is used routinely in patients presenting with or developing cardiac failure. Rather, the clinical presentation is sufficiently distinctive for it to be recognised and appropriate treatment undertaken without use of such elaborate investigations. A problem that remains, nevertheless, is whether different doctors have the same threshold for deciding that a given patient has clinically important cardiac failure.

A search of the medical literature suggests that there is no single agreed definition of cardiac failure, based on clinical findings and relatively simple investigations, equivalent to the diagnostic criteria for AMI promulgated by the World Health Organization (Tunstall-Pedoe et al. 1994). In reading the literature, one quickly encounters the Norris (Norris et al. 1969a) and Killip (Killip & Kimball 1967) Indices, but both of these were developed to assess the presence and severity of cardiac failure in the specific setting of AMI. In addition, even in that sub-set of patients, agreement between the two scales is far from perfect (Horwitz et al. 1984), and both misclassify a substantial proportion of patients with AMI with regard to the probability that they will survive the event, even in the short-term.

The Norris Index (Norris et al. 1969a) is a weighted score that takes into account the patient's age, site of infarction (or presence of left bundle branch block), first systolic blood pressure (SBP) taken after admission to hospital, history of angina or previous AMI, cardiac size and status of the pulmonary vasculature. These last two features are to be obtained from a chest X-ray taken as early as possible after the patient arrives at hospital. By contrast, the Killip Class (Killip & Kimball 1967) is entirely dependent on clinical assessment. Patients may have either no signs of heart failure, established heart failure (defined by the presence of signs that 'include' [sic] crepitations, a third heart sound and a raised jugular venous pressure), severe heart failure (defined in the original paper simply as 'frank pulmonary oedema') or cardiogenic shock (defined by a combination of systolic hypotension (SBP <90 mmHg) and clinical evidence of peripheral vasoconstriction).

The extent to which either index, or the definitions for particular categories within each system, could be applied to validate diagnoses of cardiac failure in patients without AMI is unclear because the primary purpose of both the Norris and Killip Indices is to divide patients with AMI into groups according to their prognosis (Horwitz et al. 1984; Norris et al. 1969b). Thus Norris, for example, gives greatest weight to the first SBP after admission of the patient and relatively more modest weight to the two features recorded from a chest film that are more directly related to increased LVEDP. Alternative scales, such as the New York Heart Association Classification, are also unsuitable, as they tend to measure the impact of cardiac morbidity in terms of symptoms and limitation of function, rather than providing strict definitions of particular clinical entities (Smith et al. 1993). Killip, however, goes at least some way to defining a cluster of clinical findings that might be used to determine whether a given patient has cardiac failure and, if so, its severity.

Practical considerations in applying the Killip classification

As already described earlier in this report, inspection of medical records for admissions leading to discharge diagnoses of cardiac failure soon leads to the conclusion that the extent of documentation of relevant symptoms and signs varies widely according to the particular clinical presentation. In order to assess the extent of this difficulty, we initially inspected 183 sets of medical notes for patients in the Perth MONICA register who were readmitted within 12 months of AMI with a main diagnosis at discharge of cardiac failure. The medical records for a further 17 relevant patients could not be located. Using a structured datasheet, a research nurse with extensive clinical experience in cardiovascular disease recorded details of presenting symptoms and signs, radiological and laboratory investigations, evidence of conditions that might have led to the development of cardiac failure and evidence of other conditions that might have been confused clinically with cardiac failure. Care was taken to distinguish between records of definite negative findings—meaning that a specific feature had been sought, found not to be present and a record of this fact had been made—and missing information, meaning that there was no reference to the presence or absence of that specific feature in the clinical notes. A further category of coding indicated that no record was expected because a certain investigation, usually a chest X-ray (CXR), had not been done.

The methods used in the pilot study were then applied to a further 844 admissions with cardiac failure mentioned anywhere in the electronic discharge record. These admissions had been accrued by 379 patients from the Perth MONICA register who were initially selected on the basis of a readmission within one year of AMI with cardiac failure mentioned somewhere in the discharge record other than in the field for main diagnosis. These index admissions occurred between 1984 and 1994. Once each index admission had been documented, all subsequent admissions for a given patient to the same hospital through to the end of 1997 were searched for discharge diagnoses of cardiac failure or pulmonary oedema, and the same information was sought from each such medical record.

The final series of 844 admissions included 267 (32%) where cardiac failure (ICD-9-CM code 428) was recorded as the main diagnosis, 531 where this diagnosis was recorded only in another field, and one admission with a diagnosis of pulmonary oedema coded to ICD-9-CM code 514. The medical records of six further patients eligible for the study could not be located. In 809 admissions (96%), the patient survived to leave hospital alive. Cardiac failure was mentioned in the written discharge summary in 93% of the 844 admissions and on the hard copy of the discharge coding form in 64%, being identified as the principal condition treated in 47% of cases. The corresponding figures were 81% for any mention of the phrase 'pulmonary oedema' in the discharge summary, 0.4% for mention on the hard copy of the coding form and 0.2% as the principal condition treated. As these data imply, the HMDS allows a distinction to be drawn between main diagnosis present and principal condition treated.

Table 5.8: Levels of documentation of symptoms in 844 admissions with mention of cardiac failure[a] (per cent)

	Record of symptom			
Symptom	Definitely present	Definitely absent	Not relevant	Missing (no mention)
Exertional dyspnoea	52	14	—	34
Paroxysmal nocturnal dyspnoea	18	27	—	55
Orthopnoea	36	24	—	41

(a) Figures in the table are row percentages, based on n = 844.

Interestingly, and despite the origin of this sample, a history of previous AMI was recorded in only 71.6% (n = 604) of admissions. Almost one in five of the records (18.4%, n = 155) mentioned that the patient had previously undergone coronary artery bypass graft surgery and 41 (4.9%) mentioned a history of PTCA. However, as may be seen from Table 5.8, between one-third and one-half of the medical records contained no mention of at least one of the classical symptoms of cardiac failure.

Table 5.9 presents an equivalent analysis for important clinical signs of cardiac failure. Information relevant to the Killip definition of established cardiac failure is well recorded, with between 1.7% and 2.8% of records lacking any reference to the presence or absence of at least one of crepitations, fourth heart sound or a raised jugular venous pressure (JVP).

Table 5.9: Levels of documentation of signs in 844 admissions with mention of cardiac failure[a] (per cent)

	Record of clinical sign			
Clinical sign	Definitely present	Definitely absent	Not relevant	Missing (no mention)
Peripheral oedema	46.2	45.3	—	8.5
Sacral oedema	14.3	19.1	—	66.6
Dyspnoea	82.8	15.9	—	1.3
Tachypnoea	93.1	5.8	—	1.1
Cyanosis	6.2	88.6	—	5.2
Use of accessory muscles	0.5	0.4	0.1	99.1
Frothy sputum	5.2	80.8	—	14.0
Crepitations[b]	88.6	10.9	—	0.5
Pleural effusion	5.2	94.1	—	0.7
Tachycardia	31.8	68.0	—	0.2
Dysrhythmia	31.0	68.7	—	0.2
Fourth heart sound[b]	7.9	91.5	—	0.6
Raised JVP[b]	55.8	42.5	—	1.7

JVP = jugular venous pressure.

(a) Figures in the table are row percentages, based on n = 844.

(b) Contribute to Killip Classification.

At least one CXR was obtained in 770 (91.2%) of the admissions reviewed. In 80 of these cases (10.4%) the radiology report(s) indicated that no abnormality had been detected. For ease of comparison with the other tables describing these records, the summary of

radiological findings presented in Table 5.10 includes the 74 admissions in which no CXR was obtained.

Table 5.10 demonstrates that there was considerable variation between radiologists in the extent to which they only reported abnormalities or also offered diagnoses as well. In part, this could reflect variation in the amount of information made available to them on the request form, copies of which were not filed in the medical record. We have not undertaken any independent double-reading of the chest films.

Table 5.10: Summary of radiological findings in 844 admissions with mention of cardiac failure [a]

	Record of radiological sign or diagnosis			
Radiological sign or diagnosis	**Definitely present**	**Definitely absent**	**Not relevant (no CXR)**	**Missing (no mention)**
'Cardiac failure'	23.1	68.5	8.4	—
'Pulmonary oedema'	60.9	30.7	8.4	—
Cardiac enlargement	56.0	35.4	8.4	0.1
Pleural effusion	32.2	59.4	8.4	—
Vascular congestion	45.7	45.9	8.4	—
Other abnormality	7.5	84.1	8.4	—

CXR = chest X-ray.

(a) Figures in the table are row percentages, based on n = 844.

A variety of other investigations were performed. For example, arterial blood gases were measured in 231 (27.4%) of admissions, and were abnormal in 219 instances. Echocardiography was performed during 269 (31.9%) admissions, and all but three of the reports included reference to some abnormality being present. This may not be surprising, as all of the patients in this series had previously suffered an AMI. One in nine (11.5%) of patients underwent coronary angiography, with abnormalities reported in 96 out of 97 cases. Forty-nine (5.8%) patients had a radionuclide cardiac scan, with 45 reports referring to definite abnormalities.

We also sought evidence in the records of cardiac conditions that might have led to the patient developing cardiac failure. Given the source of the sample, it is not surprising that, in all but one admission, established CHD was clearly documented. In two records (0.2%) there were references to congenital heart disease, none referred to previous myocarditis, 41 (4.9%) mentioned valvular disease, 32 (3.8%) a secondary cardiomyopathy, 104 (12.3%) a primary cardiomyopathy, and 70 (8.3%) one of a range of other possible aetiological conditions. The high apparent proportion of primary cardiomyopathy almost certainly arises from use of the malapropism 'ischaemic cardiomyopathy'; the pathological lesion in CHD is in the blood supply to the cardiac muscle, not in the myocytes themselves.

Finally, we recorded evidence of other, non-cardiac diagnoses that might have been confused with cardiac failure or contributed to its development. These data are summarised in Table 5.11. Apart from pleural effusions, which might themselves be manifestations of cardiac failure, the single largest additional or alternative diagnosis was chronic obstructive lung disease (19.5%), a condition characterised by exertional dyspnoea, perhaps orthopnoea and certainly widespread crepitations in the lung fields. Asthma (5.1%) was less prominent, and there were similarly infrequent mentions of other problems, such as anaemia, that might have precipitated the development of cardiac failure in a patient with impaired cardiac function.

As we do not have information on symptoms, signs and investigations suggestive of CCF in patients with other cardiac diagnoses in this data set, we cannot measure the sensitivity of a code for CCF in the HMD and do not know how much other CCF is recognised clinically (and treated) but not recorded in the HMDS.

Table 5.11: Mention of non-cardiac causes in 844 admissions with cardiac failure[(a)] (per cent)

Condition	Mention in the medical record
Asthma	5.1
Chronic obstructive lung disease	19.5
Pneumonia	1.8
Pulmonary embolus	0.7
Pleural effusion	29.9
Pulmonary dust disease	0.2
Malignancy	0.1
Anaemia	5.5
Fluid overload	1.8
Use of non-steroidal analgesic drugs	5.7
Use of steroids	3.2
Use of carbenoxolone	—
Renal hypoproteinaemia	0.6
Hepatic hypoproteinaemia	0.9
Other conditions	6.4

(a) Figures in the table are percentages, based on n = 844.

5.1.4 Discussion

Hospital admissions for cardiac failure are increasing in absolute numbers at a time when the principal epidemiological indices of the main underlying vascular condition in the community, coronary atherosclerosis, are continuing to fall. After allowance is made for changes in the population, most of the increase since 1980 in admissions for cardiac failure is seen to be in cases where this condition is listed as a supplementary rather than the main diagnosis. Potential explanations for such a trend might include changes in coding of discharge data without any change in the underlying frequency of the problem, increased clinical recognition of cardiac failure without any change in the underlying frequency of the problem, or a true increase in the incidence of cardiac failure. The first of these explanations could reflect a tendency for hospitals to code additional or complicating problems of patients more carefully, perhaps because it has implications for reimbursement. The second might reflect greater clinical interest in cardiac failure as new treatments of demonstrated efficacy, especially ACE inhibitor drugs, became available. The third explanation is consistent with changes in the management of AMI bringing about improved survival from the acute attack but also yielding a fraction of patients with borderline residual cardiac function.

One cannot quantify the respective contributions of each of these developments to the upward trend in admissions for cardiac failure because retrospective validation of clinical diagnoses of cardiac failure is not possible. Cardiac failure tends to be poorly documented when it develops as a complication of AMI during the initial admission for management of the acute coronary event, its clinical recognition frequently being implied mainly from a

change in the pharmacological treatment of the patient. Thus it can be difficult to apply the standard Norris and Killip criteria in this setting. What is more, both of these indices were developed specifically for assessment of patients who had suffered an acute infarction, and their applicability to other admissions involving patients with cardiac failure is not at all certain. In any case, patients with long-standing cardiac failure that is prone to intermittent acute exacerbations tend to have extremely poor documentation of these episodes in their medical records.

Nonetheless, monitoring the incidence of CCF is an important issue because an increase in the incidence of CCF may reflect changes in the management of CHD in general and AMI in particular. Adequate epidemiological studies of trends in admissions for cardiac failure will require prospective application of a widely applicable set of relatively simple diagnostic criteria that are sensitive, specific and reliable for cardiac failure as judged against its principal pathophysiological marker, raised left ventricular end diastolic pressure. A pilot study of methods for obtaining such data is described in Chapter 6.

5.2 Newcastle

5.2.1 Introduction and methodology

In the analysis of the validity of a diagnosis of CCF in Perth, data were collected retrospectively for patients who were given a discharge diagnosis of cardiac failure and who had previously suffered an AMI. These data were used to assess the availability of information in medical records to diagnose CCF correctly. The data collected in the study of CCF at John Hunter Hospital (JHH) in Newcastle were substantially different. Patients were included in this study if they had an admission diagnosis of CCF and signs and symptoms that satisfied the Framingham diagnosis of CCF (Table 5.12). The patients were identified prospectively by research nurses who read through computerised admission records of all patients in the hospital. Individuals were only included in the study if they satisfied the inclusion criteria during the study period. In essence, the data allow us to estimate the sensitivity of diagnoses of CCF in the HMD based on discharge diagnoses as a method of measuring the incidence of CCF, assuming that the selection criteria of this study represent the 'gold standard' for CCF.

5.2.2 Results

Between 1 May and 31 November 1993, 257 patients admitted to the JHH had signs and symptoms of CCF that satisfied the inclusion criteria set for this study. Of the 257 patients, 86 (33%) were given a primary diagnosis of CCF (ICD-9-CM code 428) at discharge, 66 (26%) were given a secondary diagnosis of CCF and the other 105 (41%) did not have a diagnosis of CCF in any of the discharge diagnosis fields. If we assume that the selection criteria for this study constitute the 'gold standard', then a primary discharge diagnosis of CCF in the HMD records has a sensitivity of 0.33 for CCF. A diagnosis of CCF as the primary diagnosis or in a supplementary field of the HMD records has a sensitivity of 0.59 for CCF. The data from Perth show that the rate of secondary discharge diagnoses of CCF rose sharply after the introduction of DRGs in 1992. The data for Newcastle in 1993 are also likely to have been affected by the introduction of DRGs to some extent and it is reasonable to assume that there would have been a further impact after 1993. If this is

true, the sensitivity of HMD records based on primary and secondary discharge diagnoses of CCF would have increased after the present data were collected.

As was the case in Perth, investigation of ventricular function was not used routinely at the JHH to diagnose CCF. Cardiac catheterisation was performed on less than 4% of the patients, radionuclide scan on 8% and echocardiography on 29% (Table 5.13). Other signs and symptoms of CCF were well recorded in the medical records. The aims of the study at the JHH were to determine the incidence of CCF, to examine management of patients with CCF, and to look at factors that are associated with variations in outcome. The study was a prospective study and it is possible that the level of information in the medical records increased as a result of the study. Therefore it may not be appropriate to compare the level of information in the medical records in this study with the level of information in the medical records in Perth.

An important observation from the data collected in Newcastle is that a search of HMD records for patients with CCF would have identified only 60% of this group of patients, all of whom had an admission diagnosis of CCF and had signs and symptoms that satisfied the Framingham diagnostic criteria for CCF. The 40% who would not have been identified by a search of HMD records had no obvious clinical feature or characteristic of CCF that distinguished them from the other 60%. It would have been expected that most, if not all, of the patients included in this study would have been given at least a secondary diagnosis of CCF.

Table 5.12: Framingham criteria for diagnosis of congestive cardiac failure (CCF)

Framingham criteria for CCF
Major criteria
Paroxysmal nocturnal dyspnoea
Neck vein distension
Rales
Cardiomegaly
Acute pulmonary oedema
S3-gallop
Increased venous pressure (>16 cm H_20)
Circulation time ≥ 120 bpm
Hepatojugular reflex
Minor criteria
Ankle oedema
Night cough
Hepatomegaly
Pleural effusion
Vital capacity ≤ a third of maximum
Tachycardia ≥120 bpm
Major or minor criterion
Weight loss >4.5 kg over five days of treatment

Note: Diagnosis is made in the presence of two major or one major and two minor criteria.

5.2.3 Discussion

Patients who were admitted to JHH with clinical features consistent with CCF during the study period in 1993 were poorly represented in the HMD records in terms of having a primary or secondary diagnosis of CCF. This implies that the sensitivity of HMD records for identification of CCF is very low and therefore that the use of HMD records to estimate the incidence or prevalence of CCF will tend to give an underestimate of the true value.

Table 5.13: Prevalence of signs and symptoms for patients admitted to the John Hunter Hospital from 1 May 1993 to 30 November 1993 with an admission diagnosis of CCF and with signs and symptoms that satisfied the Framingham diagnoses criteria for CCF (per cent)

	Location of code for CCF in the HMD (ICD-9-CM 428)		
Signs or symptoms	**Primary discharge diagnosis of CCF (n = 86)**	**Secondary discharge diagnosis of CCF (n=66)**	**No primary or secondary discharge diagnosis of CCF (n=105)**
History of CCF	48	58	49
History of previous AMI	41	24	39
Dyspnoea	93	80	81
Chest pain	36	45	45
Peripheral oedema	64	64	51
Cough	41	39	39
Raised JVP	62	52	58
Lung crepitations	90	85	92
3rd heart sound	20	17	20
Chest X-ray			
Performed	98	85	85
Pulmonary oedema	60	52	54
Cardiomegaly	72	58	61
Echocardiography			
Performed	30	35	25
ECG			
Performed	99	94	95
Left bundle branch block	19	15	14
Right bundle branch block	10	12	7
Acute Q Wave	1	8	4
Radionuclide scan			
Performed	9	3	10
Cardiac catheterisation			
Performed	2	2	6

AMI = acute myocardial infarction; CCF = congestive cardiac failure; ECG = electrocardiograph; HMD = hospital morbidity data; JVP = jugular venous pressure.

5.3 Conclusion

There are severe limitations to monitoring trends in congestive cardiac failure using hospital admissions. This is because

- signs and symptoms are poorly recorded in medical records
- diagnostic criteria vary and are not used uniformly
- large changes in rates can be caused by changes in coding practice

As the incidence of congestive cardiac failure is believed to be increasing due to changes in the treatment of cardiovascular disease it is necessary to improve data quality. At present little credence can be given to available data.

6 Pilot study of methods to validate hospital data on cardiac conditions

6.1 Introduction

The aims of the present validation study were to:

1. investigate the feasibility of validation of diagnoses of cardiac conditions by retrospective review of hospital medical records; and
2. provide data from which sample sizes for full validation studies (if feasible) could be estimated.

Validation of a diagnosis of stroke was not undertaken in this study.

6.2 Methodology

6.2.1 Data collection form

The data collection form developed for this study was based on the questionnaire used for the New South Wales ACCS. It is given in Appendix 2 of this report.

The form covered basic diagnostic information about AMI, UAP and CCF—whether these were the presenting conditions or complications occurring during the stay in hospital. ECGs were photocopied for external classification according to the WHO MONICA protocol, which is based on the Minnesota coding system.

6.2.2 Case selection

Two hospitals, one large teaching hospital and one smaller community hospital, were chosen in each of southeast Queensland, Perth and the Hunter region of New South Wales. The hospitals were chosen on the basis of numbers of cardiovascular separations, representativeness of hospital type and logistic feasibility.

Consecutive separations for people aged under 85 years with the primary discharge diagnoses coded (ICD-9-CM) 410 (AMI), 411 (other acute and subacute forms of heart disease), 413 (angina pectoris), 428 (heart failure) and 786.5 (chest pain), and a further sample of separations with a discharge diagnosis coded 428 in any secondary diagnosis field were selected from the computerised databases. For each hospital, 10 records were selected for each category of discharge diagnosis. Patients who were admitted for some other condition but who had a cardiac event during hospital were eligible for selection. For

these cases the time of onset referred to onset of the cardiac event, not the (often unrelated) symptoms which led to the admission. Initial signs and symptoms therefore referred to the signs and symptoms of the cardiac event, rather than the initial admission, and complications referred to complications of the cardiac event, not complications of the admission.

Cases selected also included routine admissions for angiography, since booked as well as unbooked admissions were eligible. The relevance of including these in a large validation study would need to be assessed, as these types of admissions resulted in missing data for most questions. Length of stay was not used in selection of cases. It may be necessary to limit case selection for further validation studies based on length of stay, as well as type of admission (booked or unbooked). The eligibility criteria could vary according to the discharge diagnosis code.

6.2.3 Collection and reliability of data

Using information obtained from medical records, a trained research nurse completed the data collection form for each subject selected for the sample. From experience of the New South Wales ACCS it was expected that each nurse would take about four weeks to complete the 120 forms (60 from each hospital).

There were large variations between ambulance records, the resident medical officer's notes, the registrar's notes, and the notes made by anyone else who had taken a history, including the local medical officer who had referred the patient, as to the times that events such as the onset of symptoms had occurred. It is unlikely that the 'correct' time can be determined in these cases. Admission diagnosis was written in two places (in Newcastle, at least). The first diagnosis was written at the bottom of the triage sheet and the provisional diagnosis was recorded again after the Registrar had seen and examined the patient. In some cases it was possible to have at least three diagnoses—if a specialist also examined the patient. This could result in several different admission diagnoses for the same patient and admission.

The reliability of information was also dependent on the quality of the medical record data, which varied geographically and among types of hospitals. For some data, such as drugs used, it is reasonable to equate 'not reported' with 'no' or 'not provided/not present'. However, for other questions, such as symptoms, information may not be included because the symptom was absent, or it was present but this fact was not written in the notes. Thus, 'not reported' or not mentioned in the notes does not imply 'not present'.

The section on symptoms was difficult to complete as there were many terms or descriptors which were difficult to code to the appropriate category. For example:

- does 'radiating pain' or 'pressure on chest' fit into 'pain in upper abdomen, jaw, arm or neck' (category iv)?
- 'chronic failure' was not coded to 'acute left heart failure' (category v);
- differences between shortness of breath, dyspnoea and 'mild respiratory distress' (category vi); uncomfortable beating of the heart and palpitations (category ix); sweating and diaphoresis (category x) are indistinct. Similarly, it is unclear whether 'swelling to mid-calf', 'tibial swelling', 'pitting oedema bilateral to knees' should be coded to ankle oedema, peripheral oedema or both. Although technically there may be differences between these terms, in practice the terms are often used interchangeably in the medical records;
- the coding of dysrhythmias was not well defined and therefore subject to interpretation;

- nausea or vomiting are not included in the list of symptoms—these were very common symptoms;
- it may be possible to reduce the symptom list by combining similar symptoms. This of course depends on the depth of information required to determine diagnosis;
- the column for symptoms of complications was difficult to complete. An alternative method of obtaining data on complications would be to provide a column for each day of the stay in hospital and record the complications present on each day. This would provide a complete picture of the progress of the patient during the admission.

6.2.4 Transfers

Transfers are always a complicated issue, as data from one hospital provide only partial information for the complete cardiac event in patients who are transferred. In the field test, information was obtained based on the current admission, even if the patient had been transferred in from (or to) another hospital. This meant that the data recorded on symptoms, enzymes, ECGs were from the current admission, and may not provide an adequate or appropriate picture of the event. For example, if a patient is transferred after 24 hours, the ECG, symptom and/or enzyme data from the hospital they are transferred to may not provide an accurate diagnosis. For further validation studies, consideration needs to be given to whether transferred cases should be included, and, if so, whether cases need to be tracked between hospitals to obtain complete data on the event of interest. This could be done manually, from transfer information obtained in the medical records, or electronically by tracking and combining all data on relevant admissions. Complete electronic tracking of any given individual is presently only possible in Western Australia, where linked hospital separations data are available; and in the Hunter Area, where the Heart and Stroke Register links data from all patients admitted to Hunter Area hospitals.

6.2.5 Other issues

There appeared to be some local abbreviations or coding jargon, specific to individual sites and not commonly known. An example is 'J.A.C.C.O.', Jaundice, Cyanosis, Claudication and Oedema. Local conventions of this kind would need to be explained in an appendix to the coding manual if the same protocol for validation was to be used in many different hospitals and the study was to be conducted by extramural staff.

Thrombolysis needs to be added to the list of possible causes of raised cardiac enzymes.

6.2.6 Recommendations

Most of the proposals put forward in this report are based on information extracted from historical data. It is therefore recommended that a regular process of validation be undertaken to identify any changes that may have occurred in the structure of the mortality and morbidity data used in forming these proposals. The process of validation should be conducted through regular sampling of registered events, similar to the method outlined in this chapter but taking into account the following issues that have been highlighted by the field test:

- Guidelines need to be established to determine which admission diagnosis should be included on the data collection form. This may depend on when the patient was examined (i.e. time since arrival), and who initiated treatment for the patient.

- Definitions and rules for time of onset need to be established, possibly in consultation with Accident and Emergency staff and cardiologists. Guidelines may vary from site to site depending on local processes and practices.
- A well-defined and detailed definition of signs and symptoms is required so that consistency can be achieved in recording these clinical features.
- Depending on the objectives of a validation study, consideration should be given to the inclusion or exclusion of transferred patients and booked admissions.

However, it is unlikely that instituting guidelines would completely eliminate the problems of reliability and validity.

6.3 Results

Medical records were examined for 359 of the patients who were selected for the validation study.

6.3.1 Acute myocardial infarction

Approximately 93% of patients who had a primary discharge diagnosis of AMI (ICD-9-CM 410) stayed in hospital for three or more days (Tables 6.1 and 6.2). The 'cardiac' enzyme CPK was measured for all of these patients and the 'cardiac' enzyme AST was measured for all the patients with AMI who were admitted to the teaching hospitals and 67% of AMI patients admitted to the community hospitals. These enzymes were also measured for the majority of patients who had a primary diagnosis of other acute and subacute forms of CHD (ICD-9-CM 411) and chest pain (ICD-9-CM 786.5). Although cardiac enzymes were measured for the majority of patients discharged from community hospitals with a primary diagnosis of angina pectoris (ICD-9-CM 413), they were not measured as frequently for patients discharged from teaching hospitals with the same primary diagnosis. This observation may be explained by the fact that only 34% of patients who were discharged from a teaching hospital with a primary diagnosis of angina pectoris were emergency cases, compared with 77% of the patients discharged from community hospitals. Tables 6.1 and 6.2 show that 83% of patients who were discharged from a teaching hospital with a primary diagnosis of AMI had CPK enzyme levels that were raised to more than twice the upper limit of normal in the laboratory performing the test. In contrast, less than 10% of patients with other primary diagnoses had cardiac enzymes that were raised to this extent. Other cardiac enzymes, such as Troponin I, were not used as frequently. Only about 30% of patients with AMI in teaching hospitals and 3% of patients with AMI in community hospitals had levels of Troponin I measured.

ECGs were performed on over 95% of patients with a primary diagnosis of AMI, other subacute or acute forms of CHD, or chest pain. For those with a primary discharge diagnosis of angina pectoris, 97% of patients from the community hospitals had an ECG performed compared with only 59% of patients from teaching hospitals. Patients discharged with a primary discharge diagnosis of AMI were more likely to have had definite ECG changes (according to the MONICA definition) than other patients (30% vs 4% in teaching hospitals and 30% vs 7% in community hospitals). Similarly, patients discharged with a primary diagnosis of AMI were more likely to have had 'definite' or 'probable' ECG changes than other patients (83% vs 22% in teaching hospitals and 73% vs 29% in community hospitals). These data show that ECGs were performed routinely in both teaching and community hospitals and that the results from the ECGs were used to help diagnose AMI.

Table 6.1: Teaching hospitals: distribution of clinical features of coronary heart disease within each discharge diagnostic category (per cent)

	Primary discharge diagnosis					
	AMI (410)	Other acute & subacute forms of CHD (411)	Angina pectoris (413)	Chest pain (786.5)	Congestive cardiac failure (428)	Secondary diagnosis of heart failure
Type of admission						
Booked	—	7	41	7	7	26
Direct	—	3	17	7	13	3
Emergency	83	83	34	82	70	62
Transfer	17	7	7	4	10	9
LOS (> 2 days)	93	69	24	15	72	85
Chest pain						
≥ 20 minutes	80	69	31	64	10	24
< 20 minutes	7	17	—	11	10	9
Duration unknown	13	10	24	18	20	12
No chest pain	—	3	24	7	57	38
Not recorded	—	—	21	—	3	18
Raised CPK enzymes						
Definite	83	7	3	7	10	9
Probable	10	24	3	7	10	24
Normal	7	62	28	68	53	26
Not recorded	—	7	66	18	27	41
Raised AST enzymes						
Definite	67	3	—	4	10	12
Probable	27	21	10	11	27	24
Normal	7	69	55	64	47	35
Not recorded	—	7	34	21	17	29
ECG						
Definite	30	7	—	—	—	12
Probable	53	28	10	11	20	18
Other	13	59	48	79	70	47
Not recorded	3	7	41	11	10	24

AMI = acute myocardial infarction; AST = aspartate transaminase; CPK = creatinine phosphokinase; ECG = electrocardiograph; LOS = length of stay.

Table 6.2: Community hospitals: distribution of clinical features of coronary heart disease within each discharge diagnostic category (per cent)

	Primary discharge diagnosis					
	AMI (410)	Other acute & subacute forms of CHD (411)	Angina pectoris (413)	Chest pain (786.5)	Congestive cardiac failure (428)	Secondary diagnosis of heart failure
Type of admission						
Booked	0	3	10	0	3	7
Direct	17	7	10	10	20	18
Emergency	73	83	77	84	70	64
Transfer	10	7	3	6	7	11
LOS (> 2 days)	93	63	45	55	70	68
Chest pain						
≥ 20 minutes	67	70	40	48	3	4
< 20 minutes	3	10	13	19	23	11
Duration unknown	30	20	37	32	13	7
No chest pain	0	0	10	0	57	64
Not recorded	0	0	0	0	3	14
Raised CPK enzymes						
Definite	67	3	3	0	13	11
Probable	27	13	10	10	13	4
Normal	7	83	80	90	57	50
Not recorded	0	0	7	0	17	36
Raised AST enzymes						
Definite	37	0	0	3	7	14
Probable	20	27	10	6	23	4
Normal	10	40	57	55	30	18
Not recorded	33	33	33	35	40	64
ECG						
Definite	30	10	10	3	10	0
Probable	43	37	27	10	13	21
Other	20	50	60	87	73	64
Not recorded	7	3	3	0	3	14

AMI = acute myocardial infarction; AST = aspartate transaminase; CHD = coronary heart disease; CPK = creatinine phosphokinase; ECG = electrocardiograph; LOS = length of stay.

A close approximation to the MONICA definition of non-fatal definite AMI would be:

1. definite ECG changes; or
2. chest pain lasting longer than 20 minutes together with ECG changes that are either probable, ischaemic or uncodable and cardiac enzyme levels that are twice the upper limit of the normal range for the laboratory.

Using this definition, Table 6.3 shows that clinically defined AMI coincides closely with the MONICA definition of definite acute myocardial infarction. Together, these data show that the clinical features of AMI are well-recorded in medical records and that a relatively simple algorithm could be used with information obtained from medical records to validate a diagnosis of AMI retrospectively. However, such a strategy suffers from the drawback that classification of ECGs using the Minnesota code is very labour intensive.

Table 6.3: Patients in each discharge diagnostic category that satisfy the MONICA definition of non-fatal definite AMI (per cent)

	Primary discharge diagnosis					
	AMI (410)	Other acute and subacute forms of CHD (411)	Angina pectoris (413)	Chest pain (786.5)	Congestive cardiac failure (428)	Secondary diagnosis of heart failure
MONICA definite AMI	83	14	7	8	15	16

AMI = acute myocardial infarction; CHD = coronary heart disease.

6.3.2 Angina pectoris

Retrospective review of medical records to validate a diagnosis of angina pectoris would require consensus on the definition to be used for angina pectoris. There are ICD-9-CM rubrics for a number of conditions that might be described as non-infarction acute coronary events, including other acute and subacute forms of CHD (411), angina pectoris (413) and chest pain (786.5). The ICD-9-CM rubric 411 was intended to be used for patients with impending infarction or unstable angina. This is an ill-defined entity that is sometimes applied to some patients who develop recurrent bouts of angina having previously been free of all such symptoms, and to others who previously developed anginal pain predictably in certain circumstances but whose pain has become more frequent, more prolonged, more severe or more easily provoked. In addition, a diagnosis of unstable angina may be made when AMI is suspected but the ECG changes and cardiac enzyme levels are not sufficient to satisfy clinical criteria for definite AMI. The ICD-9-CM rubric 413 is often used for patients who are admitted for procedures. This is illustrated by the high proportion of booked cases (41%) among patients who are discharged from a teaching hospital with a primary diagnosis of angina pectoris.

Although patients discharged from hospital with a primary diagnosis of unstable angina are more likely to have 'probable' ECG changes or 'probable' cardiac enzyme changes than patients with diagnoses of angina pectoris or chest pain, there are no signs and symptoms of CHD that clearly distinguish patients with these three related conditions. However, ECGs, cardiac enzyme levels and duration of chest pain were available in the medical records of almost all patients sampled in the validation study. This suggests that retrospective review of medical records could be used to validate a broad definition of angina pectoris and distinguish coronary patients from those with other conditions.

6.3.3 Congestive cardiac failure

It was suggested in Chapter 5 that a diagnosis of CCF is usually based on the clinical presentation of the patient rather than on invasive or labour-intensive tests. It was also stated that the clinical presentation was sufficiently distinctive to ensure that a correct diagnosis was made but that there would be some differences in threshold levels between doctors. An essential requirement of the process of reviewing medical records to validate a diagnosis of CCF is a 'gold' standard to use as the benchmark for this diagnosis. The Norris (Norris et al. 1969a) and Killip (Killip & Kimball 1967) Indices were designed to diagnose CCF in patients who have AMI but the Framingham criteria (McKee et al. 1971) were intended to define CCF in a more general setting.

The three classical symptoms of CCF, namely exertional dyspnoea, paroxysmal nocturnal dyspnoea and orthopnoea, were recorded more often in the medical records of patients with a primary diagnosis of CCF than of patients discharged with a secondary diagnosis of CCF (Tables 6.4 and 6.5). The combined analysis of these two groups showed that there was no mention of at least one of these symptoms in the medical records of 30–50% of these patients, which is similar to that observed in the Perth study. In teaching hospitals, patients with either a primary or secondary diagnosis of CCF were more likely to have affirmative mention of each of these symptoms in their medical records than were equivalent patients discharged from community hospitals.

Crepitations, fourth heart sound and raised JVP are signs of CCF that are relevant to the Killip definition of CCF. These signs were recorded for almost all patients with a primary discharge diagnoses of CCF, especially in the teaching hospitals (Tables 6.4 and 6.5). Other signs that were well recorded in the medical records were tachypnoea, tachycardia and dysrhythmias, with tachypnoea and tachycardia apparently being far more likely in patients with a primary diagnosis of CCF than in patients with another primary discharge diagnosis.

At least one chest X-ray was obtained for approximately 90% of patients who had a primary discharge diagnosis of CCF and 70% of patients who had a secondary diagnosis of CCF (Tables 6.6 and 6.7). In teaching hospitals cardiac enlargement, pleural effusion or vascular congestion were mentioned when present but a specific absence was often not recorded. Similarly, it was less likely that a diagnosis of cardiac failure or pulmonary oedema was mentioned by radiologists in teaching hospitals than in community hospitals.

Retrospective review of medical records for the diagnosis of CCF may not be feasible for a number of reasons. Firstly there are no universally accepted criteria of CCF. Secondly there is inconsistent mention in the medical records of negative findings relating to symptoms and signs of CCF. Finally, definitive tests for diagnosing CCF are not routinely used.

Table 6.4: Teaching hospitals: distribution of clinical features of congestive cardiac failure within each discharge diagnostic category (per cent)

	Primary discharge diagnosis					
	AMI (410)	Other acute & subacute forms of CHD (411)	Angina pectoris (413)	Chest pain (786.5)	Heart failure (428)	Secondary diagnosis of heart failure
Symptoms						
Exertional dyspnoea	13 (43)	24 (45)	14 (24)	4 (32)	80 (80)	44 (59)
Paroxysmal nocturnal dyspnoea	0 (40)	7 (38)	3 (16)	3 (25)	40 (54)	15 (38)
Orthopnoea	3 (37)	7 (48)	0 (17)	7 (21)	63 (87)	26 (53)
Signs						
Peripheral oedema	7 (57)	7 (52)	7 (21)	4 (54)	37 (67)	35 (64)
Sacral oedema	3 (57)	3 (34)	0 (14)	0 (36)	20 (57)	12 (33)
Dyspnoea	23 (63)	17 (64)	3 (21)	14 (46)	57 (63)	35 (56)
Tachypnoea	37 (100)	28 (100)	7 (86)	21 (100)	83 (97)	56 (91)
Cyanosis	3 (30)	3 (34)	0 (17)	0 (36)	17 (57)	9 (32)
Use of accessory muscles	3 (7)	0 (10)	0 (0)	0 (4)	10 (23)	0 (9)
Frothy sputum	0 (30)	0 (28)	0 (17)	0 (21)	13 (66)	0 (47)
Crepitations	67 (97)	38 (90)	21 (66)	18 (93)	90 (100)	74 (85)
Pleural effusion	7 (40)	7 (31)	3 (17)	0 (25)	30 (53)	21 (29)
Tachycardia	23 (100)	24 (100)	3 (97)	18 (100)	67 (100)	68 (91)
Dysrhythmias	60 (90)	45 (100)	17 (72)	39 (82)	57 (93)	71 (79)
Fourth heart sound	13 (100)	7 (93)	0 (62)	0 (89)	3 (100)	9 (88)
Raised JVP	27 (97)	10 (93)	3 (55)	4 (86)	77 (97)	38 (82)

AMI = acute myocardial infarction; CHD = coronary heart disease; JVP = jugular venous pressure.

Note: Per cent of all patients with the clinical feature present (per cent of all medical records in which the clinical feature is mentioned).

Table 6.5: Community hospitals: distribution of clinical features of congestive cardiac failure within each discharge diagnostic category (per cent)

	Primary discharge diagnosis					
	AMI (410)	Other acute & subacute forms of CHD (411)	Angina pectoris (413)	Chest pain (786.5)	Heart failure (428)	Secondary diagnosis of heart failure
Symptoms						
Exertional dyspnoea	7 (37)	17 (43)	7 (40)	16 (42)	43 (63)	43 (68)
Paroxysmal nocturnal dyspnoea	7 (30)	3 (43)	7 (53)	3 (42)	20 (63)	4 (54)
Orthopnoea	3 (27)	3 (40)	10 (50)	3 (42)	40(73)	18 (50)
Signs						
Peripheral oedema	7 (50)	3 (40)	3 (43)	0 (52)	20 (60)	18 (53)
Sacral oedema	3 (47)	0 (30)	3 (33)	0 (45)	10 (33)	7 (43)
Dyspnoea	7 (37)	17 (40)	17 (53)	0 (48)	40 (63)	21 (57)
Tachypnoea	17 (100)	3 (100)	7 (100)	19 (100)	57 (100)	39 (93)
Cyanosis	0 (53)	7 (40)	0 (43)	0 (48)	13 (67)	0 (43)
Use of accessory muscles	0 (20)	0 (13)	0 (27)	0 (29)	10 (33)	4 (29)
Frothy sputum	3 (40)	0 (33)	3 (50)	6 (61)	13 (86)	11 (68)
Crepitations	50 (90)	30 (80)	33 (87)	26 (90)	83 (97)	75 (93)
Pleural effusion	0 (37)	7 (37)	0 (53)	0 (48)	17 (47)	5 (46)
Tachycardia	30 (100)	13 (100)	13 (100)	16 (100)	53 (100)	46 (96)
Dysrhythmias	37 (97)	47 (97)	47 (93)	19 (94)	53 (90)	54 (93)
Fourth heart sound	0 (83)	3 (77)	0 (83)	3 (93)	0 (90)	0 (71)
Raised JVP	10 (80)	17 (83)	7 (83)	3 (87)	53 (90)	36 (89)

AMI = acute myocardial infarction; CHD = coronary heart disease; JVP = jugular venous pressure.

Note: Per cent of all patients with the clinical feature present (per cent of all medical records in which the clinical feature is mentioned).

Table 6.6: Teaching hospitals: distribution of radiological findings within each discharge diagnostic category (per cent)

	Primary discharge diagnosis					
	AMI (410)	Other acute & subacute forms of CHD (411)	Angina pectoris (413)	Chest pain (786.5)	Heart failure (428)	Secondary diagnosis of heart failure
Chest X-ray performed	**80**	**79**	**38**	**68**	**87**	**76**
'Cardiac failure'	0 (30)	0 (34)	0 (3)	0 (21)	23 (37)	12 (26)
'Pulmonary oedema'	20 (43)	10 (41)	0 (10)	0 (21)	63 (70)	29 (41)
Cardiac enlargement	7 (23)	17 (38)	7 (10)	18 (43)	63 (73)	50 (59)
Pleural effusion	17 (43)	7 (41)	3 (10)	0 (25)	47 (60)	38 (50)
Vascular congestion	10 (33)	3 (34)	0 (7)	0 (25)	30 (43)	21 (35)
Other abnormalities	50 (60)	38 (59)	17 (21)	29 (46)	43 (57)	47 (62)

AMI = acute myocardial infarction; CHD = coronary heart disease.

Note: Per cent of all patients with the clinical feature present (per cent of all medical records in which the clinical feature is mentioned).

Table 6.7: Community hospitals: distribution of radiological findings within each discharge diagnostic category (per cent)

	Primary discharge diagnosis					
	AMI (410)	Other acute & subacute forms of CHD (411)	Angina pectoris (413)	Chest pain (786.5)	Heart failure (428)	Secondary diagnosis of heart failure
Chest X-ray performed	**83**	**70**	**67**	**61**	**93**	**64**
'Cardiac failure'	7 (33)	3 (33)	0 (36)	0 (35)	30 (73)	21 (50)
'Pulmonary oedema'	10 (33)	3 (27)	7 (33)	0 (35)	43 (80)	4 (35)
Cardiac enlargement	10 (37)	30 (43)	20 (37)	13 (58)	50 (80)	32 (39)
Pleural effusion	7 (30)	3 (27)	3 (33)	0 (42)	27 (70)	21 (43)
Vascular congestion	3 (33)	7 (27)	0 (33)	0 (35)	23 (70)	7 (32)
Other abnormalities	23 (40)	13 (33)	20 (47)	16 (45)	37 (77)	36 (46)

AMI = acute myocardial infarction; CHD = coronary heart disease.

Note: Per cent of all patients with the clinical feature present (per cent of all medical records in which the clinical feature is mentioned).

6.4 Conclusion

Based on a pilot study of validation methodology for cardiac conditions (but not stroke) using hospital data it is suggested that:

1. Diagnosis of AMI can be validated through retrospective review of hospital records as the necessary information is usually available;
2. Information in hospital records is insufficient to distinguish between unstable angina; angina pectoris and chest pain, but if a broader category of angina is used then validation is possible;
3. For congestive cardiac failure lack of universally accepted diagnostic criteria or evidence from a definitive test, inadequacies in hospital records make validation from retrospective review of records unfeasible. Only prospective data collection for patients admitted for a broad range of conditions could produce adequate information.

Appendix 1

Table A1: Cases of AMI selected from HMD by MONICA registration status and diagnostic category for unlinked data

Number of restrictions	Diag field	5th digit	Atype	LOS	Registered by MONICA: Definite + ICA No.	Definite + ICA Sens (%)	Possible No.	Possible Sens (%)	Not AMI No.	Not AMI Sens (%)	Total MONICA No.	Total MONICA Sens (%)	Unregistered No.	Unregistered Sens (%)	Not AMI + unregistered No.	Not AMI + unregistered Sens (%)	Total HMD No.	Total HMD Sens (%)
0	Any	Any	Any	Any	1,360	100.0	377	100.0	136	100.0	**1,873**	**100.0**	909	100.0	1,045	100.0	**2,782**	**100.0**
1	Any	Any	Any	3+	1,335	98.2	346	91.8	129	94.9	**1,810**	**96.6**	419	46.1	548	52.4	**2,229**	**80.1**
1	Any	Any	Unbooked	Any	1,312	96.5	357	94.7	103	75.7	**1,772**	**94.6**	377	41.5	480	45.9	**2,149**	**77.2**
1	Any	1	Any	Any	1,331	97.9	346	91.8	121	89.0	**1,798**	**96.0**	209	23.0	330	31.6	**2,007**	**72.1**
1	Main	Any	Any	Any	1,288	94.7	324	85.9	87	64.0	**1,699**	**90.7**	261	28.7	348	33.3	**1,960**	**70.5**
2	Any	Any	Unbooked	3+	1,288	94.7	329	87.3	98	72.1	**1,715**	**91.6**	295	32.5	393	37.6	**2,010**	**72.3**
2	Any	1	Any	3+	1,307	96.1	317	84.1	115	84.6	**1,739**	**92.8**	161	17.7	276	26.4	**1,900**	**68.3**
2	Any	1	Unbooked	Any	1,287	94.6	328	87.0	96	70.6	**1,711**	**91.4**	151	16.6	247	23.6	**1,862**	**66.9**
2	Main	Any	Any	3+	1,266	93.1	295	78.2	80	58.8	**1,641**	**87.6**	153	16.8	233	22.3	**1,794**	**64.5**
2	Main	Any	Unbooked	Any	1,260	92.6	313	83.0	78	57.4	**1,651**	**88.1**	144	15.8	222	21.2	**1,795**	**64.5**
2	Main	1	Any	Any	1,274	93.7	317	84.1	84	61.8	**1,675**	**89.4**	157	17.3	241	23.1	**1,832**	**65.9**
3	Any	1	Unbooked	3+	1,264	92.9	301	79.8	91	66.9	**1,656**	**88.4**	130	14.3	221	21.1	**1,786**	**64.2**
3	Main	Any	Unbooked	3+	1,239	91.1	285	75.6	73	53.7	**1,597**	**85.3**	119	13.1	192	18.4	**1,716**	**61.7**
3	Main	1	Any	3+	1,252	92.1	289	76.7	78	57.4	**1,619**	**86.4**	121	13.3	199	19.0	**1,740**	**62.5**
3	Main	1	Unbooked	Any	1,247	91.7	307	81.4	77	56.6	**1,631**	**87.1**	120	13.2	197	18.9	**1,751**	**62.9**
4	Main	1	Unbooked	3+	1,226	90.1	280	74.3	72	52.9	**1,578**	**84.2**	100	11.0	172	16.5	**1,678**	**60.3**

AMI = acute myocardial infarction; Atype = type of admission—booked or unbooked; Diag = diagnostic; HMD = hospital morbidity data; LOS = length of stay; Sens = sensitivity.

Table A2: Cases of AMI selected from HMD by MONICA registration status and diagnostic category for linked data and 28-day events

Number of restrictions	Diag field	5th digit	Atype	LOS	Registered by MONICA: Definite + ICA No.	Definite + ICA Sens (%)	Possible No.	Possible Sens (%)	Not AMI No.	Not AMI Sens (%)	Total MONICA No.	Total MONICA Sens (%)	Unregistered No.	Unregistered Sens (%)	Not AMI + unregistered No.	Not AMI + unregistered Sens (%)	Total HMD No.	Total HMD Sens (%)
Unlinked	Any	Any	Any	Any	1,360	100.0	377	100.0	136	100.0	**1,873**	**100.0**	909	100.0	1,045	100.0	**2,782**	**100.0**
0	Any	Any	Any	Any	1,341	98.6	366	97.1	133	97.8	**1,840**	**98.2**	456	50.2	589	56.4	**2,296**	**82.5**
1	Any	Any	Any	3+	1,316	96.8	335	88.9	127	93.4	**1,778**	**94.9**	184	20.2	311	29.8	**1,962**	**70.5**
1	Any	Any	Unbooked	Any	1,294	95.1	347	92.0	101	74.3	**1,742**	**93.0**	162	17.8	263	25.2	**1,904**	**68.4**
1	Any	1	Any	Any	1,329	97.7	343	91.0	121	89.0	**1,793**	**95.7**	151	16.6	272	26.0	**1,944**	**69.9**
1	Main	Any	Any	Any	1,269	93.3	318	84.4	85	62.5	**1,672**	**89.3**	153	16.8	238	22.8	**1,825**	**65.6**
2	Any	Any	Unbooked	3+	1,270	93.4	319	84.6	96	70.6	**1,685**	**90.0**	128	14.1	224	21.4	**1,813**	**65.2**
2	Any	1	Any	3+	1,305	96.0	313	83.0	115	84.6	**1,733**	**92.5**	107	11.8	222	21.2	**1,840**	**66.1**
2	Any	1	Unbooked	Any	1,284	94.4	326	86.5	96	70.6	**1,706**	**91.1**	106	11.7	202	19.3	**1,812**	**65.1**
2	Main	Any	Any	3+	1,247	91.7	289	76.7	79	58.1	**1,615**	**86.2**	90	9.9	169	16.2	**1,705**	**61.3**
2	Main	Any	Unbooked	Any	1,242	91.3	308	81.7	77	56.6	**1,627**	**86.9**	91	10.0	168	16.1	**1,718**	**61.8**
2	Main	1	Any	Any	1,269	93.3	314	83.3	84	61.8	**1,667**	**89.0**	116	12.8	200	19.1	**1,783**	**64.1**
3	Any	1	Unbooked	3+	1,261	92.7	298	79.0	91	66.9	**1,650**	**88.1**	91	10.0	182	17.4	**1,741**	**62.6**
3	Main	Any	Unbooked	3+	1,221	89.8	280	74.3	72	52.9	**1,573**	**84.0**	76	8.4	148	14.2	**1,649**	**59.3**
3	Main	1	Any	3+	1,247	91.7	285	75.6	78	57.4	**1,610**	**86.0**	83	9.1	161	15.4	**1,693**	**60.9**
3	Main	1	Unbooked	Any	1,242	91.3	305	80.9	77	56.6	**1,624**	**86.7**	87	9.6	164	15.7	**1,711**	**61.5**
4	Main	1	Unbooked	3+	1,221	89.8	277	73.5	72	52.9	**1,570**	**83.8**	72	7.9	144	13.8	**1,642**	**59.0**

AMI = acute myocardial infarction; Atype = type of admission—booked or unbooked; Diag = diagnostic; HMD = hospital morbidity data; LOS = length of stay; Sens = sensitivity.

Table A3: Cases of AMI selected from HMD by MONICA registration status and diagnostic category for linked data and 56-day events

Number of restrictions	Diag field	5th digit	Atype	LOS	Registered by MONICA: Definite +ICA No.	Definite +ICA Sens (%)	Possible No.	Possible Sens (%)	Not AMI No.	Not AMI Sens (%)	Total MONICA No.	Total MONICA Sens (%)	Unregistered No.	Unregistered Sens (%)	Not AMI + unregistered No.	Not AMI + unregistered Sens (%)	Total HMD No.	Total HMD Sens (%)
Unlinked	Any	Any	Any	Any	1,360	100.0	377	100.0	136	100.0	**1,873**	**100.0**	909	100.0	1,045	100.0	**2,782**	**100.0**
0	Any	Any	Any	Any	1,332	97.9	355	94.2	126	92.6	**1,813**	**96.8**	256	28.2	382	36.6	**2,069**	**74.4**
1	Any	Any	Any	3+	1,307	96.1	324	85.9	120	88.2	**1,751**	**93.5**	132	14.5	252	24.1	**1,883**	**67.7**
1	Any	Any	Unbooked	Any	1,285	94.5	336	89.1	97	71.3	**1,718**	**91.7**	121	13.3	218	20.9	**1,839**	**66.1**
1	Any	1	Any	Any	1,328	97.6	343	91.0	120	88.2	**1,791**	**95.6**	145	16.0	265	25.4	**1,936**	**69.6**
1	Main	Any	Any	Any	1,268	93.2	318	84.4	85	62.5	**1,671**	**89.2**	139	15.3	224	21.4	**1,810**	**65.1**
2	Any	Any	Unbooked	3+	1,261	92.7	308	81.7	92	67.6	**1,661**	**88.7**	101	11.1	193	18.5	**1,762**	**63.3**
2	Any	1	Any	3+	1,304	95.9	313	83.0	114	83.8	**1,731**	**92.4**	107	11.8	221	21.1	**1,838**	**66.1**
2	Any	1	Unbooked	Any	1,283	94.3	326	86.5	95	69.9	**1,704**	**91.0**	107	11.8	202	19.3	**1,811**	**65.1**
2	Main	Any	Any	3+	1,246	91.6	289	76.7	79	58.1	**1,614**	**86.2**	88	9.7	167	16.0	**1,702**	**61.2**
2	Main	Any	Unbooked	Any	1,241	91.3	308	81.7	77	56.6	**1,626**	**86.8**	89	9.8	166	15.9	**1,715**	**61.6**
2	Main	1	Any	Any	1,268	93.2	314	83.3	84	61.8	**1,666**	**88.9**	113	12.4	197	18.9	**1,779**	**63.9**
3	Any	1	Unbooked	3+	1,260	92.6	298	79.0	90	66.2	**1,648**	**88.0**	92	10.1	182	17.4	**1,740**	**62.5**
3	Main	Any	Unbooked	3+	1,220	89.7	280	74.3	72	52.9	**1,572**	**83.9**	74	8.1	146	14.0	**1,646**	**59.2**
3	Main	1	Any	3+	1,246	91.6	285	75.6	78	57.4	**1,609**	**85.9**	83	9.1	161	15.4	**1,692**	**60.8**
3	Main	1	Unbooked	Any	1,241	91.3	305	80.9	77	56.6	**1,623**	**86.7**	87	9.6	164	15.7	**1,710**	**61.5**
4	Main	1	Unbooked	3+	1,220	89.7	277	73.5	72	52.9	**1,569**	**83.8**	72	7.9	144	13.8	**1,641**	**59.0**

AMI = acute myocardial infarction; Atype = type of admission—booked or unbooked; Diag = diagnostic; HMD = hospital morbidity data; LOS = length of stay; Sens = sensitivity.

Table A4: Number of non-fatal MONICA definite AMI and number of cases of AMI from HMD using record linkage or other selection criteria

	1984	1985	1986	1987	1988	1989	1990	1991	1992	1993
Males										
MONICA non-fatal definite and HMD = 410	393	420	417	412	420	399	426	422	397	388
HMD linked 410 (28-day)	524	556	595	561	577	568	607	586	530	563
HMD linked 410 (56-day)	516	539	573	544	555	547	580	575	530	561
HMD unlinked Any 410	649	692	730	722	826	828	870	871	793	852
HMD unlinked Main = 410	553	603	648	615	620	632	657	631	550	592
HMD unlinked 410, LOS 3+ days	502	534	564	523	541	520	558	555	495	532
HMD unlinked 410, unbooked	485	522	576	579	575	553	562	564	520	549
HMD unlinked 410, LOS 3+ days, unbooked	456	496	533	491	514	492	527	528	476	510
Females										
MONICA non-fatal definite and HMD = 410	91	72	76	83	83	96	101	81	81	74
HMD linked 410 (28-day)	137	107	133	138	122	145	156	134	122	103
HMD linked 410 (56-day)	134	106	126	133	117	142	147	131	121	103
HMD unlinked Any 410	180	137	179	181	178	202	218	195	184	183
HMD unlinked Main = 410	144	112	142	150	134	155	165	146	127	105
HMD unlinked 410, LOS 3+ days	123	103	117	128	109	139	141	121	116	99
HMD unlinked 410, unbooked	131	104	130	138	126	148	145	126	117	101
HMD unlinked 410, LOS 3+days, unbooked	116	99	114	119	106	134	132	112	110	97

AMI = acute myocardial infarction; HMD = hospital morbidity data; LOS = length of stay.

Table A5: The PPV and sensitivity of HMD diagnoses for cases of stroke as recorded by the Perth Community Stroke Study registers

					1989 register					1995 register				
Group	**Diag field**	**Atype**	**LOS**	**Diagnosis**	**PCSS**	**HMD**	**PPV**	**Sens**	**PPV/sens**	**PCSS**	**HMD**	**PPV**	**Sens**	**PPV/sens**
Age <75 years														
A	Any	Any	Any	All linked CeVD	184	562	0.33	1.00	0.33	94	394	0.24	1.00	0.24
B	Main	Any	Any	Stroke	108	146	0.74	0.59	1.26	59	70	0.84	0.63	1.34
C	Other	Unbooked	Any	Stroke	6	10	0.60	0.03	18.40	6	20	0.30	0.06	4.70
B+C	**Stroke as main diagnosis OR stroke recorded in another field of an unbooked admission**				**114**	**156**	**0.73**	**0.62**	**1.18**	**65**	**90**	**0.72**	**0.69**	**1.04**
D	Main	Unbooked	3+	Other CVD	21	46	0.46	0.11	4.00	9	23	0.39	0.10	4.09
A–(B:D)	Residual	All remaining cases from A			49	360	0.14	0.27	0.51	20	281	0.07	0.21	0.33
Age 75+ years														
A	Any	Any	Any	All linked CeVD	141	578	0.24	1.00	0.24	117	376	0.31	1.00	0.31
B	Main	Any	Any	Stroke	94	126	0.75	0.67	1.12	70	77	0.91	0.60	1.52
C	Other	Unbooked	Any	Stroke	17	27	0.63	0.12	5.22	16	33	0.48	0.14	3.55
B+C	**Stroke as main diagnosis OR stroke recorded in another field of an unbooked admission**				**111**	**153**	**0.73**	**0.79**	**0.92**	**86**	**110**	**0.78**	**0.74**	**1.06**
D	Main	Unbooked	3+	Other CVD	10	37	0.27	0.07	3.81	15	33	0.45	0.13	3.55
A–(B:D)	Residual	All remaining cases from A			20	388	0.05	0.14	0.36	16	233	0.07	0.14	0.50

Atype = type of admission—booked or unbooked; CeVD = cerebrovascular disease; CVD = cardiovascular disease; HMD = hospital morbidity data; Other CeVD = 342, 432, 433, 437, 438; PPV = positive predictive value; Sens = sensitivity; Stroke = ICD-9-CM codes 430, 431, 434, 436.

Appendix 2

CODER ID ☐☐

CVD DIAGNOSIS VALIDATION PROJECT

1. HOSPITAL (name): _____ ☐☐☐☐

2. HOSPITAL UNIT RECORD NUMBER: _____ ☐☐☐☐☐☐☐☐

3. SEX: 1 MALE 2 FEMALE ☐

4. DATE OF BIRTH (day, month, year): _____ ☐☐ ☐☐ ☐☐

5. ADMISSION TIME AND DATE: _____

(hours [24-hour clock], day, month, year) ☐☐☐☐ ☐☐ ☐☐ ☐☐

6. TYPE OF ADMISSION:

1 Booked admission 2 Emergency admission 3 Direct admission

4 Transferred from another hospital (please specify) _____ ☐

7. TIME AND DATE OF ONSET OF SYMPTOMS LEADING TO THIS ADMISSION:

_____

(hours [24-hour clock], day, month, year): ☐☐☐☐ ☐☐ ☐☐ ☐☐

(If ill-defined onset, code TIME and DAYS to 99)

8. ADMISSION DIAGNOSIS:

1 AMI 2 UAP 3 CCF 4 OTHER (please specify) _____ ☐☐

9. DISCHARGE DATE (day, month, year): _____ ☐☐ ☐☐ ☐☐

10. DISCHARGE DETAILS:

1 Discharged home 2 Nursing home/hostel 3 Deceased

4 Other hospital (please specify) _____ ☐

11. HOSPITAL DISCHARGE DIAGNOSES:

(i) Principal diagnosis _____ ☐☐☐☐☐

(ii) Other diagnoses (code up to 4) _____ ☐☐☐☐☐ ☐☐☐☐☐

_____ ☐☐☐☐☐ ☐☐☐☐☐

12. CLINICAL SITE OF INFARCTION (if applicable—circle as many as appropriate):

1 Anterior 2 Inferior 3 Lateral 4 Posterior

5 Other 8 No AMI 9 Not known ☐☐

13. SYMPTOMS:

Code: ***Yes 2 No 8 Not applicable 9 Not known***

		ON INITIAL PRESENTATION	**COMPLICATION**
i	Chest pain lasting longer than 20 minutes continuously or terminated by injection, syncope or death, or duration estimated from concurrent events as longer than 20 minutes.	☐	☐
ii	Chest pain lasting less than 20 minutes continuously	☐	☐
iii	Chest pain that seems typical of MI but no evidence of duration	☐	☐
iv	Pain in upper abdomen, jaw, arm or neck	☐	☐
v	Acute left heart failure (sudden onset of pulmonary oedema and congestion leading to dyspnoea, orthopnoea, basal crepitations (rales) and coughing up of frothy sputum)	☐	☐
vi	Shock (restlessness, stupor, pallor, cold sweat, feeble pulse, hypotension, tachycardia)	☐	☐
vii	Syncope (transient loss of consciousness)	☐	☐
viii	Shortness of breath	☐	☐
ix	Uncomfortable beating of heart		

		ON INITIAL PRESENTATION	COMPLICATION
x	Diaphoresis (profuse sweating)	☐	☐
xi	Presentation cardiac arrest – **dead on arrival** (resuscitation failed)	☐	☐
xii	Presentation cardiac arrest – **alive**	☐	☐
xiii	Exertional dyspnoea	☐	☐
xiv	Paroxysmal nocturnal dyspnoea	☐	☐
xv	Orthopnoea	☐	☐
xvi	Swollen ankles	☐	☐
xvii	Peripheral oedema	☐	☐
xviii	Sacral oedema	☐	☐
xix	Dyspnoea	☐	☐
xx	Cough with frothy sputum	☐	☐
xxi	Elevated JVP	☐	☐
xxii	Cyanosis	☐	☐
xxiii	Accessory resp. muscles	☐	☐
xxiv	Creps	☐	☐
xxv	Effusion	☐	☐
xxvi	4th heart sound	☐	☐
xxvii	Dysrhythmias	☐	☐
xxviii	Tachypnoea	☐	☐
xxiv	Tachycardia		

14. RADIOLOGY REPORT ON CHEST X-RAYS:

Code: 1 Yes 2 No 8 Not applicable (no chest X-rays)

NORMAL CHEST FILM / CHEST CLEAR on all films	☐
Presence of CARDIAC FAILURE on any film	☐
Presence of PULMONARY OEDEMA on any film	☐
Presence of CARDIAC ENLARGEMENT on any film	☐
Presence of PLEURAL EFFUSIONS on any film	☐
Presence of PULMONARY VASCULAR CONGESTION on any film	☐
Presence of any other ABNORMALITY on any film	☐

15. THROMBOLYSIS GIVEN:

1 Yes 2 No, reason given 3 No, no reason given

4 Not applicable (no AMI) ☐

16. SERUM ENZYMES:

AST:		Highest level recorded for this admission	☐☐☐☐
		Upper limit of normal range	☐☐☐
CPK:		Highest level recorded for this admission	☐☐☐☐☐
		Upper limit of normal range	☐☐☐
CK-MB:		Highest level recorded for this admission	☐☐☐☐
		Upper limit of normal range	☐☐☐
cTnI:		Highest level recorded for this admission	☐☐☐☐
		Upper limit of normal range	☐☐☐
CK-MB	i	Percentage of total CPK	☐☐
	ii	Total CPK on same sample (code 9999 if not available)	☐☐☐☐

	iii	Was it a sample after peak CPK?	1	Yes	2	No	9	No data
	iv	Consistent with myocardial necrosis?	1	Yes	2	No	9	No data
Troponin-I (cTnl)		Consistent with myocardial necrosis?	1	Yes	2	No	9	No data

Any other possible causes for raised enzymes (intramuscular injection, defibrillation, recent surgery, cardiac massage, intravascular manipulation, liver disease, recent major infection)?

1 Yes 2 No 9 No data

17. ECGs:

ECGs to be selected and photocopied:

1. The first available, codable ECG in the index attack (or one recorded within 28 days before the attack).

2. The next two codable ECGs on dates different from the first and from each other.

3. The last codable ECG in the record file for the admission.

Remember to ensure that patient's name and diagnostic information are concealed (liquid paper, black texta, etc.) and to include on each copy the date, time of ECG, hospital number, MR number, study number, and the number of the ECG (1, 2, 3, 4)

ECG number (1, 2, 3, 4)	Date performed	Time performed (24-hour clock)

How many ECGs in total were performed on this patient during this event?

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AIHW website

Information relating to cardiovascular disease, its treatment and risk factors can be found on the Cardiovascular Health portal and the National Cardiovascular Disease Database, both located on the Institute's website http://www.aihw.gov.au