Self-reported economic difficulties and coronary events in men: evidence from the Whitehall II study

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Background Numerous studies have demonstrated social inequalities in coronary heart disease using a variety of measures of social position. In this study we examine associations between persistent economic difficulties and serious coronary events. Our aim is to assess whether these associations are (i) explained by other measures of socioeconomic status, and (ii) mediated by psychosocial, behavioural and biological factors.

Methods The data come from 5021 middle-aged, white-collar men in the Whitehall II study. Self-reported household financial problems, measured at baseline (1985–88) and Phase 3 (1991–93), were used to construct a five-category score of persistent economic difficulties. Associations between economic difficulties and incident coronary events were determined over an average follow-up of 7 years. Other socioeconomic, psychosocial, behavioural and biological explanatory variables were obtained from the Phase 3 questionnaire and clinical examination.

Results Age-adjusted Cox regression analyses demonstrated steep gradients in the incidence of coronary events with economic difficulties. The relative hazard between the bottom and the top of the difficulties hierarchy was 2.5 (95% confidence intervals CI 1.2–5.2) for fatal and non-fatal myocardial infarction (MI), 2.1 (1.3–3.6) for MI plus definite angina and 2.8 (1.9–4.2) for total coronary events. Adjustment for other markers of socioeconomic position, early life factors, psychosocial work environment characteristics and health-related behaviours had little effect, while adjustment for the biological factors reduced the association between difficulties and coronary events by 16–24%.

Conclusion We have demonstrated an economic difficulties gradient in coronary events in men that is independent of other markers of socioeconomic position and appears to be only partially mediated by well-known risk factors in mid-life.

Keywords Behavioural, biological, CHD, coronary events, economic difficulties, household, early life, social gradient, work environment characteristics

Numerous studies have demonstrated social inequalities in coronary heart disease (CHD) using a variety of measures of social position, the most common being occupation, education and income.1–4 While social inequalities are usually found regardless of the measure used, the strength of the association differs between measures (P. Martikainen unpublished work). For example, social position measured using the Cambridge scale, in which social classes are defined by similarities in lifestyle and resources, has been shown to have a stronger linear association with CHD than the Registrar General’s Social Classification, which is based on occupational standing.5 These different measures of social position tap into different dimensions of inequality and consequently adjustments of social gradients in CHD for potential confounders and mediating factors have been shown to be important.6,7

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Data and methods
Participants
The target population for the Whitehall II study was all London-based office staff, aged 35–55, in 20 Civil Service departments. With a response rate of 73%, the final cohort consisted of 10 308 participants: 6895 men and 3413 women. The true response rate would have been higher but ~4% of those invited were ineligible. Although mostly white-collar, respondents covered a wide range of employment grades from messenger to permanent secretary, the highest grade in the British Civil Service.

Data collection
Baseline screening (Phase 1) took place between late 1985 and early 1988. This involved a clinical examination in which height, weight, blood pressure, and serum cholesterol were determined, among other anthropometric and biomedical measures. A self-administered questionnaire containing sections on demographic characteristics, health, lifestyle factors, work characteristics, social support, life events and chronic difficulties was completed by each respondent. In Phase 2 (1989–90) the same questionnaire data were collected by post. Since then data collection phases including a questionnaire and clinical examination, in Phase 3 (1992–93) and Phase 5 (1997–99), have alternated with questionnaire only data collection, in Phase 4 (1995–96) and Phase 6 (2001).

Measures
Economic difficulties
A measure of economic difficulties was constructed from two questions from Pearl’s list of chronic strains, available from both the Phase 1 and Phase 3 questionnaires. These questions asked about difficulty in the payment of bills and how often the participant lacked sufficient money to afford the kind of food or clothing he/she or the family should have. The response categories were scored as follows: ‘never’ or ‘very little’ = 0; ‘seldom’ or ‘slight’ = 1; ‘sometimes’ or ‘some’ = 2; ‘often’ or ‘great’ = 3; and ‘always’, ‘very great’ or ‘very great problems’ = 4, giving a maximum score for economic difficulties of 8 at each phase. As these questions were introduced after the start of the baseline survey, values from the Phase 2 survey (1989–90) were used where baseline data were missing. The measure has a high internal consistency with correlations of ~0.6 at both phases.

A persistent economic difficulties score was constructed from the score at Phase 1/2 and Phase 3. Participants in the reference group had an economic difficulties score of 0 at both phases, while participants in the highest category had a score of 3+ at both phases, see Box 1.

Personal details
Age and employment grade were derived from the Phase 3 questionnaire. Employment grade was determined from the participant’s Civil Service grade title. For analysis, employment grade titles were divided into six categories in order of decreasing salary. Grade 6 represented the lowest status jobs and was defined as low employment grade.

Markers of early life
Father’s social class was determined at baseline using the Registrar General’s classification. Data from Phase 6 were used for participants with missing values. Participants whose fathers were from classes III manual, IV and V formed the group father’s social class manual. Height was measured to the nearest millimetre.

Behavioural risk factors
From the Phase 3 questionnaire, three health-related behaviours were examined: alcohol, exercise, and smoking. High alcohol consumption was defined as 22 or more units/week, which is the recommended limit for safe drinking among men used in the UK General Household Survey. Based on energy utilization, self-reported leisure-time physical activity was categorized as vigorous, moderate and mild. The

<table>
<thead>
<tr>
<th>Box 1 Categorization of economic difficulties scores</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>Economic difficulties score</td>
<td></td>
</tr>
<tr>
<td>0/0</td>
<td>A score of 0 both at Phase 1 and Phase 3 (reference group)</td>
</tr>
<tr>
<td>0/1–2</td>
<td>A score of 0 at either Phase 1 or Phase 3 and 1–2 at the other phase</td>
</tr>
<tr>
<td>1–2/1–2</td>
<td>A score of 1–2 both at Phase 1 and Phase 3</td>
</tr>
<tr>
<td>0–2/3+</td>
<td>A score of 0–2 at either Phase 1 or Phase 3 and 3+ at the other phase</td>
</tr>
<tr>
<td>3+/3+</td>
<td>A score of 3+ both at Phase 1 and Phase 3</td>
</tr>
</tbody>
</table>
cholesterol was calculated using the Freidewald equation. Biological risk factors

All the risk factors below were measured at the Phase 3 screening examination. Fibrinogen in grams/litre (g/litre) was determined by immunoturbidimetric methods. Blood pressure in millimetres of mercury (mm Hg) was measured twice with the participant seated after a 5 minute rest, using a Hawksley random-zero sphygmomanometer. Total, HDL cholesterol, and triglyceride concentration in millimoles/litre (mmol/litre) were measured using enzymic colorimetric methods, and waist and hip circumference was measured as previously described. LDL cholesterol was calculated using the Friedewald equation. Insulin resistance was estimated according to the homeostasis model assessment (HOMA), as the product of fasting glucose (mmol/litre) and serum insulin, divided by the constant 22.5. Higher HOMA scores indicate greater insulin resistance. Diabetic included all known diabetic associations.

Body Mass Index (BMI) was calculated from weight in kilograms (kg) and height in metres (m) as kg/m².

Oral glucose tolerance tests were administered following an overnight fast or in the afternoon after no more than a light fat-free breakfast taken before 8.00 hours. Plasma glucose and serum insulin were measured respectively by an electrochemical glucose oxidase method and by radioimmunossay. Insulin resistance was estimated according to the homeostasis model assessment (HOMA), as the product of fasting glucose and insulin, divided by the constant 22.5. Higher HOMA scores indicate greater insulin resistance. Diabetic included all known diabetics.

Work environment characteristics

Four psychosocial characteristics of the work environment were derived from the Phase 3 questionnaire. Low control and high demands at work were based on the Job Strain Model. Low work support had three components; support from colleagues, support from supervisors, and sufficient and consistent information from supervisors. Responses on a four-point scale from ‘often’ to ‘never/least never’ were combined into summary scales and then divided into tertiles. A high effort/reward ratio represented a high level of imbalance between extrinsic effort expended and reward received.

Outcome measures

In the analyses, three measures of incident coronary events between Phase 3 and the end of Phase 5 were examined. Myocardial infarction (MI) was defined as a coronary death (ICD 9 codes 410–414) or non-fatal MI verified in clinical records. Potential cases of non-fatal MI were ascertained by questionnaire items on chest pain, and doctor’s diagnosis of heart attack. Details of physician diagnoses and investigation results were sought from clinical records for all potential cases of MI. Twelve lead resting electrocardiograms were performed at Phases 3 and 5 (Siemens Mingeorec) and assigned Minnesota codes. Based on all available data (from questionnaires, study electrocardiograms, hospital acute ECGs and cardiac enzymes), non-fatal MI was defined following MONICA criteria. Classification of MI was carried out blind to other study data independently by two trained coders, with adjudication by a third in the (rare) event of disagreement. MI plus definite angina included, in addition to fatal and non-fatal MI, participants who reported symptoms of angina, with corroborating evidence in clinical records or abnormalities on a resting ECG, exercise ECG, or coronary angiogram. In addition to the above, total coronary events included self-reported cases in the absence of any clinical record evidence of coronary disease. All three outcomes comprised incident events only and all participants with prevalent CHD (including angina) at Phase 3 were excluded.

Study sample and statistical analysis

Of the 6895 men who participated in the baseline screening 83% (5739) completed a full questionnaire at Phase 3. Economic difficulties data were only available at Phase 1 for 75% of the men included in these analyses. Data for the remaining 25% were taken from the Phase 2 questionnaire. The 5021 men included in these analyses comprise those with data on economic difficulties, employment grade and smoking, and who did not have prevalent coronary events at Phase 3 (420 cases).

Phase 3 formed the baseline for the follow-up of incident coronary events. In the 7 years from Phase 3 to the end of follow-up there were 301 coronary events in men, including 85 cases of definite angina and 92 MIs. The paper examines associations in men as there were only 11 MIs among the 2142 women.

Event rates were calculated using person years at risk and standardized for age at Phase 3 by the direct method. Associations between the economic difficulties score and other risk factors with incident coronary events were described using hazard ratios and 95% confidence intervals (CI), computed using Cox’s proportional hazards models. The overall effect of the economic difficulties score, comparing the highest vs the lowest difficulties category, was summarized using the relative index of inequality (RII). This index, for each individual, is a score on a scale from 0 to 1 equal to the proportion of the sample that has higher economic difficulties. It overcomes the problem of comparing small groups at the extremes of the difficulties score distribution, as it takes into account both the population size and the relative position of the economic difficulties in all five score categories. In the analysis of coronary events, the RII shows the ratio of the instantaneous event rates between the extremes of the economic difficulties distribution (highest vs lowest difficulties).

Analyses to estimate the joint effects of other markers of socioeconomic position, early life, behavioural and biological factors and work characteristics on the RII in incident coronary events for the economic difficulties score, resulted in a proportion of the participants having data missing for one or more variables. In order to avoid having a selected dataset for multivariate analyses (in Table 3), multiple imputed values were generated for the missing data using the program NORM, from which five datasets were randomly selected. Analyses conducted on each of these five datasets gave very similar results and it is the mean of these estimates that is presented. The standard errors for these means are computed as the average standard error across the five datasets plus a term that allows for the variation in estimates across the five imputations. Since the RII summarizes a gradient across the whole range of economic difficulties, we have estimated effects of adjustment for other factors on the RII by calculating percentage changes using the logarithm of the hazard ratio for
the RII. Apart from the imputations, all statistical analyses were performed using the software package SAS 8.2.

Results
Table 1 shows that the greater the economic difficulties score, the higher the incidence of coronary events. The RII shows that men with the greatest economic difficulties score had 2.5 times higher incidence of MI than men with the lowest difficulties ($P < 0.001$). Similar trends are seen for MI plus definite angina and total coronary events ($P < 0.001$). The hazard ratios for the persistent difficulties score categories confirm the usually monotonically increasing gradient in coronary events.

The association between economic difficulties and other risk factors for heart disease are shown in Table 2. A strong inverse association is observed between economic difficulties and age. Strong positive associations are seen between economic difficulties and both rented housing and low employment grade with a non-linear association between economic difficulties and car access ($P$-value for heterogeneity, $P = 0.03$).

**Early life factors.** There is no association between economic difficulties and father's social class, but a strong direct association with height.

**Health related behaviours.** A strong economic difficulties gradient is observed for exercise and current cigarette smoking, but there appears to be no association between economic difficulties and alcohol consumption.

**Biological factors.** In these data there is no evidence of an association between economic difficulties and systolic blood pressure or any measure of cholesterol, except HDL ($P = 0.003$). However, there is a strong economic difficulties gradient in triglyceride level, waist-hip ratio, BMI, and insulin resistance ($P < 0.001$) and evidence of a gradient in diastolic blood pressure ($P = 0.03$) and diabetes ($P = 0.02$). No gradient is observed for fibrinogen.

**Work environment characteristics.** Strong, economic difficulties gradients are observed for all the psychosocial work characteristics ($P < 0.005$).

Table 3 shows the RII for the association between economic difficulties and coronary events after adjustment for other risk factors. The hazard ratio for the model adjusted for age, socioeconomic and early life factors is taken as the baseline. This model still shows strong associations between economic difficulties and coronary events. Psychosocial work characteristics and health-related behaviours only have a small effect on the RII for the three event outcomes, while adjustment for all the biological factors attenuates the association by 19% in the case of MI and MI plus definite angina, and by 11% for total coronary events.

Adjusting for all the potential explanatory variables simultaneously attenuates the RII by 16% for MI, 24% for MI plus definite angina and 17% for total coronary events.

Discussion
**Synopsis of results**
We observed a steep gradient between persistent economic difficulties in mid-life and coronary events in white-collar men. The markers of adult socioeconomic position, low employment grade and housing tenure, were highly correlated with economic difficulties, while car access showed a non-linear association. However, the associations between economic difficulties and coronary events were independent of all these socioeconomic markers.

In analyses adjusted for age, height but not father’s social class was associated with economic difficulties. By contrast there were gradients in lack of exercise, current smoking, diastolic blood pressure, HDL cholesterol, triglyceride, waist-hip ratio, BMI, insulin resistance, diabetes and all the psychosocial characteristics of the work environment. However, less than one-quarter of the gradients in coronary events generated by persistent economic difficulties appeared to be accounted for by these psychosocial, behavioural and biological measures.

**Relationship to previous work**
In addition to economic difficulties, five measures of socioeconomic position were examined in this study. One of the two early life factors, father’s social class, was not associated with economic difficulties in adulthood. This was unexpected as previous work has shown that father’s social class, as a marker of advantage or disadvantage in childhood, is correlated with...
Two of the three markers of adult socioeconomic position, low employment grade and housing tenure, were highly correlated with economic difficulties. However, adjustment for these measures produced little attenuation of the RII in economic difficulties for any of the coronary event outcomes. Extensive work in the Whitehall II study has documented employment grade gradients in coronary events and coronary risk factors. Although both employment grade and economic difficulties are markers of socioeconomic position, employment grade is primarily a work-based measure. That the association between economic difficulties and coronary events survives adjustment for employment grade indicates that our measure of persistent economic difficulties partly reflects a different set of factors than those captured by measures of job hierarchy. It also includes a contemporaneous measure of spending power amongst those who were no longer in paid employment at Phase 3. Furthermore, as indicated at the beginning of the article, different measures of social position tap into different dimensions of inequality and so adjustments of social gradients in coronary events for potential confounders and mediating factors will tend to produce different findings. In other analyses we have shown that the household wealth gradient for minor psychiatric morbidity and self-rated health in men remains highly significant after adjustment for employment grade.

Other studies have documented independent effects on health for different markers of socioeconomic position. The Helsinki Health study, which used data from middle-aged municipal employees, examined associations between seven measures of socioeconomic position and self-rated health. It was found that the association of economic difficulties in adulthood with health was independent of the conventional

<table>
<thead>
<tr>
<th>Economic difficulties score</th>
<th>0/0</th>
<th>0/1–2</th>
<th>1–2/1–2</th>
<th>0–2/3+</th>
<th>3+/3+</th>
<th>Test for trend</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coronary risk factor</td>
<td></td>
<td></td>
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<td></td>
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</tr>
<tr>
<td>Age</td>
<td>50.1 (0.1)</td>
<td>49.1 (0.2)</td>
<td>48.8 (0.2)</td>
<td>48.2 (0.2)</td>
<td>47.8 (0.3)</td>
<td>P &lt; 0.001</td>
</tr>
<tr>
<td>Socioeconomic measures</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Household tenure (rented) (%)</td>
<td>3.9 (0.5)</td>
<td>4.8 (0.6)</td>
<td>4.3 (0.8)</td>
<td>5.73 (0.8)</td>
<td>10.0 (1.4)</td>
<td>P &lt; 0.001</td>
</tr>
<tr>
<td>No car access (%)</td>
<td>11.3 (0.8)</td>
<td>10.3 (0.9)</td>
<td>8.3 (1.0)</td>
<td>9.4 (1.0)</td>
<td>14.6 (1.7)</td>
<td>P = 0.81</td>
</tr>
<tr>
<td>Low employment grade (%)</td>
<td>3.5 (0.4)</td>
<td>5.7 (0.7)</td>
<td>6.8 (1.0)</td>
<td>8.3 (1.0)</td>
<td>16.9 (2.0)</td>
<td>P &lt; 0.001</td>
</tr>
<tr>
<td>Early life factors</td>
<td></td>
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</tr>
<tr>
<td>Father manual social classb (%)</td>
<td>38.4 (1.2)</td>
<td>42.3 (1.5)</td>
<td>39.0 (2.0)</td>
<td>38.7 (1.8)</td>
<td>40.1 (2.6)</td>
<td>P = 0.68</td>
</tr>
<tr>
<td>Height (cm)</td>
<td>176.8 (0.2)</td>
<td>176.6 (0.2)</td>
<td>176.1 (0.2)</td>
<td>176.1 (0.2)</td>
<td>176.1 (0.3)</td>
<td>P = 0.003</td>
</tr>
<tr>
<td>Health related behaviours</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>High alcohol consumption (%)</td>
<td>17.6 (0.9)</td>
<td>19.2 (1.2)</td>
<td>16.9 (1.4)</td>
<td>18.8 (1.3)</td>
<td>16.7 (1.8)</td>
<td>P = 0.95</td>
</tr>
<tr>
<td>Little exercise (%)</td>
<td>13.5 (0.8)</td>
<td>12.1 (1.0)</td>
<td>11.6 (1.2)</td>
<td>16.4 (1.3)</td>
<td>18.4 (1.9)</td>
<td>P = 0.01</td>
</tr>
<tr>
<td>Current cigarette smoker (%)</td>
<td>8.1 (0.6)</td>
<td>12.8 (1.0)</td>
<td>12.8 (1.3)</td>
<td>13.0 (1.1)</td>
<td>20.5 (1.9)</td>
<td>P &lt; 0.001</td>
</tr>
<tr>
<td>Biological factors</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Systolic blood pressure (mm Hg)</td>
<td>122.2 (0.3)</td>
<td>121.2 (0.4)</td>
<td>121.8 (0.5)</td>
<td>122.2 (0.4)</td>
<td>121.8 (0.6)</td>
<td>P = 0.88</td>
</tr>
<tr>
<td>Diastolic blood pressure (mm Hg)</td>
<td>80.9 (0.2)</td>
<td>80.5 (0.3)</td>
<td>81.1 (0.4)</td>
<td>81.6 (0.3)</td>
<td>81.4 (0.4)</td>
<td>P = 0.03</td>
</tr>
<tr>
<td>Cholesterol (mmol/litre)</td>
<td>6.42 (0.03)</td>
<td>6.47 (0.03)</td>
<td>6.42 (0.04)</td>
<td>6.48 (0.04)</td>
<td>6.48 (0.05)</td>
<td>P = 0.19</td>
</tr>
<tr>
<td>LDL (mmol/litre)</td>
<td>4.41 (0.02)</td>
<td>4.45 (0.03)</td>
<td>4.42 (0.04)</td>
<td>4.45 (0.03)</td>
<td>4.43 (0.05)</td>
<td>P = 0.51</td>
</tr>
<tr>
<td>HDL (mmol/litre)</td>
<td>1.34 (0.01)</td>
<td>1.33 (0.01)</td>
<td>1.31 (0.01)</td>
<td>1.30 (0.01)</td>
<td>1.27 (0.02)</td>
<td>P = 0.002</td>
</tr>
<tr>
<td>Triglyceride (mmol/litre)</td>
<td>1.48 (0.03)</td>
<td>1.56 (0.04)</td>
<td>1.57 (0.05)</td>
<td>1.61 (0.04)</td>
<td>1.88 (0.06)</td>
<td>P &lt; 0.001</td>
</tr>
<tr>
<td>Fibrinogen (g/litre)</td>
<td>2.32 (0.01)</td>
<td>2.34 (0.02)</td>
<td>2.32 (0.02)</td>
<td>2.34 (0.02)</td>
<td>2.35 (0.03)</td>
<td>P = 0.18</td>
</tr>
<tr>
<td>Waist-hip Ratio</td>
<td>0.894 (0.001)</td>
<td>0.898 (0.002)</td>
<td>0.904 (0.002)</td>
<td>0.909 (0.002)</td>
<td>0.912 (0.003)</td>
<td>P &lt; 0.001</td>
</tr>
<tr>
<td>BMI (kg/m²)</td>
<td>24.7 (0.1)</td>
<td>25.0 (0.1)</td>
<td>25.2 (0.1)</td>
<td>25.4 (0.1)</td>
<td>25.5 (0.1)</td>
<td>P &lt; 0.001</td>
</tr>
<tr>
<td>Insulin resistance (HOMA units)</td>
<td>0.20 (0.02)</td>
<td>0.23 (0.02)</td>
<td>0.22 (0.03)</td>
<td>0.28 (0.03)</td>
<td>0.37 (0.04)</td>
<td>P &lt; 0.001</td>
</tr>
<tr>
<td>Diabetic (%)</td>
<td>0.7 (0.2)</td>
<td>0.5 (0.2)</td>
<td>1.3 (0.4)</td>
<td>1.4 (0.4)</td>
<td>1.3 (0.6)</td>
<td>P = 0.02</td>
</tr>
<tr>
<td>Psychosocial characteristics</td>
<td></td>
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</tr>
<tr>
<td>Low job control (%)</td>
<td>16.6 (0.9)</td>
<td>18.7 (1.2)</td>
<td>17.0 (1.5)</td>
<td>22.0 (1.5)</td>
<td>35.0 (2.4)</td>
<td>P = 0.001</td>
</tr>
<tr>
<td>High job demands (%)</td>
<td>36.9 (1.2)</td>
<td>36.0 (1.5)</td>
<td>32.9 (1.9)</td>
<td>30.1 (1.6)</td>
<td>32.9 (2.5)</td>
<td>P = 0.005</td>
</tr>
<tr>
<td>Low work support (%)</td>
<td>29.3 (1.1)</td>
<td>34.0 (1.5)</td>
<td>33.1 (1.9)</td>
<td>37.1 (1.8)</td>
<td>44.2 (2.5)</td>
<td>P &lt; 0.001</td>
</tr>
<tr>
<td>High effort/reward ratio (%)</td>
<td>32.8 (1.2)</td>
<td>31.8 (1.4)</td>
<td>34.7 (1.9)</td>
<td>35.0 (1.7)</td>
<td>38.9 (2.4)</td>
<td>P &lt; 0.001</td>
</tr>
</tbody>
</table>

a All associations, except age, are age-adjusted.
b Determined at baseline (Phase 1).
Table 3  Association between the relative index of inequality (RII) for economic difficulties and coronary events in 5021 men, after adjusting for other coronary risk factors

<table>
<thead>
<tr>
<th>Adjustments</th>
<th>Total coronary events</th>
<th>MI plus definite angina</th>
<th>MI</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Hazard Ratioa for RII (95% CI)</td>
<td>% change in RIIb</td>
<td>Hazard Ratioa for RII (95% CI)</td>
</tr>
<tr>
<td>Age</td>
<td>2.80 (1.9–4.2)</td>
<td>1.86 (1.1–3.2)</td>
<td>2.02 (0.9–4.4)</td>
</tr>
<tr>
<td>Age + SES measuresc</td>
<td>2.67 (1.7–4.1)</td>
<td>2.05 (1.3–3.6)</td>
<td>2.29 (1.0–5.0)</td>
</tr>
<tr>
<td>Age + SES measures + early life factorsd</td>
<td>2.70 (1.8–4.1) Baseline</td>
<td>2.09 (1.2–3.7) Baseline</td>
<td>2.49 (1.1–5.4) Baseline</td>
</tr>
<tr>
<td>Age + SES measures + early life factors + psychosocial work characteristicsd</td>
<td>2.56 (1.7–3.9) −6</td>
<td>2.09 (1.2–3.7) −6</td>
<td>2.49 (1.1–5.4) +5</td>
</tr>
<tr>
<td>Age + SES measures + early life factors + health-related behavioursd</td>
<td>2.60 (1.7–4.0) −4</td>
<td>2.05 (1.3–3.6) −6</td>
<td>2.29 (1.0–5.0) −5</td>
</tr>
<tr>
<td>Age + SES measures + early life factors + biological factorsd</td>
<td>2.42 (1.6–3.7) −11</td>
<td>1.86 (1.1–3.2) −19</td>
<td>2.02 (0.9–4.4) −19</td>
</tr>
<tr>
<td>Allh</td>
<td>2.28 (1.5–3.5) −17</td>
<td>1.78 (1.0–3.1) −24</td>
<td>2.07 (0.9–4.5) −16</td>
</tr>
</tbody>
</table>

a Hazard ratio for the RII represents the ratio of the incident coronary event rate for those with the greatest economic difficulties compared with those with the least.

b Percentage changes in RII are calculated using the logarithm of the hazard ratio for the relative index of inequality.

c Socioeconomic status (SES) measures, housing tenure, car access and employment grade.

d Early life factors, father’s social class and height.

e Psychosocial work characteristics, job control, job demands, social support at work and effort-reward imbalance.

f Health-related behaviours, alcohol, exercise and smoking.

gh Biological factors, systolic and diastolic blood pressure, cholesterol, HDL cholesterol, triglycerides, fibrinogen, waist-hip ratio, BMI, insulin resistance (HOMA units) and diabetes.

h All = age + SES measures + early life factors + psychosocial work characteristics + health-related behaviours + biological factors.
proportion of the socioeconomic gradient in coronary events.40,41

Methodological considerations
The present findings are only for men, all nominally white-collar civil servants on entry to the study. However, generalizability may be less limited than first imagined. Household income and low control at home are stronger determinants of health for women than men in the Whitehall II cohort.30,42 Thus, we expect to see these findings replicated in women when there are sufficient events for analysis. Furthermore, participants covered a wide range of employment grades with annual full-time salaries in 1995 ranging from £4995 to £150 000.

Of obvious concern in our analyses is the potential bias caused by inability to adjust for income. Unfortunately data on income were not collected in the Whitehall II study before Phase 5 (1997–99) as personal income in the British Civil Service was closely tied to employment grade, at least until the mid-1990s.43 To evaluate this potential residual confounding bias, we analysed the associations between household income at Phase 5 and economic difficulties at earlier phases. These analyses show that the correlation between household income at Phase 5 and the economic difficulties score between Phases 1 and 3 is weak, i.e. −0.11.

Further, to evaluate the extent of unmeasured income bias, we compared the longitudinal relationship between our persistent economic difficulties measure and self-rated health at Phase 5 with the cross-sectional relationship between household income and self-rated health at Phase 5. When entered into the same age-adjusted Cox regression model both measures demonstrated an independent association with poor self-rated health. The RII (95% CI) for economic difficulties was 2.30 (1.6–3.3) and that for household income was 2.58 (1.7–3.3), indicating strong independent effects for the two measures. It is thus very unlikely—because of weak correlations between economic difficulties and income, and independent associations of the two measures with another health outcome—that failure to adjust for income could be driving the association between economic difficulties and coronary events.

However, non-measurement of further socioeconomic and other explanatory factors may complicate the interpretation of our analyses. Such covariates include education, heritability, pre-clinical disease, perception of symptoms and diagnosis, ethnicity, diet, processes involving homocysteine, infection, and inflammation. A question on education was included part-way through the baseline screening of the Whitehall II cohort. However, exclusion of participants with these data missing would have unduly restricted the number of men included in the analyses. In addition to the covariates already discussed, economic difficulties may also reflect psychosocial determinants of health outside work, such as lack of control over life, low social integration in the local neighbourhood, and a local social infrastructure that does not allow full social engagement and participation in society.44,45

Our composite economic difficulties measure and 41% (124) of our total coronary events were derived from self-reported data only. For these 124 events there is the possibility that reporting bias has led to an overestimate of the association with economic difficulties. If we assume that the magnitude of the effects of economic difficulties on MI and angina are the same, then any differences in the strength of the association between total coronary events and MI plus definite angina may be due to reporting bias. Furthermore, if all of this difference is attributable to reporting bias then the overestimate is 26%. However, the gradient based on events with full clinical verification is still 2.14 and highly significant. A further possible source of bias relates to non-response. In common with other studies, response in this study was lower in the lower employment grades. Non-responders are more likely to have economic difficulties and be at greater risk of coronary events than responders. The theoretical inclusion of non-responders in analyses thus would probably make the distribution of economic difficulties more even and would also be likely to increase the RII for coronary events.

In addition to non-response and unmeasured explanatory variables we must also consider the role that imprecise measurement of correlated risk factors might have played in biasing our observed excess risk.46 It has been shown that the direction and magnitude of such bias is unpredictable in multivariate analyses,47 so it is possible that the magnitude of the excess risk remaining after adjustment may be due in part to imprecisely measured risk factors. While measurement of biological risk factors in the Whitehall II study is executed using standardized protocols with frequent quality control checking,48 measurement error cannot be discounted.

Conclusion
We have demonstrated an economic difficulties gradient in coronary events in men that is independent of other markers of socioeconomic position and appears to be only partially mediated by well-known risk factors in mid-life. Public health recommendations arising from this work are that policies ensuring households can meet their bills and afford adequate food and clothing should be considered. The experience of economic difficulties represents a dimension of socioeconomic inequality that has been largely neglected in social epidemiology. As a consequence the causes underlying the association between economic difficulties and coronary events and other health outcomes remain largely unknown.

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KEY MESSAGES

- There is a steep graded association between economic difficulties and coronary events in men, which is independent of other markers of socioeconomic position.
- Less than one-quarter of this gradient appears to be accounted for by traditional coronary risk factors.
- The experience of economic difficulties represents a dimension of socioeconomic inequality largely neglected in social epidemiology. Consequently, the causes underlying the association between economic difficulties and coronary events and other health outcomes remain largely unknown.

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