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

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Background—Out-of-hospital deaths constitute the majority of all coronary heart disease (CHD) deaths and are therefore of considerable public health significance.

Methods and Results—We used population-based myocardial infarction register data to examine trends in out-of-hospital CHD deaths in Finland during 1983 to 1997. We included in out-of-hospital deaths also deaths in the emergency room and all deaths within 1 hour after the onset of symptoms. Altogether, 3494 such events were included in the analyses. The proportion of out-of-hospital deaths of all CHD deaths depended on age and gender. In the age group 35 to 64 years, it was 73% among men and 60% among women. These proportions did not change during the study. The annual average decline in the age-standardized out-of-hospital CHD death rate was 6.1% (95% CI, −7.3, −5.0%) among men and 7.0% (−10.0, −4.0%) among women. These declines contributed among men 70% and among women 58% to the overall decline in CHD mortality rate. In all, 58% of the male and 52% of the female victims of out-of-hospital CHD death had a history of symptomatic CHD. Among men with a prior history of myocardial infarction, the annual average decline in out-of-hospital CHD deaths was 5.3% (−7.2, −3.2%), and among men without such history the decline was 2.9% (−4.4, −1.5%). Among women, the corresponding changes were −7.8% (−14.2, −1.5%) and −4.5% (−8.0, −1.0%).

Conclusions—The decline in out-of-hospital CHD deaths has contributed the main part to the overall decline in CHD mortality rates among persons 35 to 64 years of age in Finland. (Circulation. 2003;108:691-696.)

Key Words: coronary disease ♦ myocardial infarction ♦ population ♦ mortality
during the 15-year period 1983 to 1997. To consider the effects of primary and secondary prevention, we broke these trends further down to out-of-hospital deaths in persons with and those without a history of MI. We also calculated the contribution of the decline in out-of-hospital CHD deaths to the overall decline in CHD mortality rate. The main analyses focused on persons 35 to 64 years of age, but for the last 5-year period, 1992 to 1997, we included data on persons older than 64 years.

Methods

FINAMI is a population-based MI register aiming to record every CHD event in the populations of monitored areas.\(^{10}\) It continues the work of the FINMONICA MI register,\(^ {11}\) with comparable data collection procedures. The geographical areas covered by the register are the town of Turku in southwestern Finland, the town of Kuopio in eastern Finland, the town of Joensuu, and some surrounding rural areas in North Karelia, eastern Finland. Also included is the town of Oulu in northern Finland. Oulu joined in the project at a later stage compared to other areas, and the years between these surveys were estimated by means of regression analysis. We took the proportions of persons who reported having had an MI for each 5-year age group beginning from age 45 years and then applied these proportions to the population counts of the FINAMI areas to establish the proportions of population with and without a history of prior MI. The age group 35 to 44 years was excluded from this analysis because of small numbers. Also, these rates were age-standardized to the European Standard Population. The 95% CIs were calculated assuming Poisson distribution for the annual numbers of deaths.

The proportion of out-of-hospital CHD deaths and the 28-day case-fatality rate were age-standardized by using weights derived from the combined age distribution of patients with MI and stroke in the WHO MONICA Project.\(^ {15}\) The trends in event rates and case-fatality rates were determined by means of log-linear Poisson regression models, with the year as the independent variable.\(^ {15}\) Trends were estimated for the age group 35 to 64 years, because that was the common age group for the whole 15-year period. Oulu was excluded from the trend analyses because it had data only for the years 1993 and 1997. Data for the other areas were pooled because the results for each area were similar.

The proportion of CHD mortality rate decline due to the decline in out-of-hospital CHD deaths was estimated using the formula

\[
\frac{dM_s}{dM_t} = \frac{dM_s}{dM_t} \times \frac{dM_s}{dM_t},
\]

where \(dM_s\) is out-of-hospital CHD mortality rate in 1983 minus out-of-hospital CHD mortality rate in 1997, and \(dM_t\) is total CHD mortality rate in 1983 minus total CHD mortality rate in 1997. Smoothed mortality rates taken from the log-linear models were used for these calculations. For the age group–specific analyses, we included all age groups \(\geq 35\) years and all FINAMI areas, but only the last 5-year period 1993 to 1997 for which we had data on persons older than 64 years.

Results

During the 15-year period, 1622 out-of-hospital CHD deaths occurred in the FINAMI areas among men and 242 among women 35 to 64 years of age. Another 853 out-of-hospital CHD deaths were observed during the period 1993 to 1997 among men and 777 among women \(\geq 65\) years of age. The average age-standardized proportion of out-of-hospital CHD deaths of all CHD deaths in the age group of 35 to 64 years was 73% among men and 60% among women. These proportions did not change during the study period (trend, 0.3% per year (95% CI, \(-0.8, 1.5\)) among men and \(-0.4\%\) per year \((-3.5, 2.7\%)\) among women).

The out-of-hospital CHD death rate declined on average by 6.1% per year \((-7.3, -5.0\%)\) among men and by 7.0% per year \((-10.0, -4.0\%)\) among women (Table 1). Rates and
trends in in-hospital CHD mortality rate and in total CHD deaths are also shown for comparison. The declining trends did not differ much, but the rates in in-hospital CHD deaths were much lower than those in out-of-hospital CHD deaths.

The out-of-hospital CHD death rate was further broken down to deaths among persons with and without a history of prior MI (Figure 1). Significant declines were observed in both, but the rates were much higher in persons with prior MI. Among the victims of out-of-hospital death from a recurrent CHD event, the time interval to the previous MI showed an increasing trend: Among men who died during the 5-year periods 1983 to 1987, 1988 to 1992, and 1993 to 1997, the time intervals to the previous MI event were 4.7, 5.6, and 7.1 years, respectively. Among women, the corresponding time intervals were 3.1, 4.8, and 5.2 years.

Of all men 35 to 64 years of age who died of CHD out-of-hospital during the 15-year period, 37.1% (35.9% to 38.3%) had a history of MI. Another 20.8% (18.8% to 22.8%) had a history of symptomatic CHD without MI. Among women of similar age, 29.0% (26.8% to 31.2%) had a history of MI, and another 22.6% (17.4% to 27.8%) had a history of CHD without MI. Thus, for approximately half of the cases, out-of-hospital death was the first clinical manifestation of CHD.

The case-fatality rate due to out-of-hospital CHD death increased with age, in particular among women (Table 2). However, the proportion of out-of-hospital deaths of all CHD deaths declined with age. Among persons younger than 75 years, out-of-hospital CHD deaths constituted the majority of all CHD deaths, but not among persons ≥75 years of age. Likewise, the proportion of out-of-hospital deaths of all CHD deaths was smaller for recurrent than for first events (66.2% for recurrent and 77.7% for first events among men and 46.8% and 65.3% among women 35 to 64 years of age).

Figure 2 depicts changes in total CHD mortality rate partitioned to out-of-hospital and in-hospital CHD deaths among men and women 35 to 64 years of age. Rates shown in the figure are smoothed by use of the log-linear model. The decline in out-of-hospital CHD death rate contributed among men 70% and among women 58% to the overall decline in CHD mortality rate.

### Discussion

Consistent with other epidemiological studies, our study confirmed that the majority of CHD deaths take place out-of-hospital. The out-of-hospital CHD death rate in FINAMI areas declined significantly during the 15-year period. A similar development has recently been reported on the basis of routine mortality statistics from the United States and from Scotland. In our study, the proportion of out-of-hospital deaths of all CHD deaths did not change over time, whereas in the United States, the proportion of sudden cardiac deaths of all cardiac deaths increased by 12.4% during the period 1989 to 1998. Both in Finland and in the United States, the proportion of out-of-hospital deaths decreased with increasing age. In the Scottish study, however, the proportion of patients with MI who survived to hospital decreased with age. These different findings may reflect technical differences between the studies but may also reflect real differences in the behavior of patients and health care systems.

The decline in CHD mortality rate has been a universal finding in all Western countries. To our knowledge, however, no earlier study has partitioned the mortality rate decline to the contributions of out-of-hospital and in-hospital CHD deaths. Our calculations showed that more than two thirds of the mortality rate decline in men and more than half in women were due to the decline in out-of-hospital CHD deaths. In the United States, the Minnesota Heart Survey has reported a faster decline in in-hospital than in out-of-hospital mortality rates. In our study, the declining trends in out-of-hospital and in-hospital deaths did not differ substantially, but

<table>
<thead>
<tr>
<th>Time Period</th>
<th>Men N</th>
<th>In-Hospital CHD Mortality Rate N</th>
<th>Women N</th>
<th>Out-of-Hospital CHD Mortality Rate N</th>
<th>CHD Mortality Rate N</th>
</tr>
</thead>
<tbody>
<tr>
<td>1983–1987</td>
<td>691</td>
<td>270</td>
<td>76</td>
<td>22</td>
<td>181</td>
</tr>
<tr>
<td>1988–1992</td>
<td>521</td>
<td>192</td>
<td>27</td>
<td>20</td>
<td>152</td>
</tr>
<tr>
<td>1993–1997</td>
<td>410</td>
<td>145</td>
<td>15</td>
<td>11</td>
<td>84</td>
</tr>
<tr>
<td>Trend, %/y</td>
<td>−6.1</td>
<td>−7.3</td>
<td>−7.0</td>
<td>−7.2</td>
<td>−7.0</td>
</tr>
<tr>
<td>95% CI</td>
<td>−7.3 to −5.0</td>
<td>−9.2 to −5.3</td>
<td>−10.0 to −4.0</td>
<td>−10.7 to −3.6</td>
<td>−9.3 to −4.7</td>
</tr>
</tbody>
</table>

Rates are expressed as averages for each 5-year period per 100,000 inhabitants and age-standardized to the European Standard Population.

Trends in total CHD mortality rate have been discussed in more detail in Reference 10.
the much larger amount of out-of-hospital CHD deaths made their contribution to the decline in total CHD mortality rate greater. This supports the importance of the roles that primary prevention and treatment of chronic CHD have played in the decline in CHD mortality rate in Finland.

The FINAMI register data allowed us to analyze the history of prior MI or CHD among the persons who had out-of-hospital CHD death. We found that for less than half of these cases, out-of-hospital death was the first manifestation of CHD, whereas more than half were receiving treatment for CHD or previous MI at the time of their fatal event. The history of clinically manifest CHD among persons who had out-of-hospital death appears to be of the same order of magnitude in Finland as in Olmsted County, Minnesota, since a recent study reported that the proportion of "unexpected" sudden cardiac deaths of all sudden cardiac deaths was 49% in the Olmsted county.9 Our results clearly show that for a substantial proportion of cases, out-of-hospital death does not come out of the blue, and thus there are possibilities for prevention with appropriate treatment of chronic CHD.

The declining trends in out-of-hospital CHD deaths tended to be steeper among persons with a history of MI than among those without such history, but the 95% CIs were overlapping. A special feature of these analyses was that by using data from the FINRISK population surveys,14 we were able to calculate the annual numbers of persons in the population who had and who had not had a prior MI. Thus, we could use correct denominators for persons at risk of out-of-hospital death from first or recurrent MI. Our results also showed that the time interval between the out-of-hospital death from a recurrent CHD event and the previous MI event was increasing over time. Furthermore, the proportion of out-of-hospital deaths was smaller for recurrent than for the first-MI events. Taken together, these findings suggest that primary prevention and secondary prevention and the treatment of chronic CHD have all contributed to the reduction of out-of-hospital CHD deaths. The slightly faster decline in persons with prior MI than in those without prior MI is consistent with recent findings from the Olmsted County, Minnesota,9 and emphasizes the need for effective primary prevention measures.
A strength of our study is the long period of data collection, according to a standardized protocol. Completeness of case finding could be ascertained by using national registers, causes-of-death register, and the hospital discharge register. Furthermore, the frequency of autopsies among cases of out-of-hospital death was high, 70% among men and 76% among women. Two features of the study limited the representativeness of the results. First, the FINAMI register covered 4 mainly urban areas, which may not be representative of the country as a whole. Since the out-of-hospital death rate is higher in rural than in urban areas, our study may give a slightly too optimistic view on out-of-hospital deaths in

<table>
<thead>
<tr>
<th>Age Group</th>
<th>n*</th>
<th>Case Fatality Rate due to Out-of-Hospital Death, %</th>
<th>Proportion of Out-of-Hospital Deaths of All CHD Deaths, %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Men</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>35–54</td>
<td>205</td>
<td>22(19–25)</td>
<td>75(69–82)</td>
</tr>
<tr>
<td>55–64</td>
<td>397</td>
<td>26(24–29)</td>
<td>73(69–78)</td>
</tr>
<tr>
<td>65–74</td>
<td>801</td>
<td>25(23–27)</td>
<td>59(55–62)</td>
</tr>
<tr>
<td>75–84</td>
<td>580</td>
<td>24(22–27)</td>
<td>44(40–48)</td>
</tr>
<tr>
<td>85+</td>
<td>291</td>
<td>30(25–34)</td>
<td>41(36–47)</td>
</tr>
<tr>
<td>Women</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>35–54</td>
<td>16</td>
<td>10(4–16)</td>
<td>65(43–86)</td>
</tr>
<tr>
<td>55–64</td>
<td>78</td>
<td>12(8–15)</td>
<td>52(41–64)</td>
</tr>
<tr>
<td>65–74</td>
<td>429</td>
<td>17(15–19)</td>
<td>52(47–57)</td>
</tr>
<tr>
<td>75–84</td>
<td>786</td>
<td>17(15–19)</td>
<td>38(34–41)</td>
</tr>
<tr>
<td>85+</td>
<td>768</td>
<td>24(22–27)</td>
<td>35(31–38)</td>
</tr>
</tbody>
</table>

*n indicates No. of persons who died during the 28-day period after the beginning of symptoms.
Finland. Second, the first 10 years of our study included only persons younger than 65 years. We were therefore not able to calculate 15-year trends in out-of-hospital CHD deaths for persons ≥65 years of age, even though the majority of CHD events occurs in this age group. We have, however, included all age groups in the FINAMI register since 1993. In the current study, we show results for the last 5-year period of 1993 to 1997, including also elderly individuals to improve the coverage of this important segment of patients with CHD. The third limitation was the composite definition of out-of-hospital CHD deaths used in our study. Clinical studies often define sudden, out-of-hospital deaths as deaths within 1 hour after the onset of symptoms. It is, however, the inherent nature of out-of-hospital deaths that exact information about the time between the onset of symptoms and the death is often not available. We agree with the conclusion presented by Zheng and coworkers that this makes the 1-hour definition impractical for public health surveillance. Therefore, the wider definition is often the only feasible solution.

In conclusion, out-of-hospital CHD death rates have been declining in the FINAMI areas, and their decline explains the main part of the overall decline in CHD mortality rate. Despite this favorable development, out-of-hospital CHD deaths continue to constitute the majority of all CHD deaths in persons younger than 75 years. In almost half of the cases, out-of-hospital death is the first clinical manifestation of CHD. The main way to reduce these deaths further is the primary prevention of CHD at the population level. The other half of out-of-hospital CHD deaths occurs among persons who are receiving treatment for symptomatic CHD. For them, carefully tailored treatment and secondary prevention provides a possibility to reduce the risk of out-of-hospital death.

Acknowledgments

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References

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