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Is adult education associated with reduced coronary heart disease risk?

Tarani Chandola,[1]* Ian Plewis,[1] Jerry M Morris,[2] Gita Mishra[3] and David Blane[4]

[1]Social Statistics, University of Manchester, Manchester, UK, [2]Public & Environmental Health Research Unit, London School of Hygiene & Tropical Medicine, London, UK, [3]MRC National Survey of Health and Development, MRC Unit for Lifelong Health and Ageing, London, UK and [4]Department of Primary Care and Social Medicine, Imperial College London, London, UK

*Corresponding author. CCSR, University of Manchester, Humanities Bridgeford Street, Manchester, M13 9PL, UK. E-mail: tarani.chandola@manchester.ac.uk

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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 life-course. 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 years (2002). The effect of highest academic and vocational qualifications obtained by the age of 23 years, and after the age of 23 years 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 with 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.

Keywords Health inequalities, CHD risk, adult learning, education

Introduction

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 conceptualized as any additional qualifications gained after the age of 33 years. 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 ∼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 life-long 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; and
(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 1 week in 1958 in Great Britain.[9] Following the initial 1958 survey ($n = 17\,416$), additional surveys were carried out in 1965 (at the age of 7 years, $n = 15\,425$), 1969 (age 11 years, $n = 15\,337$), 1974 (age 16 years, $n = 14\,647$), 1981 (age 23 years, $n = 12\,537$), 1991 (age 33 years, $n = 11\,469$), 1999/2000 (age 42 years, $n = 11\,419$), 2004 (age 46 years, $n = 9534$) and 2008 (age 50 years, $n \sim 9790$). In 2002 (age 44 years), 9349 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 CHD in the biomedical survey at the age of 44 years.[11] This uses data from the Framingham Heart Study[12] to estimate 10-year risk for 'hard' CHD 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 years are available from the NCDS data sets deposited at the UK Data Archive. Highest qualifications at both ages were categorized into four groups: none; 'O level' academic and vocational equivalent qualifications (usually gained at the age of 16 years, indicating the end of compulsory schooling); 'A level' academic and vocational equivalent qualifications (usually gained at the age of 18 years, 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 the age of 42 years 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 the age of 42 years, their qualifications at the age of 33 years were used.

The measure of higher qualifications gained between the age of 23 and 42/33 years was derived from the cross-tabulation of these two variables (Table 1) after removing those still completing educational qualifications at the age of 23 years ($n = 730$). As those with degree or higher qualifications by the age of 23 years 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 8535 people who were not in full-time education at the age of 23 years and had lower than degree qualifications, there were 1216 people who went on to obtain higher qualifications by the age of 42 years.

Confounders

Socio-economic 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 the age of 7 years), economic inactivity (employed/full-time education vs unemployed/inactive), family income (£per week at the age of 23 years), home ownership (at the age of 42 years) and social class (at the age of 42 or age 33 years, if missing). Health and disability in early life were measured using low birthweight (<2515 g), any speech problems diagnosed by a doctor (age 7 years) and any longstanding illness (age 23 years). Cognitive ability was measured by reading and maths test scores at the age of 7 years. CHD risk behaviours included smoking (age 23 years), physical inactivity (age 23 years: no reported sports activity in the last 4 weeks), overweight [age 23 years: body mass index (BMI) > 25] and obesity (age 42 years: BMI > 30). Disposition for learning was measured at the age of 23 years 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 (Figure 1). The patterns of missing data in the

Table 1 Distribution of qualifications gained by the age of 23 years by qualifications gained after the age of 23 years

	Additional qualifications gained after the age of 23 years					
Qualifications gained by the age of 23 years	No qualifications	'0'-level equivalent	'A'-level equivalent or below degree	Degree or higher	No qualifications gained after the age of 23 years	Additional higher qualifications gained after the age of 23 years
No qualifications	3273	457	78	30	3273	565
'0'-level equivalent	Na	2813	230	131	2813	361
'A'-level equivalent/below degree	Na	Na	1233	290	1233	290
Degree/higher	Na	Na	Na	937	937	Na

Na: not applicable.

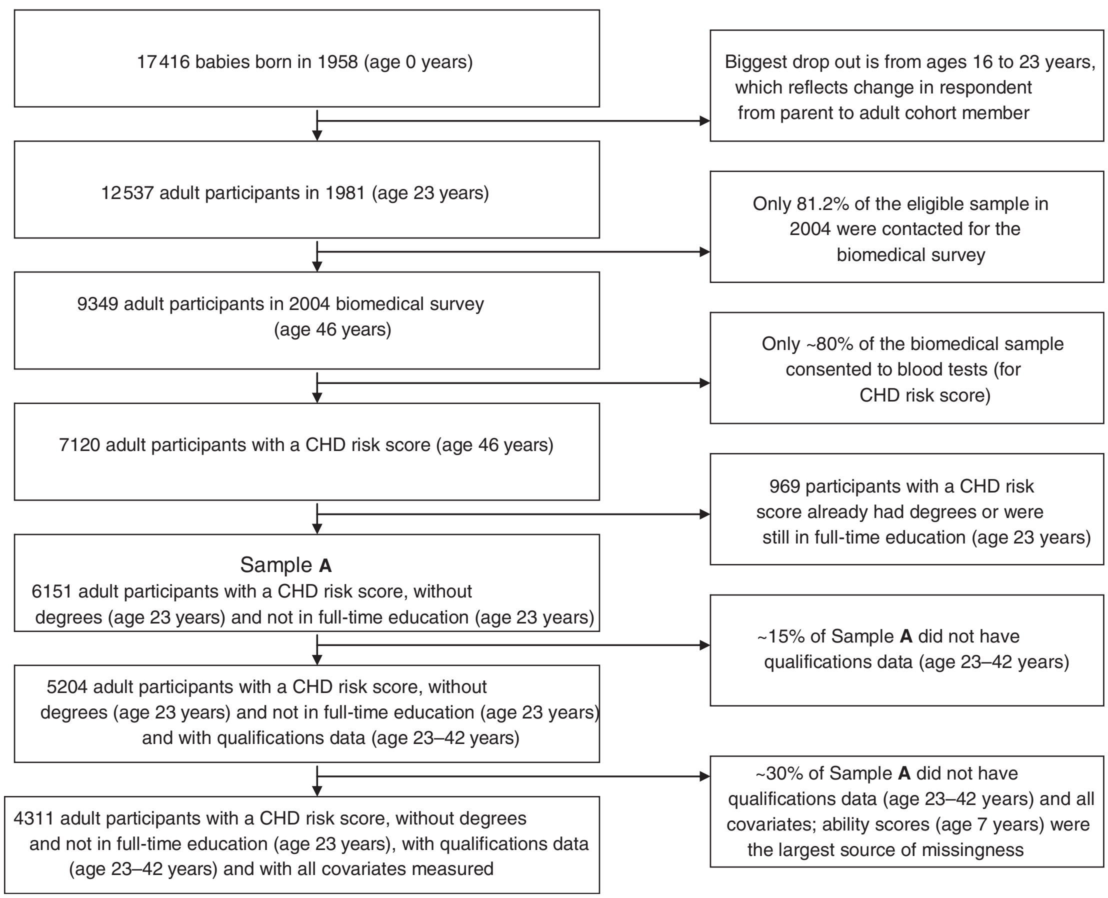

Figure 1 Flow chart showing the derivation of the sample analysed from the NCDS population

NCDS have been described and modelled in previous articles.[15,16] There is a sharp drop in sample size between the age of 16 and 23 years when the respondent changed from the parent/carer to the adult cohort member. The biomedical survey (age 44 years) 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 the age of 44 years) is derived from a combination of data including cholesterol obtained from blood samples, blood pressure, medication use and smoking status. Of the 9377 participants in the biomedical survey, 7120 could be assigned a CHD risk score, out of which 969 already had a degree or 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 the age of 23 and 42/33 years and be included in the biomedical survey. When the analysis was restricted to participants who did not have degree-level qualifications by the age of 23 years, were not in full-time education as well as those who had a CHD risk score at the age of 44 years, the sample size was reduced to 5204. This further reduced to 4311 participants when restricted to the sample with all the confounders measured, with missing ability scores (at the age of 7 years) accounting for much of the attrition. Much of the reduction in the sample size from the original sample participants 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 the age of 23 years (Table 2). Multiple regression models (Tables 3 and 4) were used to estimate the effect of the exposure variables (qualifications gained by the age of 23 years and additional higher qualifications gained after the age of 23 years) 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 imputation by chained equations (ICE) 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 the age of 7 years, being overweight at the age of 7 years, internalizing and externalizing behaviours at the age of 7 years, being taken into care at the age of 7 years, being a smoker (age 42 years), obese (age 42 years) and having a non-manual vs manual job (age 42 years)—were included in the imputation models along with the variables in the main analysis described above. The interaction between qualifications gained before and after the age of 23 years 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% confidence interval (95% CI).

Results

Table 2 shows the distribution (by gender) of the main variables in the analysis by qualifications gained by the age of 23 years. 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 the age of 23 years) 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 the age of 23 years). They had higher maths and reading test scores (at the age of 7 years), and healthier behaviours (at the age of 23 years) in terms of being non-smokers, more physically active and lower levels of overweight (age 23 years) and obesity (age 42 years).

Men and women with higher qualifications also had lower CHD risk scores at the age of 44 years [reflected in their lower blood pressure, higher high density lipoprotein (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 years. 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 the age of 23 years and higher qualifications gained after the age of 23 years 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 the age of 23 years (the reference group), the average (log) CHD risk score is −1.98, which when

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

CHD risk factors	Qualifications gained by the age of 23 years: No qualifications	'O'-level equivalent	'A'-level equivalent or below degree	Degree or higher	*n*
Women					
Percentage manual fathers age 0	85.0	73.1	57.1	37.3	5899
Percentage mothers left full-time education before minimum age	88.8	78.0	61.4	38.3	5948
Percentage living in rented housing age 0 years	75.2	56.6	43.4	23.2	5344
Percentage economically inactive age 23 years	43.4	25.6	11.2	5.9	5953
Mean £family income age 23 years	80.0	97.6	101.2	93.1	5766
Percentage considering doing more courses at the age of 23 years	9.7	17.0	28.0	30.9	5957
Percentage in manual social class age 42 years	51.4	28.8	13.3	3.3	4946
Percentage in rented homes age 42 years	29.7	12.5	6.8	2.8	4689
Percentage low birthweight	9.8	6.0	3.8	5.0	5938
Mean maths test score age 7 years	4.0	5.2	5.9	6.9	5413
Mean reading test score age 7 years	20.7	25.9	27.4	28.8	5415
Percentage with speech problems age 7 years	16.7	8.8	4.7	3.3	5166
Percentage overweight/obese age 23 years	16.6	11.1	8.4	3.9	5848
Percentage limiting longstanding illness age 23 years	3.4	2.6	2.3	0.7	5917
Percentage inactive age 23 years	86.8	78.7	69.1	64.1	5959
Percentage smokers age 23 years	56.0	37.6	28.5	21.2	5960
Percentage obese age 42 years	20.40	14.76	13.74	7.76	4601
Mean CHD risk score age 44 years (%)	1.3	0.7	0.4	0.3	3121
Mean log CHD risk score age 44 years	−1.9	−2.8	−3.3	−3.6	3121
Mean systolic blood pressure (mmHg) age 44 years	120.4	119.7	119.1	118.5	3874
Mean total cholesterol (mg/dl) age 44 years	223.5	219.5	215.2	217.8	3248
Mean HDL cholesterol (mg/dl) age 44 years	62.2	65.6	67.3	69.9	3244
Percentage current smoker age 44 years	39.4	21.6	13.1	7.4	3825
Men					
Percentage manual fathers age 0	83.4	72.4	64.7	40.2	5854
Percentage mothers left full-time education before minimum age	88.4	78.7	68.5	43.5	5913
Percentage living in rented housing age 0	73.5	58.1	48.9	28.0	5282
Percentage economically inactive age 23 years	2.8	1.3	1.2	3.8	5912
Mean £family income age 23 years	79.4	94.5	96.0	79.8	5592
Percentage considering doing more courses age 23 years	15.7	22.6	30.1	33.9	5915
Percentage in manual social class age 42 years	76.6	28.8	13.3	3.3	4866
Percentage in rented homes age 42 years	27.5	12.1	6.9	5.3	4342
Percentage low birthweight years	6.8	5.4	4.3	2.4	5902
Mean maths test score age 7 years	4.1	5.3	5.8	7.1	5342
Mean reading test score age 7 years	18.1	23.5	24.8	27.9	5356
Percentage with speech problems aged 7 years	28.1	13.2	10.6	5.2	5107
Percentage overweight/obese aged 23 years	22.9	16.0	13.2	6.7	5794
Percentage limiting longstanding illness aged 23 years	4.0	3.0	2.5	2.0	5854
Percentage inactive aged 23 years	65.0	57.8	52.6	53.8	5914
Percentage smokers aged 23 years	56.1	41.7	32.5	20.6	5920
Percentage obese aged 42 years	21.1	16.32	13.2	7.2	4356
Mean CHD risk score aged 44 years (%)	5.3	4.3	3.7	2.9	3052
Mean log CHD risk score aged 44 years	1.3	1.1	1.0	0.8	3052
Mean systolic blood pressure (mm Hg) age 44 years	133.5	132.8	131.5	129.7	3731
Mean total cholesterol (mg/dl) age 44 years	234.0	236.6	234.4	235.3	3192
Mean HDL cholesterol (mg/dl) age 44 years	53.8	55.5	55.8	58.2	3180
Percentage current smoker age 44 years	37.3	24.6	17.2	6.7	3618

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

CHD risk score (log) women	Model 1 *Rsq = 0.04*	Model 2 *Rsq = 0.08*	Model 3 *Rsq = 0.23*	Model 4 *Rsq = 0.26*	*n*
Average log CHD risk score	−1.98 (−2.17 to−1.80)	−2.83 (−3.48 to −2.18)	−4.31 (−5.05 to −3.57)	−4.76 (−5.66 to−3.85)	*2227*
Qualifications by age 23 years					
No qualifications (ref.)	0.00	0.00	0.00	0.00	740
'O'-level equivalent	−0.85 (−1.09 to −0.61)	−0.54 (−0.79 to −0.30)	−0.38 (−0.61 to −0.15)	−0.22 (−0.45 to 0.02)	972
'A'-level equivalent or below degree	−1.34 (−1.62 to −1.06)	−0.86 (−1.17 to −0.55)	−0.63 (−0.91 to −0.36)	−0.33 (−0.63 to -0.04)	515
Higher qualifications after age 23 years					
No additional higher qualifications (ref.)	0.00	0.00	0.00	0.00	1900
Additional higher qualifications	−0.31 (−0.61 to −0.02)	−0.23 (−0.52 to 0.06)	−0.33 (−0.59 to −0.06)	−0.29 (−0.56 to −0.03)	327
P-value for interaction between qualifications by age 23 and higher qualifications after age 23 years	0.62	0.47	0.54	0.62	

Rsq = R square.

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

CHD risk score (log) men	Model 1 *Rsq = 0.02*	Model 2 *Rsq = 0.05*	Model 3 *Rsq = 0.17*	Model 4 *Rsq = 0.18*	*n*
Average log CHD risk score	1.32 (1.24 to 1.39)	1.17 (0.91 to 1.42)	0.57 (0.24 to 0.90)	0.39 (−0.01 to 0.79)	2084
Qualifications by age 23 years					
No qualifications (ref.)	0.00	0.00	0.00	0.00	596
'O'-level equivalent	−0.24 (−0.33 to −0.14)	−0.15 (−0.25 to −0.05)	−0.09 (−0.18 to 0.01)	−0.04 (−0.14 to 0.05)	706
'A'-level equivalent or below degree	−0.32 (−0.42 to −0.22)	−0.20 (−0.31 to −0.10)	−0.11 (−0.20 to −0.01)	−0.04 (−0.14 to 0.06)	782
Higher qualifications after age 23 years					
No additional Higher qualifications (ref.)	0.00	0.00	0.00	0.00	1814
Additional higher qualifications	−0.07 (−0.18 to 0.05)	−0.03 (−0.14 to 0.09)	−0.03 (−0.14 to 0.08)	−0.01 (−0.12 to 0.10)	270
P-value for interaction between qualifications by the age of 23 years and higher qualifications after age 23 years	0.08	0.06	0.31	0.28	

Variables in Model 1 include qualifications gained by age 23 years and additional higher qualifications gained after the age of 23 years.
Variables in Model 2 include Model 1 and socio-economic position and disposition for learning variables.
Variables in Model 3 include Model 1 and health, ability and behaviour variables.
Variables in Model 4 include Models 1–3 variables.

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 the age of 23 years, 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 the age of 23 years but who gained additional higher qualifications after the age of 23 years had a lower CHD risk (0.10%, from exponentiating the sum of −1.98 and −0.31) compared with women without any qualifications by the age of 42 years. In absolute terms, among women without any qualifications by the age of 23 years, 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 with 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 the age of 23 years on reducing CHD risk for women is not zero. However, there was little evidence of an interaction between qualifications gained by the age of 23 years and higher qualifications gained after the age of 23 years. In other words, the effect of higher qualifications after the age of 23 years on reducing CHD risk was similar across women of different qualification levels by the age of 23 years. Adjusting for confounders in Models 2 (socio-economic and disposition towards educational courses), 3 (health, ability and behaviours) and 4 (all confounders) reduced the effect of qualifications gained by the age of 23 years, but did not substantially change the effect of higher qualifications gained after the age of 23 years.

Table 4 shows the effect 'among men' of qualifications gained by the age of 23 years and higher qualifications gained after the age of 23 years regressed on (log) CHD risk. In Model 1, men without any qualifications by the age of 23 years (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 the age of 23 years had lower CHD risk. Men who left school without any qualifications but who went on to obtain some qualifications after the age of 23 years 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 the age of 23 years 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 the age of 23 years and higher qualifications gained after the age of 23 years in the baseline model and the model adjusted for socio-economic 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 the age of 23 years were associated with reduced CHD risk among women. Among men, compared with the complete case analysis, there was stronger evidence of an interaction between qualifications gained by the age of 23 years and higher qualifications gained after the age of 23 years. This interaction effect (Figure 2) shows a greater reduction in CHD risk associated with obtaining additional higher qualifications after the age of 23 years, for men who left school without any qualifications compared with 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 the age of 23 years, although the CIs 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 that 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 with women who completed their qualifications by the age of 23 years. 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.

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

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

Variables in Model 1 include qualifications gained by the age of 23 years and additional higher qualifications gained after the age of 23 years.
Variables in Model 2 include Model 1 and socio-economic position and disposition for learning variables.
Variables in Model 3 include Model 1 and health, ability and behaviour variables.
Variables in Model 4 include Models 1–3 variables.

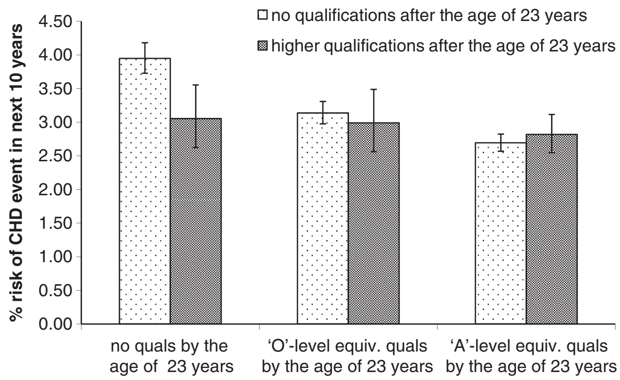

Figure 2 Interaction effect on CHD risk among men, between qualifications obtained by the age of 23 years and additional higher qualifications obtained after age 23 years (estimates taken from Model 4, Table 5)

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 socio-economic returns to gaining additional qualifications that 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 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 the age of 23 years are imprecisely estimated, especially among men. Some of that imprecision is because of the relatively few men and women in the study who obtained higher qualifications after the age of 23 years (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 with 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 socio-economic position, 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 socio-economic improvement in mid-life 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 article 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 life-course. 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 that limit any causal interpretation of the results.

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KEY MESSAGES

- CHD risk among British women who left school in the 1970s without any qualifications but went on to obtain some qualifications later on in life was lower compared with 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.

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