ORIGINAL ARTICLE


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Objectives. Coronary event rates have declined in most Western countries during the past decades, but the trends in the former Eastern block have not been established. The purpose of the present study was to examine the trends in acute coronary events during 1991–2005 in Tallinn, Estonia.


Results. Altogether, 4889 AMI events were recorded. The average age-standardized incidence and attack rate of AMI events were lower in the second than in the first registration period in both sexes. When analyzed annually, the AMI event rates increased from 1991 to 1993 in both sexes. Thereafter from 1993 to 2005 the incidence of first AMI events declined significantly, 2.7%/year in men and 5.0%/year in women (P<0.001 for both). Also the other event types, except the attack rate among men, tended to decline after 1993.

Conclusions. The year 1993 denoted a significant turning-point in the trends in AMI events in Tallinn, Estonia. After that especially the incidence of first AMI started to decline, and the declines have continued until 2005.

Key messages
- Coronary event rates have declined in Western countries, but the trends in former Eastern block countries have been less well known.
- Increasing trends were observed in the incidence, attack rate, and mortality of acute coronary events in the beginning of the 1990s in Tallinn, Estonia, but there was a significant change in direction in 1993.
- After 1993 especially the incidence of first AMI events has been declining among inhabitants aged 35–64 years of Tallinn, Estonia, and the decline has continued at least until 2005.

Introduction
Cardiovascular diseases (CVD) are the leading causes of death worldwide (1). During the past decades declining trends in coronary heart disease (CHD) mortality have been observed in several industrialized countries. Nevertheless, mortality from CHD varies between populations and countries (2–4). Over the last decades, treatment of acute myocardial infarction (AMI) has advanced markedly—a decline in CHD and especially in AMI mortality has resulted from increasing introduction of early reperfusion and revascularization, improved medical care, and effective primary and secondary preventive interventions on risk factors such as smoking, diabetes, arterial hypertension, and hyperlipidemia (5–8).

At the same time, available routine mortality statistics from 1965 to 1989 have suggested that total, CVD, and CHD mortality in Estonia, formerly a part of the Soviet Union, were high (9), but there were no data on the incidence of acute CHD events. Based on first investigations on epidemiology of AMI events after independence, Estonia was facing major health problems in 1991, including high incidence, attack rates, and mortality of acute coronary events, comparable with countries with the highest CHD event rates (2,10,11).

The need to explain the divergent trends in CHD mortality in different populations and to validate the findings from routine mortality statistics led the World Health Organization (WHO) to develop a standardized methodology for the assessment of the incidence and mortality of CHD, applied in the WHO MONICA (multinational MONItoring of trends and determinants in CArdiovascular disease) Project (12). Although not a part of the WHO MONICA Project, the same methodology has been used in the Tallinn AMI Registry.
The purpose of this paper was to describe the trends in the incidence, attack rates, and mortality rates of AMI in Tallinn, the capital of Estonia, from 1991 through 2005.

Material and methods

The Tallinn AMI Registry follows the protocol of the WHO MONICA Project in data collection and diagnostic evaluation of suspected AMI events (11,12). The Registry covers the population aged 35–64 years with official residence in the capital of Estonia. The total number of inhabitants in Estonia was 1.57 million on 1 January 1991 and 1.35 million on 1 January 2006 and in Tallinn, respectively, 476,591 and 396,193 inhabitants. In the age group 35–64 years the respective figures in Tallinn were 187,515 and 155,538 inhabitants (13). Data were collected in two periods from 1991 to 1997 and from 2003 to 2005.

A detailed description of population structure (age, sex, immigration, nationality, health service and economic situation, coronary care system, data collection procedures, and quality control have been published earlier (10,14). Briefly, in Estonia it is standard practice to admit and treat all patients with suspected AMI in a hospital. In all cases with chest pain an electrocardiogram (ECG) is taken. Each coronary event must have been detected and diagnosed within 28 days. Multiple events occurring during a 28-day period from the onset of the attack were considered as one event. Obviously, some asymptomatic non-fatal acute coronary events are missed in the AMI Registry. Information on in-hospital deaths was obtained from the hospital and autopsy records, and on out-of-hospital deaths from official death certificates. In Estonia, medico-legal autopsies are common in cases of death without a known history of disease.

Diagnostic classification

In the Tallinn AMI Registry diagnostic classification of coronary events was based on the protocol of the WHO MONICA Project (15). The following variables were used: 1) symptoms, 2) ECG findings, 3) cardiac enzymes, 4) autopsy findings, 5) history of previous AMI event, and 6) history of chronic CHD.

The symptoms were classified as typical, atypical, other, none, inadequately described, or insufficient data. ECG findings were combined to form six categories: definite, probable, ischemic, other, uncodable, or insufficient data. The classification was based on Minnesota coding of serial ECGs according to the WHO MONICA Project protocol (15). Creatine phosphokinase (CK), its MB isoenzyme (CK-MB), lactate dehydrogenase (LD), its isoenzyme-1 (LD-1), and aspartate aminotransferase (ASAT) were used in 1991–1997. Enzymes were coded as abnormal if the highest value of any of them was higher than twice the upper limit of the normal range and no other cause than AMI for elevated enzymes was apparent. Code equivocal was used if the enzyme levels were higher than the upper limit of normal but did not reach the level required for abnormal. If non-cardiac causes, including cardiac resuscitation, were present the enzyme category non-specific was used. CK-MB or maximal concentration of troponin T (TnT) or I (TnI) exceeding the decision limit on one occasion during the first 24 hours after the index clinical event were used in 2003–2005. Typical rise and gradual fall of troponins with ischemic symptoms and ECG changes was indicative for ischemia (16). The value of TnT or TnI was classified as diagnostic, normal, or missing on the basis of the limits given by the laboratory of the hospital. The classification of autopsy findings, history of previous AMI event, and history of chronic CHD prior to the present attack also followed the WHO MONICA Project protocol (15).

According to the protocol each suspected AMI event was classified as definite AMI, possible AMI, ischemic cardiac arrest with successful resuscitation, no AMI, or insufficient data (for fatal cases only). The incidence of AMI was defined as the occurrence of first-ever definite or possible AMIs, and the attack rate included all such events, whether the first or not.

Statistical methods

The attack rate, incidence, and mortality were expressed per 100,000 inhabitants per year. The age-standardized rates were calculated by direct method using 5-year age groups and the World Standard Population. The 95% confidence intervals (CIs) for the rates were calculated assuming Poisson distribution for the number of events within the age groups (17,18). We first compared the average age-standardized AMI event rates between the two study periods. Next, trends in the incidence, mortality, and attack rates were estimated using log-linear regression models with year as an independent variable. Model deviance was used to evaluate the goodness of fit of the models. The models fitted reasonably well because the goodness of fit chi-square test was not statistically significant, except in 3 out of the 12 analyses performed. Those three analyses were re-done using correction for over-dispersion to fulfill the model assumptions. Linear interpolation was used for the missing part of the data between the two study periods, both for the annual event numbers and for the population counts. The change in direction in the year 1993 was examined by testing whether the trend estimates were significantly different from 1993 onwards than the trend estimates calculated for the whole study period 1991–2005. The statistical analyses were carried out with SAS, version 9.1.3 (SAS Institute Inc., NC, USA).

The local Ethics Committee approved the study protocol.

Results

During the two study periods, 1991–1997 and 2003–2005, altogether 4889 AMI events (3810 (78%) among men and 1079 (22%) among women) were recorded in Tallinn among the population aged 35–64 years. The average age-standardized incidence and attack rate of AMI events were significantly lower in both sexes in the second than in the first study period, but the mortality rates did not differ between these periods (Table I). An analysis of annual rates showed that the age-standardized incidence of AMI events increased in the beginning of

Table I. Average age-standardized incidence, attack rate, and mortality of AMI events (per 100,000 population, 95% CI) in the years 1991–1993 and 2003–2005 among men and women aged 35–64 years in Tallinn, Estonia.

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<tr>
<td>Incidence</td>
<td>557 (528; 586)</td>
<td>485 (455; 515)</td>
<td>0.026</td>
<td>134 (121; 147)</td>
<td>88 (77; 99)</td>
<td>0.002</td>
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<td>Attack rate</td>
<td>438 (412; 464)</td>
<td>309 (285; 333)</td>
<td>&lt; 0.0001</td>
<td>113 (101; 125)</td>
<td>63 (53; 73)</td>
<td>0.0002</td>
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<tr>
<td>Mortality</td>
<td>257 (237; 277)</td>
<td>223 (203; 243)</td>
<td>0.12</td>
<td>51 (43; 59)</td>
<td>37 (30; 44)</td>
<td>0.13</td>
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Trends in acute myocardial infarction in Estonia

In women the attack rate and mortality followed the same pattern as the incidence, but in men the declines in the attack rate and mortality remained modest. The annual age-standardized event rates and their 95% CIs are shown by 10-year age group in Supplementary Tables I (incidence and attack rate for men), II (incidence and attack rate for women), and III (mortality rate for men and women) to be found online at http://informahealthcare.com/doi/10.3109/07853890.2011.645380.

Table II shows the trend estimates and demonstrates that the initial increase was significant for all event types in both sexes, except for mortality among women. The change in direction in 1993 was also significant for all other event types, except for the attack rate among men. The decline after 1993 until 2005 was statistically significant for all event types among women. Among men, the incidence declined very significantly after 1993, but the decline in mortality was of borderline significance ($P = 0.05$) only, and the change in attack rate was non-significant.

### Discussion

The main finding of our study was the biphasic trend in AMI events in Tallinn, Estonia: a steep increase in 1991–1993, then a significant change in direction in 1993, followed by declining trends in the incidence until 2005. The attack rate and mortality also declined after 1993 among women. Among men, mortality tended to decline, but the change in attack rate was clearly non-significant. On average, however, both incidence and attack rates were lower in the second than in the first registration period. A similar biphasic pattern has been reported

![Graph](image-url)
Previously for CHD mortality on the basis of routine mortality statistics (19–21), but the present study confirms this finding on mortality using a standardized AMI register protocol and extends the trend information to the incidence and attack rate of AMI events.

Because of uncertainty about the true nature of the CHD epidemic (risk factors, morbidity, mortality) WHO initiated AMI registry studies in the 1970s and 1980s (11,22). The Tallinn AMI Registry was established mainly on the same principle—the lack of reliable data on incidence, attack rate, and mortality of AMI events in Estonia. In our previous reports we have presented data on high morbidity and mortality of AMI events with a suggestion of their increase after the major social changes in Tallinn in the late 1980s (10,14). But, on the other hand, we also assumed that the time period (first four years, 1991–1994) was too short to make firm inferences regarding the time trends. In our present study, we analyzed a longer time period from 1991 to 2005 and produced more stable trend estimates. This revealed a significant change in direction in 1993 and mainly declining trends after that. The shortness of the registration period before the peak in 1993 makes it difficult to establish the change in direction with a high degree of statistical certainty. We believe, however, that the turning-point is real, because the registration was based on careful reviewing of relevant hospital documents, death certificates, and autopsy reports by the Tallinn AMI registration team. Furthermore, the turning-point is consistent with the development in other Eastern European countries, described earlier by analyzing the routine mortality statistics (19–21).

In spite of the stable attack rate of AMI events among men in Tallinn (trend 0.2%/year, 1993–2005), the level was high. In the WHO MONICA study, carried out in the 1980s and 1990s, higher attack rates than the present ones in Tallinn were observed only in eastern Finland and in the United Kingdom (23,24). Approximately similar attack rates were observed in several MONICA centers such as Newcastle Australia, Charleroi Belgium, Halifax Canada, Czech Republic, Glostrup Denmark, Turku/Loimaa Finland, Iceland, Kaunas Lithuania, northern Sweden, Poland, and Russia. In most of these centers with comparable figures to the Tallinn AMI Registry declining trends in event rates began earlier than in Tallinn, except in Charleroi Belgium, Kaunas Lithuania, Warsaw Poland, and the Russian centers (23,24). It is important to emphasize that exact comparison of the rates of acute coronary events between Estonia and the WHO MONICA Project centers is hindered by differences in the monitoring periods between these studies (the WHO MONICA Project began almost ten years earlier than the AMI registry in Tallinn).

Detailed reasons for the high AMI event rates and mortality (especially at the beginning of the 1990s) in Tallinn are unknown, but the treatment and control of CHD risk factors, such as arterial hypertension, diabetes, smoking, diet, and physical inactivity, have only recently begun to receive more attention in Estonia (10). Altogether social, economic (mass privatization), and political changes affected all aspects of people’s lives, which resulted in changes (increases) in mortality and morbidity in Eastern Europe and the former Soviet Union (25–27). On the other hand, it is encouraging that the decline in incidence among men during the period 1993–2005 was significant, probably due to the special education programs and understanding of the importance of risk factors in the development of acute coronary events. The decreasing trends are probably true and may even be under-estimates because the older enzymatic biomarkers of myocardial injury were replaced during the study period with troponins, which are known to be more sensitive and detect more AMIs (28). The non-declining attack rate among men may also reflect a greater number of small non-fatal AMIs detected with troponins.

The high age-standardized AMI mortality among men in Tallinn was comparable with the same MONICA centers as the high attack rate. Mortality was higher only in the WHO MONICA centers of East-Finland, Glasgow United Kingdom, and Poland (23,24,29). High but declining CHD mortality among men in Estonia was reported also by a recent analysis of the official mortality statistics from the years 1985–1989 and 1995–1998 (30). In the present analysis, a declining trend (2.4%/year) was seen in the AMI mortality in Tallinn. However, this decline seems to have taken place mainly during a few years after the peak in 1993, and after 1997 there does not seem to be much decline. Interestingly, also in women the attack rate and mortality of AMI events were relatively high in Tallinn during our study period compared with the same MONICA centers, as among men (23,24,31). Our study demonstrated clear declining trends in the incidence, attack rate, and mortality of AMI events in women since 1993. This is in agreement with the earlier study based on the official mortality statistics (30). Future analyses on case fatality will shed more light on the reasons for the changes in mortality. In principle, they may reflect more active in-hospital treatment (thrombolysis and especially angioplasty) and out-of-hospital treatment (lipid-lowering drugs, β-blockers, ACE-/AT-II-inhibitors) of CHD patients (10). Since the clearest changes were observed in the incidence of first AMI events in both sexes, it is likely that primary prevention and the improvements in out-of-hospital treatments have played the main role in these favorable developments in Tallinn.

In conclusion, we found that the incidence, attack rate, and mortality of AMI events were high in Tallinn during the period 1991–2005. An increase took place from 1991 to 1993, but after that especially the incidence rates have been steadily declining.
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References


Supplementary material available online