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Impact of educational attainment on the association between social class at birth and multimorbidity in middle age in the Aberdeen Children of the 1950s cohort study

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ABSTRACT

Objective Multimorbidity (the coexistence of two or more health conditions) is increasingly prevalent. No long-term cohort study has examined the impact of contemporaneously measured birth social class along with educational attainment on adult self-reported multimorbidity. We investigated the impact of educational attainment on the relationship between social class at birth and adult self-reported multimorbidity in the Aberdeen Children of the 1950s (ACONF) cohort.

Methods A prospective cohort study using the ACONF cohort. ACONF included 12 150 individuals born in Aberdeen, Scotland 1950–1956. In 2001, 7184 (64%) responded to a questionnaire providing information including self-reported morbidity and educational attainment. The exposure was father's social class at birth from birth records and the outcome was self-reported multimorbidity. Logistic regression assessed the association between social class and multimorbidity with adjustment for gender, then by educational attainment and finally by childhood cognition and secondary school type. ORs and 95% CIs were presented.

Results Of 7184 individuals (mean age 48, 52% female), 5.4% reported multimorbidity. Birth social class was associated with adult multimorbidity. For example, the OR of multimorbidity adjusted by gender was 0.62 (95% CI 0.39 to 1.00) in the highest social class group (I/II) in relation to the reference group (III (manual)) and was 1.85 (95% CI 1.19 to 2.88) in the lowest social class group. This was partially attenuated in all social class categories by educational attainment, for example, the OR was 0.74 (95% CI 0.45 to 1.21) in group I/II following adjustment.

Conclusion Lower social class at birth was associated with developing multimorbidity in middle age. This was partially mediated by educational attainment and future research should consider identifying the other explanatory variables. The results are relevant to researchers and to those aiming to reduce the impact of multimorbidity.

Strengths and limitations of the study

► Our study uses birth records to measure social class at birth, thus removing the chance of recall bias which could occur if the data had been sourced from the participant.

► The use of a longitudinal cohort means that the measurement of the exposure occurred before the measurement of the outcome, providing support for a causal relationship.

► There is selection bias in response to the questionnaire in that respondents were more likely to be women and from a higher social class at birth.

► There are a number of important residual mediators for which data were only available at the timing of the measure of the outcome and so were not included in regression models (body mass index, smoking, alcohol and adult social class).

conditions within an individual.[1 2] It is associated with poorer outcomes and is becoming an increasing challenge for individuals and health and social care services.[3–7] Understanding the determinants of multimorbidity is a crucial part of addressing its impact. However, there is a lack of longitudinal research into the determinants of multimorbidity using large study populations.[3–5]

An influential study of Scottish primary care patients by Barnett *et al* demonstrated a cross-sectional relationship between socioeconomic status (SES) and multimorbidity.[8] This is consistent with the findings of systematic reviews of the multimorbidity literature.[3 5 9 10] However, there has been little study of the impact of childhood SES on adult multimorbidity. Previous studies have relied on retrospective recall (with its associated risk of bias) or had relatively small sample sizes.[11–13]

INTRODUCTION

Multimorbidity is commonly defined as the coexistence of two or more health

Furthermore, poorer SES in childhood is linked to lower academic achievement.[14] Poorer educational attainment has been shown to be associated with multimorbidity.[3 15] Understanding the role of educational attainment in the path between childhood SES and multimorbidity can point to routes to intervention.

The Aberdeen Children of the 1950s (ACONF) cohort study has birth SES measured contemporaneously by birth records, and information on multimorbidity and educational attainment measured by survey in adulthood. It is a large cohort with complete follow-up data available for over 6500 individuals.[16] The aim was to assess the relationship between social class at birth and adult self-reported multimorbidity and to investigate the role of educational attainment in the ACONF cohort.

METHOD
This was a prospective cohort study. The Strengthening the Reporting of OBservational Studies in Epidemiology checklist was used to guide the reporting of the study.[17]

Cohort description
The ACONF cohort is described in detail elsewhere.[16] It contains 12150 individuals born in Aberdeen in the North of Scotland, between 1950 and 1956. All members were linked to birth records. There are cognitive data available from school testing, and in 2001, 7184 (64% of those alive and traced) participated in a postal questionnaire, providing information on morbidity, educational attainment and other characteristics. Responders were more likely to be women, from a higher birth social class and have a higher childhood cognition score than non-responders.[16] This study includes all individuals responding to the questionnaire.

Patient and public involvement
No patients or public were directly involved in the development of the research question, selection of the outcome measures, design and implementation of the study or interpretation of the results.

Exposure
The exposure is social class at birth, sourced from birth records and based on the father's occupation at the birth of the participant. It is coded using the General Register Office's Occupational classification (1950).[18] The categories range from I (professional) to V (unskilled). Categories I and II (managerial) are combined for analysis. There is an additional category for those whose fathers were unemployed, unknown, disabled or dead at the time of the participant's birth.

Outcome
The outcome is self-reported multimorbidity. In the questionnaire, individuals were asked to list up to six '…long-term illnesses, health problems or disabilities which limit (their) daily activities or work (they) can do'. Multimorbidity is defined as two or more self-reported conditions.

Educational attainment
Educational attainment may mediate the relationship between social class at birth and multimorbidity. In the questionnaire, participants were asked about their qualifications ranging from 'degree level' through to 'no formal qualifications'.[19] The level of educational attainment is summarised in five categories which capture similar levels of academic attainment.

Other variables
Cognition scores at age 7 and secondary school type
Routine cognition tests were carried out at age 7 in the 1950s in Aberdeen using the Moray House Picture Intelligence Tests (numbers 1 or 2).[20] As cognition scores are not normally distributed in the study, they are categorised as quintiles for analysis.

Selective schooling for secondary education was in place in Aberdeen in the 1950s and 1960s. These data are sourced from the questionnaire. Using terminology from previous ACONF research, these are defined as 'elite schools' (including private schools) for those deemed to be more academically able and 'non-elite schools' for those defined as less academically able.[21] The type of school attended was based on school test results, primary school teacher assessment of ability and primary school head-teacher view on 'suitability' for an elite school. It was also possible to attend an elite private school by paying.[21] There were three non-private and three private elite schools and there were 15 non-elite schools (including two special needs schools and a convent).

Adult social class, body mass index, smoking status and hangover frequency
These variables were sourced from the questionnaire and form part of the baseline characteristic analysis in this study. The Registrar General's social classes became the Standard Occupational Classification in 1990 (SOC90)[22] and the adult social class categories were formed using SOC90. The category names are the same as for the social class at birth variable, but did not include the final category (father being unemployed, unknown, disabled or dead).

Body mass index (BMI) was derived from self-reported height and weight using the standard calculation: weight (kg)/height (m)^2. Normal weight is classed as a BMI between 18.5 and 24.9. Below 18.5 is underweight and between 25 and 29.9 is overweight. BMI of 30 and above indicates obesity, and this is further divided in to classes 1, 2 and 3. Smoking was categorised as current, past and never-smoked. There was no question about average alcohol consumption and, as a proxy, a question regarding the frequency of hangovers was used.

Statistical analysis
Analyses were conducted using STATA V.13. Statistical significance was set at the 5% level. In the mediation analysis, only individuals with complete data in all the included variables (exposure, outcome, confounders
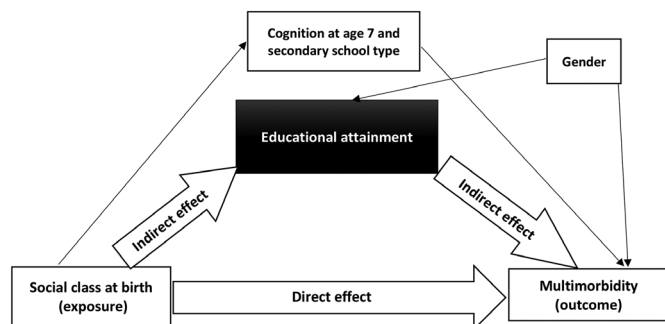
Figure 1 Directed acyclic graph of hypothesised association between social class at birth and multimorbidity with mediation by educational attainment.

and mediators) were included. Baseline characteristics were summarised by gender using proportions and means.

The hypothesis is outlined in the directed acyclic graph (DAG) in figure 1. To establish whether education is a potential mediator of the exposure–outcome relationship, steps set out by Baron and Kenny were followed.[23 24] First, the relationships between the exposure (social class at birth) and outcome (multimorbidity) and between the exposure and the potential mediator (educational attainment) were tested (using logistic regression for the former and ordinal logistic regression for the latter). Next, the relationship between the mediator and the outcome was tested with logistic regression and finally the impact of controlling for the exposure (social class at birth) on this relationship was tested by including it in the model.

Following this, the role of educational attainment as a mediator of the relationship between exposure and outcome was assessed. It is important that exposure–outcome confounders and mediator–outcome confounders are controlled for prior to estimating the effect.[25] Gender is a mediator–outcome confounder (figure 1). Therefore, the first step was to create a logistic regression model with social class at birth as the exposure, multimorbidity as the outcome and adjusted by gender. The model was then further adjusted by educational attainment to assess the effect. Finally, it was adjusted by cognition at age 7 and school type as these are potentially further mediators (figure 1). The model was not adjusted for adult social class, BMI, smoking status or hangover frequency as these were measured cross-sectionally with the outcome. The model was not adjusted for age as all participants were within 6 years of age of each other and including this variable made no difference to the results reported.

Social class category III (skilled manual) was by far the largest category and so was the reference group when social class was the exposure. Education category tertiary (degree) was the reference group where education was the exposure. Coefficients were exponentiated to OR and were presented with 95% CI.

Missing data

The technique of multiple imputation by chained equations (MICE) was used to assess the impact of missing data in the covariates in the mediation analysis. Variables predictive of missing values and variables which influence the process causing the missing data were included. Adult social class, BMI, smoking status and hangover frequency were included along with social class at birth, multimorbidity, educational attainment, cognition scores at age 7, secondary school type and gender. Twenty imputed data sets were created for the analysis and the estimates were pooled using Rubin's rules.[26]

RESULTS

The study population characteristics are in table 1. Of 7184 responders, 52% were women and the mean age was 48 years. The prevalence of self-reported multimorbidity was 5.4% and was slightly higher in women compared with men (6.0% compared with 4.8%, respectively). The majority of participant's fathers were in social class III (skilled manual) at the birth of the participant (44%). There were 633 men (19%) and 636 women (17%) in cognition quintile '50–95'. There were 698 men (20%) and 782 women (21%) in quintile '123–153'.

The majority of participants (66%) attended a non-elite school. 'Ordinary level' qualifications was the largest category of educational attainment for both genders. A higher proportion of men than women had a 'degree' level tertiary education (21% compared with 17% respectively). The largest adult social class category for men was I/II (Professional/Managerial) (48%) and the largest for women was III (skilled non-manual) (38%).

The largest BMI categories were normal weight (40%) and overweight (35%). Smoking rates were similar between the genders with 27% being smokers. More women than men reported no hangovers in the past year (50% vs 36%).

For the mediation analysis steps, the population was limited to those with complete data across all included variables (n=6561). The association between social class at birth and multimorbidity is in table 2. There was a trend for increasing ORs of multimorbidity with decreasing social class category (p=0.002). In relation to the reference group III (skilled manual), the OR of self-reported multimorbidity was 0.62 (95% CI 0.38 to 0.99) in those in the highest birth social class and 1.85 (95% CI 1.19 to 2.88) in those whose fathers were unemployed, unknown, disabled or dead at the participant's birth.

Table 2 also shows that those in higher birth social classes were more likely to have a higher educational attainment (p<0.001). For example, the proportional OR of being in the highest educational attainment category (tertiary degree) compared with the other four categories combined was 4.12 (95% CI 3.50 to 4.85) in social class category I/II in relation to the reference group of III (skilled manual). Similarly, the OR of being in the top two educational categories versus all others combined was

Table 1 Baseline characteristics of ACONF study population, n=7184*

Characteristic	All n=7184		Male n=3430		Female n=3754	
	Total	%	Total	%	Total	%
Total	7184	100	–	–	–	–
Gender						
Male	3430	47.7	–	–	–	–
Female	3754	52.3	–	–	–	–
Mean age in May 2001	48.2	SD 1.5	48.3	SD: 1.5	48.2	SD 1.5
Multimorbidity						
Absent	6796	94.6	3267	95.2	3529	94.0
Present	388	5.4	163	4.8	225	6.0
Social class of the father at birth of the participant						
I/II (Professional/Managerial)	789	11.0	388	11.3	401	10.7
III (Skilled non-manual)	869	12.1	415	12.1	454	12.1
III (Skilled manual)	3154	43.9	1482	43.2	1672	44.5
IV (Partly skilled)	976	13.6	482	14.1	494	13.2
V (Unskilled)	1048	14.6	503	14.7	545	14.5
Unemployed/unknown/disabled/dead	348	4.8	160	4.7	188	5.0
Cognition score age 7 (quintiles)						
50–95	1269	17.7	633	18.5	636	16.9
96–105	1445	20.1	701	20.4	744	19.8
106–112	1277	17.8	622	18.1	655	17.5
113–122	1453	20.2	695	20.3	758	20.2
123–153	1480	20.6	698	20.4	782	20.8
Missing	260	3.6	81	2.4	179	4.8
School type						
Non-elite	4726	65.8	2242	65.4	2484	66.2
Elite	2067	28.8	1006	29.3	1061	28.3
Other	56	0.8	20	0.6	36	1.0
Missing	335	4.7	162	4.7	173	4.6
Educational attainment						
Tertiary (degree)	1374	19.1	734	21.4	640	17.1
Tertiary (non-degree)	1138	15.8	624	18.2	514	13.7
Advanced level	926	12.9	494	14.4	432	11.5
Ordinary level	1970	27.4	775	22.6	1195	31.8
School leaving/none	1676	23.3	757	22.1	919	24.5
Missing	100	1.4	46	1.3	54	1.4
2001 adult social class						
I/II (Professional/Managerial)	2944	41.0	1631	47.6	1313	35.0
III (Skilled non-manual)	1758	24.5	323	9.4	1435	38.2
III (Skilled manual)	1271	17.7	1012	29.5	259	6.9
IV (Partly skilled)	745	10.4	286	8.3	459	12.2
V (Unskilled)	304	4.2	99	2.9	205	5.5
Missing	162	2.3	79	2.3	83	2.2
2001 adult body mass index categories						
Underweight (<18.5)	53	0.7	13	0.4	40	1.1
Normal (18.5–24.9)	2838	39.5	1100	32.1	1738	46.3

Table 1 Continued

Characteristic	All n=7184		Male n=3430		Female n=3754	
	Total	%	Total	%	Total	%
Overweight (25–29.9)	2516	35.0	1416	41.3	1100	29.3
Obese class 1 (30–34.9)	885	12.3	460	13.4	425	11.3
Obese class 2 (35–39.9)	251	3.5	82	2.4	169	4.5
Obese class 3 (40+)	105	1.5	25	0.7	80	2.1
Missing	536	7.5	334	9.7	202	5.4
2001 adult smoking status						
Current smoker	1958	27.3	931	27.1	1027	27.4
Ex-smoker	1788	24.9	939	27.4	849	22.6
Non-smoker	3420	47.6	1552	45.3	1868	49.8
Missing	18	0.3	8	0.2	10	0.3
2001 adult alcohol related hangovers in past year						
At least once a week	161	2.2	111	3.2	50	1.3
1–3 times a month	766	10.7	524	15.3	242	6.5
Less than once a month	2688	37.4	1407	41.0	1281	34.1
Not at all in the last year	3122	43.5	1238	36.1	1884	50.2
Missing	447	6.2	150	4.4	297	7.9

*Figures presented are numbers and proportions unless stated otherwise.
ACONF, Aberdeen Children of the 1950s.

4.12 (95% CI 3.50 to 4.85) for social class I/II versus the reference group, and so on. Conversely, those in lower birth social classes were less likely to have a higher educational attainment. For example, the OR of being in the highest educational attainment category versus all others combined was 0.45 (95% CI 0.40 to 0.52) for those in birth social class category V in relation to the reference group.

Table 3 shows ORs of multimorbidity generally increasing as educational attainment decreased (p<0.001). The CI for 'tertiary (non-degree)','advanced level' and 'ordinary level' crossed one. Those with the lowest educational attainment (school-leaving certificate or no qualification) had an OR of 2.42 (95% CI 1.71 to 3.42) for multimorbidity compared with the reference group of 'tertiary (degree)'. The association remained when controlling for social class at birth (table 3). For example, the OR for those with the lowest educational attainment was 2.15 (95% CI 1.49 to 3.11).

These steps established educational attainment as a potential mediator. In table 4, the mediating role is investigated. The relationship between the exposure (social class at birth) and the outcome (multimorbidity) remained in the model adjusted by gender (p=0.002). For example, in relation to the reference group III (skilled manual), the OR of self-reported multimorbidity was 0.62 (95% CI 0.39 to 1.00) in those in the highest birth social class and 1.85 (95% CI 1.19 to 2.88) in those

Table 2 Association between social class at birth and multimorbidity (logistic regression) and educational attainment (ordinal regression), n=6561

Social class of the father at birth of the participant	Multimorbidity *		Educational attainment†	
	OR	95% CI	OR	95% CI
I/II (Professional/Managerial)	0.62	0.38 to 0.99	4.12	3.50 to 4.85
III (Skilled non-manual)	0.95	0.66 to 1.37	1.76	1.54 to 2.03
III (Skilled manual)	1 (reference group)			
IV (Partly skilled)	1.18	0.85 to 1.64	0.56	0.49 to 0.65
V (Unskilled)	1.43	1.06 to 1.93	0.45	0.40 to 0.52
Unemployed/unknown/disabled/dead	1.85	1.19 to 2.88	0.84	0.66 to 1.05

*Model statistically significant, p=0.002.
†Model statistically significant, p<0.001.

Table 3 Association between educational attainment and multimorbidity, models unadjusted and adjusted by social class at birth, n=6561

Educational attainment	Unadjusted*		Adjusted by social class at birth*	
	OR	95% CI	OR	95% CI
Tertiary (degree)	1 (reference group)			
Tertiary (non-degree)	1.13	0.74 to 1.73	1.06	0.69 to 1.63
Advanced level	1.09	0.69 to 1.71	1.05	0.66 to 1.66
Ordinary level	1.34	0.93 to 1.92	1.22	0.84 to 1.78
School leaving/none	2.42	1.71 to 3.42	2.15	1.49 to 3.11

*Models statistically significant, P<0.001

whose fathers were unemployed, unknown, disabled or dead.

The model adjusted by educational attainment and gender was also statistically significant (p<0.001). In comparison with the gender-only analysis, the inclusion of education caused ORs to approach one. For example, in the gender-only analysis, the OR of multimorbidity in the highest birth social class category was 0.62 (95% CI 0.39 to 1.00), and in this analysis, it was 0.74 (95% CI 0.45 to 1.21). However, the inclusion of educational attainment did not fully mediate the relationship between social class at birth and multimorbidity.

The inclusion of secondary school type and cognition at age 7 had no additional impact on the effect of educational attainment. For example, the OR in group I/II was 0.73 (95% CI 0.44 to 1.20) in the model adjusted by all variables, compared with 0.74 (95% CI 0.45 to 1.21) in the model adjusted by educational attainment and gender only.

The results of using MICE to impute missing values are in online supplementary table 1. Imputing missing values had no important impact on the findings.

DISCUSSION

We found that a lower social class at birth was associated with a higher likelihood of self-reported multimorbidity in middle age. This was partially mediated by educational attainment.

To our knowledge, this is the first large longitudinal study examining the relationship between contemporaneously measured birth SES and adult self-reported multimorbidity. Other studies in the field are not directly comparable in terms of the measurement of SES and multimorbidity, and are either smaller than this study or are not longitudinal. Neeleman *et al* studied the prevalence of multimorbidity (based on participant selection from a list of conditions) in 3162 individuals aged 43 years who had contemporaneously collected data on the social class of their father when they were 15 years old.[12] Paternal social class was not directly associated with multimorbidity in adulthood, but was linked to multimorbidity via some temperamental and behavioural variables.[12] In a cross-sectional study by Tucker-Seeley *et al* of 7305 individuals aged 50 and older, participants were asked to retrospectively recall the presence of childhood financial hardship.[11]

Table 4 Logistic regression analysis of the association between social class of the father at the birth of the participant and multimorbidity, models adjusted by gender, adjusted by educational attainment and gender and adjusted by educational attainment, gender, cognition at age 7 and school type

Social class of the father at birth of the participant	Number	Adjusted for gender*		Adjusted by educational attainment and gender†		Adjusted by educational attainment, gender, cognition at age 7 and school type†	
		OR	95% CI	OR	95% CI	OR	95% CI
I/II (Professional/Managerial)	655	0.62	0.39 to 1.00	0.74	0.45 to 1.21	0.73	0.44 to 1.20
III (Skilled non-manual)	802	0.95	0.66 to 1.38	1.03	0.71 to 1.50	1.03	0.71 to 1.50
III (Skilled manual)	2929	1 (reference group)					
IV (Partly skilled)	900	1.18	0.85 to 1.64	1.08	0.77 to 1.50	1.07	0.77 to 1.49
V (Unskilled)	985	1.43	1.06 to 1.94	1.26	0.93 to 1.71	1.24	0.91 to 1.70
Unemployed/unknown/ disabled/dead	290	1.85	1.19 to 2.88	1.79	1.15 to 2.79	1.74	1.11 to 2.72

Complete case analysis (n=6561).
*Model statistically significant, p=−0.002.
†Models statistically significant, p<0.001.

Childhood financial hardship was associated with higher number of chronic conditions (sourced from participant selection from a list of six conditions). Humphreys *et al*, in a study of 2299 individuals in the Hertfordshire birth cohort, found an association between paternal social class (measured by interview of family members when the participant was a child) and multimorbidity at age 64 to 68 years (measured by participant selection from a list of 10 conditions).[13]

There are a number of explanations for our findings. The association between birth SES and later life health likely reflects the accumulative effects of adverse childhood circumstances over the life course.[27 28] For example, parents or caregivers with lower SES are more likely to have low-income insecure occupations with antisocial hours. Parental stress may affect family well-being and cohesion leading to stress in the child, and low income may detrimentally impact on the ability to afford healthy food. There is an increased likelihood of living in poorer quality housing and in areas with high rates of crime.[27 28] Chronic stress can lead to poorer physical health, even in childhood.[27] Control and empowerment lead to improved health and well-being and are shown to be lower in individuals with lower SES.[27]

Exposure to stressors when young can impact directly on neurobiological development.[29] Children in families in poverty may have changes in brain function due to the impact of cortisol on the developing brain. This can manifest as poorer language skills, learning ability and mental health.[27 29] The lack of an available adult role model may impact on a child's ability to engage with education and carry out homework and other extracurricular activities.[27] Our finding of an association between lower social class at birth and lower educational attainment is thus consistent with what would be expected based on these factors.

We found that higher educational attainment was associated with a lower prevalence of self-reported multimorbidity and this remained when adjusted for social class at birth. Higher educational qualifications give opportunities to access higher income occupations and confer the protections of higher SES.[30] Additionally, the sense of achievement, empowerment and control due to gaining qualifications and achieving higher status occupations can confer psychosocial protections.[27 30] Therefore, individuals may not only have fewer health conditions but may be better able to manage existing health conditions and may have been less likely to report these in the questionnaire.

Education partially mediated the relationship between social class at birth and multimorbidity. This means it explains some of the relationship however there is a need to find further explanations. We adjusted for other potential mediators (cognition at age 7 and secondary school type) but they had little additional impact.

There are a number of strengths and weaknesses in our approach. Using contemporaneously measured SES is a strength as it removes the chance of recall bias. Another study in the ACONF cohort comparing contemporaneously measured childhood social class with adult recall of childhood social class found participants tended to report a higher social class than that which had been recorded at the time.[31]

Multimorbidity may be measured in a number of ways, including data from healthcare usage, clinician report and patient survey.[32] In this study, we present the prevalence of multimorbidity based on any condition an individual considers to be high burden to them (as opposed to selecting from a preset list or documenting clinically diagnosed conditions). To our knowledge, few other studies have measured multimorbidity in this way. It is important given that what individuals may view as important conditions may vary from the view of clinicians[33] and self-reported measures of health have been shown to be powerful predictors of future morbidity and mortality.[34 35] Therefore, even though the cohort are relatively young at the time of measurement, these findings may translate into socioeconomically patterned uses of healthcare services and poorer long-term outcomes as they age.

Drawing on Bradford-Hill criteria for demonstrating causality,[36] in this longitudinal analysis, we can show that the measurement of the exposure precedes the measurement of the outcome. The association between birth social class and multimorbidity may not be strong but the direction of effect is consistent with accepted evidence regarding the association between SES and health.

Those not responding to the questionnaire may have more severe illnesses than those who do, and so the prevalence of multimorbidity may be underestimated compared with the general population. Questionnaire responders were more likely to have a higher birth social class. It may be that those who have responded from lower birth social class categories are not representative of the remainder of the group. For example, it could be that those who do not have multimorbidity were more likely to respond and that those who do have multimorbidity were more likely to respond if they had higher educational attainment.

We did not conduct formal mediation analysis but we used the steps for establishing mediation, set out by Baron and Kenny.[23 24] Cognition scores and secondary school type were included in the regression modelling as these may be additional mediators of the exposure–outcome relationship, but we did not formally test whether they fulfil the criteria for being mediators in the way we did for educational attainment. Their consideration alongside educational attainment had little impact.

Furthermore, while we conducted analysis on the basis of the hypothesis laid out in figure 1, a limitation of our approach is that it does not account for other potential inter-relationships between variables. For example, cognition scores from tests later in childhood formed part of the selection process of secondary school type for Aberdeen children and only those attending elite schools could sit for advanced-level examinations. However, given the lack of life course study of

multimorbidity, studies such as ours are important early steps in highlighting important variables to consider in more complex life course models.

Educational attainment and secondary school type were measured at the time of the questionnaire (and thus at the time of the assessment of the outcome), however this can be justified. First, given the age of the population, schooling will definitely have occurred in the past. Second, only 28 individuals (0.4%) reported being a student at the time of the questionnaire (data not shown) and so the impact of future changes in educational attainment is likely to be negligible. It was reasonable to not include BMI, smoking, alcohol and adult social class as their relationship to the outcome could be bidirectional. For example, an individual who smokes may develop multimorbidity but an individual who develops multimorbidity may choose to give up smoking to improve their health. Nonetheless, these are important residual mediators.

The analysis was conducted on those responding to the questionnaire in 2001. Imputation techniques were not used to impute the missing values of those who did not respond as the proportion of missing data was large. However, imputation techniques were used to account for missing data in the covariates included in the regression analysis. The use of MICE as a sensitivity analysis had no impact on the findings.

The findings have a number of implications. Multimorbidity is a growing public health challenge and understanding its determinants across the life course is a crucial part of addressing its impact. The study highlights the important influence of very early life SES and thus measures which mitigate the impacts of SES in early years are crucial (eg, psychological and financial support for pregnant mothers, adequate paid parental leave and access to preschool education or childcare).[27] Furthermore, education may at least partially mediate the association and so support in allowing access to education and addressing factors which may limit educational attainment in those from lower SES backgrounds is important.

Given our results show only partial mediation by educational attainment, researchers should consider identifying the other potential explanatory variables (which may include variables we were unable to include such as BMI, smoking and alcohol consumption). Next stages in multimorbidity research are to develop complex life course models. For example, the technique of structural equation modelling can simultaneously examine multiple effects and the relationships between variables in addition to their impact on the outcome.[37] This study identifies important variables to consider in the development of these models.

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