Incidence of myocardial infarction in women. A cohort study of risk factors and modifiers of effect

G Engström, P Tydén, G Berglund, O Hansen, B Hedblad, L Janzon

Abstract
Study objective—To assess whether the increased incidence of myocardial infarction and death associated with smoking, hypertension, hyperlipidaemia and diabetes varies significantly between groups defined in terms of occupation, education and marital status.

Participants—9351 women, aged 28–55, with a mean follow up of 10.7 years.

Main results—Smoking, hypertension (≥160/95 mm Hg or treatment), hyperlipidaemia (cholesterol ≥6.5 mmol/l or triglycerides ≥2.3 mmol/l), diabetes, low occupation and education levels were significantly more common among women who experienced a fatal or non-fatal myocardial infarction during the follow up (n=104) than in other women (n=9247). Exposure to smoking, hypertension and hyperlipidaemia showed substantial differences between groups defined in terms of education, occupation and marital status. The association between low occupation and myocardial infarction remained statistically significant after adjustments for several potential confounders (RR=2.6, 95%CI 1.1, 6.0). Single women had similarly higher adjusted mortality rates than married women (RR=1.4, 95%CI 1.1, 1.8). When other major risk factors were taken into account, the relative risk for mortality and myocardial infarction associated with smoking was 2.6 (95%CI 2.0, 3.4) and 7.8 (95%CI 4.4, 13.9), respectively.

Conclusion—In this urban female population, short education and low occupation level were both associated with an increased prevalence of smoking, hypertension, hyperlipidaemia and diabetes. Low occupation level increases the rate of cardiac events caused by exposure to these four risk factors.

In a statement for health care professionals from the American Heart Association in 1997 it was concluded that the major risk factors for coronary heart disease (CHD) in women are smoking, hypertension, hyperlipidaemia, diabetes, obesity, sedentary life style and poor nutrition.1

Incidence of disease has by others been found to vary between groups defined in terms of education, occupation and civil status.2–9 Whether in fact these markers may modify individual susceptibility or whether they rather should be considered factors modifying probability of exposure to the risk factors listed by the AHA remains controversial.

The aim of this cohort study of women from the city of Malmö in Sweden has been to assess whether the increased incidence of myocardial infarction and death associated with smoking, hypertension, hyperlipidaemia and diabetes varies significantly between groups defined in terms of occupation, education and marital status.

Methods

SUBJECTS

The study cohort consists of 9351 women, 28–55 years of age, who between May 1977 and February 1991 attended the health examination programme at the Department of Preventive Medicine in Malmö.10 A total of 9351 women corresponds to an attendance rate of 72%.

Information on smoking habits was available for 9300 women, on blood pressure for 9297, on blood glucose for 9226, on serum lipid concentrations for 9314 women, civil status for 9255 women, on education for 8940 and on occupation for 9301 women. All cases were followed up from the baseline examination until the first cardiac event, death or 31 December 1994. Mean (SD) follow up time was 10.7 (4.3) years (range 0.3–17.9 years).

Mortality and cardiac events

Acute myocardial infarctions (ICD-9 code 410) and deaths attributable to ischaemic heart disease (ICD-9 code 410–414) were counted as cardiac events.11 New cases of non-fatal myocardial infarction were retrieved from the Malmö Myocardial Infarction Register.12 13 This register is built on information from the patient administrative register at the Malmö University Hospital, which is the only hospital in Malmö that cares for and treats patients with myocardial infarction. Information on deaths from all causes and deaths attributable to ischaemic heart disease was retrieved by data linkage with the Swedish Causes of Deaths register. One hundred and four women had a cardiac event during the follow up period. Seven of those had a history of myocardial infarction before the baseline examination.

SCREENING EXAMINATION

The screening examination took place in the morning with subjects in smoke free and fasting condition. A computerised questionnaire was used for assessments of smoking habits, physical activity, diabetes mellitus, self reported stress and working conditions.10
Table 1  Cardiovascular risk factors in relation to education, occupation and marital status in 9351 women aged 28–55

<table>
<thead>
<tr>
<th>Education</th>
<th>Occupation</th>
<th>Marital status</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>College or university</td>
<td>Low level</td>
</tr>
<tr>
<td>Smoking</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Current smokers n (%)</td>
<td>1412 (19)</td>
<td>435 (1.3)</td>
</tr>
<tr>
<td>Ex-smokers n (%)</td>
<td>2351 (30)</td>
<td>268 (1.1)</td>
</tr>
<tr>
<td>Never n (%)</td>
<td>7643 (45.4)</td>
<td>387 (2.0)</td>
</tr>
</tbody>
</table>

Stress and working conditions

Probands who reported that they disliked their work or who worked much overtime were considered to have unsatisfactory working conditions. Probands who confirmed periods of stress during the past five years, stress at work, difficulties to relax after a normal working day or difficulties to fall asleep were considered to have self-reported stress.

Blood pressure, blood glucose, serum lipids

Blood pressure (mm Hg) was measured twice in the right arm in supine position after a 10 minute rest. The average of two measurements was used. A sphygmomanometer and a rubber cuff of appropriate size were used. Hypertension was defined as systolic blood pressure $\geq 160$ mm Hg, diastolic blood pressure $\geq 95$ mm Hg or medical treatment of hypertension. 

Serum cholesterol and triglyceride concentrations after an overnight fast were analysed with standard methods at the laboratory of the hospital. Hyperlipidaemia was defined as total cholesterol concentrations $\geq 6.5$ mmol/l (251 mg/dl) or triglyceride levels $\geq 2.3$ mmol/l (204 mg/dl).

Body mass index (BMI) was calculated as weight/height$^2$ (kg/m$^2$).

Blood glucose was analysed with a hexokinase method. Women with a fasting blood sugar $\geq 6.7$ mmol/l or who reported treatment of diabetes were considered to have diabetes.

Table 2  Mortality and cardiac event rates in women in relation to risk factor category

<table>
<thead>
<tr>
<th>Occupation</th>
<th>Cardiac events n (%)</th>
<th>Follow up (PY)</th>
<th>Deaths (95% CI)</th>
<th>Cardio events n (%)</th>
<th>Follow up (PY)</th>
<th>Events (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Education</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Primary school</td>
<td>110 (2.1)</td>
<td>55200 (1.2)</td>
<td>1.09 (1.64, 2.40)</td>
<td>15 (1.9)</td>
<td>25214</td>
<td>0.83 (0.52, 1.27)</td>
</tr>
<tr>
<td>High school</td>
<td>30 (1.3)</td>
<td>25268</td>
<td>1.19 (0.80, 1.69)</td>
<td>21 (0.9)</td>
<td>25214</td>
<td>0.83 (0.52, 1.27)</td>
</tr>
<tr>
<td>College/university</td>
<td>19 (1.3)</td>
<td>15435</td>
<td>1.23 (0.74, 1.92)</td>
<td>3 (0.2)</td>
<td>15424</td>
<td>0.19 (0.04, 0.57)</td>
</tr>
<tr>
<td>All</td>
<td>286 (3.1)</td>
<td>100167</td>
<td>2.86 (2.53, 3.21)</td>
<td>104 (11)</td>
<td>99881</td>
<td>1.04 (0.85, 1.26)</td>
</tr>
</tbody>
</table>

PV=person years.
Table 3  Baseline characteristics in women who had and had not a cardiac event during an average of 10.7 years follow up. Mean (SD) and unadjusted odds ratios (OR). For age and BMI expressed as relative risks associated with 1 unit increase.

<table>
<thead>
<tr>
<th>Variable</th>
<th>Age (years, mean (SD), range)</th>
<th>BMI (n=9247)</th>
<th>BMI (n=104)</th>
<th>OR (95% CI)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Smoking habits</td>
<td>48.5 (7.4) (28–59)</td>
<td>51.0 (5.6) (29–59)</td>
<td>1.06 (1.02, 1.10)</td>
<td></td>
</tr>
<tr>
<td>Never smoked, n (%)</td>
<td>4537 (45)</td>
<td>14 (14)</td>
<td>reference</td>
<td></td>
</tr>
<tr>
<td>Former smoker, n (%)</td>
<td>1747 (19)</td>
<td>15 (14)</td>
<td>2.54 (1.2, 5.3)</td>
<td></td>
</tr>
<tr>
<td>Current smoker, n (%)</td>
<td>3412 (36)</td>
<td>75 (72)</td>
<td>6.69 (3.8, 11.0)</td>
<td></td>
</tr>
<tr>
<td>Mostly sedentary during leisure time*</td>
<td>No 6442 (81)</td>
<td>78 (79)</td>
<td>reference</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Yes n (%)</td>
<td>1509 (19)</td>
<td>21 (21)</td>
<td>1.15 (0.71, 1.9)</td>
</tr>
<tr>
<td>Body mass index (kg/m²)</td>
<td>24.2 (4.1)</td>
<td>24.6 (3.7)</td>
<td>1.026 (0.98, 1.07)</td>
<td></td>
</tr>
<tr>
<td>Hypertension n (%)</td>
<td>No 7794 (88)</td>
<td>72 (69)</td>
<td>reference</td>
<td></td>
</tr>
<tr>
<td></td>
<td>Yes 1399 (15)</td>
<td>32 (31)</td>
<td>2.48 (1.6, 3.8)</td>
<td></td>
</tr>
<tr>
<td>Diabetes mellitus, n (%)</td>
<td>No</td>
<td>8943 (98)</td>
<td>91 (88)</td>
<td>reference</td>
</tr>
<tr>
<td></td>
<td>Yes 1505 (19)</td>
<td>21 (21)</td>
<td>1.15 (0.71, 1.9)</td>
<td></td>
</tr>
<tr>
<td>Smoking habits</td>
<td>No</td>
<td>2224 (24)</td>
<td>42 (41)</td>
<td>1.26 (1.46, 3.21)</td>
</tr>
<tr>
<td></td>
<td>Yes</td>
<td>6687 (76)</td>
<td>61 (59)</td>
<td>reference</td>
</tr>
<tr>
<td>Education†</td>
<td>Primary school, n (%)</td>
<td>5113 (58)</td>
<td>64 (73)</td>
<td>reference</td>
</tr>
<tr>
<td></td>
<td>High school, n (%)</td>
<td>2330 (26)</td>
<td>21 (24)</td>
<td>0.72 (0.44, 1.18)</td>
</tr>
<tr>
<td></td>
<td>College/university, n (%)</td>
<td>1409 (16)</td>
<td>3 (2.4)</td>
<td>0.17 (0.05, 0.54)</td>
</tr>
<tr>
<td>Occupation</td>
<td>High level, n (%)</td>
<td>1654 (18)</td>
<td>6 (6)</td>
<td>reference</td>
</tr>
<tr>
<td></td>
<td>Low level, n (%)</td>
<td>7543 (82)</td>
<td>98 (94)</td>
<td>3.58 (1.57, 8.17)</td>
</tr>
<tr>
<td>Marital status n (%)</td>
<td>Married</td>
<td>6568 (72)</td>
<td>71 (68)</td>
<td>reference</td>
</tr>
<tr>
<td></td>
<td>Single</td>
<td>2583 (28)</td>
<td>33 (31)</td>
<td>1.18 (0.78, 1.79)</td>
</tr>
<tr>
<td>Working conditions*</td>
<td>Satisfactory</td>
<td>7460 (83)</td>
<td>90 (91)</td>
<td>reference</td>
</tr>
<tr>
<td></td>
<td>Non-satisfactory</td>
<td>476 (6)</td>
<td>9 (9)</td>
<td>1.57 (0.78, 3.13)</td>
</tr>
<tr>
<td>Self reported stress</td>
<td>No</td>
<td>4276 (52)</td>
<td>43 (43)</td>
<td>reference</td>
</tr>
<tr>
<td></td>
<td>Yes</td>
<td>3966 (47)</td>
<td>58 (57)</td>
<td>1.45 (0.98, 2.16)</td>
</tr>
<tr>
<td>Previous myocardial infarction</td>
<td>No</td>
<td>9208 (99.6)</td>
<td>97 (93.3)</td>
<td>reference</td>
</tr>
<tr>
<td></td>
<td>Yes 9208 (99.6)</td>
<td>97 (93.3)</td>
<td>17.0 (7.4, 39.0)</td>
<td></td>
</tr>
</tbody>
</table>

Because of missing information analysis is based on (*) 99 cases and 7936 controls and on (†) 88 cases and 8852 controls, respectively.

risk factors over time. The results indicated that the application of the model was appropriate.

Results

EXPOSURE IN RELATION TO EDUCATION, OCCUPATION, MARITAL STATUS AND AGE

The prevalence of all risk factors was higher in women with low education and occupation levels (table 1). Smoking and hyperlipidaemia was more prevalent in single than in married women (table 1).

In the youngest age group (28–40 years, n=1577) 47% were smokers, 6.9% had hypertension, 8.8 % had hyperlipidaemia and 0.2% had diabetes. In the oldest age group (51–55 years, n=4281), 32% were smokers, 20% had.

Table 4  Cox proportional hazards regression model. Adjusted relative risks (see footnote) for mortality and cardiac events (95% CI)

<table>
<thead>
<tr>
<th>Variable</th>
<th>Mortality</th>
<th>Cardiac events</th>
</tr>
</thead>
<tbody>
<tr>
<td>Hypertension (yes v no)</td>
<td>Model 1*</td>
<td>Model 2†</td>
</tr>
<tr>
<td></td>
<td>1.6 (1,2, 2.1)</td>
<td>1.7 (1.3, 2.3)</td>
</tr>
<tr>
<td>Diabetes (yes v no)</td>
<td>3.6 (2.3, 5.6)</td>
<td>2.9 (1.8, 4.6)</td>
</tr>
<tr>
<td>Hyperlipidaemia (yes v no)</td>
<td>1.3 (1.0, 1.7)</td>
<td>1.1 (0.98, 1.5)</td>
</tr>
<tr>
<td>Smoking habits</td>
<td>3312 (36)</td>
<td>reference</td>
</tr>
<tr>
<td>Former v never</td>
<td>1.5 (1.1, 2.2)</td>
<td>1.5 (1.04, 2.1)</td>
</tr>
<tr>
<td>Current v never</td>
<td>2.5 (1.9, 3.2)</td>
<td>2.6 (2.0, 3.4)</td>
</tr>
<tr>
<td>Civil status (single v married)</td>
<td>1.6 (1.3, 2.1)</td>
<td>1.4 (1.1, 1.8)</td>
</tr>
<tr>
<td>Occupation (low v high level)</td>
<td>1.25 (0.89, 1.8)</td>
<td>1.1 (0.78, 1.6)</td>
</tr>
<tr>
<td>Education</td>
<td>High school v primary school</td>
<td>0.79 (0.53, 1.2)</td>
</tr>
<tr>
<td>University v primary school</td>
<td>0.94 (0.58, 1.5)</td>
<td>1.29 (0.78, 2.1)</td>
</tr>
</tbody>
</table>

*Adjusted for age. †Adjusted for age, hypertension, diabetes, hyperlipidaemia, history of myocardial infarction, and smoking habits.

KEY POINTS

- Exposure to cardiovascular risk factors varies substantially between groups of women defined in terms of education, occupation and marital status.
- This variation does not fully explain the higher rate of myocardial infarction in women with low occupation level or the higher mortality rate among single women.
- Smoking contributes more than hypertension, hyperlipidaemia and diabetes to the incidence of myocardial infarction in middle aged urban women.

MORTALITY AND CARDIAC EVENT RATES

Two hundred and eighty six (2.86/1000 person years) women died during the follow up period, 28 in this group died from ischaemic heart disease (ICD 410–414). One hundred and four (1.04/1000 person years) had a fatal or non-fatal cardiac event during the follow up period (table 2).

RISK FACTORS IN RELATION TO CARDIAC EVENTS

Smoking habits, age, diabetes, hypertension, hyperlipidaemia, occupation and education were all significantly associated with cardiac events (table 3).

MULTIVARIATE ANALYSIS

Smoking, hypertension, and diabetes remained significantly associated with mortality and cardiac events after adjustments for possible confounders (table 4). The associations between marital status and mortality (RR=1.4, 95%CI 1.1, 1.8) and between occupation level and cardiac events (RR=2.6, 95%CI 1.1, 6.0) remained similarly statistically significant when other risk factors were taken into account.

Discussion

A number of studies have shown that mortality and incidence of myocardial infarction varies between groups defined in terms of education, occupation and civil status. Although pattern of disease is strongly related to the prevalence of hypertension, smoking, and other risk factors.
Myocardial infarction in women

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smoking cessation rate.24 The lower prevalence to results from cross sectional studies it seems related to knowledge about the potential health extent di

be estimated that smoking explains 71% of major risk factors.

being single disappeared however in the multi-

increased cardiac event rate associated with hyperlipidaemia and diabetes it seems that potential confounders. Our results do not indicate that this association is attributable to an increased susceptibility for ischemic heart disease.

Smoking was in terms of relative risk and prevalence by far the most significant risk factor for myocardial infarction and death. Expressed in terms of attributable risk it can be estimated that smoking explains 71% of events of myocardial infarction and 37% of the deaths in this cohort.

Low level of education and low occupation level were both associated with an increased prevalence of smoking, hypertension, hyperlipidaemia and diabetes. Low occupation level increases the rate of cardiac events caused by exposure to these four risk factors.

Conflicts of interest: none.

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