

Long-Term Survival and Recurrence After Acute Myocardial Infarction in England, 2004 to 2010

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Background—There are limited population-based national data on prognosis in survivors of acute myocardial infarction (AMI), particularly on long-term survival and the risk of recurrence.

Methods and Results—Record linkage of hospital and mortality data identified 387 452 individuals in England who were admitted to hospital with a main diagnosis of AMI between 2004 and 2010 and who survived for at least 30 days. Seven years after an AMI, the risk of death from any cause in survivors of first or recurrent AMI was, respectively, 2 and 3 times higher than that in the English general population of equivalent age. For all survivors of a first AMI, the risk of a second AMI was highest during the first year and the cumulative risk increased more gradually thereafter. For men, 1- and 7-year cumulative risks were 5.6% (95% confidence interval [CI], 5.5–5.7) and 13.9% (95% CI, 13.7–14.1); for women, they were 7.2% (95% CI, 7.1–7.4) and 16.2% (95% CI, 16.0–16.5). Older age, higher deprivation, no revascularization procedures, and presence of comorbidities were associated with higher recurrence risk.

Conclusions—Survivors of both first and recurrent AMI remained at a significantly higher risk of death compared with the general population for at least 7 years after the event. For survivors of first AMI, the influence of predisposing factors for second AMI lessened with time after the initial event. The results reinforce the importance of acute clinical care and secondary prevention in improving long-term prognosis of hospitalized AMI patients. (*Circ Cardiovasc Qual Outcomes*. 2012;5:532-540.)

Key Words: myocardial infarction ■ survival ■ prognosis ■ epidemiology

Long-term survival after acute myocardial infarction (AMI) has improved over the last 3 decades in developed countries.^{1–8} Studies have reported improving survival after both first and recurrent AMIs.^{9,10} These improvements have been attributed to the increasingly widespread use of revascularization procedures, effective acute treatment, and long-term secondary prevention.^{1,2,4,6} We have recently published on short-term survival within 30 days after AMI in England during the 2000s^{11,12} and have shown substantial improvements over time in short-term survival.¹²

As short-term survival from AMI improves, the study of long-term prognosis becomes ever more important. This information is of interest to clinicians, public health professionals, and decision-makers because it can be used to support clinical and funding decisions. However, much of the existing data on outcomes after AMI come from clinical trials, which have limited representativeness and generalizability. Population-based studies provide a more accurate evidence base for assessment of risk. Yet, only a few such studies have examined long-term prognosis in unselected patient populations, measured as long-term survival and as risk of recurrence.^{4,10,13–17} Of those that have, most used a combined end point of recurrent AMI or death from any

cause^{14–16} but did not analyze risks of recurrent event and death separately.^{10,17}

One possible means for obtaining information on prognosis is the analysis of routinely collected national hospital admission and death certificate data. Since 1998, it has been possible to do person-based linkage of routine national hospital and mortality data for England. Using a linked dataset of these patient-level records, we provide an account of long-term AMI prognosis in England. Specifically, we report on 7-year survival in 30-day survivors, distinguishing survivors of first and recurrent AMI, and on the risk of a second AMI in survivors of first AMI. We also compare long-term mortality rates of 30-day AMI survivors with those of the general population.

Methods

Data Sources

Data were obtained from 2 datasets, Hospital Episode Statistics (HES) and mortality statistics, which were linked together by the Oxford Record Linkage Study team.¹⁸ The record matching and linkage methods used encrypted versions of each person's National Health Service (NHS) number (unique to the individual), HESID (a

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national hospital number unique to each individual), date of birth, sex, and postcode. Both datasets cover all of England and include information on all hospital admissions and deaths. The HES dataset provides information on all patients admitted to hospital and whose care is funded by the NHS. The mortality data are collected by the Office for National Statistics (ONS) and include all deaths that occur in England, whether in hospital or outside.

WHAT IS KNOWN

- Prognosis after acute myocardial infarction (AMI) varies with age at the time of AMI, with a higher risk of death and recurrence in older individuals. Data on the magnitude of this risk and the time during which it persists is scarce.
- There are limited population-based representative national data on long-term outcomes, particularly survival and risk of recurrence.

WHAT THE STUDY ADDS

- This large population-based study of AMI in England (population 52 million) provides a comprehensive account of 7-year prognosis in 30-day AMI survivors by quantifying the extent to which survivors of AMI have worse mortality rates than the general population, and reporting their risk of having a second AMI.
- The results show that AMI survivors remain at high-risk for at least 7 years after an AMI and reinforce the importance of both clinical care and secondary prevention in improving the long-term outcomes of hospitalized AMI patients.

Study Population

England (population 52 million) is 1 of 4 constituent countries of the United Kingdom (the others, excluded from this analysis, are Scotland, Wales, and Northern Ireland). Residents of England were included in the study if they experienced an AMI event between January 1, 2004, and December 31, 2010, and were still alive after 30 days. An AMI event was defined as an emergency hospital admission with a main discharge diagnosis of AMI (*International Classification of Diseases* [ICD-10] codes I21 or I22) and a length of stay of at least 1 day for someone discharged alive (for first and second AMIs), or a death with AMI coded as the underlying cause of death on the death certificate without a corresponding hospital admission (only for second AMIs). The 1-day criterion for hospital stay was applied to avoid counting suspected AMIs in patients who were discharged home when AMI was not confirmed. Any hospital or death records that occurred within 30 days of the admission date for an identified AMI event were considered to relate to the same AMI.

For each person, the first occurrence of a hospital admission for AMI during the study period was recorded as the index event. To classify each index AMI as first or recurrent, we used a 6-year clinical history (defined as a previous hospital record with AMI as primary or secondary diagnosis) for 1998 to 2003. If the index AMI event occurred in individuals with no clinical history of AMI during the previous 6 years, it was categorized as a first AMI, as a proxy for true first AMI. Otherwise, the index event was categorized as a recurrent AMI. Individuals were followed until March 31, 2011, and all therefore had a minimum follow-up period of 3 months.

Statistical Analyses

Survival time was calculated as the time from the date of admission for the index AMI to the date of death from any cause, or censored

at the end of the study period (March 31, 2011), whichever came first. Survival curves were estimated for age groups, for men and women, and after first and recurrent AMI using Kaplan–Meier methods. Comparisons of survival between groups were performed using log-rank tests.

Cox proportional hazards models, yielding hazard ratios (HRs), were used to examine the effect on survival of age, sex, previous AMI, deprivation category, coronary revascularization procedures, and comorbidities. The proportional hazards assumption was checked visually using log-log plots of the survival function and Nelson–Aalen plots of the cumulative hazard function. Results are reported separately for men and women and for different age groups because of a strong interaction between sex and age (likelihood ratio test, $P < 0.001$).

Age-standardized mortality ratios (SMRs) were used to compare mortality rates for AMI survivors with mortality rates of the general English population (for the latter, rates published by the ONS were used). SMRs were calculated using the indirect method of standardization and the age- and sex-specific rates in the English national population as the standard. Age stratification was in 5-year age groups. Average values for 2004 to 2010 for the English mortality rates for each 5-year age group and sex combination were used as the reference rates.

For the analysis of risk of a second AMI, that is, recurrence risk, only survivors whose index event was their first AMI were included. The recurrence risk was calculated using cumulative incidence methods for survival data, developed by Fine and Gray¹⁹ for situations where individuals can experience a competing event instead of the event of interest during the follow-up period. In this study, the event of interest was a second AMI and the competing event was death from causes other than AMI. Second AMIs were classified as fatal or nonfatal events. Fatal second AMIs were defined as hospitalizations for AMI that ended in death within 30 days of the date of event, irrespective of the cause or place of death, or a death with AMI coded as the underlying cause of death on the death certificate without a corresponding hospital admission.

Comorbidities and coronary revascularization procedures were studied as prognostic factors. A comorbidity was defined as a condition listed as a secondary diagnosis alongside the primary discharge diagnosis of AMI in the index admission or in any subsequent admission within 30 days of AMI occurrence. Comorbidities were divided into the following 5 groups (ICD-10 codes): (1) cancer (C00–C97); (2) diabetes (E10–E14); (3) respiratory disease (J00–J99); (4) renal disease (N17–N19); and (5) selected cardiovascular diseases (CVD), including: cerebrovascular disease (G45, I60–I69), hypertension (I10–I15), other CHD (I20, I23–I25), arrhythmia (I28–I29), heart failure (I50), and peripheral vascular disease (I70–I74). A coronary revascularization procedure was defined as either of the following procedures listed in any operative field in any hospital record within 30 days of AMI date: coronary artery bypass graft (CABG) (English Office of Population Censuses and Surveys (OPCS-4) codes K40–46) and percutaneous transluminal coronary angioplasty (PTCA) (OPCS-4 codes K49–50 and K75).

The Index of Multiple Deprivation (IMD 2004)²⁰ score for the individual's area of residence was used as a proxy measure of socioeconomic status. This is a standard composite score, covering several domains of social and economic deprivation, widely used in research in the United Kingdom. The IMD scores of the individuals in the 7-year study cohort were grouped into deprivation quintiles.

Differences in the distributions of baseline variables were examined using t tests of statistical significance for continuous variables and χ^2 tests for categorical variables. Significance was accepted at the $P < 0.05$ level; all tests were 2-tailed. All analyses were performed using STATA version 11 (Stata Corporation, College Station, TX).

Results

Survivor Cohort

Between January 1, 2004, and December 31, 2010, in England, 449 677 individuals were admitted to hospital for

Table 1. Characteristics of AMI 30-Day Survivors by Type of AMI, England, 2004 to 2010

Characteristic	First AMI					Recurrent AMI				
	Total All Cases n	Men		Women		Total All Cases n	Men		Women	
		All Cases n	Died* n	All Cases n	Died* n		All Cases n	Died* n	All Cases n	Died* n
Total	371 619	236 317	49 215	135 302	42 874	15 833	9676	4576	6157	3777
Age, y										
Mean	69.3	66.3	77.0	74.6	82	74.1	71.2	77.4	78.7	82
Median	71	67	79	77	83	77	73	79	81	83
Age group, y										
0–29	871	653	16	218	7	5	5	3	0	0
30–54	59 308	48 292	1652	11 016	520	1443	1210	143	233	44
55–64	73 136	56 223	4357	16 913	1537	1993	1585	355	408	108
65–74	88 149	58 451	10 868	29 698	5676	3476	2415	1005	1061	497
75–84	97 375	52 392	20 371	44 983	16 713	5563	3060	1979	2503	1612
85+	52 780	20 306	11 951	32 474	18 421	3353	1401	1094	1952	1516
Deprivation										
Least deprived, 1	78 666	51 546	9968	27 120	8201	2728	1703	811	1025	611
2	76 475	49 428	10 205	27 047	8526	3048	1880	925	1168	743
3	73 793	46 536	9894	27 257	8857	3094	1864	886	1230	767
4	72 511	45 166	9745	27 345	8956	3346	2034	937	1312	817
Most deprived, 5	70 174	43 641	9403	26 533	8334	3617	2195	1017	1422	839
Operation										
CABG†	2930	2285	279	645	86	74	60	11	14	7
PTCA‡	72 813	54 160	3665	18 653	1796	1360	1052	179	308	90
Comorbidity										
Cancer	9779	7139	3989	2640	1675	546	411	311	135	125
Cardiovascular disease	277 945	173 491	39 125	104 454	34 340	13 617	8225	3877	5392	3296
Diabetes	67 055	41 690	12 143	25 365	9548	4628	2754	1450	1874	1181
Respiratory disease	74 157	41 715	15 489	32 442	13 182	3901	2298	1413	1603	1070
Renal disease	18 597	11 272	6131	7325	4284	1628	1003	728	625	491

AMI indicates acute myocardial infarction.

*Died during the study period; median follow up was 2.8 years.

†CABG, coronary artery bypass graft within 30 days of admission.

‡PTCA, percutaneous transluminal coronary angioplasty within 30 days of admission.

AMI. Of these, 387 452 (86%) patients survived for at least 30 days and were included as the study cohort. Table 1 shows the characteristics of the survivor cohort by first and recurrent index AMI. The mean age at admission was higher for the survivors of recurrent AMI than for survivors of first AMI (74 versus 69 years, $P<0.001$). Around a quarter of all patients with a first AMI and a half of all those with a recurrent AMI died during the study period. The prevalence of comorbidities was significantly higher in women than men ($P<0.001$ for each comorbidity) and in survivors of recurrent AMI compared with survivors of first AMI ($P<0.001$ for each comorbidity). Median follow-up time was 2.8 years.

Long-Term Survival After AMI

Figure 1 shows 7-year Kaplan–Meier survival curves by sex and age group for first and recurrent AMI, respectively. For each type of AMI, similar survival patterns were observed for men and women within the same age groups. Kaplan–Meier

survival probability estimates based on the survival curves indicated that survivors of a first AMI fared better than survivors of a recurrent AMI ($P<0.001$): overall, 7-year survival estimates for patients with a first AMI were almost twice as high as for those with a recurrent AMI. For men, 69% (95% CI, 68–69) were still alive 7 years after a first AMI and 42% (95% CI, 41–43) after a recurrent AMI. For women, the corresponding figures were 53% (95% CI, 53–53) and 26% (95% CI, 25–28).

The associations between the following prognostic factors for mortality were examined in AMI survivors: age, sex, prior AMI, deprivation level, revascularization procedures, and comorbidities. Results are presented in the Data Supplement Tables available online. Importantly, findings indicate that after adjusting for prior AMI, deprivation, revascularization procedures, and comorbidities, women faced a slightly higher risk of dying than men in individuals under 55 years, whereas men faced a higher risk of dying than women in individuals

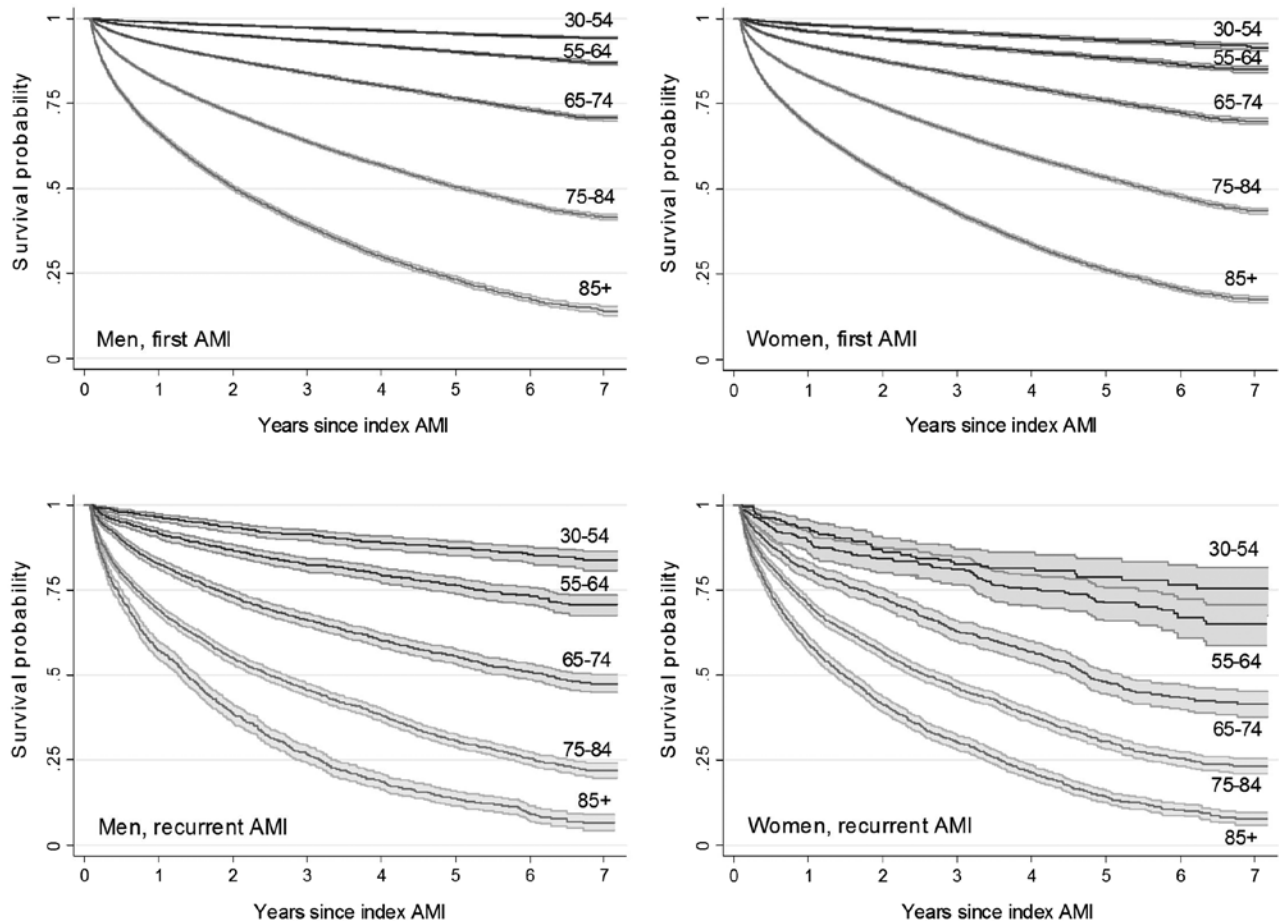


Figure 1. Seven-year survival in 30-day survivors of acute myocardial infarction (AMI) by type of AMI, sex, and age group, 2004 to 2010, England.

75 years and older; there was no difference between men and women aged 55 to 74 years.

Standardized Mortality Ratios

Standardized mortality ratios (SMRs) were used to compare long-term mortality rates among 30-day AMI survivors with the general population. The SMR at 4 months after a first index AMI peaked at 370 (95% CI, 363–378) in men and 420 (95% CI, 412–428) in women (Figure 2). SMRs declined with time and stabilized at about 200 for both sexes, without any noteworthy changes in the following 4 years. At 7 years, the risk of all-cause mortality in male and female survivors of first AMI was about twice the risk of all-cause mortality in the English general population. The age-specific SMRs in the 7th year after a first AMI were highest among younger individuals aged 55 to 64 years and decreased with older age, approaching the mortality rate of the general population for those aged 85 years or more (Figure 3).

For survivors of a recurrent index AMI, the SMR at 4 months was 614 (95% CI, 576–654) in men and 597 (95% CI, 557 to 640) in women (Figure 2). The SMR for both sexes had almost halved by the end of 2 years. In the following 5 years, it stabilized for men at around 300, but there was no clear pattern for women (probably because of the low number of cases). There were also no clear patterns in the differences between men and women. By 7 years, the risk of all-cause

mortality in both male and female survivors of recurrent AMI was about 3 times higher than the risk of dying in the English general population. The age-specific SMRs in the 7th year after a recurrent AMI exhibited similar patterns as for first AMIs; however, among those individuals aged 85 years or more, the mortality rate was about twice as high as the rate in the general population (Figure 3).

Risk of a Second AMI

The index AMI event was a first-ever AMI for 371 619 (96%) of all 30-day AMI survivors. Among these individuals, 40 726 (11%) experienced a second AMI event during the study period, of which 13 248 (33%) were fatal. A further 68 423 (18%) people died from a cause other than AMI during the study period.

Figure 4 shows cumulative incidence plots for risk of a second AMI (fatal or nonfatal) over 7 years by sex and age. The recurrence risk was greatest in the first year after the index first AMI, accounting for just less than half the cumulative 7-year risk. The risk continued to increase in subsequent years, but more gradually. For men, the risk of any second AMI (fatal or nonfatal) was 5.6% (95% CI, 5.5–5.7) at 1 year, 11.1% (95% CI, 10.9–11.2) at 4 years, and 13.9% (95% CI, 13.7–14.1) at 7 years. The corresponding figures for women were 7.2% (95% CI, 7.1–7.4), 13.4% (95% CI, 13.2–13.6), and 16.2% (95% CI, 16.0–16.5), respectively. The risk of a second AMI increased

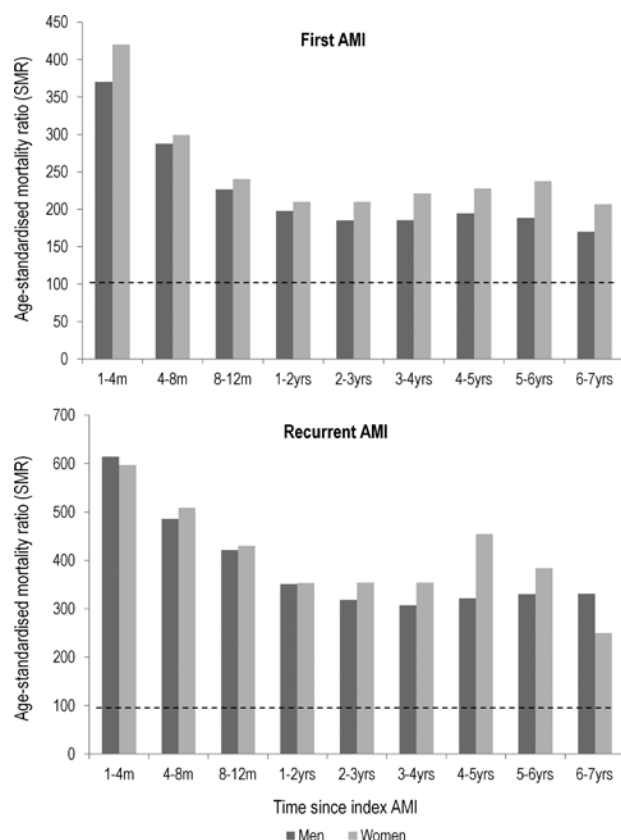


Figure 2. Age-standardized mortality ratios over 7 years in 30-day survivors of acute myocardial infarction (AMI), by sex and type of AMI, 2004 to 2010, England.

with older age in both sexes. The cumulative incidence plots by age and sex for risk of a second nonfatal AMI were similar to the plots for any second AMI, but the risks were lower (data not shown).

Prognostic Factors for a Second AMI

Table 2 shows HRs for the risk of a second AMI for men and women, after adjusting for age, deprivation, procedures, and comorbidities. The risk of a second AMI increased with older age and greater deprivation: the HRs were 3.21 (95% CI, 3.05–3.38) in men and 2.98 (95% CI, 2.74–3.25) in women, when comparing the age group of 85 years and older with the age group of 30 to 54 years; and 1.38 (95% CI 1.33–1.44) in men and 1.24 (95% CI, 1.18–1.30) in women, when comparing the most deprived group with the least deprived group. Having a PTCA or CABG procedure was associated with a lower risk of a second AMI. Generally, the presence of comorbidities was associated with an increased risk of a second AMI. Similar patterns were observed for the risk of a nonfatal second AMI (data not shown).

Table 3 shows adjusted HRs for the risk of a second AMI by age. Generally, there were no large differences in the risk between men and women, with men having only slightly higher risk of recurrence after adjusting for the other factors. However, in those aged 85 years and older, men had about a 30% higher risk than women after adjustment. The effect of deprivation on recurrence risk decreased with increasingly older age. The effect of comorbidities varied by age group,

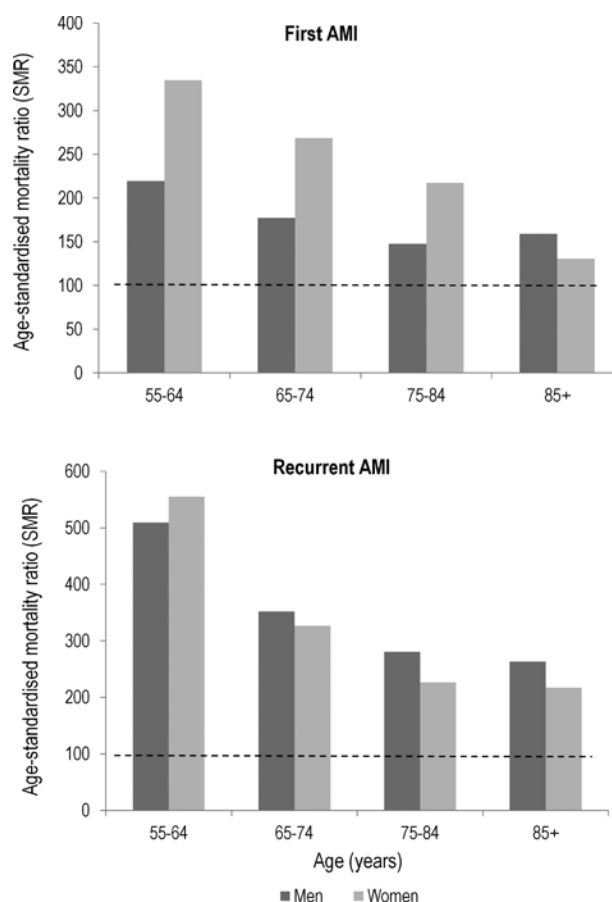


Figure 3. Age-standardized mortality ratios in 30-day survivors of acute myocardial infarction (AMI), in the 7th year after the AMI, by sex, age, and type of AMI, 2004 to 2010, England.

but generally also attenuated with increasing age. Diabetes continued to be a risk factor for a second AMI at all ages. The strength of the association between having a revascularization procedure and longer survival increased with older age. However, very few patients aged over 85 years had undergone CABG and its effect could not be determined in this age group. Similar patterns were observed for the risk of a nonfatal second AMI (data not shown).

Discussion

This study provides a comprehensive account of 7-year prognosis in 30-day AMI survivors in England between 2004 and 2010. It extends current knowledge of AMI epidemiology by reporting long-term survival, quantifying the extent to which AMI survivors have a worse prognosis than the general population, and reporting their risk of having a second AMI. Around 1 in 7 men and 1 in 6 women who survived their first AMI experienced a second AMI within 7 years, with the recurrence risk increasing with older age. By 7 years, all-cause mortality in survivors of first and recurrent AMI remained, respectively, 2 and 3 times higher than that of the English general population of equivalent age.

Long-Term Survival

Overall, we showed that 30-day survivors of AMI continue to be a high-risk group of patients, with about one-quarter of survivors

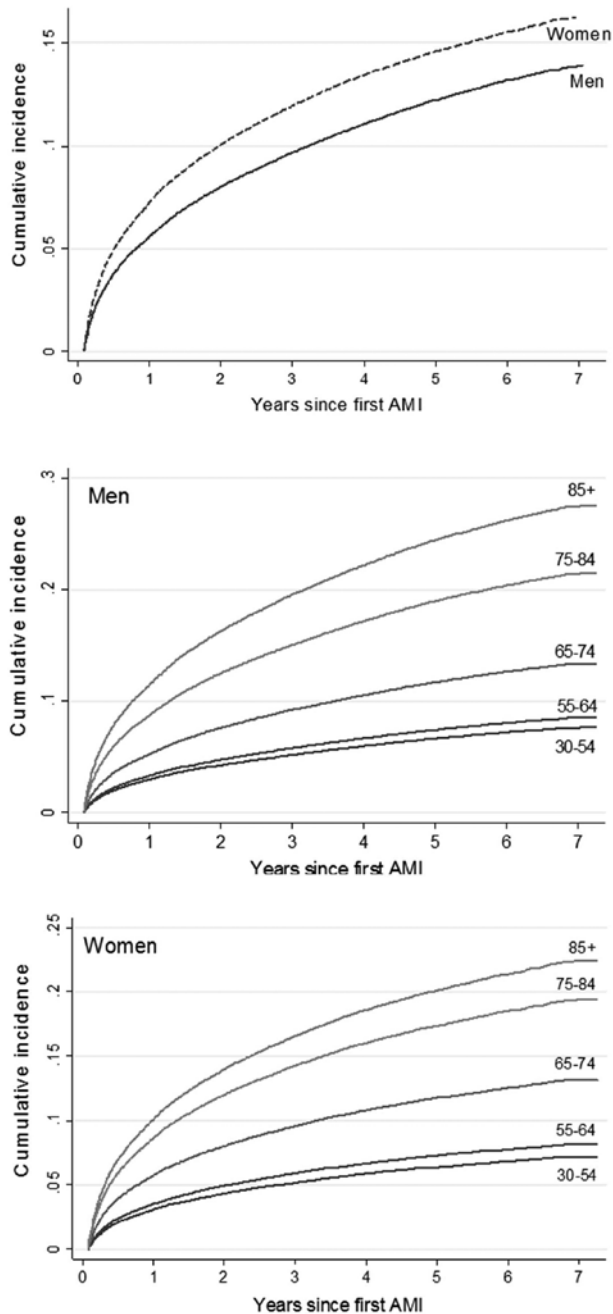


Figure 4. Risk of a second acute myocardial infarction (AMI) over 7 years among 30-day survivors of first AMI by sex, age, and year since first AMI, 2004 to 2010, England. Risk of a second AMI in % = cumulative incidence $\times 100$.

of first index AMI and half of survivors of recurrent index AMI dying within 7 years of the event. Importantly, survivors of both first and recurrent AMI had a sustained worse prognosis than the general population. Studies from Canada and Sweden also found a similarly higher mortality risk in AMI survivors compared with the general population (about 3 times as high at 1 year after the event).^{4,21} We also report that the increased risk of death is particularly high in the middle-aged AMI survivors. These results carry an important message for clinicians: even several years after the event, AMI patients continue to have an elevated risk of death and may benefit from long-term secondary prevention.

Table 2. Factors Influencing the Risk of a Fatal or Nonfatal Second AMI Among 30-Day Survivors of First AMI by Sex, 2004 to 2010, England

Factor	Men HR* (95% CI)	Women HR* (95% CI)
Age, y		
30–54	Ref.	Ref.
55–64	1.06 (1.01–1.12)	1.10 (0.99–1.22)
65–74	1.56 (1.49–1.63)	1.70 (1.56–1.86)
75–84	2.46 (2.36–2.58)	2.51 (2.31–2.73)
85+	3.21 (3.05–3.38)	2.98 (2.74–3.25)
Deprivation		
Least deprived, 1	Ref.	Ref.
2	1.06 (1.02–1.1)	1.05 (1.00–1.10)
3	1.17 (1.13–1.22)	1.05 (1.00–1.11)
4	1.21 (1.17–1.26)	1.13 (1.08–1.19)
Most deprived, 5	1.38 (1.33–1.44)	1.24 (1.18–1.30)
Procedure		
CABG†	0.30 (0.25–0.37)	0.38 (0.27–0.54)
PTCA‡	0.57 (0.55–0.59)	0.60 (0.56–0.64)
Comorbidity		
Cancer	0.97 (0.90–1.03)	0.78 (0.69–0.88)
Cardiovascular disease	1.36 (1.32–1.41)	1.43 (1.37–1.49)
Diabetes	1.59 (1.54–1.64)	1.66 (1.60–1.72)
Respiratory disease	1.18 (1.15–1.22)	1.06 (1.02–1.10)
Renal disease	1.19 (1.13–1.25)	1.03 (0.97–1.10)

AMI indicates acute myocardial infarction; HR, hazard ratio; and CI, confidence interval.

*Adjusted for all other factors shown.

†CABG, coronary artery bypass graft; reference group is those without CABG.

‡PTCA, percutaneous transluminal coronary angioplasty; reference group is those without PTCA.

We found that long-term prognosis for AMI survivors is worse in younger and better in older women than men, a finding similar to that in earlier reports from the United States,²² Canada,²³ Norway,⁷ and Sweden.²⁴ Others have found no sex differences in age-adjusted long-term mortality after AMI,^{13,25–27} but age-specific rates for men and women were not reported in these studies. Some of the higher mortality in younger women can be attributed to a higher prevalence of diabetes and other comorbidities and more in-hospital complications than men.^{22,24,25,28–30} Other possible explanations include premature coronary heart disease, different pathophysiological mechanisms, anatomic differences, and atypical symptom presentation in women.^{22,28,31–33}

Risk of a Second AMI

We found that among survivors of a first AMI who experienced a second event, about half of these second AMIs occurred within the first year. These results indicate that patients who survived their first AMI are most prone to recurrence in the earlier period after the initial infarct, indicating that the influence of predisposing factors for second AMI lessens with time. Another study recently reported similar results: in Sweden, a study of recurrence among survivors of AMI between 1972 and 2001 found that the risk of a second AMI decreased sharply within the first

Table 3. Factors Influencing Occurrence of a Fatal or Nonfatal Second AMI Among 30-Day Survivors of First AMI by Age Group, 2003 to 2007, England

Factor	30–54 Years HR* (95% CI)	55–64 Years HR* (95% CI)	65–74 Years HR* (95% CI)	75–84 Years HR* (95% CI)	85+ Years HR* (95% CI)
Sex					
Women	Ref.	Ref.	Ref.	Ref.	Ref.
Men	1.11 (1.02–1.22)	1.11 (1.04–1.19)	1.03 (0.99–1.08)	1.11 (1.07–1.14)	1.24 (1.19–1.29)
Deprivation					
Least deprived, 1	Ref.	Ref.	Ref.	Ref.	Ref.
2	1.01 (0.89–1.16)	1.15 (1.04–1.28)	1.06 (0.99–1.14)	1.07 (1.02–1.13)	1.01 (0.95–1.07)
3	1.14 (1.01–1.29)	1.34 (1.21–1.48)	1.14 (1.06–1.22)	1.12 (1.06–1.18)	1.04 (0.98–1.11)
4	1.32 (1.17–1.48)	1.51 (1.37–1.66)	1.24 (1.16–1.33)	1.16 (1.11–1.22)	1.00 (0.94–1.07)
Most deprived, 5	1.52 (1.36–1.70)	1.76 (1.60–1.94)	1.44 (1.35–1.54)	1.22 (1.16–1.28)	1.08 (1.01–1.16)
Procedure					
CABG†	0.51 (0.31–0.85)	0.40 (0.26–0.60)	0.31 (0.23–0.42)	0.25 (0.18–0.35)	-
PTCA‡	0.88 (0.81–0.96)	0.64 (0.59–0.69)	0.53 (0.50–0.57)	0.49 (0.46–0.52)	0.58 (0.51–0.66)
Comorbidity					
Cancer	1.24 (0.78–1.96)	1.25 (1.00–1.58)	1.07 (0.95–1.21)	0.86 (0.78–0.94)	0.82 (0.73–0.92)
Cardiovascular disease	1.27 (1.18–1.37)	1.32 (1.23–1.41)	1.40 (1.32–1.48)	1.41 (1.35–1.48)	1.34 (1.27–1.42)
Diabetes	1.77 (1.63–1.93)	2.17 (2.03–2.32)	1.90 (1.81–1.98)	1.46 (1.41–1.52)	1.22 (1.16–1.29)
Respiratory disease	1.30 (1.17–1.44)	1.30 (1.20–1.40)	1.34 (1.27–1.40)	1.11 (1.07–1.15)	0.91 (0.87–0.96)
Renal disease	2.35 (1.92–2.87)	1.95 (1.68–2.26)	1.46 (1.34–1.59)	1.07 (1.01–1.14)	0.92 (0.85–0.98)

AMI indicates acute myocardial infarction; HR, hazard ratio; and CI, confidence interval.

*Adjusted for all other factors shown.

†CABG, coronary artery bypass graft; reference group is those without CABG.

‡PTCA, percutaneous transluminal coronary angioplasty; reference group is those without PTCA.

two years, reached its minimum at 5 years, and then started to slowly increase again.¹⁷ The greater recurrence risk during the first few years immediately after the initial event is likely to be caused by ongoing disease processes. These findings indicate that patients who have experienced an AMI will benefit from prompt initiation of evidence-based secondary prevention.

Prognostic factors for a second AMI were similar to those for death: older age, higher deprivation, and the presence of other diseases as comorbidities. The effect of deprivation and comorbidities decreased with age. Diabetes was confirmed to be a strong risk factor for recurrence for both men and women and for all age groups.^{15,16,34} Because of the limited information available in the dataset used for this study, the effect of the main coronary risk factors (smoking status, high blood cholesterol levels, and high blood pressure), which have been shown to affect AMI recurrence,¹⁵ could not be assessed. Other factors that may have influenced recurrence, but could not be investigated in this study, include infarct severity, pharmaceutical treatment, psychological factors, social environment, and patient compliance with drug therapy and advice on physical activity, weight control, and healthy diet.

Study Strengths and Limitations

The strengths of this study include its large size, population-level representation, complete national coverage, and recent data. In addition, we report age-specific information and distinguish between first and recurrent events. This study also demonstrates the use of very large scale national record-linkage

resources for the study of outcomes in cardiovascular (and other) diseases. Methodologically, this is the first study, to the best of our knowledge, to use competing risk analysis to estimate AMI recurrence—an approach that has been previously used in a number of cancer studies and recently, for stroke recurrence.³⁵

The main limitation is the reliance on the accuracy and validity of routinely collected data. However, a systematic review of studies comparing routine hospital discharge statistics with medical records conducted in England, Wales, and Scotland reported, on average, high coding accuracy rates.³⁶ Linked Scottish Morbidity Record Database and Patient Episode Database for Wales, equivalents of the English HES, were reported to have high accuracy rates for the diagnosis of AMI.^{16,37}

Further limitations include the absence of clinical information, making it impossible to adjust for coronary risk factors and infarct severity, or to report on the diagnostic criteria used in making the clinical diagnosis of AMI. HES records do not contain information on drug prescriptions and thus treatment effect could not be examined. Information on previous episodes of AMI was limited to 6 years of prior history and, inevitably, a small proportion of events that were classified as “first” were in fact recurrent. It is also possible that some AMIs that were identified as recurrent (based on the 30-day cut-off to distinguish separate events) might not have been new events and were still related to the previous AMI. Some AMI hospital admissions with a length of stay of 1 day or less and live discharge or with only a secondary

diagnosis of AMI—excluded from this study—could have been true instances of AMI. Silent AMIs that did not lead to a hospital admission or a death record could not be captured by the available data and thus would not have been included in the study. Some deaths coded with other CHD as the underlying cause of death could have been cases of AMI, but, as this is not knowable, they could not be included. The introduction of the new diagnostic criteria for AMI in 2000 could have influenced our estimates. However, studies have shown that this change in criteria does not affect hospitalized case fatality.^{38–41} It is plausible that estimates of long-term survival are also not affected to any great extent. Unfortunately, we did not have access to clinical information and therefore could not adjust for the change in diagnostic criteria for AMI.

Conclusions

This study extends and updates current information on prognosis after an AMI, specifically long-term survival and the risk of a second event. Survivors of either a first or a recurrent AMI remained at a significantly higher risk of death compared with the general population over at least 7 years, particularly the middle-aged individuals. A substantial proportion of 30-day survivors of first AMI experienced a second AMI within the subsequent 7 years. The influence of predisposing factors for a second AMI lessened with time after the initial event. The results highlight the fact that AMI survivors remain a high-risk group for recurrent events and mortality and reinforce the importance of both acute clinical care and secondary prevention in improving the long-term prognosis of hospitalized AMI patients.

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Disclosures

None.

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