# BMJ

# RESEARCH

# Determinants of the decline in mortality from acute myocardial infarction in England between 2002 and 2010: linked national database study

OPEN ACCESS

Kate Smolina *DPhil candidate*[1], F Lucy Wright *cardiovascular epidemiologist*[2], Mike Rayner *director*[3], Michael J Goldacre *professor of public health*[1]

[1]Unit of Health-Care Epidemiology, Department of Public Health, Headington, Oxford OX3 7LF, UK; [2]Cancer Epidemiology Unit, Department of Public Health, Oxford; [3]British Heart Foundation Health Promotion Research Group, Department of Public Health, Oxford

## Abstract

**Objective** To report trends in event and case fatality rates for acute myocardial infarction and examine the relative contributions of changes in these rates to changes in total mortality from acute myocardial infarction by sex, age, and geographical region between 2002 and 2010.

**Design** Population based study using person linked routine hospital and mortality data.

**Setting** England.

**Participants** 840 175 people of all ages who were admitted to hospital for acute myocardial infarction or died suddenly from acute myocardial infarction.

**Main outcome measures** Acute myocardial infarction event, 30 day case fatality, and total mortality rates.

**Results** From 2002 to 2010 in England, the age standardised total mortality rate fell by about half, whereas the age standardised event and case fatality rates both declined by about one third. In men, the acute myocardial infarction event, case fatality, and total mortality rates declined at an average annual rate of, respectively, 4.8% (95% confidence interval 3.0% to 6.5%), 3.6% (3.4% to 3.7%), and 8.6% (5.4% to 11.6%). In women, the corresponding figures were 4.5% (1.7% to 7.1%), 4.2% (4.0% to 4.3%), and 9.1% (4.5% to 13.6%). Overall, the relative contributions of the reductions in event and case fatality rates to the decline in acute myocardial infarction mortality rate were, respectively, 57% and 43% in men and 52% and 48% in women; however, the relative contributions differed by age, sex, and geographical region.

**Conclusions** Just over half of the decline in deaths from acute myocardial infarction during the 2000s in England can be attributed to a decline in event rate and just less than half to improved survival at 30 days. Both prevention of acute myocardial infarction and acute medical treatment have contributed to the decline in deaths from acute myocardial infarction over the past decade.

## Introduction

Declines have been observed in population based mortality rates from coronary heart disease and acute myocardial infarction in many developed countries, including England, since the 1970s.[1 2] For any given condition, the mortality rate in a population is a function of the event rate and case fatality rate. Several studies have investigated the drivers of the decline in mortality from coronary heart disease. The most notable is the World Health Organization's Multinational Monitoring of Trends and Determinants in Cardiovascular Disease (MONICA) project, which examined trends in mortality rates, event rate, and one month case fatality in men and women aged 35-64 from 38 populations in 21 countries over 10 years, from 1985-7 to 1995-7. The MONICA study found that, between the mid-80s and mid-90s, two thirds of the decline in mortality from coronary heart disease in people aged less than 65 years could be attributed to the decline in coronary event rate and one third to the decline in case fatality.

Studies from the MONICA centres showed that the relative contributions of event rate and case fatality to the decline in mortality from coronary heart disease vary by region and country. The MONICA populations in the United Kingdom were Glasgow and Belfast—there was no English population. The relative contributions of event rate and case fatality for acute myocardial infarction to the observed decline in mortality from acute myocardial infarction have not been studied for England. Routinely collected national hospital and mortality data can be informative. However, data linkage is necessary to undertake a systematic analysis of the occurrence of person based disease from routine national statistics. Since 1998 it has been possible to link routinely collected hospital and mortality data for the entire population of England. Using such a linked dataset, we report trends in event rate and case fatality for acute myocardial infarction and examine the relative contributions of

Correspondence to: K Smolina kate.smolina@spc.ox.ac.uk

changes in these rates to changes in mortality from acute myocardial infarction by sex and age between 2002 and 2010 in England.

## Methods

We obtained data from two national datasets, hospital episode statistics and mortality statistics, which were linked by the Oxford record linkage team. The hospital episode statistics dataset provides information on all patients admitted to hospital and whose care is covered by the English National Health Service, a publicly funded healthcare system that serves all residents of England. The Office for National Statistics collects the data on mortality, including all deaths in residents of England, whether in hospital or not.

### Study population

Residents of England were included in the study if they experienced an acute myocardial infarction event between 1 January 2002 and 31 December 2010. Such an event was defined as either an emergency hospital admission with a primary diagnosis of acute myocardial infarction (ICD-10 codes I21-I22, international classification of diseases, 10th revision) and a length of stay of more than one day for someone discharged alive, or a death with acute myocardial infarction coded as the underlying cause of death on the death certificate (ICD-9 code 410 and ICD-10 codes I21-I22). We applied the one day criterion for hospital stay to avoid counting suspected acute myocardial infarctions in patients who were discharged home when acute myocardial infarction was not confirmed (2.8% of records). In agreement with the MONICA definition of a new acute myocardial infarction, we assumed any hospital or death records that occurred within 30 days of an admission for acute myocardial infarction to relate to the same event. We excluded records with invalid dates, missing age, or missing sex from the analysis (<0.1% of records).

Acute myocardial infarction events were categorised as fatal or non-fatal. We defined fatal acute myocardial infarctions as sudden deaths from acute myocardial infarction or admission to hospital for acute myocardial infarction events that had a death record within 30 days of a hospital admission for acute myocardial infarction, irrespective of the cause or place of death. For the purpose of this study sudden deaths from acute myocardial infarction were those deaths with acute myocardial infarction coded as the underlying cause of death on the death certificate and with no linked hospital admission for acute myocardial infarction in the previous 30 days.

To study regional differences in England we used the government office region classification, based on the borders defined by the Office for National Statistics. We obtained the code, derived from the postal code of residence, from hospital and mortality records.

### Statistical analyses

The event rate was defined as the annual rate of occurrence of acute myocardial infarction. We defined total mortality rate as the annual rate of occurrence of deaths with acute myocardial infarction recorded as the underlying cause of death. Using the mid-year population estimates published by the Office for National Statistics we calculated event and mortality rates per 100 000 population of England by age group and sex. Rates were directly age standardised to the European standard population. We estimated the 95% confidence intervals assuming

that the observed number of events followed a Poisson distribution.

Using the total number of acute myocardial infarctions as the denominator and all fatal acute myocardial infarctions as the numerator, we calculated the overall 30 day case fatality rate in each year. We calculated the 30 day case fatality rate during hospital stay using the total number of hospital admissions for acute myocardial infarction as the denominator and the number of fatalities within 30 days in the population admitted to hospital as the numerator. Case fatality rates were directly age standardised using five year age groups and the age distribution of the nine year acute myocardial infarction event cohort as the standard population.

For event and mortality rates we estimated the average annual percentage changes using Poisson regression analysis with the natural logarithm of the age standardised annual rate as a dependent variable and calendar year as an independent variable. For case fatality, we estimated the average annual percentage changes using generalised linear model with binomial distribution and a log link function. We calculated the average annual percentage change from the $\beta$ coefficient for the calendar year, using $-100\times[1-\exp(\beta)]$ as an approximation.

The relative contribution of event and case fatality rates to the decline in deaths from acute myocardial infarction was calculated using the same method as in the MONICA study. In essence, the average annual change in mortality rate is the sum of the average annual changes in event and case fatality rates, expressed as percentages. This is based on the formulas that mortality rate (M)=event rate(E)×case fatality rate(C) in each year, and that M'/M=E'/E+C'/C, where M', E', and C' stand for the average annual change for each rate in absolute terms. Letting $\Delta M=(M'/M)$, $\Delta E=(E'/E)$, and $\Delta C=(C'/C)$—that is, expressing the average annual change in percentage terms, gives $\Delta M=\Delta E+\Delta C$.

All analyses were done using STATA version 11.

## Results

Between 1 January 2002 and 31 December 2010, 861 134 acute myocardial infarctions occurred in 840 175 people in England. Table 1⇓ shows the characteristics of the acute myocardial infarction events over the study period by sex. Of all acute myocardial infarctions, 61% occurred in men, 36% were fatal, and 73% occurred in people aged 65 years and over. Of the 311 419 fatal events, 70% were sudden deaths from acute myocardial infarction.

### Trends in event rate

From 2002 to 2010, the age standardised acute myocardial infarction event rate per 100 000 population decreased in men from 230 (95% confidence interval 228 to 232) to 154 (153 to 155) and in women from 95.4 (94.5 to 96.3) to 66.0 (65.3 to 66.7) (table 2⇓). Comparing 2002 with 2010, acute myocardial infarction event rates fell by 33% in men and by 31% in women. A declining event rate was seen in all age groups and for both sexes. The greatest rates of decline occurred in men and women aged 65-74 and the lowest in men and women aged 30-54 and 85 and older. The age standardised average annual change in men was −4.8% (95% confidence interval −6.5% to −3.0%) and in women was −4.5% (−7.1% to −1.7%). Declines were observed in age standardised rates for both hospital admissions for acute myocardial infarction and sudden deaths from acute myocardial infarction for both sexes (fig 1⇓).

## Trends in 30 day case fatality

From 2002 to 2010, the age standardised case fatality for acute myocardial infarction decreased in men from 42.0% (95% confidence interval 41.6% to 42.4%) to 32.1% (31.7% to 32.6%) and in women from 42.2% (41.7% to 42.7%) to 29.9% (29.4% to 30.4%) (table 2). Comparing 2002 with 2010, case fatality rates fell by 24% in men and by 29% in women. A declining case fatality rate was seen in all age groups and for both sexes. The rates of decline were broadly similar between age groups in men and in women, with only slightly higher rates in middle aged people and slightly lower rates in younger and older people. The age standardised average annual change in men was −3.6% (95% confidence interval −3.7% to −3.4%) and in women was −4.2% (−4.3% to −4.0%).

Case fatality among patients admitted to hospital for acute myocardial infarction decreased at a slightly faster rate than the overall case fatality rate, which includes sudden deaths from acute myocardial infarction. Figure 2⇓ illustrates the declines in both admissions to hospital and overall case fatality rates for men and women over the study period. Rates for admissions to hospital were about half the overall rates in each year. Comparing 2002 with 2010, case fatality rates for admissions to hospital decreased by 34% in men, from 18.5% (95% confidence interval 18.2% to 18.9%) to 12.2% (11.8% to 12.5%), and by 38% in women, from 20.0% (19.6% to 20.5%) to 12.5% (12.1% to 12.9%). The age standardised average annual change in men was −5.2 (95% confidence interval −5.5 to −4.9) and in women was −5.6 (−5.9 to −5.3).

## Trends in mortality

From 2002 to 2010, the age standardised mortality rate from acute myocardial infarction per 100 000 population decreased in men from 78.7 (95% confidence interval 77.7 to 79.8) to 39.2 (38.6 to 39.9) and in women from 37.3 (36.8 to 37.9) to 17.7 (17.4 to 18.1) (table 2). Comparing 2002 with 2010, mortality rates fell by 50% in men and by 53% in women. A declining mortality rate was seen in all age groups and for both sexes. The greatest rates of decline occurred in men and women aged 65-74 and the lowest in those aged 30-54 and 85 and older. The age standardised average annual change in men was −8.6% (95% confidence interval −11.6% to −5.4%) and in women was −9.1% (−13.6% to −4.5%).

## Determinants of mortality trends

In men, the relative contribution of reductions in event rate to the decline in mortality was higher than the contribution of reductions in case fatality in all age groups except for those aged 85 and older, for whom the contributions were about equal (table 2). In women, the change in event rate played a larger part than the change in case fatality in those aged 65-84, but the opposite was found in women aged less than 55 and 85 and older.

Overall for all ages, just over half of the decline in total mortality could be attributed to a decline in event rate (57% in men, 52% in women) and just less than half to a decline in case fatality rate (43% in men, 48% in women). A similar pattern was observed for those aged less than 75, with about half of the decline in mortality being driven by a decline in acute myocardial infarction event rate (57% in men, 50% in women) and about half by a decline in case fatality rate (43% in men, 50% in women).

Figure 3⇓ illustrates the relative contributions of event and case fatality rates to the change in acute myocardial infarction mortality rate from 2002 to 2010 by government office region.

All three rates declined in all the regions over the study period. The relative contributions of reductions in event rate and case fatality to the decline in mortality differed by region and there was no consistent geographical pattern. The event rate played a slightly bigger part than case fatality in six out of nine regions, accounting for just over half of the decline in mortality. Notably, the reductions in case fatality explained two thirds of the decline in deaths from acute myocardial infarction in London. Detailed examination of data showed that this was driven by either temporary increases or plateaus in acute myocardial infarction event rates between 2007 and 2009 in both sexes and in all age groups.

## Discussion

This study reports on recent trends in acute myocardial infarction events, 30 day case fatality, and total mortality rates between 2002 and 2010 in England. The results show that all rates have declined. In other words, compared with earlier years, fewer acute myocardial infarctions occurred in the past decade, and of those that did occur, fewer were fatal. Total age standardised deaths from acute myocardial infarction decreased by about half, whereas the age standardised event rate and case fatality each declined by about one third. The relative contributions of the reductions in both event rate and case fatality to the decline in deaths from acute myocardial infarction differed by sex, age, and geographical region, with changes in case fatality playing a greater part in women and older people. Overall, the average annual reductions were similar for event and case fatality rates, indicating that they contributed about equally to the decline in mortality.

## Trends over time

We have shown that the decline in the acute myocardial infarction event rate and one month case fatality in the United Kingdom, observed in previous decades, continued into the 21st century. We report declines for all ages, both sexes, and all geographical regions. However, the magnitude of the declines differed by age group, with the greatest annual reductions in event rate, case fatality, and mortality occurring among middle aged people.

The annual declines in event rate were not statistically significant for men and women aged 30-54 and 85 and older, which raises the possibility that there was no real improvement in the rate of occurrence of acute myocardial infarction in these age groups over the past decade in England. For younger people, the rising rates of obesity and diabetes may be potential contributing factors to a levelling of event rate. For older people, the lack of decline could result from a shift in the first presentation of disease from middle age to older age[10 16 17] or a change in diagnostic criteria, which possibly led to more cases of acute myocardial infarction being diagnosed in this age group.

We also found non-significant annual declines in deaths from acute myocardial infarction in men and women aged 30-54 years. These findings support previous reports of a flattening and a possible reversal in coronary heart disease mortality rates in young adults towards the end of the century,[13 14 17 21] and reinforce the importance of monitoring and managing risk factors in this population.

### Explaining the decline in deaths from acute myocardial infarction

Our findings that the reductions in event rate contributed just over half and case fatality just less than half to the observed

decline in acute myocardial infarction mortality contrast with the results of the MONICA study, which reported that the decline in event rate accounted for two thirds of the total decline in mortality. However, the MONICA findings were based on data from previous decades, did not include adults aged older than 65, and did not cover England. Therefore the MONICA results are unlikely to apply to more recent years, be representative of whole populations, or be directly applicable to England.

In our study, the relative contribution of event rate and case fatality differed by age: changes in the event rate played a bigger part in middle aged people, whereas changes in case fatality played a slightly bigger part in young and very old people. This can be explained by the fact that, while the average annual changes between 2002 and 2010 in case fatality rate did not differ substantially between age groups, the declines in event rate did. Changes in the event rate were lowest, as well as non-significant, in the 30-54 and 85 and older age groups. As a result, the relative contribution of changes in case fatality differed by age and was higher for younger and for older people.

We report, similar to others,[21][22] that most fatal acute myocardial infarctions were sudden deaths. Others have found that about half of those dying suddenly from coronary heart disease or acute myocardial infarction already have a history of symptomatic coronary heart disease.[21][23][24] It is reasonable to assume that our cohort also consisted of people with and without pre-existing coronary heart disease. At least some of them are likely to have been taking preventive drugs or making lifestyle changes, particularly with the implementation of the National Service Framework for coronary heart disease from 2000 onwards. Therefore, both primary prevention and secondary prevention would have contributed to the decline in the rate of sudden deaths from acute myocardial infarction. In addition to reducing rates of sudden death, coronary prevention can reduce disease severity and therefore may contribute to the decline in case fatality for those who survive long enough to receive hospital care for acute myocardial infarction. Furthermore, changes in fatal outcomes among people admitted to hospital for acute myocardial infarction also reflect, at least in part, the contribution of improvements in acute medical treatment during the study time period.

Our data did not include clinical information on risk factors, comorbidities, disease history, or current and past drug prescriptions for the population studied, and thus we could not address the relative importance of specific elements of prevention and treatment. One modelling study suggested that between 1981 and 2000 in England and Wales, reductions in main risk factors contributed 58% to the decline in deaths from coronary heart disease, and medical treatment contributed 42%. During our study period, national survey data for England indicates that the prevalence of smoking, high blood pressure, and high cholesterol levels decreased, while the prevalence of obesity and diabetes increased. In addition, drug prescriptions for the prevention and treatment of coronary heart disease have risen, as has the use of percutaneous coronary intervention procedures.

We observed regional variation in the determinants of decline in deaths from acute myocardial infarction, with the relative contribution of event rate ranging from about one third to about two thirds, but being just over half in most regions. These findings are in agreement with the regional variation found within and between countries in the MONICA study. Our study provides further evidence that the drivers behind declining mortality rates differ geographically and that results specific to one region cannot necessarily be applied to other regions. The

increase in acute myocardial infarction event rate in London between 2007 and 2009 may be a result of the financial crisis that peaked in 2008 and greatly affected the London financial district. As a result, the reductions in case fatality accounted for most of the decline in deaths from acute myocardial infarction in that region during the 2000s.

It is important to note that we only examined deaths from acute myocardial infarction, and not all coronary heart disease. We did not attempt a similar analysis of determinants of trends in deaths from coronary heart disease because we could not reliably identify all new coronary heart disease events (other than acute myocardial infarction) using just hospital and mortality data. Extrapolation of results presented here to all coronary heart disease should be made with caution. Age standardised mortality rates from causes of non-acute myocardial infarction coronary heart disease in England declined less than acute myocardial infarction mortality over the study period (data not shown). This could be driven by the decreasing severity of coronary heart disease in the population, with fewer people developing the acute manifestation of the disease as an acute myocardial infarction. However, the precise reasons behind these trends merit further research but lie beyond the scope of this study.

## Strengths and limitations of the study

The strengths of this study include the large size of the cohort, population level representation, complete national coverage, and recent statistics. To the best of our knowledge, this is the first study to apply MONICA's statistical approach to administrative data to explain recent trends in decline in deaths from acute myocardial infarction on a national level. With wider availability of record linkage, analysis similar to the one presented in this paper is increasingly possible in other countries.

The main limitation was the reliance on the accuracy and validity of routine data. However, a systematic review of studies comparing routine hospital discharge statistics with medical records carried out in England, Wales, and Scotland reported, on average, high accuracy rates for coding. In addition, the quality of hospital data varies by condition, and common diagnoses such as acute myocardial infarction are less likely to be subject to miscoding than rare ones.[28][29] Linked Scottish morbidity record database and patient episode database for Wales, equivalents of the English hospital episodes statistics, were reported to have high accuracy rates for the diagnosis of acute myocardial infarction.[15][30]

Any acute myocardial infarction events that occurred while under private hospital care were not captured by the hospital episodes statistics and thus not included in this study; however, these events are likely to represent a small proportion of all acute myocardial infarctions in England. Some of the excluded people with hospital admissions for acute myocardial infarction with a stay of one day or less or those with a secondary diagnosis of acute myocardial infarction could have been true instances of acute myocardial infarction. Any silent acute myocardial infarctions that did not result in a hospital admission or a death record could not be captured by the available data and thus were not included in the study. Some deaths coded as non-acute myocardial infarction coronary heart disease as the underlying cause of death could have been cases of acute myocardial infarction, but, as this was not knowable, they were not included.

New diagnostic criteria for acute myocardial infarction, which rely on the use of more sensitive biochemical markers of damage to myocardium (troponins) for detection of acute myocardial infarction, were introduced in 2000 by the European Society of Cardiology and the American College of Cardiology.[31] The

introduction of these new criteria could have influenced our estimates of event rate, especially in the early 2000s, because adaptation and integration of troponins into clinical practice happened gradually over time. Studies have shown that this change in criteria affects estimates of trends in hospital admissions for acute myocardial infarction but not for case fatality within 30 days of admission to hospital for acute myocardial infarction.[18 19 32 33] We could not directly quantify the effect of the change in diagnostic criteria for acute myocardial infarction on trends in hospital admissions because we did not have any of the clinical information used in making the diagnosis of acute myocardial infarction. However, the fact that we still observed a decline in event rate during the 2000s despite the use of the new criteria during that time provides evidence of a real and beneficial change in the occurrence of acute myocardial infarction in the English population.

## Conclusions

Our study reports trends in event, case fatality, and total mortality rates for acute myocardial infarction over the past decade in England. It also examines the relative contribution of changes in event rate and case fatality to the observed decline in deaths from acute myocardial infarction. Most fatalities from acute myocardial infarction continue to be sudden deaths. Overall, just over half of the decline in deaths from acute myocardial infarction can be attributed to a reduction in event rate and just less than half to improved survival at 30 days. However, the drivers behind declining mortality rates differ by sex, age, and geographical region. The results also highlight groups, particularly young and very old people, who experienced the least improvement in the occurrence of and mortality from acute myocardial infarction. Further research is required to elucidate the roles of population risk factor profiles, primary and secondary prevention, and acute medical treatment in the observed declines in acute myocardial infarction event, case fatality, and mortality rates.

1  Scarborough P, Bhatnagar P, Wickramasinghe K, Smolina K, Mitchell C, Rayner M. Coronary heart disease statistics. British Heart Foundation, 2010.
2  Allender S, Scarborough P, Peto V, Rayner M. European cardiovascular disease statistics. European Heart Network, 2008.
3  Tunstall-Pedoe H, Kuulasmaa K, Amouyel P, Arveiler D, Rajakangas AM, Pajak A. Myocardial infarction and coronary deaths in the World Health Organization MONICA Project. Registration procedures, event rates, and case-fatality rates in 38 populations from 21 countries in four continents. Circulation 1994;90:583-612.
4  Tunstall-Pedoe H, Kuulasmaa K, Mähönen M, Tolonen H, Ruokokoski E, Amouvel P. Contribution of trends in survival and coronary event rates to changes in coronary heart disease mortality: 10-year results from 37 WHO MONICA Project populations. Lancet 1999;353:1547-57.
5  Salomaa V, Miettinen H, Kuulasmaa K, Niemela M, Ketonen M, Vuorenmaa T, et al. Decline of coronary heart disease mortality in Finland during 1983 to 1992: roles of incidence, recurrence, and case-fatality: the FINMONICA MI Register Study. Circulation 1996;94:3130-7.
6  Marques-Vidal P, Ruidavets J, Cambou J, Ferrieres J. Incidence, recurrence, and case fatality rates for myocardial infarction in southwestern France, 1985 to 1993. Heart 2000;84:171-5.
7  Rosamond W, Chambless L, Folsom A, Cooper LS, Conwill DE, Clegg L, et al. Trends in the incidence of myocardial infarction and in mortality due to coronary heart disease, 1987 to 1994. N Engl J Med 1998;339:861-7.
8  Hardoon S, Whincup P, Lennon L, Wannamethee SG, Capewell S, Morris RW. How much of the recent decline in the incidence of myocardial infarction in British men can be explained by changes in cardiovascular risk factors? Circulation 2008;117:598-604.
9  Lampe F, Morris R, Walker M, Shaper AG, Whincup PH. Trends in rates of different forms of diagnosed coronary heart disease, 1978 to 2000: prospective, population based study of British men. BMJ 2005;330:1046-51.
10 Davies A, Smeeth L, Grundy E. Contribution of changes in incidence and mortality to trends in the prevalence of coronary heart disease in the UK: 1996-2005. Eur Heart J 2007;28:2142-7.
11 Goldacre M, Roberts S. Myocardial infarction: an investigation of measures of mortality, incidence and case fatality. Department of Health, 2001.
12 Capewell S, Livingston BM, MacIntyre K, Chalmers JW, Boyd J, Finlayson A, et al. Trends in case-fatality in 117 718 patients admitted with acute myocardial infarction in Scotland. Eur Heart J 2000;21:1833-40.
13 O'Flaherty M, Ford E, Allender S, Scarborough P, Capewell S. Coronary heart disease trends in England and Wales from 1984 to 2004: concealed levelling of mortality rates among young adults. Heart 2008;94:178-81.
14 Vaartjes I, O'Flaherty M, Grobbee D, Bots ML, Capewell S. Coronary heart disease mortality trends in the Netherlands 1972-2007. Heart 2011;97:569-73.
15 Brophy S, Cooksey R, Gravenor M, Weston C, Macey SM, John G, et al. Population based absolute and relative survival to 1 year of people with diabetes following a myocardial infarction: a cohort study using hospital admissions data. BMC Public Health 2010;10:338-45.
16 Reikvam A, Hagen TP. Markedly changed age distribution among patients hospitalized for acute myocardial infarction. Scand Cardiovasc J 2002;36:221-4.
17 Allender S, Scarborough P, O'Flaherty M, Capewell S. Patterns of coronary heart disease mortality over the 20th century in England and Wales: possible plateaus in the rate of decline. BMC Public Health 2008;8:148-60.
18 Salomaa V, Ketonen M, Koukkunen H, Immonen-Raiha P, Lehtonen A, Torppa J, et al. The effect of correcting for troponins on trends in coronary heart disease events in Finland during 1993-2002: the FINAMI study. Eur Heart J 2006;27:2394-9.
19 Abildstrom S, Rasmussen S, Madsen M. Changes in hospitalization rate and mortality after acute myocardial infarction in Denmark after diagnostic criteria and methods changed. Eur Heart J 2005;26:990-5.
20 Pell J, Simpson E, Rodger J, Finlayson A, Clark D, Anderson J, et al. Impact of changing diagnostic criteria on incidence, management, and outcome of acute myocardial infarction: retrospective cohort study. BMJ 2003;326:134-5.
21 Salomaa V, Ketonen M, Koukkunen H, Immonen-Raiha P, Jerkkola T, Karja-Koskenkari P, et al. Decline in out-of-hospital coronary heart disease deaths has contributed the main part to the overall decline in coronary heart disease mortality rates among persons 35 to 64 years of age in Finland: the FINAMI study. Circulation 2003;108:691-6.
22 Sigfusson N, Sigurdsson G, Agnarsson U, Gudmundsdottir II, Stefansdottir I, Sigvaldason H, et al. Declining coronary heart disease mortality in Iceland: contribution by incidence, recurrence and case fatality rate. Scand Cardiovasc J 2002;36:337-41.
23 Fox C, Evans J, Larson M, Kannel WB, Levy D. Temporal trends in coronary heart disease mortality and sudden cardiac death from 1950 to 1999: the Framingham Heart Study. Circulation 2004;110:522-7.
24 Goraya T, Jacobsen S, Kottke T, Frye RL, Weston SA, Roger VL. Coronary heart disease death and sudden cardiac death: a 20-year population-based study. Am J Epidemiol 2003;157:763-70.
25 Department of Health. National service framework for coronary heart disease. DoH, 2000.
26 Unal B, Critchley J, Capewell S. Explaining the decline in coronary heart disease mortality in England and Wales between 1981 and 2000. Circulation 2004;109:1101-7.
27 Campbell SE, Campbell MK, Grimshaw JM, Walker AE. A systematic review of discharge coding accuracy. J Public Health Med 2001;23:205-11.
28 Dixon J, Sanderson C, Elliott P, Walls P, Jones J, Petticrew M. Assessment of the reproducibility of clinical coding in routinely collected hospital activity data: a study in two hospitals. J Public Health Med 1998;20:63-9.
29 Aylin P, Lees T, Baker S, Prytherch D, Ashley S. Descriptive study comparing routine hospital administrative data with the vascular society of Great Britain and Ireland's National Vascular Database. Eur J Vasc Endovasc Surg 2007;33:461-5.

**What is already known on this topic**

Population based mortality rates from coronary heart disease and acute myocardial infarction have been declining in England and other developed countries since the 1970s

The relative contributions of changes in event rate and case fatality to the decline in total acute myocardial infarction mortality vary by country and are not known for England and many other countries

**What this study adds**

In England during 2002-10 the age standardised total mortality rate fell by about half and the age standardised event and case fatality rates both declined by about one third

The determinants of the declining mortality rates differed by sex, age, and geographical region

Overall, just over half of the decline in acute myocardial infarction mortality rate can be attributed to a decline in event rate and just less than half to a decline in case fatality

30 Harley K, Jones C. Quality of Scottish Morbidity Record (SMR) data. *Health Bull (Edinb)* 1996;54:410-7.

31 Alpert JS, Thygesen K, Antman E, Bassand J. Myocardial infarction redefined—a consensus document of the Joint European Society of Cardiology/American College of Cardiology committee for the redefinition of myocardial infarction: the Joint European Society of Cardiology/American College of Cardiology Committee. *J Am Coll Cardiol* 2000;36:959-69.

32 Roger VL, Weston SA, Gerber Y, Killian JM, Dunlay SM, Jaffe AS, et al. Trends in incidence, severity, and outcome of hospitalized myocardial infarction. *Circulation* 2010;121:863-9.

33 Sanfilippo FM, Hobbs MST, Knuiman MW, Hung J. Impact of new biomarkers of myocardial damage on trends in myocardial infarction hospital admission rates from population-based administrative data. *Am J Epidemiol* 2008;168:225-33.

# Tables

**Table 1| Characteristics of acute myocardial infarction events by sex, 2002-10, England**

| Characteristics | All events (n=861 134) | Events in men | | Events in women | |
| --- | --- | --- | --- | --- | --- |
| | | All (n=523 472) | Fatal (n=175 280) | All (n=337 662) | Fatal (n=136 139) |
| Hospital admission | 643 987 | 396 731 | 48 539 (12) | 247 256 | 45 733 (18) |
| Sudden death | 217 147 | 126 741 | 126 741 (100) | 90 406 | 90 406 (100) |
| Mean (SD) age (years), median | 72.5 (14), 75 | 69.4 (14), 71 | 74.4 (12), 77 | 77.4 (12), 80 | 81.0 (10), 83 |
| Age group: | | | | | |
| 0-29 | 1314 | 994 | 178 (18) | 320 | 70 (22) |
| 30-54 | 97 818 | 79 932 | 12 245 (15) | 17 886 | 2840 (16) |
| 55-64 | 131 951 | 101 842 | 22 219 (22) | 30 109 | 6273 (21) |
| 65-74 | 193 012 | 128 823 | 41 274 (32) | 64 189 | 19 777 (31) |
| 75-84 | 266 062 | 145 339 | 64 098 (44) | 120 723 | 51 777 (43) |
| ≥85 | 170 976 | 66 542 | 35 266 (53) | 104 434 | 55 401 (53) |
| Year: | | | | | |
| 2002 | 107 313 | 65 317 | 24 914 (38) | 41 996 | 19 711 (47) |
| 2003 | 105 812 | 63 938 | 23 707 (37) | 41 874 | 19 089 (46) |
| 2004 | 103 309 | 62 720 | 21 963 (35) | 40 589 | 17 148 (42) |
| 2005 | 98 781 | 59 725 | 20 394 (34) | 39 056 | 16 125 (41) |
| 2006 | 94 471 | 57 396 | 18 990 (33) | 37 075 | 14 606 (39) |
| 2007 | 91 997 | 56 200 | 17 716 (32) | 35 797 | 13 742 (38) |
| 2008 | 90 059 | 54 694 | 16 755 (31) | 35 365 | 12 892 (36) |
| 2009 | 87 140 | 53 411 | 15 861 (30) | 33 729 | 11 757 (35) |
| 2010 | 82 252 | 50 071 | 14 980 (30) | 32 181 | 11 069 (34) |

Table 2| Trends in event rate, 30 day case fatality, and mortality for acute myocardial infarction by sex and age, 2002-10, England

| Age group | Event rate (per 100 000) | | | | Case fatality rate (%) | | | | Mortality rate (per 100 000) | | | | | Contribution to mortality decline§ | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2002 | 2010 | Overall change† (%) | Annual trend (%) | 2002 | 2010 | Overall change (%) | Annual trend (%) | 2002 | 2010 | Overall change (%) | Annual trend (%) | Estimated annual trend‡ (%) | Event rate (%) | Case fatality rate (%) |
| Men: | | | | | | | | | | | | | | | |
| 30-54 | 11.9 | 8.8 | −26 | −3.2* | 17.6 | 13.8 | −22 | −2.7 | 2.0 | 1.2 | −39 | −5.7* | −5.9 | 55 | 45 |
| 55-64 | 46.8 | 31.7 | −32 | −4.4 | 25.0 | 14.2 | −43 | −3.2 | 11.2 | 5.8 | −49 | −7.7* | −7.6 | 58 | 42 |
| 65-74 | 89.7 | 53.3 | −41 | −6.2 | 37.2 | 19.5 | −48 | −3.8 | 31.3 | 13.7 | −56 | −10.1 | −10.0 | 62 | 38 |
| 75-84 | 161 | 102 | −37 | −5.7 | 50.4 | 28.0 | −44 | −3.7 | 76.0 | 34.7 | −54 | −9.7 | −9.5 | 61 | 39 |
| ≥85 | 254 | 199 | −22 | −3.2 | 61.2 | 37.9 | −38 | −3.3 | 145 | 84.8 | −42 | −7.0 | −6.5 | 49 | 51 |
| <75 | 156 | 104 | −34 | −4.7 | 28.9 | 22.1 | −23 | −3.5 | 41.4 | 20.3 | −51 | −8.6 | −8.2 | 57 | 43 |
| All ages | 230 | 154 | −33 | −4.8 | 42.0 | 32.1 | −24 | −3.6 | 78.7 | 39.2 | −50 | −8.6 | −8.3 | 57 | 43 |
| Women: | | | | | | | | | | | | | | | |
| 30-54 | 2.4 | 2.1 | −12 | −1.2* | 20.1 | 13.3 | −34 | −4.9 | 0.5 | 0.3 | −41 | −5.9* | −6.1 | 20 | 80 |
| 55-64 | 14.0 | 9.0 | −36 | −4.8* | 24.8 | 17.4 | −30 | −4.8 | 3.3 | 1.5 | −54 | −9.3* | −9.6 | 50 | 50 |
| 65-74 | 40.8 | 23.7 | −42 | −6.7 | 37.2 | 25.3 | −32 | −5.1 | 14.3 | 5.5 | −62 | −11.6 | −11.8 | 56 | 44 |
| 75-84 | 89.8 | 59.7 | −34 | −5.2 | 50.7 | 35.8 | −29 | −4.5 | 42.3 | 19.0 | −55 | −9.9 | −9.7 | 53 | 47 |
| ≥85 | 167 | 139 | −16 | −2.7 | 61.5 | 45.7 | −26 | −3.7 | 97.0 | 57.4 | −41 | −6.8 | −6.3 | 42 | 58 |
| <75 | 51.7 | 34.1 | −34 | −5.0 | 29.2 | 19.9 | −32 | −5.0 | 14.9 | 6.3 | −58 | −10.3 | −10.0 | 50 | 50 |
| All ages | 95.4 | 66.0 | −31 | −4.5 | 42.2 | 29.9 | −29 | −4.2 | 37.3 | 17.7 | −53 | −9.1 | −8.7 | 52 | 48 |

*P>0.05.

†(1−[rate in 2010]/[ rate in 2002])×100.

‡Based on average annual trends in event rate and case fatality.

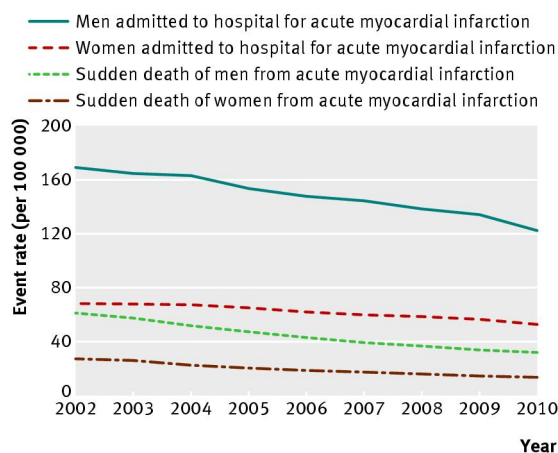§(event or case fatality annual trend/estimated mortality trend)×100.

# Figures



**Fig 1** Age standardised event rates of acute myocardial infarction by sex and type of event, 2002-10, England
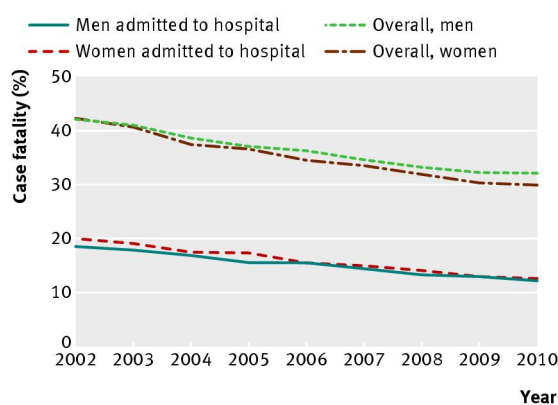


**Fig 2** Age standardised 30 day overall and case fatality rates for admissions to hospital (%) for acute myocardial infarction by sex, 2002-10, England
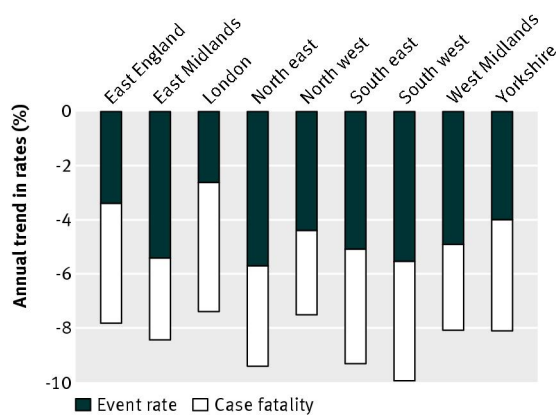


**Fig 3** Contribution of average annual trends in event rate and case fatality to average annual trend in mortality for acute myocardial infarction by government office region, 2002-10, England