

# Clustering of adverse health and educational outcomes in adolescence following early childhood disadvantage: population-based retrospective UK cohort study



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## Summary

**Background** Disadvantage in early childhood (ages 0–5 years) is associated with worse health and educational outcomes in adolescence. Evidence on the clustering of these adverse outcomes by household income is scarce in the generation of adolescents born since the turn of the millennium. We aimed to describe the association between household income in early childhood and physical health, psychological distress, smoking behaviour, obesity, and educational outcomes at age 17 years, including the patterning and clustering of these five outcomes by income quintiles.

**Methods** In this population-based, retrospective cohort study, we used data from the Millennium Cohort Study in which individuals born in the UK between Sept 1, 2000, and Jan 1, 2002, were followed up. We collected data on five adverse health and social outcomes in adolescents aged 17 years known to limit life chances: psychological distress, self-assessed ill health, smoking, obesity, and poor educational achievement. We compared how single and multiple outcomes were distributed across early childhood quintile groups of income, as an indicator of disadvantage, and modelled the potential effect of three income-shifting scenarios in early childhood for reducing adverse outcomes in adolescence.

**Findings** We included 15 245 adolescents aged 17 years, 7788 (51·1%) of whom were male and 7457 (48·9%) of whom were female. Adolescents in the lowest income quintile group in childhood were 12·7 (95% CI 6·4–25·1) times more likely than those in the highest quintile group to have four or five adverse adolescent outcomes, with poor educational achievement (risk ratio [RR] 4·6, 95% CI 4·2–5·0) and smoking (3·6, 3·0–4·2), showing the largest single risk ratios. Shifting up to the second lowest, middle, and highest income groups would reduce multiple adolescent adversities by 4·9% (95% CI –23·8 to 33·6), 32·3% (–2·7 to 67·3), and 83·9% (47·2 to 120·7), respectively. Adjusting for parental education and single parent status moderately attenuated these estimates.

**Interpretation** Early childhood disadvantage is more strongly correlated with multiple adolescent adversities than any of the five single adverse outcomes. However, shifting children from the lowest income quintile group to the next lowest group is ineffective. Tackling multiple adolescent adversities requires managing early childhood disadvantage across the social gradient, with income redistribution as a central element of coordinated cross-sectoral action.

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## Introduction

Child poverty in the UK is returning to the mid-1990s rate (33%), with almost a third (31%, or 4·3 million) of children living below the poverty line in 2019–20 after considering housing costs.<sup>1</sup> Children in lone parent families and from Black and other minority ethnic groups are particularly likely to live in poverty.<sup>2</sup> The COVID-19 pandemic and cost of living crisis could be amplifying these trends.<sup>3,4</sup> In the absence of effective policy intervention, rates of child poverty in the UK will rise, damaging the education, physical and mental health, and life chances of individuals exposed to early material deprivation.

Socioeconomic gradients in health and development start in early childhood (ages 0–5 years).<sup>5–7</sup> Long-term associations between lower household income in childhood and worse performance on educational

outcomes, health outcomes, and health behaviours have been observed in some cohorts in the UK and other high-income countries.<sup>8,9</sup> These adolescent outcomes drive adult outcomes, such as employment status, income and wealth, life satisfaction, and lifetime physical and mental illness.<sup>10–16</sup> The problem of socioeconomic inequalities is recognised at the government level, and the government's response is encapsulated in the political slogan “levelling up”, which refers broadly to reducing inequalities in life chances and health.<sup>17</sup>

Literature on the effects of poverty in early childhood has separately examined single adverse outcomes in adolescence,<sup>18–29</sup> and some studies have highlighted the need for examining clusters of outcomes.<sup>30</sup> Studies of inequality in individuals born after 2000 (Generation Z) are sparse. Due to the current economic and welfare policy, it is important to understand the lives of adolescents

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### Research in context

#### Evidence before this study

We searched Ovid MEDLINE, with no language restrictions, for articles (focusing on longitudinal studies) published between Jan 1, 1946, and March 9, 2022, with the search terms “longitudinal studies” or “cohort studies”, and “poverty”, “socioeconomic factors”, “social class”, “income” and “infant” or “child” or “preschool” and “adolescent”, “teen”, “youth” or “juvenile” (appendix pp 26–29). We included longitudinal studies that related to psychological distress, self-rated health, obesity, cigarette smoking, and academic achievement (the five focus outcomes in this study), included outcomes measured in adolescence (age 10–19 years) as defined by WHO, and measured socioeconomic conditions in early childhood. The longitudinal studies were generally of a high quality, using large samples. Studies consistently showed that lower socioeconomic status in early childhood was associated with each of these five adverse outcomes. None of the studies analysed clustering of multiple adverse outcomes or compared the potential health and educational gains from different strategies that reduce income inequalities in early childhood.

#### Added value of this study

Our analysis of longitudinal data representing the UK shows that multiple adversities in adolescence, involving the clustering of several adverse health and educational outcomes,

is much more strongly associated with socioeconomic disadvantage in early childhood than any single adverse outcome. This study also provides new estimates of the potential effects on single and multiple adolescent adversity of different early childhood income-shifting scenarios, which show that moving children from the lowest income quintile to the next lowest income quintile would have much smaller effects than anticipated. To our knowledge, this is the first longitudinal study to examine the clustering of adverse health and educational outcomes in adolescence as a later correlate of early childhood socioeconomic disadvantage, and the first to estimate the potential health and educational gains from reducing socioeconomic disadvantage in the poorest families.

#### Implications of all the available evidence

Disadvantaged socioeconomic status in early life is strongly associated with several adverse health and educational outcomes in adolescence. This association is remarkably strong for multiple (combined) adolescent adversity involving outcomes across domains (health, health behaviour, educational achievement). Achieving substantial reductions in adverse health and educational outcomes in adolescence requires an ambitious whole system programme of early childhood inequality reduction that does not merely shift children from the lowest income quintile group to the next lowest group.

aged 16–18 years and to consider the implications for population health and policy in coming decades.

We used data from the Millennium Cohort Study, the most recent nationally representative longitudinal study of adolescents aged 16–18 years available in the UK. We studied key adolescent health and educational outcomes separately and examined how these outcomes cluster according to childhood household income, which we treated as a general indicator of socioeconomic disadvantage in early childhood. We calculated counterfactual outcome prevalence on the basis of observed distributions according to three hypothetical early childhood income-shifting scenarios. We aimed to describe the association between household income in early childhood and physical health, psychological distress, smoking behaviour, obesity, and educational outcomes at age 17 years, including the patterning and clustering of these five outcomes by income quintile. We also aimed to examine the maximum potential benefits of alternative strategies for reducing socioeconomic disadvantage in early childhood in terms of reducing the population burden of adverse adolescent outcomes.

## Methods

### Study design and participants

We did a population-based, retrospective cohort study using data from the Millennium Cohort Study that followed-up individuals born in the UK between Sept 1, 2000, and Jan 11, 2002. A detailed description of

the Millennium Cohort Study, including the sampling frame and strategy, and inclusion criteria, is provided elsewhere.<sup>31</sup> Ethics approval was obtained for each of the survey sweeps through the National Health Service Research Ethics Committee system. Parents of participants up to age 14 years provided written informed consent and participants aged at least 16 years provided verbal informed consent.

### Procedures

Between 2001 and 2006, household income in early childhood (ages 0–5 years; after tax and other deductions but before housing costs) was reported by the main parent or caregiver at ages 9 months, 3 years, and 5 years, collected by a home interviewer. Banded responses were used to impute continuous income, which was equalised to consider household size and composition using modified scales by the Organisation for Economic Co-operation and Development.<sup>32</sup> Household income was averaged across these first three waves (ie, ages 9 months, 3 years, and 5 years) of the Millennium Cohort Study and transformed into income quintiles for this study.

In 2018, adverse health and social outcomes in adolescence were collected at age 17 years, based on five measures that we constructed by dichotomising responses to questions. The first measure was psychological distress, which was self-reported by the participants using the six-item Kessler scale. We used the clinically determined

threshold ( $\geq 13$ ) as indicating the presence of psychological distress.<sup>33</sup> The second measure was self-rated health, which was assessed by asking “How would you describe your health generally?”. We classified responses of excellent, very good, and good as being in good health, and responses of fair and poor as being in poor health. The third measure was obesity. This factor was based on the adolescents’ weight and height, taken by the interviewer at the participant’s home, and classified using the obesity threshold from the British 1990 (UK90) growth reference chart for children.<sup>34</sup> The fourth measure was regular cigarette smoking (excluding e-cigarettes), which was self-reported smoking of more than six cigarettes per week. The fifth measure was poor academic achievement based on self-reported exam results at the end of secondary school—ie, General Certificate of Secondary Education (GCSE) results in England, Wales, and Northern Ireland, and National 4 and National 5 (N5) results in Scotland. Poor academic attainment was classified as not achieving five or more GCSEs, including in maths and English, graded C or above, or five or more N5s, including in maths and English, graded D or above.

To examine the clustering of multiple outcomes, we computed an index of multiple adverse adolescent outcomes by counting how many negative outcomes were present for each participant. We created a categorical variable that grouped together participants with four and five adverse outcomes, as very few participants had five adverse outcomes (35 [0·2%] of 15 245, and therefore the measure used in the analyses had five levels: none, one, two, three and four or five adverse outcomes).

Biological sex (male or female) at birth and ethnicity of cohort members (which were used in this study as moderators), and highest educational level in the household and single parent status (which were used as control variables in additional analyses), were all ascertained from the main parent during the initial survey at 9 months.

### Statistical analyses

We cross-tabulated quintiles of childhood household income and our index of multiple adverse adolescent outcomes at age 17 years in the form of contingency tables showing the count in each cell alongside the row and column percentages. Our first aim was to compare the strength of association between early childhood income and adverse adolescent outcomes. To do this, we compared the proportions of respondents at each level of our index of adverse adolescent outcomes in the highest income quintile to the proportions in each of the other income quintiles. We used a modified Poisson regression approach<sup>35</sup> to obtain the 95% CIs around risk ratios. We also calculated estimates for each single outcome separately. For the index of multiple adversities, we stratified results by sex and ethnicity (with interactions testing for any difference), which we report in the appendix.

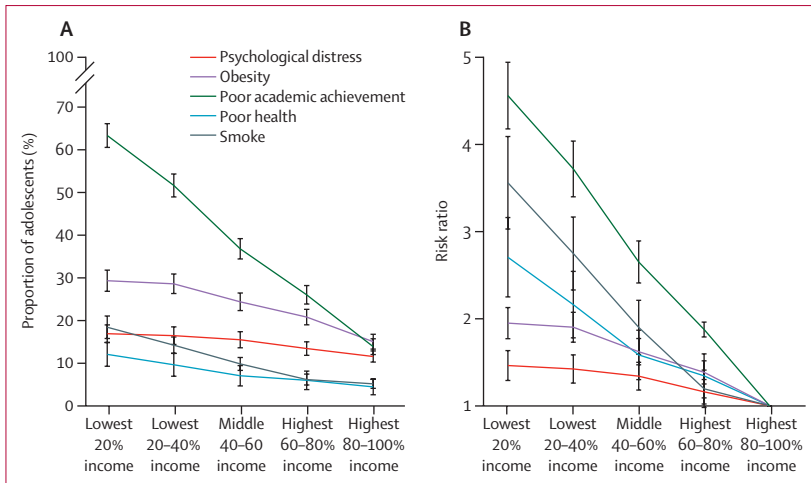
Our second aim was to do a simple calculation about the maximum potential reductions in adverse outcomes at age 17 years that could be achieved by reducing socioeconomic disadvantage in early childhood. We used a population attributable fraction approach<sup>36,37</sup> to calculate the effects of three hypothetical levelling-up scenarios on reducing adverse adolescent outcomes. In scenario one, we calculated reductions in adverse outcomes if adolescents in the lowest income quintile group moved to the next lowest income quintile. We labelled this scenario the absolute disadvantage elimination scenario. In scenario two, we shifted adolescents in the bottom two income quintile groups to the middle quintile group and labelled this the relative disadvantage elimination scenario. In scenario three, we moved the whole cohort to the same level of adverse adolescent outcomes as those in the highest income quintile group. We labelled this scenario the absolute inequality elimination scenario. Our scenario labels are convenient simplifications, based loosely on the concepts of absolute and relative poverty. In the UK, the relative poverty line is officially defined as 60% of median income.<sup>38</sup> Scenario two would therefore eliminate relative poverty at the current poverty line, although not necessarily at the new recalibrated poverty line.

In our main analyses, we did not include covariates when examining the association between childhood income and adverse adolescent outcomes. First, we did not want to over-adjust for mediating variables that might alter the association between early childhood disadvantage and adolescent outcomes, such as parental mental health, neighbourhood deprivation, and adverse childhood experiences. Research designs that over-adjust for these processes could completely miss or vastly underestimate any association, as highlighted in a controversial study.<sup>39–41</sup> Second, we wanted to use income as a proxy for general socioeconomic disadvantage in childhood rather than focus on income specifically and independently of intersecting markers of social disadvantage. However, to assess income more independently, we did additional analyses that adjusted for household education and single-parent status to address potential confounding by important drivers of household income.<sup>42,43</sup> Our adjusted income-shifting scenarios represent the maximum potential benefits of income redistribution alone, assuming no residual confounding bias, whereas our main scenarios represent the maximum potential benefits of broader strategies of cross-sectoral action to reduce general socioeconomic disadvantage by strengthening public services and tackling discrimination as well as redistributing income. We did not control for sex or ethnicity in our main analyses, but they were examined as potential moderators.

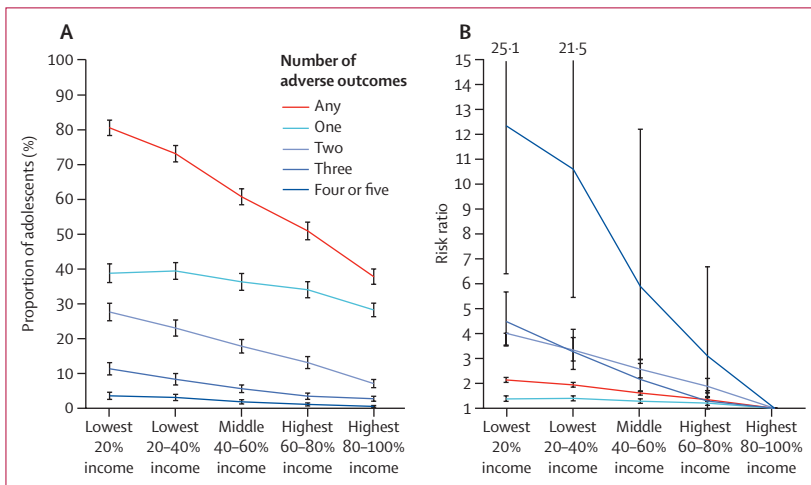
We used multiple imputation and inverse probability weighting to manage attrition over time, and implemented appropriate weighting methods to adjust for the complex initial sampling design (appendix p 1).

All analyses were done using STATA (version 17).

See Online for appendix



**Figure 1: Five adverse outcomes at age 17 years by early childhood income** (A) Absolute differences. Data based on percentage (95% CI) in each income quintile who have each of these adverse outcome (appendix pp 3–7). (B) Relative differences (risk ratio [95% CI], with the highest quintile as the reference category). Data based on regression results (appendix p 10).



**Figure 2: Number of adverse outcomes at age 17 by early childhood income** (A) Absolute differences. Data based on percentage (95% CI) in each income quintile who have each of these number of adverse outcomes (appendix p 8). (B) Relative differences (risk ratio [95% CI], with the highest quintile as the reference category). Data based on regression results (p 10).

**Role of the funding source**

The funders of the study had no role in study design, data collection, data analysis, data interpretation, or writing of the report.

**Results**

Of 15 245 adolescents aged 17 years, 7788 (51.1%) were male and 7457 (48.9%) were female (appendix p 2). Adolescents from households in the lowest income quintile had an average weekly equivalised household income of £117 in childhood compared with those from the highest quintile with an average weekly household income of £664. Overall, of the 15245 adolescents, 2236 (14.7%) had psychological distress, 1166 (7.6%) self-

reported poor health, 1585 (10.4%) were regular smokers, 3549 (23.3%) were obese, and 5636 (37.0%) achieved poor academic outcomes. When clustering adverse adolescent outcomes, 6214 adolescents (40.8%) had none, 5317 (34.9%) had one, 2578 (16.9%) had two, 881 (5.8%) had three, and 255 (1.7%) had four or more, which translated to 12 124 (95% CI 10 148–14 496) adolescents per year in the total UK population (appendix p 25).

Poor academic achievement in the lowest-income quintile was the most prevalent adverse outcome of the quintiles (63.6%, 95% CI 60.8–66.3; figure 1). The relative differences between the lowest and highest quintiles for household income were largest for poor academic achievement (risk ratio [RR] 4.6, 95% CI 4.2–5.0) and smoking (3.6, 3.0–4.2), and smallest for psychological distress (1.5, 1.3–1.7). Formal testing of differences between all quintiles of income and cross-tabulations of quintiles of childhood household income against single and multiple adverse outcomes in adolescence are in the appendix (pp 3–8, 10).

Clustering of adverse outcomes is shown in figure 2. Inequalities based on household income in childhood were larger the more adverse outcomes adolescents had. Relative inequality between the quintiles of lowest and highest household income was modest for one adverse outcome (RR 1.4, 95% CI 1.3–1.5), increasing in magnitude for two (4.0, 3.5–4.6) and three outcomes (4.5, 3.5–5.7), and highest for four or five adverse outcomes (12.7, 6.4–25.1). Comparisons of RRs between the quintile of highest childhood household income and all other household income quintiles are reported in the appendix (appendix p 10). In additional analyses, there was little difference in the pattern of inequality in adverse adolescent outcomes by childhood household income when stratifying by sex (appendix pp 17–19). Inequalities were slightly higher (borderline significant interaction) for White adolescents than for adolescents from other ethnic groups—ie, having three or more adverse outcomes (appendix pp 20–22). We also did sensitivity analyses excluding participants from Scotland because Scotland measures school graduation results differently to other UK countries; however, the results were almost identical to those including all four UK countries (appendix pp 23–24).

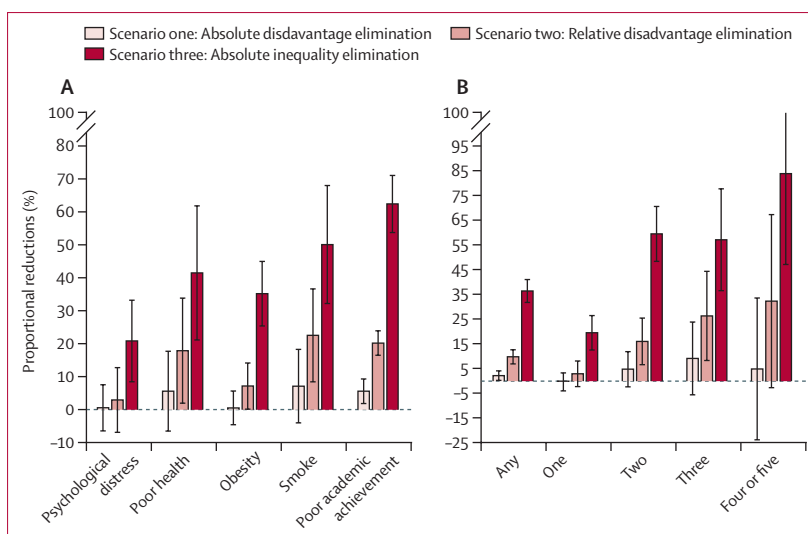
The results of modelling the three income-shifting scenarios are presented in figure 3 (see appendix pp 3–8 for data on which results are based). In the absolute disadvantage elimination scenario, total psychological distress would reduce by 0.6% (95% CI –0.4 to 0.5), self-reported poor health by 5.6% (–6.5 to 0.5), obesity by 0.5% (–4.6 to 5.6), regular smoking by 7.1% (–4.0 to 18.3), and poor academic achievement by 5.6% (1.9 to 9.3). In the relative disadvantage elimination scenario, total psychological distress would reduce by 2.9% (–6.9 to 12.7), self-reported poor health by 17.9% (2.0 to 33.8), obesity by 7.1% (0.2 to 14.1), regular smoking by 22.5% (8.4 to 36.6), and poor academic

achievement by 20.2% (16.5 to 23.9). In the absolute inequality elimination scenario, total psychological distress would reduce by 20.8% (8.5 to 33.2), self-reported poor health by 41.4% (21.1 to 61.8), obesity by 35.1% (25.4 to 44.9), regular smoking by 50.0% (32.2 to 67.9), and poor academic achievement by 62.3% (53.7 to 71.0).

In terms of multiple adverse outcomes, in the absolute disadvantage elimination scenario, the proportion of adolescents with only one adverse outcome would increase by 0.3% (95% CI -4.0 to 3.3), as some individuals who would go on to have more than one adverse outcome have only one adverse outcome at present. The proportion of adolescents with two adverse outcomes would reduce by 4.8% (-2.3 to 11.9), with three adverse outcomes by 9.2% (-5.6 to 23.9), and with four or five adverse outcomes by 4.9% (-23.8 to 33.6). In the relative disadvantage elimination scenario, the proportion of adolescents with only one adverse outcome would reduce by 3.0% (-2.2 to 8.1), with two adverse outcomes by 16.1% (6.6 to 25.5), with three adverse outcomes by 26.4% (8.3 to 44.4), and with four or five adverse outcomes by 32.3% (-2.7 to 67.3). In the absolute inequality elimination scenario, the proportion of adolescents with one adverse outcome would reduce by 19.5% (12.6 to 26.5), with two adverse outcomes by 59.5% (48.4 to 70.6), with three adverse outcomes by 57.2% (36.6 to 77.8), and with four or five adverse outcomes by 83.9% (47.2 to 120.7).

The estimates of reduction for the absolute number of individuals in the Millennium Cohort Study sample and at national level for each of the scenarios are in the appendix (pp 25). The simulated total annual reductions in the number of individuals in the UK with four or five adverse outcomes at age 17 years are 597 per year (95% CI -2879 to 4074) in the absolute disadvantage elimination scenario, 3920 per year (-323 to 8164) in the relative disadvantage elimination scenario, and 10 174 per year (5718 to 14631) in the absolute inequality elimination scenario.

Additional analyses included household education and single-parent status as control variables in the models for individual and multiple outcomes, and income-shifting scenarios (appendix pp 11–14, 16). Adjustment for single-parent status did not reduce the effect of household income on adverse outcomes, except for smoking (appendix p 15). Adjustment for parental education attenuated the income coefficient by 9% for poor health, by 32% for obesity, by 27% for smoking, by 31% for poor academic achievement, but for psychological distress the coefficient increased by 16%. The corresponding models adjusted for single parenthood and education for the three scenarios generated marginally smaller estimates of health gain (appendix p 16). Four or five adolescent adversities were reduced in three (1.2%) of 255 adolescents in the absolute disadvantage elimination scenario, 62 (24.3%) of 255 in the relative disadvantage



**Figure 3: Proportional reduction in adverse outcomes from three hypothetical levelling-up scenarios** (A) Individual adverse outcomes. (B) Multiple adverse outcomes. Data are proportional reduction in outcome (95% CI). Scenario one (ie, absolute disadvantage elimination) is the shifting of children from the lowest income quintile to the next lowest income quintile. Scenario two (ie, relative disadvantage elimination) is the shifting of children from the bottom two income quintiles to the middle income quintile. Scenario three (ie, absolute inequality elimination) is the shifting all children to the highest income quintile.

elimination scenario, and 200 (78.6%) of 255 in the absolute inequality elimination scenario. By comparison, with unadjusted estimates, four or five adolescent adversities were reduced in 13 (4.9%) of 255 adolescents in the absolute disadvantage elimination scenario, 82 (32.3%) of 255 in the relative disadvantage elimination scenario, and 214 (83.9%) of 255 in the absolute inequality elimination (appendix p 25).

## Discussion

In this retrospective cohort study, adolescents aged 17 years in the quintile group of lowest household income in early childhood were almost 13 times more likely than those in the quintile group of highest household income to have multiple adolescent adversities involving four or more adverse adolescent outcomes. Only a small proportion (1.7%) of adolescents had four or more adverse adolescent outcomes, translating to about 12 124 additional adolescents leaving school with extremely poor life chances per year in the UK population, which represents a substantial and cumulative long-term burden to society due to financial and human costs in term of risk of lifelong adversity on a wide range of outcomes.

Eliminating socioeconomic inequality in early childhood could reduce this burden of multiple adversity by a maximum of about 80% and shifting the bottom two quintile groups to the middle could reduce the burden by a maximum of about 30% (figure 3). However, merely shifting the children from the lowest-income quintile group to the next lowest-income quintile group would only yield a maximum 5% reduction in multiple adolescent adversity.



Previous longitudinal studies have consistently shown that a range of adverse child and adolescent outcomes are patterned according to early childhood household income, with those growing up in families with a low household income being more likely to have negative outcomes, such as poor mental health, poor physical health, smoking, obesity, and poor academic achievement than those from higher-income households.<sup>18–29</sup> The examination of each of our five single adverse outcomes support these previous findings.

We add to existing studies by showing that disadvantage in early childhood is more strongly associated with having multiple adversities in adolescence than with any single adverse outcome. We also contribute by providing estimates of the maximum potential gains of alternative early childhood income-shifting scenarios by reducing the prevalence of health and educational adversity in adolescence. Previous studies with a similar approach have mostly used a single scenario in which income-shifting involves moving of individuals to the most advantaged position,<sup>44,45</sup> similar to scenario three. This study goes further by examining more realistic scenarios.

A strength of this study is its use of the Millennium Cohort Study, a representative population-based longitudinal survey of individuals born in 2000. The richness of the dataset allowed us to explore a range of different outcomes in adolescence and the clustering of these outcomes in relation to childhood household income. By contrast, most previous studies on health inequalities focus on single outcomes and often rely on cross-sectional rather than longitudinal data.

Our study has several important limitations. Except for obesity, we relied on self-reported measures for adverse outcomes. Although we do not believe that any biases in self-reported values would be patterned by childhood household income, it was not possible to verify this assumption and it could have affected our findings. We treated childhood household income as a single key indicator of general childhood social disadvantage and interpreted our findings as associations between childhood disadvantage and adverse adolescent outcomes. We did not identify causal effects of changes in childhood household income, which were likely to be smaller than the associations we estimated due to family-level confounding factors (eg, parental personality traits, heritable risk factors) that cause both childhood income and adolescent adversity. Hence our hypothetical and uncosted policy scenario estimates should be regarded as upper bounds, designed to gauge the maximum possible reductions that could be achieved. Further analyses in which we controlled for parental education and single-parent status show some attenuation of estimates, minor with regard to single parenthood, and moderate with regard to parental education. Associations between early childhood income and multiple adolescent adversity were large and the pattern in our income-shifting scenarios also remained. Another limitation of the study

is that we only measured the degree of clustering on the basis of the number of adversities but did not measure the effect of clustering on health, wellbeing, and public cost in adulthood. These effects are an important area for future research.

Mechanisms and mediating pathways that link childhood household income and adverse outcomes are beyond the scope of the analysis. A substantial part of the association between socioeconomic conditions and adverse adolescent outcomes (about a fifth according to one study<sup>18</sup>) appears to be mediated by adverse childhood experiences, which include domestic violence and abuse, poor parental mental health, divorce, and parental alcohol and substance use.<sup>18,26,27</sup> Clustering of multiple adverse outcomes in adolescents facing early-life poverty and disadvantage in this cohort is consistent with pathways affected by one or more adverse childhood experiences.

Our findings suggest that public health research should look more closely at clustering of health risk factors, just as the study of multimorbidity has transformed aspects of clinical research. Social disadvantage, indexed by low household income, in early childhood is related to clustering of multiple adverse adolescent outcomes. Our modelling shows that reduction of absolute poverty might be a necessary component of levelling-up, but it is not sufficient to reduce the poor health and educational attainment associated with early disadvantage that extends beyond the lowest quintile group of household income. Our main policy scenarios are intended to be understood as reductions in overall disadvantage in early childhood, achieved not exclusively via redistribution of income but also via provision of in-kind educational and childcare services, reduction of social discrimination and stigma, and other cross-sectoral actions. However, the estimated effects are moderately attenuated by adjusting for parental education and single parent status, suggesting household material resources and social factors are important targets for broad cross-sectoral policy action to be effective.

The association between income and multiple adversities was less pronounced in minority ethnic groups. Systemic racism could be an additional barrier for some young people. An effective levelling-up agenda will recognise the complexities of childhood and multiple interacting and intersecting factors that determine the health trajectories of children growing up in disadvantaged areas. We provide evidence in support of whole system approaches to tackling multiple childhood inequalities, such as that described in the Royal College of Paediatric and Child Health's inequality programme.<sup>46</sup> Coordinated multi-agency working across health, education, and other public services has been elusive, but might be necessary to address the complex problems of children growing up in disadvantaged communities. Data-driven place-based approaches could help to target vulnerabilities in this context.<sup>47</sup>

### Contributors

AV curated data, accessed and verified the underlying data, did the formal analyses, interpreted data, and wrote the original draft. MA reviewed the literature, interpreted data, and wrote the original draft. IS searched and reviewed the literature, accessed and verified the underlying data, did the formal analysis, and wrote the original draft. EB and RC conceptualised the study. EB, GP, MM-W, and RC acquired funding, interpreted data, and reviewed and edited the manuscript. All authors had full access to the data and take full responsibility for the decision to submit for publication.

### Declaration of interests

We declare no competing interests.

### Data sharing

We used secondary data for our analyses. Data from all sweeps of the Millennium Cohort Study are freely available to bona fide researchers from the UK Data Service at [beta.ukdataservice.ac.uk/datacatalogue/series/series?id=2000031](https://beta.ukdataservice.ac.uk/datacatalogue/series/series?id=2000031). Prospective users are required to register with the UK Data Service and agree to the end user licence before downloading data. Code for the substantial analyses for this paper is available at <https://github.com/AaseVilladsen/Childhood-income-and-clustering-of-adverse-outcomes-in-adolescence>.

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