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Is adult education associated with reduced coronary heart disease risk?

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Key Words:	Health inequalities, CHD-risk, Adult learning, Education

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Abstract

Background: Although there is consistent evidence that higher levels of education are associated with better health and reduced disease risk, there is little evidence on whether this is true throughout the lifecourse. This study examines whether additional higher educational qualifications acquired later on in adulthood are associated with a reduction in Coronary Heart Disease (CHD) risk over and above qualifications from earlier on in life.

Methods: The National Child Development Study 1958 British birth cohort was analysed, with data at birth, age 7 (1965), age 23 (1981), 42 (2000) and age 44 (2002). The effect of highest academic and vocational qualifications obtained by age 23, and after age 23 on 10-year risk of developing CHD was estimated.

Results: CHD-risk among women who left school without any qualifications but went on to obtain some qualifications was lower (0.1% risk) compared to their peers who left school without any qualifications (0.14% risk). Among men, the effect of additional higher qualifications on CHD risk was also negative but restricted to those who left school without any qualifications.

Conclusions: Men and women who leave school without any qualifications may be able to "catch up" to some extent with more qualified people in terms of lowered CHD risk, if they obtain qualifications later on in life. However, there are important limitations to these observed associations which limit any causal interpretation of the results.

Word count: 3419 (manuscript only)

Key words: Health inequalities, CHD-risk, adult learning, education

MESH headings: Socioeconomic Factors, Educational Status

Key messages:

- CHD risk among British women who left school in the 1970's without any qualifications but went on to obtain some qualifications later on in life was lower compared to their peers who remained without any qualifications.
- Additional higher qualifications gained later on in life were also associated with a reduction in CHD risk among British men, but only for those who left school without any qualifications.
- Men and women who leave school without any qualifications may be able to "catch up" to some extent with more qualified people in terms of lowered CHD risk, provided these associations are causal.

Is adult education associated with reduced coronary heart disease risk?

Although higher education is associated with better health,[1 2] there is little evidence on whether this effect remains throughout the lifecourse. Staying on in full time education after compulsory schooling is associated with better health[3] however most studies only examine the effect of qualifications gained upon first leaving full time education. The period around the completion of secondary and/or tertiary education is an important developmental period in the life-course. Exposure to educational qualifications during this sensitive period may be particularly important for health later on in life. There may be little health returns to educational qualifications acquired later on in life.

There is some evidence of health benefits of adult education and learning.[4] Participation in adult learning is associated with health behaviours such as giving up smoking and sustained exercise, although not with obesity.[5] Adult learning is also associated with positive changes in well-being, optimism, self-efficacy and self-rated health. [5] Adult learning in these studies is conceptualised as *any* additional qualifications gained after the age of 33. As educational qualifications are measured on an ordinal scale, *any* qualifications gained later on in life does not necessarily measure the accumulation of educational qualifications, as these qualifications may be at the same or lower level when the person first left full time education. An accumulation model of qualifications needs to measure exposure to qualifications gained when the person first leaves full time education (this sensitive period is around 16-23 years on average) and then exposure to *higher* qualifications gained later on in life. The effect of this measure of additional higher qualifications on health has not been examined before, as other studies have tended to measure the accumulation of education in terms of number of years in education.

Educational gradients in Coronary Heart Disease (CHD) are well established and are a major component of health inequalities in the developed world. As education is one of the main social determinants of health, increasing educational opportunity and lifelong learning is one of the main strategies for reducing inequalities in health.[7 8] However, there is as yet little research on whether young adults who leave school with no or few qualifications are able to 'catch up' in terms of reducing their CHD risk, by acquiring further educational qualifications later on in adulthood.

Hypotheses:

1. Additional higher educational qualifications acquired later on in adulthood are associated with reduced CHD risk over and above qualifications gained upon first leaving full time education.

2. The effect of additional higher qualifications acquired later on in life on reducing CHD risk is greater for those who left school without any qualifications.

Materials and Methods

Data:

The National Child Development Study (NCDS) sampled babies born one week in 1958 in Great Britain.[9] Following the initial 1958 survey (N= 17,416), additional surveys were carried out in 1965 (at age 7, N= 15,425), 1969 (age 11, N= 15,337), 1974 (age 16, N= 14,647), 1981 (age 23, N=12,537), 1991 (age 33, N=11,469), 1999/2000 (age 42, N=11,419), 2004 (age 46, N=9,534) and 2008 (age 50, N~9,790). In 2002 (age 44), 9,349 cohort members took part in a biomedical survey.[10]

Variables:

Outcomes:

A CHD risk score was derived from the Framingham risk assessment tool for estimating 10-year risk of developing coronary heart disease in the biomedical survey at age 44.[11] This uses data from the Framingham Heart Study[12] to estimate 10-year risk for "hard" coronary heart disease outcomes (myocardial infarction and coronary death). The Framingham risk score has been validated for the UK population [13] [14] although it tends to overestimate absolute numbers of CHD events. For the regression analyses, the CHD risk score was log transformed to obtain a more normal distribution (after adding '0.01' to the CHD risk score to enable valid log transformations of CHD risk scores of zero).

Exposures:

Derived variables for highest academic and vocational qualifications obtained by ages 23 and 42 are available from the NCDS datasets deposited at the UK Data Archive. Highest qualifications at both ages were categorised into four groups: none, 'O level' academic and vocational equivalent qualifications (usually gained at age 16, indicating the end of compulsory schooling), 'A level' academic and vocational equivalent qualifications (usually gained at age 18, indicating any level above compulsory education that is distinct from the education offered in universities), and university degree or higher qualifications. Additional qualifications gained by age 42 could reflect equivalent qualifications gained from specialist adult education centres as well as from further and higher educational institutions. If respondents had missing qualifications at age 42, their qualifications at age 33 were used.

The measure of higher qualifications gained between age 23 and 42/33 was derived from the cross tabulation of these two variables (Table 1), after removing those still completing educational qualifications at age 23 (n=730). As those with degree or higher qualifications by age 23 could not gain any higher qualifications later on in life by this classification, they were removed from the subsequent analyses (N=937). In total, out of 8,535 people who were not in full time education at age 23 and had lower than degree qualifications, there were 1,216 people who went on to obtain higher qualifications by age 42.

Confounders:

Socioeconomic position at different times across the lifecourse was measured using father's social class at birth (non-manual vs. manual/economically inactive), mother's education (whether or not left school at the minimum age), housing tenure (rented vs. other tenure at age 7), economic inactivity (employed/ full time education vs. unemployed/inactive), family income (£ per week at age 23), home ownership (at age 42) and social class (at age 42 or age 33, if missing). Health and disability in early life were measured using low birthweight (<2515 grams), any speech problems diagnosed by a doctor (age 7), and any longstanding illness (age 23). Cognitive ability was measured by reading and maths test scores at age 7. CHD risk behaviours included smoking (age 23), physical inactivity (age 23: no reported sports activity in the last 4 weeks), overweight (age 23: BMI> 25) and obesity (age 42: BMI>30). Disposition for learning was measured at age 23 by asking if the respondent was seriously considering taking any educational courses of any kind.

Missing data: There is considerable attrition from the original sample of 17,416 babies to the biomedical survey (see Figure 1). The patterns of missing data in the NCDS have been described and modelled in previous papers.[15 16] There is a sharp drop in sample size between age 16 and 23 when the respondent changed from the parent/carer to the adult cohort member. The biomedical survey (age 44) did not attempt to contact 18.8% of the eligible sample resulting in further attrition. In addition, there are missing data for the outcome, explanatory variables and confounders.

The CHD risk score (at age 44) is derived from a combination of data including cholesterol obtained from blood samples, blood pressure, medication use and smoking status. Of the 9,377 participants in the biomedical survey, 7,120 could be assigned a CHD risk score, out of which 969 already had a degree of were still in full time education. The other major source of missing data was the main explanatory variable, 'additional qualifications gained between age 23 and 42'. This needed participants to have responded to the questions on qualifications at age 23 and age 42/33

and be included in the biomedical survey. When the analysis was restricted to participants who did not have degree level qualifications by age 23, were not in full time education, as well as those who had a CHD risk score at age 44, this reduced the sample size to 5,204. This further reduced to 4,311 participants when restricted to the sample with all the confounders measured, with missing ability scores (at age 7) accounting for much of the attrition. Much of the reduction in the sample size from the original sample born in 1958 can thus be explained by changing respondent status (from parents to young adults), changing mode of measurement (survey/exam tests/biomedical tests), as well as longitudinal attrition.

Statistical analyses:

We first examined the distribution of the main variables in the analysis by qualifications gained by age 23 (Table 2). Multiple regression models (Tables 3 and 4) were used to estimate the effect of the exposure variables (qualifications gained by age 23 and additional higher qualifications gained after age 23) on CHD risk, adjusted for confounders. All the analyses were gender-specific as the Framingham CHD risk score algorithm differs by gender.

Sensitivity analyses for missing data were carried out with multiple imputation using the ICE (Imputation by Chained Equations) method in STATA.[17] Existing literature on missing data in the NCDS from the earlier waves[15] and biomedical survey[16] were used to identify predictors of non-response in the cohort. These predictors- region of birth, birthweight, household size at birth, whether breastfed, whether the mother smoked during pregnancy, short stature at age 7, being overweight at age 7, internalising and externalising behaviours at age 7, being taken into care at age 7, being a smoker (age 42), obese (age 42) and having a non-manual vs. manual job (age 42)- were included in the imputation models along with the variables in the main analysis described above. The interaction between qualifications gained before and after age 23 was defined using the "passive" option. Fifty copies of the data were formed in the process, each with missing values imputed. These copies were independently analysed and estimates of parameters were averaged across the copies using Rubin's rules[18] to obtain a mean estimate and 95% CI.

Results

Table 2 shows the distribution (by gender) of the main variables in the analysis by qualifications gained by age 23. Men and women with higher levels of qualifications came from more advantaged social positions (in terms of social class, mother's education, housing tenure, economic activity and family income). They were more likely to consider doing more educational courses (at age 23) and end up as home owners and in non-manual social classes. They had better health in terms of higher birthweight and less limiting long standing illness (at age 23). They had higher maths and reading test scores (at age 7) and healthier behaviours (at age 23) in

terms of being non-smokers, more physically active and lower levels of overweight (age 23) and obesity (age 42).

Men and women with higher qualifications also had lower CHD risk scores at age 44 (reflected in their lower blood pressure, higher HDL cholesterol and lower rates of smoking). The mean CHD risk score for women without any qualifications was 1.3% (Table 2). In other words, according to the Framingham model, 1 out of every 100 women with no qualifications is likely to have a heart attack or fatal CHD event in the next 10 years from ages 44 to 54. The corresponding mean of the log transformed CHD risk score for this combination of risk factors is -1.9. The exponent of -1.9 is 0.15, which is much less than the original 1.3 value for the mean of the untransformed CHD risk score. Hence the interpretation of the exponent of the log transformed CHD risk score does not directly correspond to the untransformed CHD risk score.

Table 3 shows the effect *among women* of qualifications gained by age 23 and higher qualifications gained after age 23 regressed on (log) CHD risk. In Model 1, only these two qualification variables are entered into the regression model. For women with no qualifications by age 23 (the reference group), the average (log) CHD risk score is -1.98, which when exponentiated, results in an estimated 0.14% risk of CHD in the next 10 years. In other words 1.4 out of every 1000 women is likely to have a CHD event. For women with 'O' level equivalent qualifications by age 23, this risk is reduced to 0.06% (from exponentiating the sum of -1.98 and -0.85); and for women with 'A' level equivalent qualifications, this risk is reduced to 0.04%. Women without any qualifications by age 23 but who gained additional higher qualifications after age 23 had a lower CHD risk (0.10%, from exponentiating the sum of -1.98 and -0.31) compared to women without any qualifications by age 42. In absolute terms, among women without any qualifications by age 23, those who went on to acquire some qualifications later on in life had a 1 in a 1000 risk of having a CHD event, compared to a 1.4 in a 1000 risk for those who remained without any qualifications.

The statistical tests suggest that this effect of higher qualifications gained after age 23 on reducing CHD risk for women is not zero. However, there was little evidence of an interaction between qualifications gained by age 23 and higher qualifications gained after age 23. In other words, the effect of higher qualifications after age 23 on reducing CHD risk was similar across women of different qualification levels by age 23. Adjusting for confounders in Models 2 (socioeconomic and disposition towards educational courses), 3 (health, ability and behaviours) and 4 (all confounders) reduced the effect of qualifications gained by age 23, but did not substantially change the effect of higher qualifications gained after age 23.

Table 4 shows the effect *among men* of qualifications gained by age 23 and higher qualifications gained after age 23 regressed on (log) CHD risk. In Model 1, men without any qualifications by age 23 (the reference group) have a 3.7% risk (the exponent of 1.32) of having a CHD event in the next 10 years- these men have a 37 out of a 1000 risk of having a CHD event. Men with higher qualifications by age 23 had lower CHD risk. Men who left school without any qualifications but who went on to obtain some qualifications after age 23 had a 3.5% risk (the exponent of the sum of 1.32 and -0.07) of having a CHD event; or in other words, a 35 out of a 1000 risk.

The effect of higher qualifications gained after age 23 on reducing CHD risk for men was not significantly different from zero. Also, this estimate was smaller in comparison with the equivalent coefficient for women (although the absolute reduction in CHD risk is larger in men, as men are much more likely to experience a CHD event by their mid 50s). There was weak evidence for an interaction between qualifications gained by age 23 and higher qualifications gained after age 23 in the baseline model and the model adjusted for socioeconomic factors, although little evidence for such an interaction after adjusting for health, ability and behaviours.

Sensitivity analyses for the missing data were carried out using multiple imputation analysis. The results (Table 5) were similar to the main set of analyses described in Tables 3 and 4. There was evidence that higher qualifications after age 23 were associated with reduced CHD risk among women. Among men, compared to the complete case analysis, there was stronger evidence of an interaction between qualifications gained by age 23 and higher qualifications gained after age 23. This interaction effect (Figure 2) shows a greater reduction in CHD risk associated with obtaining additional higher qualifications after age 23, for men who left school without any qualifications compared to men who left school with O or A level equivalent qualifications. Furthermore, there is little educational difference in CHD risk among men who went on to obtain additional higher qualifications after age 23, although the confidence intervals for this group are large.

Discussion

There is some evidence that higher qualifications obtained later on in life are associated with lower CHD risk in both women and men. From a lifecourse perspective, this suggests that the health returns to educational qualifications are not restricted to a sensitive period (when first leaving full time education), but rather the effect of qualifications on health accumulates over the adult lifecourse.

The results from this study are congruent with the improvements in health behaviours (quitting smoking and physical activity) and psychosocial processes like well-being, optimism and self-

efficacy, following adult learning.[4 5] Our results also suggest there are cardiovascular benefits to qualifications associated with adult learning leading to qualifications and that such learning may actually help to reduce the educational gradient in CHD risk. Women who went on to obtain higher qualifications later on in adulthood were associated with a reduced risk of CHD compared to women who completed their qualifications by age 23. This reduction in CHD risk was observed to a lesser extent among men, with this effect being primarily observed for men who left school without any qualifications. So in both men and women, we observe that those who left school without any qualifications and who went on to obtain higher qualifications were able to "catch up" to some extent with their more qualified peers, in terms of a reduction in their CHD risk.

There are a number of mechanisms by which additional qualifications gained later on in life can affect health over and above qualifications gained earlier on in life. There may be socioeconomic returns to gaining additional qualifications which confer health benefits.[2 19] Additional qualifications may also raise awareness of risky lifestyles and behaviours, although such awareness may explain only a small part of the impact of education upon health.[20] Psychosocial processes such as the a sense of belonging to a wider community, social support, self-efficacy and personal control [5 21] are associated with adult learning and better health. Qualitative research suggests that adult education can both sustain and transform health and well-being.[22] Other studies show that adult learning is associated with improvement in cognitive ability in later life[23] and the uptake of preventive health care[24] The evidence for such mechanisms has already been established in previous work.[5]

The reduction in CHD risk observed for those who went on to obtain additional higher qualifications after age 23 are imprecisely estimated, especially among men. Some of that imprecision is due to the relatively few men and women in the study who obtained higher qualifications after age 23 (Table 1).

It is possible that the effect of obtaining qualifications later on in life on CHD risk may not be causal. There is a large social gradient in many of the observed confounders as shown in Table 2. Although the analyses adjust for a wide range of potential confounders that could affect CHD risk and educational attainment, there may be unobserved factors that result in the association of additional qualifications gained and lower CHD. The assumption underlying the analysis is that those who left school without any qualifications are comparable to those who also left school without any qualifications but who went on to obtain some qualifications later on in adulthood. We tried to take account of differences between these two groups in terms of socioeconomic, health, ability and disposition towards learning. However these two groups may differ in terms of other observed or unobserved factors. For example, the reduction in CHD risk associated with higher

qualifications obtained later on in life may be confounded by social class and health in mid-life, which we control for in the analysis to some extent. There may be socioeconomic improvement in midlife that may result in better opportunities for further education. Similarly, having good health in mid life may be conducive for further education. Furthermore, personality characteristics like commitment and dedication that are needed to return to education in later life may also affect the adoption and maintenance of healthy behaviours. Additionally, the high levels of missing data and non-response in the biomedical survey may have introduced biases. However, sensitivity analyses suggest that such missing data may not have severely biased the results.

The paper was able to distinguish between earlier and later life exposure to qualifications as they are meant to measure equivalent educational assessments, regardless of the age of the student. However, the educational experience of someone who had educational success earlier on in life is likely to be different from someone who initially lacked educational success but finished schooling or college later on in life. So while the exposure in either period is the same, it may reflect very different educational experiences. However, this limitation is true for most analyses of social processes over the lifecourse. Another limitation of the main exposure is that we were not able to differentiate between men and women who went on to obtain 'O', 'A' and degree level qualifications later on in life; instead we analysed this group together. There may be heterogeneous effects by the type of additional higher qualification obtained. However the very small numbers who obtained the highest qualifications prevented any meaningful analysis of such heterogeneity.

Additional higher qualifications obtained later on in life are associated with a reduction in CHD risk among women and to a lesser extent among men. Men and women who leave school without any qualifications may be able to "catch up" to some extent with more qualified people in terms of lowering their CHD risk, if they obtain higher qualifications later on in life. Obtaining higher qualifications later on in life may be one of the mechanisms of reducing the social gradient in CHD risk. However, there are important limitations to these observed associations which limit any causal interpretation of the results.

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All the references have been checked for accuracy and completeness.

The first (and corresponding) author is the guarantor for the paper and vouches for the validity of the analyses and text presented in the manuscript.

The material in the manuscript has not been published previously.

The manuscript has been carefully edited by someone whose first language is English.

Table 1: Distribution of qualifications gained by age 23 by qualifications gained after age 23

	Additional qualifications gained after age 23					
Qualifications gained by age 23	no qualifications	'0' level equiv.	'A' lev equiv. or below degree	degree or higher	no quals gained after 23	additonal higher quals gained after 23
no qualifications	3,273	457	78	30	3,273	565
'0' level equivalent	na	2,813	230	131	2,813	361
'A' lev equivalent/below degree	na	na	1,233	290	1,233	290
degree/higher	na	na	na	937	937	na

na: not applicable

Table 2: Distribution of CHD risk and potential confounders by qualifications gained by age 23, men and women

WOMEN	Qualifications gained by age 23				
	no qualifications	0 level equiv.	A lev equiv. or below degree	degree or higher	*N*
% manual fathers age 0	85.0%	73.1%	57.1%	37.3%	*5,899*
% mothers left FT educ before min age	88.8%	78.0%	61.4%	38.3%	*5,948*
% living in rented housing age 0	75.2%	56.6%	43.4%	23.2%	*5,344*
% economically inactive age 23	43.4%	25.6%	11.2%	5.9%	*5,953*
Mean £ family income age 23	80.0	97.6	101.2	93.1	*5,766*
% considering doing more courses age 23	9.7%	17.0%	28.0%	30.9%	*5,957*
% in manual social class age 42	51.4%	28.8%	13.3%	3.3%	*4,946*
% in rented homes age 42	29.7%	12.5%	6.8%	2.8%	*4,689*
% low birthweight	9.8%	6.0%	3.8%	5.0%	*5,938*
Mean math test score age 7	4.0	5.2	5.9	6.9	*5,413*
Mean reading test score age 7	20.7	25.9	27.4	28.8	*5,415*
% with speech problems age 7	16.7%	8.8%	4.7%	3.3%	*5,166*
% overweight/obese age 23	16.6%	11.1%	8.4%	3.9%	*5,848*
% limiting longstanding illness age 23	3.4%	2.6%	2.3%	0.7%	*5,917*
% inactive age 23	86.8%	78.7%	69.1%	64.1%	*5,959*
% smokers age 23	56.0%	37.6%	28.5%	21.2%	*5,960*
% obese age 42	20.40%	14.76%	13.74%	7.76%	*4,601*
Mean CHD risk score age 44 (%)	1.3%	0.7%	0.4%	0.3%	*3,121*
Mean log CHD risk score age 44	-1.9	-2.8	-3.3	-3.6	*3,121*
Mean Systolic blood pressure (mmHg) age 44	120.4	119.7	119.1	118.5	*3,874*
Mean Total cholesterol (mg/dL) age 44	223.5	219.5	215.2	217.8	*3,248*
Mean HDL cholesterol (mg/dL) age 44	62.2	65.6	67.3	69.9	*3,244*
% current smoker age 44	39.4%	21.6%	13.1%	7.4%	*3,825*
MEN					
% manual fathers age 0	83.4%	72.4%	64.7%	40.2%	*5,854*
% mothers left FT educ before min age	88.4%	78.7%	68.5%	43.5%	*5,913*
% living in rented housing age 0	73.5%	58.1%	48.9%	28.0%	*5,282*
% economically inactive age 23	2.8%	1.3%	1.2%	3.8%	*5,912*
Mean £ family income age 23	79.4	94.5	96.0	79.8	*5,592*
% considering doing more courses age 23	15.7%	22.6%	30.1%	33.9%	*5,915*
% in manual social class age 42	76.6%	28.8%	13.3%	3.3%	*4,866*
% in rented homes age 42	27.5%	12.1%	6.9%	5.3%	*4,342*
% low birthweight	6.8%	5.4%	4.3%	2.4%	*5,902*
Mean math test score age 7	4.1	5.3	5.8	7.1	*5,342*
Mean reading test score age 7	18.1	23.5	24.8	27.9	*5,356*
% with speech problems age 7	28.1%	13.2%	10.6%	5.2%	*5,107*
% overweight/obese age 23	22.9%	16.0%	13.2%	6.7%	*5,794*
% limiting longstanding illness age 23	4.0%	3.0%	2.5%	2.0%	*5,854*
% inactive age 23	65.0%	57.8%	52.6%	53.8%	*5,914*
% smokers age 23	56.1%	41.7%	32.5%	20.6%	*5,920*
% obese age 42	21.1%	16.32%	13.2%	7.2%	*4,356*
Mean CHD risk score age 44 (%)	5.3%	4.3%	3.7%	2.9%	*3,052*
Mean log CHD risk score age 44	1.3	1.1	1.0	0.8	*3,052*
Mean Systolic blood pressure (mmHg) age 44	133.5	132.8	131.5	129.7	*3,731*
Mean Total cholesterol (mg/dL) age 44	234.0	236.6	234.4	235.3	*3,192*
Mean HDL cholesterol (mg/dL) age 44	53.8	55.5	55.8	58.2	*3,180*
% current smoker age 44	37.3%	24.6%	17.2%	6.7%	*3,618*

Table 3: Regression coefficients (95% CI) of log CHD risk on qualifications gained before and after age 23: Women

CHD risk score (Log) Women	Model 1	Model 2	Model 3	Model 4	*N*
	Rsq=0.04	*Rsq=0.08*	*Rsq=0.23*	*Rsq=0.26*	
Average log CHD risk score	-1.98 (-2.17, -1.80)	-2.83 (-3.48, -2.18)	-4.31 (-5.05, -3.57)	-4.76 (-5.66, -3.85)	*2227*
Qualifications by age 23					
no qualifications (ref.)	0.00	0.00	0.00	0.00	740
0 level equivalent	-0.85 (-1.09, -0.61)	-0.54 (-0.79, -0.30)	-0.38 (-0.61, -0.15)	-0.22 (-0.45, 0.02)	972
A lev equivalent or below degree	-1.34 (-1.62, -1.06)	-0.86 (-1.17, -0.55)	-0.63 (-0.91, -0.36)	-0.33 (-0.63, -0.04)	515
Higher quals after age 23					
No additional Higher quals (ref.)	0.00	0.00	0.00	0.00	1,900
Additional higher quals	-0.31 (-0.61, -0.02)	-0.23 (-0.52, 0.06)	-0.33 (-0.59, -0.06)	-0.29 (-0.56, -0.03)	327
p value for interaction between qualifications by age 23 and higher quals after age 23	*0.62*	*0.47*	*0.54*	*0.62*	

Table 4 Regression coefficients (95% CI) of log CHD risk on qualifications gained before and after age 23: Men

CHD risk score (Log) Men	Model 1	Model 2	Model 3	Model 4	*N*
	Rsq=0.02	*Rsq=0.05*	*Rsq=0.17*	*Rsq=0.18*	
Average log CHD risk score	1.32 (1.24, 1.39)	1.17 (0.91, 1.42)	0.57 (0.24, 0.90)	0.39 (-0.01, 0.79)	2,084
Qualifications by age 23					
no qualifications (ref.)	0.00	0.00	0.00	0.00	596
0 level equivalent	-0.24 (-0.33, -0.14)	-0.15 (-0.25, -0.05)	-0.09 (-0.18, 0.01)	-0.04 (-0.14, 0.05)	706
A lev equivalent or below degree	-0.32 (-0.42, -0.22)	-0.20 (-0.31, -0.10)	-0.11 (-0.20, -0.01)	-0.04 (-0.14, 0.06)	782
Higher quals after age 23					
No additional Higher quals (ref.)	0.00	0.00	0.00	0.00	1,814
Additional higher quals	-0.07 (-0.18, 0.05)	-0.03 (-0.14, 0.09)	-0.03 (-0.14, 0.08)	-0.01 (-0.12, 0.10)	270
p value for interaction between qualifications by age 23 and higher quals after age 23	*0.08*	*0.06*	*0.31*	*0.28*	

Variables in Model 1 include qualifications gained by age 23 and additional higher qualifications gained after age 23.
Variables in Model 2 includes Model 1 and socioeconomic and disposition for learning variables.
Variables in Model 3 includes Model 1 and health, ability and behaviour variables.
Variables in Model 4 includes Models 1, 2 and 3 variables.

Table 5: Multiple imputation results for analyses presented in Tables 3 and 4

CHD risk score (Log) Women	Model 1	Model 2	Model 3	Model 4	*N*
Average log CHD risk score	-1.73 (-1.87, -1.59)	-2.40 (-2.78, -2.02)	-3.95 (-4.55, -3.36)	-4.45 (-5.11, -3.79)	7757
Qualifications by age 23					
no qualifications (ref.)	0.00	0.00	0.00	0.00	*2970*
0 level equivalent	-0.91 (-1.08, -0.74)	-0.58 (-0.79, -0.38)	-0.35 (-0.52, -0.17)	-0.19 (-0.39, 0.01)	*3132*
A lev equivalent or below degree	-1.39 (-1.61, -1.18)	-0.87 (-1.12, -0.61)	-0.53 (-0.78, -0.29)	-0.23 (-0.49, 0.03)	*1656*
Higher quals after age 23					
No qualifications after age 23 (ref.)	0.00	0.00	0.00	0.00	6688
Obtained higher qualifications after age 23	-0.43 (-0.64, -0.22)	-0.34 (-0.57, -0.12)	-0.36 (-0.56, -0.17)	-0.30 (-0.50, -0.09)	1069
p value for interaction between qualifications by age 23 and higher quals after age 23	*0.44*	*0.57*	*0.43*	*0.50*	
CHD risk score (Log) Men	Model 1	Model 2	Model 3	Model 4	*N*
Average log CHD risk score	1.36 (1.30, 1.41)	1.19 (1.05, 1.34)	0.38 (0.12, 0.64)	0.19 (-0.10, 0.49)	8137
Qualifications by age 23					
no qualifications (ref.)	0.00	0.00	0.00	0.00	*2890*
no qualifications (ref.)	-0.20 (-0.26, -0.13)	-0.14 (-0.22, -0.06)	-0.07 (-0.14, -0.01)	-0.04 (-0.12, 0.04)	*2538*
0 level equivalent	-0.33 (-0.41, -0.26)	-0.24 (-0.32, -0.17)	-0.13 (-0.21, -0.05)	-0.08 (-0.16, 0.01)	*2709*
A lev equivalent or below degree					
Higher quals after age 23					
No qualifications after age 23 (ref.)	0.00	0.00	0.00	0.00	*7102*
Obtained higher qualifications after age 23	-0.09 (-0.18, 0.00)	-0.07 (-0.16, 0.03)	-0.06 (-0.15, 0.03)	-0.04 (-0.13, 0.05)	1035
p value for interaction between qualifications by age 23 and higher quals after age 23	*0.00*	*0.00*	*0.01*	*0.02*	

Variables in Model 1 include qualifications gained by age 23 and additional higher qualifications gained after age 23.
Variables in Model 2 includes Model 1 and socioeconomic and disposition for learning variables.
Variables in Model 3 includes Model 1 and health, ability and behaviour variables. Variables in Model 4 includes Models 1, 2 and 3 variables.

Figure 1: Flow chart showing the derivation of the sample analysed from the National Child Development Study (NCDS) population

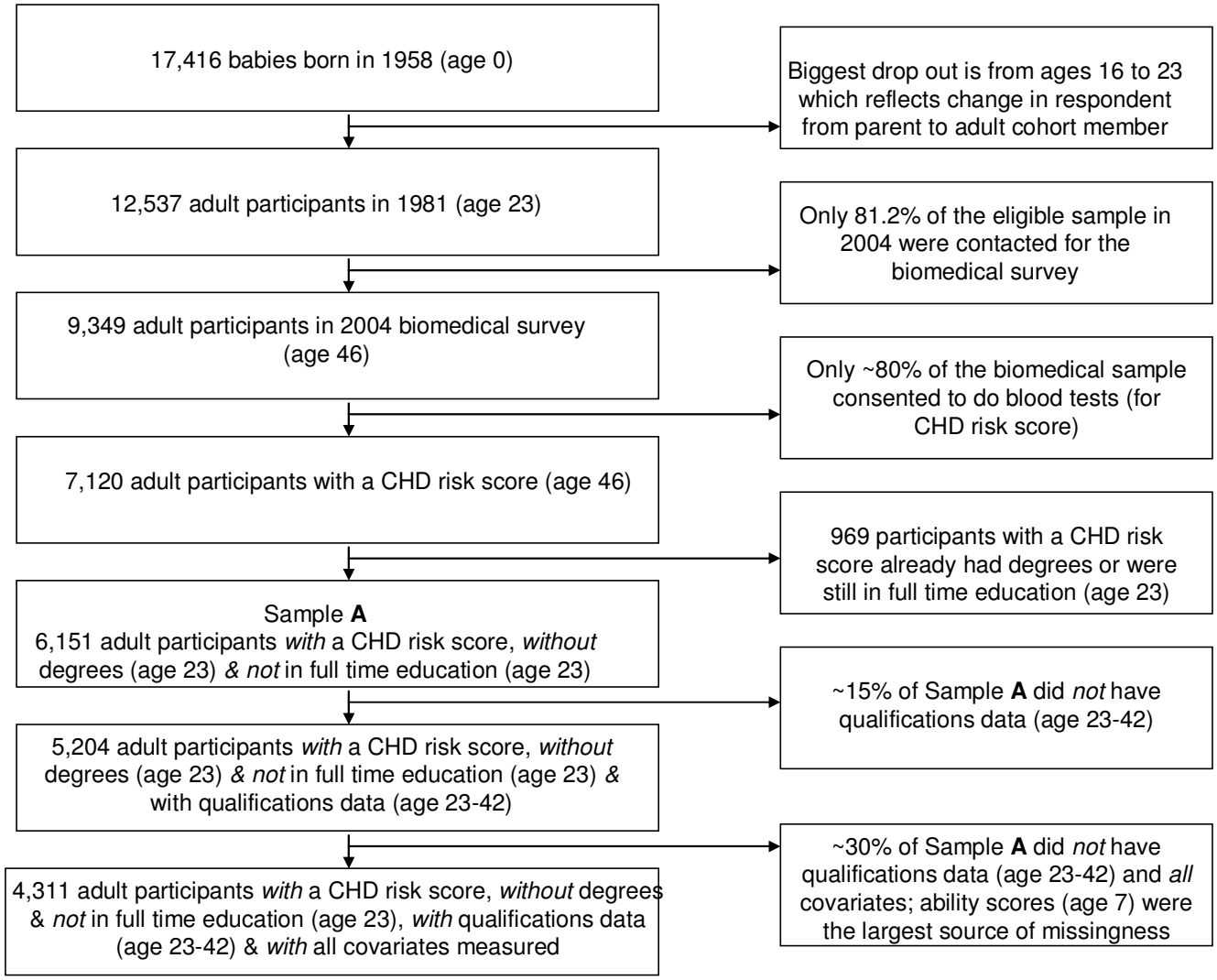
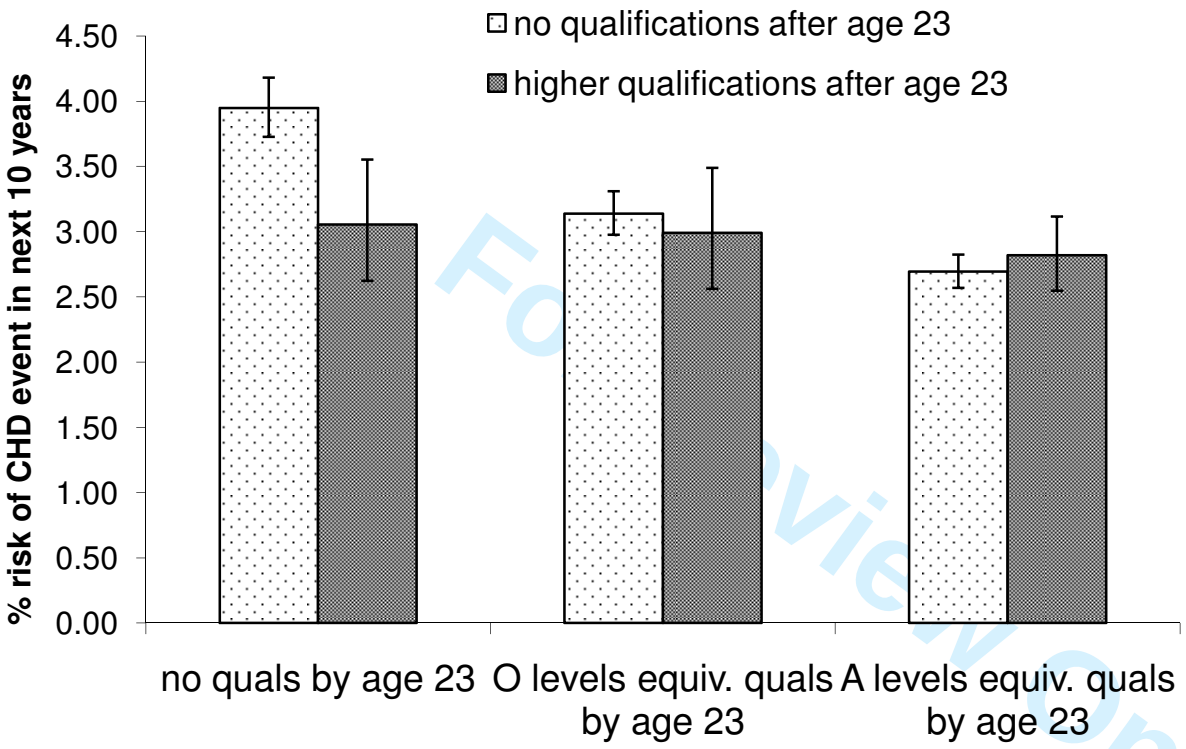


Figure 2: Interaction effect on CHD risk among men, between qualifications obtained by age 23 and additional higher qualifications obtained after age 23 (estimates taken from Model 4, Table 5)



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