Uses of the record linkage in planning services for the prevention and control of cardiovascular disease

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1. Background

During the past three decades mortality from cardiovascular disease (CVD) has declined dramatically. This is believed to be due to both declining incidence and improved survival in those with clinical disease although the contributions of public health programs on the one hand, and clinical interventions on the other, is hard to quantify. While aged standardised hospital admissions rates for acute coronary and stroke events have declined, hospital admission rates for CVD continue to increase (Figure 1), driven principally by investigation for and performance of coronary artery revascularization procedures (CARPs). The use of selected pharmacological agents for prevention and treatment of CVD has also increased dramatically. Some of the major issues in planning and evaluation of services for CVD are thus:

• What is the appropriate balance between public health and clinical interventions in terms of costs and benefits?

• What are the factors influencing the demand for CARPs?

• How large are the potential benefits of secondary prevention and how systematically is it being implemented? How cost-effective is secondary prevention based primarily on medical treatment compared with other interventions including CARPs?

• What further measures need to be taken to improve the emergency treatment of acute coronary and cerebro-vascular (CeVD) events?

• How adequate are existing data sources for planning CVD services in terms of coverage and accuracy of coding, taking into account rapidly evolving medical and surgical in treatment? ? in-treatment?

2. Objectives

The objectives of this presentation are:

• To define the information requirements for planning and evaluation of health services for CVD, including the role of record linkage;

• To demonstrate applications of record linkage in Western Australia relevant to planning and evaluation of health services for CVD

3. Information requirements for planning services for CVD

A conceptual framework for information requirements for planning and evaluation of health services for CVD is shown in Figure 2. This depicts first (top row of boxes), the stages in the natural history of CVD; secondly the range of public health and clinical interventions (second row) that might influence this, and finally (bottom row) the information that would be required to quantify and evaluate each of the intervention options. In general, the essential requirement is for longitudinal data that can be used to determine transitional probabilities for the progression of disease and how these are likely to be changed by selected interventions. This necessarily requires the linkage of relevant data.

4. Data sources and methods

The studies described here are based firstly, on the linkage of hospital morbidity data (HMD) and death to data (the core file) and secondly, through cross-linkage to data collected from special studies. The core file is a subset of the Western Australian Health Services Research Linked Database, and includes records of all persons admitted to hospital or dying from and any form of CVD since 1980. The additional special study data that have been linked to HMD and death data for various purposes, are listed in the Table below:

Type of study	Source of Data
Prevalence of coronary risk factors; development of coronary risk equations	Busselton Survey data 1966 – 1979; Perth risk factor surveys (6) 1978–99
Incidence and medical treatment of acute coronary events; Validation of diagnostic coding of AMI in HMD	Perth Coronary Register (PCR) 1970–71; 1978 Heart Attack validation study[1–3]; Perth MONICA Heart Attack Register 1984–93 1998 Perth Heart Attack Study (PHAS- 98) Laboratory test results – bio-markers of myocardial damage (as part of PHAS–98)
Stroke incidence and management; Validation of diagnostic coding for stroke in HMD	Perth Community Stroke Study Registers (PCSS) 1989–90; PCSS 1995–96;(PCSS 2000)
Planning and evaluation of CARPs	Departments of Cardiology and Cardiothoracic surgery databases
Uptake of secondary prevention following AMI	Postal surveys of ongoing medical treatment in persons included in the Perth MONICA and PHAS–98 studies

5. Applications of record linkage in CVD in Western Australia

5.1. Validation of diagnostic coding of AMI in HMD

Accurate monitoring of the incidence of AMI and stroke is fundamental to planning and evaluation of health services for CVD. Ideally this should be through disease registers but these are logistically and economically difficult to sustain and can usually be used only for selected populations. Routinely collected administrative data can provide information on the whole population but also have several disadvantages, including inflation because of multiple admission records for the same disease episode and variability in the quality and consistency over time of diagnostic coding. Record linkage can partly offset these disadvantages by fixed-length disease episodes that eliminate the effects of multiple admissions and through linkage of administrative records to register data, when these exist, in order to validate disease coding against previously defined criteria.

In Western Australia, information from both heart attack and stroke registers has been cross-linked to corresponding event data in the HMD to determine the validity and predictive value of hospital discharge diagnoses for true cases of AMI or stroke. This has led to the development of coding algorithms based on principal and additional diagnoses, length of stay and admission type (unbooked or booked) that optimise the balance between false positive and false negative diagnoses in HMD for validated cases of AMI or stroke. This work is described in detail in a report for the Australian Institute of Health and Welfare[4].

A further innovation for validation of diagnostic codes for AMI has been the direct linkage of laboratory data for biochemical markers of myocardial damage to HMD. This was undertaken during the 1998 Perth Heart Attack Study (PHAS–98) as an additional method of case finding in cases with hospital discharge codes other than AMI. With the introduction of troponins, which are highly sensitive and specific tests for myocardial damage, this promises to provide a much more economical way of accurately monitoring acute coronary events in the future. For example, rather than running full coronary registers, linkage of laboratory data to HMD and death data will provide a sampling frame from which cases may be selected for diagnostic validation and the collection of additional data relating to treatment not included in the HMD records.

While the introduction of troponins is likely to improve diagnosis in borderline cases of AMI, there is concern that their high sensitivity may lead to a spurious increase in AMI in HMD series. Through the PHAS–98, we have determined changes in the sensitivity and PPV of HMD codes for AMI for MONICA Definite AMI by comparing the sensitivity and PPV of HMD codes for MONICA Definite MI in 1990–93 and 1998 when troponins were introduced. It is likely that these have increased cases coded as AMI by approximately 10% (Figure 3). The availability or troponins is also likely to radically change the criteria for AMI in population-based studies. For example, if positive troponins were added to the WHO (MONICA) criteria for Definite MI, many cases previously coded(s) as Possible or Not AMI would be promoted to Definite, increasing the number of such cases by 50% (Figure 4)

5.2. Incidence and prevalence of AMI and recurrent coronary events

As the result of validation studies conducted since 1971 we believe that trends in hospital admission for AMI or other IHD can be accurately monitored by constructing 28 day (acute) or one-year episodes and by applying the coding algorithms referred to above. Additionally, such episodes provide 28 day and one year case fatality. For example, Figures 5 and 6 illustrate declining cumulative mortality at one year in both men and women since 1989. One year episodes also provide an assessment of cumulative use of services within, for example one year of AMI or stroke events (see 5.5 and 5.6.2) Longer lead in intervals (for example, of five years) have been used to provide a proxy measure of first and recurrent episodes of AMI. Similarly, the prevalence of persons previous AMI can be estimated from cases admitted previously for AMI and still alive in the community (by subtracting cases known to have died before the defined prevalence point).

5.3 The potential scope of secondary prevention following AMI

Clinical trials have firmly established the efficacy of long-term preventive treatment following AMI with a number of drugs including beta-blockers, antiplatelet agents, ACE inhibitors and cholesterol lowering agents. The population benefits from their wide-spread use will depend on the absolute risk of recurrent events in persons with previous AMI. Using the methods described above acute coronary events we found first, that approximately 50% of fatal events and 25% of nonfatal events occurred in persons who had had previous admissions for MI (Figure 7). Secondly, the prevalence of persons with previous admissions for MI was determined (Figure 8), enabling the estimation of relative risk of acute events in persons with previous admissions compared to those with no previous admissions (Figure 9). From these results and the treatment effects observed in clinical trials, it is clear that systematic use of secondary treatment has the potential to substantially reduce acute coronary events.

5.4 Trends in the incidence of stroke

As in the case of coronary heart disease, mortality from stroke has been falling for over 30 years but there are few data to indicate whether this has been due to falling incidence or improved survival. In Australia the only source of such data has been the Perth Community Stroke Studies that have conducted three stroke registers in a selected area in Perth representing about 13% of the total population of the Perth Statistical Division (PSD). These studies commenced only in 1989–90 and may not necessarily be representative of the whole population. The only alternative possible source of information is linkage of HMD and death data. The disadvantages of this are:

- incomplete case ascertainment as not all stroke cases are admitted to hospital and the proportion that are may have varied over time
- multiple hospital admissions for the same event
- quality of coding of stroke diagnoses in HMD and the fact that this may have changed over time with improved diagnostic certainty.

In order to develop a diagnostic algorithm that would distinguish between acute stroke and other cerebrovascular disease, the records of the PCSS 1989–90 and 1995–6 registers were linked to equivalent HMD records for the same study area and time period. The utility of factors such as principal and other diagnoses, type of admission (booked or unbooked) and length of stay were assessed[4]. Figures 10 and 11 show the point estimates for admission rates for males and females for stroke based on the PCSS registers, and on HMD using the recommended selection algorithm. The latter is shown for both the PCSS area and the whole PSD. All methods show a decline in the hospital admission rate from 1989–90 to 1995–96 in both men and women. It is notable however that the rate for the PSD in men (but not in women) is lower than for the PCSS area.

Figure 12 shows trends in aged standardised hospital admission rates for stroke in the PSD using the same selection criteria. These have declined by approximately 40% over the past eighteen years. These data do not represent stroke incidence, as they take no account of cases treated out of hospital. The PCSS registers of 1989–90 and 1995–6 demonstrated a decline in the proportion of cases treated out of hospital (from 13% to 5% in persons less than 75 years and from 23% to 11% in persons 75 years and over[5]). Figure 12 thus provides a conservative estimate of the true decline in stroke in this period.

5.5. Services following admission to hospital for stroke

The ongoing service requirements for persons with continuing disability resulting from stroke are difficult to determine because they are provided by different agencies in a range of clinical settings. The Continuing Care Linkage Study (CCLS) has been established to integrate information from HMD, Aged Care Assessment teams, Home and Community Care Services, residential care and mortality data. Preliminary results relating to the outcomes up to 12 months following hospital admission for stroke (Figure 13) indicate that of all persons admitted for stroke in 1996:

- approximately 30% died within one year (20% within 28 days) of admission;
- nearly half were referred to Aged Care Assessment Teams for either rehabilitation or assessment for residential care;
- at lease 19% were referred for HACC services (under-ascertained); and
- nearly 20% were referred for residential care.

5.6. Estimating future requirements for CARPs

Figure 1 demonstrated that while hospital admission rates for of AMI in Perth have declined since 1980, hospital admissions for other ischaemic heart disease (IHD) have increased sharply, due principally to admissions for coronary angiography and subsequent CARPs. An understanding of the factors behind this apparently unrelenting trend is important for future planning. A schema for simulation modelling of future needs for CARPs is shown in Figure14. Current research using record linkage is attempting to determine transitional probabilities to be used in the model.

5.6.1. Rates of primary and secondary CARPs

One factor behind the apparently unrestrained increase in CARPs has been the problem of restenosis following Percutaneous Angioplasty, leading to revision procedures in approximately 30% of cases (Figure 15). There are reasons however for predicting that the rates of CARP may stabilise in the medium-term. First, rates of first-ever angiography, a necessary prerequisite for CARPs appears to have levelled off in persons under 65 years and to some extent in those aged 65–74 (Figure 16) with parallel changes in first CARPs. Secondly, following the introduction of coronary artery stents in 1995 for percutaneous coronary interventions (PCI) there has been an approximate halving of the readmission rate for repeat PCI (Figures 17 and 18). These changes are in line with results of randomised clinical trials of stents versus standard PTCA but rapid uptake of secondary prevention – for example increasing use of cholesterol lowering drugs – must also be considered as a reason for this change. Understanding the relative importance of the stents versus improved and more intensive adjunct medical treatment is the subject of current research.

5.6.2. Coronary artery revascularisation following AMI

Approximately 35% of CARPs occur in persons who first present to hospital with AMI. Such cases therefore provide an important guide to demographic variables that influence the performance of CARPs and how these have changed over time. The cumulative frequency of CARPs following AMI has also been developed as a measure of the uptake of new technology in comparative international studies conducted by the Centre of Economic Evaluation and Stanford University and by the OECD. Figure 19 shows trends in the cumulative incidence of CARPs within 12 months of AMI in Perth since 1981. Apart from the continuous increase over time, the frequency of such procedures is related inversely to age. The rate of increase is greatest in older age groups however, indicating that overall rates are likely to continue to rise.

6. Future developments in record linkage for planning CVD services

The applications described above are based principally on the internal linkage of HMD data to mortality data and to special registry data. There are a number of ways in which linkage for CVD can be enhanced. The first is for further routine linkage to clinical data sets. For example: laboratory results for markers of myocardial damage; databases maintained by Departments of Cardiology and Cardiothoracic Surgery; Emergency Department and the Ambulance Service records. In addition more relevant detail could be extracted from the patient management information systems maintained by major Teaching Hospitals regarding admissions to Coronary Care Intensive Care Units. This enhanced information system would provide more complete information relating to the management of acute coronary and cerebro-vascular events (Figure 20) and coronary artery revascularization procedures (Figure 21). Even greater enhancement would be gained from cross-jurisdictional linkage between the hospital statistical collections maintained by State Health Departments, MBS and PBS maintained by the Health Insurance Commission, and Residential Care data maintained by the Commonwealth Department of Health and Community Services. This would, for example, facilitate the monitoring of secondary prevention in persons discharged from hospital for various forms of CVD (Figure 23). Cross-jurisdictional linkage would in addition provide information for coordination of services administered by different levels of government and provide a comprehensive view of costs attributable to particular disease syndromes and CVD in general (Figure 23).

References

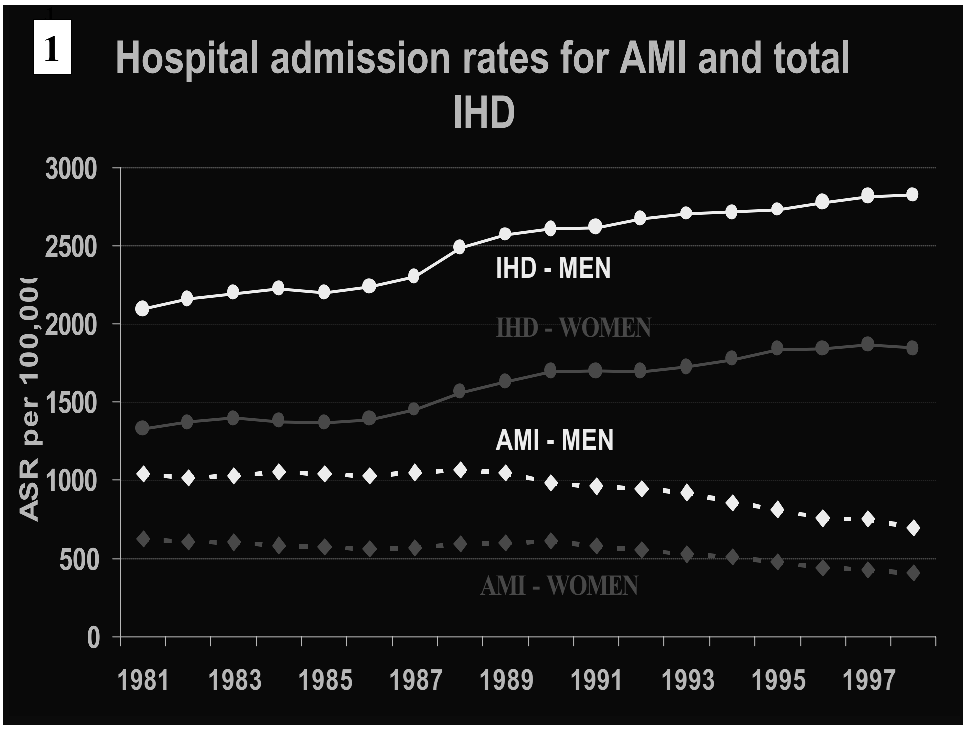
Martin CA, Hobbs MST, Armstrong BK. Estimation of myocardial infarction mortality from routinely collected data in Western Australia. Journal of Chronic Diseases 1987; 40:7: 661–669.

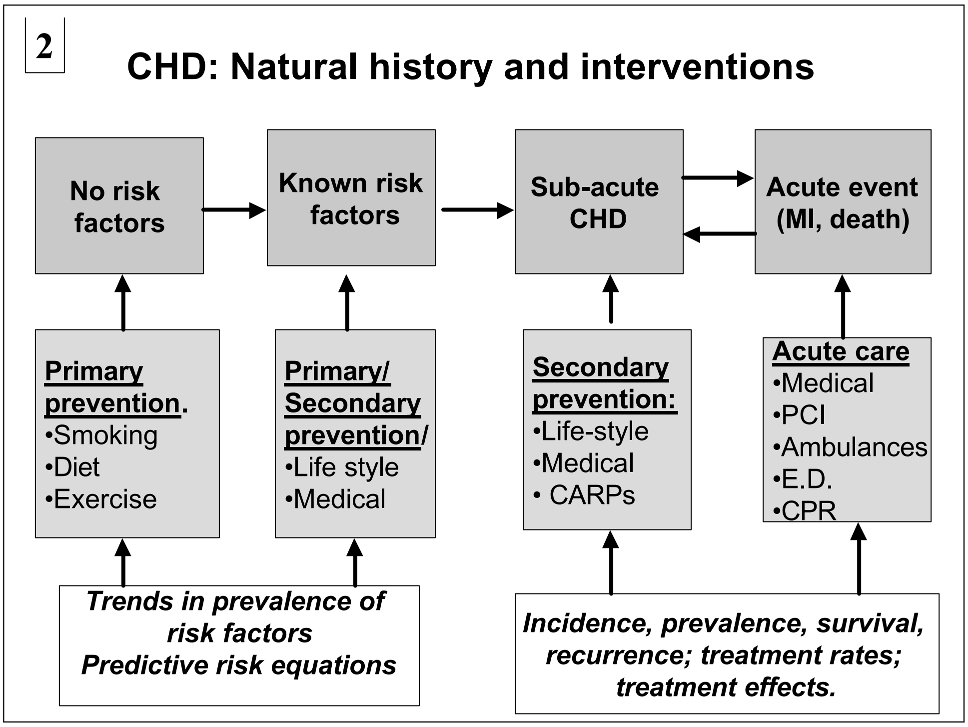
Martin CA, Hobbs MST, Armstrong BK, Identification of non-fatal myocardial infarction from hospital discharge data in Western Australia. Journal of Chronic Diseases 1987; 40: 12: 1111–1120.

Martin CA, Hobbs MST, Armstrong BK, de Klerk NH. Trends in the Incidence of myocardial infarction in Western Australia between 1971 and 1982. American Journal of Epidemiology 1989; 129: 665–668.

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

Jamrozik k, Broadhurst RJ, Lai N, Hankey GJ, Burvill PW, Anderson CS. Trends in incidence, severity and short-term outcome of stroke in Perth, Western Australia. Stroke, 1999;30(10):2105–11

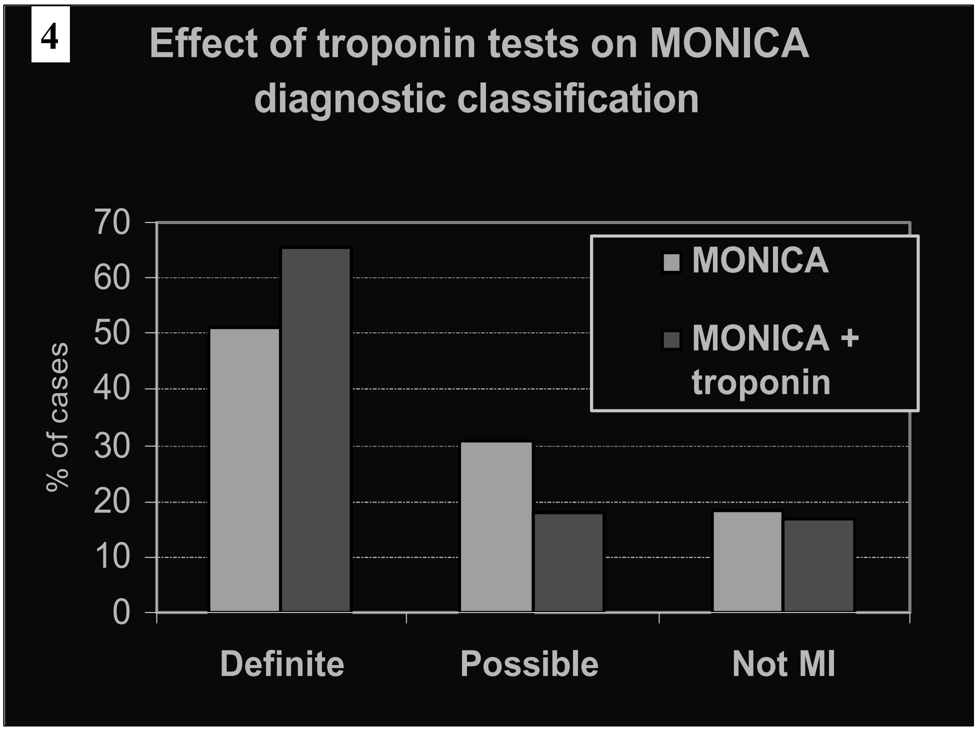

1
Hospital admission rates for AMI and total IHD
3000
2500
2000
1500
1000
500
0
ASR per 100,000
IHD - MEN
IHD - WOMEN
AMI - MEN
AMI - WOMEN
1981
1983
1985
1987
1989
1991
1993
1995
1997

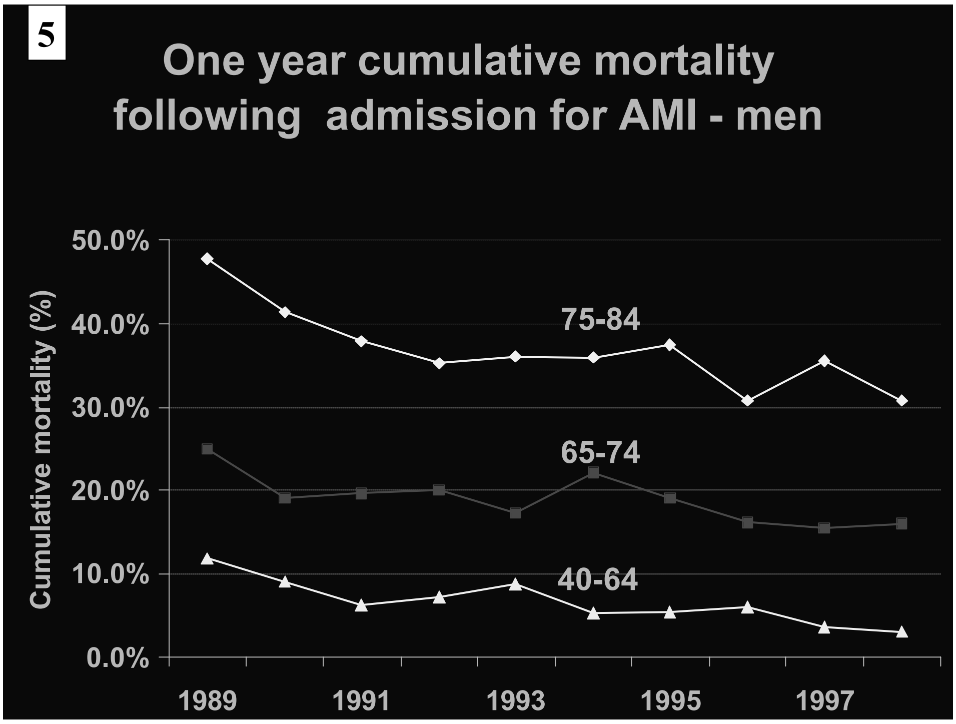

2
CHD: Natural history and interventions
No risk factors
Known risk factors
Sub-acute CHD
Acute event (MI, death)
Primary prevention. •Smoking •Diet •Exercise
Primary/ Secondary prevention/ •Life style •Medical
Secondary prevention: •Life-style •Medical • CARPs
Acute care •Medical •PCI •Ambulances •E.D. •CPR
Trends in prevalence of risk factors
Predictive risk equations
Incidence, prevalence, survival, recurrence; treatment rates; treatment effects.

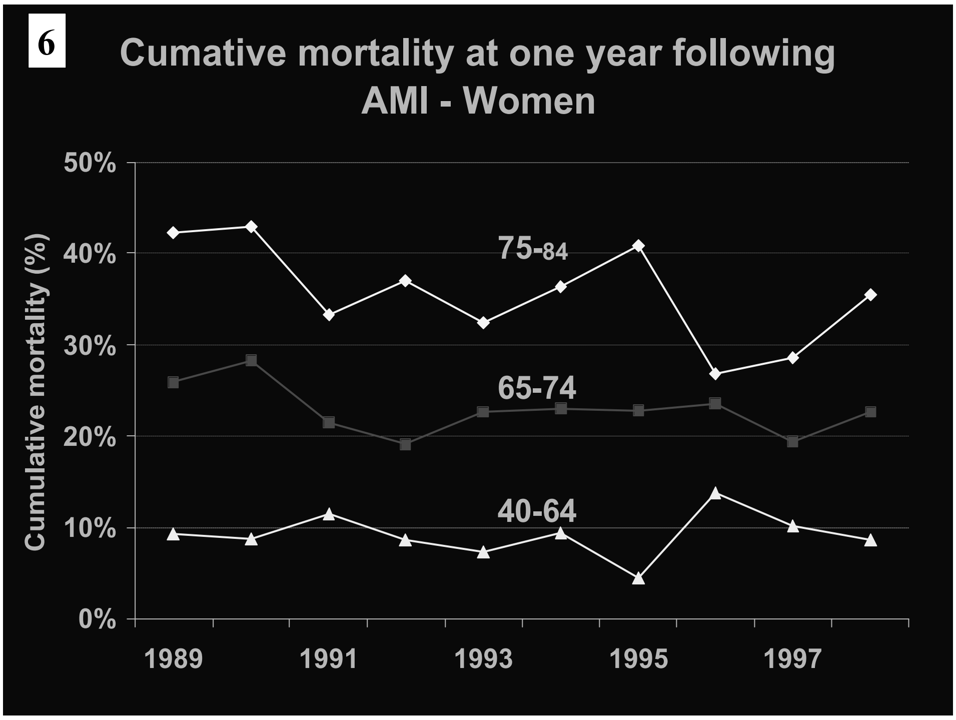
3

Effect of troponin tests on PPV and sensitivity of HMD codes for AMI compared with MONICA Definite MI with % over-estimate

Period	PPV (%)	Sensitivity (%)	over-estimate (%)
1990-93	76.0	93.0	22.0
1998 (troponin)	69.0	95.0	38.0




5
One year cumulative mortality following admission for AMI - men
Cumulative mortality (%)
50.0%
40.0%
30.0%
20.0%
10.0%
0.0%
75-84
65-74
40-64
1989
1991
1993
1995
1997


6
Cumative mortality at one year following AMI - Women
Cumulative mortality (%)
50%
40%
30%
20%
10%
0%
75-84
65-74
40-64
1989
1991
1993
1995
1997

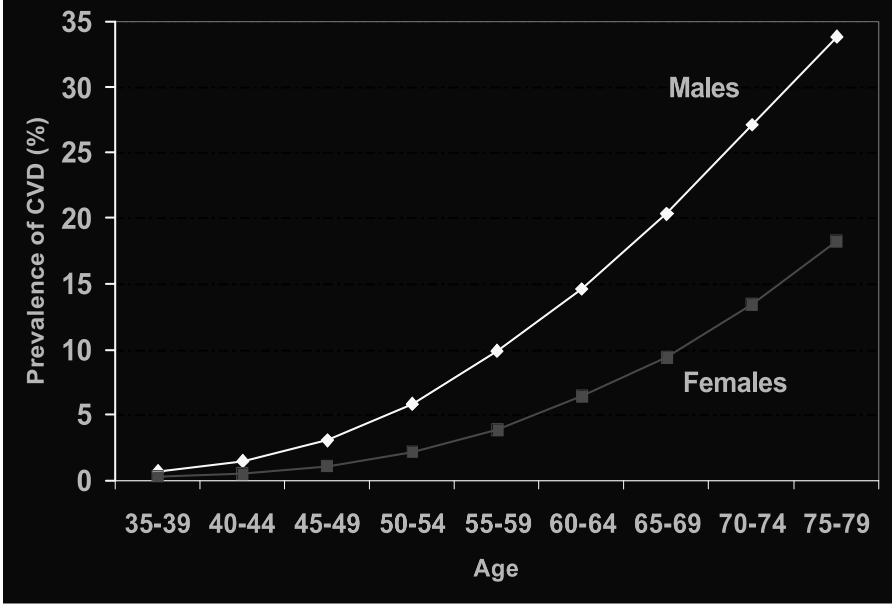
7

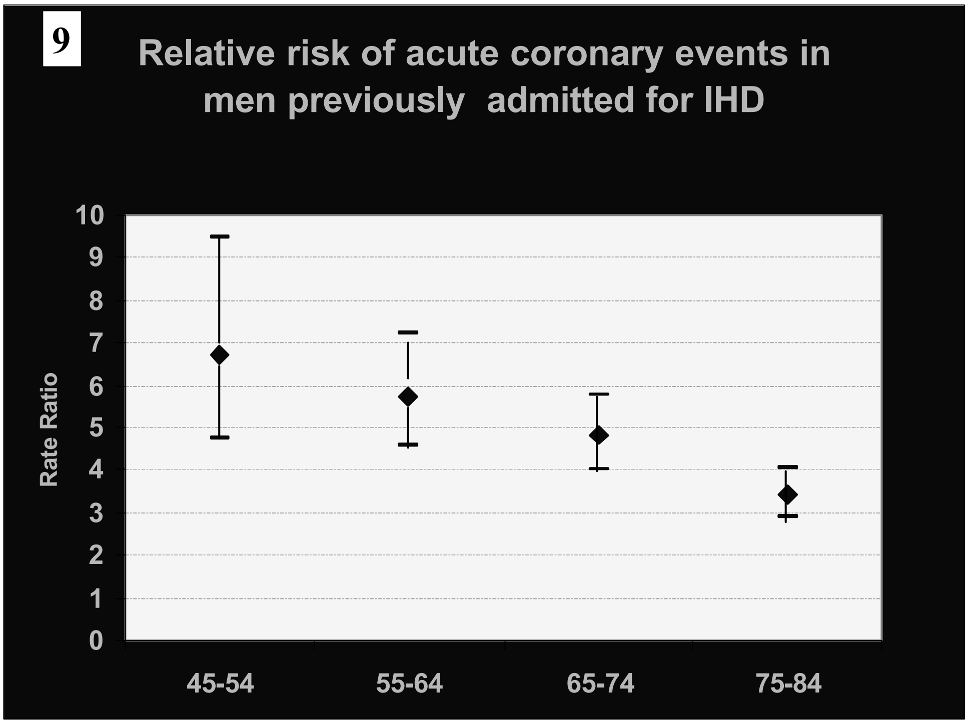
Proportions of acute coronary events in persons with previous admissions for IHD

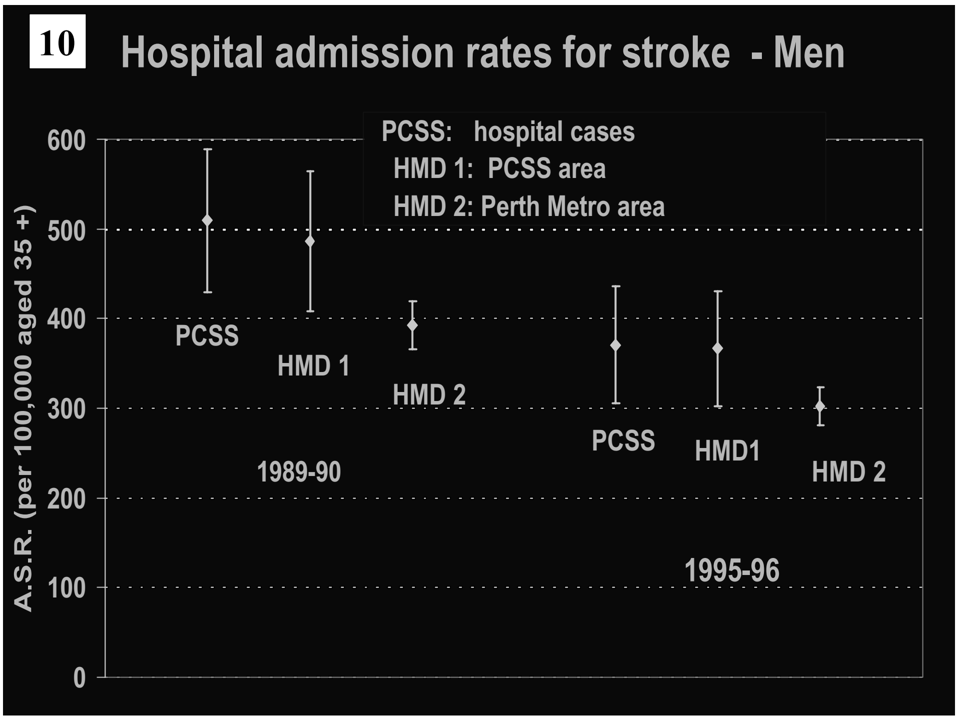
	Males		Females	
Age	Non-fatal	Fatal	Non-fatal	Fatal
45-54	17.4%	32.9%	12.9%	40.6%
55-64	26.0%	48.4%	17.2%	42.7%
65-74	28.8%	54.5%	25.2%	45.4%
75-84	40.3%	51.4%	33.9%	57.4%

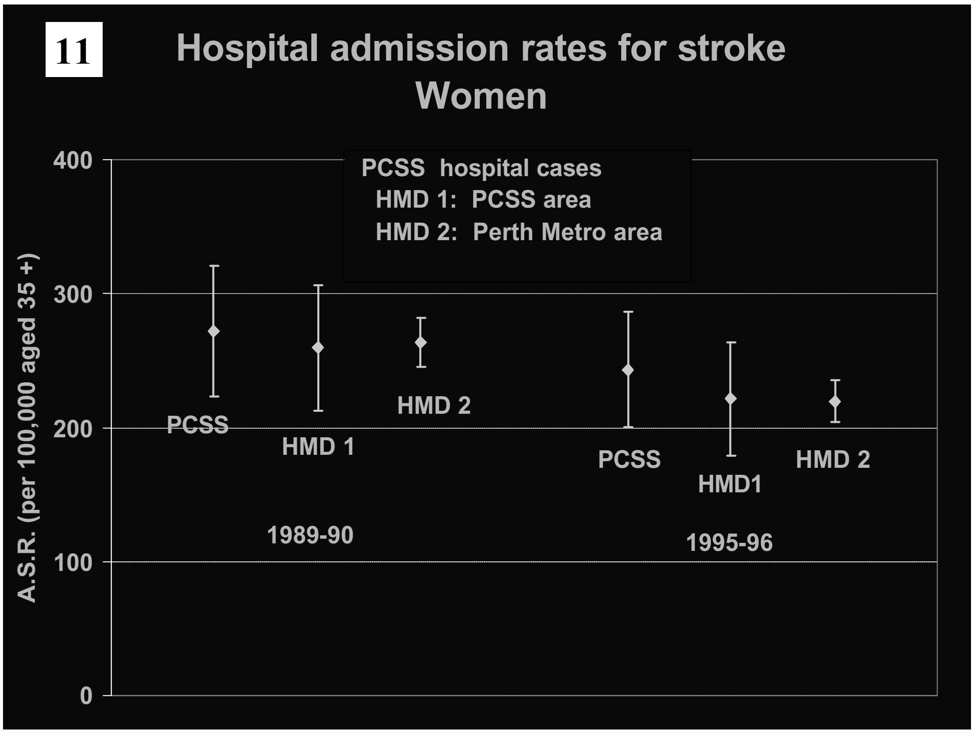
8

Prevalence of previous admission for cardiovascular disease 1994




9
Relative risk of acute coronary events in men previously admitted for IHD
Rate Ratio
10
9
8
7
6
5
4
3
2
1
0
45-54
55-64
65-74
75-84


10
Hospital admission rates for stroke - Men
PCSS: hospital cases
HMD 1: PCSS area
HMD 2: Perth Metro area
A.S.R. (per 100,000 aged 35 +)
600
500
400
300
200
100
0
PCSS
HMD 1
HMD 2
1989-90
PCSS
HMD1
HMD 2
1995-96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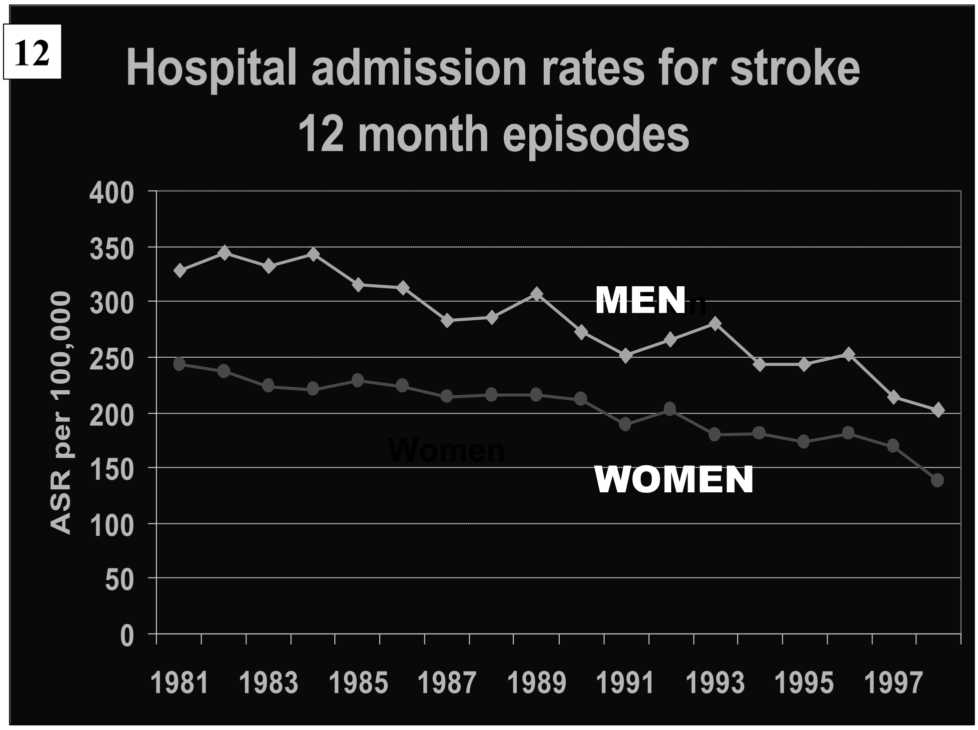
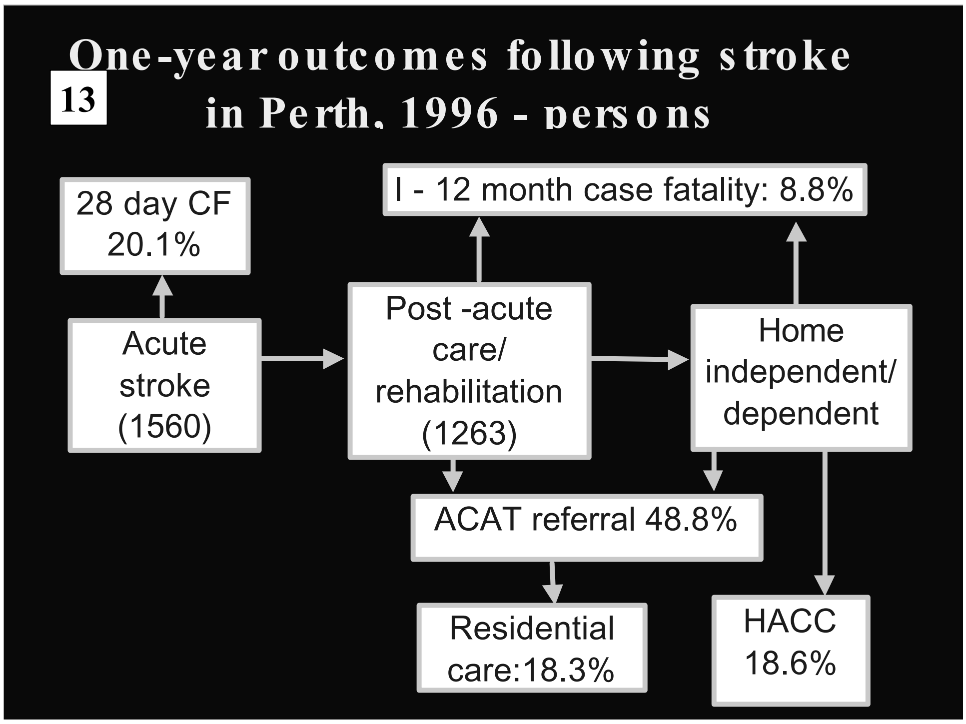
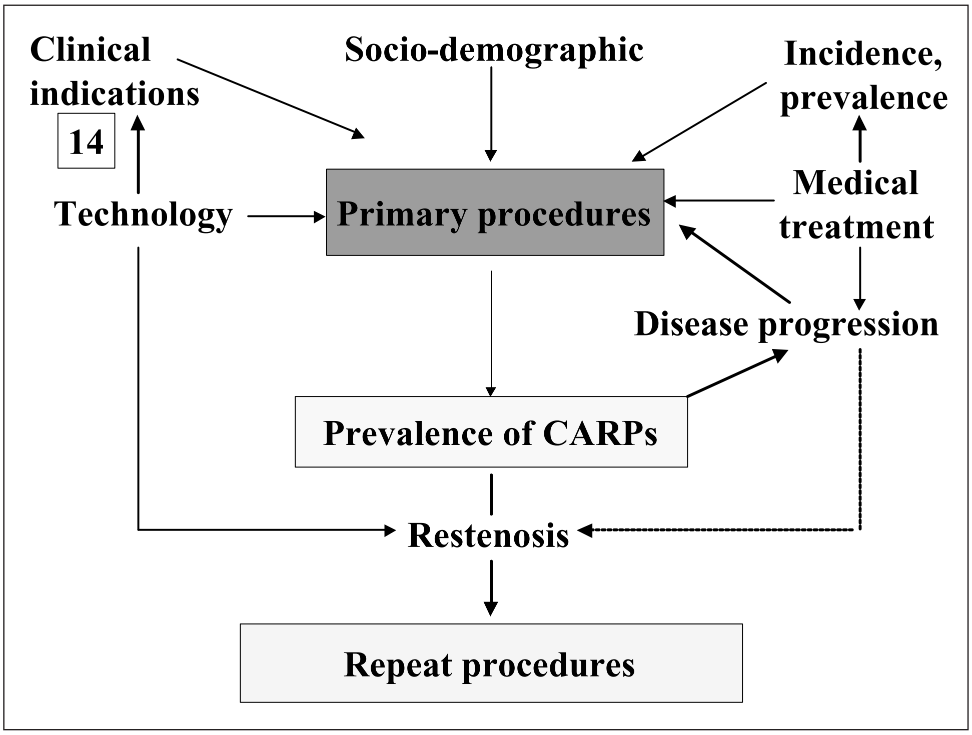
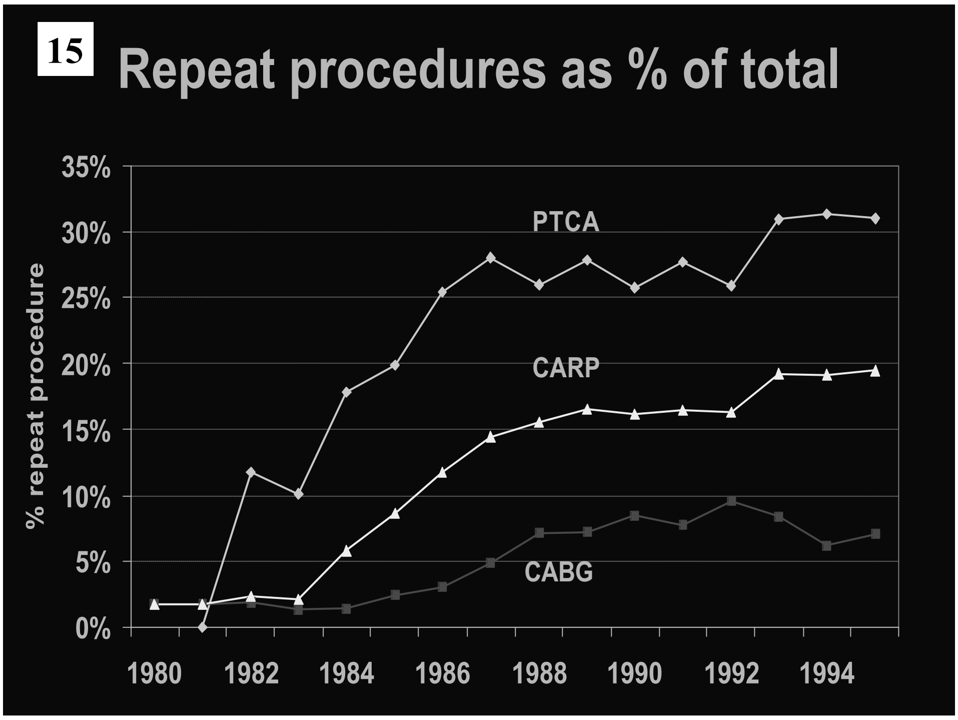
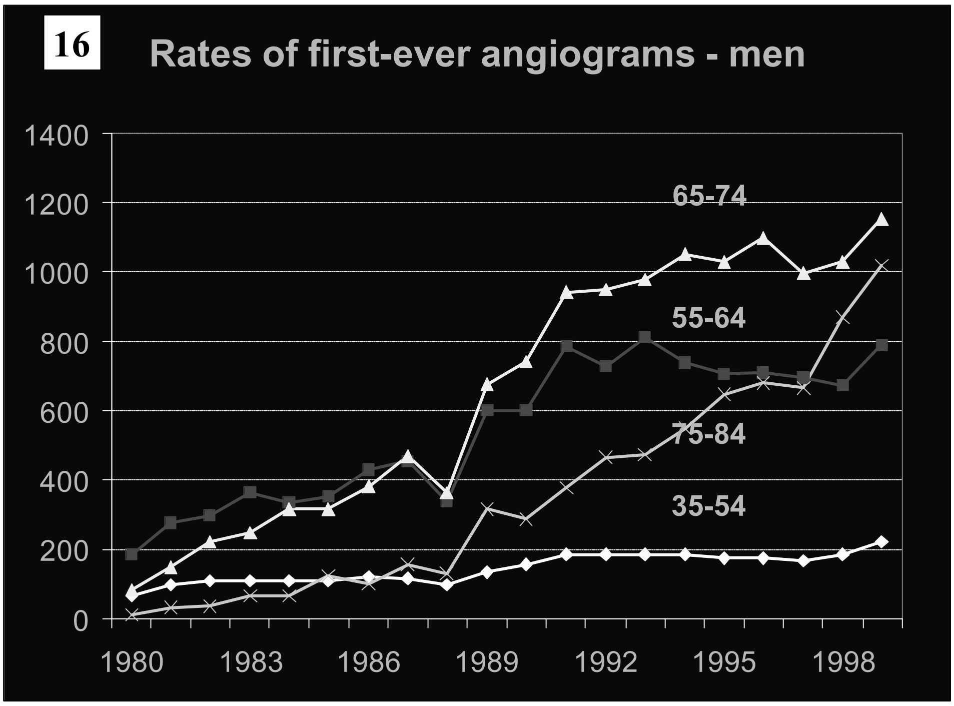
Hospital admission rates for stroke
Women
PCSS hospital cases
HMD 1: PCSS area
HMD 2: Perth Metro area
A.S.R. (per 100,000 aged 35 +)
400
300
200
100
0
PCSS
HMD 1
HMD 2
1989-90
PCSS
HMD1
HMD 2
1995-96

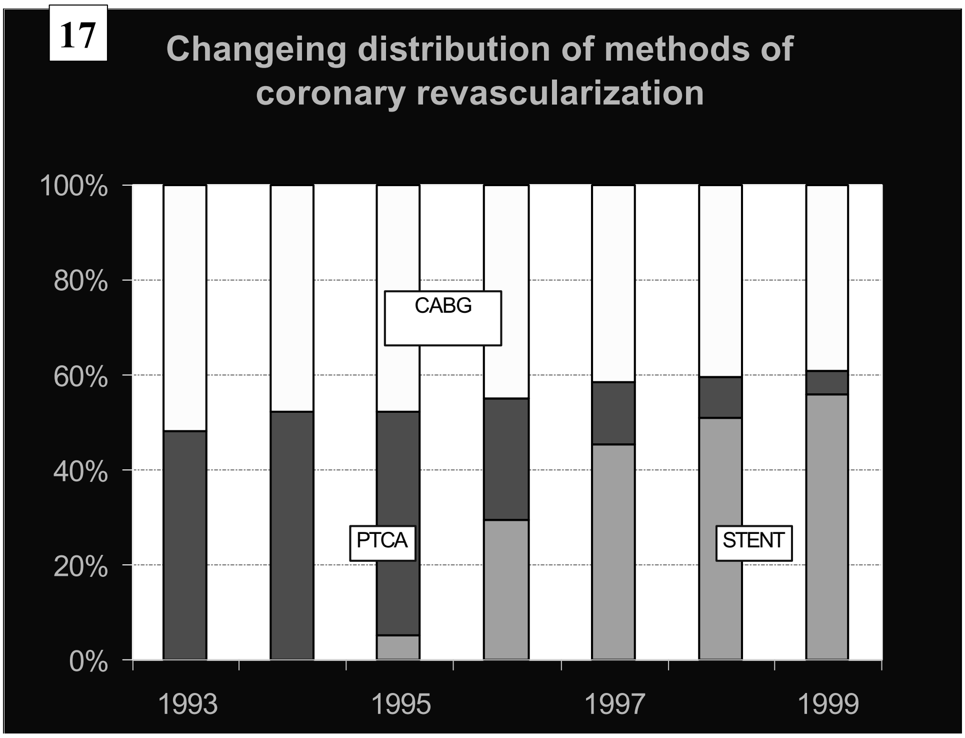

12
Hospital admission rates for stroke
12 month episodes
ASR per 100,000
400
350
300
250
200
150
100
50
0
MEN
WOMEN
1981
1983
1985
1987
1989
1991
1993
1995
1997

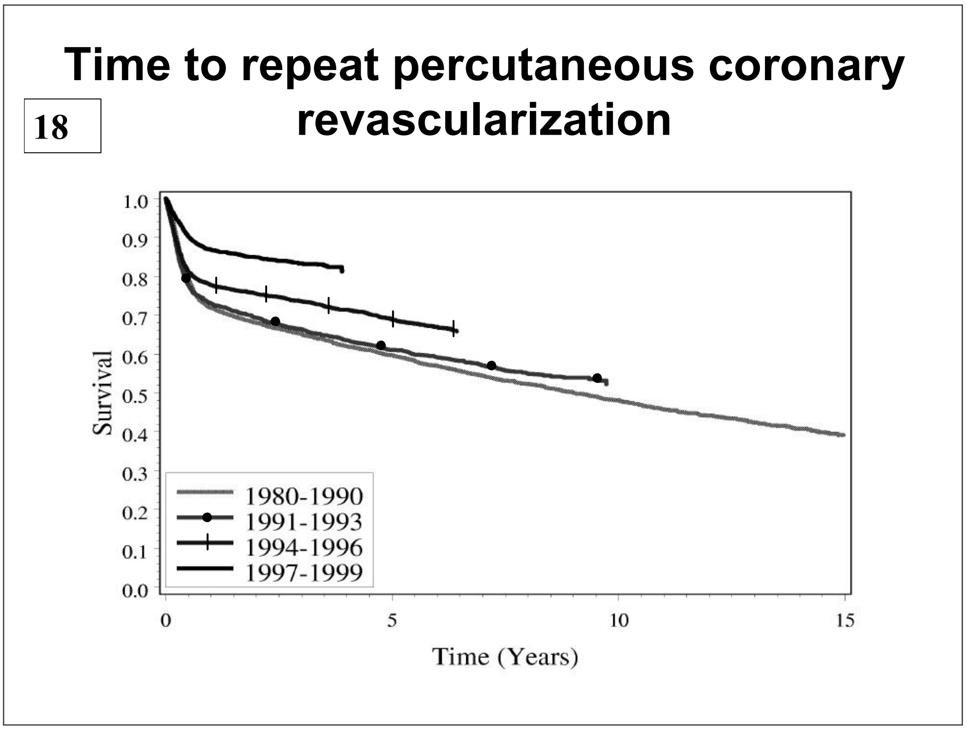

One-year outcomes following stroke in Perth, 1996 - persons
13
28 day CF 20.1%
I - 12 month case fatality: 8.8%
Acute stroke (1560)
Post -acute care/ rehabilitation (1263)
Home independent/ dependent
ACAT referral 48.8%
Residential care:18.3%
HACC 18.6%

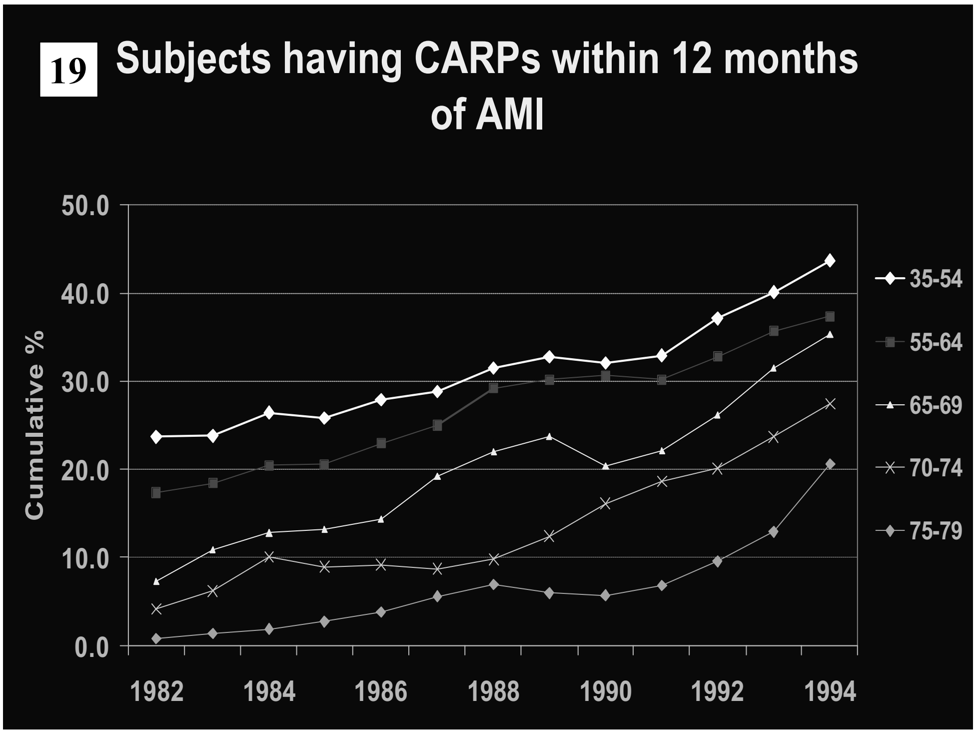

Clinical indications
14
Socio-demographic
Incidence, prevalence
Technology
Primary procedures
Medical treatment
Disease progression
Prevalence of CARPs
Restenosis
Repeat procedures

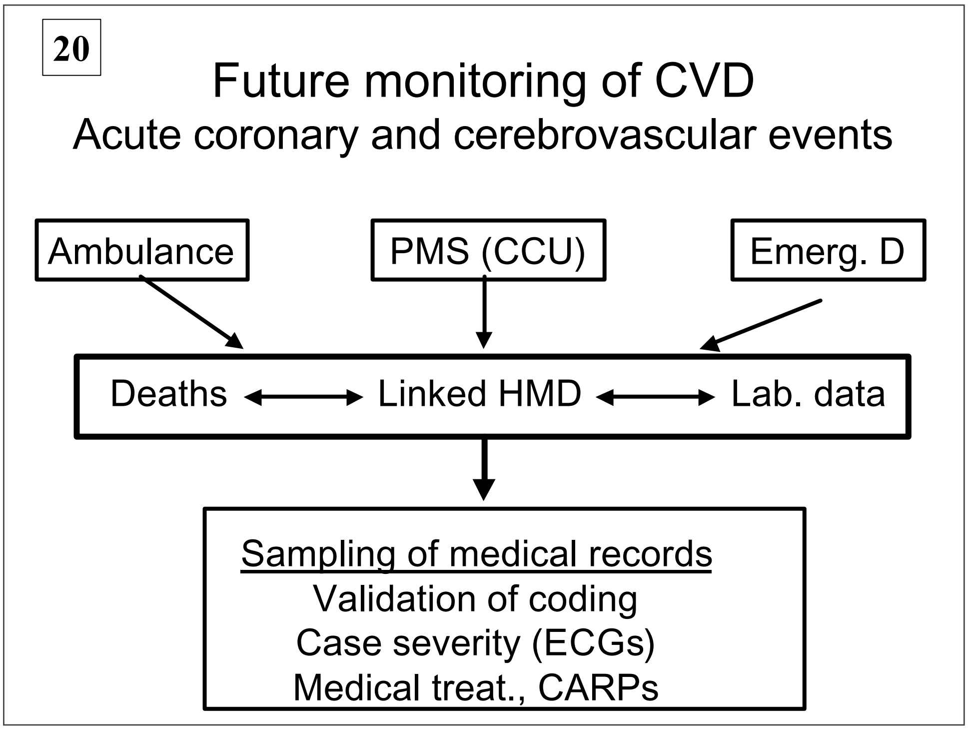

15
Repeat procedures as % of total
% repeat procedure
35%
30%
25%
20%
15%
10%
5%
0%
PTCA
CARP
CABG
1980
1982
1984
1986
1988
1990
1992
1994

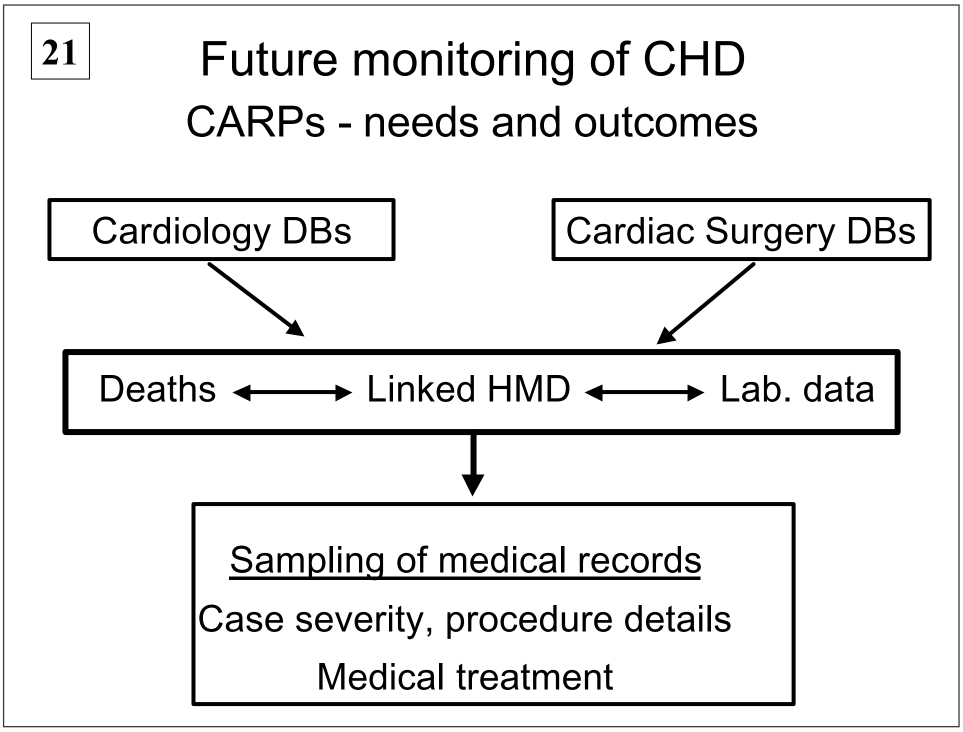

16
Rates of first-ever angiograms - men
1400
1200
1000
800
600
400
200
0
65-74
55-64
75-84
35-54
1980
1983
1986
1989
1992
1995
1998

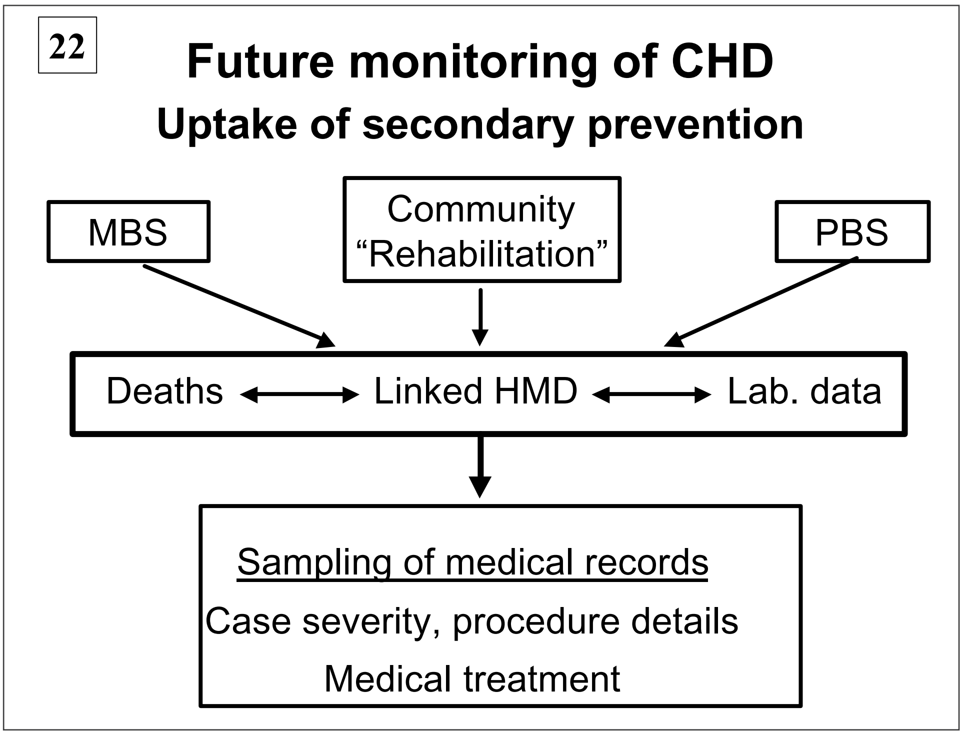

17
Changeing distribution of methods of coronary revascularization
100%
80%
60%
40%
20%
0%
CABG
PTCA
STENT
1993
1995
1997
1999

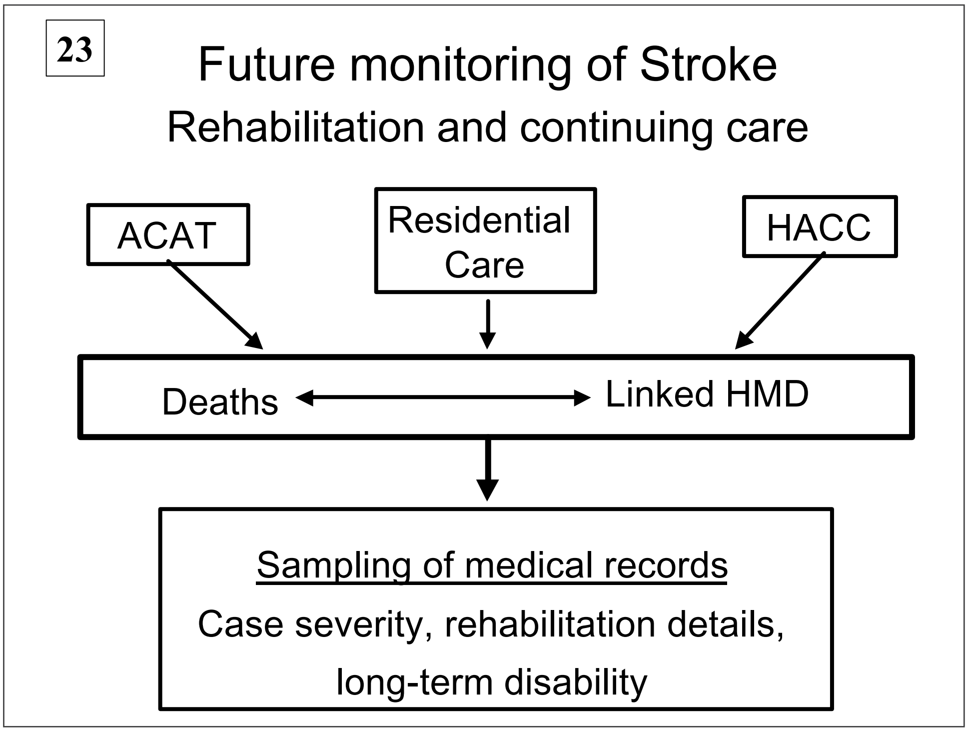

Time to repeat percutaneous coronary revascularization
18
1.0
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0.1
0.0
Survival
1980-1990
1991-1993
1994-1996
1997-1999
0
5
10
15
Time (Years)


19
Subjects having CARPs within 12 months of AMI
Cumulative %
50.0
40.0
30.0
20.0
10.0
0.0
1982
1984
1986
1988
1990
1992
1994
35-54
55-64
65-69
70-74
75-79


20
Future monitoring of CVD
Acute coronary and cerebrovascular events
Ambulance
PMS (CCU)
Emerg. D
Deaths
Linked HMD
Lab. data
Sampling of medical records
Validation of coding
Case severity (ECGs)
Medical treat., CARPs


21
Future monitoring of CHD
CARPs - needs and outcomes
Cardiology DBs
Cardiac Surgery DBs
Deaths
Linked HMD
Lab. data
Sampling of medical records
Case severity, procedure details
Medical treatment


22
Future monitoring of CHD
Uptake of secondary prevention
MBS
Community "Rehabilitation"
PBS
Deaths
Linked HMD
Lab. data
Sampling of medical records
Case severity, procedure details
Medical treatment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Future monitoring of Stroke
Rehabilitation and continuing care
ACAT
Residential Care
HACC
Deaths
Linked HMD
Sampling of medical records
Case severity, rehabilitation details, long-term disability