Coronary heart disease: from a disease of middle-aged men in the late 1970s to a disease of elderly women in the 2000s

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Aims To analyse secular changes in the prevalence of coronary heart disease (CHD) and to assess changes in the burden of CHD at population level.

Methods and results Data were used from two large cross-sectional health examination surveys representing the entire Finnish adult population in 1980 and 2000. In the 1978–80 survey, the sample covered 5101 individuals aged ≥45, of whom 88% participated. The 2000–2001 survey comprised 5310 individuals in the same age range. Participation rate in the health examination was 87%. Prevalence of CHD decreased in men and women under the age of 65 and increased among those aged ≥75. Prevalence of large Q-waves indicating previous myocardial infarction decreased in all male age groups and in women aged 65–74. The total estimated number of persons with CHD increased by 18% (95% CI = 6–30) during the past 20 years in Finland. In 1980, the most dominant CHD group was men aged 45–64, whereas in 2000, women aged ≥75 comprised the largest CHD group.

Conclusion Although the prevalence of CHD has decreased among middle-aged persons, the number of CHD cases has increased during the past 20 years in Finland.

KEYWORDS Coronary disease; Angina; Myocardial infarction; Sex; Epidemiology

Introduction The population in Finland, as in many developed countries, is rapidly ageing.1 The number of persons aged ≥65 will increase by 75% over the next 30 years.2 Cardiovascular diseases are major causes of illness, disability, and death.3 The incidence and prevalence of these diseases increase greatly with age. The burden of a chronic disease on society depends on its prevalence in each age group, determined by its incidence and prognosis, the degree of disability it causes, and the age structure and size of the population.

Mortality from coronary heart disease (CHD) has decreased >70% among middle-aged Finns during the last 30 years.4 Time trends in CHD mortality have also been declining in many other northern and western European countries, whereas increases have been noted in eastern European countries.5,5 According to the NHANES studies, mortality, incidence, and case fatality of CHD have declined in the United States from 1971–82 to 1982–92.6 The incidence of acute CHD events among middle-aged Finns has also decreased,7 but less than mortality. Mortality from CHD has also decreased among elderly persons,8 but information on changes in incidence in the elderly is limited.

The main reasons for the decline in morbidity and mortality rates from CHD are most probably changes in known risk factors,9,10 as well as improvement of treatment.11 Survival after myocardial infarction (MI) has improved during the past decades.12 Significant advances have been achieved in surgical and medical treatment of CHD.13 It has been suggested that the improved survival rate of acute coronary syndromes has resulted in a growing population of patients with chronic cardiovascular conditions.14 Although information on mortality and incidence trends of CHD events is abundant, it is unclear how decreased mortality and incidence, and improved survival among middle-aged persons, have reflected on the prevalence of the
disease. The aim of this study was to analyse secular changes in the prevalence of CHD by age group and sex, and to assess changes in the burden of CHD at population level using data from two large cross-sectional health examination surveys conducted 20 years apart, and representing the entire Finnish adult population in 1980 and 2000.

Methods

Description of the surveys

This study is based on two representative stratified two-stage cluster samples of the Finnish population aged ≥30. The individuals were sampled by systematic sampling and the list order was based on age. The Mini-Finland Health Survey\textsuperscript{15} was carried out from 1978 to 1980. The sample size was 8000 individuals. During the first phase of the survey, nurses interviewed subjects in their homes or in the institutions in which they were living. The subjects were then invited to attend the second phase, a health examination.

The Health 2000 Survey was carried out in Finland from fall 2000 to spring 2001. The sample size was 8028 persons, and for the population aged ≥80, the sampling probability was twice as high as among those <80. After a home interview, a comprehensive health examination including questionnaires, measurements (e.g., blood pressure, resting ECG), and doctor’s physical examination was performed. Nurses visited the homes of individuals who did not attend field examinations and performed shorter home health examinations. The implementation of the survey is described in detail elsewhere.\textsuperscript{16} One of the goals of the Health 2000 Survey was to determine changes in population health since 1978–80.

This study concerns persons aged ≥45. In the 1978–80 survey, the sample covered 5101 individuals (2190 men and 2911 women), of whom 88% participated in the health examination. The Health 2000 sample comprised 5310 individuals (2298 men and 3012 women) in the same age range. The participation rate in the health interview was 91% and in the field health examination 80%. Another 7% were examined during home health examinations. The National Hospital Discharge Register and the national register on rights to reimbursements for medication costs were linked to the Health 2000 Survey data.

Definition of CHD

The same persons were responsible for the design and execution of the two surveys and this enabled to keep the methodology as similar as possible in both surveys. Persons with typical angina pectoris (AP) symptoms were identified by the WHO chest pain questionnaire.\textsuperscript{17} Resting ECGs were recorded, and structured physical examinations were carried out by trained physicians. The examining physicians followed detailed written instructions and applied uniform diagnostic criteria in accordance with good clinical practice. The diagnostic criteria in the two surveys were similar. The examining physician critically assessed history and available documents and performed a structured physical examination. Diagnostic assessments were recorded on structured forms. AP was defined as typical chest pain brought on by exertion and relieved by nitroglycerine or by rest. MI was defined as a positive history of the condition in the medical records or old MI on ECG or typical self-reported history of MI treated in hospital. ECG findings were coded according to the Minnesota code in both surveys identically and according to the generally accepted international guidelines.\textsuperscript{18} Large Q-waves indicating probable previous MI included Minnesota codes 1.1 or 1.2 together with 5.1–2. Other ischaemic ECG changes included Minnesota codes 1.2 without 5.1–2, 1.3, 4.1–3, 5.1–2, 6.1–2, 7.1–2, 7.4, or 8.3.\textsuperscript{19}

Information on previous hospitalization for MI or CHD was obtained from hospital discharge summaries that study participants brought along or from the National Hospital Discharge Register. The Finnish hospital discharge register has been shown to be valid in identifying major CHD events.\textsuperscript{20} Information of the right for drug reimbursements was obtained from the national register on rights to reimbursements for medication costs. All persons with CHD in Finland are entitled to special reimbursement for medication costs. To obtain that right, they have to apply for it and append a medical certificate by their physician to show that the objective criteria of CHD are fulfilled.

Information on coronary revascularization procedures and medication use was obtained during the home health interview. The study participants were asked whether they use any medications and the names and doses of these medications were recorded. They were also asked whether a coronary artery bypass grafting or percutaneous coronary intervention has been performed or not.

Classification for MI required either a clinical diagnosis of MI by the examining physician, large Q-waves in resting ECG, or a previous hospital discharge with a diagnosis of MI (ICD-8 or ICD-9 code 410 or ICD-10 codes I21–I22). Classification for CHD group required at least one of the following: diagnosis of MI and/or AP during the field health examination by a physician, large Q-waves in resting ECG, hospitalization for CHD (ICD-8 or ICD-9 codes 410–414 or ICD-10 codes I20–I25), a history of coronary revascularization procedure, the right to drug reimbursements for CHD, or the use of nitroglycerine combined with an anticoagulant, acetylsalicylic acid, or beta-blocker. Typical AP symptoms identified by the WHO chest pain questionnaire only were not considered as indicator of CHD.

The study protocol of the Health 2000 survey was approved by the Epidemiology Ethics Committee of the Helsinki and Uusimaa hospital region. The participants of the survey signed an informed consent both before the health interview and at the beginning of the health examination.

Statistical analysis

Statistical analyses were performed using SAS/SUDAAN statistical Software (SAS version 8.2 and SUDAAN version 8.0.2) to account for the complex sampling design. Oversampling of the persons aged ≥80 was accounted for by using post-stratification weights. The total number of persons with CHD in Finland was estimated using expansion weights. The effect of the age structure in the totals was demonstrated by direct standardization. Differences in the prevalences of CHD between the two surveys were analysed by logistic regression models; continuous age and survey were included in the models. Data for men and women were analysed separately throughout the article. The analysis was first performed separately in 10-year age groups (45–54, 55–64, 65–74, 75–84, 85+) using the summary variable CHD as the response. Continuous age was included in these analyses in order to obtain model-adjusted prevalence estimates for CHD in the two surveys using the predicted margins method proposed by Lee.\textsuperscript{22} After that the persons aged ≥45 were analysed using a model with continuous age, survey, and the interaction term of age and survey. The interaction between survey and continuous age was tested to assess whether the age trends in the two surveys were the same. In the further analyses, the two younger and the two older age groups were joined and the stratification of three age groups 45–64, 65–74, 75+ was used. We used two-sided tests separately for each group defined by gender and/or age class.

Results

The number of participants and participation rates by age group are shown in Table 1. The model age-adjusted prevalence of CHD in men was 21% in the 1978–80 survey and 16% in the 2000–2001 survey (P < 0.001 for the difference between the surveys); the corresponding numbers in women were 17 and 14% (P = 0.019). The prevalence of CHD decreased among working-age men and women, but increased among the elderly (Figure 1). There was a significant interaction between age and survey (P < 0.001) in

\begin{table}[h]
\centering
\begin{tabular}{|c|c|c|}
\hline
Age group & Male & Female \\
\hline
45–54 & 21 & 17 \\
55–64 & 16 & 14 \\
65–74 & 12 & 10 \\
75+ & 9 & 7 \\
\hline
\end{tabular}
\caption{Prevalence of CHD among working-age men and women.}
\end{table}
both men and women. The decrease in the prevalence of CHD was statistically significant in both men and women in the age groups of 45–54 (\(P < 0.001\) both for men and women) and 55–64 (\(P < 0.001\) both for men and women) years. Among men and women aged 65–74, no significant change occurred (\(P = 0.14\) for men and \(P = 0.97\) for women). After that age, the prevalence of CHD increased significantly (\(P = 0.008\) for men and \(P = 0.038\) for women aged 75–84; \(P = 0.01\) for men aged 85+). In women, however, the increase was not statistically significant in the oldest age group of \(\geq 85\) years (\(P = 0.08\)), possibly due to the low number of women in the 1978–80 survey in this age group.

Time trends in different indicators of CHD by age group are shown in Table 2. Time trends in MI were similar to the trends in CHD; a clear decrease among men and women aged 45–64, no change among those aged 65–74, and a slight increase, although not statistically significant, among persons aged \(\geq 75\).

In resting ECGs, the prevalence of large Q-waves, indicating previous MI, decreased in all age groups in men. Among women, the decrease of large Q-waves reached significance in the age group of 65–74, and in other age groups, statistically non-significant decreases were observed. The prevalence of any ischaemic ECG change, indicating possible CHD, was significantly lower in all age groups in both sexes in the 2000–2001 survey than in the 1978–80 survey. According to the WHO chest pain questionnaire, the prevalence of typical AP symptoms clearly decreased in all age groups, although the decrease did not reach quite statistical significance among those aged \(\geq 75\).

To assess the burden on health services caused by CHD, the total number of persons with CHD in 1980 and 2000 was calculated using the prevalence estimates from the 1978–80 and the 2000–2001 surveys and the expansion weights (the Finnish population in 1980 and 2000). The number of persons with CHD in Finland has increased by 18% (95% CI = 6–30), or around 50 000 individuals, during the past 20 years. The number of persons with CHD in Finland was 284 226 (95% CI = 266 144–302 309) in 1980 and 335 310 (95% CI = 309 729–360 891) in 2000 (Figure 2). In 1980, the most dominant CHD group was men aged 45–64 (76 000), whereas in 2000, women aged \(\geq 75\) comprised the largest CHD group (92 000). The number of persons aged \(\geq 75\) has increased in Finland by 70% (95% CI = 6–30), or around 50 000 individuals, during the past 20 years. The number of persons with CHD in Finland was 284 226 (95% CI = 266 144–302 309) in 1980 and 335 310 (95% CI = 309 729–360 891) in 2000 (Figure 2). In 1980, the most dominant CHD group was men aged 45–64 (76 000), whereas in 2000, women aged \(\geq 75\) comprised the largest CHD group (92 000). The number of persons aged \(\geq 75\) has increased in Finland by 70%, meaning an increase of almost 140 000 persons from 1980 to 2000. The proportional increase has been similar in men and women, but due to the larger number of elderly women, the absolute increase has been greater in women than in men, meaning an increase of 95 000 women and 43 000 men aged \(\geq 75\). If the age structure of the Finnish population in 1978–80 would have been similar as in the year 2000, the number of persons with CHD had not increased, but decreased by around 51 000 persons from 1980 to 2000.
Discussion

The prevalence of CHD has decreased among working-age Finns and increased among the elderly during the past 20 years. Although the overall prevalence of CHD has decreased among Finns aged ≥45, the total number of persons with CHD has increased by almost 20%. The increase in the number of persons with CHD is largely due to the ageing of the Finnish population, and the shift of the disease towards older age groups has also contributed to this increase. At the same time, the age and sex dominance of the disease has changed from middle-aged men to elderly women. The decreased prevalence of ECG Q-waves, in particular, suggests that the most serious forms of CHD have decreased. The decreased prevalence of typical AP symptoms may indicate better treatment of CHD; both invasive and medical treatments have improved over the past 20 years.

The validity of our results depends on the representativeness and comparability of the study samples and the comparability of the diagnostic criteria. The study was based on two large nationally representative health examination surveys conducted 20 years apart in Finland. One of the main goals of the latter survey was to determine time trends in population health from the late 1970s, and largely, the same persons were involved in the design and implementation of both surveys. Participation rates in both surveys were high, especially when home visits in the 2000–2001 survey were taken into account. Because non-participation is selective with regard to morbidity and disability, high participation rates are essential in examining the prevalence of a chronic disabling disease.24 It is possible that persons with the most severe disease were selected for the home health examinations. Home health examinations were not performed in the 1978–80 survey. To avoid this type of bias, analyses were also performed among the participants of the field health examinations of the two surveys. These analyses did not change the basic results (data not shown).

Trained physicians following detailed written instructions and applying uniform diagnostic criteria, in accordance with good clinical practice, carried out standardized physical examinations. Although similar diagnostic criteria were used in both surveys, variation in clinical judgment could have occurred. The changing diagnostics and treatment practices have an influence on the observed prevalence of CHD. At the time of the latter survey, it is possible that more mild cases of CHD were diagnosed than at the time of the 1978–80 survey. It seems that the prevalence of large Q-waves and other ischaemic ECG findings have declined in all age groups, although the decline of Q-waves did not reach statistical significance among

### Table 2 Age-adjusted prevalence (%) of different measures of CHD in 1978–80 and 2000–2001

<table>
<thead>
<tr>
<th></th>
<th>Men OR 95% CI</th>
<th>Women OR 95% CI</th>
</tr>
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<tbody>
<tr>
<td></td>
<td>Prevalence (%)</td>
<td>Prevalence (%)</td>
</tr>
<tr>
<td>AP symptomsa</td>
<td></td>
<td></td>
</tr>
<tr>
<td>45–64</td>
<td>n = 1955</td>
<td>n = 1919</td>
</tr>
<tr>
<td>65–74</td>
<td>9.8</td>
<td>4.2</td>
</tr>
<tr>
<td>75+</td>
<td>20.6</td>
<td>9.3</td>
</tr>
<tr>
<td>Total</td>
<td>13.1</td>
<td>5.8</td>
</tr>
<tr>
<td>ECG Q-wavesb</td>
<td></td>
<td></td>
</tr>
<tr>
<td>45–64</td>
<td>n = 1972</td>
<td>n = 1873</td>
</tr>
<tr>
<td>65–74</td>
<td>1.7</td>
<td>0.2</td>
</tr>
<tr>
<td>75+</td>
<td>5.0</td>
<td>1.1</td>
</tr>
<tr>
<td>Total</td>
<td>2.9</td>
<td>0.6</td>
</tr>
<tr>
<td>+ Other ischaemic ECG findingsc</td>
<td></td>
<td></td>
</tr>
<tr>
<td>45–64</td>
<td>15.5</td>
<td>6.3</td>
</tr>
<tr>
<td>65–74</td>
<td>34.8</td>
<td>25.1</td>
</tr>
<tr>
<td>75+</td>
<td>57.1</td>
<td>37.4</td>
</tr>
<tr>
<td>Total</td>
<td>23.0</td>
<td>12.8</td>
</tr>
<tr>
<td>MIc</td>
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<tr>
<td>45–64</td>
<td>6.4</td>
<td>3.6</td>
</tr>
<tr>
<td>65–74</td>
<td>15.5</td>
<td>15.1</td>
</tr>
<tr>
<td>75+</td>
<td>17.3</td>
<td>24.9</td>
</tr>
<tr>
<td>Total</td>
<td>9.6</td>
<td>7.9</td>
</tr>
</tbody>
</table>

OR, odds ratio (the 1978–80 survey was the reference class); n, number of observations.

aTypical AP symptoms according to the WHO chest pain questionnaire.
bQ-waves in the resting ECG (Minnesota codes 1.1 or 1.2 together with 5.1–2) indicating probable old MI.
cQ-waves (Minnesota codes 1.1 or 1.2 together with 5.1–2) or other ischaemic ECG changes (Minnesota codes 1.1, 1.2 without 5.1–2, 1.3, 4.1–3, 5.1–2, 6.1–2, 7.1–2, 7.4, or 8.3.) indicating possible CHD.
dPrevious MI as defined in the Methods section.
women aged 45–64 and ≥75. The prevalence of angina symptoms according to the WHO chest pain questionnaire also declined in all age groups, but the decline did not just reach statistical significance among men and women aged ≥75. The decline in the prevalence of angina symptoms indicates better treatment, both invasive and drug treatments, and thus better symptom control. It is likely that the observed increase in the prevalence of CHD among the elderly, in part, reflects changing diagnostics and treatment practices. However, the dramatic decrease in CHD mortality and case fatality due to decreased risk factor levels and better treatment support the view that the observed increase in the prevalence of CHD among the elderly is at least partly real. In the 1970s, many CHD patients died before reaching old age, whereas nowadays the same patients may live with their disease for a long time. In this study, the diagnosis of CHD was used to assess the burden of the disease on health care. Persons with diagnosed CHD need health care services regardless of their MI history. The CHD that was diagnosed and treated 20 years ago was a different type of disease than the CHD diagnosed and treated nowadays. CHD has changed from a severe fatal disease to a more chronic condition. Previous studies on time trends in the occurrence of CHD in Finland have considered mainly CHD mortality and incidence of acute CHD events. Our results are in line with the decreasing trend in CHD mortality and incidence of acute CHD events among middle-aged persons. Mortality from CHD has decreased 68% both in middle-aged men and women from 1980 to 2001. Among middle-aged, all-cause mortality has decreased 39% in men and 25% in women during the same time period. Studies on time trends in the prevalence of CHD are scarce. A study from one municipality in south-western Finland also suggested that the prevalence of CHD has decreased during the 1990s among persons aged 64–71. In addition, we have studied earlier time trends in self-reported CHD. The findings of our present study with strict criteria for CHD are in line with these earlier findings.

There are some reports of time trends in CHD prevalence in middle-aged or elderly persons from other countries. It is difficult to draw general conclusions on the basis of these studies due to differences in the study populations, age groups included, and definitions of CHD. However, it seems that usually the prevalence rates have declined in younger age groups, but changes in the elderly have varied considerably.

More than half of the decline in mortality from ischaemic heart disease in Finland is explained by changes in the main cardiovascular risk factors. Changes in nutrition and lifestyle have contributed to these positive changes in the main cardiovascular risk factors. The prevalence of high blood pressure and high serum cholesterol concentration has declined in all age groups among adults. Smoking has decreased in men and increased in women. The decrease in the prevalence of CHD among working-age Finns probably can also be largely explained by changes in risk factors. It has been suggested that the older age cohorts carry their developing disease burden until old age. Declining severity of coronary events with improvements in the treatment and secondary prevention of CHD, leading to improved survival of persons with CHD, have probably contributed to the shifting of CHD occurrence towards older age groups. The recent increase in the prevalence of obesity among young and middle-aged persons and the estimated rising burden of diabetes may increase the prevalence of CHD in the future. Good health and functional capacity during old age is a consequence of good health and good care of risk factors and chronic diseases during youth and middle age. Thus, active interventions to reduce risk factors should begin at young adulthood or midlife.

**Conclusions**

CHD is changing from a fatal disease of middle-aged men to a more chronic condition of elderly women. As the population suffering from CHD becomes older, their functional ability becomes more important. It is essential to understand the need for secondary prevention, treatment, and rehabilitation of these elderly CHD patients in order to maintain and improve their functional capacity. Mortality cannot be the only measure of success in treatment and rehabilitation; quality of life and functional capacity should be equally important endpoints. CHD has not disappeared, it has changed. Information limited to mortality and incidence trends is not enough to assess the current and future burden of CHD on society, information on prevalence trends is also needed.

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