

Women's exposure to early and later life socioeconomic disadvantage and coronary heart disease risk: the Stockholm Female Coronary Risk Study

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- Background** Measures of low socioeconomic position have been associated with increased risk for coronary heart disease (CHD) among women. A more complete understanding of this association is gained when socioeconomic position is conceptualized from a life course perspective where socioeconomic position is measured both in early and later life. We examined various life course socioeconomic indicators in relation to CHD risk among women.
- Methods** The Stockholm Female Coronary Risk Study is a population-based case-control study, in which 292 women with CHD aged ≤ 65 years and 292 age-matched controls were investigated using a wide range of socioeconomic, behavioural, psychosocial and physiological risk factors. Socioeconomic disadvantage in early life (large family size in childhood, being born last, low education), and in later life (housewife or blue-collar occupation at labour force entry, blue-collar occupation at examination, economic hardships prior to examination) was assessed.
- Results** Exposure to early (OR = 2.65, 95% CI: 1.12-6.54) or later (OR = 5.38, 95% CI: 2.01-11.43) life socioeconomic disadvantage was associated with increased CHD risk as compared to not being exposed. After simultaneous adjustment for marital status and traditional CHD risk factors, early and later socioeconomic disadvantage, exposure to three instances of socioeconomic disadvantage in early life was associated with an increased CHD risk of 2.48 (95% CI: 0.90-6.83) as compared to not being exposed to any disadvantage. The corresponding adjusted risk associated with exposure to later life disadvantage was 3.22 (95% CI: 1.02-10.53). Further analyses did not show statistical evidence of interaction effects between early and later life exposures ($P = 0.12$), although being exposed to both resulted in a 4.2-fold (95% CI: 1.4-12.1) increased CHD risk. Exposure to cumulative socioeconomic disadvantage (combining both early and later life), across all stages in the life course showed strong, graded associations with CHD risk after adjusting for traditional CHD risk factors. Stratification of cumulative disadvantage by body height showed that exposure to more than three periods of cumulative socioeconomic disadvantage had a 1.7- (95% CI: 0.9-3.2) and 1.9- (95% CI: 1.0-7.7) fold increased CHD risk for taller and shorter women, respectively. The combination of both short stature and more than two periods of cumulative socioeconomic disadvantage resulted in a 4.4-fold (95% CI: 1.7-9.3) increased CHD risk.

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Conclusions Both early and later exposure to socioeconomic disadvantage were associated with increased CHD risk in women. Later life exposure seems to be more harmful for women's cardiovascular health than early life exposure to socioeconomic disadvantage. However, being exposed to socioeconomic disadvantage in both early and later life magnified the risk for CHD in women. Cumulative exposure to socioeconomic disadvantage resulted in greater likelihood of CHD risk, even among women who were above median height. In terms of better understanding health inequalities among women, measures of socioeconomic disadvantage over the life course are both conceptually and empirically superior to using socioeconomic indicators from one point in time.

Keywords Socioeconomic position, life course, women, cardiovascular health, coronary heart disease

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Coronary heart disease (CHD) contributes almost half of all deaths in both men and women in the industrialized world¹ and dominates mortality and morbidity in some developing countries as well.² While measures of low socioeconomic position have been associated with increased risk for CHD in a large number of studies,³⁻⁶ only a small fraction of past research has investigated associations between socioeconomic position and CHD risk in women. Some studies have suggested that associations between socioeconomic position and health are weaker among women than men,⁷ while others have actually demonstrated stronger associations in women.⁸ There seems no *a priori* reason to assume that exposure to socioeconomic disadvantage should have weaker effects on women's than men's health, but this may depend on which measure of socioeconomic position is used^{7,9,10} and how well it captures the relevant exposures for particular disease outcomes in women. For instance, in countries such as Sweden, where female labour force participation is as high in women as in men,¹¹ exposures related to paid employment may be particularly important in understanding socioeconomic differences in CHD risk, as well as other health outcomes.¹²

In addition to the potential for gender-biased measurement of socioeconomic position in women, another issue of exposure assessment involves measuring socioeconomic conditions at more than one point in the life course.¹³⁻¹⁶ It may be important to assess socioeconomic disadvantage at multiple points over the life course to gain a more complete understanding of how socioeconomic position, its dynamics, and the various exposures and experiences it implies, influences later health.¹⁷ Such a life course approach to socioeconomic disadvantage among women has rarely been examined.

We investigated socioeconomic indicators that are relevant to particular stages (in early and later life) of the life course. A woman's exposure to socioeconomic disadvantage in early life was based on large childhood family size, being born last, less than high school education and in later life was based on housewife or blue-collar occupation at labour force entry, occupation at examination, and economic hardships in her household prior to the CHD event. We used data from the Stockholm Female Coronary Risk Study which is a population-based case-control investigation of risk factors for CHD among women aged 30-65 years living in the greater Stockholm area.

Materials and Methods

The Stockholm Coronary Risk Study is a population-based case-control study which comprised all female patients below 66 years, who were admitted to the ten coronary care units in Stockholm for an acute event of CHD (either acute myocardial infarction [AMI], or recurrent or unstable angina pectoris [AP] between 1991 and 1994. All patients were contacted first by mail, and then by phone. During the 3-year study period, 335 women with CHD were identified.

Forty-three of the identified patients (13%) could not be included in the study due to inability to speak Swedish fluently (n = 21), death (n = 5), sickness (n = 13), transportation difficulties (n = 2), or enrolment in other studies (n = 2). The remaining 292 patients were compared to 292 healthy controls, matched on age and area of catchment, who were obtained from the general Stockholm population through the census register. In this register each individual has a unique identification number based on birth date and sex. For each patient, a 'healthy' control born on the same day or another day as close as possible (within one year) was chosen. 'Healthy' was defined as being free from symptoms of heart disease during the prior 5-year period.

The Swedish health care system provides care to all residents regardless of income, socioeconomic or insurance status. Thus, we were certain to reach virtually all patients who needed and sought hospital care for an acute CHD event during this time period. The criteria for admission to intensive coronary care units were the same at all ten cardiology clinics. They were developed and agreed upon by a special clinical co-ordination group. Criteria upon which patients were recruited and a more detailed description of the study groups has been given elsewhere.^{6,18}

The study group was restricted to Swedish-speaking female patients below 66 years. Patients who died in hospital or before reaching the hospital, were not included. All patients were examined between 3 and 6 months after hospitalization. Matched control subjects were examined during a corresponding time period. The study was approved by the Karolinska Hospital Ethics Committee (No. 91;119), Stockholm. The non-response rate was 13% and 17% for patients and controls, respectively. Control subjects were compared on educational level with a

random sample of 2500 women of the same age range from the general population of Stockholm¹⁹ and no differences were found.

Data collection and assessments

A questionnaire on behavioural and psychosocial factors was mailed to the subjects prior to their visit to the research clinic. Questionnaires were filled out at home and brought to the research clinic, where the research nurse reviewed them together with the subject to complete missing answers. Internal non-response rate was <10%. Anthropometric measures, blood pressure and fasting blood samples were all collected and assessed at the research clinic. Behavioural and psychosocial characteristics, such as smoking, physical activity, social isolation, hopelessness, poor coping and job stress were assessed using standardized and validated instruments.²⁰⁻²² Supplementary data were collected using structured interview and the interviewers were blinded to subject status. A detailed description of these measurements is presented elsewhere.^{6,18}

Socioeconomic indicators

Early life

Measures of early life socioeconomic disadvantage were collected by structured interview and were constructed based on a woman's family size in childhood, birth order and her education. Family size was assessed by asking about the number of siblings. Additional data were collected on the number of 'whole'- and 'half'-siblings. Birth order was assessed by asking the subjects whether they were singletons, or born first, in the middle, or last among siblings. Low education was defined as mandatory or having <9 years of formal education, and was taken to reflect socioeconomic disadvantage in later childhood and adolescence.

Later life

Measures of later life socioeconomic disadvantage were constructed based on a woman's occupation at labour force entry, her occupation at examination and economic hardships in her household prior to examination. Occupation at labour force entry was categorized as housewife, blue- or white-collar. In all, 49 women reported working in the home as their first occupation (19 controls and 30 patients). Reporting being a housewife or holding a blue-collar occupation at labour force entry was considered to indicate socioeconomic disadvantage in early adulthood at the time of entry into the labour market. Blue-collar occupations included unskilled factory workers, cleaners, and unskilled assistants working in catering, laundries, home care, shops and nursing.

Occupation at examination was based on present or the most recent occupation: 12 controls and 39 patients were on sick leave, 32 controls and 29 patients were either on studies or out of employment and 52 controls and 45 patients were on early pension. For this latter group, the most recent occupation was considered. There were only 2 women (1 control and 1 patient) who had been housewives their entire lives, and these were excluded from the analyses. Women with present occupation had held their jobs for a long period of time, median = 15 and 13 years for controls and patients, respectively. Earned income from the registers were considered incomplete as they do not include supplementary income benefits from, for example, the social welfare system. We therefore used a qualitative measure of economic hardships before hospitalization. Economic hardships

have been shown to be indicative of actual income levels and predict health outcomes.²³ Economic hardship was determined by questions in a structured interview including whether: the subject was the main or sole bread winner, her income was absolutely necessary for her household financial needs, the subject had had economic difficulties previously. A subject was considered having economic hardship if more than two of the above questions were true.

Cumulative score

A cumulative score of socioeconomic disadvantage was created for each stage summarizing socioeconomic indicators in early and later life course stages. This score was based on the sum of instances of socioeconomic disadvantage in early and late life separately (minimum = 0 and maximum = 3).

A total cumulative score of socioeconomic disadvantage summarized socioeconomic indicators over the entire life course. This score was based on the sum of instances of socioeconomic disadvantage both in early and late life (minimum = 0 and maximum = 6).

Body height

Among healthy women, the lowest 25% of the height distribution was 160 cm, the median and mean height was 164 cm. Among the CHD patients the lowest 25% of the height distribution was 159 cm, the median and mean height were 162 cm and 163 cm, respectively.

We preferred defining short stature as the lowest 25% of height distribution (160 cm) among the healthy women because they represent the normal population of women in a metropolitan area of Sweden. This cut-off is more conservative than using (mean height [164 cm] minus one standard deviation [6.0]), which would be equal to 158 cm). In fact, we have previously reported this cut-off of 160 cm to be a strong predictor of poor CHD prognosis in women patients of the same sample.²⁴ Body height is associated with upward mobility, taller people achieving higher socioeconomic position,²⁵ and attained body height is determined by both genetic growth potential and early life socioeconomic and nutritional factors. Thus, as body height is an inherently 'confounded' indicator of childhood socioeconomic disadvantage, we examined the effects of cumulative socioeconomic disadvantage stratified on body height.

Statistical analyses

Chi-square tests were used to test distributional differences in the measures of socioeconomic position among women with and without CHD. Controls were matched to patients based on age and catchment area and so conditional logistic regression analyses were used to estimate the effects of cumulative socioeconomic disadvantage on CHD risk. Odds ratios (OR) and 95% CI are reported.

Sequential analyses included: (1) examining distributions of socioeconomic indicators in patients and controls, (2) examining each indicator of socioeconomic disadvantage separately and mutually adjusting for these indicators, (3) examining a cumulative score for each stage separately, and simultaneously adjusting for traditional CHD risk factors, early and later life, (4) examining interaction effects between early and later life socioeconomic disadvantage, (5) examining the additive effects (total cumulative score across early and later life), and (6) examining the total cumulative score after stratifying on body height. Because singletons (46 CHD patients and 37 controls) did not

show a statistically significant increased CHD risk, they were categorized as not being exposed to early life socioeconomic disadvantage in the analyses of cumulative socioeconomic disadvantage. Statistical analyses were performed using Stata version 6.0.

Results

Distribution of socioeconomic indicators among women with CHD and healthy women

Table 1 shows the distributions of the separate measures of socioeconomic disadvantage among patients and controls. Women with CHD were statistically significantly more likely to be socioeconomically disadvantaged on all indicators both in early and later life. In relation to early life exposure, a large childhood family, being born last, and having low education were present in 27%, 20%, and 63%, respectively, among women with CHD, as compared to 19%, 13%, and 53%, respectively, among healthy women. In relation to later life exposure, being a housewife, holding a blue-collar occupation at labour force entry, blue-collar occupation at examination and economic hardship were present in 13%, 41%, and 16%, respectively, of women with CHD, as compared to 7%, 32%, and 10%, respectively, of healthy women (Table 1). The proportion of women who were not working at the time of examination due to disability, sickness or unemployment did not substantially differ between women with CHD and healthy women ($P = 0.16$).

We found associations between early and later life socioeconomic disadvantage. For example, 32% of women who had blue-collar occupation at labour force entry were from larger families (>3 siblings) compared with 16% who had a white-collar occupation and 75% of women in blue-collar jobs had low education compared with 44% in white-collar occupations ($P < 0.0001$). There was a tendency for women who reported being a housewife (33%) at labour force entry to come from a larger family ($P = 0.09$). In addition, women from a large family

had lower education than those from smaller families (54% versus 70%, $P = 0.002$). In relation to blue-collar occupation (at examination), 83% had low education as compared with 54% who had a white-collar occupation ($P < 0.0001$). Some 72% of women who reported economic hardship were last-borns compared with 60% who did not report such hardship ($P = 0.03$). Low education was also associated with being born last as compared to being born first or as an intermediate (59% versus 63%). Women who were singletons were more likely to have held a blue-collar job at labour force entry than those who had siblings (48% versus 35%, $P = 0.045$).

In relation to body height, a larger proportion of women from larger families were shorter as compared to women from smaller families (42% versus 30%, $P = 0.01$). Short stature was also associated with low education (25% versus 38%, $P = 0.002$) and with blue-collar occupation at labour force entry (27% versus 42%, $P = 0.001$) as compared with women of high education and white-collar occupation, respectively.

Risk of CHD in relation to separate measures of early and later life socioeconomic disadvantage

Table 2 shows elevated risks for CHD for early and later socioeconomic disadvantage after adjusting for marital status. A large family size, being born last and low education were associated with 1.7 (95% CI: 1.1–2.5), 1.8 (95% CI: 1.0–3.3), and 1.7 (95% CI: 1.2–2.4) increased CHD risk as compared with smaller family size, not being last, and high school/college education, respectively (Table 2). Being a singleton was not associated with increased risk for CHD as compared to women who had siblings (OR = 0.77; 95% CI: 0.48–1.23). Interestingly, women who were born last and at the same time had a large family (>3 siblings) and had an elevated CHD risk of 3.33 (95% CI: 1.1–6.07) (data not shown).

In relation to later life socioeconomic disadvantage the OR for CHD associated with blue-collar occupation or being a housewife at labour force entry were 2.0 (95% CI: 1.2–2.6) and 2.5

Table 1 Distribution of various measures of socioeconomic disadvantage over the life-course among women with coronary heart disease (CHD) and healthy control women

Measure of socioeconomic disadvantage	Women with CHD	Healthy control women	P-value ^a
Body height <160 cm	114 (39%)	79 (27%)	0.002
Early life socioeconomic disadvantage			
Early life family size (siblings >3)	78 (27%)	55 (19%)	0.023
Birth order			
Singletons	37 (19%)	46 (17%)	
Last	46 (28%)	36 (15%)	
Low education (≤ 9 years)	181 (63%)	153 (53%)	0.014
Later life socioeconomic disadvantage			
Occupation at labour force entry			
Housewife	30 (13%)	19 (7%)	
Blue-collar	97 (41%)	80 (32%)	0.004
Occupation at examination			
Blue-collar	47 (16%)	29 (10%)	0.024
Not working ^b	80 (27%)	63 (21%)	0.10
Economic hardship prior to CHD event	113 (39%)	96 (33%)	0.16

^a P-value from χ^2 tests.

^b Not working due to disability, sickness, early pension, studies or unemployment.

Table 2 Coronary heart disease (CHD) risk in relation to various measures of socioeconomic position in early and later life

Measure of socioeconomic disadvantage ^a	Unadjusted OR (95% CI) ^b	Simultaneous adjustment for measures of socioeconomic position in early and later life OR (95% CI) ^b
Short stature (<160 cm)	1.78 (1.25–2.54)	1.66 (1.06–3.06)
Early life socioeconomic disadvantage		
Large early life family size (>3 siblings)	1.67 (1.12–2.48)	1.16 (0.61–1.89)
Singletons (versus born first with siblings)	1.32 (0.57–2.29)	1.12 (0.36–2.79)
Born last (versus born first with siblings)	1.80 (1.01–3.25)	1.46 (0.81–2.64)
Low education (≤9 years)	1.71 (1.16–2.55)	1.46 (1.03–2.42)
Adult life socioeconomic disadvantage		
Occupation at labour force entry		
Blue-collar	1.97 (1.20–2.60)	1.80 (1.12–3.12)
Housewife	2.50 (1.32–4.73)	1.48 (0.89–2.97)
Blue-collar occupation at examination	1.88 (1.04–3.91)	1.69 (0.95–2.88)
Economic hardship prior to CHD event	1.79 (1.15–2.77)	1.62 (1.04–3.32)

^a A higher position was used as the reference level for each measure of socioeconomic position.

^b Odds ratio and 95% CI from the conditional logistic regression models.

(95% CI: 1.3–4.7), respectively, as compared with women who had a white-collar occupation. Blue-collar occupation at examination and economic hardship prior to examination were associated with 1.9 (95% CI: 1.0–3.9) and 1.8 (95% CI: 1.2–2.8) risk of later life socioeconomic disadvantage as compared with women with white-collar occupation and those not experiencing economic hardship, respectively (Table 2).

Table 2 also shows simultaneous adjustment for indicators of early and later life socioeconomic disadvantage. Among indicators of early life socioeconomic disadvantage, only low education remained statistically significantly associated with increased CHD risk. The CHD risk associated with being a last-born or coming from a large family were still elevated but no longer statistically significant after adjustment for later disadvantage (Table 2). Among the indicators of later life socioeconomic disadvantage, blue-collar occupation at labour force entry, and at examination, and economic hardship remained statistically significantly associated with increased CHD risk after simultaneous adjustment for early and later life socioeconomic disadvantage. Short stature also remained statistically significantly associated with increased CHD risk (Table 2).

CHD risk in relation to cumulative score in early and later life

A cumulative score was categorized as not exposed at any time (reference), or being exposed at one, two or all three instances (Table 3). Being exposed to socioeconomic disadvantage at all three instances in early life, was associated with a 2.5-fold (95% CI: 1.1–5.7) increased risk for CHD as compared with not being exposed. Exposure to one or two instances of socioeconomic disadvantage in early life did not show statistically significantly elevated CHD risk (Table 3, model I). Being exposed to any socioeconomic disadvantage in later life, however, was associated with increased CHD risk, and this risk increased with the higher number of instances of exposure to socioeconomic disadvantage. The OR for CHD risk associated with being exposed at one, two and three exposures were 1.9 (95% CI: 1.2–2.7),

2.2 (95% CI: 1.2–4.1), and 5.4 (95% CI: 2.0–14.4) respectively (Table 3, model I).

When we simultaneously adjusted for early and late life cumulative scores (model II), early life exposure did not show any strong pattern or statistically significant increased CHD risk. The CHD risk associated with cumulative score in later life, although attenuated, remained statistically significant even when exposed at one instance (Table 3, model II). The risk for CHD in relation to exposure in later life, independent of the early life exposure, at one, two and three instances were 1.9 (95% CI: 1.1–3.2), 2.0 (95% CI: 1.0–4.0), 3.6 (95% CI: 1.2–10.8), respectively (Table 3, model II).

In model III, further adjustment for traditional CHD risk factors (smoking, physical activity, obesity, high-density lipoprotein (HDL)-cholesterol, triglycerides, hypertension and fibrinogen), showed that the effects of early socioeconomic exposures on CHD risk somewhat strengthened, while that of later life disadvantage persisted (Table 3, model III).

Interaction effects between early and later life cumulative score of socioeconomic disadvantage in relation to CHD risk

In the evaluation of interaction effects between early and later life cumulative socioeconomic disadvantage, we collapsed socioeconomic disadvantage into no exposure (0–1 instances) and exposed (2–3 instances). Firstly, we run logistic regression analyses with simultaneous adjustment for early and later life socioeconomic disadvantage. The analyses showed that dichotomized socioeconomic disadvantage was associated with 1.4-fold (95% CI: 0.8–3.1) and 2.4-fold (95% CI: 1.1–6.2) increased CHD risk in early and later life, respectively (Table 4). Interaction analyses showed that being exposed to later life socioeconomic disadvantage in the absence of early life exposure showed a modest (OR = 1.3, 95% CI: 0.4–4.0) increased CHD risk, but being exposed in early life in the absence of later life exposure did not show any increased CHD risk (OR = 0.96, 95% CI: 0.5–2.0) as compared with women who were not

Table 3 Cumulative exposure to socioeconomic disadvantage in early and later life in relation to coronary heart disease risk. Odds ratios and 95% CI from the conditional logistic regression models

Instances of cumulative exposure to socioeconomic disadvantage	Unadjusted (I)	Multivariable adjusted (II)	Multivariable adjusted (III)
Short stature (<160 cm)	1.78 (1.25–2.54)	1.63 (1.08–2.47)	2.32 (1.33–4.05)
Early life exposure^a			
Not exposed (n = 145)	1	1	1
One instance (n = 103)	1.51 (0.67–3.41)	1.56 (0.72–3.23)	1.96 (0.84–4.58)
Two instances (n = 60)	1.73 (0.96–3.88)	1.34 (0.62–2.88)	1.90 (0.77–4.56)
Three instances (n = 64)	2.65 (1.12–6.54)	1.68 (0.68–4.17)	2.48 (0.90–6.83)
Later life exposure^b			
Not exposed (n = 255)	1	1	1
One instance (n = 68)	1.89 (1.10–2.74)	1.88 (1.10–3.22)	1.57 (0.87–2.86)
Two instances (n = 116)	2.18 (1.17–4.06)	2.02 (1.01–4.01)	1.92 (0.76–2.87)
Three instances (n = 41)	5.38 (2.01–11.43)	3.57 (1.18–10.83)	3.22 (1.02–10.53)

^a Socioeconomic disadvantage in early life: low education, large childhood family size (>3 siblings) and being born last.

^b Socioeconomic disadvantage in later life: first job as blue-collar or housewife, present job as blue-collar and severe economic hardship.

Multivariable adjusted (II): Simultaneously adjusted for early and later life socioeconomic disadvantage. Multivariable adjusted (III): Model (II) + marital status, smoking, physical activity, abdominal obesity, high-density lipoprotein (HDL)-cholesterol, triglycerides, hypertension, fibrinogen.

Table 4 Interaction effects of exposure to early and later life socioeconomic disadvantage on coronary heart disease risk. Odds ratios and 95% CI from the conditional logistic regression models

Exposed to early life socioeconomic disadvantage ^a	Exposed to later life socioeconomic disadvantage ^b	
	NO (0–1 instance) (n = 372)	YES (2–3 instances) (n = 109) OR = 2.43 (1.09–6.21) ^c
NO (0–1 instance) (n = 206)	1	1.26 (0.42–4.03)
YES (2–3 instances) (n = 167) OR = 1.42 (0.83–3.07) ^c	0.96 (0.46–2.03)	4.16 (1.43–12.10)

^a Socioeconomic disadvantage in early life based on being exposed to ≥ 2 of the following: low education, large childhood family size (>3 siblings) and being born last.

^b Socioeconomic disadvantage in later life based on being exposed to ≥ 2 of the following: first job as blue-collar or housewife, present job as blue-collar and economic hardship.

Log rank χ^2 test for interaction was not statistically significant ($\chi^2 = 2.44$, $P = 0.12$).

^c From the logistic regression model after simultaneously adjusting for early and later socioeconomic disadvantage.

exposed (Table 4). Being exposed to economic disadvantage in both early and later life was associated with a fourfold (95% CI: 1.4–12.1) increased risk for CHD (Table 4). The χ^2 test for the interaction effect, however, did not support an extra-multiplicative effect of this combination, at least at traditional alpha levels of 0.05 ($P = 0.12$).

Total cumulative score and CHD risk

There was no strong statistically significant evidence of the interaction effects between early and later life exposure (Table 4). We therefore examined the cumulative effects by evaluating the total, additive socioeconomic disadvantage score across both early and later life stages (Table 5). Compared with women who were not exposed to socioeconomic disadvantage at any instance, women who were exposed at 1, 2, 3–4 and 5–6 instances had an increased CHD risk of 1.8 (95% CI: 0.6–5.5), 2.8 (95% CI: 1.0–8.2), 4.5 (95% CI: 1.5–10.9), and 6.3 (95% CI: 1.6–19.0), respectively (Table 5). Adjustment for adult levels of traditional CHD risk factors had a modest attenuating effect on the strength of this association. Being exposed to five instances

of socioeconomic disadvantage was still associated with a 4.1-fold (95% CI: 1.1–15.4) increased CHD risk.

Interaction effects of body height with cumulative socioeconomic disadvantage in relation to CHD risk

We evaluated interaction effects between dichotomized total cumulative socioeconomic disadvantage and short stature, by first running analyses when simultaneously adjusting for total cumulative socioeconomic disadvantage and short stature. These analyses showed that exposure to cumulative socioeconomic disadvantage or short stature was associated with 2.3-fold (95% CI: 1.4–5.1) and 1.9-fold (95% CI: 1.1–4.1) increased CHD risk, respectively (Table 6). Being exposed to cumulative socioeconomic disadvantage over the life course was associated with increased risk of CHD in taller women (OR = 1.7, 95% CI: 0.9–3.2), and especially so among shorter women (OR = 1.9, 95% CI: 1.0–7.7). However, being short and exposed to cumulative socioeconomic disadvantage over the life course was associated with a 4.4-fold (95% CI: 1.7–9.3) increased CHD risk. The χ^2 test for the interaction effect, however,

Table 5 Total cumulative exposure to socioeconomic disadvantage in relation to coronary heart disease risk. Odds ratio and 95% CI from the conditional logistic regression models

Instances of exposure to socioeconomic disadvantage over a life course	Unadjusted	Multivariable adjusted ^a
Not exposed (n = 24)	1	1
One instance (n = 75)	1.76 (0.57–5.47)	1.25 (0.43–3.66)
Two instances (n = 79)	2.80 (0.96–8.21)	1.71 (0.61–4.80)
Three or four instances (n = 125)	4.52 (1.48–10.85)	2.63 (0.92–7.56)
Five or six instances (n = 23)	6.31 (1.59–18.99)	4.08 (1.08–15.35)

^a Multivariable adjusted for marital status, smoking, physical activity, abdominal obesity, high-density lipoprotein (HDL)-cholesterol, triglycerides, hypertension, fibrinogen.

Table 6 Interaction effects of body height and total cumulative exposure to socioeconomic disadvantage on coronary heart disease risk. Odds ratio and 95% CI from the conditional logistic regression models

Body height	Exposed to cumulative socioeconomic disadvantage over a life course	
	NO (0–1 instance) (n = 99)	YES (2–6 instances) (n = 227) OR = 2.58 (1.38–5.12) ^a
Taller women (>160 cm) (n = 390)	1	1.66 (0.92–3.18)
Shorter women (>160 cm) (n = 193) OR = 1.87 (1.09–4.08) ^a	1.92 (0.98–7.72)	4.40 (1.72–9.31)

Log rank χ^2 test for interaction was not statistically significant (χ^2 ratio = 0.28, $P = 0.60$).

^a From the logistic regression model after simultaneously adjusting for body height and total cumulative socioeconomic disadvantage.

did not support a statistically significant extra-multiplicative effect of such a combination ($P = 0.60$) (Table 6).

Discussion

Both early and later exposure to socioeconomic disadvantage were associated with increased CHD risk in women. Socioeconomic disadvantage in later life, however, seemed to be more harmful for women's cardiovascular health than disadvantage in early life, perhaps because of poorly measured indicators of early life disadvantage. It is also possible that in this population of Swedish women, indicators of disadvantage in later life may tell us more about the social distribution of relevant proximal risk factors for CHD, than do measures of disadvantage earlier in life. There is some evidence for this in Table 3, where adjustment for traditional CHD risk factors on the risk of CHD associated with early life disadvantage, actually increased the risk of CHD for the most disadvantaged groups. Thus, traditional behavioural and biological risk factors measured in later life, exacerbated rather than attenuated CHD associations with early life socioeconomic disadvantage.

There was no statistical evidence of an interaction between early and later life socioeconomic disadvantage, although given the relatively small numbers available for these analyses and when limited to the bounds of traditional statistical significance, such interaction tests may be prone to low power.²⁶ A cumulative indicator of socioeconomic disadvantage was created that showed the risk for CHD increased in a graded fashion with a higher number of exposures to socioeconomic disadvantage over the life course. This elevated and graded risk was quite robust to control for traditional CHD risk factors. Finally, while the increased CHD risk associated with more life course socioeconomic disadvantage was greater among shorter women, life course socioeconomic disadvantage also increased CHD risk

among women who were taller than 160 cm. Again, the formal test of model-based interaction between height and cumulative socioeconomic disadvantage failed to reach statistical significance. Shorter adult stature remained a significant determinant of CHD risk, even after adjustment for life course socioeconomic disadvantage and traditional CHD risk factors. While short stature has been associated with increased risk for cardiovascular incidence in men and women,^{24–29} the reasons for this association have not been clearly identified. Short adult stature has further been associated with physiological risk factors for CHD, such as narrower cross-sectional diameter of carotid arteries,³⁰ narrower coronary arterial luminal diameter,^{31,32} and a lower forced expiratory volume in one second as percentage of expected value (FEV_1).³³

Our finding, that height remained an important predictor of CHD after adjustment for adult risk factors and cumulative socioeconomic disadvantage may in part reflect residual confounding, or genetic, intrauterine or other early life growth factors that affect height and later risk of CHD. Several studies have found that low birthweight^{34,35} and in particular babies born disproportionately long and thin have increased adult CHD risk.^{36,37} This thinness—lower birthweight relative to length—has been taken as potential evidence of growth restriction late in pregnancy, and it is this growth restriction that affects CHD risk via the compromised anatomical and physiological development of the fetus.^{37–39} Interestingly though, results from recent studies have shown that it is birth length rather than birthweight *per se*, that is associated with attained adult height.^{40,41} So on one hand, longer thin babies have increased CHD risk, but on the other, if birth length is also predictive of adult height, then longer babies should be protected from CHD. There are likely to be complex multiple pathways that link birth anthropometry (and the genetic potential and intrauterine conditions which such anthropometric

indicators represent), to catch-up or catch-down growth,⁴² later adolescent and adult obesity, and attained height. In the present study, we found elevated CHD risk in shorter women even in the absence of cumulative socioeconomic disadvantage.

Other studies

In a study of men aged 35–64 years from the west of Scotland in which socioeconomic position was investigated at multiple times over a life course,⁴³ the authors consistent with the present study, found that men who were exposed to socioeconomic disadvantage at all three stages compared with men who were not exposed at any stage had a twofold increased risk for dying from cardiovascular diseases, independent of biological and behavioural risk factors in adult life.⁴³ Unlike results from the present study, however, the Scottish men whose fathers had manual occupations had statistically significantly increased risk for cardiovascular mortality which was independent of adult social class.⁴³ Results from the Scottish study are supported by the Swedish cohort study of men, where a similarly increased risk for mortality from CHD was observed in men whose fathers had manual occupations.⁴⁴ The discrepancy in the results on the effect of childhood socioeconomic disadvantage on CHD risk from the present study are supported by results from the Finnish and the British studies.^{45,46} Lynch *et al.* showed that poor childhood socioeconomic conditions were not important predictors of adult cardiovascular death among men.⁴⁵ In Lamont *et al.*'s study from Newcastle, simultaneous adjustment for early and later life socioeconomic indicators, showed statistically significant increased cardiovascular risk (as shown by the carotid intima—media thickness) with later but not early life indicators in both men and women.⁴⁶ The mixed results on the independent effects of early life socioeconomic disadvantage on cardiovascular risk may be due to the measure of socioeconomic position in childhood; at what stage it is measured, or the particular life course social conditions that existed for different birth cohorts, and in different countries. Nevertheless, for a variety of reasons, studies have consistently found later life socioeconomic effects to be stronger than those of early life socioeconomic disadvantage.^{43–48}

Lifecourse processes

The underlying pathological processes involved in the clinical manifestation of CHD are likely to be due to the result of a life-long cascade of circumstances, and experiences that ultimately lead to more proximal, biologically recognizable manifestations of disease. Thus, examining exposure to socioeconomic disadvantage over the life course, may better reflect the accumulated susceptibility to CHD. While behavioural and biological risk factors were only measured at one point in time, and may not accurately reflect their cumulative contribution, we nevertheless found that, within the specifications of our statistical model, behavioural and biological risk factors were not overwhelmingly important in understanding why women who were exposed to socioeconomic disadvantage had increased risk for CHD. This result should not necessarily be interpreted to mean that biological or behavioural risk factors are unimportant to understanding socioeconomic inequalities in women's CHD risk. There are important issues of measurement error and residual confounding that should be the first place to look for an interpretation of this lack of effect of adjustment by traditional

CHD risk factors. Clearly, traditional biological and behavioural risk factors constitute an important pathway through which socioeconomic disadvantage is translated into CHD. The study by Blane *et al.*⁴⁷ showed that behavioural risk factors, smoking and physical activity were more strongly associated with adulthood socioeconomic position, while physiological risk factors, total cholesterol, FEV₁ and blood pressure were associated with both childhood and adult socioeconomic position.⁴⁷ Results from the Whitehall II study showed that in general cardiovascular risk factors were weakly associated with father's social class.⁴⁹ In women, however, father's social class was associated with adult cigarette smoking, HDL-cholesterol and fibrinogen levels.⁴⁹

Limitations of the study

Early life socioeconomic disadvantage did not include father's or mother's socioeconomic position, which has often been used as a good indicator of early life socioeconomic conditions.⁴⁸ The present study instead used family size and birth order as indirect measures of socioeconomic conditions. Father's social class however, was available for a small number of women with CHD ($n = 41$). Preliminary analyses (not shown) revealed that women born to fathers in manual occupations had a higher number of siblings, were more likely to be the last-born, were shorter and had lower levels of education compared to women born to fathers with non-manual occupations. While these results increase confidence that our indicators of early life disadvantage are useful, they nevertheless are limited markers of childhood socioeconomic conditions. Although there are no 'gold standards' for measures of socioeconomic position in early life, each of the indicators used in the present study was associated with CHD risk in bivariate analyses.

A large family size is believed to affect a family's socioeconomic conditions, simply because there are more individuals to use family resources. A large family size has further been associated with lower IQ, lower academic achievement, lower occupational performance and poorer psychological functioning in adulthood⁵⁰ and increased risk for adult myocardial infarction.⁵¹ Being born last may be related to being born when economic resources are already restricted, and living in a crowded home, particularly when born into a large family with limited financial resources. However, many studies have shown that later-born siblings tend to have higher birthweights than first-borns⁵² so our finding of increased CHD risk among last-borns is despite the fact that they may have had higher birthweights on average. Birth order, however, may entail methodological problems including survival bias due to healthy selection of first-borns as opposed to last-borns.⁵³ Nevertheless, in the present study, lower education was associated with both larger family and being born last. Also being born last in combination with coming from a large family was associated with greater CHD risk than that associated with only one factor. In a review of 20 studies on the relationship between birth order and health outcomes one study demonstrated a higher incidence of hospitalizations in later-borns as opposed to those first-born.⁵⁴ Thus birth order may be an important marker of health outcomes in adulthood.

Finally, education as a measure of early life socioeconomic circumstances has long been regarded as a good measure of later childhood conditions.⁵⁵

In later life we used both first and current occupation. In addition, we assessed self-reported economic hardship prior to hospitalization so as to avoid biased effects of disease on the financial situation. It is possible that these indicators performed better as markers of later life socioeconomic conditions, than did our socioeconomic indicators of early life. This would bias our findings toward showing stronger effects of later rather than early life socioeconomic disadvantage.

The measure of cumulative exposure to socioeconomic disadvantage used in this study ignores the timing of the exposure and assumes that any particular instance of disadvantage has the same value regardless of when it occurs in the life course. The study group comprised women aged between 30 and 65 years, and it is therefore plausible that these women may have been exposed to socioeconomic disadvantage for different amounts of time, thereby underestimating the true effects of such exposure. Finally, lack of statistical power due to small numbers and conditional modelling on matching factors, resulted in relatively low power, wide confidence limits, thus making the results less definitive.

In order to understand social inequalities in CHD risk, cumulative experiences of socioeconomic disadvantage should

be examined over a lifetime. Such cumulative social and economic exposures are theoretically more cogent and potentially useful for creating more complete causal models of the disease process. Individuals are not static, nor are they segmented into the independent socioeconomic, behavioural, psychosocial and biological risk factors that are so often the focus of epidemiological studies, like this one. Further studies which investigate health risks across life course stages from childhood to adult life are needed to clarify the interrelation between early life exposures, adult risk factor profiles and subsequent disease and mortality.

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KEY MESSAGES

- Both early and later life socioeconomic disadvantage are associated with worse cardiovascular health in women but these effects were stronger for later life disadvantage.
- Exposure to cumulative socioeconomic disadvantage across the life course showed strong, graded associations with CHD risk after adjusting for a range of traditional CHD risk factors.
- The highest CHD risk was observed among women of shorter stature who had experienced the greatest cumulative socioeconomic disadvantage over their life course.

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