RESEARCH REPORT

Can cardiovascular risk factors and lifestyle explain the educational inequalities in mortality from ischaemic heart disease and from other heart diseases? 26 year follow up of 50 000 Norwegian men and women

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Objective: Investigate the degree to which smoking, physical activity, marital status, BMI, blood pressure, and cholesterol explain the association between educational level and ischaemic heart disease (IHD) mortality and other forms of cardiovascular mortality, with main focus on IHD mortality.

Design: Prospective health examination survey study conducted in the period 1974–78.

Setting: Oppland, Sogn og Fjordane, and Finnmark counties in Norway.

Participants: The sample comprised 22 712 men and 21 972 women, aged 35–49 at screening. The subjects were followed up with respect to mortality throughout year 2000.

Main results: 4342 men and 2164 women died during the follow up, 1343 men and 258 women of IHD. IHD mortality risk was higher for people with low education compared with people with high education, and people with low education had more adverse risk factors. After adjustment for smoking the IHD mortality relative risk (RR) with 95% confidence limits, in the low educational group decreased from 1.33 (1.18 to 1.50) to 1.16 (1.03 to 1.31) for men, and from 1.72 (1.23 to 2.41) to 1.58 (1.13 to 2.22) for women. Further adjustment for physical activity, marital status, BMI, blood pressure, and cholesterol reduced the RR to 1.03 (0.91 to 1.17) for men and 1.24 (0.88 to 1.75) for women.

Conclusions: Unfavourable cardiovascular risk factors and high IHD mortality are more prevalent among less educated than their highly educated peers. After simultaneous adjustment for all recorded risk factors, the excess IHD mortality in the low educational groups was reduced by 91% for men and 67% for women.

Despite a distinct decline in ischaemic heart disease (IHD) mortality in the late 1980s, IHD is still the commonest cause of death in both Norwegian men and women.¹ An inverse relation between IHD and socioeconomic status (SES) in industrialised western societies has been reported for middle aged men by several investigators in the past two decades, and many have reported that the SES associated differences in IHD and IHD mortality are only partly accounted for by differences in the distribution of the established risk factors such as cigarette smoking, raised blood pressure, and serum lipid concentrations.^{2–5} For women, we have less research. To our knowledge only one study⁶ has examined SES associated differences in IHD mortality among women, and SES associated differences in other heart disease mortality showing more diverse results among women.^{7–8} If SES affects health in some way independent of known risk factors, this has implications both for research and public health policy.

We investigated the role of classic risk factors and marital status in determining the association between educational level and cardiovascular mortality, with main focus on IHD mortality using individual data collected in 1974–78 in a prospective cardiovascular disease study in the three Norwegian counties.⁹ The cardiovascular disease study provides an opportunity to analyse the lifestyle patterns and physiological factors in relation to educational differences in mortality not only for men, but also for women.

METHODS

In 1974–76, a cardiovascular disease study was started in the three Norwegian counties Finnmark, Sogn og Fjordane, and Oppland. The counties are less urbanised, with a more rural

and fishery occupational structure, than Norway as a whole. Details of the screening procedure and organisation of the study have been described elsewhere,⁹ and will only be summarised briefly. The study population comprised all residents aged 35–49 in the three counties, total 66 200 people. The screening procedure included a questionnaire, which covered known cardiovascular disease and diabetes, symptoms pointing towards angina pectoris, physical activity, smoking habits, as well as family history of coronary heart disease. Height, weight, and blood pressure were measured, and a non-fasting blood sample was drawn for serum analyses of cholesterol concentrations. The screening data were linked to the National Cause of Death Register and to the 1970 census with the unique 11 digit personal identification number, and linkage was nearly complete for all participants. Mortality rates were based upon person years from screening date until the date of death, emigration, or 31 December 2000. Respondents with history of heart disease or symptoms pointing in the direction of angina pectoris were excluded from the analyses.

End point

Mortality from heart diseases was studied in two groups, IHD and sudden deaths (IHD), and other cardiovascular deaths (CVD). Sudden death was grouped together with IHD because there was strong evidence that these deaths were actually heart infarctions.¹⁰ Death certificate diagnoses were

Abbreviations: IHD, ischaemic heart disease; CHD, coronary heart disease; BMI, body mass index; SES, socioeconomic status; CVD, cardiovascular disease

obtained from the National Cause of Death Register. The register used the International Classification of Diseases 8th, 9th, and 10th revision. IHD codes were: ICD-8 and 9: 410–414 and ICD-10 code: I20–I25. For sudden death the codes were ICD-8: 782.4, 795 and ICD-9: 798.1–798.2, ICD-10: R96. Cardiovascular deaths were coded ICD-8: 390–458, ICD-9: 390–459, ICD-10: I00–I99.

Social characteristics and background factors

Educational level was used as a measure of SES, and was taken from the 1970 census. Level of educational attainment was stratified into two classes because of narrow educational distribution; high (secondary level/university/college) and low (primary or no schooling). The participants were divided into four categories groups by marital status as never married, divorced/separated, widowed, and married.

Participants were asked about current or previous smoking, and classified into three categories. Leisure time physical activity was aggregated in the two groups physically inactive (watching television mostly) and physically active (light walking, intermediate exercise activities, or intensive exercise). Further characteristics examined at the baseline screening included resting diastolic and systolic blood pressure (measured using a sphygmomanometer), serum cholesterol, body mass index (BMI: weight in kg/height in m²). Education, marital status, smoking status, and physical activity were all treated as categorical variables in the analyses. The other variables were included as continuous. An additional squared term of the continuous variables was included in the model if this gave significantly better model fit (table 3).

Statistical analyses

The association between mortality risk and educational level, adjusted for other risk factors, was measured by relative risk (RR) estimated in Cox regression, using SPSS software (release 11.0.1 standard version, SPSS). The reference category was the highly educated subjects. Reduction in relative risk was used to assess the extent to which the risk factors could explain the mortality risk associated with educational level. These percentage reductions were calculated as previously reported^{7 11}:

$$\left(\frac{RR_{fullyadjusted} - RR_{ageadjusted}}{1 - RR_{ageadjusted}} \right)$$

When we refer to a difference or trend as significant in this article, and the exact p value is not reported, we use the

5% level. We used χ^2 analyses for comparing the distribution of causes of death of high educated with low educated (table 2).

RESULTS

The response rate was 91% (89% for men and 94% for women), and there were only minor differences between the counties (data not shown). Respondents with a history of heart disease, 8% of the men and 10% of the women, were excluded, and the “healthy” sample comprised 22 881 men and 22 120 women. Because of missing information on education the sample for analysis comprised 22 712 men and 21 972 women (table 1).

There was a more unfavourable risk factor pattern among the low educated for both men and women (table 1). There were higher percentage smokers and physical inactive, as well as higher mean serum cholesterol, higher mean systolic and diastolic blood pressure, and higher mean body mass index among the less educated compared with their more highly educated counterparts. The smoking prevalence in less educated women was comparable to that in highly educated men. All differences were significant.

The mean follow up time was 23.6 years (SD 4.0). During the follow up period 6506 deaths occurred, and two out of three deaths were men. The IHD deaths constituted about one third of the deaths among men and about one tenth of the deaths among women (table 2). The distribution of causes of death differed significantly across educational strata among women, whereas in men the difference was not beyond chance (table 2).

The relative mortality risk according to educational level was adjusted for age, for age and smoking, physical activity, marital status, cholesterol, systolic and diastolic blood pressure, and BMI one at a time (table 3). In the final model all the variables were included. For each model the percentage reduction in excess risk for low versus high educated, compared with the age adjusted model was calculated.

IHD mortality

Age adjusted relative risk for IHD mortality for low compared with high educated respondents was 1.33 for men and 1.72 for women, both significant (table 3). Smoking was the single largest contributor for reduction in excess risk for men. Cholesterol was the second largest contributor, followed by systolic blood pressure, and marital status. For women smoking was just the fourth single largest contributor. Systolic blood pressure was the largest single contributor for women, closely followed by cholesterol, diastolic blood pressure. The educational gradient was still significant when

Table 1 Baseline characteristics for men and women aged 35–49 in two educational classes

	Men's education		Women's education	
	Low	High	Low	High
Total	15657	7055	16895	5077
Age, mean (SD)	42.4 (4.3)	41.6 (4.4)	42.2 (4.4)	41.3 (4.4)
Oppland county, (%)	68	32	75	25
Sogn og Fjordane county, (%)	68	32	77	23
Finnmark county, (%)	74	26	82	18
Not married, (%)	20	10	10	10
Smoker, (%)	58	43	39	30
Former smoker, (%)	22	25	12	16
Low exercise, (%)	18	15	24	13
Mean cholesterol (SD)	6.4 (1.3)	6.2 (1.3)	6.3 (1.2)	6.0 (1.1)
Mean systolic blood pressure (SD)	136.7 (16.0)	133.6 (14.8)	131.9 (17.4)	127.0 (15.3)
Mean diastolic blood pressure (SD)	84.7 (10.6)	83.8 (10.2)	81.1 (10.4)	79.1 (9.9)
Mean body mass index (SD)	25.1 (3.0)	24.7 (2.7)	24.8 (4.0)	23.7 (3.4)

Table 2 Number of deaths in the period 1974–2000 by cause and educational level for men and women aged 35–49 at baseline

(Person years)	Men's education		Women's education	
	Low (362034)	High (165287)	Low (405349)	High (121714)
IHD deaths	1023	320	224	34
Sudden deaths	99	37	26	5
Other cardiovascular deaths	372	115	212	35
Total deaths other than cardiovascular/sudden	1781	595	1315	313
Total deaths	3275	1067	1777	387
*Homogeneity	8.27 (p=0.04)		1.44 (p=0.70)	

*Homogeneity in distribution of causes of death between high and low educated, χ^2 , df=3.

age and one additional risk factor were included, for both men and women. When all the factors were included in the model, 91% of the IHD mortality excess risk for low educated men was accounted for, and 67% for women. The educational difference in IHD mortality was no longer significant.

Mortality from other cardiovascular diseases (other CVD)

The age adjusted relative other CVD mortality rate for low compared with high education was 1.37, for men and 1.61 for women (table 3). As for IHD mortality, smoking was the largest single contributor for reduction in excess other CVD mortality risk for low educated men (table 3). The second largest contributor for men was marital status, with the same magnitude as smoking, and systolic blood pressure was the third largest contributor. As for IHD mortality, systolic blood pressure explained 30% of the excess other CVD mortality risk for low compared with high educated women. Adjusted for age and systolic blood pressure, education was no longer significant for women. Smoking and diastolic blood pressure came second and third. Marital status explained, as for IHD, a very low portion of the excess mortality risk in low compared with high educated women. When all the factors

were included in the model, 69% of the excess risk for low educated men was accounted for, and 56% for the women. The educational difference was no longer significant, neither for men nor women.

Results from the unadjusted and fully adjusted analysis with details of the other risk factors are given in an appendix.

DISCUSSION

The low educated had larger IHD mortality than the high educated, both for men and women. When adjusted for classic cardiovascular risk factors the educational difference in IHD mortality was attenuated, and was no longer significant. The greater part of the reduction in excess risk for low educated men was associated with smoking, cholesterol, and systolic blood pressure, with smoking as the largest single contributor.

In contrast with a study of Danish men,³ which surprisingly found smoking to have a marginal explanatory fraction for socioeconomic differences in IHD mortality, we found, as in most other studies,^{2,8} that smoking had a high explanatory fraction. The smoking rate in Norway among less educated is increasing slightly, while it decreases among the highly educated.¹² This may result in an increase in the educational differences in heart disease mortality.

Table 3 Relative risk (95% confidence limits) of death from ischaemic heart disease (IHD) and other cardiovascular diseases for low compared with highly educated men and women. RR is estimated in Cox regression with 26 years of follow up time

	Men		Women	
	Low versus high education	Reduction in excess risk*	Low versus high education	Reduction in excess risk*
Ischaemic heart disease including sudden death				
Unadjusted	1.44 (1.28 to 1.62)		1.91 (1.37 to 2.68)	
Adjusted for age only	1.33 (1.18 to 1.50)		1.72 (1.23 to 2.41)	
Adjusted for age and smoking	1.16 (1.03 to 1.31)	51	1.58 (1.13 to 2.22)	19
Adjusted for age and physical activity	1.33 (1.18 to 1.50)	2	1.70 (1.21 to 2.39)	3
Adjusted for age and marital status	1.28 (1.14 to 1.45)	16	1.72 (1.23 to 2.41)	0
Adjusted for age and BMI (+BMI squared)†	1.31 (1.16 to 1.48)	7	1.60 (1.14 to 2.25)	17
Adjusted for age and diastolic blood pressure	1.31 (1.16 to 1.47)	9	1.58 (1.12 to 2.22)	20
Adjusted for age and systolic blood pressure	1.25 (1.11 to 1.41)	24	1.51 (1.07 to 2.12)	30
Adjusted for age and cholesterol (+cholesterol squared)†	1.25 (1.11 to 1.40)	27	1.55 (1.10 to 2.17)	24
Fully adjusted	1.03 (0.91 to 1.17)	91	1.24 (0.88 to 1.75)	67
Death from other cardiovascular diseases				
Unadjusted	1.48 (1.20 to 1.83)		1.80 (1.26 to 2.58)	
Adjusted for age only	1.37 (1.11 to 1.69)		1.61 (1.13 to 2.30)	
Adjusted for age and smoking	1.25 (1.01 to 1.55)	32	1.47 (1.03 to 2.11)	22
Adjusted for age and physical activity	1.36 (1.10 to 1.67)	2	1.58 (1.11 to 2.27)	4
Adjusted for age and marital status	1.26 (1.02 to 1.56)	29	1.60 (1.12 to 2.30)	1
Adjusted for age and BMI (+BMI squared)†	1.36 (1.10 to 1.69)	1	1.53 (1.06 to 2.22)	13
Adjusted for age and diastolic blood pressure	1.32 (1.07 to 1.62)	13	1.49 (1.04 to 2.13)	20
Adjusted for age and systolic blood pressure	1.27 (1.03 to 1.57)	25	1.43 (0.99 to 2.04)	30
Adjusted for age and cholesterol	1.33 (1.07 to 1.63)	11	1.56 (1.09 to 2.23)	8
Fully adjusted	1.11 (0.89 to 1.39)	69	1.27 (0.87 to 1.84)	56

*The percentage of excess risk that is reduced when including more risk factors, than just age, in the model; $(R_{adj} - R_{ageadj}) / (1 - R_{ageadj})$. †A quadratic term was added when this gave a significantly better fit.

Key points

- Both unfavourable cardiovascular risk factor profiles and increased ischaemic heart disease mortality are more common among people with low education.
- Few previous prospective studies have assessed which proportion of the excess ischaemic heart disease mortality among women in lower educational classes is associated with major coronary risk factors.
- For men about 90% of the excess IHD mortality among low educated was associated with their unfavourable risk factor profile. The association was 65% for women.
- For men smoking was the dominant factor explaining the increased IHD mortality risk for people with low education. For women the most influential factor was blood pressure.
- It may be possible to narrow social class difference in health through improvements in health behaviour among the lower educated classes

Adjustment for marital status reduced the excess risk for the low educated men, but not for women. Unlike two studies of British men, where the increased mortality for single men was no longer evident after adjustment for risk factors,^{13 14} we found an effect of marital status on mortality even after adjustment. Physical activity explained a minor part of the educational difference in IHD mortality in both men and women.

Blood pressure and cholesterol were the main confounders for women. The difference in BMI between high and low educated men was very small, and BMI explained a minor part of the excess IHD and other CVD mortality in low compared with high educated men. BMI differences between high and low educated women were more distinct, and there was a large reduction in excess risk when adjusted for BMI.

Generally the pattern for educational difference in other CVD mortality was similar to that of IHD mortality, with some distinctions. Cholesterol explained much of the reduction in IHD mortality excess risk, but for other CVD cholesterol only explained a small portion. For men marital status was an even more important factor for reduction in other CVD excess risk than for IHD excess risk.

Several prospective studies have examined the association of heart disease mortality with the risk factors among men^{2 5 6 8 12 15–18} but few among women.^{6 8} In a study of Danish men it was found more than 70% decrease in excess IHD mortality for low occupational class after adjustment for classic risk factors.³ As in a Finnish study,⁸ which found a 60% reduction in coronary heart disease (CHD) excess risk among unskilled blue collar male workers and 11% among women, we found a larger reduction in excess heart disease mortality risk for men than for women. In a study of British men,² adjustment for cigarette smoking, blood pressure, cholesterol, BMI, and physical activity reduced the manual/non-manual ratio in IHD mortality from 1.44 to 1.24 (45% reduction), and in the Oslo study about half of the CHD mortality excess risk for low status was explained by the risk factors.¹⁵

For women such studies are few and with divergent findings. In a study of Danish women on income inequalities in IHD mortality, 40% of the excess risk of the low income group was explained by the risk factors.⁶ In a study of Finnish women only 11% of the association with mortality from CHD and occupation was explained by the risk factors.⁸ Quite the

Policy implications

Our findings suggest that most of the excess IHD mortality in lower educational classes seems to be mediated through the known cardiovascular risk factors both for men and women. In women smoking, blood pressure, and cholesterol stand out as large contributors for the excess risk of IHD mortality among the less educated.

opposite was found in a Danish study of educational gradient in CHD where the risk factors explained nearly all of the excess odds of CHD.⁷

Limitations of the study

This study has a large sample with high response rate, a long follow up time and a large number of IHD deaths, even for women. This gives precise estimates. A drawback with a long follow up period is that the respondents are likely to change their lifestyle and their biological measures during follow up: participants divorce/marry, quit/start smoking, increase/decrease exercise, gain/lose weight, etc. Duration of follow up is found to dilute the effect of the explanatory variables, and may reduce the size of the explainable difference in educational IHD mortality.³ This confounder misclassification could account for some of the unexplained difference, because adjustment using imperfectly classified confounders has been shown to remove only part of the confounding effect of that variable.¹⁹ Another problem is unmeasured possible confounders like psychosocial factors, particularly related to work.¹⁶

The follow up period covers three versions of International Classification of Diseases (ICD). The definition of IHD was almost identical in ICD-8 and ICD-9, whereas major changes were made in ICD-10. Anderson *et al* have studied the comparability of cause of death between ICD-9 and ICD-10.²⁰ Their definition of IHD was 410–414, 429.2 in ICD-9, and I20–25 in ICD-10. As no deaths in this study were classified as 429.2 the definition of IHD in this study was identical to that used by Anderson *et al*. They reported a comparability ratio of 0.9990 for IHD, which means that coding according to ICD-9 gives substantially the same result for IHD deaths as coding according to ICD-10. Furthermore, the ratio of IHD mortality rates between the educational groups was nearly the same in the three ICD versions of this study. This suggests that the transition from ICD-9 to ICD-10 has not introduced any differential bias.

Another source of error is the actual death examination and the report from the physician on the death certificate, as well as the coding done by medical trained coders. In practice the underlying cause of death can be difficult to classify and code when multiple causes has been reported.

In conclusion, our findings suggest that most of the excess IHD mortality in lower educational classes seems to be mediated through the known cardiovascular risk factors both for men and women. In women smoking, blood pressure, and cholesterol stand out as large contributors for the excess risk of IHD mortality among the less educated.

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Conflicts of interest: none declared.

APPENDIX

Table 4 Relative risk (95% confidence limits) of death from ischaemic heart disease (IHD), unadjusted and adjusted for risk factors. RR is estimated in Cox regression with 26 years of follow up time

	Men			Women		
	Unadjusted	Fully adjusted	p Value	Unadjusted	Fully adjusted	p Value
Age	1.11	1.09 (1.07 to 1.10)	<0.001	1.14	1.09 (1.06 to 1.13)	<0.001
Education			0.614			0.212
Low	1.44	1.03 (0.91 to 1.17)		1.91	1.24 (0.88 to 1.75)	
High	ref	ref		ref	ref	
Smoking			<0.001			<0.001
Never	ref	ref		ref	ref	
Former	1.46	1.27 (1.03 to 1.58)		1.13	1.32 (0.82 to 2.13)	
Smoker	3.66	3.25 (2.72 to 3.89)		3.34	3.67 (2.80 to 4.81)	
Physical activity			0.342			0.290
Low	1.25	1.07 (0.94 to 1.21)		1.38	1.15 (0.89 to 1.50)	
High	ref	ref		ref	ref	
Marital status			0.001			0.476
Not married	1.50	1.28 (1.12 to 1.46)		1.45	1.33 (0.85 to 2.09)	
Divorced/separated	1.36	1.21 (0.84 to 1.76)		1.39	1.35 (0.69 to 2.63)	
Widowed	0.43	0.28 (0.07 to 1.14)		1.24	0.87 (0.43 to 1.76)	
Married	ref	ref		ref	ref	
Diastolic blood pressure	1.03	1.01 (1.01 to 1.02)	<0.001	1.05	1.02 (1.00 to 1.03)	0.011
Systolic blood pressure	1.02	1.01 (1.01 to 1.02)	<0.001	1.03	1.02 (1.01 to 1.02)	<0.001
BMI*	-0.136*	-0.143 (0.082)*	0.061	1.08	1.03 (1.00 to 1.06)	0.029
BMI squared*	0.004*	0.003 (0.002)*	0.032	—	—	—
Cholesterol*	0.990*	0.654 (0.099)*	<0.001	1.41	1.27 (1.19 to 1.35)	<0.001
Cholesterol squared*	-0.041*	-0.025 (0.006)*	0.001	—	—	—

* $\beta = \ln(RR)$ and $SE(\beta)$ is presented instead of RR for variables with squared effects.

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