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A national record linkage to study acute myocardial infarction incidence and case fatality in Sweden

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Background	During the last decades substantial temporal changes, as well as population differences, in coronary heart disease mortality have occurred in Sweden. There is little information to what extent these changes and differences also apply to myocardial infarction incidence. The aim of this paper was to describe the methods used to identify cases in a recently developed National Acute Myocardial Infarction Register in Sweden, and to present estimates of incidence and case fatality in Sweden.
Material and Methods	Incident cases of acute myocardial infarction (AMI) were identified by record linkage of routinely collected data on hospital discharges and deaths. Case fatality within 28 days was ascertained by linkage of incident cases to the National Cause of Death Register.
Results	About 40 000 new cases of AMI per year were recorded in Sweden during 1987–1995. Well-known differences in incidence with regard to age and gender were observed, as well as a decline in incidence between 1987 and 1995. A similar case fatality was seen in men and women aged 30–89 among hospitalized cases. When fatal cases outside hospital were also considered the case fatality was somewhat higher in men. Examination of medical records for a national sample of ischaemic heart disease patients suggested a high sensitivity (94%) and a high positive predictive value (86%) for ICD-9 code 410 in hospital discharge data with regard to definite AMI.
Conclusions	The National Acute Myocardial Infarction Register offers a new possibility to study the incidence of AMI, as well as case fatality, in Sweden.

Keywords	Acute myocardial infarction, surveillance, record linkage, registers
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Coronary heart disease mortality has declined in Sweden during the last decades as in several other western countries.[1] Over the period 1984–1994 the decline was about 35% in both men and women. There are also large regional differences in coronary heart disease mortality within the country.[2] Thus, there is higher coronary heart disease mortality in the northern part of Sweden and in the mid-west than in the south including the two largest cities of Stockholm and Gothenburg. There is little information as to what extent these temporal changes and population differences apply to the incidence of myocardial infarction. Information about incidence of acute myocardial infarction (AMI) in Sweden is available primarily from the Swedish MONICA centres in Gothenburg and northern Sweden.[3,4] However, the population covered by these two centres represents only about 10% of the Swedish population aged 35–64 years. Thus, we know little about time trends and population differences in the population as a whole. A record linkage method to identify incident cases of AMI based on routinely collected data on hospital discharges and deaths

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has previously been applied in Sweden.[5,6] This method was adopted by the National Board of Health and Welfare in Sweden for the development of a National Register of Acute Myocardial Infarction. Time trends in AMI incidence and in case fatality during 1987–1995 based on this register have recently been presented.[7] The aim of this paper was to describe the methods used to identify cases in the National Acute Myocardial Infarction Register and to present estimates of incidence by sex and age as well as estimates of case fatality for all cases and for hospitalized cases in Sweden.

Methods

In Sweden there is a long history of a reliable population registration system and also national registers of hospital discharges and deaths, where individuals can be identified by a unique personal identification number. Hospital discharges have been registered at the National Board of Health and Welfare since the 1960s and from 1987 this registration has been national. The Hospital Discharge Register covers all discharges from public hospitals including hospitals treating acute medical cases. There are essentially no diagnosed cases of non-fatal AMI in Sweden treated out of hospitals.[8] The National Cause of Death Register covers all deaths in Sweden since 1952 and there is basically no loss of deaths in this register.

To identify cases of AMI for the Swedish national register all hospital discharges with International Classification of Diseases Ninth Revision (ICD-9) code 410 during the period 1987–1995 were selected from the National Hospital Discharge Register. From the National Cause of Death Register all deaths with AMI (ICD-9: code 410) as the underlying or contributory cause of death during these years were extracted. This information was combined by record linkage in accordance with a previously developed algorithm.[5] As a rule, all hospital admissions or death for the same subject occurring within 28 days were considered to reflect one myocardial infarction episode. Otherwise a subject was considered to have had more than one myocardial infarction episode. It was not possible in this study to distinguish between first and recurrent events. In order to study case fatality all cases were followed with regard to death from any cause in the National Cause of Death Register during the years 1987 to 1996, i.e. for at least one year after the infarction. In the compilation of the national AMI register information about diagnosis was missing in 0.8% of admissions to departments of internal medicine. A valid personal identification number was missing in less than 0.5% of all potential cases.

In order to assess the quality of the diagnostic information, a national sample of hospital-treated patients discharged from hospital in 1987 or in 1995 respectively was selected for examination. In all, 2065 patients with a discharge diagnosis of AMI (ICD-9 code 410), or other ischaemic heart disease (ICD-9 codes 411–414) were selected. Medical records, and for fatal cases autopsy protocols and death certificates, were obtained for about 90% of the patients (1848 patients). These hospital records were examined using diagnostic criteria at the time recommended for national use in Sweden. In brief, definite AMI was considered to be present if there were (1) signs of a recent myocardial infarction at autopsy, (2) a new pathological Q wave on the ECG, or (3) typical symptoms or new ST segment elevation or T wave inversion on the ECG in combination with typical serum enzyme (or other biochemical marker) changes. Typical changes were defined as (a) creatine kinase (CK) >3.3 μkat/l (men) or >2.5 μkat/l (women) together with CK isoenzyme B (CK-B) >0.2 μkat/l and a ratio of CK to CK-B of 0.03–0.12, or (b) CK or CK-B exceeding the limits above together with lactate dehydrogenase (LD) isoenzyme 1 (LD-1) >3.3 μkat/l, or a ratio of aspartate aminotransferase (ASAT;μkat/l) and alanin aminotransferase (ALAT;μkat/l) >2 and ASAT >0.75 μkat/l, or (c) CK isoenzyme MB mass (CK-MB mass) >10 μg/l, or (d) troponin-T >0.2 μg/l or (e) myoglobin >100 μg/l in combination with LD-1 >3.3 μkat/l or a ASAT to ALAT ratio >2 and ASAT >0.75 μkat/l, or (f) LD >0.8 μkat/l and LD-1 >3.3 μkat/l.

Incidence rates were computed by age and sex in 1987 and 1995 using the mean population as an estimate of the person-years at risk. The relative risk of AMI in 1995, as compared to 1987, adjusted for differences in age distribution, was estimated by means of a multiplicative model assuming that the observed number of cases followed a Poisson distribution. From this model a 95% CI for the relative risk was also obtained. Age-adjusted case fatality for the whole period 1987–1995 was compared between men and women by means of standardized risk ratios (SRR) together with 95% CI. In the age standardization the age distribution in 5-year age groups for all cases during 1987–1995 was utilized.

Results

In the evaluation of diagnostic quality, 713 cases with a discharge diagnosis of AMI were included and 612 of these (86%) were classified as definite AMI according to the diagnostic criteria. Another 9% were classified as possible AMI and 5% were classified as not being AMI. There were in all 1135 patients with a discharge diagnosis of other ischaemic heart disease. Of these, 37 (3%) fulfilled the criteria for definite AMI, whereas most patients (97%) were classified as not AMI. The sensitivity for ICD-9 code 410 for definite AMI as computed using this range of ischaemic heart disease diagnoses was 94%.

Out of hospital deaths constituted 22% of all cases, and 15% of cases in ages 30–64 years. The autopsy rate for out of hospital deaths was 43% for men and 35% for women, and higher in subjects below 75 years of age. In the age group 30–64 years, 5% of all male cases and 4% of all female cases were out of hospital deaths without an autopsy supporting the diagnosis. The corresponding proportions for cases above 75 years of age were 19% in men and 20% in women and for all cases 13% in men and 15% in women.

During the period 1987–1995, in all, 368 905 cases of AMI among 345 254 individuals were identified in Sweden. This corresponds to about 40 000 new cases of AMI per year, which makes it almost as common as all cancer. Among men aged 30–89 years the crude incidence rate per 10 000 inhabitants was 105.1 in 1987 and 91.7 in 1995 (Table 1). The corresponding incidence for women was 56.5 per 10 000 inhabitants in 1987 and 52.0 in 1995, i.e. about half of that among men. The incidence was lower in women than in men in all age groups but increased steeply with age in both genders. For men the crude incidence rate was 13% lower in 1995 than in 1987, and for women it was 8% lower. Taking changes in the age distribution between these years into account, the relative risk of AMI in Sweden in 1995 as compared to 1987 was

Table 1 Incidence of acute myocardial infarction per 10 000 inhabitants in Sweden 1987 and 1995. By gender and age

	Men			Women		
Age (years)	1987	1995	Difference (%)	1987	1995	Difference (%)
30–34	1.3	1.0	0.3 (23)	0.5	0.5	0.0 (0)
35–39	5.2	3.9	1.3 (25)	1.0	0.7	0.3 (30)
40–44	11.4	9.9	1.5 (13)	2.2	2.5	–0.3 (–14)
45–49	29.2	21.3	7.9 (27)	6.0	5.1	0.9 (15)
50–54	51.5	40.1	11.4 (22)	9.3	9.3	0.0 (0)
55–59	92.5	70.7	21.8 (24)	19.2	17.2	2.0 (10)
60–64	135.2	108.4	26.8 (20)	37.7	34.7	3.0 (8)
65–69	196.4	155.9	40.5 (21)	66.9	54.9	12.0 (18)
70–74	277.8	230.2	47.6 (17)	119.3	101.7	17.6 (15)
75–79	369.3	333.2	36.1 (10)	195.4	162.0	33.4 (17)
80–84	438.4	442.1	–3.7 (–1)	270.7	247.5	23.2 (9)
85–89	483.9	544.7	–60.8 (–13)	325.5	325.6	–0.1 (0)
30–89	105.1	91.7	13.4 (13)	56.5	52.0	4.5 (8)

0.87 (95% CI : 0.85–0.88) in men and 0.89 (95% CI : 0.87–0.91) in women.

The overall crude 28-day case fatality in Sweden during the period 1987–1995 for patients with AMI 30–89 years old was 42% among men and 45% among women (Table 2). Taking into account that women on average were older than men when they experienced the infarction a higher age-adjusted 28-day case fatality was seen in men than in women (SRR = 1.07, 95% CI : 1.06–1.08). Notably, 60% of these early deaths among men and 53% among women occurred out of hospital. The 28-day case fatality was about 25% for all hospitalized cases of AMI in Sweden in those aged 30–89 years. When differences in age distribution were taken into account in the analyses there was only a very small difference between genders with a slightly lower case fatality in men (SRR = 0.98, 95% CI : 0.97–1.00). A detailed description of case fatality by age and gender in Sweden based on these data has been given previously.[9] During the period 1987–1995 there was an improvement in survival after AMI in Sweden among both men and women. The age-adjusted case fatality among hospital-treated patients fell from 30% in men and 28% in women in 1987 to 23% in both genders in 1995.[7]

The decline in incidence and case fatality in Sweden between 1987 and 1995 contributed to a decrease in mortality from AMI during the study period. Taking changes in the age distribution into account the mortality decreased by 7.7 cases per 10 000 inhabitants from 1987 to 1995 among men and by 4.2 cases per 10 000 inhabitants among women 30–89 years old. If the case fatality had been the same in 1995 as in 1987 in each 5-year age group the decline in mortality over this period would have been 3.5 cases per 10 000 inhabitants less in men and 1.8 cases per 10 000 inhabitants less in women. The improved case fatality may thus have contributed to 45% (3.5/7.7) of the reduction in mortality from AMI in men and 43% (1.7/4.3) of the reduction in women.

Discussion

The National Acute Myocardial Infarction Register in Sweden provides for the first time an opportunity to study disease incidence and case fatality for the entire Swedish population. Information from this register suggests that about 40 000 cases of AMI occur each year in Sweden. Analyses of incidence rates by age and sex show a well-known pattern of a higher incidence among men than among women, and a steep increase with age for both genders. Furthermore, a decline in incidence of AMI in Sweden between 1987 and 1995 was seen. In a previous report we estimated the average annual decline in incidence over this period to be 1.6% per year among men and 1.3% per year among women.[7] These national data suggest that this decline in incidence is the main reason for the parallel reduction in mortality from AMI but also that improved survival contributes substantially. A strong improvement in survival after AMI during the period 1985–1994 for men but not for women aged 25–64 years has been reported from the Northern Sweden MONICA study.[10]

The Swedish national registers of the population and of hospital discharges and deaths that can be linked using the Swedish personal identification number constitute important prerequisites for the method employed in the National Acute

Table 2 Case fatality within 28 days after acute myocardial infarction. Men and women 30–89 years old in Sweden 1987–1995

	All cases		Hospitalized cases	
	Men	Women	Men	Women
No. of cases	221 390	132 514	166 108	101 139
Fatal cases within 28 days	92 750	59 127	37 468	27 752
Crude case fatality (%)	42	45	23	27
Age-standardized risk ratio (95% CI)	1.07 (1.06–1.08)	1.0	0.98 (0.97–1.00)	1.0

Myocardial Infarction Register for identification of cases. This record linkage method also relies on the validity of the ICD-9 code 410 for case ascertainment. The retrospective examination of diagnostic information for a national sample of patients suggests a high positive predictive value as well as a high sensitivity for the ICD-9 code 410 in the national register. Similar results have been obtained in previous Swedish studies. Thus, in a recent study Alfredsson *et al.* found a sensitivity of the ICD-9 code 410 for detecting cases of definite AMI of 96% and a positive predictive value of 88%.[11] In a smaller study by Lindblad *et al.* these figures were even higher.[12] A fairly high sensitivity of the ICD-9 code 410 in hospital discharge data has also been reported from a number of studies in other countries including Finland, the US, Australia and New Zealand[13–19] (Table 3). The positive predictive value, however, has been lower in studies outside the Scandinavian countries. This may indicate that the ICD-9 code 410 in hospital discharge data perhaps corresponds more closely with established diagnostic criteria in Scandinavia than in many other countries.

In Sweden, the record linkage method used for identifying cases of AMI in the National Acute Myocardial Infarction Register has also been compared to other methods for case identification. Two such comparisons concerned WHO community registers and the Stockholm Heart Epidemiology Program (SHEEP) respectively.[6,20] The WHO community registers were in operation in five Swedish cities in the 1970s and early 1980s. The Stockholm Heart Epidemiology Program was a population-based case-control study in Stockholm that was conducted during the years 1992–1994 where the aim was to identify cases of first AMI in subjects aged 45–70 years.[21] For this purpose a special organization was established at each hospital in Stockholm treating acute medical cases. In addition, information from registers was used for case identification. The sensitivity of the record linkage method vis-à-vis the WHO community registers was 81% and vis-à-vis SHEEP 97%.[6,20] When compared the other way around, the sensitivity was of about the same order for the WHO community registers and SHEEP vis-à-vis the record linkage method. In part, the higher sensitivity of the record linkage method in the comparison to SHEEP was due to a better quality of the hospital discharge register. The positive predictive value for the ICD-9 code 410 was over 90% in both comparisons.

One important limitation of the record linkage method concerns the lack of information in the registers used to identify cases regarding diagnostic indicators, treatment factors and risk factors. This limits the possibilities for interpretation of observed differences and time trends. Thus, to go beyond a purely descriptive level it is necessary to obtain additional information. To some extent information from national registers of clinical data and from censuses may be added, by record linkage, to the National Acute Myocardial Infarction Register in Sweden.

In conclusion, a National Acute Myocardial Infarction Register has been formed in Sweden. Through this register about 40 000 cases of AMI were recorded each year in Sweden during the period 1987–1995. A decline in AMI incidence as well as in case fatality has been observed during this period. The quality controls that have been carried out suggest that this type of information can give valuable information on AMI in the whole population. However, there are limitations in using this method including a lack of detailed information about the cases. In addition, there is inherent a certain misclasification of disease which needs continuous monitoring and which has to be taken into account in interpreting observed population differences or time trends in disease incidence or case fatality.

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Table 3 Results from studies of the sensitivity and positive predictive value of the International Classification of Diseases (ICD) code 410 in hospital discharge records for the identification of cases of definite acute myocardial infarction (AMI)

First author	Year of publication	Country	Validated cases	Non-AMI ICD codes	Sensitivity %	Positive predictive value %
Kennedy[13]	1984	USA	20 276	All	94	61
Beaglehole[14]	1987	New Zealand	858	All	86	67
Dobson[15]	1988	Australia	1560	411–414	85	70
Mascioli[16]	1989	USA	1845	412–414	87	60
Lindblad[12]	1993	Sweden	432	410–411	99	96
Palomäki[17]	1994	Finland	1565	All	89	86
Boyle[18]	1995	Australia	2492	411–414, 426–429, 786.5	79	66
Pladevall[19]	1996	USA	734	36, 99, 411–414, 427, 429, 440, 786	81	55
Alfredsson[11]	1997	Sweden	1046	411–414	96	88

KEY MESSAGES

- A National Acute Myocardial Infarction Register has been formed in Sweden.
- Through this register about 40 000 cases of acute myocardial infarction (AMI) were recorded each year in Sweden during the period 1987–1995.
- A decline in AMI incidence, as well as in case fatality, was observed during this period.
- Quality controls suggest that this register can give valuable information on AMI in the Swedish population.

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