health outcome indicators

Myocardial infarction:

an investigation of measures of mortality incidence and case-fatality

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Chapter 1: Introduction

Acute myocardial infarction is a common, dramatic, life-threatening emergency. Like other manifestations of coronary heart disease, its incidence increased greatly in industrialised countries through the early and middle decades of the 20th century and then started to decline in the latter decades.[1] In some countries, like the United States, Australia and Sweden, its incidence started to decline from the late 1960s. The decline in the United Kingdom (UK) started later; but in recent years has been substantial. Myocardial infarction remains, however, the single most common cause of death in both men and women in the UK below the age on 75 years of age.

No doubt because of its high incidence and high case-fatality rate, it is one of the most extensively studied diseases in epidemiology and health care evaluation. Well-known, large-scale epidemiological studies aimed at furthering understanding of its incidence, changes over time, geographical variation and risk factors include the Framingham study,[2] Ancel Keys' Seven Countries study,[3] and the MONICA studies.[4,5] Within the UK, examples include the British Regional Heart Study,[6] the Nottingham heart attack register,[7] two studies of incidence and fatality 30 years apart in Oxfordshire,[8,9] and studies by the United Kingdom Heart Attack Study Group.[10,11] One method of ascertainment used in these studies, when reliance on clinicians to register cases was deemed insufficient, has been the method of so-called 'hot pursuit' in which the investigators have contacted every acute medical hospital ward and every general practitioner at frequent intervals (say once a week) to ask if they have had any new cases since the last contact. Outside the scope of special studies such as these, mortality data from death certification tend to be used to study trends over time, and geographical variation, as proxies for trends and geographical variation in incidence. Compared with many other industrialised countries, the countries of the UK are relatively high incidence and high mortality countries. Within the UK, there are substantial geographical differences in mortality: in general, mortality rates are higher in the north than south and the magnitude of differences between high and low areas is about three-fold.[12] Even within relatively low mortality populations in the UK, such as the South East region, there are also substantial differences between subgroups of the population. For example, defining the population by measures of status and lifestyle, there are three-fold differences between the most and least advantaged neighbourhoods within the South East.[13] In the UK, reduction in the incidence and mortality of myocardial infarction and coronary heart disease are important public health targets.[14, 15]

The outcomes of myocardial infarction – case-fatality rates, particularly in the acute phase, for those who have had a heart attack – have also attracted considerable attention. For example, the enthusiastic introduction of high-technology hospital care and of coronary care units in the 1960s led to one of the most celebrated challenges to unevaluated technological medicine in the history of randomised controlled trials. In the late 1960s Archie Cochrane challenged clinicians to provide evidence that admission of

acutely ill, and typically distressed, heart attack patients to hospital achieved any better outcome than managing the patients with low-technology care in their own homes.[16] No evidence beyond clinical deduction was available and Mather and Cochrane eventually persuaded clinicians in the Bristol area to undertake a randomised controlled trial of home versus hospital care.[17] At least for those eligible for randomisation, and at least at that time, the studies showed no benefit of hospital care over home care.[17]

Advances in cardiac resuscitation and in the use of new therapies, particularly thrombolysis, led to final acceptance that hospital is the place of choice for the treatment of heart attack. Another classic study in the evaluation of medical care showed that, if all the evidence available from different studies on the effects of thrombolysis had been systematically pooled as it emerged, the therapeutic benefit of thrombolysis would have become evident many years before in fact it did.[18] The ISIS studies, among others, have been models of experimental studies of death and survival following non-surgical interventions.[19] Surgical interventions, notably coronary artery bypass grafting and percutaneous transluminal angioplasty, have become widely used in recent years, much more so in some countries than in others.[20]

Studies of the working of health services in their local settings have to place reliance on observational rather than experimental data. Within a population – England, for example – there are questions of great importance about whether incidence rates, mortality rates and case-fatality rates for myocardial infarction are changing over time, whether they vary from place to place, and whether they differ in different subgroups of the population defined by (say) sex, social class and ethnic group. Outside the framework of special studies with clinical contact and follow-up, reliance must be placed on the collection and analysis of routine health and health service data. In this context, mortality data and hospital admission data, preferably with linkage of the two datasets, are likely to be the mainstays. In this report we consider the use of routinely collected hospital admission statistics, like Hospital Episode Statistics, but most of the considerations would apply to similar data on hospital admissions collected in clinical audit systems.

We consider the indicator of “incidence rates”, to be monitored as “failures to prevent” myocardial infarction. With a condition like myocardial infarction, which may afflict an individual more than once, incidence may be defined either as the occurrence of a “first ever” infarct in an individual or as the occurrence of each new heart attack. Some would call the latter measure the “attack rate”; we have stuck with the term incidence to mean each new event. The measure of incidence is of interest in its own right; and knowledge about incidence is also an essential prerequisite, as the denominator to calculating and interpreting case-fatality rates.

We consider the indicator of “case-fatality rates” in which the denominator is all incident events and the numerator is those which are fatal. In general we have considered case fatality rates within 30 days of the incident event. In some of our work we explore and report on case fatality rates at longer intervals.

We consider the indicator of population-based “mortality rates”, in which the numerator

is all people who died with myocardial infarction as the certified cause of death and the denominator is the resident population from which they come. We focus mainly on myocardial infarction as the underlying cause of death but, by using multiple-cause coding, we also comment on the extent to which rates based on underlying cause reflect all deaths in people who die within 30 days of an acute myocardial infarct.

Incidence and mortality rates are population-based indicators. Case fatality rates could be constructed as either population-based or institution-based indicators, i.e. either as those in people from a given resident population or those in people treated in a given hospital. We consider both, but focus in particular on comparisons between hospitals.

The use of these measures as performance indicators, perhaps particularly the use of case-fatality rates, has intuitive attraction. As stated at the beginning, myocardial infarction is dramatic and life-threatening; and, intuitively, good health care should achieve measurably good results. Furthermore, the fact that myocardial infarction is common, and the fact that a high percentage of people who experience it will die in the acute episode, means that in many hospitals there should be sufficient patients and sufficient "adverse end-points" to give statistical power to detect real differences if they exist. However, the natural history of death from myocardial infarction – the fact that, of those who die, many die suddenly and die outside hospital[21,22] – foreshadows potential problems in constructing and interpreting indicators from routine data. Several large clinical and epidemiological studies have shown that between 50% and 70% of all people who die in the acute attack die outside hospital. Typically, case-fatality rates based on all people who reach hospital are reported in the range of 15% to 25%; and, typically, case-fatality rates which include those who die before they reach hospital care, as well as those admitted, are reported with levels closer to 50%.[23] Case-fatality rates are also highly age-dependent (they are considerably higher in the old than the young) and they differ by sex (they are higher in women than men). Accordingly, quoted rates need to be judged in the knowledge of the age distribution of the population from which they come. More fundamentally, however, the numerical values taken by case-fatality rates are likely to be highly influenced by referral patterns, speed of referral, speed of service response, and, as we show in this report, recording practices in terms of when someone sent to hospital with myocardial infarction is first counted as a "hospital admission".

A further issue in interpreting all three measures – incidence, mortality and case-fatality – is that myocardial infarction may occur in someone who was otherwise well, but it may also be the terminal event in someone who has other conditions. As an extreme example, consider a patient, otherwise well, admitted to hospital for a minor elective operation. Perioperatively, the patient has a fatal heart attack. Does the individual count as an incident case? And should he count as a death in the calculation of the hospital's case-fatality rate for myocardial infarction?

We started our investigation of the indicators by studying trends over time. We then

studied indicators comparing different hospitals using contemporary data. We started with time trends for several reasons. Firstly, time trends are of interest in their own right – how are these measures improving over time? Their study, as indicators, will be important in monitoring Our Healthier Nation targets, the National Service Framework targets, and health inequalities targets. Secondly, we adopted the logic used by the TECH investigators in studying trends in different populations.[20] They argued that biasing, confounding and case-mix factors are more readily identified and teased out in making comparisons over time within a single place than they are in making comparisons between places at a single point in time. Accordingly, the insights gained from time trends can then be applied to geographical comparisons.

Considerations of diagnostic criteria for myocardial infarction are largely beyond the scope of this report. It should be noted, however, that this is an important issue. A substantial but unknown percentage of all cases of myocardial infarction recorded in hospital statistics, and on death certificates, would not meet the stringent diagnostic criteria used in epidemiological and clinical studies like MONICA. Diagnostic criteria are discussed in an earlier NCHOD report on outcome indicators for myocardial infarction and are reproduced as an Appendix to this report. The sensitivity, specificity and positive and negative predictive values of hospital ICD discharge codes for myocardial infarction, validated against 'gold standards', have been studied by MONICA.[24] An already complicated issue is complicated further by the implementation of new diagnostic methods, notably the use of troponins, in recent years. The European Society of Cardiology and the American College of Cardiology have recently issued radical redefinitions of myocardial infarction[25] which have drawn both endorsement and criticism.[26,27] Clearly, differences in definitions used, and changing practices in the use of definitions, will affect data on both trends and geographical comparisons.

Key points:

- The use of indicators about MI has intuitive attraction: MI is a common, life-threatening condition; death in the acute illness is common; and prompt treatment can be life-saving.
- There are, however, some important factors which need consideration in the interpretation of MI indicators.
- Full, standard diagnostic criteria for making the diagnosis are often not met in practice; and the criteria are changing.
- Many people with MI die suddenly, out of hospital or very soon after they arrive at hospital; and this can complicate the construction and interpretation of indicators.
- MI may be the terminal event in people admitted to hospital for other conditions; whether, and how, to count or exclude such events needs consideration.

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Chapter 2: Towards an understanding of mortality, incidence and case-fatality rates

The use of hospitalisation data and mortality data, in combination, allows a number of different measures to be constructed (Exhibit). In this report, we use these as the main measures of analysis. The importance of understanding these subdivisions, and identifying them where the date allow, will be explored in this report. Following the conventions used in MONICA and TECH studies, we regarded two different events 30 days or more apart as two new infarcts. Events less than 30 days apart were regarded as relating to the same infarct. Similar analyses to those in this report can be made using different time intervals between successive events.

1. Myocardial infarction: All deaths and
   Deaths outside hospital as identified from death certificates

   1a. Those within 30 days of a hospital admission for MI
   1b. Those within 30 days of a hospital admission for a condition other than MI
   1c. Those within no hospital admission for MI in the previous 30 days

   Deaths in hospital as identified from death certificates: all and

   1d. Those with a corresponding hospital admission record for MI
   1e. Those with a corresponding hospital admission for other ischaemic heart disease
   1f. Those with a corresponding hospital admission for conditions other than 1d and 1e
   1g. Those with no corresponding hospital admission

2. Myocardial infarction: understanding incidence

   2a. Hospitalised incidence, identified from admission records (includes 1d, above)
   2b. Hospital-associated deaths, identified from death certificates which specify that the death occurred in hospital, without a corresponding hospital
   2c. Deaths outside hospital, identified from death certificates with no admission for MI within the previous 30 days
   2d. Those with a corresponding hospital admission for conditions other than MI (1e and 1f above)

3. Myocardial infarction: understanding case fatality rates (within 30 days of occurrence of MI)

   3a. Based on hospitalised incidence as the denominator (2a above)
   3b. Based on hospitalised incidence plus hospital associated deaths as the denominator (2a + 2b above)
   3c. Based on hospitalised incidence, hospital associated deaths, and deaths outside hospital (2a + 2b = 2c above)
   3d. Based on 2a + 2b + 2c + 2d above

Chapter 3: Trends over time: in mortality, incidence and case-fatality rates

Data from death certification show that mortality rates for myocardial infarction (MI) have declined in England, as in many other industrialised countries, for the past thirty years. The components of the decline – changes in incidence and case-fatality rates – are much less well understood. As we report in this chapter, we have supplemented data from routine sources – hospital admission data and death-certificate-based mortality data – with record linkage to construct indicators of incidence and survival which are not available from unlinked sources alone.

The aims of this chapter are to:

- put forward for discussion indicators derivable from routine statistics to document mortality, incidence and case-fatality rates.
- document time trends in mortality, incidence, and case-fatality rates for MI.

Methods

Data from the Oxford record linkage study (ORLS) were used. The linkage dataset comprises statistical abstracts of records of hospital admissions, and death certificates, organised such that successive records for the same individual can be linked together. Data coverage commenced in 1963 but, because MI did not have a separate code in the International Classification of Diseases (ICD) until 1968, the analyses presented here are start at 1968. From 1968-1974 the covered population comprised two health districts (population: 850,000 people), from 1975-1986 six districts (1.9 million), and from 1987 eight former health districts (2.5 million). Records are available for all people treated in the covered region but the analyses were confined to those who were both treated and resident in it. The ICD codes used were 410 in ICD8 and ICD9 and, from 1994, I21 and I22 in ICD10.

In the trend analyses, following standard conventions, hospital admissions were excluded if they were coded as MI but the patient stayed less than four days and was discharged alive (we used record linkage to identify transfers and link them together as a continuous spell across hospitals). The 3-day criterion is intended to remove records of patients whose admission was for “query MI” but who were soon discharged when MI was not confirmed (see also Chapter 7). Hospital admissions, and deaths which occurred outside hospital, were counted as new episodes of MI if they occurred more than 30 days after a previous admission for the condition.

Mortality rates

Data from death certificates were used to calculate the following three main mortality rates (each of which is obtainable from national unlinked death certificate data):

- Overall mortality rates, regardless of place of death.
- Mortality rates for deaths which occurred in hospital.
- Mortality rates for deaths which occurred outside hospital.

Incidence rates

Three main measures of 'incidence' were calculated:

- Hospital admission rates.
- It is well recognised that counts of deaths in hospital, certified as MI on death certificates, are higher than counts of deaths in hospital for people admitted with MI according to hospital admission statistics. Because MI deaths often occur very shortly after the onset of infarction, it is common for people to be certified dead on arrival at hospital or soon after. Furthermore, MI is sometimes the terminal event in patients admitted to hospital for other conditions. Hospital records and death certificates were used together to identify people whose death certificate specified that they died in hospital but who had no record of hospital admission for MI in the previous 30 days. We added the death-certificate-only deaths to the hospital admissions and termed the combined measure 'hospital-associated incidence'.
- We combined these two groups with data on people with a death certificate which specified that the individual died outside hospital. We refer to this combined group as 'total identified incidence'.

Some people have MI and are neither referred to hospital nor die. We are unable to identify them. Numbers in people under 65 years are likely to have been few, at least in recent years.

Case-fatality rates

Three measures of case-fatality were calculated:

- Hospital case-fatality, in which the denominator is all people admitted to hospital and the numerator is all of those admitted who died within 30 days.
- Hospital-associated case-fatality, in which people who died in hospital without an admission record for MI are added to the numerator and denominator.
- Total case-fatality, in which people who died outside hospital are also added to the numerator and denominator.

Age-specific and age-standardised rates

Age-specific rates were calculated separately for males and females in 5-year age-groups. They were calculated for the following grouped 5-year intervals, 1968-1973, 1974-1978, 1979-1983, 1984-1988, 1989-1993 and 1994-1998. Mortality rates and admission rates were summarised as standardised rates by using the direct method and the European standard population. Case-fatality rates were summarised by the indirect method applied to the age-specific incidence rates for MI in the ORLS study population.

Results and comment

Mortality rates

Overall, age-specific mortality rates for MI declined substantially throughout the study period in every age group under the age of 85 years and in every time interval from each 5-year period to the next (Table 3.1). As expected, mortality rates were considerably higher in men than women in every age group and at every time period. Declines in mortality rates were greater in people under 65 years of age than in older age groups.

The decline in rates for deaths in hospital (Table 3.2) was less than that for deaths outside (Table 3.3). Indeed, mortality rates for in-hospital deaths increased in the 1970s and early 1980s in the older age groups. This no doubt reflects both a change in clinical practice in referring a higher percentage of elderly people with MI to hospital and an increase in the speed with which people were sent to hospital (including the increase in use of cardiac ambulances). Over the whole study period, 50.3% of all deaths occurred outside hospital and 49.7% of all deaths inside hospital.

The age-standardised mortality rate for overall mortality among men almost halved from 416 to 212 per 100,000 population over the study period (Figure 3.1). The age standardised rate for deaths out of hospital declined far more (273 to 106) than for in-hospital deaths (143 to 107). The trends in the corresponding mortality rates for the women were broadly similar to those for the men although, while the absolute values were much smaller for the women, the percentage decreases in rates from the mid 1970s onwards were not as great in women as in men (Figure 3.2).

Standardised mortality rates for deaths, regardless of place of death, for the three age groups, 35-64, 65-75 and 74 years are shown for men in Figure 3.3 and women in Figure 3.4. For both men and women, there were increases in mortality rates for all three age groups from the first time interval to the second and, for men aged 75 and over, a further increase from the second to third interval. The rates then declined for all age-sex groups in all subsequent time intervals.

For both men and women the mortality rates were by far the highest for the oldest age group, aged 75 and over, and the (absolute) decline in rates during the 1980s and 1990s was also largest for this age group. The relative decline in rates, however, was greater for the younger age groups. Among men, for example, the percentage decline in rates from the first time interval to the last was 31% for the oldest age group; it was 51% for men aged 65-74 years and 66% for men aged 35-64 years. Similarly, for women, the corresponding percentage reductions for the three age groups were 25%, 41% and 62%.

Standardised rates for deaths inside hospital for the three age groups are shown in Figure 3.5 (men) and Figure 3.6 (women). The mortality rates for deaths in hospital, among both men and women, also declined from the first time interval up to the mid 1970s for all three age groups. For the youngest age group, 35-64 years, they subsequently declined throughout the rest of the study period. For the middle age group, aged 65-74 years, they appear to have levelled off from 1974-1978 to 1979-1983 before declining thereafter. For the oldest age group, however, the mortality rates for deaths in hospital continued to increase into the early 1980s, before subsequently falling. This increase no doubt reflects a move away from managing elderly patients with MI at home.

Although the absolute decline in mortality rates during the 1980s and 1990s for in-hospital deaths for MI was largest among the older patients, the relative decline has been greater for patients in the youngest age groups. For men, the percentage decline from 1979-1983 to 1994-1998 was 44% for patients aged 75 and over, 56% for those aged 65-74 and 75% for those aged 35-64. Corresponding percentage reductions in rates for women were 37% (aged 75 and over), 48% (aged 65-74 years) and 64% (aged 35-64).

Standardised mortality rates for deaths outside hospital, by age group, are illustrated in Figure 3.7 for men and Figure 3.8 for women. After early increases in rates from the first time interval to the second, there has been great reduction in out-of-hospital deaths due to MI, for all age-sex groups, from the mid 1970s onwards.

As with in-hospital mortality due to MI, the largest absolute reductions in rates for MI deaths outside hospital were found among the oldest age groups; and the greatest relative reductions were found in the younger age groups. For men, the percentage reductions in rates from the first to last of the six time intervals was 46% for those aged 75 and over, 64% for those aged 65-74 and 75% for those aged 35-64. Corresponding figures for women were 39%, 56% and 73% and show the same pattern.

Key points:

- The extent of mortality which occurs outside hospital is considerable: considering the period as a whole, 50.3% of all death-certificate-certified deaths occurred outside hospital and 49.7% in hospital.
- Age-standardised mortality for men almost halved over the period; and the decline in out-of-hospital deaths was much greater than that in deaths following admission for hospital care. Mortality in women declined substantially, too, but the decline was less than that for men.
- Mortality rates for deaths in hospital increased in the early years of the study, particularly in the elderly. This probably reflects changes in referral patterns, away from managing elderly people with MI at home.

Table 3.1 Age specific mortality rates (per 100,000 population) for myocardial infarction: all mortality

	Age group										
Time Period	35-39	40-44	45-49	50-54	55-59	60-64	65-69	70-74	75-79	80-84	85+
Men											
1968-1973	17	42	118	179	304	530	819	1075	1546	1810	2431
1974-1978	14	50	118	246	351	564	876	1309	1696	2175	2974
1979-1983	17	41	102	184	325	525	827	1207	1652	2293	3107
1984-1988	12	29	66	136	258	417	606	1025	1493	2162	2567
1989-1993	10	21	40	84	178	292	512	759	1257	1704	2139
1994-1998	6	14	31	58	101	201	368	572	931	1374	1812
Women											
1968-1973	5	7	16	35	65	148	256	468	765	1137	1561
1974-1978	3	8	20	41	79	169	319	580	910	1392	2023
1979-1983	1	6	13	35	71	164	297	527	898	1347	1845
1984-1988	1	3	10	23	64	139	245	470	776	1199	1800
1989-1993	1	3	6	15	40	104	210	371	644	1057	1621
1994-1998	1	2	6	9	22	68	154	275	506	854	1294

Table 3.2 Age specific mortality rates (per 100,000 population) for myocardial infarction: deaths in hospital

	Age group										
Time Period	35-39	40-44	45-49	50-54	55-59	60-64	65-69	70-74	75-79	80-84	85+
Men											
1968-1973	6	12	37	57	113	196	289	368	517	543	859
1974-1978	7	23	50	104	151	245	355	488	623	739	1159
1979-1983	8	21	46	83	152	215	356	497	663	891	1285
1984-1988	7	13	34	65	121	192	284	463	678	1009	1099
1989-1993	6	10	20	44	89	145	259	376	608	809	978
1994-1998	4	6	16	32	51	107	192	295	475	692	790
Women											
1968-1973	0	2	4	15	26	65	102	183	279	439	570
1974-1978	1	3	10	20	36	71	142	242	368	563	755
1979-1983	1	2	7	16	34	71	141	230	407	598	718
1984-1988	0	1	4	13	30	64	118	211	356	521	692
1989-1993	0	2	4	7	24	55	119	199	329	519	695
1994-1998	1	2	4	5	13	37	84	152	269	438	576

Table 3.3 **Age specific mortality rates (per 100,000 population) for myocardial infarction: deaths outside hospital**

	Age group										
Time Period	**35-39**	**40-44**	**45-49**	**50-54**	**55-59**	**60-64**	**65-69**	**70-74**	**75-79**	**80-84**	**85+**
Men											
1968-1973	**11**	**30**	**80**	**122**	**192**	**334**	**530**	**707**	**1029**	**1267**	**1572**
1974-1978	**7**	**27**	**67**	**142**	**200**	**320**	**521**	**821**	**1072**	**1437**	**1815**
1979-1983	**9**	**20**	**55**	**100**	**174**	**310**	**470**	**710**	**989**	**1402**	**1822**
1984-1988	**5**	**16**	**32**	**71**	**138**	**225**	**322**	**562**	**815**	**1153**	**1467**
1989-1993	**4**	**11**	**20**	**40**	**89**	**148**	**253**	**383**	**649**	**895**	**1161**
1994-1998	**2**	**7**	**14**	**26**	**49**	**94**	**176**	**277**	**457**	**682**	**1022**
Women											
1968-1973	**5**	**5**	**12**	**20**	**39**	**83**	**153**	**286**	**486**	**698**	**990**
1974-1978	**2**	**5**	**10**	**21**	**43**	**97**	**178**	**339**	**543**	**830**	**1268**
1979-1983	**1**	**4**	**6**	**20**	**37**	**94**	**156**	**297**	**491**	**749**	**1127**
1984-1988	**0**	**2**	**6**	**10**	**34**	**75**	**126**	**259**	**420**	**678**	**1107**
1989-1993	**0**	**1**	**2**	**9**	**16**	**49**	**90**	**171**	**315**	**538**	**926**
1994-1998	**0**	**0**	**3**	**4**	**9**	**31**	**70**	**123**	**238**	**417**	**718**

Figure 3.1 **Standardised mortality rates for myocardial infarction among men. Deaths anywhere, deaths in hospital and outside**

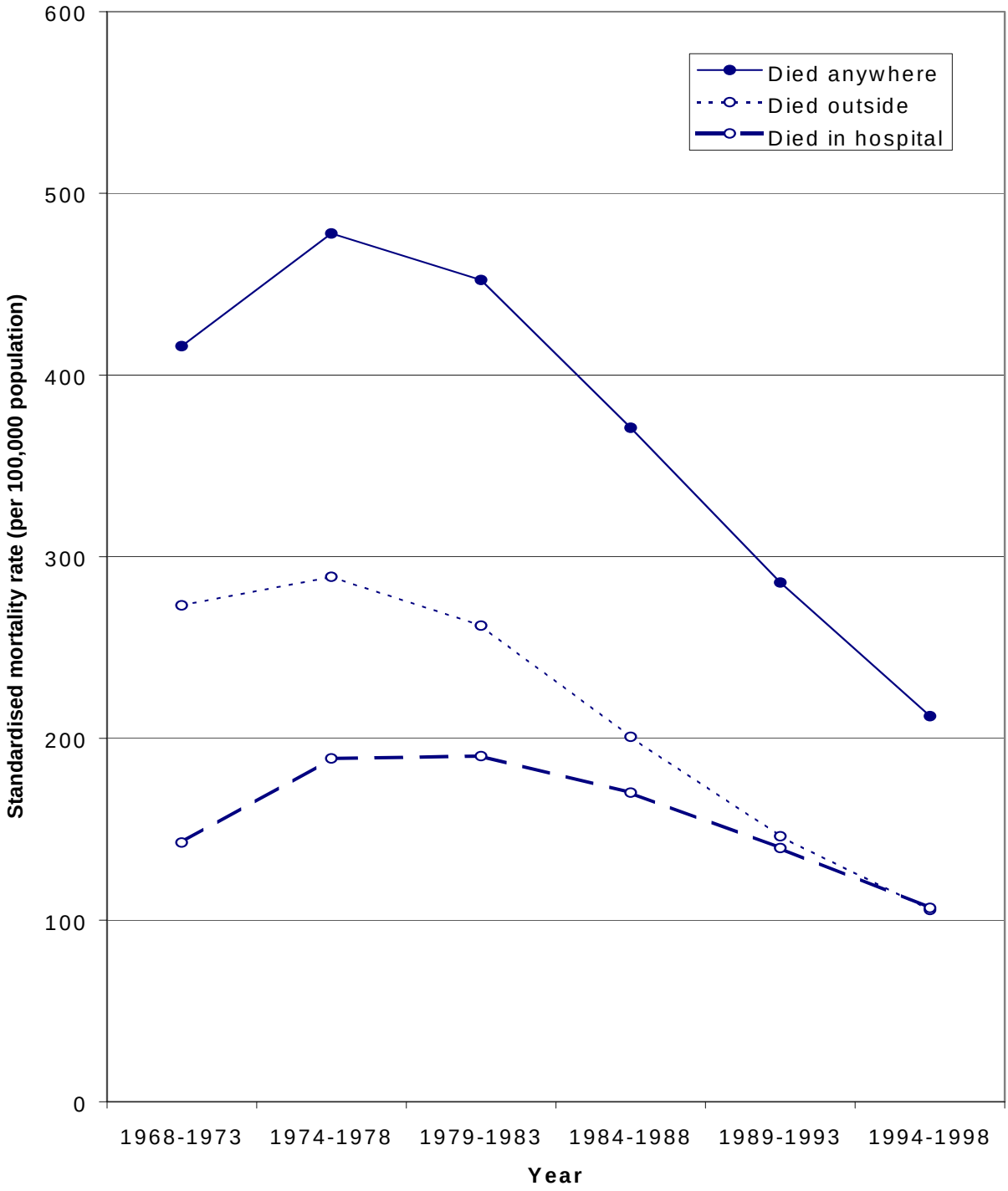


Figure 3.2 **Standardised mortality rates for myocardial infarction among women. Deaths anywhere, deaths in hospital and outside**

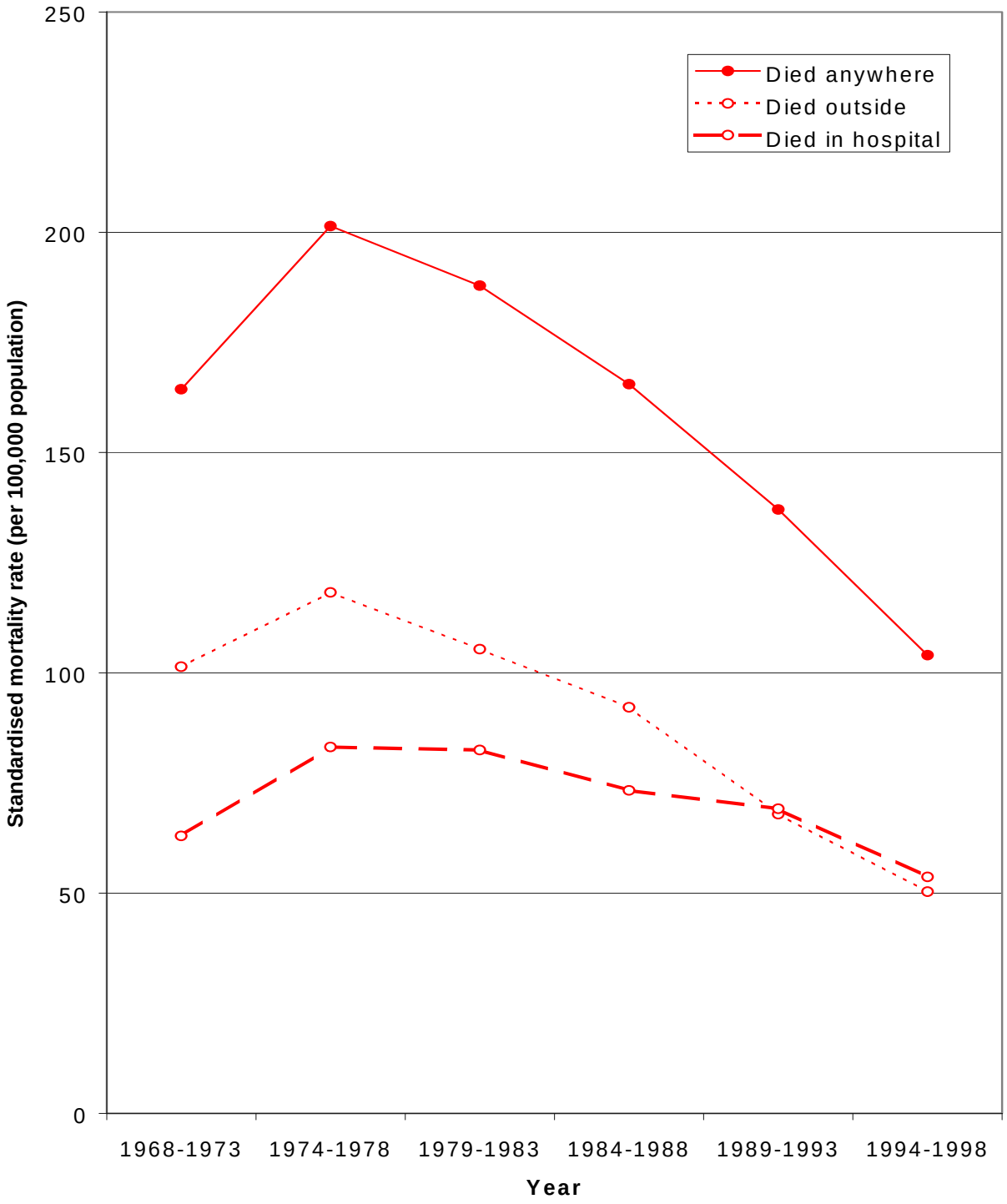


Figure 3.3 **Standardised mortality rates for myocardial infarction among men. Deaths anywhere by age group**

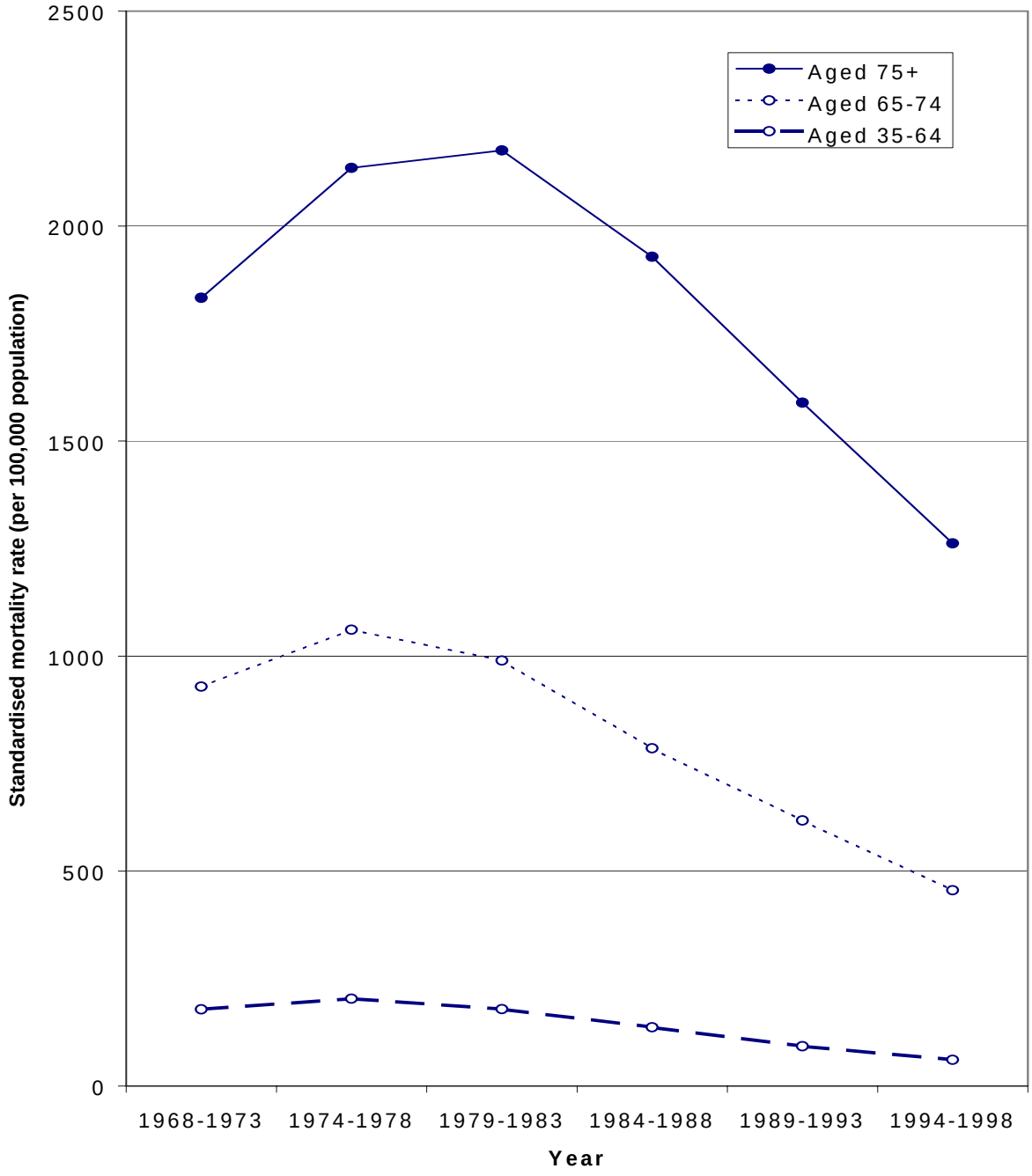


Figure 3.4 **Standardised mortality rates for myocardial infarction among women. Deaths anywhere by age group**

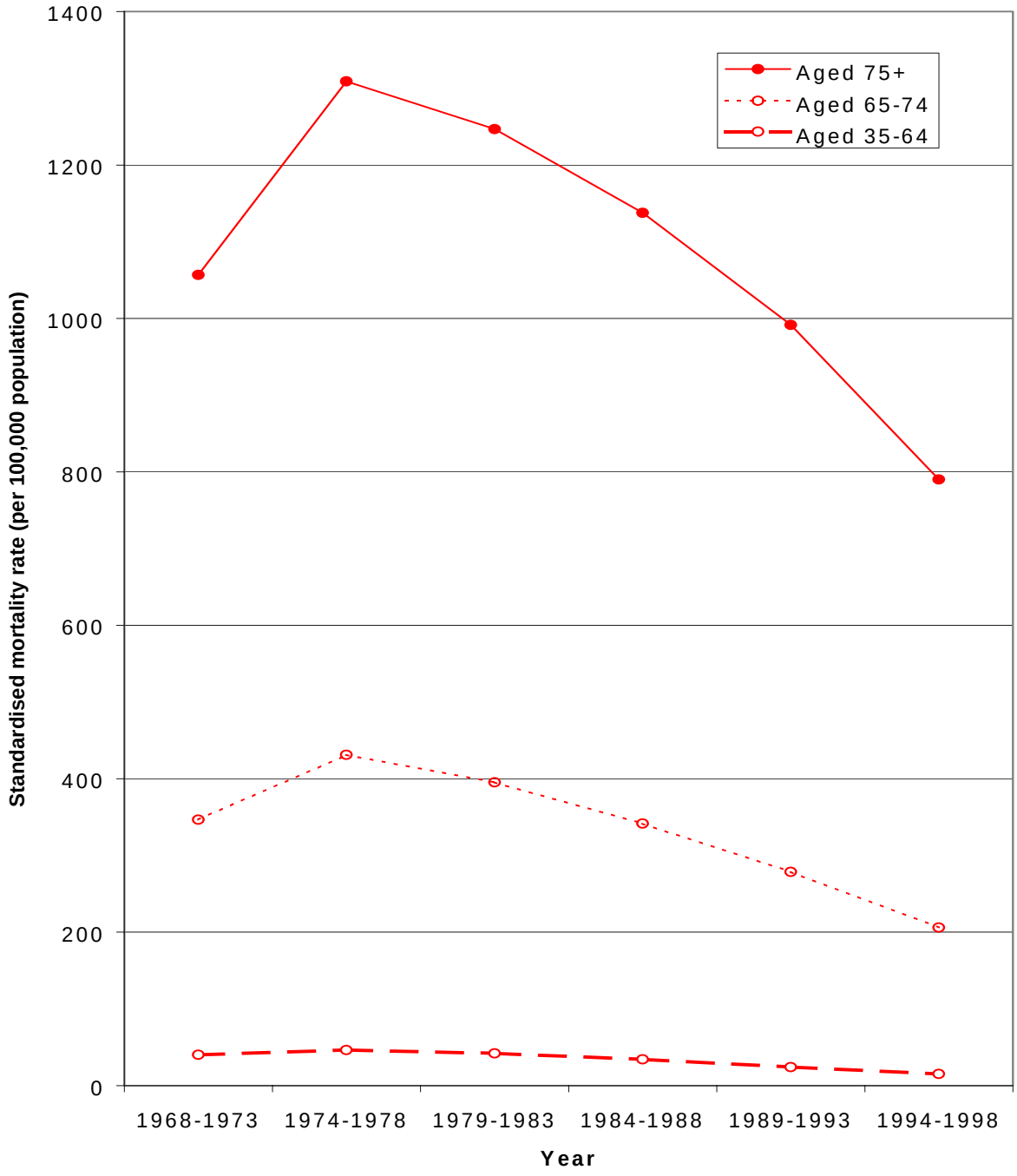


Figure 3.5 **Standardised mortality rates for myocardial infarction among men. Deaths in hospital by age group**

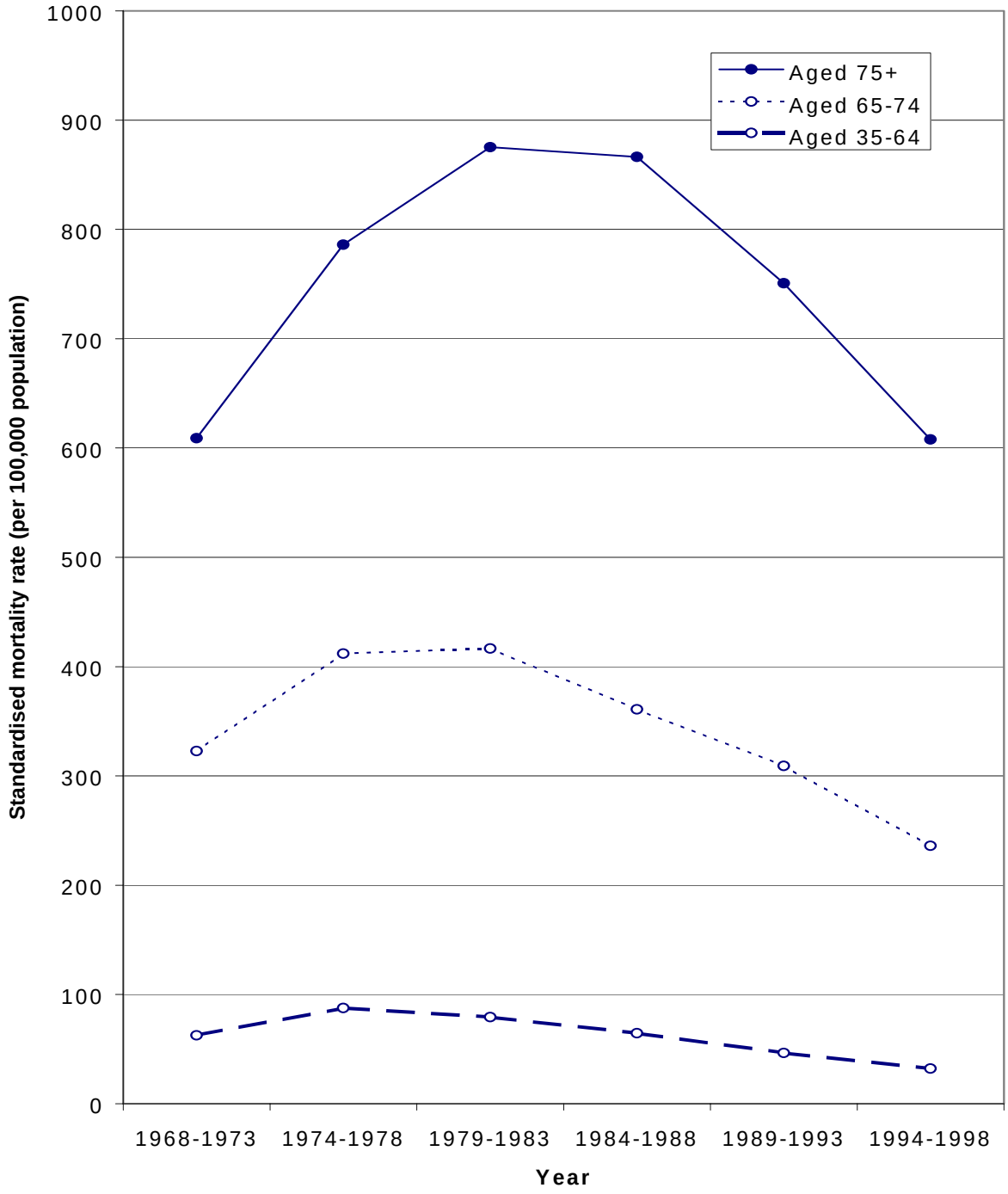


Figure 3.6 **Standardised mortality rates for myocardial infarction among women. Deaths in hospital by age group**

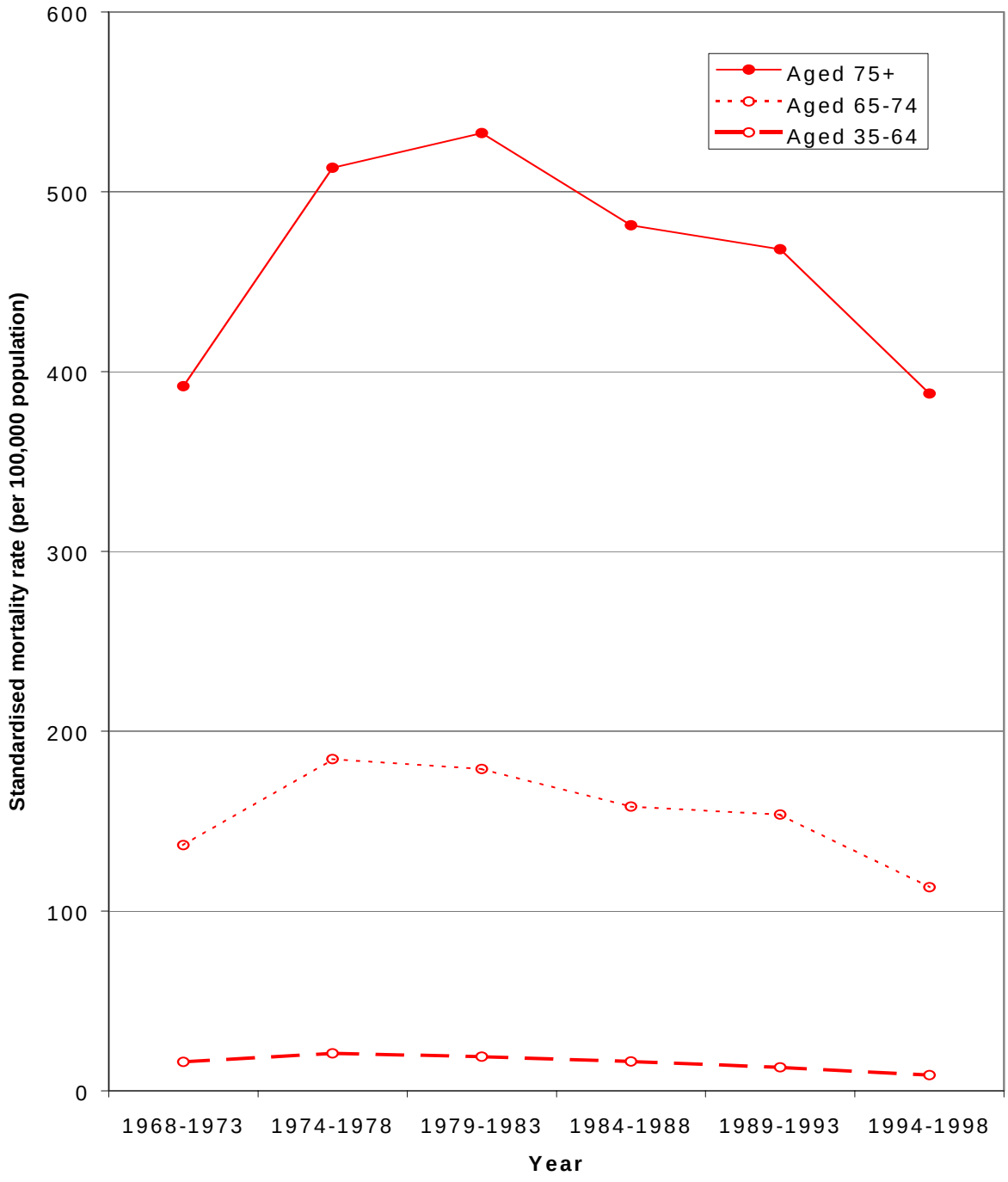


Figure 3.7 **Standardised mortality rates for myocardial infarction among men. Deaths outside hospital by age group**

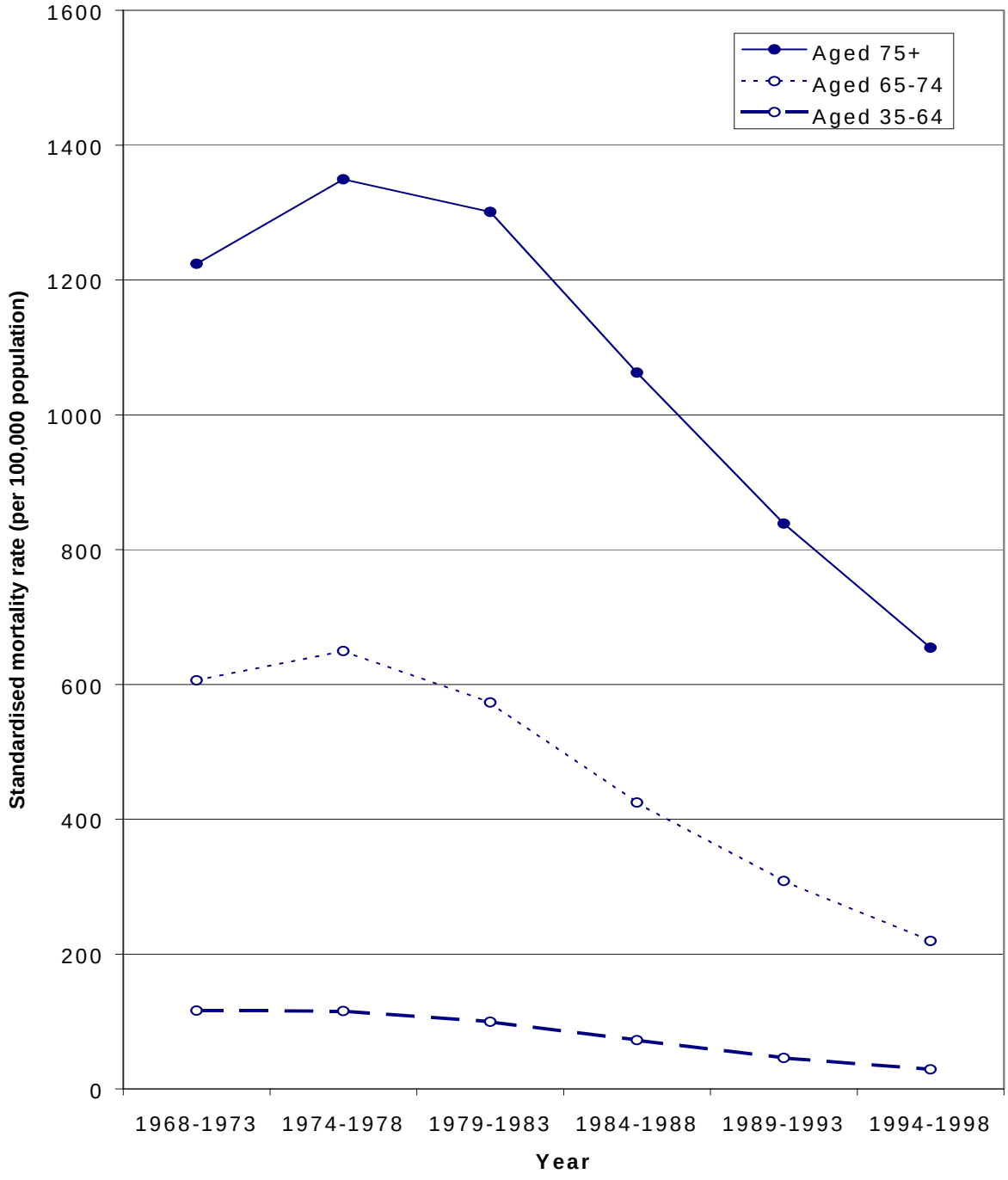
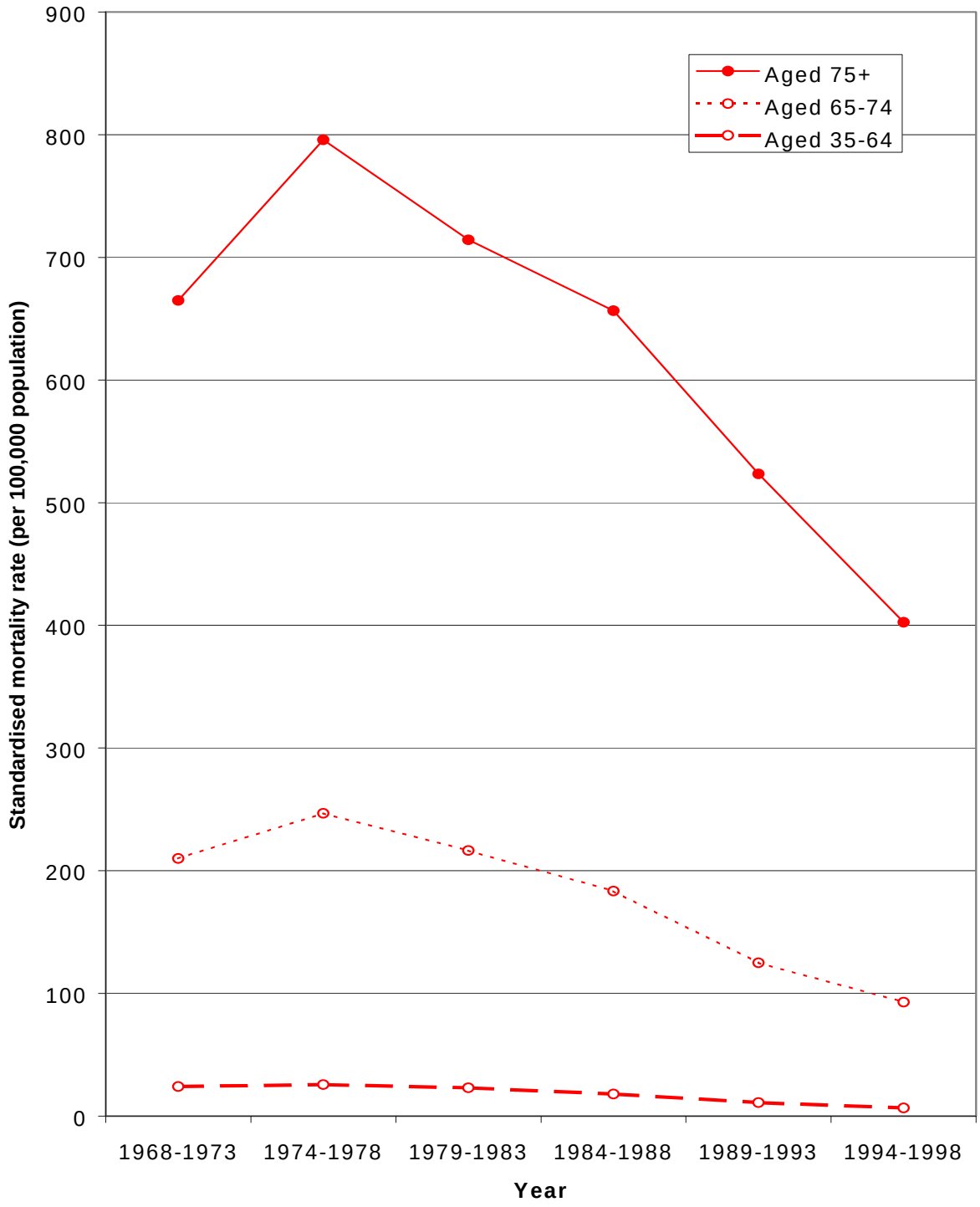


Figure 3.8 **Standardised mortality rates for myocardial infarction among women. Deaths outside hospital by age group**



Further components of mortality

The above section on mortality addressed three main measures - overall mortality, mortality in hospital and mortality outside hospital. The latter two can be subdivided further in order to gain more understanding of MI mortality. It is possible, using record linkage, to divide deaths which occur outside hospital into those for people who received hospital care in the previous (say) 30 days, and for those who did not. At least in recent years, the great majority of the latter - particularly in people under 65 years of age - are likely to be sudden deaths. Those who had received hospital care within the 30 day period can be further differentiated according to whether the admission was for myocardial infarction or for other conditions.

Deaths which occur in hospital can be subdivided, using record linkage, into deaths in hospital following formal admission, and deaths without formal admission which often include people who die very close to the time of arrival. The deaths which occur after hospital admission can be further disaggregated according to whether the hospital care was for MI, other ischaemic heart disease (IHD), or for any condition other than IHD.

Deaths outside hospital

Mortality occurring outside hospital was disaggregated according to whether hospital care had been provided within the previous 30 days. The age specific rates for deaths where hospital admissions had occurred in the previous 30 days - for MI (Table 3.4) and for all other conditions (Table 3.5) - were much smaller than for those where no hospital care for MI had been had been provided (Table 3.6). In all, 1.7% of all out-of-hospital deaths occurred in people within 30 days of admission for MI, 3.5% in people admitted less than 30 days previously for other conditions, and 94.8% in people with no admission in the previous 30 days.

Mortality rates are very low for the group in which death occurred within 30 days of hospital care, and there are few discernible trends apparent from the age and sex specific rates (Tables 3.4 and 3.5). Out-of-hospital deaths for people with no previous admission for MI in the last 30 days increased a little from the start of the study period until the mid 1970s; and they declined substantially thereafter (Table 3.6). These, we believe, are sudden deaths in the later period. It is possible that some deaths in the earlier period occurred in people whom general practitioners elected to treat at home.

The standardised rates for men (Figure 3.9) and women (Figure 3.10) summarise the patterns. It is clear that deaths occurring outside hospital in the 30 days following a hospital admission, whether for MI or for any other condition, contribute little to the overall mortality rates for all deaths outside hospital.

Deaths inside hospital

Age specific mortality rates, for both men and women, for deaths occurring inside hospital with a corresponding hospital admission for MI show a decrease throughout the study period for the younger age groups (less than 65). Among the older age groups (75 and over) there were large increases in mortality until the 1980s but a decline thereafter (Table 3.7).

The age specific rates, relating to admissions for IHD other than MI, tend to show a decline from the mid 1980s onwards, but little change during the earliest years of the study (Table 3.8). For admissions relating to all other conditions (excluding IHD) there are similarly declining rates from the mid 1980s but increases were seen, for most age-sex groups, during the earlier years (Table 3.9). The mortality rates, with no corresponding hospital admission, tend to show sharp increases up to the mid 1970s but largely uninterrupted decreases since then (Table 3.10).

The standardised mortality rates for deaths with a corresponding admission for MI show a larger decline in the 1980s and 1990s in men than women (Figures 3.11 and 3.12). There are large decreases in rates from the mid 1970s, in both men and women, for deaths with no corresponding hospital admission. The main difference between men and women is that deaths relating to an admission for 'other IHD' accounts for more other in-hospital mortality among women, whereas deaths following hospital care for other conditions account for more in men. The former show a decline over time in women, but little change for men, and the latter fall during the later years in men but are fairly constant in women.

Of all in-hospital deaths in the last ten years of the study period, 44.8% of the deaths were in people with an admission record for MI, 24.9% in people with an admission record for other IHD, 14.0% in people with admission for other conditions, and 16.3% in people with no admission record. Among people aged 75 and over, 45.8% of all in-hospital deaths in the last ten years were in people with an admission record for MI, 27.5% in people with an admission for other IHD, 15.3% in people with admission for other conditions, and 11.5% in people with no admission record. For people aged under 75, the corresponding figures were 43.6% with an admission for MI, 21.4% with an admission for other IHD, 12.3% for other conditions, and 22.7% with no hospital admission. Hence, the older patients (aged 75 and over) who died in hospital from MI were more frequently admitted with other IHD while the younger patients (aged under 75), who were less commonly admitted, were more likely to have died suddenly.

Key points:

- Considering out-of-hospital deaths, only 1.7% occurred in people discharged after an admission for MI in the previous 30 days, only 3.5% in people after admission for other conditions, and 94.8% occurred in people with no admission in the previous 30 days. The great majority of deaths outside hospital, at least in recent years, are likely to be sudden deaths.
- The profile of deaths in hospital changed over time and differed between age groups. In the last ten years of the study period, in people under 75 years of age, 43.6% of deaths in hospital, certified as MI, were in people with a hospital admission record for MI, 21.4% in people with an admission record for other ischaemic heart disease, 12.3% in people with admission records for other conditions, and 22.7% in people with no admission record. The majority of the latter are likely to be people with rapidly fatal MI.
- The rather mixed profile of in-hospital deaths suggests that inter-hospital comparisons of CFRs for MI will be susceptible to differences between hospitals in the components of the profile.
- We suggest that analyses of death-certificate-based mortality rates for MI, both for trends over time and for comparing geographical areas, are routinely subdivided into deaths which occurred outside hospital and deaths in hospital. These data are available on death certificates.

Table 3.4 Age specific mortality rates for myocardial infarction. Deaths outside hospital with a hospital admission for myocardial infarction within the previous 30 days

	Age group										
Time Period	35-39	40-44	45-49	50-54	55-59	60-64	65-69	70-74	75-79	80-84	85+
Men											
1968-1973	0	1	1	1	3	4	7	5	6	5	27
1974-1978	0	0	1	2	4	4	6	12	4	5	10
1979-1983	0	0	2	3	6	6	12	12	10	4	17
1984-1988	0	0	1	2	6	8	9	10	18	10	3
1989-1993	0	0	0	2	2	3	5	8	12	15	21
1994-1998	0	0	0	0	1	2	6	6	10	7	9
Women											
1968-1973	0	0	0	1	0	1	1	1	0	0	0
1974-1978	0	0	0	0	1	0	1	5	0	1	3
1979-1983	0	0	0	1	1	2	4	5	3	7	4
1984-1988	0	0	0	0	1	1	3	5	4	4	4
1989-1993	0	0	0	0	1	2	1	4	4	7	10
1994-1998	0	0	0	0	0	2	2	2	5	5	2

Table 3.5 Age specific mortality rates for myocardial infarction. Deaths outside hospital with a hospital admission for a cause than other than myocardial infarction within the previous 30 days

	Age group										
Time Period	35-39	40-44	45-49	50-54	55-59	60-64	65-69	70-74	75-79	80-84	85+
Men											
1968-1973	0	0	1	1	2	3	5	8	14	19	37
1974-1978	0	1	0	2	3	5	5	12	20	24	36
1979-1983	0	0	2	1	3	3	9	12	19	51	41
1984-1988	0	0	1	1	3	5	6	13	22	36	41
1989-1993	0	0	0	1	3	4	6	15	17	27	50
1994-1998	0	0	0	0	1	4	9	6	14	31	58
Women											
1968-1973	0	1	0	0	0	1	3	5	9	9	13
1974-1978	0	0	0	0	1	1	2	5	5	11	20
1979-1983	0	0	0	0	0	2	3	7	9	14	16
1984-1988	0	0	0	0	0	1	2	7	7	22	27
1989-1993	0	0	0	0	1	1	3	6	9	19	25
1994-1998	0	0	0	0	2	2	3	5	10	14	33

Table 3.6 **Age specific mortality rates for myocardial infarction. Deaths outside hospital with no hospital admission for myocardial infarction within the previous 30 days**

	Age group										
Time Period	**35-39**	**40-44**	**45-49**	**50-54**	**55-59**	**60-64**	**65-69**	**70-74**	**75-79**	**80-84**	**85+**
Men											
1968-1973	11	29	80	121	189	330	524	702	1023	1262	1545
1974-1978	7	27	67	140	196	315	515	809	1068	1431	1805
1979-1983	9	20	53	98	168	304	458	699	980	1398	1806
1984-1988	5	16	31	69	131	217	313	552	797	1143	1464
1989-1993	4	11	20	39	86	145	248	375	637	880	1139
1994-1998	2	7	14	26	48	93	171	271	447	676	1013
Women											
1968-1973	5	5	12	19	39	82	152	285	486	698	990
1974-1978	2	5	9	21	41	97	176	334	543	828	1264
1979-1983	1	4	6	18	36	92	152	292	488	742	1123
1984-1988	0	2	6	10	33	74	123	255	416	674	1103
1989-1993	0	1	2	8	15	47	89	168	311	531	916
1994-1998	0	0	2	4	9	30	68	121	232	412	716

Figure 3.9 **Deaths outside hospital. Standardised mortality rates for myocardial infarction among men. Deaths within 30 days of a hospital admission for MI, within 30 days of an admission for a condition other than MI, and with no hospital admission for MI within the previous 30 days**

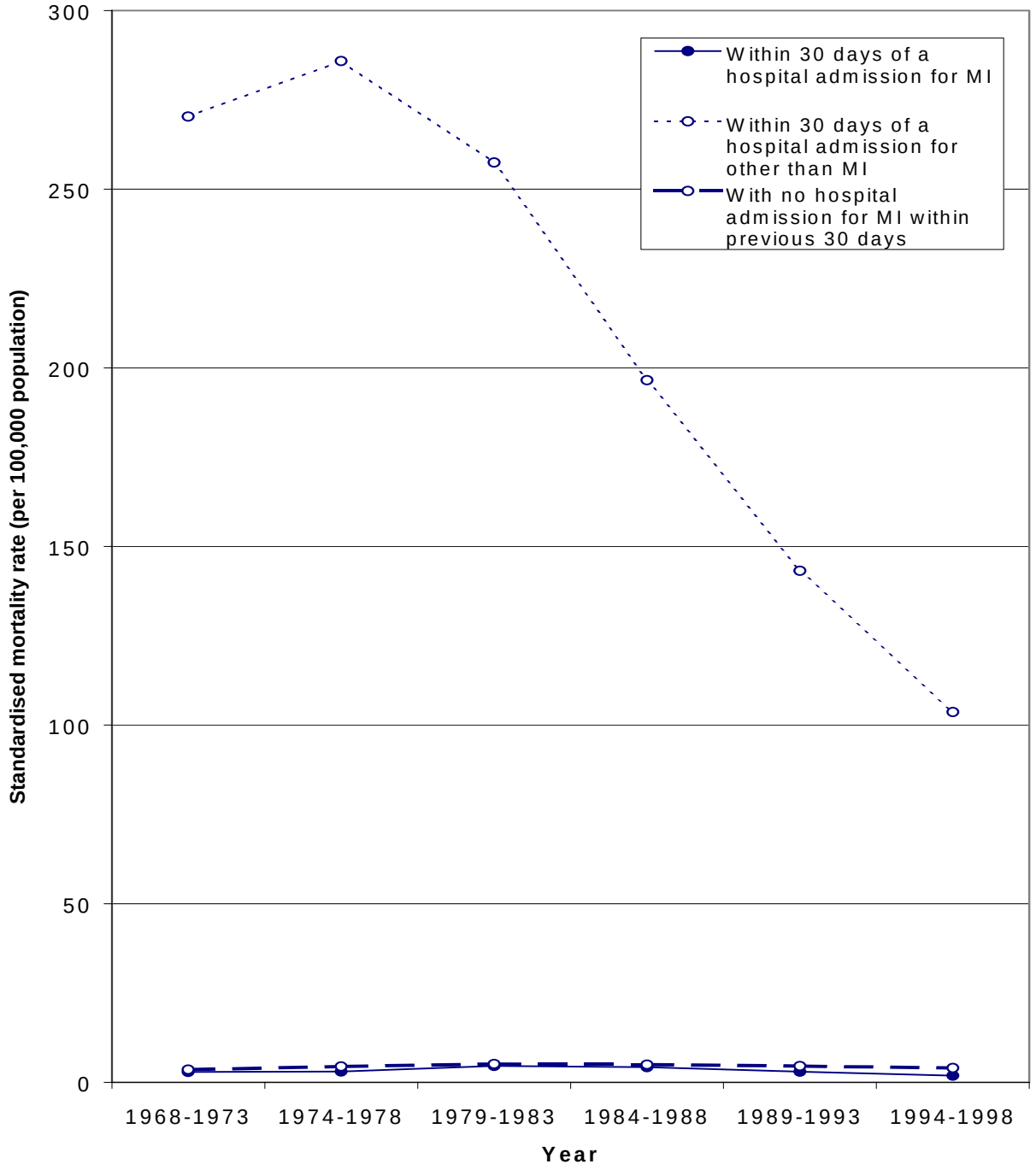


Figure 3.10 **Deaths outside hospital. Standardised mortality rates for myocardial infarction among women. Deaths within 30 days of a hospital admission for MI, within 30 days of an admission for a condition other than MI, and with no hospital admission for MI within the previous 30 days**

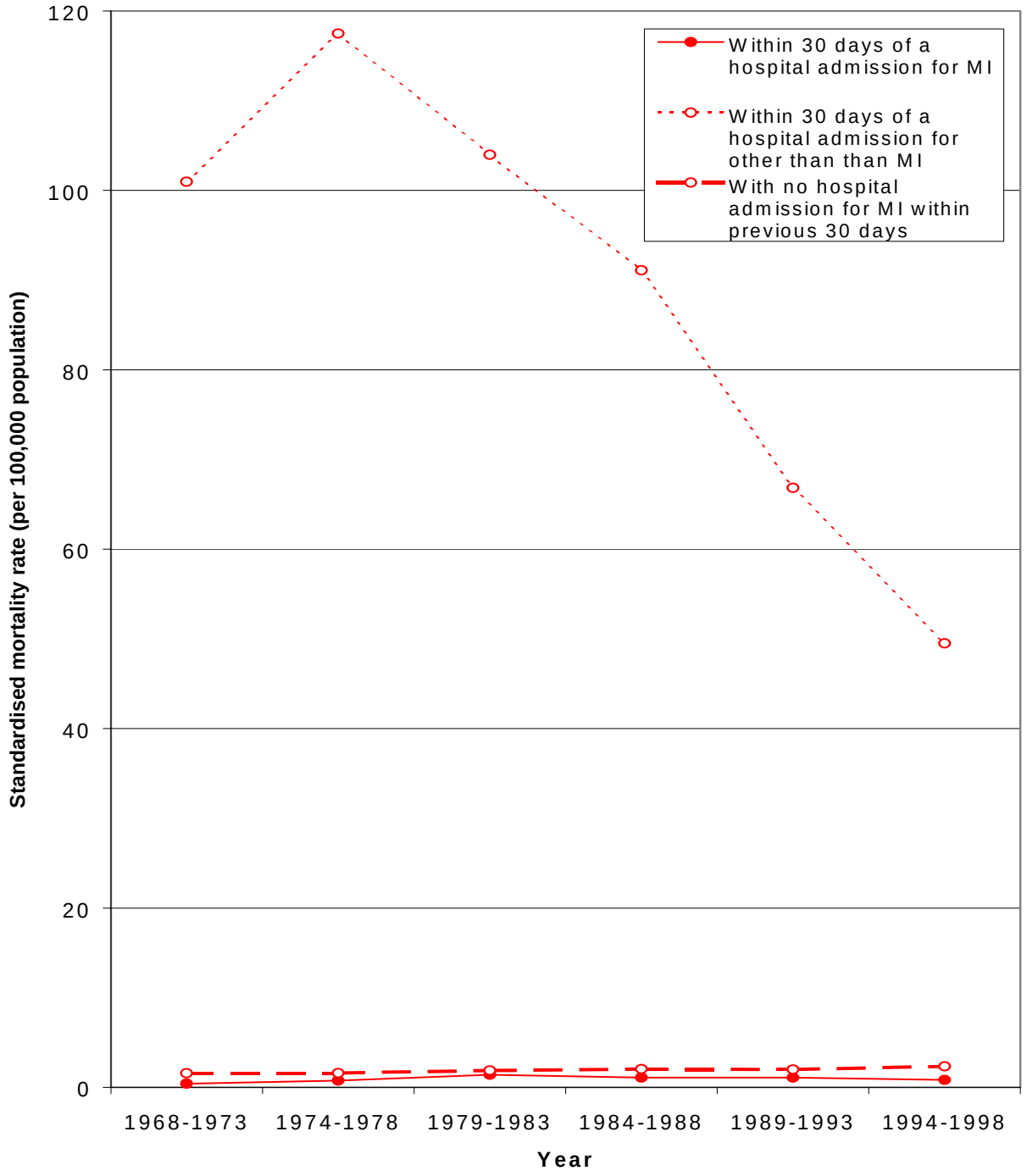


Table 3.7 **Age specific mortality rates for myocardial infarction. Deaths inside hospital with a corresponding hospital admission for myocardial infarction**

	Age group										
Time Period	**35-39**	**40-44**	**45-49**	**50-54**	**55-59**	**60-64**	**65-69**	**70-74**	**75-79**	**80-84**	**85+**
Men											
1968-1973	2	8	20	38	71	119	154	181	227	167	201
1974-1978	2	9	22	36	61	105	146	206	209	237	338
1979-1983	2	8	26	38	72	103	179	235	284	337	413
1984-1988	2	4	12	29	55	94	126	220	303	407	457
1989-1993	1	2	4	15	32	60	114	173	264	378	437
1994-1998	0	1	5	12	22	52	81	141	218	329	353
Women											
1968-1973	0	2	3	9	14	34	55	84	110	129	128
1974-1978	0	1	4	4	15	27	44	97	141	150	195
1979-1983	0	1	2	7	17	32	65	103	171	249	227
1984-1988	0	1	2	6	12	29	61	100	162	219	289
1989-1993	0	1	1	2	10	27	49	89	166	238	299
1994-1998	0	0	1	1	7	14	47	72	128	198	231

Table 3.8 **Age specific mortality rates for myocardial infarction. Deaths inside hospital with a corresponding hospital admission for other Ischaemic heart disease**

	Age group										
Time Period	**35-39**	**40-44**	**45-49**	**50-54**	**55-59**	**60-64**	**65-69**	**70-74**	**75-79**	**80-84**	**85+**
Men											
1968-1973	2	2	2	2	16	27	59	104	152	252	420
1974-1978	1	2	7	14	19	39	57	89	150	218	369
1979-1983	1	3	5	11	20	31	63	101	155	282	450
1984-1988	1	1	6	10	21	33	59	109	178	246	364
1989-1993	2	2	3	9	16	28	58	81	164	207	306
1994-1998	1	2	2	6	11	17	38	59	105	159	204
Women											
1968-1973	0	0	1	4	5	18	26	50	100	187	343
1974-1978	0	1	2	4	4	14	28	62	95	185	261
1979-1983	1	0	2	2	7	14	28	54	100	151	253
1984-1988	0	0	0	4	6	14	26	39	92	147	214
1989-1993	0	0	1	3	7	12	29	51	82	143	225
1994-1998	0	0	1	2	2	7	18	34	65	112	192

Table 3.9 Age specific mortality rates for myocardial infarction. Deaths inside hospital with a corresponding hospital admission for a condition other than Ischaemic heart disease

	Age group										
Time Period	35-39	40-44	45-49	50-54	55-59	60-64	65-69	70-74	75-79	80-84	85+
Men											
1968-1973	0	0	2	5	5	11	33	35	61	86	110
1974-1978	0	2	2	8	13	21	35	52	75	73	123
1979-1983	0	2	3	5	13	16	32	46	90	105	198
1984-1988	0	1	2	5	8	17	26	46	89	185	117
1989-1993	0	1	2	3	8	15	29	54	82	114	138
1994-1998	0	0	2	2	2	11	31	46	74	108	143
Women											
1968-1973	0	0	0	1	3	4	12	23	40	49	35
1974-1978	0	0	1	2	2	9	16	17	32	71	66
1979-1983	0	0	1	2	4	9	16	27	59	84	117
1984-1988	0	0	1	1	4	6	10	28	45	72	75
1989-1993	0	0	0	1	2	7	15	25	37	79	113
1994-1998	0	0	0	0	2	7	10	21	40	70	96

Table 3.10 Age specific mortality rates for myocardial infarction. Deaths inside hospital with no corresponding hospital admission

	Age group										
Time Period	35-39	40-44	45-49	50-54	55-59	60-64	65-69	70-74	75-79	80-84	85+
Men											
1968-1973	2	2	13	11	17	34	39	47	69	29	119
1974-1978	4	10	18	43	57	76	113	136	179	197	303
1979-1983	4	8	12	28	44	62	79	112	133	164	215
1984-1988	4	6	13	20	36	45	71	86	104	168	155
1989-1993	2	5	10	16	32	40	57	63	94	105	95
1994-1998	3	3	7	12	16	25	41	46	68	86	81
Women											
1968-1973	0	0	1	1	5	9	8	22	25	60	61
1974-1978	0	1	3	10	13	20	49	60	92	143	197
1979-1983	0	1	2	5	7	15	31	44	74	111	115
1984-1988	0	0	1	3	9	15	21	42	56	82	105
1989-1993	0	1	2	1	5	9	26	33	43	54	56
1994-1998	1	1	1	2	2	7	8	22	27	49	49

Figure 3.11 **Deaths inside hospital. Standardised mortality rates for myocardial infarction among men. Deaths with a corresponding hospital admission for MI, admission for other IHD, admission for a condition other than IHD, and with no corresponding hospital admission**

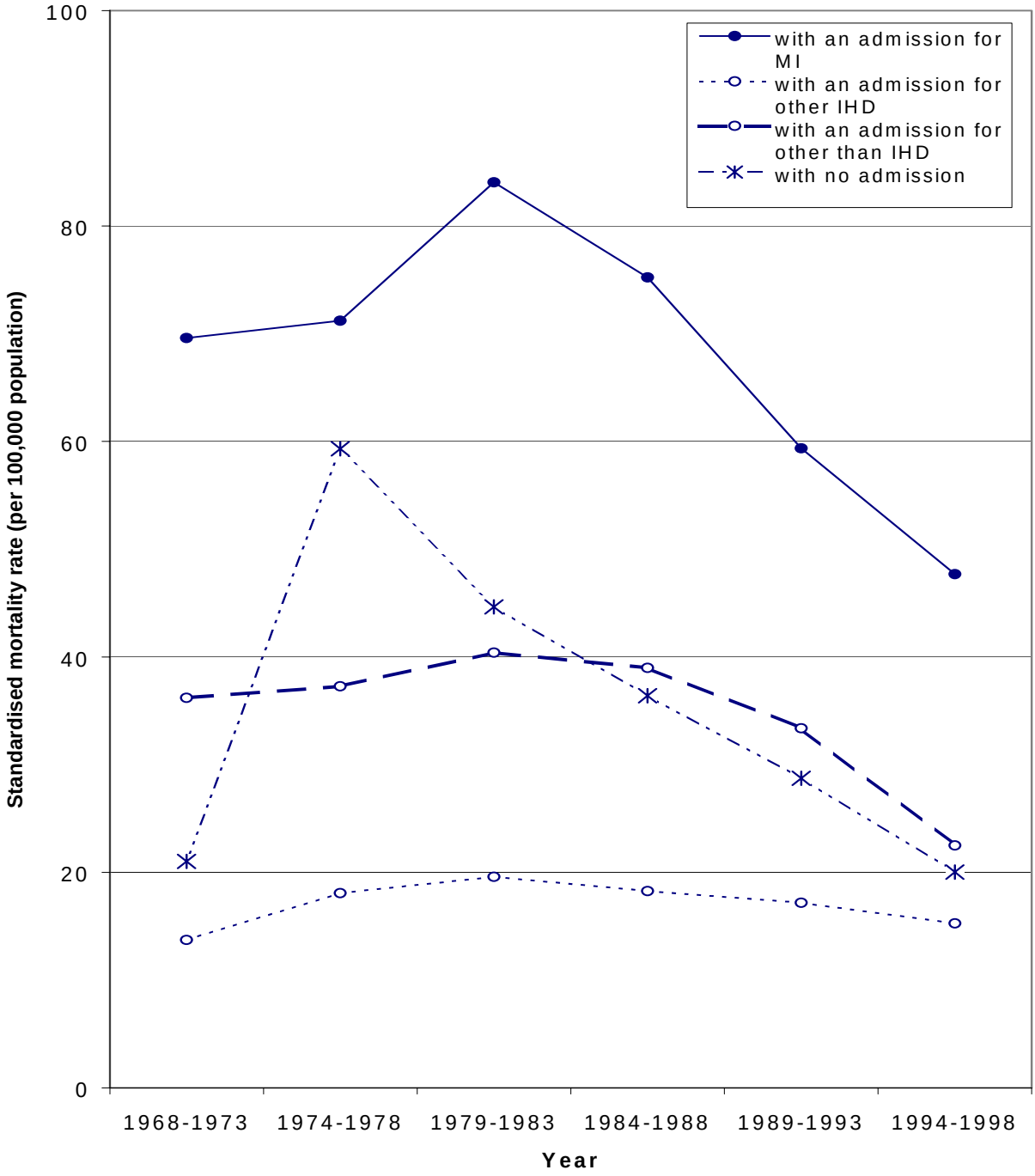
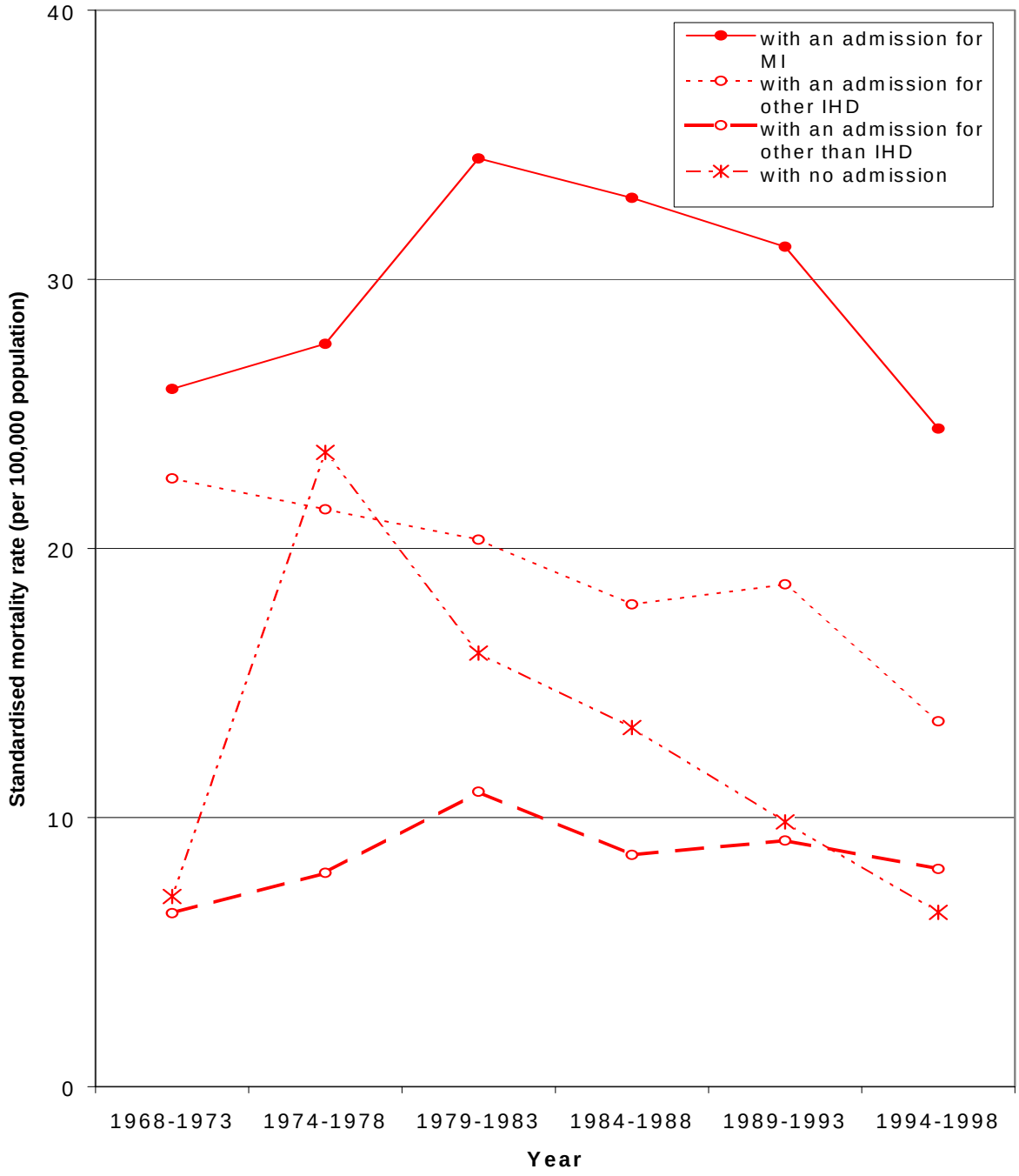


Figure 3.12 **Deaths inside hospital. Standardised mortality rates for myocardial infarction among women. Deaths with a corresponding hospital admission for MI, admission for other IHD, admission for a condition other than IHD, and with no corresponding hospital admission**



Incidence rates

Hospitalised incidence fell from each time period to the next in most age-sex groups under the age of 60 years. However, they increased in the 1970s and 1980s in some of the older age-sex groups before they subsequently fell (Table 3.11). These increases almost certainly reflect an increased tendency of general practitioners to refer patients with MI to hospital, an increased speed of being sent into hospital over time, and include a disproportionate increase in admissions of people destined to die. The hospital-associated incidence rate tended to increase during the early years of the study period, before declining from the mid 1970s onwards (Table 3.12). Total incidence, including the out-of-hospital deaths, declined in almost every time interval from each 5-year period to the next in all age groups under 50 years in both men and women; and in most but not all of the older age-sex groups (Table 3.13). In the later years covered by the analysis, declines in total incidence were seen in all age-sex groups.

The age standardised total incidence rate for men, summarising the trends, declined more sharply during the 1980s and 1990s than the hospitalised and hospital-associated incidence rates (Figure 3.13). This reflects the particularly substantial decline in out-of-hospital deaths. Some of the fall in out-of-hospital deaths in the early years (1960s and 1970s) was no doubt a decline in managing MI patients at home. Most or all of the fall in later years probably represents the true decline in sudden out-of-hospital deaths. For the women a similar pattern was evident (Figure 3.14); although while the total incidence declined from the mid 1970s onwards, the hospitalised and hospital-associated rates did not fall until the 1990s.

Standardised hospitalised incidence rates, for the three age-groups, are shown for men and women in Figures 3.15 and 3.16.

Table 3.11 **Age specific incidence rates (per 100,000 population) for myocardial infarction: hospitalised incidence**

	Age group										
Time Period	**35-39**	**40-44**	**45-49**	**50-54**	**55-59**	**60-64**	**65-69**	**70-74**	**75-79**	**80-84**	**85+**
Men											
1968-1973	25	93	161	255	372	448	473	476	509	453	439
1974-1978	26	94	159	257	381	486	527	606	502	539	626
1979-1983	33	83	184	279	370	501	627	661	667	651	719
1984-1988	25	62	131	210	337	451	508	658	744	867	756
1989-1993	19	50	89	170	260	383	486	638	813	904	871
1994-1998	17	35	69	113	188	278	375	494	660	784	770
Women											
1968-1973	1	8	23	48	73	128	172	239	259	273	244
1974-1978	4	8	22	39	87	116	191	276	307	371	417
1979-1983	2	6	20	42	88	137	234	320	414	515	505
1984-1988	1	4	18	49	84	138	218	310	446	522	594
1989-1993	1	7	15	28	77	142	219	324	459	595	626
1994-1998	1	7	12	20	59	100	177	258	377	449	476

Table 3.12 **Age specific incidence rates (per 100,000 population) for myocardial infarction: hospitalised incidence plus death-certificate-only in-hospital deaths**

	Age group										
Time Period	**35-39**	**40-44**	**45-49**	**50-54**	**55-59**	**60-64**	**65-69**	**70-74**	**75-79**	**80-84**	**85+**
Men											
1968-1973	29	96	178	273	410	520	603	662	791	819	1088
1974-1978	31	108	187	322	470	622	732	882	906	1027	1421
1979-1983	38	96	205	322	447	611	801	920	1044	1202	1583
1984-1988	30	71	152	246	402	547	664	898	1116	1466	1392
1989-1993	24	57	104	199	317	466	629	837	1153	1330	1410
1994-1998	20	40	81	133	217	332	485	644	906	1136	1199
Women											
1968-1973	1	8	24	54	85	159	218	333	423	568	683
1974-1978	4	10	28	55	106	158	285	415	526	771	940
1979-1983	2	7	25	51	105	175	308	444	647	861	991
1984-1988	1	4	21	57	102	174	275	420	638	823	988
1989-1993	2	8	17	33	91	170	288	432	621	872	1020
1994-1998	1	9	14	24	65	121	213	335	509	680	812

Table 3.13 **Age specific incidence rates (per 100,000 population) for myocardial infarction: total identified incidence**

	Age group										
Time Period	**35-39**	**40-44**	**45-49**	**50-54**	**55-59**	**60-64**	**65-69**	**70-74**	**75-79**	**80-84**	**85+**
Men											
1968-1973	40	125	257	394	599	850	1127	1364	1814	2082	2632
1974-1978	38	135	253	462	666	937	1247	1691	1974	2458	3226
1979-1983	48	116	258	420	615	916	1258	1619	2023	2600	3388
1984-1988	35	86	183	314	534	765	977	1450	1913	2609	2855
1989-1993	28	68	124	238	403	611	876	1212	1790	2210	2549
1994-1998	22	48	95	159	265	425	656	915	1353	1812	2212
Women											
1968-1973	6	13	35	73	124	241	371	618	909	1266	1673
1974-1978	6	15	38	75	147	255	461	749	1069	1599	2205
1979-1983	3	11	31	69	141	267	460	737	1135	1603	2114
1984-1988	2	6	26	66	136	247	399	674	1055	1496	2091
1989-1993	2	9	19	41	106	217	378	600	932	1403	1936
1994-1998	2	9	16	27	74	151	282	456	741	1091	1528

Figure 3.13 Standardised incidence rates for myocardial infarction among men. Hospitalised incidence, hospital-associated incidence and total identified incidence

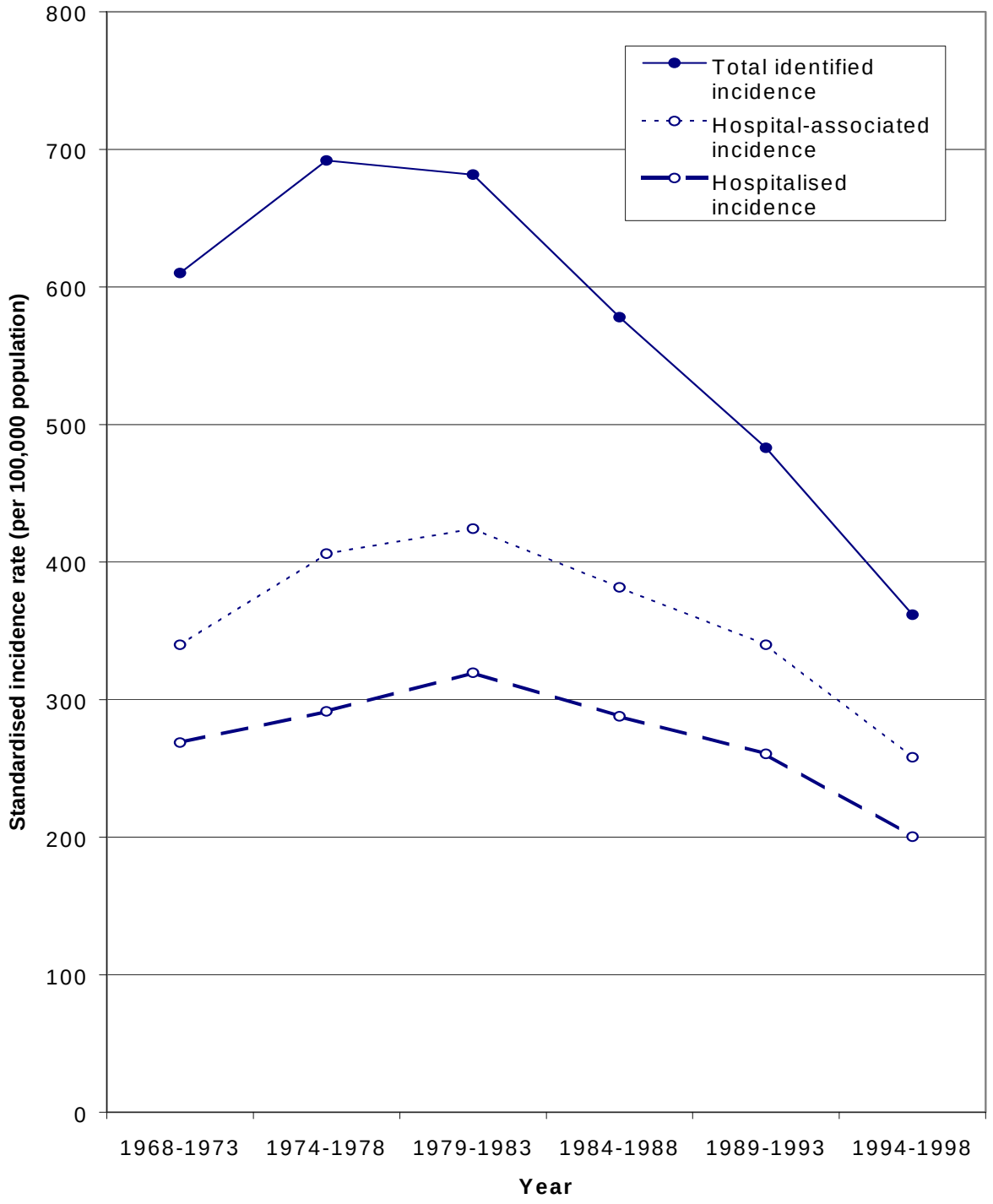


Figure 3.14 Standardised incidence rates for myocardial infarction among women. Hospitalised incidence, hospital-associated incidence and total identified incidence

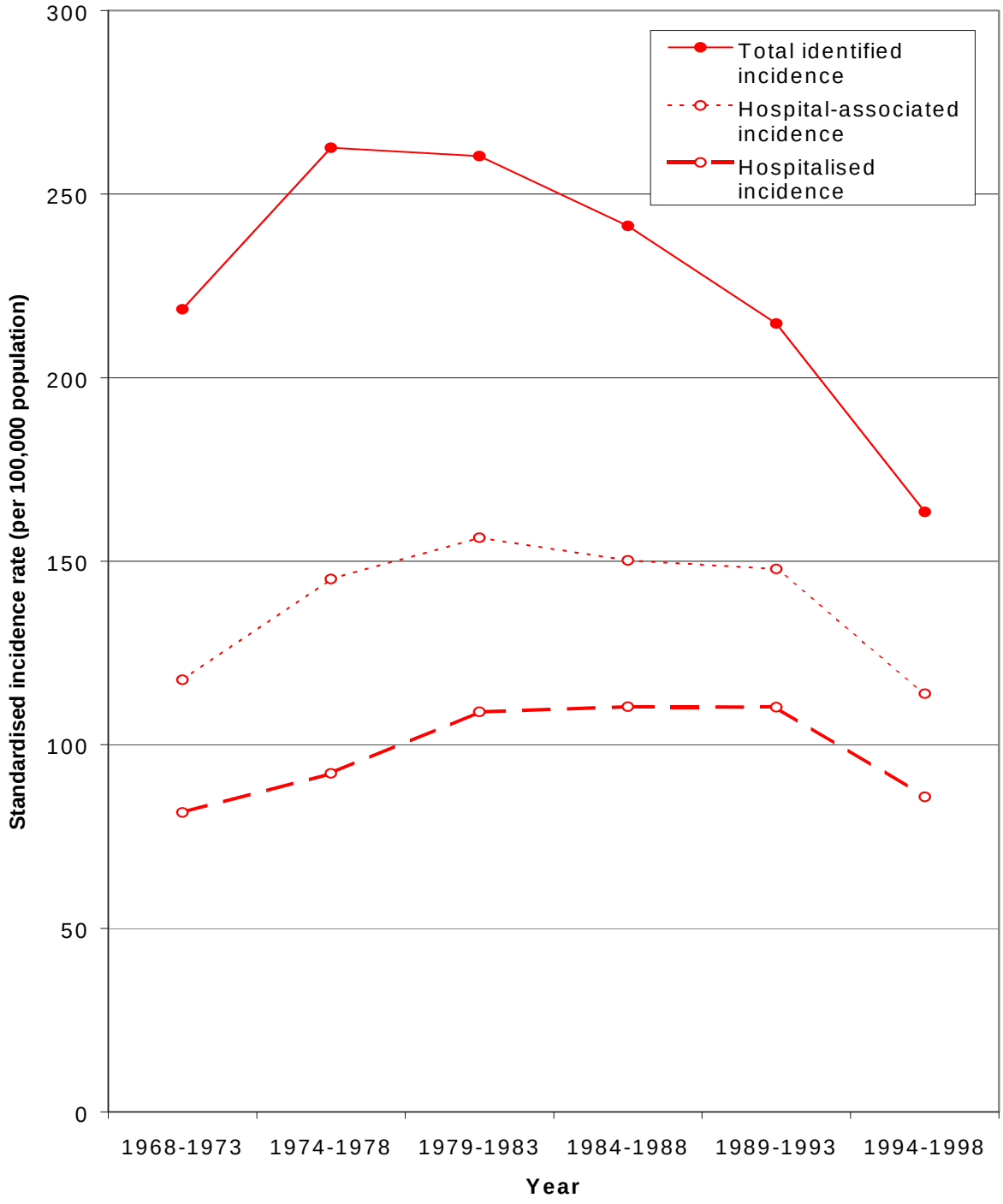


Figure 3.15 Standardised hospitalised incidence for myocardial infarction among men by age group

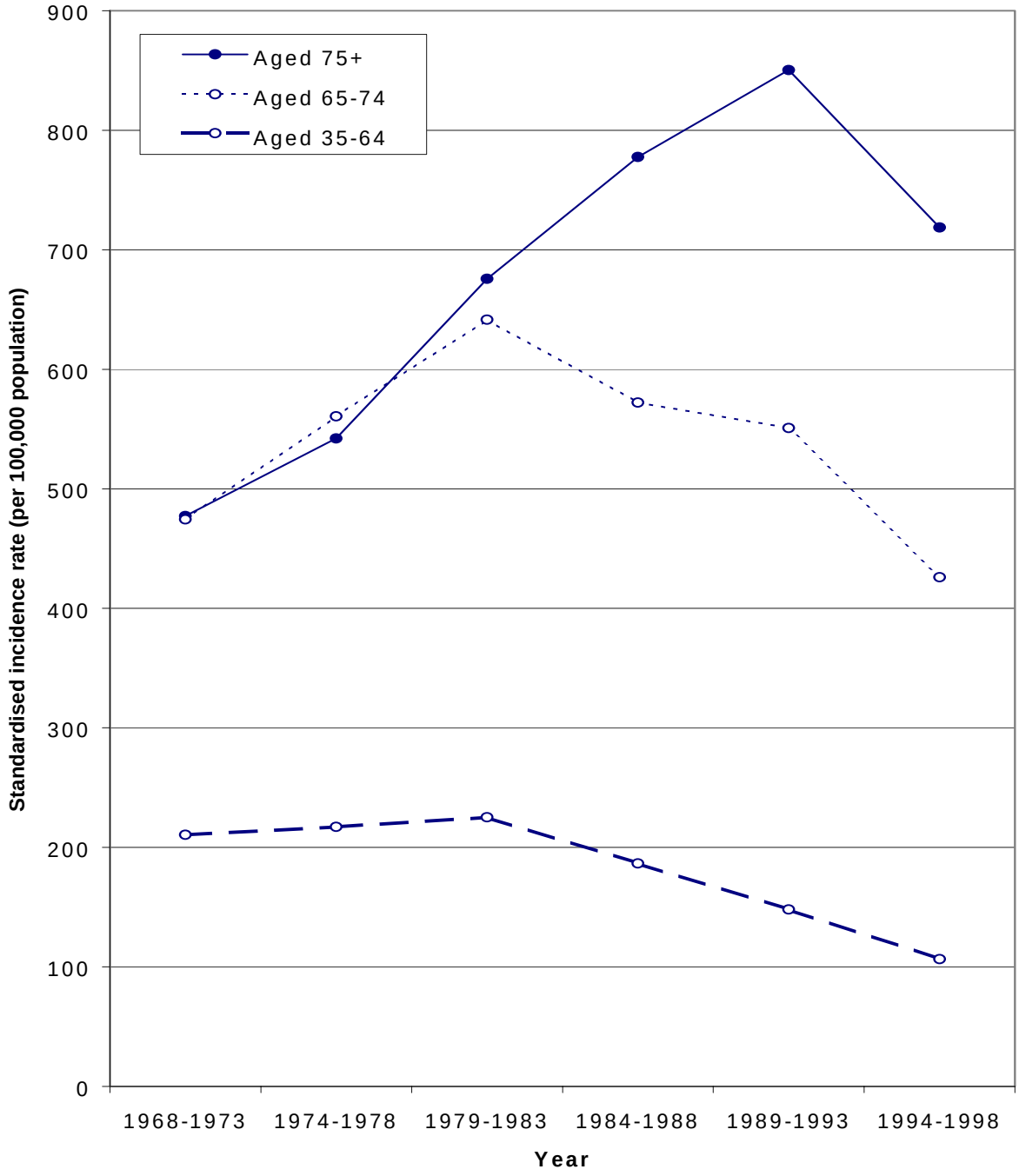
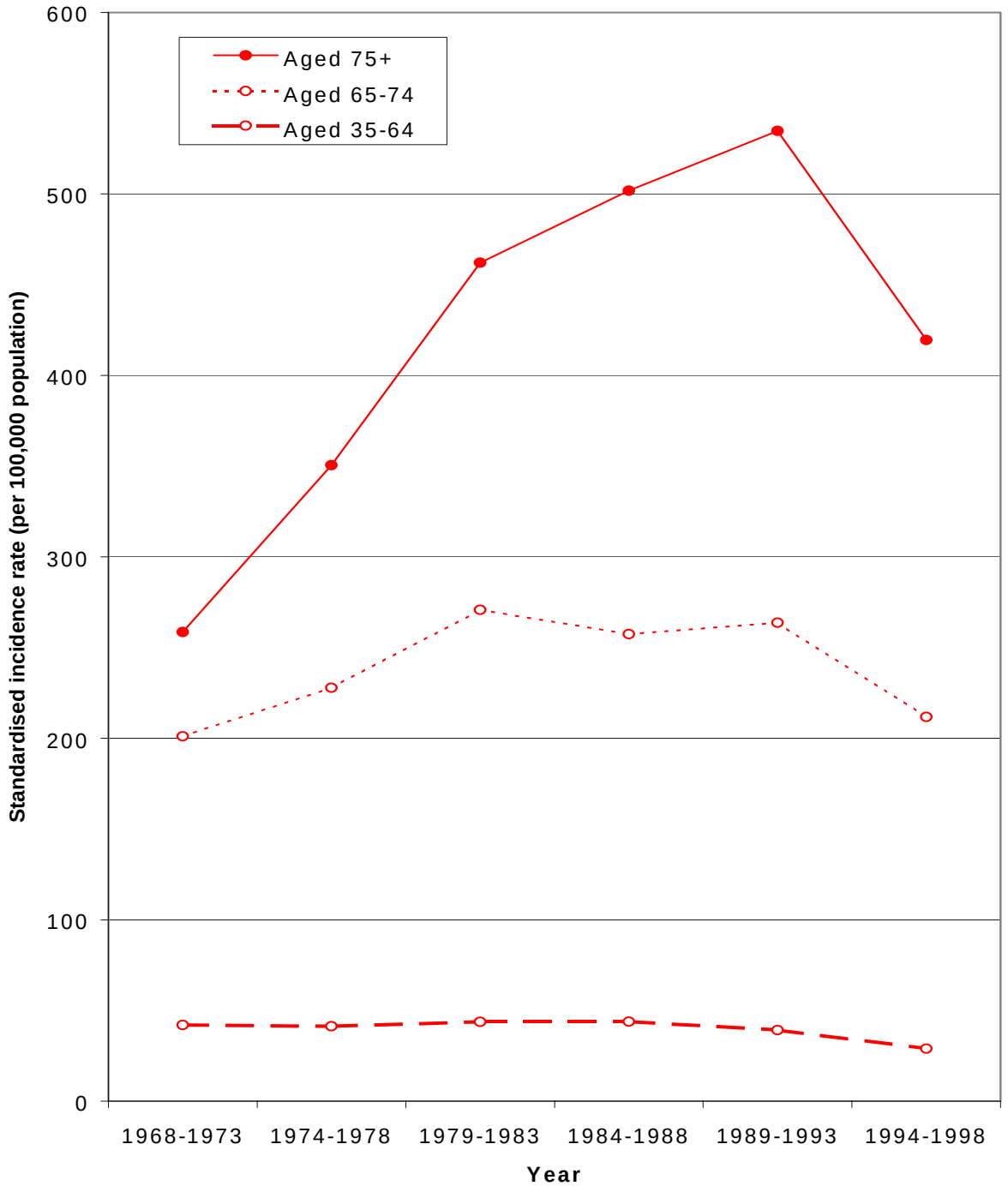


Figure 3.16 Standardised hospitalised incidence for myocardial infarction among women by age group



Further components of incidence

The component of incidence represented by death-certificate-only in-hospital deaths is shown in Table 3.14. That represented by in-hospital deaths with an admission for 'other ischaemic heart disease' is shown in Table 3.15. That represented by in-hospital deaths following admission for other conditions is shown in Table 3.16. That represented by deaths outside hospital with no admission for MI in the previous 30 days is shown in Table 3.17.

Key points:

The standardised rates for these different components of incidence show that, in both men and women, hospitalised incidence and deaths outside hospital with no hospital care within the preceding 30 days contribute most to total incidence (Figures 3.17 and 3.18). Large decreases in both are evident for men throughout the 1980s and 1990s. In women, however, the standardised rate for hospitalised incidence did not fall until the 1990s. The standardised rates for the other three components are much smaller and, although showing relatively little trend in the early years, decreases are apparent in the latter half of the study.

Table 3.14 **Age specific incidence rates (per 100,000 population) for myocardial infarction: Death-certificate-only in hospital deaths**

	Age group										
Time Period	**35-39**	**40-44**	**45-49**	**50-54**	**55-59**	**60-64**	**65-69**	**70-74**	**75-79**	**80-84**	**85+**
Men											
1968-1973	2	2	13	11	17	34	39	47	69	29	119
1974-1978	4	10	18	43	57	76	113	136	179	197	303
1979-1983	4	8	12	28	44	62	79	112	133	164	215
1984-1988	4	6	13	20	36	45	71	86	104	168	155
1989-1993	2	5	10	16	32	40	57	63	94	105	95
1994-1998	3	3	7	12	16	25	41	46	68	86	81
Women											
1968-1973	0	0	1	1	5	9	8	22	25	60	61
1974-1978	0	1	3	10	13	20	49	60	92	143	197
1979-1983	0	1	2	5	7	15	31	44	74	111	115
1984-1988	0	0	1	3	9	15	21	42	56	82	105
1989-1993	0	1	2	1	5	9	26	33	43	54	56
1994-1998	1	1	1	2	2	7	8	22	27	49	49

Table 3.15 **Age specific incidence rates (per 100,000 population) for myocardial infarction: deaths inside hospital with an admission for other ischaemic heart disease**

	Age group										
Time Period	**35-39**	**40-44**	**45-49**	**50-54**	**55-59**	**60-64**	**65-69**	**70-74**	**75-79**	**80-84**	**85+**
Men											
1968-1973	2	2	2	2	16	27	59	104	152	252	420
1974-1978	1	2	7	14	19	39	57	89	150	218	369
1979-1983	1	3	5	11	20	31	63	101	155	282	450
1984-1988	1	1	6	10	21	33	59	109	178	246	364
1989-1993	2	2	3	9	16	28	58	81	164	207	306
1994-1998	1	2	2	6	11	17	38	59	105	159	204
Women											
1968-1973	0	0	1	4	5	18	26	50	100	187	343
1974-1978	0	1	2	4	4	14	28	62	95	185	261
1979-1983	1	0	2	2	7	14	28	54	100	151	253
1984-1988	0	0	0	4	6	14	26	39	92	147	214
1989-1993	0	0	1	3	7	12	29	51	82	143	225
1994-1998	0	0	1	2	2	7	18	34	65	112	192

Table 3.16 **Age specific incidence rates (per 100,000 population) for myocardial infarction: deaths inside hospital with an admission for a condition other than ischaemic heart disease**

	Age group										
Time Period	**35-39**	**40-44**	**45-49**	**50-54**	**55-59**	**60-64**	**65-69**	**70-74**	**75-79**	**80-84**	**85+**
Men											
1968-1973	0	0	2	5	5	11	33	35	61	86	110
1974-1978	0	2	2	8	13	21	35	52	75	73	123
1979-1983	0	2	3	5	13	16	32	46	90	105	198
1984-1988	0	1	2	5	8	17	26	46	89	185	117
1989-1993	0	1	2	3	8	15	29	54	82	114	138
1994-1998	0	0	2	2	2	11	31	46	74	108	143
Women											
1968-1973	0	0	0	1	3	4	12	23	40	49	35
1974-1978	0	0	1	2	2	9	16	17	32	71	66
1979-1983	0	0	1	2	4	9	16	27	59	84	117
1984-1988	0	0	1	1	4	6	10	28	45	72	75
1989-1993	0	0	0	1	2	7	15	25	37	79	113
1994-1998	0	0	0	0	2	7	10	21	40	70	96

Table 3.17 **Age specific incidence rates (per 100,000 population) for myocardial infarction: deaths outside hospital with no hospital admission for myocardial infarction within the previous 30 days**

	Age group										
Time Period	**35-39**	**40-44**	**45-49**	**50-54**	**55-59**	**60-64**	**65-69**	**70-74**	**75-79**	**80-84**	**85+**
Men											
1968-1973	11	29	80	121	189	330	524	702	1023	1262	1545
1974-1978	7	27	67	140	196	315	515	809	1068	1431	1805
1979-1983	9	20	53	98	168	304	458	699	980	1398	1806
1984-1988	5	16	31	69	131	217	313	552	797	1143	1464
1989-1993	4	11	20	39	86	145	248	375	637	880	1139
1994-1998	2	7	14	26	48	93	171	271	447	676	1013
Women											
1968-1973	5	5	12	19	39	82	152	285	486	698	990
1974-1978	2	5	9	21	41	97	176	334	543	828	1264
1979-1983	1	4	6	18	36	92	152	292	488	742	1123
1984-1988	0	2	6	10	33	74	123	255	416	674	1103
1989-1993	0	1	2	8	15	47	89	168	311	531	916
1994-1998	0	0	2	4	9	30	68	121	232	412	716

Figure 3.17 **Incidence. Standardised rates for components of incidence for myocardial infarction among men. Deaths with a corresponding hospital admission, hospital associated death, deaths outside hospital with no admission for MI within 30 days, deaths inside with a corresponding admission for other IHD, and deaths inside with a corresponding admission for conditions other than IHD**

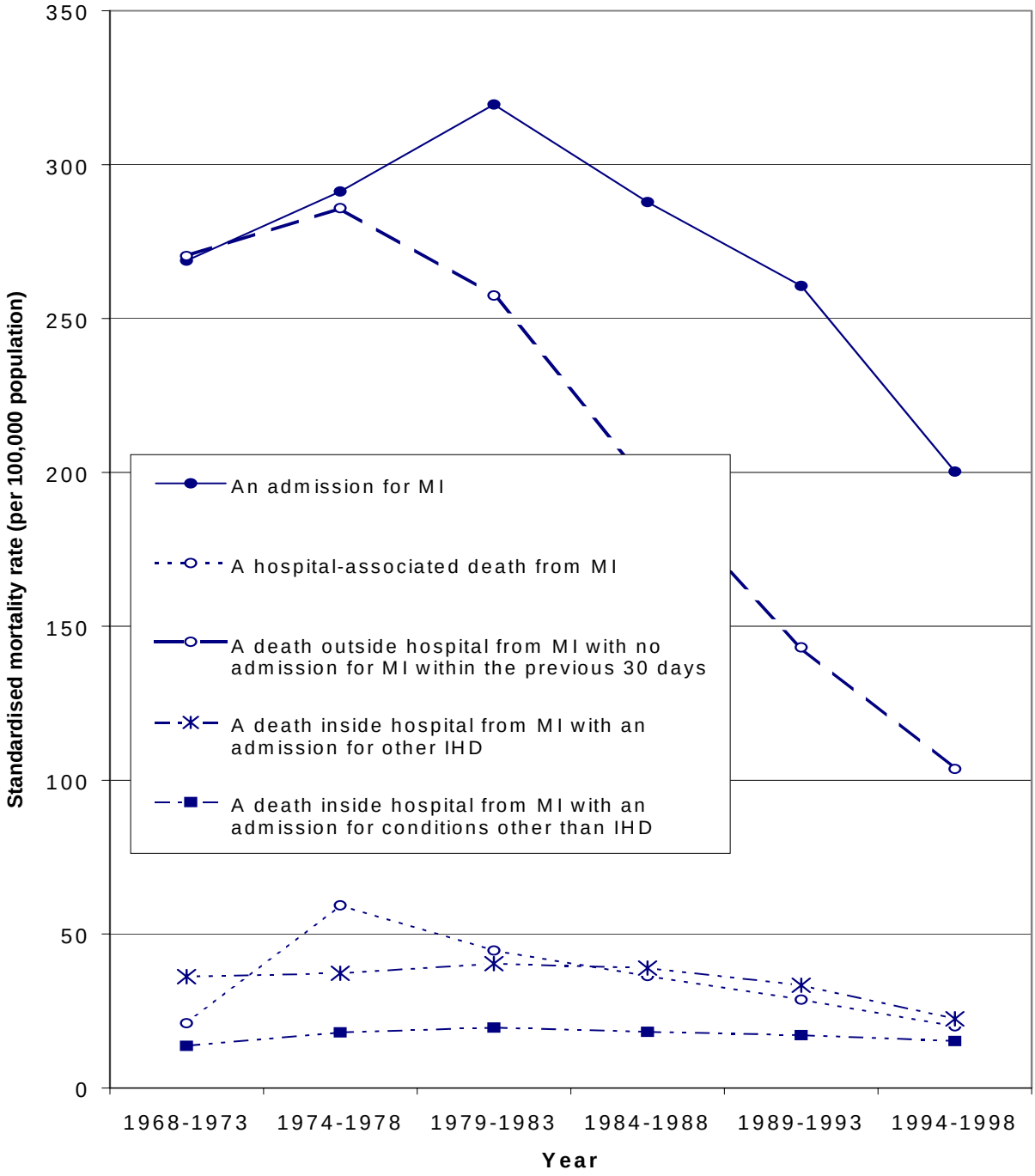
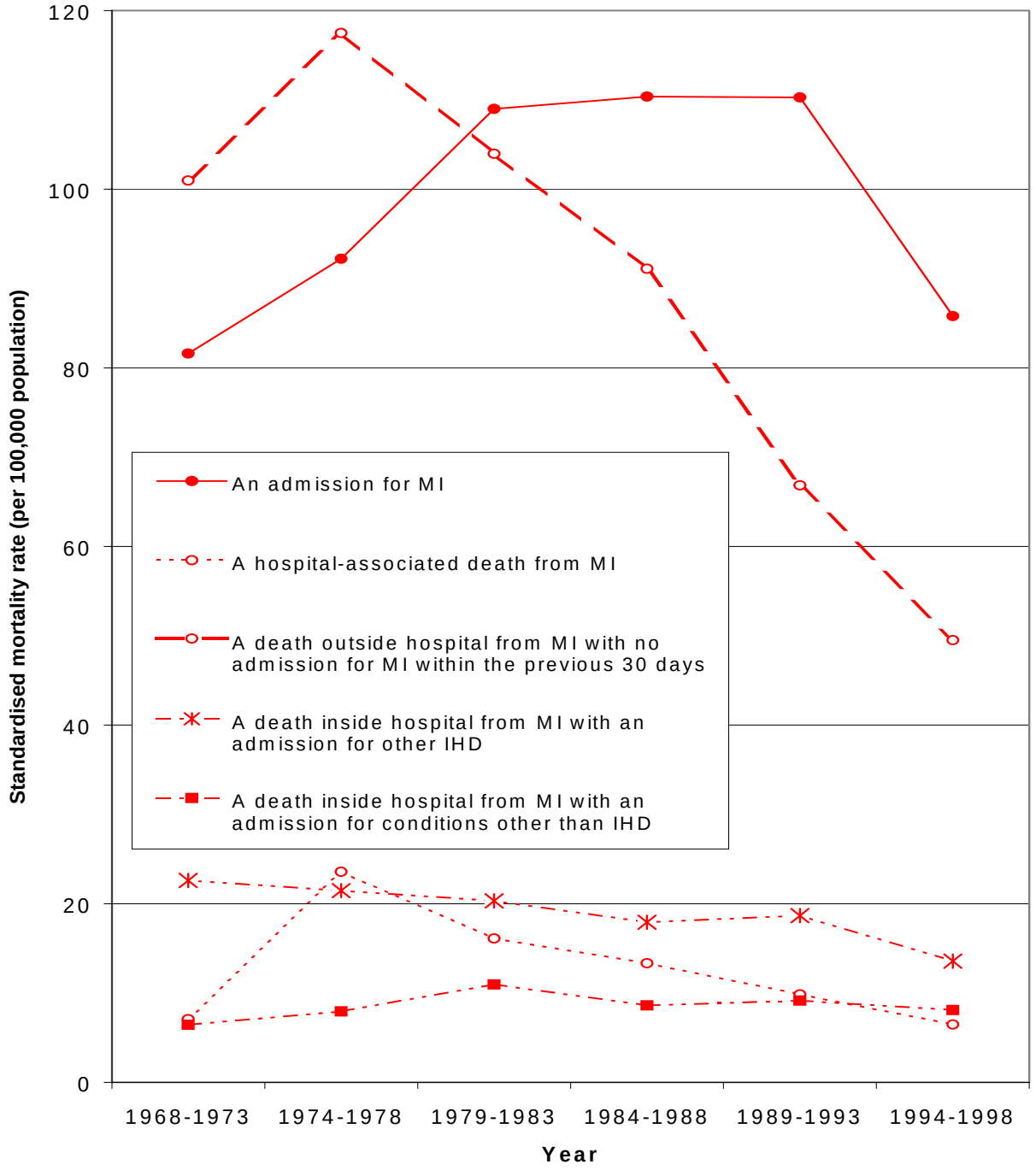


Figure 3.18 **Incidence. Standardised rates for components of incidence for myocardial infarction among women. Deaths with a corresponding hospital admission, hospital-associated deaths, deaths outside hospital with no admission for MI within 30 days, deaths inside with a corresponding admission for other IHD, and deaths inside with a corresponding admission for conditions other than IHD**



Case-fatality rates

Age-specific values for the three measures of case-fatality rates are shown separately for both sexes in Tables 3.18 to 3.20. Comparisons of each age-sex group, comparing each for CFRs following admission, for hospital-associated incidence, and for all incidence, show substantial differences between the three measures. Hospital case-fatality rates, i.e. those for people formally admitted to hospital, increased over time in the early years covered by the study. There was a tendency for hospital-associated case-fatality rates, i.e. those in all people who reached hospital, to rise too, and more so. The early increases in hospital case-fatality rates probably reflect the increased tendency to refer rather than manage MI at home in the early years of the study period, and the increased speed of being sent into hospital over time, coupled with a disproportionate increase in admissions of people destined to die. Total case-fatality rates fell across the whole time period. This reflects the decline, in particular, in sudden, out-of-hospital deaths.

The age-standardised case-fatality rates for men and women are shown in, respectively, Figures 3.19 and 3.20. Age-standardised case-fatality rates, within the three age groups, are shown for men (Figure 3.21) and women (Figure 3.22). The decline in case-fatality rates, seen in each age group, tended to accelerate in the younger age groups from the mid 1980s onwards.

Key points:

- Age-specific CFRs show that rates increase substantially with increasing age. For example, considering people admitted for MI, in the period 1994-9 they increased from 6.8% in men aged 45-49 and 32.1% in men aged 75-79.
- CFRs varied greatly depending on whether they only included people admitted with MI, included hospital-associated deaths, or included all deaths including those outside hospital. For example, for men aged 45-49 the corresponding CFRs in 1994-8 were 6.8%, 19.9% and 30.7%. For men aged 75.79 in 1994-8, the corresponding CFRs were 32.1%, 50.5% and 64.5%.
- Both in making comparisons over time and in comparing hospitals, the value taken by the CFR will be very sensitive to differences over time and between places in the likelihood and speed of referral for MI, sensitive to how deaths are recorded at or soon after the patients' arrival at hospital, and sensitive to how deaths are recorded when they occur for MI in people admitted to hospital with other conditions.

Table 3.18 **Age specific hospital case-fatality rates (per 100 patients) for myocardial infarction: based on all people admitted to hospital**

	Age group										
Time Period	**35-39**	**40-44**	**45-49**	**50-54**	**55-59**	**60-64**	**65-69**	**70-74**	**75-79**	**80-84**	**85+**
Men											
1968-1973	4.8	8.3	11.3	16.0	17.4	27.1	32.4	38.6	43.5	40.0	50.0
1974-1978	6.7	10.5	12.3	14.5	16.6	22.2	26.9	37.0	44.6	43.5	59.0
1979-1983	6.6	7.9	12.1	13.3	18.0	20.6	28.3	35.9	42.5	53.4	59.2
1984-1988	6.9	6.2	10.9	12.5	16.4	19.7	25.4	33.4	39.5	47.9	59.1
1989-1993	7.1	7.1	4.2	7.9	10.9	14.0	19.9	25.6	32.8	42.0	49.3
1994-1998	2.3	3.1	6.8	7.4	9.5	14.7	19.8	23.6	32.1	35.5	43.0
Women											
1968-1973	0.0	25.0	15.2	21.2	16.8	25.3	35.4	38.9	49.1	52.5	53.9
1974-1978	30.0	15.0	15.8	13.9	21.3	27.5	26.1	38.7	44.0	45.2	52.4
1979-1983	28.6	15.8	6.9	23.5	19.8	23.3	29.8	32.0	42.7	48.5	46.5
1984-1988	20.0	21.4	10.7	12.3	16.2	21.5	27.6	36.1	38.4	42.9	50.7
1989-1993	0.0	12.9	6.9	6.7	18.1	20.9	23.5	30.0	36.1	41.6	46.9
1994-1998	0.0	18.2	12.5	6.1	10.5	16.2	24.6	26.0	35.3	40.8	47.3

Table 3.19 **Age specific case-fatality rates for hospital associated cases (per 100 patients) for myocardial infarction: hospital (per 100 patients) admissions plus death-certificate-only in-hospital deaths**

	Age group										
Time Period	**35-39**	**40-44**	**45-49**	**50-54**	**55-59**	**60-64**	**65-69**	**70-74**	**75-79**	**80-84**	**85+**
Men											
1968-1973	16.7	12.0	19.8	21.7	25.1	37.3	47.0	55.8	63.6	66.9	79.8
1974-1978	21.3	22.1	25.2	31.8	32.4	39.3	47.4	56.7	69.3	70.3	81.9
1979-1983	19.7	20.3	21.0	24.9	32.1	34.8	43.9	54.0	63.3	74.8	81.5
1984-1988	21.5	17.8	23.3	25.1	30.0	33.8	42.9	51.2	59.7	69.2	77.8
1989-1993	25.7	19.3	18.6	21.2	26.7	29.4	38.2	43.3	52.6	60.6	68.7
1994-1998	18.9	16.4	19.9	21.5	21.6	28.5	38.0	41.4	50.5	55.5	63.3
Women											
1968-1973	0.0	25.0	20.0	29.7	28.8	39.8	49.0	56.1	68.8	77.2	83.6
1974-1978	41.7	34.6	33.3	37.9	35.4	47.0	50.3	59.2	67.3	73.6	78.9
1979-1983	44.4	27.3	25.0	36.8	32.9	40.1	46.6	51.1	63.3	69.2	72.7
1984-1988	33.3	26.7	20.6	23.4	30.9	37.5	42.7	52.8	57.0	63.8	70.4
1989-1993	25.0	27.0	20.6	19.2	30.7	34.0	41.9	47.5	52.8	60.1	67.4
1994-1998	42.9	30.8	26.9	21.4	19.0	31.0	37.3	43.0	52.1	60.9	69.1

Table 3.20 Age specific total case-fatality rates (per 100 patients) for myocardial infarction

	Age group										
Time Period	**35-39**	**40-44**	**45-49**	**50-54**	**55-59**	**60-64**	**65-69**	**70-74**	**75-79**	**80-84**	**85+**
Men											
1968-1973	**35.5**	**31.3**	**42.3**	**42.7**	**46.0**	**59.9**	**70.4**	**77.6**	**83.4**	**86.6**	**91.5**
1974-1978	**35.2**	**36.2**	**42.8**	**50.8**	**50.2**	**57.8**	**67.7**	**76.5**	**85.4**	**87.3**	**91.9**
1979-1983	**34.9**	**32.0**	**35.6**	**40.3**	**48.4**	**54.5**	**62.7**	**72.8**	**80.2**	**87.9**	**91.2**
1984-1988	**33.1**	**31.9**	**34.4**	**39.6**	**44.7**	**49.7**	**59.4**	**67.9**	**75.2**	**82.1**	**88.9**
1989-1993	**35.0**	**31.3**	**30.5**	**32.7**	**40.2**	**43.9**	**53.3**	**59.1**	**68.1**	**75.2**	**82.1**
1994-1998	**25.9**	**29.1**	**30.7**	**33.1**	**33.6**	**42.3**	**51.8**	**56.5**	**64.5**	**70.3**	**79.2**
Women											
1968-1973	**77.8**	**52.6**	**45.1**	**46.9**	**50.0**	**58.4**	**69.0**	**75.3**	**85.3**	**89.6**	**93.2**
1974-1978	**58.8**	**55.3**	**50.0**	**53.7**	**52.4**	**66.2**	**68.5**	**76.7**	**83.5**	**87.1**	**90.9**
1979-1983	**54.5**	**46.7**	**39.3**	**52.6**	**49.0**	**59.8**	**62.9**	**69.7**	**78.7**	**83.2**	**87.0**
1984-1988	**42.9**	**47.6**	**36.7**	**33.9**	**46.1**	**55.1**	**59.3**	**69.8**	**73.0**	**79.4**	**85.7**
1989-1993	**33.3**	**35.7**	**29.9**	**33.3**	**39.7**	**46.7**	**54.7**	**61.3**	**67.7**	**74.4**	**82.4**
1994-1998	**55.6**	**32.5**	**36.4**	**31.9**	**26.4**	**43.6**	**51.1**	**57.2**	**65.9**	**74.5**	**83.1**

Figure 3.19 Standardised case-fatality rates for myocardial infarction among men. Hospital case-fatality, hospital-associated case-fatality and total case-fatality rates

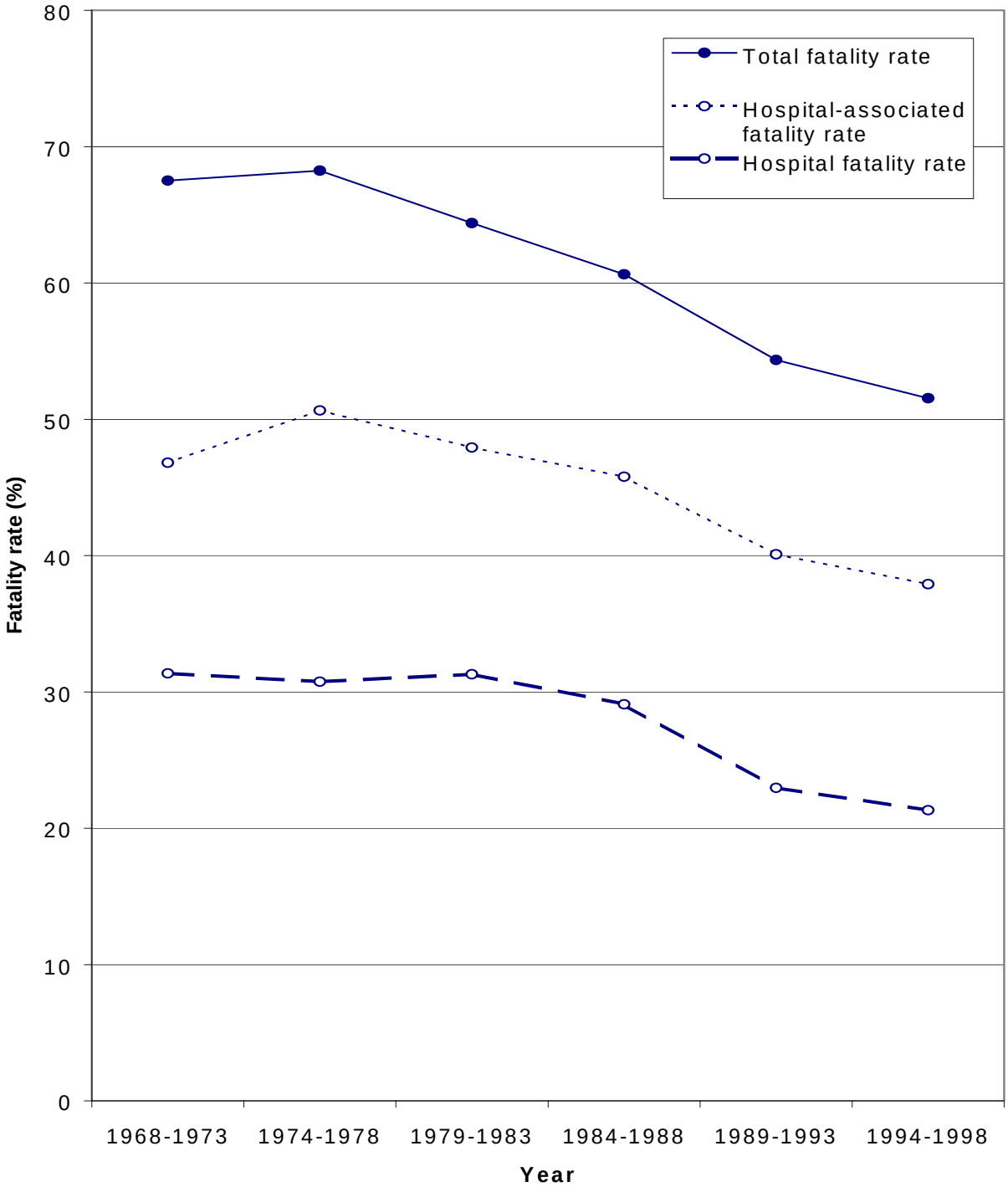


Figure 3.20 Standardised case-fatality rates for myocardial infarction among women. Hospital case-fatality, hospital-associated case-fatality and total case-fatality rates

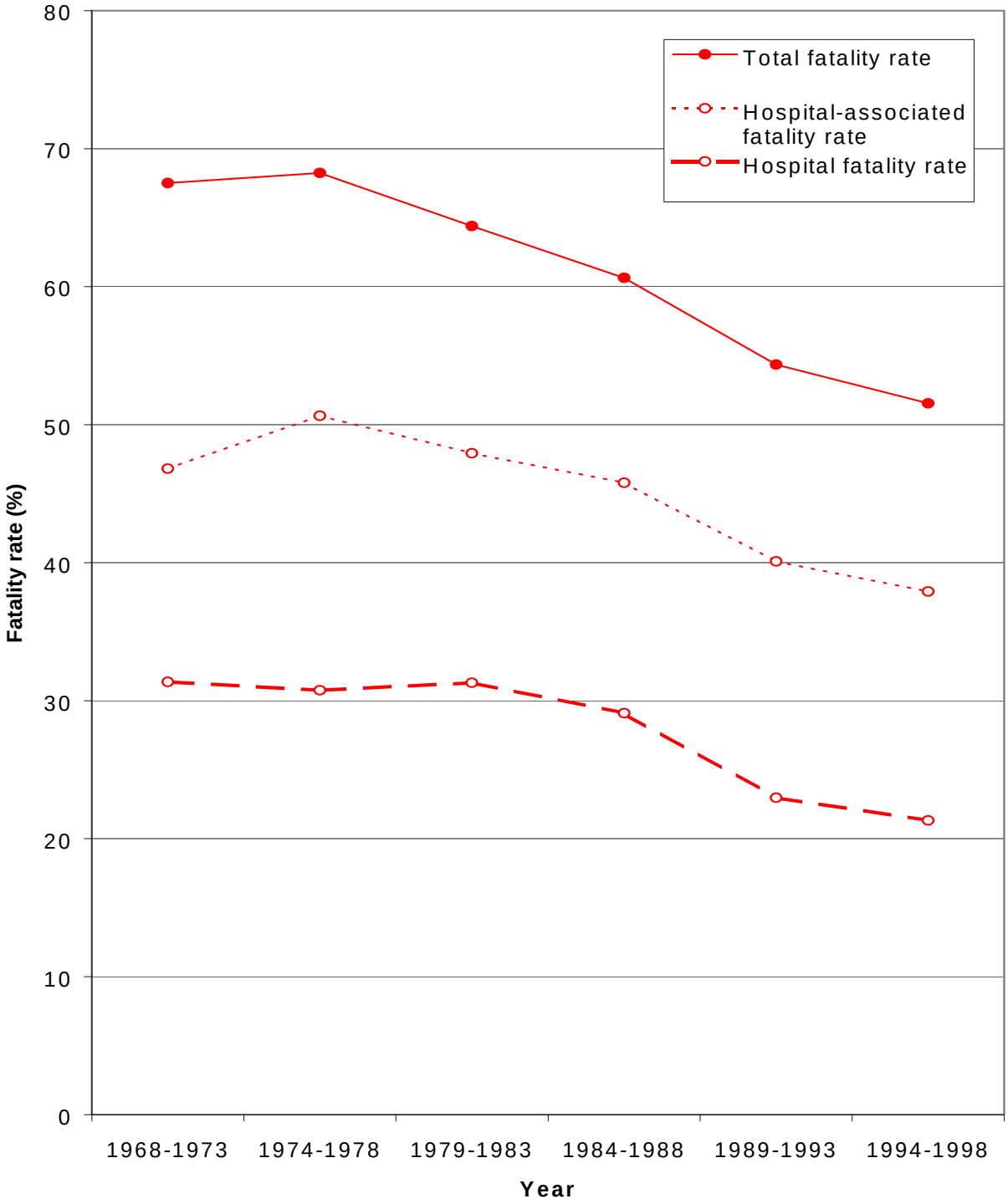


Figure 3.21 Standardised hospital case-fatality rates for myocardial infarction among men by age group

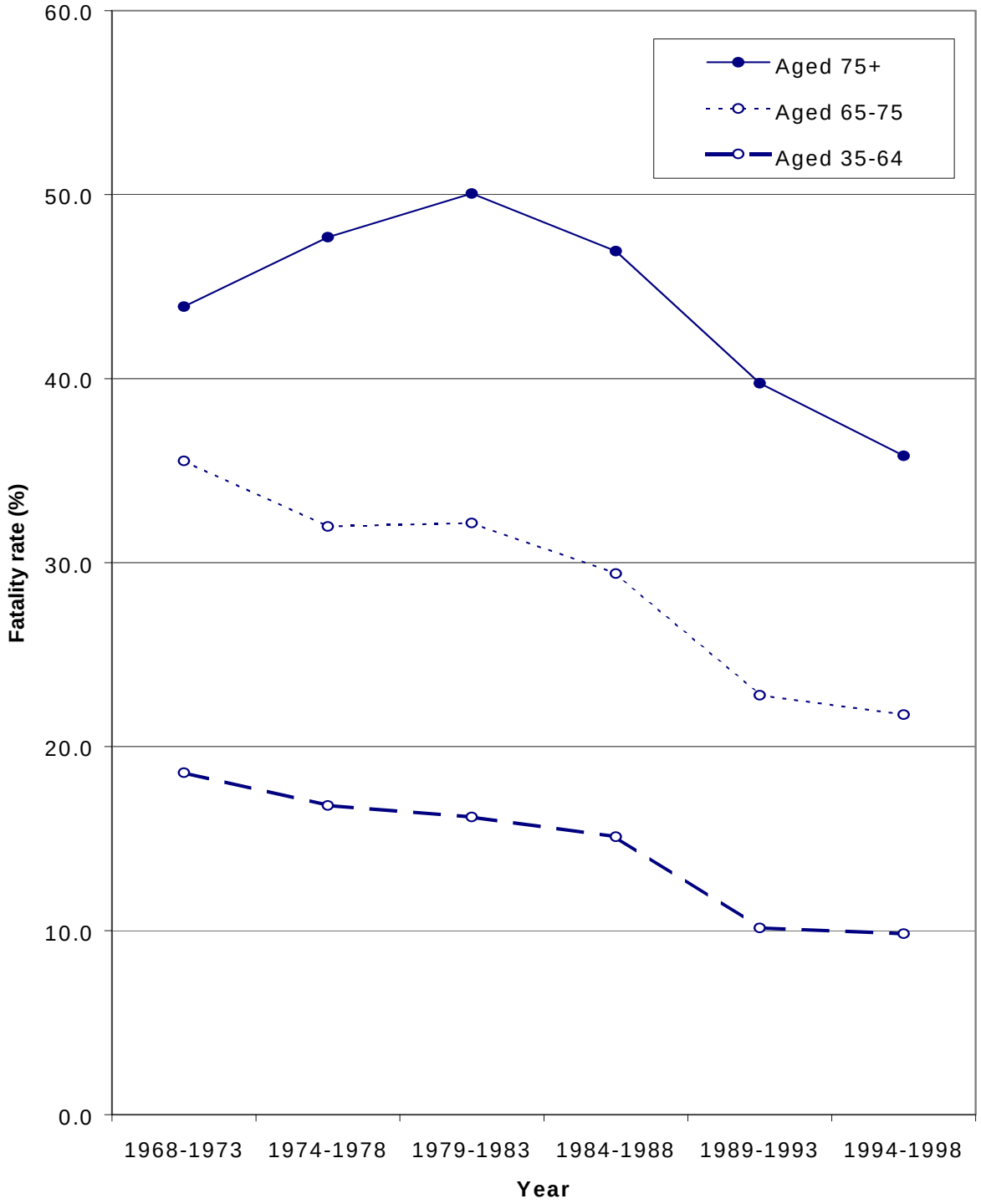
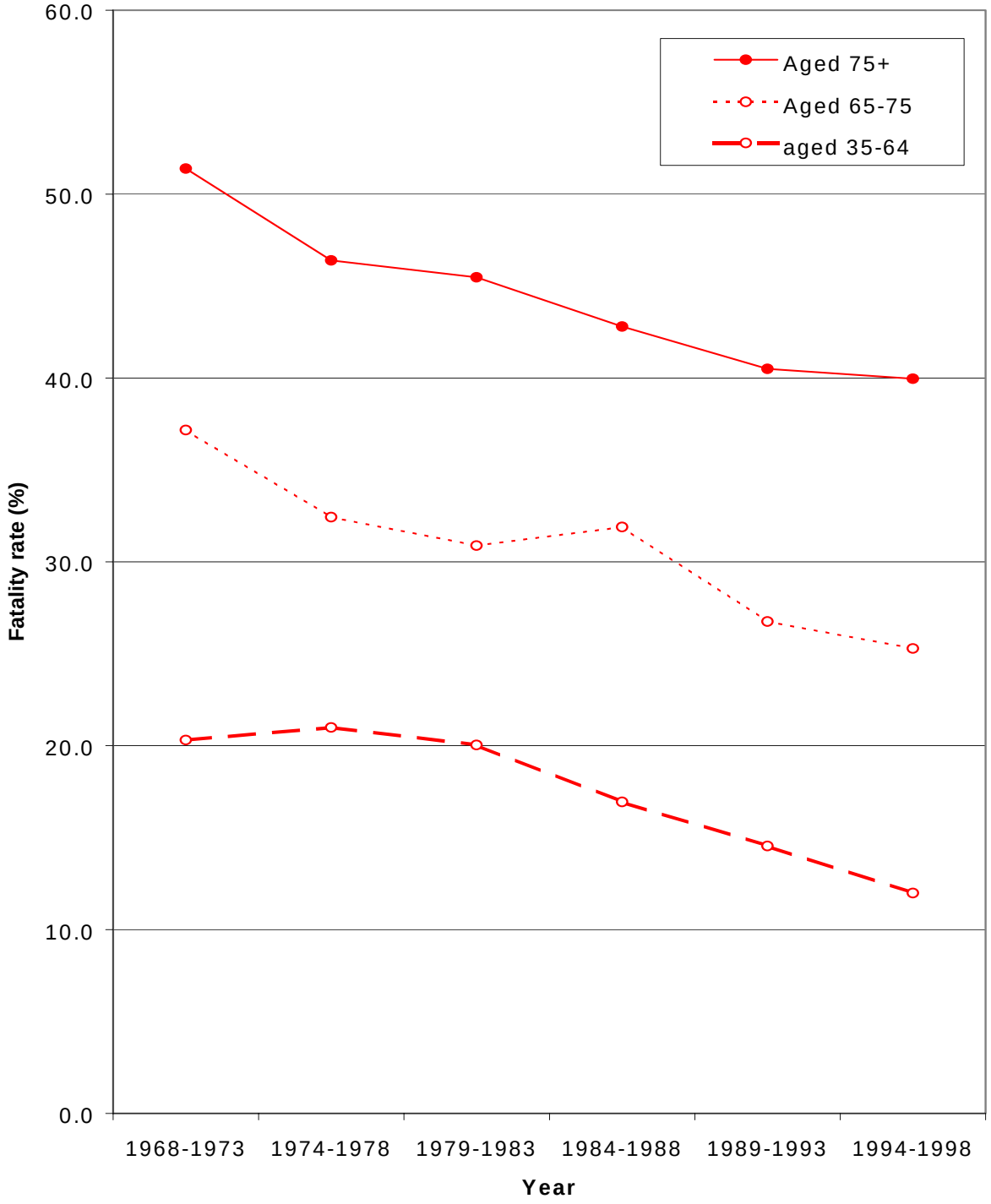


Figure 3.22 Standardised hospital case-fatality rates for myocardial infarction among women by age group



Chapter 4: Multiple-cause coding of mortality for myocardial infarction

Traditionally in England and in most other countries, only the underlying cause of death has been routinely coded and analysed in national mortality statistics. This means that diagnostic information, regarded by the certifying clinicians as relevant to the death, has simply been discarded. In 1983, major changes were made to the rules for selecting the underlying cause of death. This disrupted mortality statistics, based on underlying cause coding alone, for some conditions. In the early 1990s, the Office of National Statistics started to use an automatic encoding software package, from the United States, to select and code causes of death. This partially reversed changes made in the early 1980s in the selection of underlying cause. However, it had the benefit of allowing all certified causes of death to be coded. The relevance of multiple cause coding, and of changes to the selection of underlying cause, is undocumented in its effect on trends for mortality for myocardial infarction in England.

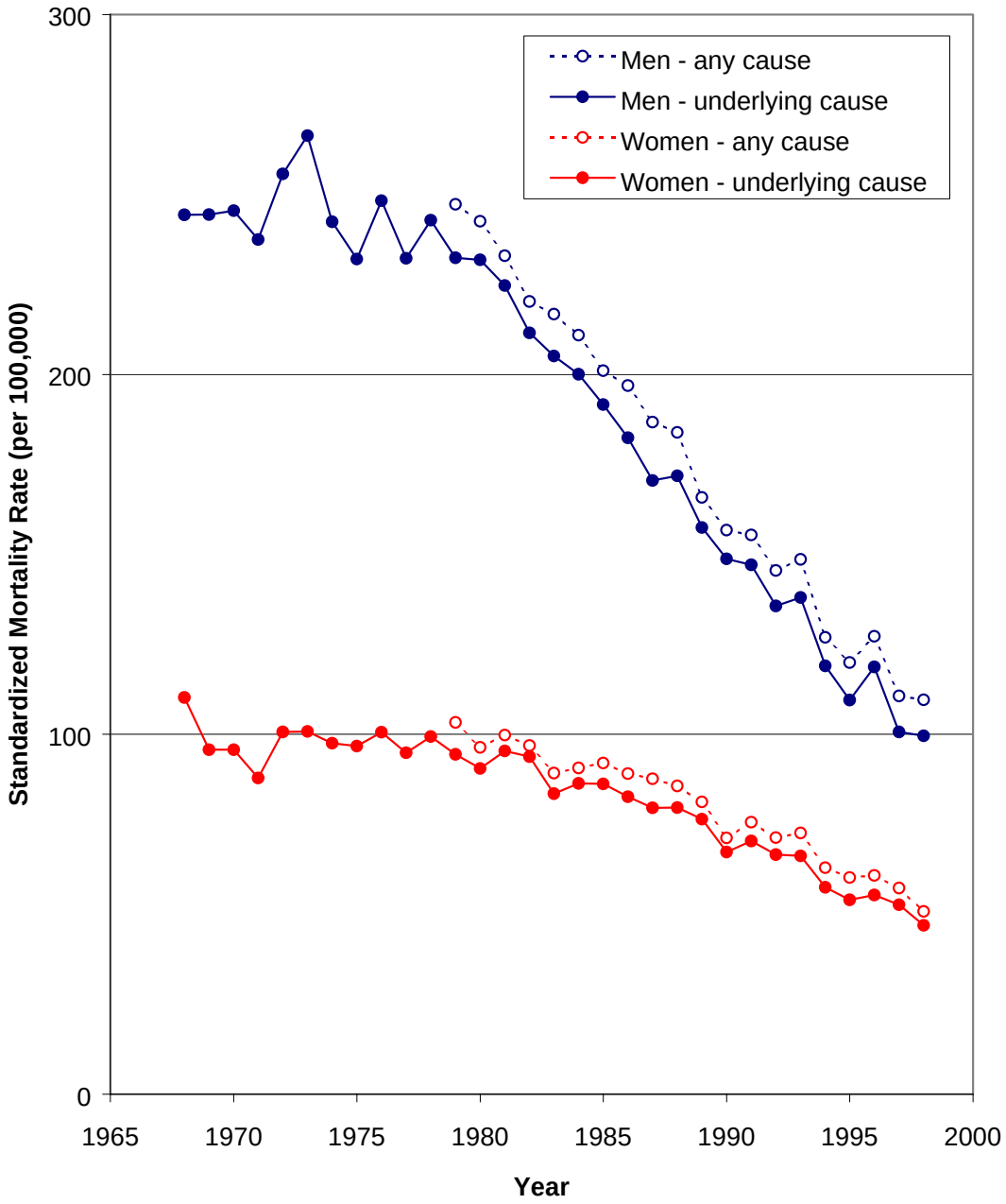
All causes of death reported on death certificates have routinely been coded in the former Oxford health region since 1979. Accordingly, we analysed these data on mortality for myocardial infarction from 1979-1998.

The Figure shows trends in mortality rates, for men and women, from 1968-1998, with multiple-cause coded rates from 1979. The ratio of 'mentions' to 'underlying cause' for myocardial infarction on death certificates was 1.06. The ratio was remarkably constant over time, the same for men and women, very similar between different age-groups, and did not vary between health districts. We conclude that the use of underlying cause of death, as distinct from analysis of all certified causes, is robust for myocardial infarction.

Key points

- Underlying-cause coding and analysis of death for MI identifies the great majority of deaths with MI on the death certificate, at least in the population studied.
- This did not change over time. Nonetheless, given the ready availability of multiple-cause coding in national statistics nowadays, it would be prudent to check that this is invariably so.

Standardized mortality rates for myocardial infarction among men and women (1968-1998): certified as the underlying cause of death and in any position on the death certificate



Chapter 5: Time, place and certified cause of death in people who die after admission for myocardial infarction

The only measure of mortality following hospital admission which is available from unlinked, routine statistics is that of in-hospital mortality. This is a count of deaths which occur in the hospital admission for MI itself. Using hospital data linked to death certificates, we have analysed the time and place of death, following admission for MI, defining the place of death as (a) death which occurred in the same episode of hospital care as the admission for MI, (b) deaths which occurred in the same hospital or trust but in a subsequent admission, (c) those which occurred in a different hospital or trust, and (d) those which occurred outside hospital. As Table 5.1 shows, the great majority of deaths in the first year after admission occur within the first 30 days. Of the deaths within 30 days, the great majority occur in the same episode as the original hospital admission (10,328/11,911, 86.7%) and will therefore be identified by the use of unlinked data.

There is considerable debate in the literature on coronary heart disease about the extent to which deaths following MI are certified as MI. One school of thought argues that to, be inclusive of post-infarct deaths, the diagnostic criteria in the analysis of death certificate data should be widened to include other codes for ischaemic heart disease, e.g. angina pectoris, other ischaemic heart disease, and perhaps heart failure and codes for arrhythmias too.

To report on this, we identified all people admitted to hospital with a principal diagnosis of myocardial infarction between 1990-1998 who died within a year of admission; and we analysed the causes of deaths on their death certificates. Table 5.2 shows the results. Considering deaths which occurred within 30 days of admission with myocardial infarction, myocardial infarction was by far the most common underlying cause of death on the death certificate (84% of all deaths). The codes for 'old myocardial infarction' and 'angina pectoris' were almost never used for deaths which occurred shortly after MI. The code for 'other forms of chronic ischaemic heart disease' was used in 6% of cases. Other codes which were used in more than 1% of cases were diabetes mellitus, the combined codes for cerebrovascular disease, and chronic obstructive airways disease.

Considering deaths which occurred between 30-89 days after admission for myocardial infarction, myocardial infarction remained the most common underlying cause of death (57% of cases). The code for chronic ischaemic heart disease was used in 21% of cases. The codes for old myocardial infarction, angina pectoris, dysrhythmias and heart failure were used very uncommonly. Considering people who died between 90-364 days after admission with myocardial infarction, myocardial infarction was the underlying certified cause of death in 36%, chronic ischaemic heart disease in 27% and the other codes for heart disease remained very uncommon.

Table 5.1 In-hospital mortality as a fraction of all mortality

Deaths from myocardial infarction within 30, 90 and 365 days of admission 1979-1998, males and females combined, all ages, tabulated by place of death

	Number and percentage of deaths by place of death									
	Same admission As MI		**Same hospital/trust, subs. admission**		**Different hospital/trust**		**Outside hospital**		**All deaths**	
within 30 days										
1979-1986	5082	87.7	249	4.3	160	2.8	305	5.3	5796	100.0
1987-1993	3529	85.4	187	4.5	223	5.4	194	4.7	4133	100.0
1994-1998	1717	86.6	118	6.0	35	1.8	112	5.7	1982	100.0
within 90 days										
1979-1976	5319	79.7	484	7.2	306	4.6	567	8.5	6676	100.0
1987-1993	3632	76.6	390	8.2	339	7.1	382	8.1	4743	100.0
1994-1998	1755	77.5	245	10.8	65	2.9	199	8.8	2264	100.0
within 365 days										
1979-1986	5397	68.1	910	11.5	604	7.6	1013	12.8	7924	100.0
1987-1993	3650	65.0	716	12.7	543	9.7	709	12.6	5618	100.0
1994-1998	1756	62.3	532	18.9	130	4.6	402	14.3	2820	100.0

Table 5.2: General hospital admissions for acute myocardial infarction, 1990-1998: people who subsequently died tabulated by certified cause of death

	Time from admission to death					
Cause (ICD9 code)	< 30 days		30-89 days		90-364 days	
	No.	%	No.	%	No	%
Myocardial infarction (410)	4082	84.1	402	57.1	443	36.3
Old M.I. (412)	1	<0.1	1	0.1	1	0.1
Angina pectoris (413)	1	<0.1	1	0.1	0	0.0
Other ischaemic heart disease (414)	276	5.7	149	0.2	328	26.7
Heart dysrhythmias (427)	7	0.1	2	0.3	1	0.1
Heart failure (428)	13	0.3	13	1.8	23	1.9
Cerebrovascular disease (430-8)	78	1.6	22	3.1	72	5.9
Diabetes mellitus (250)	93	1.9	9	1.3	22	1.8
Chronic airways disease (496)	29	0.6	12	1.7	19	1.6
Cancer of the lung (162)	11	0.2	9	1.3	36	2.9
Other	262	5.4	84	11.9	276	22.6
Total	**4853**	**100.0**	**704**	**100.0**	**1221**	**100.0**

Key points:

- Considering people who die within a year of admission for MI, the great majority have died within 30 days of hospital admission; and the great majority of deaths within 30 days occur in the initial hospital admission (87% of cases).
- When people die within 30 days of admission for MI, MI is by far the most common underlying cause of death on the death certificate (84% of cases).
- Of deaths within 30 days, chronic ischaemic heart disease was the certified cause of death in 5% of cases; and all other codes for heart disease were very uncommon.
- Gradually over time after 30 days, chronic ischaemic heart disease became more commonly used as the certified underlying cause of death.

Chapter 6: Comparing counts of MI deaths in HES and death registration data

The main hospitals in the former Oxford region were included in an analysis undertaken to compare deaths recorded as MI in hospital admission statistics and on death certificates. The analysis, Table 6.1, shows substantial differences between hospitals in the ratios of deaths in hospital statistics to those on death certificates. The data were then used to construct "case-fatality rates" calculated by using (a) deaths in hospital statistics as the numerator and deaths plus live discharges in hospital statistics as the denominator; and (b) deaths on death certificates as the numerator and deaths on death certificates plus live discharges in hospital statistics as the denominator. Differences between the hospitals in these two measures are shown in Table 6.2.

Key point:

- There are substantial differences between hospitals in the percentage of deaths which are certified as MI but for which there is no hospital admission record for MI.

Table 6.1 **Number of people who died with MI in each hospital, as recorded in hospital admission statistics (HS) and as certified on death certificates (DCs); and numbers from HS as a percentage of numbers from death certificates (HS/DC, %)**

Hospital Trust	Died in Hospital (HS)	Died in Hospital (DC)	HS/DC %
All 8 hospital trusts	4825	10731	45.0
Oxford Radcliffe	1024	2284	44.8
Kettering GH	403	1067	37.8
Northampton	689	1630	42.3
Amershan & Wycombe	611	1077	56.7
Stoke Mandeville	301	502	60.0
Milton Keynes GH	337	773	43.6
Royal Berks & Battle	812	1678	48.4
Heatherwood & Wexham Park	648	1720	37.7

Note: Analyses of all causes of death minus MI for the corresponding time period and hospitals showed that there were 71,799 deaths from hospital statistics and 77627 from death certificate data (HS/DC, % = 92.5%).

Table 6.2 Calculation of case fatality rates using deaths in hospital admission statistics (HS) as the numerator and HS deaths plus non-fatal admissions in HS as the denominator (CFR1); and using deaths on death certificates as the numerator and death certificate deaths plus nonfatal admissions in HS as the denominator (CFR2)

Hospital Trust	Admitted & died In Hosp (HS)	Admitted & Discharged Alive (HS)	Died in Hosp (DC)	CFR 1 And rank	CFR 2 And rank
All 8 hospital trusts	4825	23267	10731	17.2	31.6
Oxford Radcliffe	1024	5082	2284	16.8 (2)	31.0 (4)
Kettering GH	403	3272	1067	11.0 (1)	24.6 (1)
Northampton	689	2822	1630	19.6 (7)	36.6 (8)
Amersham & wycombe	611	2165	1077	22.0 (8)	33.2 (6)
Stoke Mandeville	301	1356	502	18.2 (6)	27.0 (2)
Milton Keynes GH	337	1641	773	17.0 (3)	32.0 (5)
Royal Berks & Battle	812	3801	1678	17.6 (5)	30.6 (3)
Heatherwood & Wexham Park	648	3128	1720	17.2 (4)	35.5 (7)

Chapter 7: Case-fatality rates, comparing hospitals

In this chapter we investigate comparisons between hospitals in their case-fatality rates. It is evident from the findings on trends that, in addition of those who die after going through an admissions procedure, there is an appreciable number of people who die in hospital without an admission for MI. It is evident, too, that there are differences between hospitals in this respect. We decided to compare hospitals, first, on the basis of their patients formally admitted with MI; and then to compare them taking into account their hospital-associated deaths as well.

Within each set of comparisons we analysed the data with and without cases where the patients were discharged three days or less after admission. We also analysed the data for all patients, then excluding those who died on the day of admission (which we designated as day 0), excluding those who died on day 0 and day 1, and excluding those who died on day 0, 1 and 2. We did the latter comparisons because of the issue of deaths which occur around the time of admission and shortly after admission. Suppose a higher percentage of patients who are destined to die early in the acute phase are sent rapidly to hospital A than hospital B. Relative to hospital B, the CFR for hospital A may be "loaded" with early and perhaps unavoidable deaths. Patients with similar prognosis in the catchment area of hospital B may have died before being admitted and therefore would not appear in hospital B's statistics. Exclusion of "day 0" deaths is intended to make the hospitals more comparable in these respects by studying the outcome of patients who survive the first few hours. Because hospital statistics include dates rather than precise times of admissions, an admission shortly before midnight followed by a death shortly after would be a "day 1" death. Accordingly, we compared hospitals without "day 0 or 1" deaths as well; and, further to assess outcomes of those surviving the early stages, we compared hospitals without "day 0, 1 or 2" deaths.

Methods

Case-fatality rates (CFRs) were calculated using linked Oxford region data. Two study periods were used. The first period covered admissions from January 1st 1994 to December 31st 1998; and, for reasons explained below, an earlier study period was also used covering admissions from January 1st 1979 to December 31st 1986. The ICD-8 and 9 code used was 410 and the corresponding ICD-10 codes were I21 and I22.

CFRs have been calculated in 12 different ways. All 12 CFRs are presented at 30 days after admission. The first six CFRs were based on hospital admissions where MI was recorded as the principal diagnosis on the hospital admission record. CFR 1 was calculated on the basis of all lengths of stay in hospital, including people who were discharged alive three days or less after admission. In CFR 1, deaths were determined on the basis of hospital disposal coding only (which is all that is available in unlinked HES). CFR 2 was calculated in the same way as CFR 1 after patients who were discharged alive 3 days or less after admission had been excluded from the denominator.

CFR 3 was calculated as for CFR 2 except that now deaths were identified by linkage to death certificates as well as hospital disposal coding. CFR 4 was calculated in the same way as CFR 3 except that deaths on the day of admission (day 0) were excluded from the numerator. CFR 5 was calculated as for CFR 4 except that deaths on the day after admission were also excluded from the numerator. CFR 6 was calculated after removing deaths occurring 0, 1 and 2 days after admission from the numerator.

CFRs were calculated for the eight main acute hospital trusts in the region in 1994 and 1998, which for simplicity we term hospitals, and which have been labelled in this paper as hospitals A to H. CFRs were calculated for admissions between 1979 and 1986 for the ten main hospitals as they were then, labelled as A to J. In comparing CFRs, logistic regression was used to adjust for differences between hospitals in the age group of their patients (in 5-year bands), and sex. Odds ratios and their 95% confidence intervals are presented for hospitals B to H (1994-1998) and B to J (1979-1986), relative to the reference hospital A, together with hospital rankings.

In the second set of comparisons, CFRs 7 to 12, we have added in the hospital-associated deaths. With the addition of these, CFR 7 corresponds to the definition of CFR 1, CFR 8 to CFR 2, and so on.

Results

CFR comparisons during the period 1994 to 1998

Table 7.1 provides figures for the 12 different CFR definitions, for each of the eight hospitals, during the five year period 1994 to 1998. Using the definition of CFR 1 - calculated at 30 days for deaths based upon hospital disposal coding, admission with MI as the principal diagnosis and all lengths of hospital stay - there were 14,041 admissions, 2,224 deaths, with a CFR of 15.8%. Excluding patients who were discharged alive within 3 days of admission (CFR 2) - and who were therefore presumptively misdiagnosed initially as MI - the number dropped from 14,041 to 13,081 and the CFR increased from 15.8% to 17.0%.

When deaths were determined on the basis of death certificates (CFR 3), as well as hospital disposal records, the number of deaths increased from 2,224 to 2,558 and the CFR increased from 17.0% to 19.6%. Excluding deaths which occurred on the day of admission (day 0) - eliminating at least some of the deaths which may have been rapid and unavoidable - the deaths decreased by about one quarter to 2,034 and the CFR reduced to 15.5%. Excluding fatalities on days 0 and 1 (CFR 5) the deaths decreased much further to 1,491, and the CFR to 11.4%. Exclusion of day 2 deaths (CFR 6) decreased the deaths further to 1,230 and reduced the CFR to 9.4% (CFR 6).

Hospital B is conspicuous by having low CFRs. The explanation for much of the shortfall is that it did not code many of its deaths as such (as shown by linkage to death certificates); but it probably also omitted some of its fatal cases altogether.

Hospital B excepted, the CFRs for the other seven hospitals did not show striking differences. As Table 7.2 shows, hospitals C and F had significantly higher CFRs than the reference hospital, Hospital A, when judged on CFR 1 and CFR 2 (deaths without linkage to death certificates). However, using CFR 3, with linkage to death certificates, hospital F was no longer significantly high; but hospital C was. With elimination of day 0 deaths , hospital C was no longer significantly high.

Including all deaths in hospital, adding those which occurred without an admission record for MI, substantially increased the CFRs. The rankings of hospitals on CFRs 7 to 12 were very similar, regardless of which CFR is used. With the exception of the result for hospital B, which we believe is largely or wholly artefactual, there were few differences between the hospitals.

CFRs were also calculated, during the same time period 1994 to 1998, for only those patients admitted who were aged under 75. We did this because, although the all-ages odds ratios are calculated using age-standardisation, they may nonetheless particularly reflect the mortality of the old. Case-fatality rates are shown in Table 7.3 and odds ratios, adjusted for age group and sex, are given in Table 7.4.

The effect of excluding all patients aged 75 and over from the analysis was to reduce the case-fatality rates considerably (compare Table 7.3 with Table 7.1). However, variation in CFRs between the hospitals, with the exception of hospital B, remained small. After adjusting for age and sex differentials in the populations of patients under 75 admitted to the different hospitals (Table 7.4), there are very few significant differences between the hospitals. Hospital C had higher mortality, relative to A, for six of the 12 CFRs but there were no significant differences between A and C when deaths occurring on the day of admission, the day after admission and two days after admission, were progressively excluded from the calculation. Hospital rankings were affected to a moderate degree by the particular definition of CFR employed.

Key to CFRs in Table 7.1

CFR indicator	Period of follow up	Diagnosis at admission	Length of stay in hospital	Deaths determined by
CFR 1	30 days	MI as principal diagnosis only	All lengths of stay	Hospital disposal coding only
CFR 2	30 days	MI as principal diagnosis only	Excludes live discharges 3 days or less after admission	Hospital disposal coding only
CFR 3	30 days	MI as principal diagnosis only	Excludes live discharges 3 days or less after admission	Hospital disposal coding or death certificate
CFR 4	30 days	MI as principal diagnosis only	Excludes live discharges 3 days or less, and deaths on day of admission (day 0)	Hospital disposal coding or death certificate
CFR 5	30 days	MI as principal diagnosis only	Excludes live discharges 3 days or less, and deaths on day 0 or 1 after admission	Hospital disposal coding or death certificate
CFR 6	30 days	MI as principal diagnosis only	Excludes live discharges 3 days or less, and deaths on day 0, 1 or 2 after admission	Hospital disposal coding or death certificate
CFR 7	30 days	MI as principal diagnosis or hospital-associated deaths	All lengths of stay	Hospital disposal coding only
CFR 8	30 days	MI as principal diagnosis or hospital-associated deaths	Excludes live discharges 3 days or less after admission	Hospital disposal coding only
CFR 9	30 days	MI as principal diagnosis or hospital-associated deaths	Excludes live discharges 3 days or less after admission	Hospital disposal coding or death certificate
CFR 10	30 days	MI as principal diagnosis or hospital-associated deaths	Excludes live discharges 3 days or less, and deaths on day of admission (day 0)	Hospital disposal coding or death certificate
CFR 11	30 days	MI as principal diagnosis or hospital-associated deaths	Excludes live discharges 3 days or less, and deaths on day 0 or 1 after admission	Hospital disposal coding or death certificate
CFR 12	30 days	MI as principal diagnosis or hospital-associated deaths	Excludes live discharges 3 days or less, and deaths on day 0, 1 or 2 after admission	Hospital disposal coding or death certificate

Table 7.1 Case-fatality rates for hospitals,1994-1998

Hospital	No. of admissions (Denominators) CFR 1	CFRs 2-6	CFR 1 No. of deaths - 30 days	(%)	CFR 2 No. of deaths - 30 days	(%)	CFR 3 No. of deaths - 30 days	(%)	CFR 4 No. of deaths - 30 days	(%)	CFR 5 No. Of deaths - 30 days	(%)	CFR 6 No. of deaths - 30 days	(%)
A	2,954	2,818	502	(17.0%)	502	(17.8%)	562	(19.9%)	468	(16.6%)	328	(11.6%)	278	(9.9%)
B	1,767	1,564	117	(6.6%)	117	(5.7%)	195	(12.5%)	138	(8.8%)	108	(6.9%)	92	(5.9%)
C	1,684	1,617	346	(20.4%)	346	(21.4%)	386	(23.9%)	288	(17.8%)	201	(12.4%)	160	(9.9%)
D	1,344	1,301	224	(16.7%)	224	(17.2%)	251	(19.3%)	206	(15.8%)	161	(12.4%)	139	(10.7%)
E	736	702	126	(17.1%)	126	(17.9%)	142	(20.2%)	115	(16.4%)	87	(12.4%)	67	(9.5%)
F	950	908	161	(16.9%)	161	(17.7%)	177	(19.5%)	143	(15.7%)	105	(11.6%)	82	(9.0%)
G	2,433	2,144	378	(15.5%)	378	(17.6%)	432	(20.1%)	337	(15.7%)	252	(11.8%)	211	(9.8%)
H	2,163	2,027	370	(17.0%)	370	(18.3%)	413	(20.4%)	339	(16.7%)	249	(12.3%)	201	(9.9%)
All 8 hospitals	14,041	13,081	2,224	(15.8%)	2,224	(17.0%)	2,558	(19.6%)	2,034	(15.5%)	1,491	(11.4%)	1,230	(9.4%)

Hospital	No. of admissions (Denominators) CFR 7	CFRs 8-12	CFR 7 No. of deaths - 30 days	(%)	CFR 8 No. of deaths - 30 days	(%)	CFR 9 No. of deaths - 30 days	(%)	CFR 10 No. of deaths - 30 days	(%)	CFR 11 No. Of deaths - 30 days	(%)	CFR 12 No. of deaths - 30 days	(%)
A	3,776	3,640	1,324	(35.1%)	1,324	(36.4%)	1,384	(38.0%)	1,290	(35.4%)	1,150	(31.6%)	1,100	(30.2%)
B	2,041	1,838	391	(19.2%)	391	(21.3%)	469	(25.5%)	412	(22.4%)	382	(20.8%)	366	(19.9%)
C	2,159	2,082	811	(37.6%)	811	(39.0%)	851	(40.9%)	753	(36.2%)	666	(32.0%)	625	(30.0%)
D	1,612	1,569	492	(30.5%)	492	(31.4%)	519	(33.1%)	474	(30.2%)	429	(27.3%)	407	(25.9%)
E	888	854	278	(31.3%)	278	(32.6%)	294	(34.4%)	267	(31.3%)	239	(28.0%)	219	(25.6%)
F	1,186	1,144	397	(33.5%)	397	(34.7%)	413	(36.1%)	379	(33.1%)	341	(29.8%)	318	(27.8%)
G	2,914	2,625	859	(29.5%)	859	(32.7%)	913	(34.8%)	818	(31.2%)	733	(27.9%)	692	(26.4%)
H	2,722	2,586	929	(34.1%)	929	(35.9%)	972	(37.6%)	898	(34.7%)	808	(31.2%)	760	(29.4%)
All 8 hospitals	17,298	16,338	5,481	(31.7%)	5,481	(33.5%)	5,815	(35.6%)	5,291	(32.4%)	4,748	(29.1%)	4,487	(27.5%)

Key to CFRs in Table 7.2

CFR indicator	Period of follow up	Diagnosis at admission	Length of stay in hospital	Deaths determined by
CFR 1	30 days	MI as principal diagnosis only	All lengths of stay	Hospital disposal coding only
CFR 2	30 days	MI as principal diagnosis only	Excludes live discharges 3 days or less after admission	Hospital disposal coding only
CFR 3	30 days	MI as principal diagnosis only	Excludes live discharges 3 days or less after admission	Hospital disposal coding or death certificate
CFR 4	30 days	MI as principal diagnosis only	Excludes live discharges 3 days or less, and deaths on day of admission (day 0)	Hospital disposal coding or death certificate
CFR 5	30 days	MI as principal diagnosis only	Excludes live discharges 3 days or less, and deaths on day 0 or 1 after admission	Hospital disposal coding or death certificate
CFR 6	30 days	MI as principal diagnosis only	Excludes live discharges 3 days or less, and deaths on day 0, 1 or 2 after admission	Hospital disposal coding or death certificate
CFR 7	30 days	MI as principal diagnosis or hospital-associated deaths	All lengths of stay	Hospital disposal coding only
CFR 8	30 days	MI as principal diagnosis or hospital-associated deaths	Excludes live discharges 3 days or less after admission	Hospital disposal coding only
CFR 9	30 days	MI as principal diagnosis or hospital-associated deaths	Excludes live discharges 3 days or less after admission	Hospital disposal coding or death certificate
CFR 10	30 days	MI as principal diagnosis or hospital-associated deaths	Excludes live discharges 3 days or less, and deaths on day of admission (day 0)	Hospital disposal coding or death certificate
CFR 11	30 days	MI as principal diagnosis or hospital-associated deaths	Excludes live discharges 3 days or less, and deaths on day 0 or 1 after admission	Hospital disposal coding or death certificate
CFR 12	30 days	MI as principal diagnosis or hospital-associated deaths	Excludes live discharges 3 days or less, and deaths on day 0, 1 or 2 after admission	Hospital disposal coding or death certificate

Table 7.2 Odds ratios, adjusted for age group and sex, for hospitals, 1994-1998

Hospital	CFR 1 Odds ratio - 30 days (95% CI) [Rank]	CFR 2 Odds ratio - 30 days (95% CI) [Rank]	CFR 3 Odds ratio - 30 days (95% CI) [Rank]	CFR 4 Odds ratio - 30 days (95% CI) [Rank]	CFR 5 Odds ratio - 30 days (95% CI) [Rank]	CFR 6 Odds ratio - 30 days (95% CI) [Rank]
A	Reference [3]	Reference [2]	Reference [2]	Reference [3]	Reference [2]	Reference [2]
B	0.38 (0.30-0.47) [1]	0.43 (0.35-0.54) [1]	0.67 (0.56-0.81) [1]	0.56 (0.46-0.69) [1]	0.66 (0.52-0.83) [1]	0.67 (0.52-0.86) [1]
C	1.35 (1.15-1.59) [8]	1.35 (1.15-1.59) [8]	1.35 (1.16-1.58) [8]	1.14 (0.97-1.35) [8]	1.12 (0.93-1.36) [4]	1.04 (0.84-1.28) [4]
D	1.06 (0.89-1.28) [4]	1.05 (0.88-1.26) [4]	1.05 (0.88-1.25) [3]	1.03 (0.85-1.24) [4]	1.16 (0.95-1.43) [7]	1.18 (0.95-1.48) [8]
E	1.08 (0.86-1.35) [5]	1.08 (0.86-1.35) [5]	1.08 (0.87-1.34) [5]	1.04 (0.83-1.31) [5]	1.13 (0.87-1.46) [6]	1.01 (0.76-1.34) [3]
F	1.23 (1.00-1.51) [7]	1.22 (0.99-1.50) [7]	1.18 (0.97-1.44) [7]	1.13 (0.91-1.39) [7]	1.18 (0.93-1.50) [8]	1.07 (0.82-1.39) [7]
G	0.97 (0.83-1.13) [2]	1.03 (0.89-1.21) [3]	1.06 (0.92-1.23) [4]	0.97 (0.83-1.14) [2]	1.06 (0.88-1.26) [3]	1.04 (0.86-1.26) [5]
H	1.09 (0.93-1.27) [6]	1.10 (0.94-1.29) [6]	1.10 (0.94-1.27) [6]	1.07 (0.91-1.26) [6]	1.12 (0.94-1.34) [5]	1.06 (0.87-1.28) [6]

	CFR 7	CFR 8	CFR 9	CFR 10	CFR 11	CFR 12
A	Reference [5]	Reference [5]	Reference [5]	Reference [5]	Reference [5]	Reference [5]
B	0.49 (0.43-0.56) [1]	0.55 (0.48-0.63) [1]	0.66 (0.58-0.75) [1]	0.61 (0.54-0.70) [1]	0.66 (0.58-0.76) [1]	0.67 (0.58-0.77) [1]
C	1.21 (1.08-1.36) [8]	1.21 (1.07-1.36) [8]	1.22 (1.09-1.37) [8]	1.10 (0.98-1.24) [8]	1.08 (0.95-1.21) [7]	1.04 (0.92-1.18) [7]
D	0.87 (0.76-1.00) [3]	0.86 (0.75-0.99) [2]	0.87 (0.76-0.99) [2]	0.85 (0.74-0.97) [2]	0.87 (0.76-1.00) [2]	0.87 (0.75-0.99) [3]
E	0.91 (0.77-1.07) [4]	0.91 (0.77-1.07) [4]	0.92 (0.78-1.09) [3]	0.88 (0.75-1.05) [3]	0.89 (0.75-1.06) [3]	0.84 (0.71-1.00) [2]
F	1.14 (0.99-1.32) [7]	1.14 (0.98-1.32) [7]	1.13 (0.97-1.30) [7]	1.09 (0.94-1.26) [7]	1.09 (0.94-1.27) [8]	1.05 (0.90-1.22) [8]
G	0.85 (0.76-0.95) [2]	0.91 (0.82-1.02) [3]	0.94 (0.84-1.05) [4]	0.88 (0.79-0.99) [4]	0.89 (0.80-1.00) [4]	0.88 (0.78-0.99) [4]
H	1.03 (0.93-1.16) [6]	1.05 (0.94-1.18) [6]	1.05 (0.94-1.18) [6]	1.03 (0.92-1.16) [6]	1.04 (0.93-1.17) [6]	1.01 (0.90-1.14) [6]

Key to CFRs in Table 7.3

CFR indicator	Period of follow up	Diagnosis at admission	Length of stay in hospital	Deaths determined by
CFR 1	30 days	MI as principal diagnosis only	All lengths of stay	Hospital disposal coding only
CFR 2	30 days	MI as principal diagnosis only	Excludes live discharges 3 days or less after admission	Hospital disposal coding only
CFR 3	30 days	MI as principal diagnosis only	Excludes live discharges 3 days or less after admission	Hospital disposal coding or death certificate
CFR 4	30 days	MI as principal diagnosis only	Excludes live discharges 3 days or less, and deaths on day of admission (day 0)	Hospital disposal coding or death certificate
CFR 5	30 days	MI as principal diagnosis only	Excludes live discharges 3 days or less, and deaths on day 0 or 1 after admission	Hospital disposal coding or death certificate
CFR 6	30 days	MI as principal diagnosis only	Excludes live discharges 3 days or less, and deaths on day 0, 1 or 2 after admission	Hospital disposal coding or death certificate
CFR 7	30 days	MI as principal diagnosis or hospital-associated deaths	All lengths of stay	Hospital disposal coding only
CFR 8	30 days	MI as principal diagnosis or hospital-associated deaths	Excludes live discharges 3 days or less after admission	Hospital disposal coding only
CFR 9	30 days	MI as principal diagnosis or hospital-associated deaths	Excludes live discharges 3 days or less after admission	Hospital disposal coding or death certificate
CFR 10	30 days	MI as principal diagnosis or hospital-associated deaths	Excludes live discharges 3 days or less, and deaths on day of admission (day 0)	Hospital disposal coding or death certificate
CFR 11	30 days	MI as principal diagnosis or hospital-associated deaths	Excludes live discharges 3 days or less, and deaths on day 0 or 1 after admission	Hospital disposal coding or death certificate
CFR 12	30 days	MI as principal diagnosis or hospital-associated deaths	Excludes live discharges 3 days or less, and deaths on day 0, 1 or 2 after admission	Hospital disposal coding or death certificate

Table 7.3 Case-fatality rates for hospitals, 1994-1998; patients aged under 75 only

Hospital	No. of admissions (Denominators) CFR 1	CFRs 2-6	CFR 1 No. of deaths - 30 days	(%)	CFR 2 No. of deaths - 30 days	(%)	CFR 3 No. of deaths - 30 days	(%)	CFR 4 No. of deaths - 30 days	(%)	CFR 5 No. Of deaths - 30 days	(%)	CFR 6 No. of deaths - 30 days	(%)
A	1,833	1,740	190	(10.4%)	190	(10.9%)	222	(12.8%)	181	(10.4%)	130	(7.5%)	111	(6.4%)
B	1,251	1,138	54	(4.3%)	54	(4.7%)	94	(8.3%)	68	(6.0%)	53	(4.7%)	46	(4.0%)
C	1,084	1,026	139	(12.8%)	139	(13.5%)	162	(15.8%)	121	(11.8%)	83	(8.1%)	67	(6.5%)
D	895	866	83	(9.3%)	83	(9.6%)	96	(11.1%)	77	(8.9%)	65	(7.5%)	57	(6.6%)
E	489	463	50	(10.2%)	50	(10.8%)	60	(13.0%)	45	(9.7%)	36	(7.8%)	28	(6.0%)
F	682	649	65	(9.5%)	65	(10.0%)	75	(11.6%)	62	(9.6%)	44	(6.8%)	36	(5.5%)
G	1,625	1,385	129	(7.9%)	129	(9.3%)	162	(11.7%)	130	(9.4%)	107	(7.7%)	87	(6.3%)
H	1,406	1,301	129	(9.2%)	129	(9.9%)	149	(11.5%)	123	(9.5%)	92	(7.1%)	66	(5.1%)
All 8 Hospitals	9,265	8,568	839	(9.1%)	839	(9.8%)	1,020	(11.9%)	807	(9.4%)	610	(7.1%)	498	(5.8%)

Hospital	No. of admissions (Denominators) CFR 7	CFRs 8-12	CFR 7 No. of deaths - 30 days	(%)	CFR 8 No. of deaths - 30 days	(%)	CFR 9 No. of deaths - 30 days	(%)	CFR 10 No. of deaths - 30 days	(%)	CFR 11 No. Of deaths - 30 days	(%)	CFR 12 No. of deaths - 30 days	(%)
A	2,135	2,042	492	(23.0%)	492	(24.1%)	524	(23.7%)	483	(23.7%)	432	(21.2%)	413	(20.2%)
B	1,386	1,273	189	(13.6%)	189	(14.8%)	229	(15.9%)	203	(15.9%)	188	(14.8%)	181	(14.2%)
C	1,290	1,232	345	(26.7%)	345	(28.0%)	368	(26.5%)	327	(26.5%)	289	(23.5%)	273	(22.2%)
D	999	970	187	(18.7%)	187	(19.3%)	200	(18.7%)	181	(18.7%)	169	(17.4%)	161	(16.6%)
E	553	527	114	(20.6%)	114	(21.6%)	124	(20.7%)	109	(20.7%)	100	(19.0%)	92	(17.5%)
F	804	771	187	(23.3%)	187	(24.3%)	197	(23.9%)	184	(23.9%)	166	(21.5%)	158	(20.5%)
G	1,855	1,615	359	(19.4%)	359	(22.2%)	392	(22.3%)	360	(22.3%)	337	(20.9%)	317	(19.6%)
H	1,640	1,535	363	(22.1%)	363	(23.6%)	383	(23.3%)	357	(23.3%)	326	(21.2%)	300	(19.5%)
All 8 hospitals	10,662	9,965	2,236	(21.0%)	2,236	(22.4%)	2,417	(24.3%)	2,204	(22.1%)	2,007	(20.1%)	1,895	(19.0%)

Key to CFRs in Table 7.4

CFR indicator	Period of follow up	Diagnosis at admission	Length of stay in hospital	Deaths determined by
CFR 1	30 days	MI as principal diagnosis only	All lengths of stay	Hospital disposal coding only
CFR 2	30 days	MI as principal diagnosis only	Excludes live discharges 3 days or less after admission	Hospital disposal coding only
CFR 3	30 days	MI as principal diagnosis only	Excludes live discharges 3 days or less after admission	Hospital disposal coding or death certificate
CFR 4	30 days	MI as principal diagnosis only	Excludes live discharges 3 days or less, and deaths on day of admission (day 0)	Hospital disposal coding or death certificate
CFR 5	30 days	MI as principal diagnosis only	Excludes live discharges 3 days or less, and deaths on day 0 or 1 after admission	Hospital disposal coding or death certificate
CFR 6	30 days	MI as principal diagnosis only	Excludes live discharges 3 days or less, and deaths on day 0, 1 or 2 after admission	Hospital disposal coding or death certificate
CFR 7	30 days	MI as principal diagnosis or hospital-associated deaths	All lengths of stay	Hospital disposal coding only
CFR 8	30 days	MI as principal diagnosis or hospital-associated deaths	Excludes live discharges 3 days or less after admission	Hospital disposal coding only
CFR 9	30 days	MI as principal diagnosis or hospital-associated deaths	Excludes live discharges 3 days or less after admission	Hospital disposal coding or death certificate
CFR 10	30 days	MI as principal diagnosis or hospital-associated deaths	Excludes live discharges 3 days or less, and deaths on day of admission (day 0)	Hospital disposal coding or death certificate
CFR 11	30 days	MI as principal diagnosis or hospital-associated deaths	Excludes live discharges 3 days or less, and deaths on day 0 or 1 after admission	Hospital disposal coding or death certificate
CFR 12	30 days	MI as principal diagnosis or hospital-associated deaths	Excludes live discharges 3 days or less, and deaths on day 0, 1 or 2 after admission	Hospital disposal coding or death certificate

Table 7.4 Odds ratios for hospitals, adjusted for age group and sex, 1994-1998; patients aged under 75 only

Hospital	CFR 1 Odds ratio - 30 days (95% CI)	[Rank]	CFR 2 Odds ratio - 30 days (95% CI)	[Rank]	CFR 3 Odds ratio - 30 days (95% CI)	[Rank]	CFR 4 Odds ratio - 30 days (95% CI)	[Rank]	CFR 5 Odds ratio - 30 days (95% CI)	[Rank]	CFR 6 Odds ratio - 30 days (95% CI)	[Rank]
A	Reference	[7]	Reference	[7]	Reference	[6]	Reference	[7]	Reference	[4]	Reference	[5]
B	0.39 (0.29-0.54)	[1]	0.42 (0.30-0.57)	[1]	0.64 (0.49-0.82)	[1]	0.56 (0.42-0.76)	[1]	0.63 (0.45-0.88)	[1]	0.65 (0.45-0.92)	[1]
C	1.30 (1.03-1.65)	[8]	1.31 (1.03-1.67)	[8]	1.32 (1.06-1.65)	[8]	1.18 (0.92-1.51)	[8]	1.12 (0.84-1.49)	[8]	1.05 (0.77-1.44)	[7]
D	0.93 (0.70-1.22)	[4]	0.91 (0.69-1.20)	[3]	0.89 (0.69-1.16)	[2]	0.88 (0.66-1.17)	[2]	1.06 (0.77-1.44)	[6]	1.09 (0.78-1.52)	[8]
E	0.98 (0.70-1.36)	[6]	0.99 (0.71-1.38)	[6]	1.02 (0.75-1.39)	[7]	0.93 (0.65-1.31)	[4]	1.04 (0.70-1.53)	[5]	0.94 (0.61-1.44)	[4]
F	0.97 (0.72-1.31)	[5]	0.97 (0.71-1.31)	[5]	0.95 (0.72-1.27)	[5]	0.97 (0.71-1.32)	[6]	0.97 (0.67-1.38)	[2]	0.92 (0.62-1.36)	[3]
G	0.77 (0.61-0.98)	[2]	0.85 (0.67-1.09)	[2]	0.93 (0.75-1.16)	[4]	0.91 (0.72-1.16)	[3]	1.07 (0.82-1.40)	[7]	1.02 (0.76-1.36)	[6]
H	0.90 (0.71-1.15)	[3]	0.93 (0.73-1.18)	[4]	0.91 (0.73-1.15)	[3]	0.93 (0.73-1.19)	[5]	0.98 (0.74-1.29)	[3]	0.81 (0.59-1.11)	[2]

	CFR 7		CFR 8		CFR 9		CFR 10		CFR 11		CFR 12	
A	Reference	[6]	Reference	[6]	Reference	[6]	Reference	[5]	Reference	[4]	Reference	[7]
B	0.54 (0.44-0.65)	[1]	0.56 (0.47-0.68)	[1]	0.65 (0.55-0.78)	[1]	0.63 (0.52-0.76)	[1]	0.67 (0.55-0.81)	[1]	0.67 (0.56-0.82)	[1]
C	1.24 (1.05-1.46)	[8]	1.25 (1.06-1.47)	[8]	1.26 (1.07-1.48)	[8]	1.18 (1.00-1.40)	[8]	1.16 (0.97-1.37)	[8]	1.13 (0.95-1.35)	[8]
D	0.80 (0.66-0.97)	[2]	0.79 (0.65-0.95)	[2]	0.79 (0.65-0.95)	[2]	0.77 (0.64-0.94)	[2]	0.82 (0.67-1.00)	[2]	0.82 (0.67-1.00)	[2]
E	0.87 (0.69-1.09)	[4]	0.87 (0.69-1.10)	[3]	0.90 (0.71-1.13)	[3]	0.84 (0.67-1.07)	[3]	0.87 (0.68-1.12)	[3]	0.83 (0.65-1.07)	[3]
F	1.07 (0.88-1.30)	[7]	1.07 (0.87-1.30)	[7]	1.05 (0.87-1.28)	[7]	1.07 (0.88-1.30)	[7]	1.08 (0.88-1.32)	[7]	1.07 (0.87-1.31)	[7]
G	0.83 (0.71-0.97)	[3]	0.92 (0.79-1.08)	[4]	0.95 (0.82-1.11)	[4]	0.95 (0.81-1.11)	[4]	1.01 (0.86-1.19)	[5]	0.99 (0.84-1.17)	[4]
H	0.98 (0.84-1.14)	[5]	1.00 (0.86-1.17)	[5]	0.99 (0.85-1.16)	[5]	1.00 (0.86-1.18)	[6]	1.03 (0.87-1.21)	[6]	0.98 (0.83-1.16)	[5]

CFR comparisons during the period 1994 to 1998 and the decision to study 1979 to 1986

In summary, the inter-hospital comparison of CFRs for MI during the recent period 1994 to 1998 showed, hospital B excepted, that there was little variation between the different hospitals. This was true for most of the indicators. This lack of discrimination may simply reflect the fact that outcomes of these hospitals differed too little to generalise about recommendations on which indicators to use. Accordingly, we decided to expand the analysis to cover the period from 1979 to 1986, with comparisons made between what were then ten main hospitals in the same geographical region, because it was known that there were substantial differences in CFRs for MI between the different hospitals. Given greater inter-hospital variability, we decided to test how changing the definition of the CFR affects comparisons between the hospitals. It was also a period of time when all data collection in all hospitals in the former Oxford region was managed by public health physicians (prior to "Kornerisation" in 1987) and was known to be an era in which data quality was particularly high.

CFRs are presented for each of the ten hospitals, during the period 1979 to 1986, in Table 7.5. The overall CFRs rates are consistently a few per cent higher than during the later study period, 1994 to 1998 (compare Tables 7.5 and 7.1).

Using the definition of CFR 1 - calculated at 30 days for deaths based upon hospital disposal coding, admissions for MI as the principal diagnosis, all lengths of hospital stay - there were 17,988 admission, 3,839 deaths and a CFR of 21.3%. Excluding patients who were discharged alive within 3 days of admission (CFR 2) - and who may therefore have been initially misdiagnosed as MI - the admissions declined from 17,988 to 17,619 and the CFR increased from 21.3% to 21.8%.

When deaths were identified by linkage to death certificates (CFR 3), as well as hospital disposal records, the number of deaths increased from 3,839 to 4,353 and the CFR increased to 24.7%. Excluding deaths which occurred on the day of admission (CFR 4), the number of deaths decreased by about one quarter to 3,459 and the CFR fell from 24.7% to 19.6%. Excluding fatalities which arose on the first and second days, the deaths fell further to respectively, 2,675 and 2,306 deaths, with corresponding reduced fatality rates of 15.2% (CFR 5) and 13.1% (CFR 6).

After adjusting for sex and age group differentials in the populations admitted to the hospitals, hospital A had a substantially lower CFR than the other hospitals on all the measures of CFR, from CFR 1 to CFR 6 (Table 7.6). Hospital I had a significantly higher CFR than A when hospitals were judged on in-hospital deaths only (CFRs 1 and 2) but it was no longer significantly different when linkage to death certificates was used (CFR 3). Regardless of definition, comparing CFR 3 to CFR 6, all of the hospitals other than I had CFRs which were substantially and significantly higher than those for hospital A. Hospital A is the Region's teaching hospital and was at the forefront of innovation in treatment for MI at the time. Regardless of definition, the ranking of the other hospitals, in relation to one another, remained almost the same.

CFRs 7 to 12 include deaths in-hospital for MI without any record of an admission for MI. Compared with CFRs 1 to 6, some changes of rank are apparent. Hospital A

still had significantly lower CFRs than most others; but its rank dropped from 1st to 3rd. Hospital I, which ranked well on CFRs 1 to 6, dropped rank from 2nd to 10th. Hospital E, which ranked 3rd on CFRs 1 to 6, ranked 1st on CFRs 7 to 12.

The values taken by CFRs 9 to 12 are interesting because CFR 9 includes death in hospital without admission for MI and therefore includes deaths at or shortly after arrival; CFR 10, by dropping day 0 deaths, should eliminate some of the difference between hospitals, in so far as differences may exist, in their recording of these deaths; and CFRs 11 and 12 show CFRs for what is increasingly a survivor population. By and large, hospitals hold rank.

CFRs were also calculated, for the earlier period 1979 to 1986, for only those patients who were aged under 75. Case-fatality rates are shown in Table 7.7 and odds ratios, adjusted for age group and sex, are given in Table 7.8. The effect of excluding all patients aged 75 and over from the analysis was to reduce the case-fatality rates considerably (compare Table 7.7 with Table 7.5).

After adjusting for sex and age-group differentials in the populations under 75 admitted to the hospitals, hospital A again tended to have significantly lower fatality rates than all other hospitals for CFRs 1 to 6 (Table 7.8). When in-hospital deaths prior to admission were included (CFRs 7 to 12) hospital A's performance, relative to the other hospitals, dropped rank as deaths occurring in the days immediately following admission (CFRs 10 to 12) were progressively excluded from the analysis. Hospital E tended to have the best survival at 30 days although, when deaths occurring within 3 days of admission were excluded, hospitals B and J fared about the same as E.

Hospital rankings for CFRs 1 to 6 are highly correlated. These differ greatly, however, from the rankings for CFRs 7 to 12 which also include in-hospital deaths without formal admission. Rankings for CFRs 7 to 12 are also strongly correlated among themselves, although some changes in rank are apparent when deaths occurring in the first few days after admission are progressively removed from the analysis.

The above analysis involved adjusting for age group and sex differentials in the populations of patients admitted to the different hospitals. There are two other confounding factors which may be associated with survival prospects after acute heart attack, social class and marital status, some data on which are recorded in the ORLS. Unfortunately, they are available in only a minority of cases. CFRs for patients for whom this information was known are shown in Table 7.9 and adjusted odds ratios, for age group, sex, social class and marital status are given in Table 7.10.

The CFRs for hospitals B, C, D, G and H were significantly higher than for the reference hospital A for all six CFRs after adjustment for age, sex, social class and marital status. The odds ratios for hospitals E and F which had recorded social class and marital status on relatively few admission records were, probably because of inadequate statistical power, not significantly different from A. However, the hospital rankings were largely unchanged across the six CFRs.

Key points:

- There were no convincing significant differences in case fatality rates between hospitals during the latest period studied, 1994-1998. One of the hospitals had a significantly high CFR and another a significantly low CFR when judged on the evidence from unlinked hospital data alone. Linkage to death certificates indicated that these differences were probably spurious.
- The fact that we did not find convincing differences in this period may be because no important differences existed.
- Accordingly we studied CFRs in an earlier period, 1979-1986, when differences between hospitals were known to exist.
- We identified much lower rates in one hospital, the region's teaching hospital, than in others.
- Significant differences persisted, despite our best efforts to eliminate them by changing definitions!
- We conclude that in-hospital CFRs alone, those available from unlinked data, would have correctly identified differences between the hospitals. However, we think that this conclusion only holds for fairly gross differences between hospitals.
- We recommend that hospital comparisons should include not only CFRs for all admissions, but also a calculation for CFRs omitting 0 day deaths, and 0 and 1 day deaths, to reduce the influence of fairly sudden, and possibly unavoidable, deaths on the statistics.
- As shown in the study of trends, substantial numbers of people die from MI in hospital following admission for other conditions. The extent to which such patients are in fact included as MI patients in hospital statistics is unknown. The extent to which hospitals vary in this respect is unknown. If they do vary, this will influence inter-hospital comparisons of CFRs for MI. Consideration should be given to recording 'diagnosis at admission' as well as 'diagnosis at discharge or death' in hospital statistical systems

Key to CFRs in Table 7.5

CFR indicator	Period of follow up	Diagnosis at admission	Length of stay in hospital	Deaths determined by
CFR 1	30 days	MI as principal diagnosis only	All lengths of stay	Hospital disposal coding only
CFR 2	30 days	MI as principal diagnosis only	Excludes live discharges 3 days or less after admission	Hospital disposal coding only
CFR 3	30 days	MI as principal diagnosis only	Excludes live discharges 3 days or less after admission	Hospital disposal coding or death certificate
CFR 4	30 days	MI as principal diagnosis only	Excludes live discharges 3 days or less, and deaths on day of admission (day 0)	Hospital disposal coding or death certificate
CFR 5	30 days	MI as principal diagnosis only	Excludes live discharges 3 days or less, and deaths on day 0 or 1 after admission	Hospital disposal coding or death certificate
CFR 6	30 days	MI as principal diagnosis only	Excludes live discharges 3 days or less, and deaths on day 0, 1 or 2 after admission	Hospital disposal coding or death certificate
CFR 7	30 days	MI as principal diagnosis or hospital-associated deaths	All lengths of stay	Hospital disposal coding only
CFR 8	30 days	MI as principal diagnosis or hospital-associated deaths	Excludes live discharges 3 days or less after admission	Hospital disposal coding only
CFR 9	30 days	MI as principal diagnosis or hospital-associated deaths	Excludes live discharges 3 days or less after admission	Hospital disposal coding or death certificate
CFR 10	30 days	MI as principal diagnosis or hospital-associated deaths	Excludes live discharges 3 days or less, and deaths on day of admission (day 0)	Hospital disposal coding or death certificate
CFR 11	30 days	MI as principal diagnosis or hospital-associated deaths	Excludes live discharges 3 days or less, and deaths on day 0 or 1 after admission	Hospital disposal coding or death certificate
CFR 12	30 days	MI as principal diagnosis or hospital-associated deaths	Excludes live discharges 3 days or less, and deaths on day 0, 1 or 2 after admission	Hospital disposal coding or death certificate

Table 7.5 Case-fatality rates for hospitals, 1979-1986

Hospital	No. of admissions (Denominators) CFR 1	No. of admissions (Denominators) CFRs 2-6	CFR 1 No. of deaths - 30 days	CFR 1 (%)	CFR 2 No. of deaths - 30 days	CFR 2 (%)	CFR 3 No. of deaths - 30 days	CFR 3 (%)	CFR 4 No. of deaths - 30 days	CFR 4 (%)	CFR 5 No. Of deaths - 30 days	CFR 5 (%)	CFR 6 No. of deaths - 30 days	CFR 6 (%)
A	3,779	3,685	607	(16.1%)	607	(16.5%)	711	(19.3%)	590	(16.0%)	463	(12.6%)	395	(10.7%)
B	1,034	1,011	284	(27.5%)	284	(28.1%)	317	(31.4%)	246	(24.3%)	192	(19.0%)	165	(16.3%)
C	2,213	2,185	447	(20.2%)	447	(20.5%)	491	(22.5%)	376	(17.2%)	292	(13.4%)	260	(11.9%)
D	2,751	2,662	569	(20.7%)	569	(21.4%)	676	(25.4%)	547	(20.5%)	434	(16.3%)	378	(14.2%)
E	1,134	1,120	184	(16.2%)	184	(16.4%)	218	(19.5%)	176	(15.7%)	139	(12.4%)	117	(10.4%)
F	955	947	312	(32.7%)	312	(32.9%)	330	(34.8%)	265	(28.0%)	204	(21.5%)	174	(18.4%)
G	1,659	1,615	370	(22.3%)	370	(22.9%)	418	(25.9%)	330	(20.4%)	249	(15.4%)	213	(13.2%)
H	1,999	1,964	542	(27.1%)	542	(27.6%)	608	(31.0%)	487	(24.8%)	374	(19.0%)	337	(17.2%)
I	1,651	1,633	374	(22.7%)	374	(22.9%)	417	(25.5%)	311	(19.0%)	230	(14.1%)	191	(11.7%)
J	813	797	150	(18.5%)	150	(18.8%)	167	(21.0%)	131	(16.4%)	98	(12.3%)	76	(9.5%)
All 10 hospitals	17,988	17,619	3,839	(21.3%)	3,839	(21.8%)	4,353	(24.7%)	3,459	(19.6%)	2,675	(15.2%)	2,306	(13.1%)

Hospital	No. of admissions (Denominators) CFR 7	No. of admissions (Denominators) CFRs 8-12	CFR 7 No. of deaths - 30 days	CFR 7 (%)	CFR 8 No. of deaths - 30 days	CFR 8 (%)	CFR 9 No. of deaths - 30 days	CFR 9 (%)	CFR 10 No. of deaths - 30 days	CFR 10 (%)	CFR 11 No. Of deaths - 30 days	CFR 11 (%)	CFR 12 No. of deaths - 30 days	CFR 12 (%)
A	4,910	4,816	1,738	(35.4%)	1,738	(36.1%)	1,842	(38.2%)	1,721	(35.7%)	1,594	(33.1%)	1,526	(31.7%)
B	1,221	1,198	471	(38.6%)	471	(39.3%)	504	(42.1%)	433	(36.1%)	379	(31.6%)	352	(29.4%)
C	2,714	2,686	948	(34.9%)	948	(35.3%)	992	(36.9%)	877	(32.7%)	793	(29.5%)	761	(28.3%)
D	3,623	3,534	1,441	(39.8%)	1,441	(40.8%)	1,548	(43.8%)	1,419	(40.2%)	1,306	(37.0%)	1,250	(35.4%)
E	1,324	1,310	374	(28.2%)	374	(28.5%)	408	(31.1%)	366	(27.9%)	329	(25.1%)	307	(23.4%)
F	1,236	1,228	593	(48.0%)	593	(48.3%)	611	(49.8%)	546	(44.5%)	485	(39.5%)	455	(37.1%)
G	2,231	2,187	942	(42.2%)	942	(43.1%)	990	(45.3%)	902	(41.2%)	821	(37.5%)	785	(35.9%)
H	2,352	2,317	895	(38.1%)	895	(38.6%)	961	(41.5%)	840	(36.3%)	727	(31.4%)	690	(29.8%)
I	2,192	2,174	915	(41.7%)	915	(42.1%)	958	(44.1%)	852	(39.2%)	771	(35.5%)	732	(33.7%)
J	1,001	985	338	(33.8%)	338	(34.3%)	355	(36.0%)	319	(32.4%)	286	(29.0%)	264	(26.8%)
All 10 hospitals	22,804	22,435	8,655	(38.0%)	8,655	(38.6%)	9,169	(40.9%)	8,275	(36.9%)	7,491	(33.4%)	7,122	(31.7%)

Key to CFRs in Table 7.6

CFR indicator	Period of follow up	Diagnosis at admission	Length of stay in hospital	Deaths determined by
CFR 1	30 days	MI as principal diagnosis only	All lengths of stay	Hospital disposal coding only
CFR 2	30 days	MI as principal diagnosis only	Excludes live discharges 3 days or less after admission	Hospital disposal coding only
CFR 3	30 days	MI as principal diagnosis only	Excludes live discharges 3 days or less after admission	Hospital disposal coding or death certificate
CFR 4	30 days	MI as principal diagnosis only	Excludes live discharges 3 days or less, and deaths on day of admission (day 0)	Hospital disposal coding or death certificate
CFR 5	30 days	MI as principal diagnosis only	Excludes live discharges 3 days or less, and deaths on day 0 or 1 after admission	Hospital disposal coding or death certificate
CFR 6	30 days	MI as principal diagnosis only	Excludes live discharges 3 days or less, and deaths on day 0, 1 or 2 after admission	Hospital disposal coding or death certificate
CFR 7	30 days	MI as principal diagnosis or hospital-associated deaths	All lengths of stay	Hospital disposal coding only
CFR 8	30 days	MI as principal diagnosis or hospital-associated deaths	Excludes live discharges 3 days or less after admission	Hospital disposal coding only
CFR 9	30 days	MI as principal diagnosis or hospital-associated deaths	Excludes live discharges 3 days or less after admission	Hospital disposal coding or death certificate
CFR 10	30 days	MI as principal diagnosis or hospital-associated deaths	Excludes live discharges 3 days or less, and deaths on day of admission (day 0)	Hospital disposal coding or death certificate
CFR 11	30 days	MI as principal diagnosis or hospital-associated deaths	Excludes live discharges 3 days or less, and deaths on day 0 or 1 after admission	Hospital disposal coding or death certificate
CFR 12	30 days	MI as principal diagnosis or hospital-associated deaths	Excludes live discharges 3 days or less, and deaths on day 0, 1 or 2 after admission	Hospital disposal coding or death certificate

Table 7.6 Odds ratios, adjusted for age group and sex, for hospitals, 1979-1986

Hospital	CFR 1 Odds ratio - 30 days (95% CI)	[Rank]	CFR 2 Odds ratio - 30 days (95% CI)	[Rank]	CFR 3 Odds ratio - 30 days (95% CI)	[Rank]	CFR 4 Odds ratio - 30 days (95% CI)	[Rank]	CFR 5 Odds ratio - 30 days (95% CI)	[Rank]	CFR 6 Odds ratio - 30 days (95% CI)	[Rank]
A	Reference	[1]	Reference	[1]	Reference	[1]	Reference	[1]	Reference	[1]	Reference	[2]
B	1.93 (1.63-2.28)	[7]	1.93 (1.63-2.29)	[8]	1.86 (1.58-2.19)	[9]	1.61 (1.35-1.92)	[8]	1.55 (1.29-1.88)	[9]	1.55 (1.26-1.89)	[9]
C	1.63 (1.41-1.87)	[5]	1.60 (1.39-1.84)	[5]	1.47 (1.29-1.69)	[4]	1.30 (1.12-1.50)	[4]	1.26 (1.07-1.46)	[4]	1.31 (1.10-1.55)	[5]
D	1.46 (1.28-1.67)	[4]	1.48 (1.30-1.69)	[4]	1.54 (1.36-1.74)	[5]	1.45 (1.27-1.65)	[5]	1.43 (1.24-1.66)	[7]	1.45 (1.24-1.69)	[7]
E	1.32 (1.09-1.59)	[3]	1.30 (1.08-1.56)	[3]	1.30 (1.09-1.55)	[3]	1.25 (1.03-1.51)	[3]	1.23 (1.00-1.52)	[3]	1.19 (0.96-1.49)	[3]
F	2.05 (1.74-2.43)	[10]	2.02 (1.71-2.39)	[9]	1.82 (1.54-2.14)	[8]	1.64 (1.38-1.95)	[9]	1.55 (1.28-1.87)	[8]	1.53 (1.26-1.87)	[8]
G	1.68 (1.44-1.95)	[6]	1.69 (1.45-1.97)	[6]	1.63 (1.41-1.89)	[6]	1.48 (1.27-1.73)	[6]	1.37 (1.16-1.63)	[6]	1.36 (1.14-1.64)	[6]
H	2.04 (1.78-2.34)	[9]	2.03 (1.77-2.33)	[10]	1.97 (1.73-2.25)	[10]	1.78 (1.55-2.05)	[10]	1.66 (1.43-1.94)	[10]	1.75 (1.49-2.05)	[10]
I	1.23 (1.01-1.52)	[2]	1.23 (1.00-1-51)	[2]	1.16 (0.95-1.41)	[2]	1.07 (0.86-1.32)	[1]	1.01 (0.79-1.28)	[2]	0.90 (0.69-1.17)	[1]
J	1.95 (1.67-2.26)	[8]	1.91 (1.64-2.22)	[7]	1.80 (1.56-2.08)	[7]	1.51 (1.29-1.77)	[7]	1.37 (1.15-1.63)	[5]	1.30 (1.08-1.57)	[4]

	CFR 7		CFR 8		CFR 9		CFR 10		CFR 11		CFR 12	
A	Reference	[3]	Reference	[3]	Reference	[3]	Reference	[4]	Reference	[6]	Reference	[7]
B	1.06 (0.93-1.22)	[4]	1.06 (0.93-1.22)	[4]	1.09 (0.95-1.25)	[4]	0.93 (0.81-1.07)	[3]	0.86 (0.74-0.98)	[3]	0.82 (0.71-0.94)	[3]
C	1.18 (1.06-1.31)	[6]	1.16 (1.04-1.29)	[6]	1.13 (1.02-1.25)	[5]	1.02 (0.92-1.14)	[6]	0.98 (0.88-1.10)	[4]	0.99 (0.88-1.10)	[5]
D	1.31 (1.19-1.44)	[7]	1.33 (1.21-1.46)	[8]	1.37 (1.25-1.51)	[8]	1.30 (1.19-1.43)	[8]	1.27 (1.16-1.40)	[8]	1.26 (1.15-1.39)	[8]
E	0.91 (0.79-1.05)	[1]	0.90 (0.78-1.03)	[1]	0.93 (0.81-1.07)	[1]	0.87 (0.76-1.01)	[1]	0.84 (0.73-0.97)	[1]	0.81 (0.70-0.94)	[2]
F	1.31 (1.15-1.50)	[8]	1.29 (1.13-1.48)	[7]	1.24 (1.09-1.42)	[7]	1.12 (0.98-1.28)	[7]	1.03 (0.90-1.18)	[7]	0.99 (0.87-1.14)	[6]
G	1.48 (1.33-1.65)	[9]	1.49 (1.34-1.67)	[9]	1.49 (1.33-1.66)	[9]	1.39 (1.24-1.55)	[9]	1.32 (1.18-1.48)	[10]	1.31 (1.17-1.46)	[10]
H	1.13 (1.01-1.25)	[5]	1.12 (1.00-1.25)	[5]	1.15 (1.03-1.28)	[6]	1.01 (0.91-1.13)	[5]	0.91 (0.81-1.01)	[5]	0.90 (0.80-1.00)	[4]
I	1.62 (1.45-1.81)	[10]	1.59 (1.42-1.78)	[10]	1.57 (1.40-1.75)	[10]	1.40 (1.25-1.56)	[10]	1.32 (1.18-1.48)	[9]	1.29 (1.15-1.45)	[9]
J	0.96 (0.82-1.11)	[2]	0.95 (0.82-1.11)	[2]	0.93 (0.80-1.09)	[2]	0.88 (0.75-1.03)	[2]	0.84 (0.72-0.98)	[2]	0.80 (0.68-0.94)	[1]

Key to CFRs in Table 7.7

CFR indicator	Period of follow up	Diagnosis at admission	Length of stay in hospital	Deaths determined by
CFR 1	30 days	MI as principal diagnosis only	All lengths of stay	Hospital disposal coding only
CFR 2	30 days	MI as principal diagnosis only	Excludes live discharges 3 days or less after admission	Hospital disposal coding only
CFR 3	30 days	MI as principal diagnosis only	Excludes live discharges 3 days or less after admission	Hospital disposal coding or death certificate
CFR 4	30 days	MI as principal diagnosis only	Excludes live discharges 3 days or less, and deaths on day of admission (day 0)	Hospital disposal coding or death certificate
CFR 5	30 days	MI as principal diagnosis only	Excludes live discharges 3 days or less, and deaths on day 0 or 1 after admission	Hospital disposal coding or death certificate
CFR 6	30 days	MI as principal diagnosis only	Excludes live discharges 3 days or less, and deaths on day 0, 1 or 2 after admission	Hospital disposal coding or death certificate
CFR 7	30 days	MI as principal diagnosis or hospital-associated deaths	All lengths of stay	Hospital disposal coding only
CFR 8	30 days	MI as principal diagnosis or hospital-associated deaths	Excludes live discharges 3 days or less after admission	Hospital disposal coding only
CFR 9	30 days	MI as principal diagnosis or hospital-associated deaths	Excludes live discharges 3 days or less after admission	Hospital disposal coding or death certificate
CFR 10	30 days	MI as principal diagnosis or hospital-associated deaths	Excludes live discharges 3 days or less, and deaths on day of admission (day 0)	Hospital disposal coding or death certificate
CFR 11	30 days	MI as principal diagnosis or hospital-associated deaths	Excludes live discharges 3 days or less, and deaths on day 0 or 1 after admission	Hospital disposal coding or death certificate
CFR 12	30 days	MI as principal diagnosis or hospital-associated deaths	Excludes live discharges 3 days or less, and deaths on day 0, 1 or 2 after admission	Hospital disposal coding or death certificate

Table 7.7 Case-fatality rates for hospitals,1979-1986; patients aged under 75 only

Hospital	No. of admissions (Denominators) CFR 1	No. of admissions (Denominators) CFRs 2-6	CFR 1 No. of deaths - 30 days	CFR 1 (%)	CFR 2 No. of deaths - 30 days	CFR 2 (%)	CFR 3 No. of deaths - 30 days	CFR 3 (%)	CFR 4 No. of deaths - 30 days	CFR 4 (%)	CFR 5 No. Of deaths - 30 days	CFR 5 (%)	CFR 6 No. of deaths - 30 days	CFR 6 (%)
A	2,866	2,796	331	(11.5%)	331	(11.8%)	405	(14.5%)	330	(11.8%)	260	(9.3%)	227	(8.1%)
B	736	721	161	(21.9%)	161	(22.3%)	181	(25.1%)	146	(20.2%)	118	(16.4%)	101	(14.0%)
C	1,827	1,799	306	(16.7%)	306	(17.0%)	335	(18.6%)	254	(14.1%)	197	(11.0%)	176	(9.8%)
D	2,181	2,106	338	(15.5%)	338	(16.0%)	416	(19.8%)	326	(15.5%)	257	(12.2%)	224	(10.6%)
E	988	976	130	(13.2%)	130	(13.3%)	158	(16.2%)	128	(13.1%)	100	(10.2%)	87	(8.9%)
F	576	570	128	(22.2%)	128	(22.5%)	139	(24.4%)	105	(18.4%)	80	(14.0%)	69	(12.1%)
G	1,320	128	243	(18.4%)	243	(18.9%)	280	(21.8%)	217	(16.9%)	168	(13.1%)	147	(11.4%)
H	1,503	1,474	304	(20.2%)	304	(20.6%)	355	(24.1%)	280	(19.0%)	210	(14.2%)	194	(13.2%)
I	1,405	1,388	270	(19.2%)	270	(19.5%)	305	(22.0%)	229	(16.5%)	173	(12.5%)	144	(10.4%)
J	624	612	83	(13.3%)	83	(13.6%)	96	(15.7%)	80	(13.1%)	59	(9.6%)	44	(7.2%)
All 10 hospitals	14,026	13,729	2,294	(16.4%)	2,294	(16.7%)	2,670	(19.4%)	2,095	(15.3%)	1,622	(11.8%)	1,413	(10.3%)

Hospital	No. of admissions (Denominators) CFR 7	No. of admissions (Denominators) CFRs 8-12	CFR 7 No. of deaths - 30 days	CFR 7 (%)	CFR 8 No. of deaths - 30 days	CFR 8 (%)	CFR 9 No. of deaths - 30 days	CFR 9 (%)	CFR 10 No. of deaths - 30 days	CFR 10 (%)	CFR 11 No. Of deaths - 30 days	CFR 11 (%)	CFR 12 No. of deaths - 30 days	CFR 12 (%)
A	3,489	3,419	954	(27.3%)	954	(27.9%)	1,028	(30.1%)	953	(27.9%)	883	(25.8%)	850	(24.9%)
B	807	792	232	(28.7%)	232	(29.3%)	252	(31.8%)	217	(27.4%)	189	(23.9%)	172	(21.7%)
C	2,125	2,097	604	(28.4%)	604	(28.8%)	633	(30.2%)	552	(26.3%)	495	(23.6%)	474	(22.6%)
D	2,736	2,661	893	(32.6%)	893	(33.6%)	971	(36.5%)	881	(33.1%)	812	(30.5%)	779	(29.3%)
E	1,106	1,094	248	(22.4%)	248	(22.7%)	276	(25.2%)	246	(22.5%)	218	(19.9%)	205	(18.7%)
F	682	676	234	(34.3%)	234	(34.6%)	245	(36.2%)	211	(31.2%)	186	(27.5%)	175	(25.9%)
G	1,666	1,633	589	(35.4%)	589	(36.1%)	626	(38.3%)	563	(34.5%)	514	(31.5%)	493	(30.2%)
H	1,651	1,622	452	(27.4%)	452	(27.9%)	503	(31.0%)	428	(26.4%)	358	(22.1%)	342	(21.1%)
I	1,765	1,748	630	(35.7%)	630	(36.0%)	665	(38.0%)	589	(33.7%)	533	(30.5%)	504	(28.8%)
J	726	714	185	(24.5%)	185	(25.9%)	198	(27.7%)	182	(25.5%)	161	(22.5%)	146	(20.4%)
All 10 hospitals	16,753	16,456	5,021	(30.0%)	5,021	(30.5%)	5,397	(32.8%)	4,822	(29.3%)	4,349	(26.4%)	4,140	(25.5%)

Key to CFRs in Table 7.8

CFR indicator	Period of follow up	Diagnosis at admission	Length of stay in hospital	Deaths determined by
CFR 1	30 days	MI as principal diagnosis only	All lengths of stay	Hospital disposal coding only
CFR 2	30 days	MI as principal diagnosis only	Excludes live discharges 3 days or less after admission	Hospital disposal coding only
CFR 3	30 days	MI as principal diagnosis only	Excludes live discharges 3 days or less after admission	Hospital disposal coding or death certificate
CFR 4	30 days	MI as principal diagnosis only	Excludes live discharges 3 days or less, and deaths on day of admission (day 0)	Hospital disposal coding or death certificate
CFR 5	30 days	MI as principal diagnosis only	Excludes live discharges 3 days or less, and deaths on day 0 or 1 after admission	Hospital disposal coding or death certificate
CFR 6	30 days	MI as principal diagnosis only	Excludes live discharges 3 days or less, and deaths on day 0, 1 or 2 after admission	Hospital disposal coding or death certificate
CFR 7	30 days	MI as principal diagnosis or hospital-associated deaths	All lengths of stay	Hospital disposal coding only
CFR 8	30 days	MI as principal diagnosis or hospital-associated deaths	Excludes live discharges 3 days or less after admission	Hospital disposal coding only
CFR 9	30 days	MI as principal diagnosis or hospital-associated deaths	Excludes live discharges 3 days or less after admission	Hospital disposal coding or death certificate
CFR 10	30 days	MI as principal diagnosis or hospital-associated deaths	Excludes live discharges 3 days or less, and deaths on day of admission (day 0)	Hospital disposal coding or death certificate
CFR 11	30 days	MI as principal diagnosis or hospital-associated deaths	Excludes live discharges 3 days or less, and deaths on day 0 or 1 after admission	Hospital disposal coding or death certificate
CFR 12	30 days	MI as principal diagnosis or hospital-associated deaths	Excludes live discharges 3 days or less, and deaths on day 0, 1 or 2 after admission	Hospital disposal coding or death certificate

Table 7.8 Odds ratios for hospitals, adjusted for age group and sex, 1979-1986; patients aged under 75 only

Hospital	CFR 1 Odds ratio - 30 days (95% CI)	[Rank]	CFR 2 Odds ratio - 30 days (95% CI)	[Rank]	CFR 3 Odds ratio - 30 days (95% CI)	[Rank]	CFR 4 Odds ratio - 30 days (95% CI)	[Rank]	CFR 5 Odds ratio - 30 days (95% CI)	[Rank]	CFR 6 Odds ratio - 30 days (95% CI)	[Rank]
A	Reference	[1]	Reference	[1]	Reference	[2]	Reference	[1]	Reference	[1]	Reference	[2]
B	2.15 (1.73-2.66)	[10]	2.14 (1.73-2.65)	[10]	1.98 (1.61-2.43)	[10]	1.89 (1.52-2.35)	[10]	1.89 (1.49-2.40)	[10]	1.82 (1.41-2.35)	[10]
C	1.77 (1.49-2.10)	[5]	1.76 (1.48-2.09)	[5]	1.54 (1.31-1.82)	[5]	1.39 (1.16-1.66)	[5]	1.35 (1.10-1.64)	[4]	1.37 (1.11-1.68)	[5]
D	1.41 (1.20-1.67)	[4]	1.44 (1.22-1.70)	[4]	1.48 (1.27-1.72)	[4]	1.38 (1.67-1.64)	[4]	1.37 (1.14-1.64)	[5]	1.35 (1.11-1.65)	[4]
E	1.30 (1.04-1.63)	[3]	1.29 (1.03-1.60)	[3]	1.28 (1.04-1.57)	[3]	1.26 (1.01-1.57)	[3]	1.23 (0.96-1.57)	[3]	1.21 (0.94-1.58)	[3]
F	1.97 (1.56-2.49)	[7]	1.96 (1.55-2.48)	[7]	1.73 (1.38-2.16)	[6]	1.52 (1.19-1.95)	[6]	1.44 (1.10-1.89)	[6]	1.41 (1.06-1.89)	[7]
G	1.82 (1.51-2.19)	[6]	1.83 (1.52-2.20)	[6]	1.73 (1.46-2.06)	[7]	1.59 (1.31-1.92)	[7]	1.52 (1.24-1.88)	[8]	1.51 (1.21-1.89)	[8]
H	2.01 (1.69-2.39)	[8]	2.01 (1.69-2.39)	[9]	1.95 (1.65-2.29)	[9]	1.80 (1.51-2.15)	[9]	1.65 (1.36-2.02)	[9]	1.75 (1.42-2.15)	[9]
I	1.21 (0.93-1.58)	[2]	1.21 (0.93-1.58)	[2]	1.14 (0.89-1.46)	[2]	1.16 (0.89-1.52)	[2]	1.07 (0.79-1.45)	[2]	0.90 (0.64-1.26)	[1]
J	2.02 (1.69-2.41)	[9]	1.99 (1.66-2.39)	[8]	1.84 (1.55-2.18)	[8]	1.61 (1.34-1.94)	[8]	1.50 (1.22-1.85)	[7]	1.40 (1.13-1.76)	[6]

	CFR 7		CFR 8		CFR 9		CFR 10		CFR 11		CFR 12	
A	Reference	[3]	Reference	[3]	Reference	[3]	Reference	[5]	Reference	[7]	Reference	[7]
B	1.05 (0.88-1.24)	[5]	1.04 (0.87-1.24)	[5]	1.06 (0.89-1.25)	[4]	0.95 (0.79-1.13)	[4]	0.87 (0.72-1.05)	[4]	0.81 (0.67-0.98)	[3]
C	1.17 (1.04-1.33)	[6]	1.16 (1.03-1.32)	[6]	1.12 (0.99-1.26)	[6]	1.02 (0.90-1.16)	[6]	0.97 (0.85-1.11)	[6]	0.96 (0.84-1.10)	[6]
D	1.29 (1.15-1.44)	[8]	1.31 (1.17-0.47)	[8]	1.35 (1.21-1.51)	[8]	1.29 (1.15-1.44)	[8]	1.26 (1.13-1.42)	[8]	1.25 (1.11-1.41)	[8]
E	0.84 (0.72-0.99)	[1]	0.83 (0.71-0.98)	[1]	0.86 (0.74-1.01)	[1]	0.82 (0.70-0.97)	[2]	0.78 (0.66-0.92)	[1]	0.76 (0.63-0.90)	[2]
F	1.22 (1.02-1.46)	[7]	1.21 (1.01-1.45)	[7]	1.17 (0.98-1.40)	[7]	1.04 (0.86-1.24)	[7]	0.96 (0.80-1.17)	[5]	0.94 (0.77-1.14)	[5]
G	1.51 (1.32-1.72)	[9]	1.52 (1.33-1.73)	[9]	1.51 (1.32-1.71)	[9]	1.41 (1.24-1.60)	[10]	1.36 (1.19-1.55)	[10]	1.34 (1.17-1.53)	[10]
H	1.01 (0.88-1.16)	[4]	1.01 (0.88-1.16)	[4]	1.06 (0.93-1.21)	[5]	0.93 (0.82-1.07)	[3]	0.82 (0.71-0.94)	[2]	0.81 (0.70-0.94)	[4]
I	1.57 (1.38-1.78)	[10]	1.55 (1.37-1.76)	[10]	1.52 (1.34-1.73)	[10]	1.39 (1.22-1.58)	[9]	1.32 (1.16-1.51)	[9]	1.28 (1.12-1.46)	[9]
J	0.92 (0.76-1.11)	[2]	0.92 (0.76-1.11)	[2]	0.91 (0.76-1.09)	[2]	0.90 (0.75-1.09)	[1]	0.85 (0.70-1.03)	[3]	0.79 (0.64-0.96)	[2]

Key to CFRs in Table 7.9

CFR indicator	Period of follow up	Diagnosis at admission	Length of stay in hospital	Deaths determined by
CFR 1	30 days	MI as principal diagnosis only	All lengths of stay	Hospital disposal coding only
CFR 2	30 days	MI as principal diagnosis only	Excludes live discharges 3 days or less after admission	Hospital disposal coding only
CFR 3	30 days	MI as principal diagnosis only	Excludes live discharges 3 days or less after admission	Hospital disposal coding or death certificate
CFR 4	30 days	MI as principal diagnosis only	Excludes live discharges 3 days or less, and deaths on day of admission (day 0)	Hospital disposal coding or death certificate
CFR 5	30 days	MI as principal diagnosis only	Excludes live discharges 3 days or less, and deaths on day 0 or 1 after admission	Hospital disposal coding or death certificate
CFR 6	30 days	MI as principal diagnosis only	Excludes live discharges 3 days or less, and deaths on day 0, 1 or 2 after admission	Hospital disposal coding or death certificate
CFR 7	30 days	MI as principal diagnosis or hospital-associated deaths	All lengths of stay	Hospital disposal coding only
CFR 8	30 days	MI as principal diagnosis or hospital-associated deaths	Excludes live discharges 3 days or less after admission	Hospital disposal coding only
CFR 9	30 days	MI as principal diagnosis or hospital-associated deaths	Excludes live discharges 3 days or less after admission	Hospital disposal coding or death certificate
CFR 10	30 days	MI as principal diagnosis or hospital-associated deaths	Excludes live discharges 3 days or less, and deaths on day of admission (day 0)	Hospital disposal coding or death certificate
CFR 11	30 days	MI as principal diagnosis or hospital-associated deaths	Excludes live discharges 3 days or less, and deaths on day 0 or 1 after admission	Hospital disposal coding or death certificate
CFR 12	30 days	MI as principal diagnosis or hospital-associated deaths	Excludes live discharges 3 days or less, and deaths on day 0, 1 or 2 after admission	Hospital disposal coding or death certificate

Table 7.9 Case-fatality rates for hospitals, 1979-1986, based on patients for whom social class and marital status were known

	No. of admissions (Denominators)		CFR 1		CFR 2		CFR 3		CFR 4		CFR 5		CFR 6	
Hospital	CFR 1	CFRs 2-6	No. of deaths - 30 days	(%)	No. of deaths - 30 days	(%)	No. of deaths - 30 days	(%)	No. of deaths - 30 days	(%)	No. Of deaths - 30 days	(%)	No. of deaths - 30 days	(%)
A	1,482	1,444	144	(9.7%)	144	(10.0%)	180	(12.5%)	151	(10.5%)	116	(8.0%)	98	(6.8%)
B	465	457	97	(20.9%)	97	(21.2%)	112	(24.5%)	94	(20.6%)	75	(16.4%)	66	(14.4%)
C	793	780	106	(13.4%)	106	(13.6%)	116	(14.9%)	90	(11.5%)	79	(10.1%)	74	(9.5%)
D	1,354	1,312	201	(14.8%)	201	(15.3%)	246	(18.8%)	201	(15.3%)	164	(12.5%)	145	(11.1%)
F	64	63	4	(6.3%)	4	(6.3%)	5	(7.9%)	4	(6.3%)	3	(4.8%)	3	(4.8%)
F	79	78	20	(25.3%)	20	(25.6%)	21	(26.9%)	20	(25.6%)	14	(17.9%)	11	(14.1%)
G	560	544	79	(13.6%)	76	(14.0%)	95	(16.9%)	77	(14.2%)	60	(11.0%)	51	(9.4%)
H	784	772	141	(18.0%)	141	(18.3%)	165	(21.4%)	138	(17.9%)	102	(13.2%)	90	(11.7%)
All 8 Trusts	5,581	5,450	789	(14.1%)	789	(14.5%)	937	(17.2%)	775	(14.2%)	613	(11.2%)	538	(9.9%)

Key to CFRs in Table 7.10

CFR indicator	Period of follow up	Diagnosis at admission	Length of stay in hospital	Deaths determined by
CFR 1	30 days	MI as principal diagnosis only	All lengths of stay	Hospital disposal coding only
CFR 2	30 days	MI as principal diagnosis only	Excludes live discharges 3 days or less after admission	Hospital disposal coding only
CFR 3	30 days	MI as principal diagnosis only	Excludes live discharges 3 days or less after admission	Hospital disposal coding or death certificate
CFR 4	30 days	MI as principal diagnosis only	Excludes live discharges 3 days or less, and deaths on day of admission (day 0)	Hospital disposal coding or death certificate
CFR 5	30 days	MI as principal diagnosis only	Excludes live discharges 3 days or less, and deaths on day 0 or 1 after admission	Hospital disposal coding or death certificate
CFR 6	30 days	MI as principal diagnosis only	Excludes live discharges 3 days or less, and deaths on day 0, 1 or 2 after admission	Hospital disposal coding or death certificate
CFR 7	30 days	MI as principal diagnosis or hospital-associated deaths	All lengths of stay	Hospital disposal coding only
CFR 8	30 days	MI as principal diagnosis or hospital-associated deaths	Excludes live discharges 3 days or less after admission	Hospital disposal coding only
CFR 9	30 days	MI as principal diagnosis or hospital-associated deaths	Excludes live discharges 3 days or less after admission	Hospital disposal coding or death certificate
CFR 10	30 days	MI as principal diagnosis or hospital-associated deaths	Excludes live discharges 3 days or less, and deaths on day of admission (day 0)	Hospital disposal coding or death certificate
CFR 11	30 days	MI as principal diagnosis or hospital-associated deaths	Excludes live discharges 3 days or less, and deaths on day 0 or 1 after admission	Hospital disposal coding or death certificate
CFR 12	30 days	MI as principal diagnosis or hospital-associated deaths	Excludes live discharges 3 days or less, and deaths on day 0, 1 or 2 after admission	Hospital disposal coding or death certificate

Table 7.10 Odds ratios for hospitals, adjusted for age group, sex, marital status and social class, 1979-1986

Hospital	30 days	CFR 1 CFR 5 Odds ratio - 30 days (95% CI) [Rank]			CFR 2 CFR 6 Odds ratio - 30 days (95% CI) [Rank]			CFR 3 Odds ratio - 30 days (95% CI) [Rank]			CFR 4 Odds ratio - (95% CI) [Rank]	
A		Reference		[3]	Reference		[2]	Reference		[2]	Reference	
	[2]	Reference		[2]	Reference		[2]					
B		2.26	(1.67-3.05)	[8]	2.28	(1.69-3.07)	[8]	2.10	(1.58-2.77)	[8]	2.01	(1.49-
2.71)	[8]	2.02	(1.45-2.80)	[8]	2.07	(1.47-2.93	[8]					
C		1.77	(1.34-2.35)	[5]	1.75	(1.32-2.32)	[5]	1.47	(1.13-1.91)	[4]	1.33	(0.99-
1.77)	[3]	1.53	(1.12-2.09)	[5]	1.68	(1.22-2.33)	[5]					
D		1.48	(1.16-1.88)	[4]	1.49	(1.17-1.90)	[4]	1.51	(1.21-1.88)	[5]	1.45	(1.14-
1.84)	[4]	1.52	(1.17-1.98)	[4]	1.59	(1.21-2.10)	[4]					
E		0.62	(0.22-1.77)	[2]	0.62	(0.22-1.77)	[1]	0.62	(0.24-1.60)	[1]	0.63	(0.22-
1.78)	[1]	0.62	(0.19-2.05)	[1]	0.73	(0.22-2.41)	[1]					
F		1.35	(0.76-2.41)	[1]	1.34	(0.75-2.40)	[3]	1.21	(0.69-2.13)	[3]	1.51	(0.85-
2.69)	[5]	1.28	(0.67-2.45)	[3]	1.20	(0.59-2.43)	[3]					
G		1.90	(1.39-2.59)	[7]	1.90	(1.39-2.60)	[7]	1.78	(1.34-2.37)	[6]	1.78	(1.31-
2.43)	[6]	1.78	(1.26-2.50)	[7]	1.74	(1.21-2.51)	[6]					
H		1.88	(1.42-2.48)	[6]	1.85	(1.40-2.45)	[6]	1.83	(1.41-2.36)	[7]	1.85	(1.40-
2.43)	[7]	1.69	(1.24-2.29)	[6]	1.76	(1.27-2.44)	[7]					

Chapter 8: Effects of confounding factors: age, sex, social class and marital status

In this chapter we illustrate the independent effects of each of the confounding factors considered in the previous chapter.

The number of hospital admissions, subsequent deaths at 30 days and the corresponding fatality rates (using the CFR 4 definition) are presented for different age groups of all patients admitted to one of the eight main hospitals between 1994 and 1998 in Table 8.1. These age-specific CFRs increase greatly and consistently with age from 2.9% for patients aged under 45 years, 4.8% at 55-59, 12.6% at 65-69, and 23.3% at 75-79.

The corresponding odds ratios for the different age groups, after adjusting for hospital of admission and sex of patient, are shown in the final column of Table 8.1. For example, relative to the reference age-group of patients aged under 45, a patient aged 75-79 years is over 9 times more likely to die within 30 days of an admission for MI (after adjusting for sex and hospital).

Table 8.2 presents similar analysis for the effect of the sex of the patient. The results show that, after adjusting for age group-group and hospital of admission, there is a significant effect of the sex of the patient on survival at 30 days. The women were 1.27 times (95% confidence interval = 1.15 - 1.41) more likely to die within 30 days of admission.

Similar results for the other two confounding factors addressed in the previous chapter, the marital status and social class of the patients, are provided in Tables 8.3 and 8.4 respectively. These two demographic factors were more widely recorded on hospital admission records in the 1970s and 1980s than in the 1990s; hence the earlier study period, 1979 to 1986, has been used to illustrate the effects of these two confounding factors.

CFRs are presented for patients by marital status in Table 8.3. After adjustment for the age group, sex and social class of patients at admission and the hospital of admission, there are no significant differences. However while the effects of marital status - as illustrated in isolation - on mortality after MI would appear to be limited here, marital status is often found to have a stronger confounding effect on mortality when marital status and sex of the patient are considered in combination. Interaction was not tested by us.

The odds ratios when comparing social classes - after adjustment for age group, sex, marital status and hospital of admission - show no significant differences between the reference class I and other social classes considered here (Table 8.4).

Key points:

- Age-groups and sex are very strongly related to CFRs at 30 days.
- On the rather limited evidence available, social class and marital status are not.

Table 8.1 **The effect of age group on survival after MI, 1994-1998. Case-fatality rates and odds ratios after adjusting for hospital of admission and sex**

Age group	No. of admissions (Denominator) CFR 4	CFR 4 No. of deaths - 30 days (%)		CFR 4 Odds ratio - 30 days (95% CI)	
< 45	500	14	(2.9%)	Reference	
45-49	613	22	(3.6%)	1.26	(0.64 - 2.49)
50-54	837	31	(3.7%)	1.33	(0.70 - 2.53)
55-59	1,213	58	(4.8%)	1.72	(0.95 - 3.12)
60-64	1,513	128	(8.5%)	3.11	(1.77 - 5.46)
65-69	1,861	235	(12.6%)	4.79	(2.76 - 8.29)
70-74	2,031	319	(15.7%)	6.07	(3.51 - 10.47)
75-79	1,899	443	(23.3%)	9.70	(5.63 - 16.69)
80-84	1,470	391	(26.6%)	11.31	(6.55 - 19.52)
85-89	849	283	(33.3%)	15.39	(8.86 - 26.76)
90+	295	110	(37.3%)	17.35	(9.67 - 31.16)
Total	13,081	2,034	(15.5%)		

Table 8.2 **The effect of sex on survival after MI, 1994-1998. Case-fatality rates and odds ratios after adjusting for hospital of admission and age group**

Sex	No. of admissions (Denominator) CFR 4	CFR 4 No. of deaths - 30 days (%)		CFR 4 Odds ratio - 30 days (95% CI)	
Men	8,516	1,062	(12.5%)	Reference	
Women	4,565	972	(21.3%)	1.27	(1.15 - 1.41)
Total	13,081	2,034	(15.5%)		

Table 8.3 **The effect of marital status on survival after MI, 1979-1986. Case-fatality rates and odds ratios after adjusting for hospital of admission, age group, sex and social class**

Marital status	No. of admissions (Denominator) CFR 4	CFR 4 No. of deaths - 30 days (%)		CFR 4 Odds ratio - 30 days (95% CI)	
Single	167	22	(13.2%)	Reference	
Married	4,411	523	(11.9%)	1.06	(0.65 - 1.73)
Widowed	775	220	(29.1%)	1.27	(0.74 - 2.20)
Divorced /separated	117	10	(8.5%)	0.87	(0.38 - 1.96)
Total	5,450	775	(14.2%)		

Table 8.4 **The effect of social class on survival after MI, 1979-1986. Case-fatality rates and odds ratios after adjusting for hospital of admission, age group, sex and marital status**

Social class	No. of admissions (Denominator) CFR 4	CFR 4 No. of deaths - 30 days (%)		CFR 4 Odds ratio - 30 days (95% CI) [Rank]	
I	276	39	(14.1%)	Reference	
II	1,033	119	(11.5%)	0.87	(0.58 - 1.31)
III	2,233	275	(12.3%)	1.00	(0.68 - 1.46)
IV	979	131	(13.4%)	1.07	(0.71 - 1.61)
V	352	46	(13.1%)	0.98	(0.60 - 1.58)
Total	4,873	610	(12.5%)		

Chapter 9: Study size calculations

It is important that any hospital-based study of a given indicator, such as a case fatality rate, should be sufficiently large in size in order to detect clinically important differences between the hospitals. The aims of this chapter are to show how study size calculations were made for the hospital-based comparison of case fatality rates (chapter 7); show how the study was designed to ensure that the study had sufficient statistical power; and comment on the likely size and duration of studies needed to have adequate power in comparing CFRs between hospitals in the development of indicators for MI. Study size requirements can be calculated by considering the three factors upon which they are dependent: statistical significance, statistical power and clinically important differences in the outcome indicator (CFRs) between two study groups (hospitals).

Given that the aim is to detect a clinically important difference in the case fatality rates for myocardial infarction between two hospitals: the study size, n, required to achieve this for two hospital case fatality rates π_1 and π_2, with statistical power = 1-β at the α significance level, is given by:

$$n > \{ Z_{\alpha/2}\sqrt{[2\pi(1-\pi)]} + Z_{1-\beta}\sqrt{[\pi_1(1-\pi_1)] + [\pi_2(1-\pi_2)]} \ / \ \pi_1 - \pi_2 \}^2$$

where $\pi = (\pi_1 + \pi_2) / 2$ and conventionally, the statistical significance α is set = 0.05 and the statistical power 1-β = 0.80 or 0.90.

Results and comments

Given that a typical case fatality rate for myocardial infarction at 30 days for a hospital in the UK might be about 20%, and that a clinically important difference between 2 hospitals might be a relative risk of 1.25 to 1.50, it would be important that a study should be sufficiently large to detect a difference between 2 hospitals with case fatality rates of 20% and 25% or, at least, 20% and 30%.

The annual numbers of admissions for myocardial infarction in the eight main hospital trusts studied in chapter 5 varied from about 140 to 600 per year during 1994-1998 depending upon the definition of a case fatality rate (see Table 7.2). Hence, a figure of 300 admissions per year would seem typical of the hospitals under study here.

Taking the statistical significance level of 5%, and power of 80%, the required study size to detect differences in CFRs of 20% and 30% (relative risk = 1.50) would be 293 admissions or an estimated study length of just under one year (Table 9.1). To detect the smaller difference between two hospitals (CFRs of 20% and 25%; relative risk = 1.25), 1,094 admissions or a study length of 3 years and 8 eight months would be necessary.

Table 9.1 Study size calculations for myocardial infarction case fatality rates at 30 days

Indicator	Case fatality rate		Relative risk (B:A)	Study size [I]	Length of study (months) [II]
	Hospital A	Hospital B			
Case fatality rate (30 days)	20%	30%	1.50	293	11.7
Case fatality rate (30 days)	20%	25%	1.25	1,094	43.8

Notes:

[I] Study size calculations are based upon statistical power of 90% ($1-\beta = 0.90$) and statistical significance at the 5% level ($\alpha=0.05$)

[II] Length of study is based upon a hospital with 300 admissions per year for myocardial infarction

The above calculations for myocardial infarction case fatality rates illustrate that it would be necessary to study hospitals over a period of at least three to four years to ensure that the study has adequate statistical power. The study periods we employed were five years (1994 to 1998) and, during a period when the hospitals being studied admitted typically, slightly smaller numbers of patients, eight years (1979 to 1986). These time periods were designed to ensure that the studies were large enough to be able to determine important differences in case fatality rates.

Key point:

- Taking the statistical significance level of 5%, and power of 80%, and assuming that hospitals typically admit 300 MI patients per year, the required study size to detect differences in CFRs of 20% and 30% (relative risk = 1.5) would be 293 admissions or an estimated study length of just under one year (Table 9.1). To detect the smaller difference between two hospitals (CFRs of 20% and 25%; relative risk = 1.25), 1,094 admissions or a study length of 3 years and 8 eight months would be necessary.

Chapter 10: Mortality, incidence and case-fatality in the context of other MI indicators

In another area of work, NCHOD undertook projects with expert groups to identify and make recommendations about 'ideal' indicators of outcome for a range of clinical conditions. Myocardial infarction was one. For completeness, we draw attention to this work here. The working group comprised specialist physicians, general practitioners, researchers, public health physicians, chief executive of trusts and health authorities, membership from the British Heart Foundation, a nurse, representation from the Department of Health, and technical support from the York Centre for Reviews and Dissemination, the Nuffield Clearing House on Health Outcomes, the Royal College of Physicians Research Unit, and CASPE Research.

An 'ideal' indicator was taken to mean what should be known, and realistically could be known, about the outcomes relevant to the prevention and care of myocardial infarction. The development of the recommendations was, of course, tempered by considerations of the likely cost and availability of information. However, the Working Group tried to be reasonably far-sighted in its views about future advances in information systems. The Working Group developed a menu of indicators which can be used by different groups of people for a variety of purposes. In particular, an attempt was made to recommend indicators which reflect a population, clinical, patient and clearer perspective. Detailed specifications for each indicator were published (Birkhead J et al. Health outcome indicators: myocardial infarction. Report of a working group to the Department of Health. Oxford: NCHOD, 1999). The recommended indicators were as follows:

Indicators related to reduction of risk of a first (MI)

Population-based heart attack rate for MI.
Annual hospital admission rate for all MI.
Annual hospital admission rate for first-ever MI.
Percentage of people who report having ceased smoking in the given year.
Mean systolic blood pressure in persons aged 16 and over.
Percentage of general practice patients, identified as hypertensive, whose most recent systolic blood pressure measurement is less than 160 mm Hg.
Percentage of general practice patients, identified as at high risk of coronary heart disease in the given year.
Summary of twelve-month changes in the risk of coronary heart disease within a general practice population.

Indicators related to reduction of risk of death from myocardial infarction

Population-based mortality rate from MI.
Case-fatality rates for patients admitted to hospital alive with a MI.
Proportion of patients attending hospital with MI who receive thrombolytic therapy.
Time from onset of symptoms to call for help.
Time from call for help to arrival at hospital.
Time from arrival at hospital to administration of thrombolytic therapy.
Time from call for help to defibrillator availability.

Indicators related to reduction of risk of subsequent myocardial infarction or other related cardiovascular events

Rate of in-patient admission for MI within one year of a previous hospitalised MI.
Rate of in-patient admission for selected cardiovascular conditions within one year of a previous hospitalised MI.
Level of risk in respect of defined risk factors CHD within a population of patients six months after first-ever MI.

Indicators related to improvement of function and well-being after myocardial infarction

Impact of symptoms on function within a population of patients six months after first-ever MI.
Assessment of health status/quality of life within a population of patients six months after first-ever MI.

Chapter 11:

From: BIRKHEAD J et al. HEALTH OUTCOME INDICATORS: MYOCARDIAL INFARCTION REPORT OF A WORKING GROUP TO THE DEPARTMENT OF HEALTH, OXFORD : NCHOD, 1999.

DEFINITION OF MYOCARDIAL INFARCTION

1. The definition of myocardial infarction varies according to the discipline of the doctor describing it and the purposes for which the information is being collected. There are broadly three types of definition relating to:

   - pathologists' perspective
   - clinicians' perspective
   - epidemiologists' perspective.

Pathologists' perspective

2. In the United Kingdom Heart Attack Study the following definition was used:

'Out-of-hospital deaths were included if either they showed ischaemic heart disease as the principal cause of death at Coroners' autopsy (87%) or, in the absence of autopsy (13%), occurred in patients with a history of ischaemic heart disease who died unexpectedly and without any other apparent cause.

Autopsy cases were required to have stenosis of > 75% of cross-sectional area in at least one major epicardial coronary artery, with or without recent coronary thrombus or old or recent myocardial infarction. Deaths from chronic cardiac failure due to ischaemic heart disease were recorded in one centre (Brighton) but are not included in the present analysis. They comprised 11% of all coronary deaths in Brighton, and only 29% occurred outside hospital.'

3. Post-mortem diagnosis of the cause of death of patients who die suddenly without being clinically investigated is often imperfect. In particular (Davies 1997):

- Visible evidence of infarction in the myocardium may not be apparent before 12 to 24 hours. Thus most cases of sudden coronary death are properly classified by the pathologist as death from ischaemic heart disease.

- The presence of fresh occlusive coronary thrombus is almost pathognomonic of developing infarction. Non-occlusive thrombus is seldom recognised at routine autopsy and its potential to lead to infarction is less certain.

- Histological examinations of serial sections of coronary arteries of victims of

sudden cardiac death show plaque fissuring in 90% of cases, non-occlusive thrombus in 44% and occlusive thrombus in 30%. However, plaque fissuring is a non-specific finding, found in 9% of non-coronary deaths.

- Platelet emboli are found in the myocardium downstream of the culprit plaque in 40% of cases of sudden ischaemic death.

- Natural lysis of the thrombus may subsequently clear the vessel of thrombus within a few hours of the incident, although this is probably more common in patients who do not die.

4. In practice, histopathologists do not perform post-mortem angiography routinely and many may limit the procedure to cursory sectioning of the coronary arteries. Histological examination is not always routine. Plaque rupture is often not recognised. If a thrombus is not found the diagnosis on death certificates is commonly 'acute on chronic myocardial ischaemia'.

Clinicians' perspective

5. In the United Kingdom Heart Attack Study (UKHAS), the following definition for hospital cases was used:

'Hospital cases of myocardial infarction showed at least two of the following three features: typical or compatible clinical history; sequential electrocardiographic changes; and a rise in serum enzymes to at least twice the upper limit of normal for the hospital laboratory. For patients who died very soon after presentation, prolonged chest pain with one electrocardiogram showing an infarct pattern was sufficient for the diagnosis.'

6. Outside hospital the position is more complex in that:

- up to 30% of infarction may be silent, depending on the means used to look for them

- a diagnosis of infarction may be made by a GP on the basis of history alone if it is felt hospital admission is unnecessary

- a GP may investigate a patient appropriately, treat the patient at home and the investigation results are only recorded in the GP notes and thus not easily accessible for inclusion in population based statistics

- there are issues related to the certification of sudden unexpected death.

7. When there is a sudden unexpected death in a patient with known coronary

disease and a post-mortem has not been performed, a GP in England may issue a death certificate indicating myocardial infarction as the cause of death provided that the patient has been seen alive within the last two weeks. It is highly likely that the diagnosis is correct whether or not there has been a prodromal illness.

8. Sudden unexpected death in people who do not have a history of coronary disease nor a post-mortem is also frequently certified due to myocardial infarction, particularly when this occurs in the very elderly. On balance, it is likely that most of these are acute coronary deaths, but this is by no means certain.

Epidemiologists' perspective

9. The epidemiological definitions of myocardial infarction depend in part on the purposes for which population-based data are being used. Denominators can be assembled of distinct groups of diagnostic probability, namely:

- standardised clinical criteria (as noted in paragraph 2.1)
- post-mortem confirmation of infarction
- prodromal symptoms in someone with known heart disease and sudden death with no autopsy
- post-mortem diagnosis of acute or chronic myocardial ischaemia
- post-mortem diagnosis of coronary artery disease but not acute syndrome.

10. The Group accepted that, in view of the clinical and pathological complexities, it would not be possible to recommend an ideal denominator. In choosing the clinical criteria noted in paragraph 2.1 as the basis, it was recognised that this definition would lead to an underestimation of the true incidence of myocardial infarction. Most of the indicators specified have used the definition involving standardised clinical criteria but some have other diagnostic groups added.