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Acute myocardial infarction and associated deaths in Switzerland – an approach to estimating incidence

Abstract

Background and question under study: In Switzerland, there is a lack of population-based data on the event rate of acute myocardial infarction (AMI) and case fatality. The aim of this study was to estimate the AMI incidence rate in Switzerland and case fatality for both in-hospital and out-of-hospital deaths due to AMI.

Methods: All data were taken from the Swiss Hospital Statistics (HOST) and Cause of Death Statistics (CoD) databases 2004. Data were coded according to ICD 10. In order to estimate AMI event rate, we considered (1.) all cases with hospital discharge diagnosis “AMI” (I 21; I 22; HOST) and (2.) all cases with AMI as underlying cause of death (I 21; I 22; CoD).

Results: In the HOST, the rate for age-standardised hospital discharges was 118/100 000 overall (60/100 000 for women; 183/100 000 for men). The age-standardised AMI incidence rate was 131/100 000 overall (for women 68/100 000; for men 202/100 000). Age-standardised out-of-hospital case fatality (5.0% for women, 5.3% for men) was higher than age-standardised in-hospital case fatality (2.3% for women, 2.4% for men). In both sexes, on average, six out of ten deaths due to AMI occurred outside the hospital.

Conclusion: To our knowledge, this was the first estimation of AMI incidence and case fatality for Switzerland. Data from the HOST database revealed only 11514 AMI cases (3799 women; 7735 men). By using both, HOST and CoD database estimated incidence could be increased to 13007 AMI cases (4414 women, 8593 men). Nevertheless, the estimated AMI incidence rate still does not represent the actual AMI incidence rate for Switzerland since an uncertain proportion of AMI cases and AMI deaths might be unrecognised due to methodological limitations.

Key words: acute myocardial infarction; estimated incidence; case fatality

Introduction

Cardiovascular disease is the most frequent cause of death in Switzerland [1]. Currently, data on acute myocardial infarction (AMI) are available from a local registry on AMI [2] and from the Federal Statistical Office's (FSO) hospital statistics database (HOST) [3]. Additionally, data on death caused by AMI are available from the FSO's Cause of Death Statistics (CoD) [4]. The HOST database keeps a record of all data on hospital discharges of AMI patients. Yet, HOST does not contain a complete set of data on AMI incidence in Switzerland. For its part, the CoD database does not provide information on case fatality nor does it differentiate between in- and out-of hospital deaths. The aim of this study was to estimate AMI incidence for Switzerland by combining data from the HOST and CoD databases. In addition, we aimed at estimating case fatality for both in-hospital and out-of-hospital deaths.

There is no conflict of interest.

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Methodology

The most recent data were taken from the FSO's HOST and CoD databases (2004) [3, 4]. Data were coded according to the International Classification of Disease (ICD) version 10. For HOST, data were coded in the hospitals where patients were discharged from, and then these codes were transferred to the HOST database. In 2004, hospital response rate was 100%.

In Switzerland all deaths are included in the CoD database. The number of deaths is based on data from the civil registry office where deaths are usually announced by family members of the deceased. The civil registry office obtains information on cause of death from the physician who verified the death. Based on this information, the primary cause of death is then coded by the FSO.

For data analysis, we used age groups as applied by the data provider (FSO) in standard morbidity and mortality tables on AMI, and as recommended by EUROCISS [5]. In order to calculate rates, the 2004 data from the Swiss Census database were used [6]. Age standardisation was calculated according to the European standard population [7]. In order to prepare the data that would be used to estimate AMI incidence, and case fatality for both in- and out-of-hospital deaths due to AMI, we applied the following procedure (for definitions see table 1):

- From the HOST database, we selected all AMI cases (I 21 and I 22) documented in one of the first five diagnosis areas (cases A). If a patient was admitted to a district hospital (eg Regional Hospital) following an acute event and later transferred to a major hospital (*ie* University Hospital, Cantonal Hospital or Heart Centre), we used a connection code to identify a patient as being the same patient in the HOST database and thus counted him/her only once.
- In addition, from the HOST database, we extracted data on all AMI cases having a discharge code of 5, which meant that the AMI patient had died while in the hospital (cases Ad). For the calculation procedure, the remaining cases were called in-hospital survivors.
- From CoD, we identified all cases that died from AMI within 28 days after the onset of myocardial infarction (cases B).

Individuals who were discharged alive from hospital after AMI and died later within the same year were not considered as AMI cases in CoD but were coded as death from “chronic ischaemic heart disease” (according to I 25.2 and I 25.8) (table 1).

Table 1

Definitions and calculation procedures.

Acute myocardial infarction	Definition according to ICD 10, code I 21: Myocardial infarction, acute or not longer than 28 days	
Recurrent myocardial Infarction	Definition according to ICD 10, code I 22: Recurrent myocardial infarction, not longer than 28 days	
Case	Individual with AMI (I 21) and/or recurrent Myocardial infarction (I 22)	
AMI hospital discharge rate (per 100 000 population)	$\frac{\text{No. of AMI cases discharged from hospital}}{\text{No. of persons in the population}} \times 100\,000$	
Incidence rate (per 100 000 population)	$\frac{\text{No. of new cases of AMI occurring in the population (referred to one year)}}{\text{No. of persons in the population during a specified period of time}} \times 100\,000$	
Case fatality of hospitalised cases (%)	$\frac{\text{No. of hospitalised individuals dying from AMI within 28 days after onset of AMI}}{\text{No. of hospitalised individuals with AMI}} \times 100$	
In-hospital case fatality (%)	$\frac{\text{No. of individuals dying from AMI in-hospital within 28 days after onset of AMI}}{\text{Estimated no. of individuals with AMI}} \times 100$	
Out-of-hospital case fatality (%)	$\frac{\text{No of individuals dying from AMI out-of-hospital within 28 days after onset of AMI}}{\text{Estimated no. of individuals with AMI}} \times 100$	
Overall case fatality (%)	$\frac{\text{No. of individuals dying from AMI within 28 days after onset of AMI}}{\text{Estimated no. of individuals with AMI}} \times 100$	
Proportion of out-of hospital AMI deaths to all AMI deaths	$\frac{\text{No. of individuals dying from AMI out-of-hospital within 28 days after onset of AMI}}{\text{No. of individuals dying from AMI within 28 days after onset of AMI}} \times 100$	
AMI = acute myocardial infarction; ICD 10 = International Classification of Disease, version No. 10; No. = number		

Calculation procedure

Using a prepared data set (see above) both AMI incidence and case fatality was determined by the following procedures (for definitions and procedure in brief see table 1):

We first determined gender and age-specific rate for AMI patients discharged from the hospital (alive or dead) per 100 000 inhabitants ($[\text{cases A} / \text{population}] \times 100\,000 = \text{AMI discharge rate}$).

We then estimated *AMI incidence rate* as follows: total number of in-hospital survivors (calculated by data from the HOST database) plus the total number of AMI deaths (CoD database), divided by gender and age-specific population per 100 000 ($[\text{cases A} - \text{cases Ad} + \text{cases B}] / \text{population} \times 100\,000 = \text{AMI incidence rate}$).

The case fatality of hospitalised patients was calculated as follows: total number of AMI patients who died from AMI while in the hospital (cases Ad) divided by the total number of AMI patients discharged from the hospital (cases A) ($\text{cases Ad} / \text{cases A} \times 100 = 28\text{-day case fatality of hospitalised cases}$).

We then calculated the *in-hospital case fatality*: total number of patients who died due to AMI inside the hospital divided by the total number of estimated AMI events ($\text{cases Ad} / \text{estimated AMI events} \times 100 = \text{in-hospital case fatality}$).

Out-of-hospital case fatality was calculated as follows: total number of deaths due to AMI reported in the CoD database minus total number in-hospital deaths due to AMI reported in the HOST database divided by the total number of estimated AMI events ($[\text{cases B} - \text{cases Ad}] / \text{estimated AMI events} \times 100 = \text{out-of-hospital case fatality}$).

The *overall case fatality* was calculated by dividing total of deaths reported in CoD database by the total number of estimated AMI events ($\text{cases B} / \text{estimated AMI events} \times 100\,000 = \text{overall case fatality}$).

The *proportion of out-of-hospital AMI deaths to the total number of AMI deaths* was calculated as follows: total number of deaths due to AMI reported in the CoD database minus the total number of in-hospital AMI deaths reported in the HOST database, divided by the total number of AMI deaths reported in the CoD database ($[\text{cases B} - \text{cases Ad}] / \text{cases B} \times 100 = \text{Proportion of out-of-hospital AMI deaths to all AMI deaths}$).

Results

Acute myocardial infarction and recurrent events

Overall, 11 514 cases with hospital discharge diagnosis “AMI” or recurrent myocardial infarctions were identified in the HOST 2004 ($n = 3779$ in women; $n = 7735$ in men). Considering the same diagnoses 2733 deaths have been recorded in CoD 2004 ($n = 1201$ in women; $n = 1532$ in men) (table 2).

For both men and women, the discharge rate (per 100 000) increased in direct proportion to age. The age-standardised hospital discharge rate was 118/100 000 overall, around 60/100 000 for women and around 183/100 000 for men (table 2, fig. 1).

The female-to-male ratio increased slightly from 1:5.7 (age group 25–34) to 1:6.1 (age group 45–54), and then began to decrease up to 1: 1.5 (age group ≥ 85).

The estimated number of cases was 13 007 overall ($n = 4414$ in women; $n = 8593$ in men). For both men and women, the estimated age-specific AMI incidence rate increased steadily up to the oldest age group. The age-standardised AMI incidence rate was 131/100 000 overall (68/100 000 for women and 202/100 000 for men) (table 2; fig. 1). Again the female-to male-ratio increased from 1:5.5 (age group 25–34) to 1:6.1 (age group 45–54) and then decreased up to 1:1.4 (age group ≥ 85) (fig. 1).

Deaths from acute myocardial infarction

The case fatality of hospitalised patients increased in direct proportion to age for both women and men. Case fatality ranged between 0% and 30% for women, and between 2% and 31% for men (fig. 2).

In women, overall case fatality decreased from 14.3% in age group 25–34 to 4.8% in age group 35–44, and then started to increase steadily from 8.6% among 45–54-year-old women to 49.9% among women aged ≥ 85 . In men, the overall case fatality decreased from 13.2% (age group 25–34) to 8.4% (age group 45–54) and then began to increase steadily to 47.9% in the age group ≥ 85 (exhibited by the total bar per age group; fig. 3A, 3B).

When differentiating between in-hospital and out-of hospital AMI deaths, the following could be observed: In men, in each age group, the out-of-hospital case fatality was higher than in-hospital case fatality. The same was true for women with the exception of age group 65–74 and 75–84. In both women and men, an average of six out of ten deaths due to AMI occurred outside of the hospital (61.7% deaths in women, 65.2% deaths in men) (fig. 3A, 3B).

Discussion

To our knowledge, this was the first estimation of AMI incidence for Switzerland based on both the HOST and CoD database. We found that

Table 2

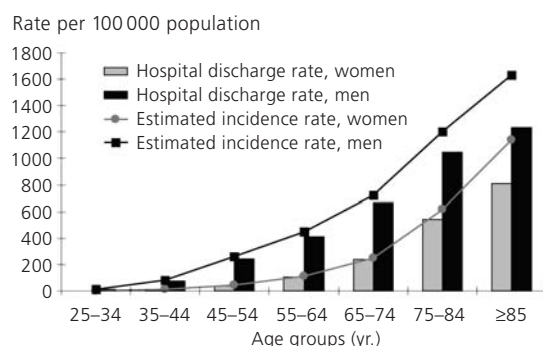
Acute myocardial infarction in Switzerland: Hospital discharge rates for patients diagnosed with acute myocardial infarction (Hospital Statistics), estimated incidence rate (per 100 000 population) (Cause of Death Statistics) and proportion of AMI cases that were not in hospital (data from 2004).

		Age groups (yr)							Total	Age-standardised rate
		25–34	35–44	45–54	55–64	65–74	75–84	≥85		
No of hospital discharges;	f	12 (2.4)	83 (13.4)	206 (39.8)	478 (107.2)	774 (234.7)	1377 (542.3)	849 (812.4)	3779 (136.4)	60.4
Hospital discharge rate (per 100 000)	m	68 (13.7)	469 (75.4)	1279 (244.1)	1810 (413.4)	1860 (665.7)	1704 (1048.3)	545 (1235.0)	7735 (301.6)	182.5
Estimated number of cases;	f	14 (2.8)	85 (13.8)	221 (42.7)	505 (113.3)	831 (251.9)	1570 (618.3)	1188 (1136.9)	4414 (159.4)	68.3
Incidence rate (per 100 000)	m	76 (15.4)	503 (80.9)	1363 (260.1)	1955 (446.5)	2017 (721.9)	1958 (1204.6)	721 (1633.8)	8593 (335.0)	202.0

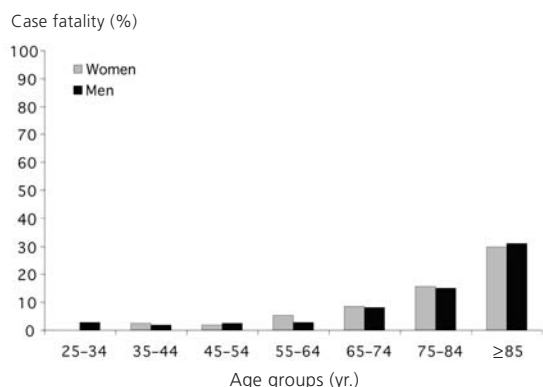
f = female; m = male

Figure 1

Acute myocardial infarction: Hospital discharge rate and estimated incidence rate per 100 000 population, women and men (2004).

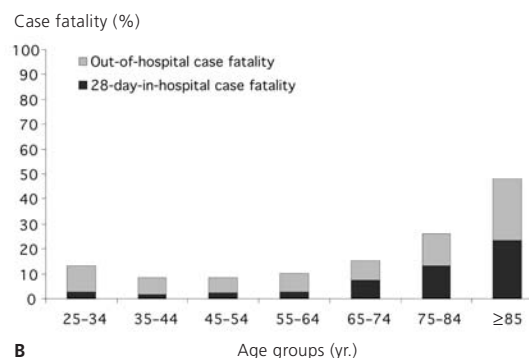
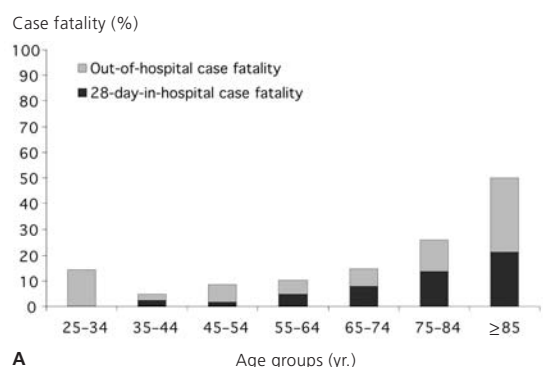
**Figure 2**

Acute myocardial infarction: 28-day case fatality for hospitalised cases, women and men (2004).

**Figure 3**

A 28-day in-hospital case fatality and out-of-hospital case fatality, women (2004).

B 28-day in-hospital case fatality and out-of-hospital case fatality, men (2004).

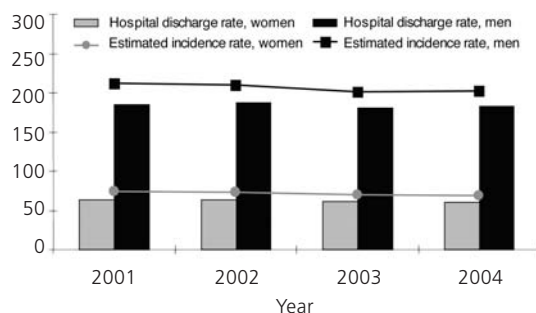


the estimated AMI incidence rate exceeded the number of cases discharged from hospital with AMI as reported by HOST database indicating that the estimated AMI incidence rate is closer to the actual AMI incidence rate. Out-of-hospital AMI deaths accounted for 65% on average of total AMI deaths. Compared 2004, data on hospital discharge rates and estimated incidence rates of the years 2001 to 2003 showed marginal differences (fig. 4).

In order to estimate AMI incidence rate, we needed to identify all patients who were discharged from the hospital alive as well as those who died from AMI either inside or outside the hospital. Nevertheless, there are still cases that are clearly not reported in the HOST or CoD databases. For example, these could be patients suffering from a silent myocardial infarction, and/or exhibiting a false-negative diagnosis of AMI. It has been reported that around 20% of all AMI patients experience silent AMI or acute myocardial infarction with atypical symptoms [8, 9]. Because non-fatal myocardial infarction occurring out of hospital was registered neither in HOST nor CoD database, a further underestimation of AMI incidence could be assumed. Moreover, death

Figure 4

Acute myocardial infarction: Age-standardised hospital discharge rate and estimated incidence rate per 100 000 population (women and men) in 2004 and in the years 2001 to 2003.



certificates do not always indicate AMI as the respective cause of death: in the case of sudden death, for example, where not enough time is available for use of diagnostic tools to justify diagnosis of AMI. Other potential causes of death in which AMI is supposedly the cause of death such as malign rhythm disorders or pulmonary embolism often remain unidentified. For cases where the cause of death is uncertain, there is no obligation to perform an autopsy in Switzerland. This may confound the estimated AMI incidence and case fatality.

In our study, coding of AMI deaths was based on a clinical diagnosis which does mean definite AMI. Contrary, an epidemiological definition could comprise not only definitive clinical diagnosis of AMI but also possible AMI or coronary death and thus, result in different findings. In the German MONICA project, for example, overall 28-day case fatality of hospitalised patients was 28% when an epidemiological definition for AMI and/or AMI death was applied using the diagnostic criteria “definite AMI” and “possible AMI” or “coronary death”. However, if AMI cases were diagnosed on the basis of a clinical definition alone (definite AMI), 28-day case fatality dropped to 13.5% [10]. According to our calculation procedure, an average of 65% of deaths due to AMI occurred outside of the hospital. A similar prevalence for out-of-hospital AMI deaths has been reported by Löwel et al. [11]: About two thirds of deaths due to definite AMI and/or possible coronary deaths occurred before patients reached the hospital. Kalusche et al. [12] stated that two-thirds of the pre-hospital deaths occurred within the first hour after onset of symptoms leading up to an AMI.

Because it was not possible to validate HOST and CoD data with data from the patients’ medical history and/or autopsy findings in our study, clinical definition of AMI may result in missing AMI data and very early deaths due to AMI. Therefore, estimated AMI incidence rate and/or case fatality determined for Switzerland hold an underestimation

compared to a calculation procedure based on a broader definition of AMI.

Comparison of the estimated AMI incidence and case fatality in Switzerland with morbidity data from other European countries is problematic because of use of different data sources (*eg* hospital discharge records, surveys, and registries; application of different coding practices) and lack of harmonised data (*eg* use of different AMI definitions; different standardisation of morbidity rates) [5].

In conclusion, our analysis provided a closer estimate of AMI incidence rate and case fatality of hospitalised patients in Switzerland than known from HOST taken as a single database. Nevertheless, because of methodological limitations, an uncertain number of AMI cases and cases of very early deaths due to AMI remain unrecorded. Therefore, the estimated AMI incidence rate as demonstrated still does not represent the actual AMI incidence rate for Switzerland. In order to obtain the actual overall AMI incidence rate, personal identification numbers would have to be used to link the data in the HOST database with the data in the CoD database as was successfully performed in Sweden [13]. As an alternative, a probabilistic record linkage method could be applied to combine both HOST and CoD databases by using date of birth, sex and zip code [13]. Due to lack of identification numbers in the FSO’s CoD database and because of strong data protection restrictions, it was not possible to link data from the HOST and CoD databases. Yet, to get more comprehensive data on AMI incidence rate, it is important for AMI diagnosis to be based on a broader definition than a clinical one.

Implication for health statistics

Precise monitoring of long-term trends and changes of cardiovascular disease in Switzerland would require the following: (1.) use of validated indicators on cardiovascular morbidity and mortality; (2.) linking of hospital and mortality statistics by means of an identification number; (3.) using validated clinical diagnosis of AMI by considering epidemiological diagnostic criteria on AMI, and (4.) including additional indicators that can show the relative impact that prevention, health promotion and treatment have on AMI event rate/incidence rate and case fatality. In addition, harmonisation of Swiss cardiovascular databases and corresponding databases in EU countries is a further objective to be pursued.

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