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The effect of multiple risk behaviours in adolescence on educational attainment at age 16 years: a UK birth cohort study

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Abstract

Objectives: To explore the association between adolescent multiple risk behaviours (MRB) and educational attainment.

Design: Prospective population-based UK birth cohort study.

Setting: Avon Longitudinal Study of Parents and Children (ALSPAC), a UK birth cohort of children born in 1991-92.

Participants: Data on some or all MRB measures were available for 5,401 ALSPAC participants who attended a clinic at age 15 years and/or completed a detailed questionnaire at age 16 years. Multiple imputation was used to account for missing data.

Primary outcome measures: Capped General Certificate of Secondary Education (GCSE) score and odds of attaining five or more GCSE examinations at grades A*-C. Both outcome measures come from the National Pupil Database (NPD) and were linked to the ALSPAC data.

Results: Engagement in MRB was strongly associated with poorer educational attainment. Each additional risk equated to -6.31 (95% CI -7.03, -5.58, $p<0.001$) in capped GCSE score, equivalent to a one grade reduction, or reduced odds of attaining five or more A*-C grades of 23% (OR 0·77, 95% CI: 0·74-0·81, $p<0.001$). The average cohort member engaged in 3·24 MRB and therefore have an associated reduction in GCSE score equivalent to three and a half grades in one examination, or reduced odds of attaining five or more A*-C grades of 75%.

Conclusion: Engagement in adolescent MRB is strongly associated with poorer educational attainment at 16 years. Preventing MRB could improve educational attainment and thereby directly and indirectly improve longer term health.

Keywords: multiple risk behaviours, adolescence, educational attainment, ALSPAC, UK birth cohort study

Strengths and limitations of this study

- This is the first longitudinal study in the UK to examine the association between multiple health risk behaviours and educational attainment.

- Owing to the scale and richness of the ALSPAC data, we have been able to control for a wide range of confounders, including socio-economic measures, previous educational attainment, and IQ.

- The risk behaviours were all reduced to binary variables in order to construct the total MRB score, which leads to a loss of information.

- By summing the risk behaviours to create a measure of total MRBs, we attribute equal weight to each behaviour, however, we found no strong evidence for an alternative classification of MRB in terms of clusters of specific MRBs or latent classes.

- There is considerable missing data for the exposure and confounder variables which reduces power and may introduce bias, however, there is no missing data on either outcome measure, and although missingness is related to MRB our imputed analyses are similar to the complete case analysis.

Competing interests

1 The authors declare that there are no competing interests.

2 **Introduction**

3 Health risk behaviours such as smoking, alcohol consumption, physical inactivity, and

4 unhealthy eating are prevalent during adolescence [1,2] and have also been shown to co-occur

5 during this period. [3-5] A growing body of evidence suggests that these behaviours are strongly

6 associated, some causally, with adverse health outcomes in later life, including chronic health

7 conditions, morbidity, and premature mortality. [5-7] Further, evidence has shown that MRB are

8 cumulatively associated with cardiovascular and all-cause mortality.[5,6] For example, having

9 four healthy lifestyle behaviours is associated with a 4-fold difference in mortality compared

10 to having none.[6] Similarly, a composite measure of MRB predicted preventable death, over

11 and above the predictive value of single lifestyle behaviours.[8] It has been posited that many

12 lifestyle behaviours are underpinned by the same neural circuitry, and as such when

13 intervening on one behaviour, changes in other behaviours can be expected.[9] Finally,

14 interventions responding to multiple risks may be more efficient and better value for money,

15 providing potentially huge benefits for considering multiple, rather than single risk

16 behaviours.

17 Successful completion of compulsory education is important to an individual's well-being

18 and lifelong opportunities. Those with lower educational attainment are more likely to

19 smoke,[10] be overweight, and have poor physical and mental health outcomes.[11] They also

20 experience reduced employment opportunities and earning potential.[11-13] Successful

21 completion of compulsory education is strongly associated with increased aspirations and life

22 satisfaction[14] and those with college degrees or higher are the most likely to engage in

23 healthy behaviours.[15]

24 Many studies consider the effects of single health risk behaviours and educational outcomes.

25 Obesity,[3,16] smoking tobacco,[4,17,18] using cannabis,[17-19] drinking alcohol,[4,18] self-harm,[20]

1 physical inactivity,[21] and screen based behaviours involving TV, internet, or computer

2 games[22] are all associated with poorer educational outcomes. Less studies consider multiple

3 risk behaviours simultaneously,[1,23-25] fewer still consider a large number of heterogeneous

4 risk behaviours concurrently.[26-28] Past research has shown that those with no or intermediate

5 qualifications are more likely to engage in MRB compared to those who attended higher

6 education. [15,29-31] However, these studies relate to adult populations and have considered only

7 a limited number or range of risk behaviours. No UK studies, to our knowledge, have

8 examined engagement in multiple risk behaviours and educational outcomes. Using data from

9 the ALSPAC cohort in England, we aimed to investigate the association of multiple risk

10 behaviours during adolescence and educational attainment at age 16.

11 **Methods**

12 **Sample**

13 Data were drawn from the Avon Longitudinal Study of Parents and Children (ALSPAC), an

14 ongoing prospective observational population-based study investigating the effects of a wide

15 range of influences on health and development across the life course. Pregnant women

16 residing in the old administrative county of Avon, who had an estimated date of delivery

17 between 1 April 1991 and 31 December 1992, were invited to participate. The initial study

18 cohort consisted of 14,062 live born children of whom 13,988 singletons or twins were still

19 alive at 12 months of age. A small number of participants withdrew from the study (n=24).[32]

20 Those who were neither enrolled nor part of the original core ALSPAC sample were

21 excluded from our analyses, along with any triplets or quadruplets whose identity, because of

22 their rarity, would be compromised. As Boyd et al. (2013) observe the ALSPAC 'enrolled

23 sample' are more likely to be White (OR= 3.85 [95%CI: 3.50–4.24] p<0.001) and less likely

24 to be eligible for free school meals (OR= 0.46 [95%CI: 0.43–0.50] p<0.001) than the

25 National Pupil Database key stage four government-maintained establishments national

1   sample[2] and 'recent responders' to ALSPAC are more likely to be female (OR= 1.88

2   [95%CI: 1.74–2.03] p<0.001), White (OR=1.34 [95%CI: 1.10–1.62 p=0.004) and less likely

3   to be eligible for free school meals (OR= 0.51 [95%CI: 0.44–0.60] p<0.001).[32]   The study

4   website contains details of all the data that are available through a fully searchable data

5   dictionary: http://www.bris.ac.uk/alspac/researchers/data-access/data-dictionary/.[33] Ethical

6   approval for the study was obtained from the ALSPAC Ethics and Law Committee and local

7   Research Ethics Committees.

8   Linkage between ALSPAC and National Pupil Database

9   The National Pupil Database (NPD) is a pupil level data source which matches pupil and

10   school characteristic data to pupil level attainment data in England. The Fischer Trust

11   completed the linkage between the NPD and ALSPAC data in 2002. It is only mandatory for

12   schools following the National Curriculum to contribute to the NPD. Independent schools

13   may provide attainment data on a voluntary basis.

14   **Exposure measure**

15   Multiple risk behaviours at age 16

16   Measures of participation in thirteen distinct risk behaviours at the ages of 15 and 16 years

17   were derived from participants' responses at two ALSPAC data collections during their late

18   teens (see Table 1). The first was a self-completed questionnaire issued during a clinic

19   attended at age 15 (median age 15 years and 5 months) and the second comprised responses

20   to a postal questionnaire administered at age 16 (median age 16 years and 7 months). The

21   MRB measure was informed by the work of Hurrelmann and Richter (2006), who present an

22   integrative model of risk behaviour. They argue that while inadequate coping processes are

23   ubiquitous during adolescence, these processes can result in very different health risk

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[2] Refers to all pupils, excluding those in ALSPAC, from English government-maintained establishments (GMEs) who sat their KS4 assessments during the same academic years as the ALSPAC cohort (academic years 2007–09).

1 behaviours among young people. However, despite variations in presentation (e.g. physically

2 hurting someone on purpose, verses not wearing a seat belt), risk behaviours reflect the very

3 similar dimensions of either externalising; internalising; or evasive forms. [34] Lending weight

4 to this position, previous analyses using this measure of MRB have shown that health risk

5 behaviours are patterned according to gender. For example, antisocial and criminal

6 behaviours, cannabis use and vehicle-related risk behaviours are more prevalent among

7 males, whilst tobacco smoking, self-harm and physical inactivity are more prevalent among

8 females. However, despite the gendered patterning of single risk behaviours, females and

9 males engaged in a similar number of risk behaviours. [35] Similarly, another previous analysis

10 showed that while the associations between individual risk behaviours and measures of

11 socioeconomic status (parental social class, maternal education and income quintile), were

12 highly variable, a more consistent relationship was established between the MRB measure

13 and socioeconomic status. When compared with the highest social class, maternal education

14 or income quintile, the odds of engaging in a greater number of multiple risk behaviours

15 increased for each incremental decrease in social position. [23] Finally, an analysis of these

16 MRB data, using latent class analysis (LCA),[36] showed that the resulting classes simply

17 varied according to the number of risk behaviours, rather than demonstrating distinct risk

18 profiles based on classes of behaviours. Having found no strong evidence for employing an

19 alternative classification of MRB based on classes of behaviour the MRB measure comprises

20 a count of the number of risk behaviours representing a breadth of domains of social and

21 health risk including: sexual health, substance use, self-harm, vehicle related injury risk,

22 criminal and antisocial behaviour (ASB), and physical inactivity. The derivation of each

23 behaviour is discussed in more detail in an earlier paper. [23] For the purposes of the analyses

24 reported here a total number of risk-behaviours score from 0 to 13 was derived for each

25 participant.

1 **Outcome measures**

2 Educational attainment at age 16

3 Pupils in England aged between 14 and 16 years complete compulsory schooling during

4 school years 10 and 11 and take their GCSE (or equivalent) examinations, this is referred to

5 as key stage four (KS4). At the time that the ALSPAC cohort were in school, UK law stated

6 that pupils were to remain in compulsory education until the age of 16, so unlike A-Levels,

7 which are taken 2 years later and are optional, GCSEs are one of very few occasions in a

8 young person's life when their educational attainment is assessed along with most of their

9 peers. Two outcomes relating to key stage four educational attainment were used in the

10 analysis. Achieving five or more A*-C grades at GCSE was chosen because it is a minimum

11 requirement for many post-16 education and training courses and as such represents an

12 important threshold for young people to exceed. The second outcome takes the individual

13 scores for each GCSE, which are calculated as A*=58 through to G=16 and ungraded U=0

14 (unlike in North America where grades range from A-F). This general attainment score is

15 calculated by summing a pupil's eight best grades, referred to as the capped GCSE score. It is

16 seen as preferable to a total GCSE score because it represents the same measure that is used

17 in the published value-added school league tables, which have become an important measure

18 of the quality of education provision. It is also considered fairer than the total (uncapped)

19 score since it moderates the scores of pupils who score highly merely by taking more

20 examinations.

21 **Possible Confounders**

22 We adjusted for a number of known confounders: sex, season of birth, parent's highest social

23 class (professional; managerial and technical; skilled non-manual; and skilled manual, part or

24 unskilled manual), mother's highest educational level (degree, A-level, O-level/GCSE and

25 less than O-level/GCSE), household income (divided into quintiles of high to low income),

housing tenure during pregnancy (mortgaged or own property, privately rented property or subsidised rental property) and claiming eligibility for a free school meal. Season of birth has been shown to be an important predictor of educational attainment. In England, where the academic year runs from September 1st to August 31st, children who are born in the autumn tend to outperform those who are born in the summer.[37] We additionally controlled for IQ score at age eight years and key stage two[3] educational attainment in order to reduce the likelihood of reverse causality between early educational performance and engagement in MRBs. Analysis of confounders and both the exposure and outcomes variables was conducted and can be found in the supplementary material.

Missing data

Of the starting sample of 13,954 subjects (enrolled cohort, singletons and twins alive at one year): 2,618 (18·8%) did not have a linked education record for key stage four and were excluded from the analysis on that basis. There are a number of possible reasons for this type of missingness. Participants' may not have the linked data from the national pupil database (NPD), the participant may have withheld consent, or the participant may have been attending a school that does not follow the National Curriculum i.e. an independent school. Independent school education is of particular interest in this case because of its prominence in Bristol and Avon. Between 2006 and 2009 (when the ALSPAC cohort would have taken their GCSE examinations), the percentage of pupils educated in independent schools in England remained stable at approximately 7%. In Bristol, it ranged between 15·1% in 2006/07 and 13·4% in 2008/09. However, with no way of confirming that those with missing attainment and school type data were independently educated, and no alternative identifier of

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[3] Key stage two is the legal term which refers to the four years of schooling in maintained schools in England and Wales when pupils are aged between 7 and 11 years. Key stage two culminates in standardized assessment tests (SATS) at age ~11 years, the results of which have been used here.

1 independent school status, we were unable to conduct a sensitivity analysis with this respect.

2 Our sample analysis is therefore less representative of Bristol at the time, but more

3 generalizable to the overall population, where independent schooling is less common. Of the

4 11,336 subjects with education outcome data, 8,398 (74.08%) were invited to the clinic and

5 of those, 4,534 (53.99%) attended; and 8,017 (70.72%) were sent the questionnaire and of

6 those, data was available for 4,052 (50.54%). Overall, 5,401 participants had some or all of

7 their MRB information and this became the imputation sample upon which our analysis is

8 based. Additional analysis regarding those with complete data (n=1,617) is available in the

9 supplementary material (see Figure 1 for how we derived the sample).

10 Multivariate imputation by chained equations was carried out using the 'ice' routine in Stata

11 version 14. This approach is based on the Missing At Random (MAR) assumption, i.e. that

12 any differences between the missing and observed values, can be explained by differences in

13 the observed data.[38] All variables used in the analyses including all measures of MRB,

14 educational attainment and potential confounders were included in the imputation model,

15 along with many other measures of the exposures, outcomes and confounders that had been

16 collected at different time points. These are included in the imputation routine as auxiliary

17 variables to reduce bias by improving the precision of the imputation model. Monte Carlo

18 errors were used to compare the results obtained when imputing 25, 100, 250, and 500 data

19 sets. [39] Imputed results shown have been pooled across the 500 data sets. Among this sample

20 there was an average missingness of 18.23%.

21 **Patient and Public Involvement**

22 No patients were involved in the design of this study. However, our choice of risk behaviours

23 was informed by discussions with two groups of adolescents through the DECIPHer ALPHA

24 young person's research advisory group (http://decipher.uk.net/public-involvement/young-

25 people/).

1   *Sample descriptive statistics*

2   Compared to the imputation sample the complete case sample had better educational

3   outcomes, a higher mean IQ score and a lower mean total MRB score. The percentage of

4   females, and all indicators of advantageous socio-economic position were over-represented in

5   the complete case sample when compared with the imputation sample (see Table 2).

6   **Associations between confounders and exposure variables**

7   We found that lower maternal education, lower parental social class, living in privately rented

8   or subsidised housing, having a lower income, and claiming eligibility for free school meals

9   (FSM) were all positively associated with the total number of multiple risk behaviours at age

10 16 years. IQ at age 8 years and higher previous educational attainment at key stage two were

11 negatively associated with total MRB score. There was no association between sex, season of

12 birth, or special educational needs (SEN) and MRB score.

13 Lower maternal education, lower parental social class, living in privately rented or subsidised

14 housing, having a lower income, and claiming eligibility for free school meals (FSM) were

15 all associated with lower educational attainment at age 16 years. This was true for both

16 educational outcomes. Being born in the spring or summer compared with the autumn was

17 associated with lower capped GCSE score, but had no association with gaining five or more

18 A*-C grades at GCSE. Having higher previous attainment levels at key stage two and a

19 higher IQ at age 8 years were associated with better educational outcomes at age 16 years and

20 being female was associated with an improved grade point average equivalent to more than

21 one and a half grades. Details of these analyses can be found in the supplementary material.

22 **Statistical analysis**

23 Linear regression was used to examine associations between total MRB and the continuous

24 outcome, capped GCSE score and logistic regression was used for the binary outcome,

25 gaining five or more GCSE grades A*-C. Analyses were conducted on the complete case and

11

1 imputed data the latter of which constitutes the main analysis. We ran unadjusted models for

2 both outcomes followed by a sequence of models adjusted for: (i) sex and season of birth, (ii)

3 sex, season of birth, maternal education, parental social class, household income, housing

4 tenure and free school meals (FSM), and (iii) sex, season of birth, maternal education,

5 parental social class, household income, housing tenure, FSM, IQ, and previous educational

6 attainment. We tested for non-linearity between exposure and outcome using the 'nlcheck'

7 function in Stata. However, we found no evidence that the linearity assumption had been

8 violated. We also tested for interactions between sex and MRB; and each of the socio-

9 economic indicators and MRB, however, we found no strong evidence of any associations (p

10 values ranged from 0·047 for housing tenure to 0·827 for FSM). All analyses were conducted

11 in Stata version 14.

12 **Results**

13 **Associations between total MRB and educational outcomes**

14 In the ALSPAC cohort at age 16 years, we found that the total number of multiple risk

15 behaviours engaged in was strongly associated with lower educational attainment (see Table

16 3). In the unadjusted models, for every additional risk behaviour a young person engaged in,

17 the capped GCSE score decreased on average 9·17 points (95% CI: -10·25, -8·10 p<0.001),

18 equivalent to a grade and a half in one GCSE examination. Similarly, the odds of attaining

19 five or more A*-C grades were reduced by 18% (OR=0·82 [95% CI: 0·79-0·85] p<0.001) for

20 each additional risk behaviour.

21 The association between multiple risk behaviours and capped GCSE score did not change

22 markedly with the inclusion of sex and season of birth in the models. However, a more

23 substantial reduction in the association was seen with the inclusion of the socio-economic

24 indicators (maternal education, parental social class, household income, housing tenure, and

25 free school meal status). The final and fully adjusted model, which additionally included IQ

at age 8 years and previous educational attainment, shows that for each additional multiple

risk behaviour, the participant had a reduction in capped GCSE score of 6·31 points (95% CI

-7.03, -5.58, p<0.001) which is equivalent to just more than one grade in one GCSE

examination. The mean number of risk behaviours engaged in was 3·24, which means that on

average young people from this cohort had a reduced GCSE score of 20·44 points, associated

with their risk taking. This is equivalent to a reduction of nearly three and a half grades in one

GCSE examination, or one grade lower in three examinations.

The negative association between engaging in MRBs and gaining five or more GCSEs

between A*-C, as demonstrated in the preliminary analysis, remained large in the adjusted

models. Indeed, after adjusting for all the confounders, the magnitude of this effect increased

and the odds of attaining five or more A*-C grades was reduced by 23% (OR = 0·77 [95%

CI: 0·74-0·81] p<0.001) for each additional risk behaviour engaged in (although it should be

noted that the confidence intervals do overlap with the previous model).

Each of the separate risk behaviours were negatively associated with educational attainment.

Smoking had the largest deleterious association and those who smoked scored an average of

57·40 capped GCSE points less than those who did not smoke. This would be equivalent to

getting an ungraded U classification instead of an A* in one GCSE examination, or put

differently getting one grade lower in nine separate GCSE examinations. Smokers were also

70% less likely to gain five or more A*-C grades at GCSE compared to non-smokers at age

16 years. Not wearing a cycle helmet, hazardous alcohol use, and physical inactivity were all

negatively associated with educational attainment, however, the evidence was less

compelling (with p values ranging from 0.007 to 0.934). Details of these analyses can be

found in the supplementary material.

Discussion

1   In our analysis of the ALSPAC cohort, adolescents with a greater number of health risk

2   behaviours had poorer educational outcomes at age 16 years. While the fully adjusted models

3   for both the complete case and the imputed datasets showed some attenuation in the

4   estimates, the effect remained strong despite adjusting for a wide range of confounders. The

5   fully adjusted model showed an associated reduction in capped GCSE score of 6.31 points,

6   which would be equivalent to a reduction of more than one grade in one GCSE examination,

7   for each additional MRB engaged in. A similarly adverse association with a young person's

8   odds of gaining five or more GCSEs between A*-C was also observed with the odds of

9   attaining five or more A*-C grades at GCSE reduced by 23% for each additional risk

10   behaviour. We also corroborated associations between a wide range of individual MRB and

11   educational outcomes at age 16 years.

12   This is the first longitudinal study in the UK to examine the association between multiple

13   health risk behaviours and educational attainment. Current research in this area often

14   considers single risk behaviours or small 'clusters' of risks, but none to our knowledge

15   consider a large number of heterogeneous risks simultaneously. Owing to the scale and

16   richness of the ALSPAC data, we have been able to control for a wide range of confounders,

17   including socio-economic measures, previous educational attainment, and IQ.

18   However, there are several limitations to our analysis. Firstly, the risk behaviours were all

19   reduced to binary variables in order to construct the total MRB score, which leads to a loss of

20   information. While each of the individual behaviours showed a negative association with

21   educational attainment, these associations would perhaps be more robust if examined using a

22   different classification of risk behaviour (e.g. hazardous alcohol use and physical inactivity).

23   However, we think it unlikely to have an impact on the relationship between number of MRB

24   and educational attainment. Secondly, by summing the risk behaviours to create a measure of

25   total MRBs, we attribute equal weight to each behaviour, however, we have found no strong

1   evidence for an alternative classification of MRB in terms of clusters of specific MRBs or

2   latent classes. Thirdly, there is considerable missing data on confounders and MRB which

3   reduces power and may introduce bias. Whilst our outcome variables, obtained through

4   linkage, were observed for the majority of the participants, we opted to restrict our analyses

5   (and our imputation) to the 5,401 providing information on at least one risk behaviour. This

6   subsample of ALSPAC were more likely to be female and to have higher IQ; and less likely

7   to be from the lowest income quintile; to be living in privately or subsidised rental property;

8   to have ever claimed eligibility for free school meals; and have lower parental social class

9   (p<0.001). The sample used is clearly not a random sample of those who enrolled, however

10   for bias to be present in our multivariable models would require the dependent variable

11   (educational attainment) to be conditionally related to whether participants are included or

12   excluded from this analysis. The pattern of positive associations observed between various

13   factors and selection might lead us to anticipate collider bias in the form of attenuated

14   estimates for MRB and educational attainment. However, by conditioning on gender, IQ,

15   income, free school meal eligibility, parental social class as well as multiple risk behaviour in

16   the regression models, we propose that any residual association between educational

17   attainment and selection should be minimal and hence so should any (attenuating) bias.

18   Fourth, some of the MRB were assessed using questionnaires, which have potential for recall

19   bias and social desirability bias. Finally, we may not have controlled for all relevant

20   confounders, for example, lone parent status and child maltreatment which are both

21   associated with poorer educational outcomes were not included in the analysis. We have

22   included multiple alternative confounders (parental social class, maternal education, housing

23   tenure and claiming eligibility for free school meals), that are all themselves strongly

24   associated with lone parent status and childhood maltreatment, however their omission may

25   still be understood as a significant limitation of the study.

1   The findings from this research build on and are consistent with other studies which have

2   shown positive associations between single risk behaviours or small numbers of similar risks

3   and poorer educational attainment. [3,4,16-22,40-42] They also echo findings from a US study

4   which found strong evidence of associations between higher educational attainment and

5   membership to the most-healthy cluster of adolescents (although that study did not show the

6   same dose-response relationship that we have found). [15]

7   Establishing the direction of the association between MRB and educational attainment would

8   provide a valuable focus for future work in this area. Analysis of repeated measures of MRB

9   at different time points throughout childhood and adolescence, would allow the exploration

10 of any differences in the association between MRB and educational outcomes according to

11 timing of MRB. Further research is also required to identify the early-life antecedents that are

12 associated with adolescent MRB, as this would facilitate effective early intervention of those

13 with the highest risk of engaging in harmful MRB.

14 **Conclusions**

15 Our findings demonstrate for the first time that multiple health risk behaviours act as an

16 important predictor of adverse educational outcomes, over and above a wide range of

17 confounders including IQ at age 8 years and previous educational attainment. This finding

18 could aid the identification and targeting of young people at risk of under-achieving during

19 their compulsory education. Further, by showing a dose-response relationship between the

20 two, we have shown the importance of intervening in and reducing each and every risk

21 behaviour. Preventing multiple risk behaviours during adolescence could improve

22 educational attainment and thereby directly and indirectly improve longer term health

23 outcomes.

24 **Contributorship Statement**

1 CW, RK, MH, RC and JH conceived and designed the study. CW and JH carried out the

2 study, including acquiring and analysing the data. CW and JH interpreted the data. CW

3 drafted the manuscript. RK, MH, RC and JH critiqued the manuscript for important

4 intellectual content. All authors have read and approved the final version of the manuscript.

5 CW serves as guarantor. MH and RC are senior investigators for the National Institute for

6 Health Research. CW and JH had full access to all of the data and can take responsibility for

7 the integrity of the data and the accuracy of the data analysis. CW, RK, MH, RC and JH had

8 access to the statistical outputs, reports, and tables. All researchers are independent of the

9 funding bodies.

10 **Data sharing statement**

11 The ALSPAC policy on data sharing is available at www.bristol.ac.uk/alspac. To discuss

12 access to ALSPAC data, please contact the ALSPAC executive team on alspac-

13 exec@bristol.ac.uk.

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Table 1: Multiple risk behaviours (MRB) and their derivation

Health risk behaviour	Definition / how derived
Physical inactivity	Young person (YP) has typically over the past year exercised <5 times per week.
TV viewing	YP spent 3 or more hours watching television on average per day across the week.
Car passenger risk	YP had been in a car passenger at least once in their lifetime where the driver (a) had consumed alcohol or (b) did not have a valid licence, or (c) the YP chose not to wear a seat belt last time travelled in a car, van, or taxi.
Cycle helmet use	If the YP reported that they had last ridden a bicycle within the previous four weeks and they had not worn a helmet on the most recent occasion.
Scooter risk	YP has driven a motorbike/ scooter off road, or without a licence on a public road at least once.
Criminal/Antisocial behaviour	YP reported that at least once in the past year they had undertaken at least one of the following 7 offences: carried a weapon; physically hurt someone on purpose; stolen something; sold illicit substances to another person; damaged property belonging to someone else either by using graffiti, setting fire to it or destroying or damaging it in another fashion; subjected someone to verbal or physical racial abuse; or been rude/rowdy in a public place.
Hazardous alcohol consumption	In the past year had scored eight or more on the Alcohol Use Disorders Identification Test (AUDIT) indicating hazardous alcohol consumption.
Regular tobacco smoking	Has ever smoked and is regularly smoking by currently smoking at least one cigarette per week.

Cannabis use	Those who reported using cannabis "sometimes but less often than once a week" or more regular use were classified as occasional users.
Illicit drug/solvent use	In the year since their 15th birthday, YP had either been a regular user (i.e. used five or more times) of one or more illicit drugs (excluding cannabis) including amphetamines, ecstasy, LSD, cocaine, ketamine or inhalants including aerosols, gas, solvents and poppers.
Self-harm	Young people who said they had purposely hurt themselves in some way in their lifetime.
Penetrative sex before age 16	YP reported having had penetrative sex in the preceding year and that they were under 16 at the time.
Unprotected sex	Penetrative sex without the use of contraception on the last occasion they had had sex in the past year

Sources of information:

Age 15 years clinic: criminal and antisocial behaviour, penetrative sex prior to age 16, and unprotected sex.

Age 16 years questionnaire: physical inactivity, TV viewing, car passenger risk, cycle helmet use, scooter risk, hazardous alcohol drinking, regular smoking, illicit drug/solvent use, and self-harm.

Table 2: Sample descriptive statistics

		Imputation sample	Complete case sample
		5,401	**1,617**
		% (SE)	**n (%)**
Educational Outcomes	n=5,401		
Capped GCSE score: Mean (SE)		350 (1·01)	376 (1·31)
Five or more A*-C grades at GCSE		74·4% (SE=0·6)	1420 (87·8%)
Four or less A*-C grades at GCSE		25·6% (SE=0·6)	197 (12·2%)
Exposure	n=2,264		
MRB total: Mean (SE)		3.24 (0·31)	3.01 (0·05)
Sex	n=5,401		
Female		55·5% (SE=0·7)	975 (60·3%)
Male		44·5% (SE=0·7)	642 (39·7%
Season of birth	n=5,401		
Autumn		33·9% (SE=0·6)	542 (33·5%)
Winter		14·8% (SE=0·5)	222 (13·7%)
Spring		23·4% (SE=0·6)	382 (23·6%)
Summer		27·9% (SE=0·6)	471 (29·1%)
Maternal education	n=5,214		
Degree		14·9% (SE=0·5)	311 (19·2%)
A level		25·9% (SE=0·6)	479 (29·6%)
O level		34·3% (SE=0·7)	596 (36·9%)
< O level		21·5% (SE=0·6)	231 (14·3%)
Parental socio-economic position	n=4,970		
Professional		14·1% (SE=0·5)	291 (18·0%)
Managerial and technical		41·2% (SE=0·7)	761 (47·1%)

Skilled non-man		23·6% (SE=0·6)	398 (24·6%)
Skilled man, part or unskilled		13·2% (SE=0·5)	167 (10·3%)
Housing tenure	n=5,227		
Mortgage/owned		84·7% (SE=0·5)	1.444 (89·3%)
Private rent		7·3% (SE=0·4)	88 (5·4%)
Subsidised rent		8·6% (SE=0·4)	85 (5·3%)
Income	n=4,809		
High		20.86% (SE=0·6)	364 (22·5%)
Mid high		21.96% (SE=0·6)	424 (26·2%)
Middle		21.34% (SE=0·6)	364 (22·5%)
Mid low		19.25% (SE=0·6)	292 (18·1%)
Low		16.58% (SE=0·5)	173 (10·7%)
Free School Meals (FSM)	n=5,401		
Ever FSM		7·7% (SE=0·4)	65 (4·0%)
Never FSM		92·3% (SE=0·4)	1,552 (96·0%)
Special Educational Needs (SEN)	n=5,075		
No SEN		84·7% (SE=0·4)	1,522 (94·1%)
School Action		6·0% (SE=0·4)	68 (4·2%)
School Action Plus		1·9% (SE=0·2)	18 (1·1%)
Statement of SEN		1·4% (SE=0·2)	9 (0·6%)
Previous educational attainment/ability			
IQ at age 8: Mean (SE)	n=4,370	105 (0·24)	109 (0·37)
KS2 educational attainment: Mean (SE)	n=4,753	830 (2·76)	901 (3·94)

Table 3: Associations between total MRB score and capped GCSE score and odds of gaining five or more GCSEs at grade A*-C

	Unadjusted (n=5,401)	Model 1 (n=5,401)	Model 2 (n=5,401)	Model 3 (n=5,401)
Capped GCSE	-9·17 (-10·25, -8·10)	-9·12 (-10·19, -8·05)	-6·90 (-7·86, -5·94)	-6·31 (-7·03, -5·58)
	$p<0·001$	$p<0·001$	$p<0·001$	$p<0·001$
5 A*-C	0·82 (0·79-0·85)	0·82 (0·79-0·85)	0·84 (0·81-0·87)	0·77 (0·74-0·81)
	$p<0·001$	$p<0·001$	$p<0·001$	$p<0·001$

Model 1: adjusted for sex and season of birth

Model 2: adjusted for sex, season of birth, maternal education, parental social class, household income, housing tenure, and FSM.

Model 3: adjusted for sex, season of birth, maternal education, parental social class, household income, housing tenure, FSM, IQ, and previous educational attainment.

Figure 1: Deriving the sample