Social inequalities in risk of ischaemic heart disease (IHD) have been consistently found in epidemiological studies in highly industrialized, so-called affluent, societies; these inequalities are only in part explained by conventional cardiovascular risk factors such as smoking, serum lipids, and blood pressure (including hypertension).

In the Copenhagen Male Study we have previously identified some new cardiovascular risk factors, and confirmed the existence of a number of conventional cardiovascular risk factors. An increased risk of IHD has been found in, (i) men with the Lewis blood group phenotype Le(a-b-), (ii) men with a relatively low serum selenium concentration, (iii) men with a low physical activity level in midlife, (iv) men with long-term occupational exposure to soldering fumes, and (v) men with long-term occupational exposure to soldering fumes.
occupational exposure to organic solvents,7 (vi) hypertensive men taking diuretics who have a relatively high intake of dietary sugar,8 (vii) men with a high concentration of serum low density lipoprotein cholesterol (LDL-C) who abstain from drinking alcohol,9 and, (viii) men with a low concentration of serum high density lipoprotein cholesterol (HDL-C) who abstain from drinking alcohol. Most studies on alcohol, serum lipids and risk have suggested that alcohol exerts its influence on cardiovascular risk by increasing the level of HDL-C. Our study showed that an inverse association between alcohol consumption and risk of IHD could be found even in men with a low HDL-C.9 Alcohol from spirits and wine had the most pronounced inverse association with risk of IHD9.

The main objective of this study was to examine if an uneven social distribution of all these potential risk factors might contribute further to the explanation of social differentials in risk.

SUBJECTS AND METHODS
The Copenhagen Male Study was set up in 1970 as a prospective cardiovascular cohort study of 5249 men from 14 randomly selected private or public companies.10,11 The men had a mean age of 48 years (range 40–59). According to a system by Svalastoga,12 later adjusted, the men were classified into five social classes, based on level of education and job profile.13 Typical jobs in the study cohort were, in social class I: officer, civil engineer, office executive, head of department; social class II: head clerk, engineer, unqualified architect; social class III: engine driver, train guard; social class IV: machine fitter in a telephone company; station foreman; social class V: unskilled labourer, mechanic, driver. For analytical purposes we used a dichotomous variable: ‘low social classes’ (classes IV and V) and ‘high social classes’ (classes I, II and III). In 1985–1986 all survivors were traced by means of the Danish Central Population Register. From the 1970–71 study we used information about physical activity and blood pressure.14

Between June 1985 and June 1986, all survivors (except for 34 emigrants) from the original cohort were invited to take part in this study where a new baseline used for the present prospective study was established. In all, 3387 (75%) men agreed and gave informed consent; their mean age was 63 years (range 53–74).

The 1985–1986 study took place at Glostrup Hospital, University of Copenhagen. Each subject was examined and measurements of blood pressure (BP), height and weight taken. The BP was measured on the right arm with the subject seated using a manometer developed by London School of Hygiene.15 Hypertension was defined as receiving antihypertensive treatment or having a systolic BP ≥150 mmHg and a diastolic BP ≥100 mmHg. Body mass index (BMI) was calculated as weight in kg/height in sqm. A venous blood sample was taken after the subject had fasted for at least 12 h for determination of serum concentration of selenium, cotinine, low density lipoprotein cholesterol (LDL-C), high density lipoprotein cholesterol (HDL-C) and triglycerides (TG); a urine sample was used for the determination of glucose. Lewis typing was carried out on red cells using a saline haemagglutination technique in test tubes with monoclonal antibodies (Seraclone, Biotest, Dreieich, Germany). One drop of antibody was mixed with one drop 5% red cell suspension, immediately spun down and read macroscopically.

Each subject was interviewed on the basis of a previously completed questionnaire. Information was obtained about occupational exposure to soldering fumes and organic solvents.7 The men answered a number of dietary questions on use of sugar in tea and coffee,8 and the category ‘use of sugar’ indicates use of sugar in tea, coffee or both. During the interview the men were queried about their use of medicine, and they reported whether they had diabetes mellitus as diagnosed by a doctor. Total weekly alcohol consumption was calculated from questionnaire items about average alcohol consumption on weekdays and at weekends. Intakes of beer, wine and spirits were reported separately. The men classified themselves as never smokers, previous smokers, or current smokers. Current tobacco smoking was calculated from information about the number of cigarettes, cheroots, cigars, or the weight of pipe tobacco smoked daily. One cigarette was taken as equivalent to 1 g tobacco, one cheroot as 3 g, and one cigar as 4 g tobacco. As previously estimated by means of measurements of serum cotinine, the validity of tobacco reporting was high.16 As regards leisure time physical activity, the men classified themselves as belonging to one of four groups. For presentation and analysis purposes the factor was dichotomized and the two categories comprised those either sedentary or moderately active <4 h per week, or those physically more active/very active. Subdivision into more categories gave no additional information or more precise statistical models.

We excluded from the prospective study men who at baseline had a history of acute myocardial infarction, angina pectoris, or stroke or who had intermittent claudication. For all who reported admission to hospital because of acute myocardial infarction before the start of the study, we checked hospital records. The diagnosis was accepted if at least two of the following symptoms/signs were recorded: retrosternal pain lasting >20 min.,
typical, serial electrocardiographic changes in more
than two electrocardiograms, acute increase of relevant
serum enzymes (alanine aminotransferase, lactate dehy-
drogenase or creatinine phosphokinase MB). Information
on angina pectoris, stroke and intermittent claudication
was established from the questionnaire. Some 342
men (10.1%) were excluded due to cardiovascular dis-
eases or symptoms, 71 men (2.1%) due to missing data
leaving 2974 men eligible for the incidence study.

In 1993 a register follow-up was carried out on
morbidity and mortality between 1985–1986 and 31
December 1991. All men who had taken part in the
1985–1986 study were traced by means of the Danish
Central Person Register. Information on hospital admis-
sions for non-fatal acute myocardial infarction and
death certificate diagnoses within the follow-up period
were obtained from the National Health Service register
and from the Danish Institute of Clinical Epidemiology.
We used the diagnoses from registers. The IHD diagnoses
accepted were codes 410–414, International Classifica-
tion of Diseases, 8th revision.

Statistical Analysis
Chi-squared analyses and Student’s t-tests were per-
formed using the SPSSPC+ basic statistical software,
version 3.1. In the logistic regression analyses, interaction terms for weekly consumption of alcohol and concentrations of HDL-C and LDL-C were included. In comparing relative risk of low versus high social classes the odds ratios were taken as estimates of relative risk (RR). For all analyses a two-tailed probability-
value of \( P < 0.05 \) was taken as statistically significant.

RESULTS
During the follow-up period 275 men (9.3%) died from
all causes, 184 men (6.2%) had a first IHD event, and
44 events were fatal.

Table 1 shows the relative strength of potential
predictors for IHD including established risk factors
and those recently identified in the Copenhagen Male
Study. The factors are presented according to strength of association with IHD after multivariable
adjustment in a multiple logistic regression analysis,
i.e. which factors most strongly separated IHD cases
from others while controlling for the effect of all expla-
natory variables. The strongest predictive factors were
the interaction of diuretics and sugar use, diastolic BP

<table>
<thead>
<tr>
<th></th>
<th>IHD event (n = 184)</th>
<th>No IHD event (n = 2790)</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Uses sugar and diuretics, %</td>
<td>7.6</td>
<td>1.3</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>Diastolic BP 1971 (mmHg)</td>
<td>85.7 (11.9)</td>
<td>81.4 (11.0)</td>
<td>&lt;0.001</td>
</tr>
<tr>
<td>LDL-C, mmol/l (alcohol × HDL-C)</td>
<td>4.60 (0.95)</td>
<td>4.42 (1.00)</td>
<td>0.01</td>
</tr>
<tr>
<td>Leisure time physical inactivity 1971, %</td>
<td>17.8</td>
<td>10.6</td>
<td>0.01</td>
</tr>
<tr>
<td>Age, years</td>
<td>64.0 (5.4)</td>
<td>62.7 (5.1)</td>
<td>0.02</td>
</tr>
<tr>
<td>Spirits, beverages/week</td>
<td>2.9 (4.8)</td>
<td>4.0 (5.0)</td>
<td>0.02</td>
</tr>
<tr>
<td>Long-term (&gt;5 y) occupational exposure to soldering fumes, %</td>
<td>12.1</td>
<td>7.8</td>
<td>0.03</td>
</tr>
<tr>
<td>HDL-C, mmol/l (alcohol × LDL-C)</td>
<td>1.31 (0.36)</td>
<td>1.36 (0.36)</td>
<td>0.03</td>
</tr>
<tr>
<td>Selenium, % &lt;1 μmol/l</td>
<td>35.0</td>
<td>27.3</td>
<td>0.07</td>
</tr>
</tbody>
</table>

* interaction term: alcoholic beverages/week × serum lipid concentration.
Variables are presented according to strength of association with IHD after multivariable adjustment. Values presented are mean (SD) or frequency in per cent of the factor in question. The \( P \)-value represents the probability outcome after multivariable adjustment in a multiple logistic regression model. All variables were entered into the model.


* \( P < 0.05 \); ** \( P < 0.01 \); *** \( P < 0.001 \).

Not significant in multivariate or univariate analysis: beer intake, physical activity in 1985–1986, smoking, diastolic BP, BMI, NIDDM, Lewis blood group phenotypes.
measured in 1970–1971, and the LDL-C concentration. Of the predictors presented, seven factors were either less established or new: the interaction of use of sugar and diuretics, the interaction of alcohol and HDL-C, physical activity level in midlife, spirits consumption, long-term exposure to soldering fumes, the interaction of alcohol and LDL-C, and (nearly significant) the concentration of serum selenium. It is denoted which factors were significantly associated with IHD before adjustment (t-test or $\chi^2$ test as appropriate).

Table 2 shows which potential cardiovascular risk factors included in Table 1 most strongly separated low social classes from higher classes in a multiple logistic regression analysis. The strongest factors were long-term occupational exposure to soldering fumes and solvents, followed by proportion of wine drinkers, serum selenium concentration, proportion of beer drinkers, proportion of spirits drinkers, leisure time physical activity in 1970–1971, and systolic blood pressure 1970–1971. It is denoted which factors were significantly associated with low or high social class before adjustment (t-test or $\chi^2$ test as appropriate).

Table 3 shows RR of IHD, death from all causes, and death from causes other than IHD with and without adjustment for potential confounders. The risk of IHD associated with low class as compared with higher classes dropped from a significant 1.44 to a not significant 1.12 ($P = 0.54$). As shown in a previous paper, when adjustments were made for established risk factors only, age, blood pressure, serum lipids, physical activity, and smoking, the RR dropped to 1.38 (95% confidence limits [CL] : 1.0–1.9), $P = 0.05$ (not shown in Table 3). With respect to death from all causes and death from causes other than IHD, the excess risk dropped by approximately 20 to 25% when including the same cardiovascular disease risk factors in the logistic regression model, and the excess risk associated with belonging to lower social classes remained significant after adjustment.

**DISCUSSION**

A number of newly identified IHD risk factors in the Copenhagen Male Study were significantly more prevalent among social classes IV and V as compared with classes I, II and III: a low serum selenium concentration, a low leisure time physical activity level in midlife, long-term occupational exposure to soldering fumes, and long-term occupational exposure to organic solvents, and low social classes had a smaller proportion of consumers of wine and spirits. Low social classes had a
higher proportion of smokers, were less physically active in their leisure time in 1970–1971 as well as in 1985–1986, and had a higher BP in 1970–1971. The association of low social class to these latter factors is well known.1–3 Studies on social differences in serum cholesterol concentration have been inconsistent.20–22 We found no social differences in the serum concentrations of LDL-C and HDL-C, but lower classes had a higher concentration of TG, possibly due to less leisure time physical activity.

Adjustment for the uneven distribution of major established and newly identified risk factors for IHD suggested that a major proportion of the excess risk of IHD associated with low social class could be ascribed to these factors. As shown in two previous papers3,7 from the Copenhagen Male Study, adjustment for established risk factors had little influence on the RR estimate. This result is in accordance with a number of major epidemiological studies.23–25 In a study by Pocock et al.20 approximately half of the increased risk in low social classes could be attributed to differences in smoking habits and blood pressure. The study population was however younger than ours and social differences in smoking habits more pronounced. In our study of fairly old men, smoking was no longer a major predictor of IHD and social differences in smoking habits were, although present, not as conspicuous as in Pocock’s study.

After multivariable adjustment, long-term exposure to soldering fumes, alcohol intake, serum selenium level, midlife physical activity (1970/71), blood pressure (1970/71 data) were associated with both risk of IHD and social class. When adjusting for these factors and established cardiovascular risk factors like blood pressure, physical activity, serum lipids and smoking, the estimated RR in low social classes, i.e. classes IV and V compared to classes I, II and III, dropped from RR = 1.44 to RR = 1.12. More than 70% of the excess risk was thus accounted for in the statistical model. It is encouraging that these factors are potentially modifiable.

Serum selenium levels were significantly higher with high social class, probably reflecting differences in dietary habits. The main sources of selenium in the Danish diet are fish and plant products like vegetables. Changing dietary habits in the population could be very difficult, but serum concentrations of selenium can be raised also by supplementation from tablets,5 which may be a more simple tool for providing social equity in this respect.

Intervention against social differences in leisure time physical activity may be more difficult. Campaigns encouraging people to perform at least some physical activity might get more attention from educated people; it has previously been shown that higher social classes, professionals and non-manual workers, responded more positively to e.g. anti-smoking campaigns.26 The result of such a campaign might accordingly be an overall lowered incidence of IHD in the population, which is of course in itself positive, but this would also imply a relative widening of social inequalities. Campaigns which aim to change lifestyle patterns should accordingly, presumably in general, be socioeconomically

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**Table 3 Relative risk (95% confidence limits) of ischaemic heart disease (IHD) (fatal/non-fatal), death from causes other than IHD, and all causes of mortality. Low social classes (IV and V) versus high classes (I, II and III)**

<table>
<thead>
<tr>
<th>Endpoint and adjustment</th>
<th>Classes I, II, III</th>
<th>Classes IV, V</th>
<th>P-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ischaemic heart disease, analysis adjusted for age only</td>
<td>1.44 (1.1–1.9)</td>
<td>0.02</td>
<td></td>
</tr>
<tr>
<td>Ischaemic heart disease, analysis adjusted for age and relevant confounders&lt;sup&gt;b&lt;/sup&gt;</td>
<td>1.12 (0.8–1.6)</td>
<td>0.54</td>
<td></td>
</tr>
<tr>
<td>Death from causes other than IHD, analysis adjusted for age only</td>
<td>1.61 (1.2–2.1)</td>
<td>&lt;0.001</td>
<td></td>
</tr>
<tr>
<td>Death from causes other than IHD, analysis adjusted for age and relevant confounders&lt;sup&gt;b&lt;/sup&gt;</td>
<td>1.45 (1.04–2.02)</td>
<td>0.03</td>
<td></td>
</tr>
<tr>
<td>Death from all causes of mortality, analysis adjusted for age only</td>
<td>1.59 (1.2–2.1)</td>
<td>&lt;0.001</td>
<td></td>
</tr>
<tr>
<td>Death from all causes of mortality, analysis adjusted for age and relevant confounders&lt;sup&gt;b&lt;/sup&gt;</td>
<td>1.47 (1.1–2.0)</td>
<td>0.01</td>
<td></td>
</tr>
</tbody>
</table>

<sup>a</sup> Reference category.

<sup>b</sup> Factors associated with IHD as well as social class: long-term exposure to soldering fumes, alcohol intake (wine and spirits), serum selenium level, midlife physical activity (1970/71), blood pressure 1970/71 (due to their interrelationship both systolic and diastolic were BP included in the analyses).
targeted with primary focus on the less educated, low social classes.

Intervention against possibly negative effects of soldering fumes exposure can be provided by proper elimination of fumes in the working environment. The mechanisms by which soldering fumes might operate are speculative.

With respect to intervening against social differences in alcohol consumption habits, the issue is controversial. Wine and spirits intake had the strongest inverse association with risk of ischaemic heart disease, although—due to the interrelationship of the two—only spirits consumption was entered into the multivariable model (Table 1). The proportion of wine drinkers was significantly higher for high social classes (65%) as compared with low classes (47%), both in the statistical and ordinary sense of the word. Should we advise the low social class middle-aged and elderly beer drinking man to take a glass of wine or a strong drink the next time he feels like a beer, not as a supplement, but instead, thus running the risk of increasing the proportion of alcoholics in the population?

Taking diuretics and consuming a fairly high amount of dietary sugar was the strongest predictor of IHD. As shown (Table 2) low social classes had a higher blood pressure in 1970–1971. They also had a significantly higher proportion of sugar users, but, despite this, in 1985–1986 the proportion of men taking diuretics and using much sugar was equally high in low and high classes. In a previous paper we presented the results of a study on social inequalities in risk of IHD during the period 1970–1988. We found a very strong inverse association between social class and risk. Compared to social class I the risk in social class V was increased by a factor 3.5. It can be speculated that the interaction of sugar use and use of diuretics might have been responsible for some of the social differentials in risk observed during that period.

We have previously shown that among work active men, i.e. approximately half of the cohort in 1985–1986, self-assessed incapability to relax after working hours was reported by approximately 9%, more frequently in high classes than in low classes. Incapability to relax was associated with a significantly increased risk of IHD. Multivariate adjustment for the impact of this factor also (not shown), had minimal influence, and none on the interpretation of the results.

Summing up, the results of this study suggest that a major proportion of the excess risk of IHD associated with low social class is mediated through lifestyle and occupational factors. A low serum selenium concentration, a low intake of wine and spirits (as compared with higher classes), a low level of leisure time physical activity, and long term occupational exposure to soldering fumes, are all factors potentially modifiable. Assuming that the associations between the potential risk factors and risk of IHD are causal, intervention against the social inequity in these factors may have substantial impact on social differentials in risk of IHD.

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