The effect of school summer holidays on inequalities in children and young people's mental health and cognitive ability in the UK using data from the millennium cohort study

Theocharis Kromydas1*, Mhairi Campbell1, Stephanie Chambers1,2, Michele Hilton Boon1, Anna Pearce1, Valerie Wells1 and Peter Craig1

Abstract

Background: Summer learning loss has been the subject of longstanding concern among researchers, the public and policy makers. The aim of the current research was to investigate inequality changes in children's mental health and cognitive ability across the summer holidays.

Methods: We conducted linear and logistic regression analysis of mental health (borderline-abnormal total difficulty and prosocial scores on the strengths and difficulties questionnaire (SDQ)) and verbal cognitive ability (reading, verbal reasoning or vocabulary) at ages 7, 11 and 14, comparing UK Millennium Cohort Study members who were interviewed before and after the school summer holidays. Inequalities were assessed by including interaction terms in the outcome models between a discrete binary variable with values representing time periods and maternal academic qualifications. Coefficients of the interaction terms were interpreted as changes from the pre- to post-holiday period in the extent of inequality in the outcome between participants whose mothers had high or low educational qualifications. Separate models were fitted for each age group and outcome. We used inverse probability weights to allow for differences in the characteristics of cohort members assessed before and after the summer holidays.

Results: Mental health (borderline/abnormal SDQ total and prosocial scores) at ages 7 and 14 worsened and verbal cognitive ability scores at age 7 were lower among those surveyed after the summer holidays. Mental health inequalities were larger after the holidays at age 7 (OR = 1.4; 95%CI (0.6, 3.2) and 14: (OR = 1.5; 95%CI (0.7, 3.2)), but changed little at age 11 (OR = 0.9; 95%CI (0.4, 2.6)). There were differences in pro-social behaviours among those surveyed before/after the school holidays at age 14 (OR = 1.2; 95%CI (0.5, 3.5)) but not at age 7 or 11. There was little change in inequalities in verbal cognitive ability scores over the school holidays [Age 7: b = −0.7; 95%CI (−4.3, 2.8); Age 11: b = −0.7; 95%CI (−4.3, 2.8); Age 14: b = −0.3; 95%CI (−1.0, 0.4)].

Conclusion: We found inequalities in mental health and cognitive ability according to maternal education, and some evidence or worsening mental health and mental health inequalities across school summer holidays. We found little evidence of widening inequalities in verbal cognitive ability. Widespread school closures during the COVID-19
6 months was widely cited by senior policy makers and could widen substantially if schools remained closed for the summer. Endowment Foundation [30] that inequalities to summer learning loss have been frequent. The finding from a rapid review of evidence by the Educational Endowment Foundation [30] that inequalities could widen substantially if schools remained closed for 6 months was widely cited by senior policy makers and politicians in the UK [31–33]. Against this backdrop of continuing debate about the effects of school closures on inequalities in attainment, and their contribution to managing the pandemic, we undertook the first analysis of UK-wide data on changes in socio-economic inequalities in children and young people’s cognitive ability and mental health over the school summer holidays.

**Introduction**

Socio-economic differences in summer learning loss have been the subject of widespread concern among researchers, the public and policy makers since a landmark US study [1] found that a large fraction of total inequality in educational attainment between children from more and less affluent backgrounds was attributable to differences that emerge over the school summer holidays. The existence and seriousness of the problem appeared to be confirmed by a systematic review published in 1996 [2], but recent research has suggested that the apparent widening of inequalities is an artefact of the way children’s ability is measured and analysed [3, 4]. Reanalyses of previously published data and analyses of other datasets indicate a much smaller effect or no effect of summer learning loss on socio-economic inequalities in attainment [5–7]. Since the review by Cooper et al. [2], analysis of socio-economic status and reading ability has not identified consistent evidence of inequalities between advantaged and disadvantaged students. While negative effects have been found for students with lower socio-economic status [8–16], other studies found negative effects for higher socio-economic students [17, 18]. Many recent studies report conflicting results, such as different effects for different school grades, datasets, measurement scaling, or analysis models used [5–7, 19–22], or no difference between socio-economic groups [21, 23–26].

Despite these recent findings, concerns persist over differential learning loss when schools are closed [27]. The National Summer Learning Association asserts on its website that the cumulative effect of summer learning loss is ‘a crisis in the making: by the fifth grade, summer learning loss can leave low-income students two-and-a-half to 3 years behind their peers.’ [28]. In the UK, concern over summer learning loss has been compounded by fears that many children experience ‘holiday hunger’ when schools close for the summer and stop providing free meals [29].

In the debates over whether and how long schools should be closed to help manage the pandemic, references to summer learning loss have been frequent. The finding from a rapid review of evidence by the Education Endowment Foundation [30] that inequalities could widen substantially if schools remained closed for 6 months was widely cited by senior policy makers and politicians in the UK [31–33]. Against this backdrop of continuing debate about the effects of school closures on inequalities in attainment, and their contribution to managing the pandemic, we undertook the first analysis of UK-wide data on changes in socio-economic inequalities in children and young people’s cognitive ability and mental health over the school summer holidays.

**Methods**

The UK Millennium Cohort Study is a nationally representative, longitudinal survey of children born in the UK from September 2000 to January 2002 [34]. The survey uses a stratified clustered sampling design to oversample children living in Wales, Scotland and Northern Ireland, disadvantaged areas and, in England, areas with high proportions of ethnic minority groups. We used data gathered when the cohort members were aged 7 (n =13,681), 11 (n =13,112) and 14 (n =11,564), with interviews spread over a year or more [34].

Since our aim is to investigate changes in mental health and verbal cognitive ability across the summer holidays, we restricted our analysis to cohort members surveyed in the 2 months (three in the case of Scotland) before and the 2 months after the summer holidays in each sweep (further detail is provided in the following section). Using the whole sample across the pre- and post-summer holiday months would have confounded the effects of the summer holiday with those of other holiday periods throughout the year, and with the effects of catch-up once cohort members return to school. In addition to the survey weights, we used stabilised inverse probability weighting to correct for the varying composition of the sample in the pre- and post-holiday months.

**School summer holidays**

We measure exposure to summer holidays using a binary variable that differentiates between cohort members surveyed in the months preceding the summer holidays (baseline) and the months after the summer holidays. We defined pre- and post-summer holiday groups differently across the four UK countries, to allow for differences in the timings of the start and finish of school summer holidays and to maximise power. We defined pre- and post-holiday months as June–July and September–October for England.
and Wales (where summer holidays tend to run from mid-July to early September), but as April–June and August–September in Scotland (where summer holidays run from late June to mid-August) and May–June and August–September for Northern Ireland (where summer holidays are throughout July and August). We included the extra month for Scotland because very few interviews are conducted in June (Table A1a).

Outcomes
Our outcomes of interest are verbal cognitive ability and mental health as represented by socio-emotional wellbeing. Verbal cognitive ability was measured using the British Ability Scale (BAS) word reading score at age 7; at age 11 we use the BAS verbal abilities scale and at age 14 we use a word activity score based on subsets of the words used in a vocabulary assessment in the 1970 British Cohort Study (BCS70) Age 16 Survey (the words used in the BCS70 assessment are derived from the standardised vocabulary tests devised by the Applied Psychology Unit at the University of Edinburgh in 1976). Although each sweep of the Millennium Cohort Study uses a different measure of verbal cognitive ability, all cohort members within each sweep are tested in the same way.

Socio-emotional wellbeing was assessed in the Millennium Cohort Study by the Strengths and Difficulties Questionnaire (SDQ), a 25-item measure completed by the main respondent (usually the mother). These 25 questions comprise 5 scales of children’s behaviour (conduct problems, hyperactivity, emotional problems, peer problems, and prosocial behaviours), containing 5 questions each. We use the total difficulties score, which is the sum of four scales (peer problems, conduct disorders, hyperactivity, and emotional problems) and applied a validated cut-off to distinguish ‘normal’ from ‘borderline-abnormal’ scores. We also analysed pro-social scores at ages 7, 11 and 14, again using a standard cut-off to distinguish normal from borderline-abnormal scores. We also analysed hyperactivity, emotional problems, and prosocial behaviours, containing 5 questions each. We use the total difficulties score, which is the sum of four scales (peer problems, conduct disorders, hyperactivity, and emotional problems) and applied a validated cut-off to distinguish ‘normal’ from ‘borderline-abnormal’ scores. We also analysed pro-social scores at ages 7, 11 and 14, again using a standard cut-off to distinguish normal from borderline-abnormal scores since prosocial behaviours could be affected by school closures due to possible reduced socialisation [35].

Socio-economic circumstances
Mother’s education is our primary measure of the cohort member’s socio-economic circumstances. We distinguish cohort members whose mothers had high (a university degree), moderate (A-levels, GCSE grades A-C, a diploma or equivalent) or low (GCSE grades D-G, equivalent or none) levels of qualifications. In sensitivity analyses, we examine differences by equivalized household income quintiles and by deciles of the Index of Multiple Deprivation, a neighbourhood deprivation measure.

Confounders
We adjusted for a range of characteristics to account for differences between cohort members surveyed before or after the school holidays. We include sex as a binary variable, child’s age in years and completed months, a measure of ethnicity based on six categories (White, Mixed, Indian, Pakistani/Bangladeshi, Black/Black British and Other (including Chinese), and a categorical variable for the four UK countries (England, Wales, Scotland, and Northern Ireland).

Analysis
First, we fitted separate regression models for each of the three Millennium Cohort Study sweeps with terms for mother’s education level and period (pre- or post-summer holiday). We included in these models all the variables that were fitted in the regressions used to derive our inverse probability weighting (i.e., gender, ethnicity, country), plus age expressed in years and completed months, to adjust for possible differences in sample composition between the two periods. We call these models 1a, 2a, 3a for Sweeps 4, 5 and 6 respectively. Next, we added an interaction term between mother’s education and period to identify whether inequalities in outcomes widened between the two periods examined. We call these models 1b, 2b and 3b.

For verbal cognitive ability scores the equation for 1b, 2b and 3b is the following:

\[
Sabh_i = a_0 + b_1M + b_2ME + b_3(M \times ME) + b_4G + b_5A + b_6E + b_7C + e_i
\]

where for a cohort member \( i \): \( a_0 \) shows the intercept, \( M \) is a binary variable where 0 represents the pre summer holidays period and 1 the post summer period, \( ME \) is a categorical variable representing mother’s education split into three levels as described above while \( M \times ME \) denotes the interaction between mother’s education and the binary variable on pre-and post-holiday periods. \( G \) is a binary variable for sex, \( A \) represents cohort members’ age in years and completed months, \( E \) and \( C \) are categorical variables for ethnicity and country respectively and \( e \) represents the error term. We use age-standardised scores but, in line with standard practice [36], we also adjust for cohort members’ age so that we can directly compare scores collected before and after the summer holidays. Scores are standardised using three-month age bands; including cohort member’s age in years and completed months as covariate controls for any variation within the bands. We used non-standardised ability scores in a sensitivity analysis.

For mental health, we followed a similar specification in terms of the exposure and other predictor variables, but since SDQ is represented by a binary variable we fitted a logistic regression model for each Millennium Cohort Study sweep:
where $Z_M = \exp(b_1Z) + \exp(b_2ME_i) + \exp(b_3(Z_M \ast Z_{ME}) + \exp(b_4Z_i) + \exp(b_5A_i + \exp(b_6E_i) + \exp(b_7C_i) + e_i)$

$$SDQ_i = a_o + \exp(b_1M_i) + \exp(b_2ME_i) + \exp(b_3(Z_M \ast Z_{ME}) + \exp(b_4Z_i) + \exp(b_5A_i + \exp(b_6E_i) + \exp(b_7C_i) + e_i) \quad (2)$$

We fitted models of the same form for SDQ prosocial scores (Additional file 1, Table A5c).

In all analyses we used survey weights to correct for the sample design in the current wave and non-response at the previous wave so that the results reflect the composition of the UK population at the relevant ages. We combined these with stabilised inverse probability weights to further account for differences by age, sex, country and socio-economic position in the composition of the samples in the pre- and post-holiday periods. Full details of the weighting strategy are provided in the Additional file 1. Separate weights were calculated for each outcome as the pattern of missingness and therefore the sample composition could differ between outcomes.

### Results

Table 1 shows the numbers of observations in the samples used in the regression analysis, broken down by period (pre- and post-summer holidays), UK country, survey Sweep and outcome variable. Further details of the weighting strategy and sample size broken down by calendar month are provided in the Additional file 1 Table A1a and b. Descriptive statistics for the outcome measures in the whole sample at each wave and a comparison of the covariate distributions in the unweighted and weighted samples are provided in Additional file 1 Table A2. Relevant flow charts were also drawn (Table A3a,b,c).

Our main findings in terms of odds ratios are presented in Table 2. Figure 1 depicts predictive margins using the margins command in Stata 17.0. Detailed results are presented in the Additional file 1, Table A5a, b, and c.

Table 2 presents the effect estimates for mother’s education (column 1) and the school summer holidays (column 2) on verbal cognitive ability and SDQ scores, adjusted for sex, ethnic and national differences in the composition of the pre- and post-holiday samples. The final column presents the coefficients of the interaction terms between school holidays and maternal education. The odds of borderline/abnormal total and prosocial SDQ scores were higher for cohort members with less educated mothers at each age. The odds of having a borderline/abnormal total difficulties score were higher among those surveyed after vs. before the school holidays at ages 7 and 14, but not at age 11. There were no substantial differences in pro-social behaviours among those surveyed before/after the school holidays. Verbal cognitive ability is lower for cohort members with less educated mothers at age 7, 11 and 14. At age 7, verbal cognitive ability scores were lower among those measured after the school holidays compared to those measured before. This was not the case at ages 11 or 14. Overall, the effects of maternal education on verbal cognitive ability and SDQ scores were lower among those measured after the school holidays compared to those measured before.

### Table 1

|                  | Word ability | SDQ | SDQ prosocial |
|------------------|--------------|-----|---------------|
|                  | Pre summer holidays | Post summer holidays | Total | Pre summer holidays | Post summer holidays | Total | Pre summer holidays | Post summer holidays | Total |
| **Sweep 4 (Age 7)** |               |     |               |       |                   |       |                   |       |                   |
| England          | 2084         | 410 | 2494          |       | 2017              | 390   | 2407              | 395   | 2435              |
| Wales            | 451          | 173 | 624           |       | 487               | 207   | 694               | 208   | 696               |
| Scotland         | 321          | 460 | 781           |       | 321               | 452   | 773               | 456   | 778               |
| N. Ireland       | 434          | 359 | 793           |       | 435               | 361   | 796               | 364   | 800               |
| Total            | 3290         | 1402| 4692          |       | 3260              | 1410  | 4670              | 1486  | 4709              |
| **Sweep 5 (Age 11)** |              |     |               |       |                   |       |                   |       |                   |
| England          | 1304         | 260 | 1564          |       | 1255              | 246   | 1501              | 249   | 1510              |
| Wales            | 448          | 110 | 558           |       | 443               | 108   | 551               | 108   | 553               |
| Scotland         | 229          | 381 | 610           |       | 233               | 380   | 613               | 380   | 613               |
| N. Ireland       | 198          | 408 | 606           |       | 199               | 408   | 607               | 410   | 609               |
| Total            | 2179         | 1159| 3338          |       | 2130              | 1142  | 3272              | 1147  | 3285              |
| **Sweep 6 (Age 14)** |              |     |               |       |                   |       |                   |       |                   |
| England          | 1531         | 640 | 2171          |       | 2101              | 642   | 2343              | 644   | 2346              |
| Wales            | 268          | 196 | 464           |       | 281               | 193   | 474               | 193   | 474               |
| Scotland         | 257          | 200 | 457           |       | 270               | 203   | 473               | 203   | 473               |
| N. Ireland       | 169          | 237 | 406           |       | 163               | 247   | 410               | 247   | 410               |
| Total            | 2225         | 1273| 3498          |       | 2415              | 1285  | 3700              | 1287  | 3703              |
scores are greater than the effects of school summer holidays.

Figure 1 presents the socio-economic gradient (according to mother’s academic qualifications, X-axis) in verbal cognitive ability scores and risks of poor socio-emotional wellbeing (Y-axis), stratified by those surveyed before (solid line) and after (dashed line) the summer holidays. As can be seen in Fig. 1 and Table 2 (Interaction column), the socio-economic gradient in total SDQ difficulties appeared to widen over the school holidays ages 7 [OR: 1.4; 95% CI(0.6, 3.2)] and 14 [1.5(0.7, 3.2)], but the confidence intervals from the interaction term were wide. Inequalities in prosocial difficulties appear to narrow at age 7 [0.4(0.1, 1.5)] and slightly widen at age 14 [1.2(0.5, 3.5)] but again with wide confidence intervals. The socio-economic gradient in verbal cognitive ability does not widen over the school holidays. The negative coefficients from the interaction terms in Table 2 indicate a slight narrowing of inequalities at ages 11 [b:-0.7; 95%CI(- 4.3, 2.8)] and 14 [-0.3 (-10.4, 0.4)], but the changes were very small and the confidence intervals wide. Sensitivity analyses using non age standardised ability scores, (Additional file 1, Table A4) and income and neighbourhood deprivation in place of mother’s education (Additional file 1, Tables A6–7) found similar results.

Table 2  Effects of mother’s education, pre/post school holidays) and their interaction on verbal cognitive ability and SDQ scores – (Ages 7, 11, 14)

|        | Effect estimates | Sample sizes |
|--------|------------------|--------------|
| Age    | Mother’s Education | School holidays | Interaction |
| SDQd   |                  |              |            |
| 7      | 5.2 (3.3, 8.1)    | 1.3 (1.0, 1.6) | 1.4 (0.6, 3.2) | 4670 |
| 11     | 2.5 (1.5, 3.9)    | 0.8 (0.6, 1.1) | 0.9 (0.4, 2.6) | 3372 |
| 14     | 3.5 (2.3, 5.2)    | 1.3 (1.0, 1.6) | 1.5 (0.7, 3.2) | 3700 |
| SDQ-prosociald |                  |              |            |
| 7      | 1.2 (0.7,2.2)     | 1.1 (0.7,1.6) | 0.4 (0.1, 1.5) | 4709 |
| 11     | 1.2 (0.8,4.2)     | 1.2 (0.7, 1.9) | 0.7 (0.1,3.1) | 3285 |
| 14     | 2.1 (1.3,3.6)     | 1.1 (0.8,1.5) | 1.2 (0.5, 3.5) | 3703 |
| Verbal cognitive abilitye |                  |              |            |
| 7      | -14.7 (−17.2, −12.3) | -2.4 (−5.0, 0.2) | 1.3 (−3.3, 6.0) | 4692 |
| 11     | -8.4 (−10.2, −6.6) | 1.2 (−1.3, 3.9) | -0.7 (−4.3, 2.8) | 3398 |
| 14     | -2.1 (−2.4, −1.7) | 0.1 (−0.3, 0.5) | -0.3 (−1.0, 0.4) | 3498 |

a Comparison of lowest (GCSE grades D-G, equivalent or none) vs highest (university degree) level of mother’s education
b Comparison of children measured in the 2–3 months after vs. 2–3 months before the school summer holidays
c Interaction of lowest education and post-holiday period (Reference category: highest education category)
d Odds Ratio (95 CI)
e b (95 CI)

Discussion
This Millennium Cohort Study analysis is the first analysis of UK-wide data on the impacts of school summer holiday closures on inequalities in children and young people’s mental health and verbal cognitive ability. We observed marked inequalities in children and young people’s mental health and verbal cognitive ability according to maternal education and other measures of social position, but the evidence is mixed, with inconsistent results across different age groups. The increase in population-level SDQ total difficulties scores over the summer holidays was greater among disadvantaged groups, leading to a widening of inequality at ages 7 and 14, but not at age 11. Analysis suggests a relative decline in prosocial behaviour at age 14, while there was a relative improvement at age 7 and 11. We found younger children’s verbal cognitive ability declined by a small amount over the holidays regardless of socio-economic background. No decline was found in verbal cognitive ability over the holidays for other older age groups. We found no evidence that inequalities in verbal cognitive ability widened over the school summer holidays. As is often the case with interaction analyses, statistical power was limited, so the differences in the changes in mental health and verbal cognitive ability are imprecisely measured, and we cannot be confident that they reflect a real narrowing or widening of inequality.

These findings are consistent with the international evidence that has accumulated since the last systematic review was published in 1996. Several recent analyses of large USA datasets examining differences in cognitive ability after school summer closures between socioeconomic groups have found different direction of results across school years [5–7]. Recent studies have questioned some of the methods used in earlier research, emphasising that measuring inequalities in attainment is problematic, and that heterogeneity in reported findings reflects
the diverse approaches taken to measurement and analysis [3, 4, 19]. A strength of our study is that this secondary analysis uses high quality nationally representative survey data, covering socio-emotional wellbeing as well as cognitive ability, among a cohort of children and young people who were measured at three separate ages covering both primary and secondary school-age. Importantly, we were able to compare pre- and post-holiday scores on the same measures within each age group, so our results should not be subject to some of the scaling problems that have affected earlier studies of summer learning loss [3, 4, 19].

A limitation of our study is that using the Millennium Cohort Study data from a restricted set of pre- and post-holiday months risks incorporating bias and we were unable to measure changes within cohort members. However, the rich socio-economic and demographic data and the sampling and attrition weights available within the Millennium Cohort Study allowed a weighting strategy which we believe has adequately compensated for this. As we only know the month in which each interview took place, rather than the exact day, some interviews at the end of each pre-holiday period and some at the end of the school holiday will be misclassified. Although we were able to compare pre- and post-holiday scores on the same measures within each age group, there remains a risk of under-estimating effects on inequalities due to floor or ceiling effects. The power of the study to detect small effects is constrained by the sample size, and with the numbers available we were unable to conduct analyses stratified according to levels of ability. Although our measures of cognitive ability were based on reading tests, the mental health measures were based on reports by parents. It is possible that reporting bias may have contributed to differences in scores given by those interviewed before and after the summer holidays. Moreover, SDQ ratings are based on the child’s behaviour over the previous 6 months so this might have biased our results; however, it is more likely parents would be replying based on the most recent behaviour of their child. We use outcome data collected between 2009 and 2016, so the results may not generalise to later periods if the experiences of children during school holidays have changed – for example, as a result of widening socio-economic inequalities or a rise in child poverty.

School closures were among the most widespread measures taken to control the spread of infection in the first wave of the COVID-19 pandemic, affecting
1.5 billion children in 190 countries in April 2020 [37], despite a lack of evidence from previous research [38], or support from modelling studies [39], to suggest that closing schools has a large effect on infection rates. Surveys conducted during the UK restrictions revealed wide differences in the nature and level of support for learning available to children from different backgrounds (for example, those attending state and private schools), and corresponding disparities in the ability of children from more or less affluent families to make use of the support provided [40]. Concerns over the impacts school closures on mental health, due to the reduction in pastoral care, and structure and routine, have contributed to calls for schools to prioritise mental wellbeing upon their return to school [41]. A shift in approach towards keeping schools open for as long as possible, and prioritising their reopening during the easing of restrictions, was evident during the second wave of the pandemic in the UK in Autumn and Winter 2020.

Our findings from the UK are consistent with other research evidence that suggests that adverse impacts do not automatically follow from the cessation of schooling over the summer. A large longitudinal study in England reported little change in pupil wellbeing across the first period of COVID-related school closures in Spring 2020 [42]. However, negative effects of school closures are being reported as further research emerges. For example, a USA study found pandemic related negative impacts on young people’s mental health [43], and learning and behaviour problems were found in a study of Italian school children [44]. These studies and a number of other surveys [45] conducted during the pandemic have reported widely differing experiences of schooling during the period when schools were closed, which may mean that pandemic related closures have a larger effect on inequalities in learning than we observe following routine summer closures when most children have a break from formal education. Evidence has also begun to emerge of attainment losses as a result of the lengthy closures in Spring and Summer 2020 [46, 47]. Future research should focus on establishing whether those early indications of adverse effects are real, what they mean for inequalities in health and educational attainment, and what are the mechanisms that cause them, so that interventions can be appropriately designed and targeted, in order to mitigate the adverse effects of future extended closures.

**Conclusions**

The results of our analyses of UK children are consistent with the mixed picture emerging from the international literature. They suggest that in normal circumstances, school summer holidays do not lead to significant additional educational disadvantage. School closures during the COVID19 pandemic may have a larger effect, because they last longer, because inequalities in support for learning have been more pronounced during the pandemic-related closures than they are during summer holidays in general, or because disadvantaged children tend to live in households more severely affected by the social and economic disruption of the pandemic. The possibility of such effects should be an important focus of future research and monitoring.

**Supplementary Information**

The online version contains supplementary material available at https://doi.org/10.1186/s12889-022-12540-2.

**Availability of data and materials**

The data used in this work is held by the UK Data Service (https://doi.org/10.5255/UKDA-SN-4683-1; https://doi.org/10.5255/UKDA-SN-6411-6; https://doi.org/10.5255/UKDA-SN-7464-2; https://doi.org/10.5255/UKDA-SN-8156-2). They can be accessed upon registration with UK-data-Archive (https://www.data-archive.ac.uk/).

**Declarations**

Ethics approval and consent to participate

N/A.

**Acknowledgements**

We are grateful to the Centre for Longitudinal Studies (CLS), UCL Social Research Institute, for the use of data from the Millennium Cohort Study, and to the UK Data Service for making the data available. Neither CLS nor the UK Data Service bear any responsibility for our analysis or interpretation of the data. We thank seminar participants at the MRC/CSO Social and Public Health Sciences Unit, University of Glasgow, and the Glasgow Lighthouse Laboratory for helpful feedback.

**Funding**

The work reported here was carried out with core funding from the UK Medical Research Council (MC_UU_00022/1 and MC_UU_00022/2) and the Scottish Government Chief Scientist Office (SPHSU17 and SPHSU16). AP is also supported by funds from the Wellcome Trust (205412/Z/16/Z) and SC was also supported by additional funds from the University of Glasgow/UK Medical Research Council (MC_PC_13027). The funders were not involved in study design; in the collection, analysis and interpretation of data; in the writing of the article; or in the decision to submit the paper for publication.

**Supplementary Information**

The online version contains supplementary material available at https://doi.org/10.1186/s12889-022-12540-2.

Additional file 1.
Consent for publication
N/A.

Competing interests
The authors declare that they have no competing interests.

Author details
1MRC/CSO Social and Public Health Sciences Unit, Institute of Health and Well-being, University of Glasgow, Berkeley Square, 99 Berkeley Street, Glasgow G3 7NR, UK. 2School of Social and Political Sciences, University of Glasgow, Glasgow, UK.

Received: 13 September 2021 Accepted: 6 January 2022
Published online: 22 January 2022

References
1. Entwisle DR, Alexander KL. Summer setback: race, poverty, school composition, and mathematics achievement in the first two years of school. Am Sociol Rev. 1992;72:74–84.
2. Cooper H, Nye B, Charlton K, Lindsay J, Greathouse S. The effects of summer vacation on achievement test scores: a narrative and meta-analytic review. Rev Educ Res. 1996;66(3):227–68.
3. Von Hippel PT. Is summer learning loss real? Education Next. 2019;19(4):8–15.
4. Quinn DM. Black–White summer learning gaps: Interpreting the variability of estimates across representations. Educ Eval Policy Anal. 2013;37(1):50–69.
5. von Hippel PT, Harnack C. Do test score gaps grow before, during, or between the school years? Measurement artifacts and what we can know in spite of them. Sociol Sci. 2019;6(3):43–80.
6. Quinn DM, Cocq N, McIntyre J, Gomez CJ. Seasonal dynamics of academic achievement inequality by socioeconomic status and race/ethnicity: updating and extending past research with new national data. Educ Res. 2016;45(8):443–53.
7. Dumont H, Ready DD. Do schools reduce or exacerbate inequality? How does the association between student achievement and achievement growth influence our understanding of the role of schooling. Am Educ Res J. 2020;57(2):728–74.
8. Alexander KL, Entwisle DR, Olson LS. Schools, achievement, and inequality: a seasonal perspective. Educ Eval Policy Anal. 2001;23(2):171–91.
9. Alexander KL, Entwisle DR, Olson LS. Lasting consequences of the summer learning gap. Am Sociol Rev. 2007;72(2):167–80.
10. Alexander KL, Entwisle DR, Olson LS. Summer learning and its implications: insights from the beginning school study. N Dir Youth Dev. 2007;2007(114):11–32.
11. Davies S, Aurini J. Summer learning inequality in Ontario. Can Public Policy. 2013;39(2):287–307.
12. Downey DB, Von Hippel PT, Broh BA. Are schools the great equalizer? Cognitive inequality during the summer months and the school year. Am Sociol Rev. 2004;69(5):613–35.
13. Meyer F, Meissel K, McNaughton S. Patterns of literacy learning in German primary schools over the summer and the influence of home literacy practices. J Res Read. 2017;40(3):233–53.
14. Rock DA, Pollack JM, Weiss M. Assessing cognitive achievement growth during the kindergarten and first grade years. ETS Res Rep Ser. 2004;2004(1):36.
15. Truichittampalam S, Nicholson T, Levin JR, Ferron JM. The effects of preliteracy knowledge, schooling, and summer vacation on literacy acquisition. J Educ Res. 2018;111(1):28–42.
16. Zvech K. A longitudinal examination of the academic year and summer learning rates of full-and half-day kindergartners. J Educ Stud Placed Risk. 2009;14(4):311–33.
17. Campbell LO, Sutter CC, Lambie GW. An investigation of the summer learning effect on fourth grade students’ Reading scores. Read Psychol. 2019;40(5):465–90.
18. Meyer F, Yao ES, Meissel K. The summer learning effect in writing in New Zealand. Read Writ. 2019;1–28.
19. Baker JA. Summer learning loss in reading achievement: effects of demographic variables and summer activity. Minnesota: Doctoral dissertation, University of Minnesota; 2018.
20. Cannon SK. When the school “faucet” turns off, the sociocultural “sprinklers” turn on: observing funds of knowledge among first and second grade English learners who experienced summer gains in reading. Davis: University of California; 2010.
21. Gilliom SC. Effect of summer learning loss on aggregate estimates of student growth. Doctoral dissertation, University of Kansas; 2015.
22. Sandberg Patton KL, Reschly AL. Using curriculum-based measurement to examine summer learning loss. Psychol Sch. 2013;50(7):738–53.
23. Coley RL, Kruzik C, Votruba-Drzal E. Do family investments explain growing socioeconomic disparities in children’s reading, math, and science achievement during school versus summer months? J Educ Psychol. 2019.
24. Fortherrgill W. Socioeconomic status and summer learning loss in reading. Doctoral dissertation, Colorado State University; 2011.
25. Quinn DM, Le QT. Are we trending to more or less between-group achievement inequality over the school year and summer? Comparing across ECLS-K cohorts. AERA Open. 2018;4(4):2332858418819995.
26. Yoon AJ, Merry JJ. Understanding the role of schools in the Asian-white gap: a seasonal comparison approach. Race Ethn Educ. 2018;21(5):680–700.
27. Long summer holidays are bad for children, especially the poor. In: The Economist. 2018. https://www.economist.com/international/2018/2009/long-summer-holidays-are-bad-for-children-especially-the-poor.
28. Why summers matter [https://www.summerlearning.org/the-challenge/].
29. Stewart H, Watson N, Campbell M. The cost of school holidays for children from low income families. Childhood. 2018;25(4):516–29.
30. Foundation EE. Impact of school closures on the attainment gap: rapid evidence assessment, 2020.
31. Chappell E. All children must be safely back in school by September,” says Labour. In: Labourlist; 2020.
32. Halfday J. Decade of progress in tackling pupil disadvantage ‘wiped out’. In: The Guardian; 2020.
33. Longfield A. A generation will suffer if our schools stay shut. In: Yorkshire Post, 2020.
34. Millennium Cohort Study: First Survey, 2001-2003 [computer file]. 6th Edition.UK Data Archive [distributor], March 2007. SN: 4683. [https://cls.ucl.ac.uk/cls-studies/millennium-cohort-study/].
35. Goodman A, Goodman R. Strengths and difficulties questionnaire as a dimensional measure of child mental health. J Am Acad Child Adolesc Psychiatry. 2009;48(4):400–3.
36. Connelly R. Millennium cohort study data note 2013/1: interpreting test scores. London Centre for Longitudinal Studies, Institute of Education, 2013.
37. COVID-19 Impact on Education. [https://en.unesco.org/covid19/education response].
38. Viner RM, Russell SJ, Cocker H, Packer J, Ward J, Stansfield C, et al. School closure and management practices during coronavirus outbreaks including COVID-19: a rapid systematic review. Lancet Child Adolesc Health. 2020;4(5):397–404.
39. Flaxman S, Mishra S, Gandy A, Unwin HJT, Mellan TA, Coupland H, et al. Estimating the effects of non-pharmaceutical interventions on COVID-19 in Europe. Nature. 2020;584(7820):257–61.
40. Gullinace C, Montacute R. COVID-19 and social mobility impact brief #1: school shutdown. In: The Sutton Trust, vol. 11; 2020.
41. Returning to school after the coronavirus lockdown [https://www.mentalhealth.org.uk/coronavirus/returning-school-after-lockdown/].
42. Lockdown Lessons: Pupil learning and wellbeing during the Covid-19 pandemic [https://www.impacted.org.uk/covid-19/].
43. McKune SL, Acosta D, Diaz N, Britain K, Beaulieu DJ, Maurelli AT, et al. Psychosocial health of school-aged children during the initial COVID-19 safer-at-home school mandates in Florida: a cross-sectional study. BMC Public Health. 2021;21(1):603.
44. Scarpellini F, Segre G, Cartabia M, Zanetti M, Campi R, Clavenna A, et al. Distance learning in Italian primary and middle school children.
during the COVID-19 pandemic: a national survey. BMC Public Health. 2021;21(1):1035.

45. Learning in lockdown. Research Brief. The Sutton Trust, January 2021. [https://www.suttontrust.com/wp-content/uploads/2021/01/Learning-in-Lockdown.pdf]

46. The impact of lockdown on children’s education: a nationwide analysis [https://www.risingstars-uk.com/media/Rising-Stars/Assessment/White papers/RS_Assessment_white_paper_1.pdf].

47. Sharp C, Nelson J, Lucas M, Julius J, T. M, Sims D. Schools’ responses to Covid-19: The challenges facing schools and pupils in September 2020. Slough: National Foundation for Educational Research; 2020.

Publisher’s Note
Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.