Does the impact of pupil absences on achievement depend on their timing?

Jascha Dräger[1], Markus Klein[2] & Edward Sosu[2]

[1] Socio-Economic Panel, German Institute for Economic Research, Berlin, Germany

[2] Strathclyde Institute of Education, University of Strathclyde, Glasgow, United Kingdom

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Correspondence
Jascha Dräger, Socio-Economic Panel, German Institute for Economic Research [DIW Berlin], Mohrenstraße 58, 10117 Berlin, Germany. Email: Jascha.draeger@web.de.

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Conflict of Interest
None.

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Abstract

Using linked data from the Millennium Cohort Study and National Pupil Database (N = 8,139), this study examined how the timing of school absences (years 1 to 11 between 2006 and 2017) affects achievement at the end of compulsory schooling in England. Absences during any school year are harmful to student achievement. However, absences in years 6 (final primary school year) to 10 (penultimate year of compulsory schooling) are between 1.6 and 2.0 times more detrimental to academic performance than in other years. Every school year, authorized absences hurt academic performance as much as unauthorized absences. To test the robustness of our findings, we used comparable data and analytic methods for Wales and reached the same conclusions. Our study points to the importance of addressing absences at every stage of the school year to improve educational achievement for all students, particularly at the transitional stages of primary to secondary school.

Keywords: academic achievement, school absences, school attendance, truancy, authorized, unauthorized, timing

1. Introduction

Evidence from numerous studies supports the notion that school absences have negative consequences for children's academic achievement (e.g., Aucejo & Romano, 2016; Gottfried, 2010, 2011; Gottfried & Kirksey, 2017; Kirksey, 2019; Klein et al., 2022). The adverse impact of school absences extends beyond the academic realm, including lower educational attainment and poorer labor market outcomes in adulthood (Cattan et al., 2022; Dräger et al., 2024; Liu et al., 2021).

A typical explanation for why school absences are detrimental is that students improve their skills through regular school attendance and miss educational gains when schooling is interrupted (Entwisle et al., 2001). As a result, students who receive fewer instructional hours during the school year are disadvantaged in their learning, receive lower grades, and perform worse on exams (Morrissey et al., 2014). In addition, students who exhibit frequent absences from school may experience reduced integration within their classroom environment, leading to difficulties in engaging in classroom activities and interacting with peers and teachers. This lack of integration can harm their learning outcomes (Korpershoek et al., 2020).

Although an alternative perspective suggests that the association between absences and achievement is the result of the effects of multiple out-of-school challenges that cause students to be absent from school (Pyne et al., 2021; Singer et al., 2021), absences remain detrimental to achievement after accounting for student and family characteristics (Klein et al., 2022). However, the negative impact of student absences on achievement may depend on the timing of absences within or across school years. A few studies have investigated whether absences have a different impact on children's achievement in end-of-year exams during different depending on when they occurred during the school year (Ansari et al., 2021; Chen et al., 2016; Gottfried & Kirksey, 2017; Keppens, 2022). For instance, for the US, Gottfried and Kirksey

(2017) found that spring absences, as opposed to autumn absences, were associated with lower spring exam scores, with the 30-day window preceding the test being the most crucial.

The timing of absences during students' schooling career may be crucial for academic achievement. Absences may have a differential effect on achievement depending on whether they occurred during elementary, middle, or high school stages. This is because the significance of directed learning and instruction and other school contextual factors, such as teacher and peer relationships, may vary across these stages. For the US, studies found that the effect of 8th-grade absences on various outcomes in adolescence and early adulthood was significantly greater than absences in kindergarten through second grade and third through sixth grade (Ansari et al., 2020; Ansari & Pianta, 2019). However, these studies did not compare the impact of earlier absences with absences during the latter years of compulsory schooling, even though absences are typically the highest during these years (e.g., Roberts et al., 2024). Overall, no studies have examined the role that the timing of absences plays in academic achievement across children's entire schooling careers.

Examining timing effects cannot be conducted in isolation from the underlying reasons for student absences, i.e. whether they are authorized or unauthorized. Teachers or other authorized school representatives record absences as authorized if a valid reason for the absence, such as illness, is provided. By contracts, absences for which the school has not granted permission are recorded unauthorized. Differentiating between these types of absences at various stages of schooling is crucial because unauthorized absences tend to increase in frequency as students progress through school (UK Department for Education, 2023). In addition, some studies suggest that unauthorized absences are more harmful to academic performance than authorized ones. (Aucejo & Romano, 2016; Gershenson et al., 2017; Gottfried, 2009; Hancock et al., 2013). However, none of the existing studies on the relationship between the timing of absences and academic performance have differentiated their analyses by the reason for absence.

Understanding how the effect of school absence depends on the timing and nature of absences can enhance our ability to implement interventions more effectively by directing which policies and practices should be prioritized at each stage of education.

Our study makes a novel contribution to the existing evidence by investigating the association between the timing of absences throughout the entire compulsory schooling period and academic achievement in the final year of compulsory schooling. We further assess whether the impact of unauthorized and authorized absences on final achievement changes across the school years. We use unique data from the Millennium Cohort Study (MCS) and linked school administrative data for England, providing detailed information on yearly absences in compulsory schooling (year 1 to year 11), achievement, and a rich set of student and family characteristics from the MCS. To evaluate the robustness of our findings, we further analyzed the MCS sample linked to school administrative data for Wales, an educational context relatively similar to England.

2. Background

2.1 Timing of absence and achievement

The holistic assessment of school absences throughout a student's school career is essential for determining whether the timing of school absences affects academic performance at the end of compulsory schooling. Theoretically, there are arguments for early or late absences to be more detrimental to educational achievement (Ansari & Pianta, 2019). Moreover, school absences may be particularly relevant during transitional school stages.

On the one hand, the *critical period hypothesis* (Lenneberg, 1967) suggests that abilities children acquire throughout the early years are a foundation for future learning. School absenteeism during the early years of primary school may thus present greater challenges, as children lack critical learning opportunities for each day missed. Due to the path dependency

of skill formation, children lacking basic skills will struggle to acquire more advanced skills (Cunha & Heckman, 2007). Consequently, if children develop fewer fundamental skills during these formative years due to school absences, they will also learn less in subsequent years, even if they attend school regularly. On the other hand, *theories of a recency effect* (Cowan, 2014) suggest that attendance during later years is more developmentally significant due to more recent exposure to the examined content in final examinations. This is because schooling missed during the later years is significantly more aligned with the knowledge and skills children are expected to acquire and demonstrate, and the criteria used to assess their academic performance. Therefore, due to more recent exposure to tested material, attendance in later years may be more significant for achievement (Ansari & Pianta, 2019). In addition, as exams approach, teachers may devote more time to test-taking strategies (Gottfried & Kirksey, 2017). Lastly, parents are less able to assist their children in making up missed schoolwork for more advanced coursework (Gershenson et al., 2017). Several studies on the consequences of absence timing within the school year provide support for a recency effect, finding that absences in the period immediately preceding assessment have the most detrimental effect on children's academic achievement (Ansari et al., 2020; Ansari & Pianta, 2019; Gottfried & Kirksey, 2017).

Finally, *transitional theories* (e.g., Jindal-Snape et al., 2021; Jindal-Snape et al., 2023) suggest that absences during the transition phase from elementary to secondary school may particularly influence students' academic achievement. For instance, the multiple and multidimensional transition theory (Jindal-Snape et al., 2023) posits that moving from one educational stage to another entails multiple transitional experiences due to changes in friendships, teachers, pedagogical approaches, curriculum, and school environment. The transition, therefore, requires students to adapt to several new educational experiences. Schools typically structure educational experiences during these stages to enable students to cope with anticipated and

new experiences (Beatson et al., 2023). Absences during these crucial stages may, therefore, be more detrimental to educational achievement than at any other period, as those who miss school during this stage might struggle to cope with challenges in secondary education. As far as we know, no studies have examined whether school absences during these transitional phases are more or less detrimental to academic achievement, a situation we aim to address in the current study.

2.2 Reason for absence and achievement

School absences may yield varying effects on academic performance depending on the reason for the absence (Klein et al., 2022). The impact of school absences on students' academic achievement may be more detrimental for unauthorized than authorized absences because of mechanisms other than learning loss. Unauthorized absences among students can be viewed unfavorably by teachers, who may link such absences to problematic behavior (Roorda & Koomen, 2021). Consequently, this perception can lead to increased conflict between students and teachers, a diminished sense of closeness between them, and heightened frustration on the part of teachers towards their students (Wilson et al., 2008).

Students frequently absent from school for unauthorized reasons may also experience a lack of academic engagement (Balfanz et al., 2007; Southworth, 1992). They may feel less motivated to make up for the missed lessons and fall further behind in their academic progress than children who miss school for authorized reasons. They may be less engaged in class when present and underestimate the importance of paying attention to new material while at school. Lastly, unauthorized absences are associated with high-risk behaviors, such as drug abuse or juvenile delinquency (Eaton et al., 2008; Rocque et al., 2017). These behaviors are, in turn, negatively linked to pupils' exam performance and can exacerbate the detrimental impact of

being absent from school on academic achievement (Fergusson & Horwood, 1995; Jeynes, 2002).

Several empirical studies have found that unauthorized absences are more detrimental to academic achievement than authorized absences (Aucejo & Romano, 2016; Gottfried, 2009; Hancock et al., 2013). Gershenson et al. (2017), using North Carolina school administrative data, also found that unauthorized absences had a greater negative impact on achievement than authorized ones - although they were unable to replicate this finding using national survey data from the Early Childhood Kindergarten Class of 1998-99 (ECLS-K). Klein et al. (2022) used detailed administrative and census data for Scotland and found that sickness absences and absences resulting from exceptional domestic circumstances are comparable to truancy in terms of their detrimental effect on academic performance.

The differential impact of reasons for absence may vary depending on when they occur. For example, unauthorized absences are uncommon during the early years because decisions on attending school are more under parents' control. However, they become more common in later years as adolescents are more likely to decide to attend school themselves (Hancock et al., 2018). As a result, it is critical to investigate whether the reason for a student's absence, authorized vs. unauthorized, has varying effects on academic performance depending on the timing of the absence within the student's academic career.

3. Current Study

Despite advances in research on the relationship between the timing of absences and academic achievement, it remains unclear whether early, intermediate, or later absences are more detrimental to students' academic performance. This is because research has yet to compare the impact of high school absences on academic achievement to the impact of absences in middle and elementary school. In addition, previous scholarly work did not disentangle the impact of

timing from the effects associated with the reason for absence. According to prior research, academic performance is more adversely affected by late middle school absences than earlier ones (Ansari et al., 2020; Ansari & Pianta, 2019). However, these findings may be influenced by the higher incidence of unauthorized absences observed in later stages of schooling (Gershenson et al., 2017), as unauthorized absences have a greater negative impact on academic achievement than authorized ones (Gottfried, 2009).

Our study contributes to the absenteeism literature by answering the following research questions:

1. In what school year are absences most detrimental to achievement at the end of compulsory schooling?
2. Does the impact of absence timing depend on the reason for the absence (unauthorized versus authorized)?

We use unique data from the Millennium Cohort Study and linked school administrative data for England, providing detailed information on yearly absences in compulsory schooling (year 1 to year 11), achievement information at several school stages, and a rich set of confounders from the survey data. A more holistic perspective on absences necessitates an analysis of school performance at the end of compulsory schooling.

The state-funded education system in England is divided into Key Stages: Key Stage 1 (KS1) is for children aged 5 to 7 (years 1 and 2), while Key Stage 2 (KS2) is for children aged 7 to 11 (years 3 to 6). Key Stage 3 (KS3) is for students aged 11 to 14 (years 7 to 9), and Key Stage 4 (KS4) is for students aged 14 to 16 (years 10 and 11). KS1 and KS2 cover the primary school stage, while secondary education consists of KS3 and KS4. Students take national exams in English, mathematics, and science at the end of KS1 and KS2. At the end of KS4, students typically take the General Certificate of Secondary Education (GCSE) national exams. While

schooling is required until age 16 (KS4), education is compulsory until age 18 and can occur outside the formal school setting, e.g., an apprenticeship.

To test the robustness of our findings, we conducted the same analysis with the Welsh MCS sample linked to Welsh administrative education data. The structure of the Welsh education system closely resembles that of the English education system.

4. Data & Methods

4.1 Data

For our analysis, we used data from the UK Millennium Cohort Study (MCS, Joshi & Fitzsimons, 2016) linked with register data of all students in state schools in England, the National Pupil Database (NPD, Jay et al., 2019). The initial survey of 19,244 families was conducted when children were nine months old. Follow-up surveys were at the ages of 3 (sweep 2), 5 (sweep 3), 7 (sweep 4), 11 (sweep 5), 14 (sweep 6), and 17 (sweep 7). Data from sweeps 1 to 6 were used for the analysis.

The MCS data are linked to the NPD, which contains information on absences from year 1 to year 11 and assessment data for KS1, KS2, and KS4. All participants residing in England during sweeps 3 through 5 (N=9,047) were asked for consent to link their data to the NPD. The NPD database was successfully matched with 8,438 of the 8,489 participants who provided consent. Because there are no weights for joint participation in sweeps 3 through 5, we used MCS weights for sweep 4 and a sample of participants who agreed to data linkage and were linked in this sweep (N = 8,206). We excluded students who lacked achievement measures on their key stage 4 exams from our analysis. This resulted in our analytic sample of N = 8,139 students.

4.2 Weighting and multiple imputation

We used MCS weights for families residing in England and participating in sweep 4. The MCS oversampled children from disadvantaged backgrounds, as attrition from the MCS is not random. We combined these MCS weights with weights that account for selective consent to data linkage and having complete information on key stage 4 achievement. The latter weight is estimated as the inverse probability of consenting and having complete achievement information. This probability is estimated using logistic regression with sociodemographic family characteristics and child characteristics as predictors (see Online Appendix A). Weighting the analysis with these weights creates a pseudo-population with the same characteristics as the target population of the MCS.

We imputed missing values on covariates using multiple imputations based on Categorization and Regression Trees (Burgette & Reiter, 2010). We created 20 imputed datasets and calculated standard errors using Rubin's rules.

4.3 Measures

School absences

The exposure in our study is school absences across different school years during compulsory schooling. The NPD contains information regarding absences during the autumn term, spring term, and first half-term of the summer for years 1 to 11 in English state schools. We operationalized absences as the proportion of absent days, accounting for differences in possible school days per year. We differentiated between authorized, unauthorized and total absences.

Figure 1 shows the trends of average absences throughout the compulsory school years. The black line represents all absences, the blue line represents authorized absences, and the red line represents unauthorized absences. The overall absence rate decreases slightly from 5.5% in the first year to 4.0% in the sixth year and then increases to 6.7% in the eleventh year.

Higher overall absence rates from year 7 are mainly attributable to a rise in unauthorized absences, which remain stable at approximately 0.6% until year 7 but then rise to 2.1% in year 11. In years one through six, authorized absences follow a similar downward pattern as overall absences (from 5% to 3.5%) but after that increase to almost the same level as in the first years (4.6%).

In addition, the plot illustrates the interplay between absence duration and type: While unauthorized absences account for less than one-tenth of total absences in the first years, they account for nearly one-third of absences in year 11. Students absent during a given school year have, on average, a much higher absence rate the following year. The correlation between overall absences in consecutive years ranges from 0.51 to 0.66. The correlation between absences in consecutive years is smaller for unauthorized absences than for authorized absences. For exact values of year-specific absence rates, correlations between absences in consecutive years, and correlations between authorized and unauthorized absences in the same year, see Online Appendix B.

Figure 1 here

Achievement

Our dependent variable is pupil achievement at the end of compulsory schooling. After two years of instruction in key stage 4 (years 10 to 11), students sit for their GCSE (General Certificate of Secondary Education). GCSE exams are taken by all students at the end of the year 11. Each GCSE qualification is available in a specific subject area. English and mathematics are compulsory “core subjects”. Students typically take at least five GCSEs,

although the exact number varies from student to student. Each grade a student gets is assigned a point score from 9 (the highest) to 1 (the lowest).

For our analysis, we consider four different outcomes for our MCS cohort.

1. A long-standing UK government school accountability measure is whether a student *passed five or more GCSEs*, including math and English. Students passed a GCSE in a subject if they reached a point score of more than or equal to four (range: 0-9). 54% of pupils in our sample passed five or more GCSEs.
2. *Attainment 8 score* (Mean = 45.1, SD = 20.0). The Attainment 8 score is calculated by adding up the point scores for students' eight best-performing GCSE subjects. English and math are counted twice. Three GCSE subjects must come from qualifications that count towards the English Baccalaureate (EBacc), such as sciences, languages, or history. The maximum attainment score is 90.
3. *GCSE Math* attainment (Mean = 9.4, SD = 4.7), the maximum attainment score is 18,
4. *GCSE English* attainment (Mean = 8.5, SD = 4.7), the maximum attainment score is 18.

The distribution of the outcomes is shown in Online Appendix C. For the analysis, we standardized Attainment 8 scores, GCSE English, and GCSE math attainment to have a mean of zero and a standard deviation of one in the weighted sample.

Covariates

The MCS allows us to account for risk factors of school absenteeism identified in the literature (Gubbels et al., 2019) that may also influence children's academic achievement. The measurement times of all baseline and time-varying covariates included in the analysis are displayed in Table 1. Multiple measures of socioeconomic status, child and family demographics, birth conditions, the occurrence of disruptive events, parental involvement,

educational motivation and aspirations, pupil's health, pupil's cognitive abilities and achievement in key stages 1 and 2, pupil's behavioral problems, and the attended school and ability group are included. Many confounders, including pupils' cognitive ability, behavior, and educational motivation, have been measured repeatedly over time. Note that we account for time-varying covariates in our modelling if they are measured prior to the year of absence considered (for more information, see Analytic Strategy). Summary statistics for all covariates can be found in Online Appendix C. A description of measuring latent constructs such as attitude towards school can be found in Online Appendix D.

Table 1 here

4.4 Analytic Strategy

To estimate associations between absences in different years and GCSE achievement, we estimated separate regressions for absences each year (thus, eleven regressions for each outcome). We used linear regression models to model the outcomes of Attainment 8, math, and English scores and linear probability models to analyze whether students passed five or more GCSEs. We assume linear relationships between school absences and student achievement, as evidenced by previous research (e.g., Gershenson et al., 2017; Kirksey, 2019).

We adjust for different sets of confounders to estimate the association between absences in different years and GCSE achievement, as shown in Online Appendix Table E.1. Generally, we adjust for all confounders that have been measured before the year of the absence for which we estimate their impact on achievement. For instance, to estimate the association between absences in year one and GCSE achievement, we control for confounders measured in MCS sweeps 1-3 (age five or earlier). For absences in year 11, we adjust for the most comprehensive

set of confounders measured in MCS sweeps 1-6 (age 14 or earlier), absences in years 1-10, and KS1 and KS2 achievement. We estimated regressions for year-specific overall absences and regressions jointly for year-specific measures of authorized and unauthorized absences.

5. Findings

5.1 Timing of absences and GCSE achievement in England

Figure 2 depicts the effects of absences in years 1 to 11 on the likelihood of obtaining five GCSEs and the Attainment 8 score. Figure 3 illustrates the effects of absences in these years on English and math grades. For ease of interpretation, we show effect sizes as a 10-percentage point change in absences, corresponding to a difference between never absent and what is typically defined as persistently absent (absence rate of 10% or above). Figures 2 and 3 depict the year-specific effects of overall absences (black dots on the left-hand side), authorized absences (blue dots in the center), and unauthorized absences (red dots on the right-hand side). The exact effect sizes of year-specific school absences on each outcome can be found in Online Appendix F.

Figures 2 and 3 here

Total absences in all years are negatively associated with children's GCSE achievement. A 10-percentage point increase in absences is associated with a 2.1 to 6.5 percentage points reduction in the likelihood that pupils obtain five or more GCSEs. The average effect across all years is a 4.6 percentage point reduction in the likelihood of achieving five or more GCSEs. Except for absences in years 3 to 5, all effects are statistically significant at the 0.05 level.

For our continuous measures, a ten-percentage point increase in absences is associated with a 0.09 to 0.21 SD reduction in the Attainment 8 score (average across all years: 0.15 SD), a 0.08 to 0.16 SD reduction in math attainment (average across all years: 0.12 SD), and a 0.05 to 0.18 SD reduction in English attainment (average across all years: 0.12 SD). All effects are statistically significant at the 0.05 level.

Although absences in any year are harmful to achievement, absences in years 6 to 11 are more detrimental than earlier absences. In years 1 to 5, a ten-percentage point increase in absences is associated with a 2.1 to 5.3 percentage point reduction in the likelihood that pupils obtain five or more GCSEs. By contrast, in years 6 to 11, the reduced likelihood of achieving five or more GCSEs ranges from 4.5 to 6.5 percentage points. We see similar patterns for the Attainment 8 score, Math GCSE, and English GCSE. In relative terms (average effect in years 6-11 divided by average effect in years 1-5), absences in years 6 to 11 are about 1.6 to 2 times more harmful to achievement than absences in years 1 to 5 across all outcomes. Within these two distinctive periods, absences in years 1-2 are more harmful than absences in years 3-5, and absences in years 6-10 are slightly more detrimental than absences year 11.

Across all outcomes, the associations between year-specific authorized absences and achievement mirror those found for total absences (see blue dots in the middle column of Figures 2 and 3). As with total absences, the negative association between sixth through eleventh-year absences and achievement is stronger than for absences in years one through five. By contrast, the association between unauthorized absences and achievement (see red dots in the right column of Figures 2 and 3) is less clear-cut and does not follow this temporal pattern. Generally, unauthorized absences are equally harmful to achievement across all outcomes, no matter their timing.

Figure 4 depicts the *difference* in the effect between authorized and unauthorized absences for each school year separately. There are no systematic differences in the effect of authorized and

unauthorized absences for all years and outcomes. In each school year, the difference in the effect between authorized and unauthorized absences is statistically non-significant for each outcome.

Figure 4 here

5.2 Timing of absences and GCSE achievement in Wales

We examined the robustness of these findings using the Welsh sample of the MCS linked to administrative attendance and achievement data through the Secure Anonymized Information Linkage databank (Lyons et al., 2009; Tingay et al., 2019). Our analytic strategy and data visualization are the same as for the English data (for more information on the Welsh data and variables, see Appendix G).

In Wales, average absences are slightly higher than in England, but their trend across school years is similar (see Figure G1 and Table G1 in the Online Appendix). The negative association between school absences and academic performance in Wales is somewhat greater than in England. On average, across school years, a 10-percentage point increase in total absences is associated with a 5.9 percentage point reduction in the likelihood of obtaining five or more GCSEs (for England, it was 4.6 percentage points). For our outcomes of Capped 9 (equivalent to Attainment 8 in England), math, and English, we also found stronger average associations between school absences and achievement in Wales than in England (see Table G2 in the Online Appendix).

As in England, absences in any given year negatively impact GCSE performance in Wales (see Figures G2 and G3 in the Online Appendix). However, effect sizes for absences vary more significantly across school years than in England. For instance, the negative association

between absences and obtaining five or more GCSEs ranges from 1.3 to 7.8 percentage points (for exact effect sizes on each outcome, see Online Appendix Table G2).

Regarding temporal patterns (see Figures G2 and G3 in the Online Appendix), the findings for Wales are consistent with those for England, indicating that absences are more harmful after the transition from primary to secondary school (years 7-10). While these patterns of total absences are less pronounced than in England and most visible for the summary outcome of Capped 9 (equivalent to Attainment 8), they are more noticeable for the effects of authorized absences across all outcomes. Again, we found no systematic differences in the effect of authorized versus unauthorized absences. In most school years, the difference in the effect between authorized and unauthorized absences on achievement is statistically non-significant.

5. Conclusion

This study investigated how the timing and nature of school absences throughout students' compulsory school careers affect final exam performance in England. Using linked school administrative data from the NPD and rich survey data from the MCS, we accounted for important baseline and time-varying covariates, which typically confound the association between school absences and achievement. To test the robustness of our findings, we conducted comparable analyses with Welsh data and found similar patterns as for England.

Our findings show that school absences in any school year are detrimental to student achievement in final exams. This contrasts Ansari and Pianta's (2019) and Ansari et al.'s (2020) studies comparing absenteeism across various stages of the US education system, which found that absences in middle school (8th grade; year 8 in England) were detrimental to achievement, but not absences in primary (KG to Grade 2) or middle grades (Grades 3 to 6) of school. We found that absences in the final year of primary school (year 6) are just as detrimental to achievement as the subsequent years of secondary school. Our findings challenge the widely

held notion that absences in early childhood are less problematic than absences in later years (e.g., Ehrlich et al., 2013) or that those in later years of schooling are the most detrimental to achievement (Ansari et al., 2020). Absences should be avoided at any stage of a student's academic career, and interventions to improve school attendance at any stage, if effective, can positively impact students' educational achievement. As early absences are risk antecedents of later absences, reducing early absences through interventions will positively affect school attendance and achievement in the future.

Although absences hurt achievement in all years, we found that the magnitude of this effect varies by the timing of absence. Three clear patterns emerged from our study. First, absences from the end of primary school (years 6) to the end of secondary school (year 11) are somewhat more detrimental to achievement than absences in earlier years of primary school, particularly years 3 to 5. Second, absences at the end of primary school (year 6) and the beginning of secondary school (year 7) consistently had the most negative associations with educational achievement. These two years represent the key transitional stage from primary to secondary school. Third, we see slightly different patterns of association with achievement within primary and secondary school stages. In primary school, early and later absences were most strongly associated with achievement. By contrast, in secondary school, associations between absences and achievement are stronger at earlier than later stages.

Our findings that absences in years 6 through 11 are consistently most harmful to achievement support neither the critical period hypothesis (Lenneberg, 1967) nor the recency effect (Cowan, 2014). School absences in early schooling are not as harmful as in later schooling. At the same time, our findings do not suggest that absences become more harmful the closer the students come to the exam period. In fact, absences in year 11, the last year before the exam, have a slightly weaker association with achievement than in previous years, for which absences show a consistently harmful effect. Our findings instead align with the transition theory (Jindal-

Snape et al., 2023), indicating that absences matter more when students transition from primary (year 6) to secondary school (years 7-10). In addition to the secondary school years, the last year of primary schooling may be equally crucial, given that primary schools prepare students for secondary school in terms of curriculum, academic expectations, and study habits (Beatson et al., 2023). Being more frequently absent during this school transition and the following secondary school years may pose academic challenges for students since the secondary school experience departs significantly from the structured environment and broad primary school curriculum, where a single teacher typically oversees most subjects.

According to previous research, unauthorized absences are more detrimental to academic performance than authorized absences (Gershenson et al., 2017; Gottfried, 2009). Consequently, unauthorized absences are increasingly the subject of research and policy consideration. For example, a meta-analysis of school absenteeism risk factors only focused on unauthorized absences but did not include studies on authorized absences (Gubbels et al., 2019). Our findings indicate that the year-specific effects of authorized absences on our achievement outcomes mirror those for overall absences. In contrast, unauthorized absences are more or less equally detrimental across school years. However, our findings for the year-specific associations of unauthorized absences with GCSE achievement need to be considered with caution, as unauthorized absences in the first years of schooling are rare. Consequently, the estimated effects are rather imprecise and vary strongly from year to year. Overall, the differences in year-specific effects of authorized and unauthorized absences on achievement are small and, in most years, statistically non-significant. In contrast to most previous research, we cannot conclude that unauthorized absences are more harmful than authorized absences.

The study's findings have clear policy implications. Interventions to improve attendance are needed at all grade levels. Policies and programs should target attendance issues early in primary school, given that early absences are one of the key risk factors for later absences.

Early support systems working with parents to support attendance will be key before students reach the most critical years. Given that most absences at this stage are authorized, policy and practice intervention to address the causes of absences should be the key focus.

A particular emphasis should be placed on avoiding absences during the transition from primary to secondary school, given that this is the critical stage for school attendance in our study. The end of primary school is particularly important for preparing students for the next phase of education, and those who miss out on this vital experience are likely to be negatively affected in later years. Therefore, understanding and addressing the causes of non-attendance during this period shouldbecome a priority for policymakers and practitioners. Additionally, the beginning of secondary school requires students to navigate multiple transitional challenges ranging from friendships, teachers, and a new curriculum. This can be a demanding time for some students in addition to negotiating adolescence. According to our findings, missing school at this stage has the most damaging consequences for achievement. As a result, it should be the crucial stage for schools and policymakers to monitor and support attendance. Where absences are unavoidable, opportunities for students to catch up on missed lessons should be implemented to mitigate the negative consequences of being absent.

Since authorized and unauthorized absences equally hurt achievement, policymakers should focus on reducing both types of absences. Policies should also focus less on punishing unexcused absences and more on prevention and intervention. Generally, it will be important to address the root causes at each stage, as unique, multifaceted reasons may drive absences in different years. Policies should be tailored to year-specific causes, not a one-size-fits-all approach. In summary, the implications point to comprehensive, proactive attendance policies starting early and continuing through secondary school, focusing on the transition period from primary to secondary school.

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Tables

Table 1. Timing of measurement of covariates.

Dimension	Variable	Age 1 Sweep 1	Age 3 Sweep 2	Age 5 Sweep 3	Age 7 Sweep 4	Age 11 Sweep 5	Age 14 Sweep 6
SES	Highest parental education (NVQ)			X			
	Highest occupational class (NS-SEC 7)			X			
	Household income			X			
	Housing tenure			X			
	Neighborhood deprivation decile			X			
Demographics	Ethnicity	X					
	Child's date of birth	X					
	Child's gender	X					
	Family structure			X			
	Household size			X			
	Number of children in household			X			
	Region				X		
Cognitive Ability/Achievement	BAS vocabulary + Bracken		X				
	BAS vocabulary + BAS pattern + BAS picture			X			
	Math + BAS reading + BAS pattern				X		
	Verbal similarities					X	
	Vocabulary						X
	Key stage English				X	X	
	Key stage Math				X	X	
Attitude towards school	Child's attitude towards school				X	X	X
	Child's attitude towards school (reported by parents)			X			
	Child's educational aspirations						X
	Parents educational aspirations				X	X	
Child behavior	Internalizing behavior		X	X	X	X	X
	Externalizing behavior		X	X	X	X	X
Child Health	Child has longstanding illness			X			

	General health		X			
Birth conditions	Birthweight	X				
	Was in special care unit	X				
	Mother smoked during pregnancy	X				
	Mother's alcohol consumption during pregnancy	X				
Parental involvement	Parents had meeting with teacher		X	X	X	X
	Joint learning-related activities		X	X		
School characteristics	Stream			X	X	
	Set (English and Math)			X	X	
	School fees		X	X	X	X
Disruptive events	Parents' mental health problems		X			
	Changed school		X	X	X	X
	Moved residence		X			

Note: "BAS" is the British Ability Scale. Summary statistics for all covariates can be found in Online Appendix C. "Attitudes towards school" and "joint learning-related activities" are latent factors created from multiple items. Information on the measurement of these latent factors is provided in Online Appendix D.

Figures

Fig 1. Average absences over pupils' school careers. Source: Linked MCS-NPD data. N=8,139. Multiple Imputed and weighted.

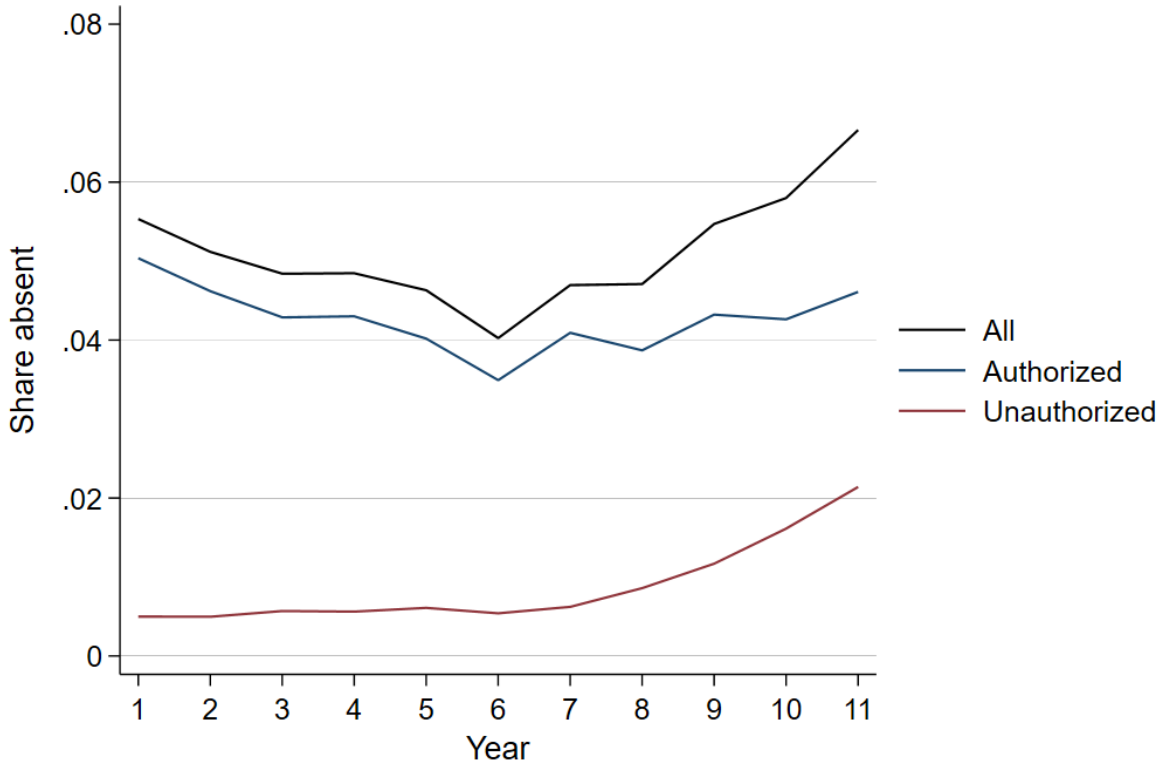
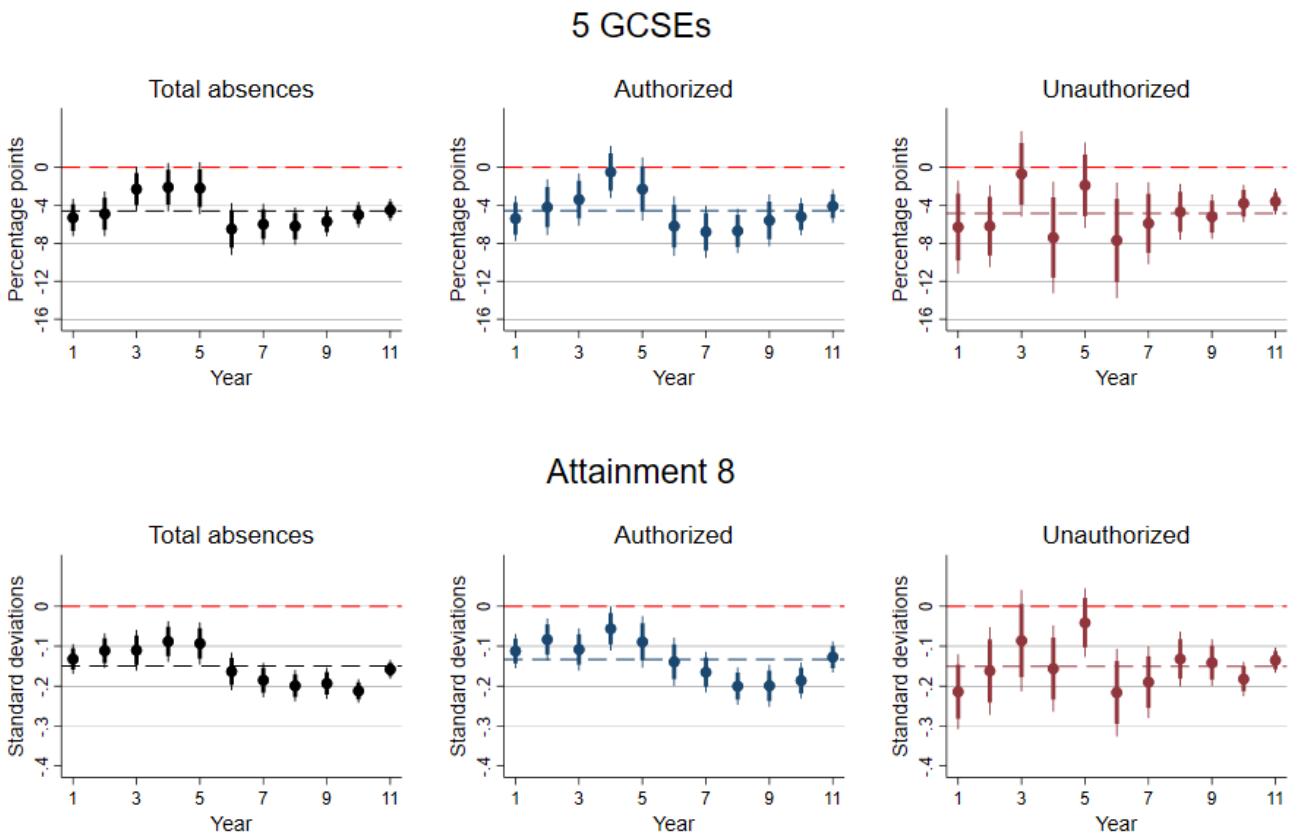
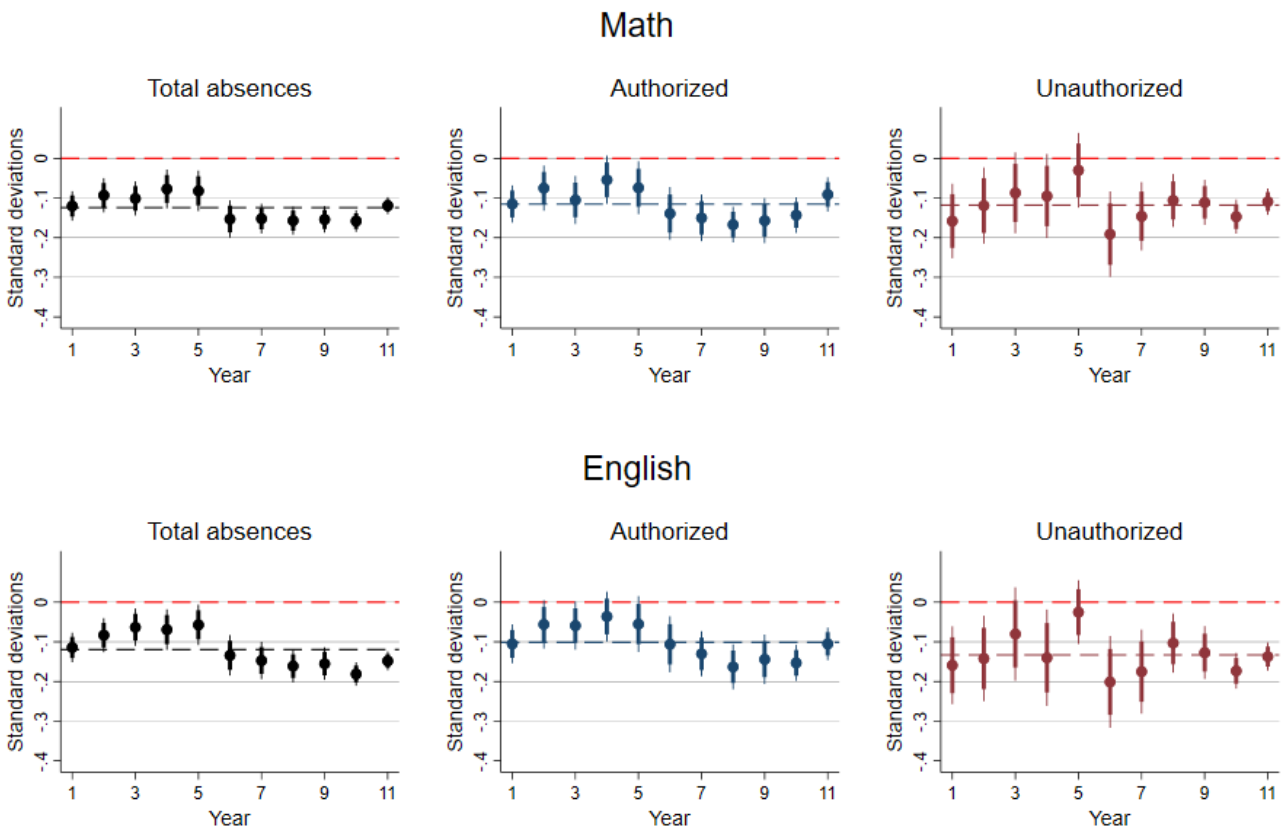


Fig 2. Effect of school absences on obtaining 5 or more GCSEs and Attainment 8 score by timing and reason for absence in England. *Source:* Linked MCS-NPD data. N=8,139. Multiple Imputed and weighted.



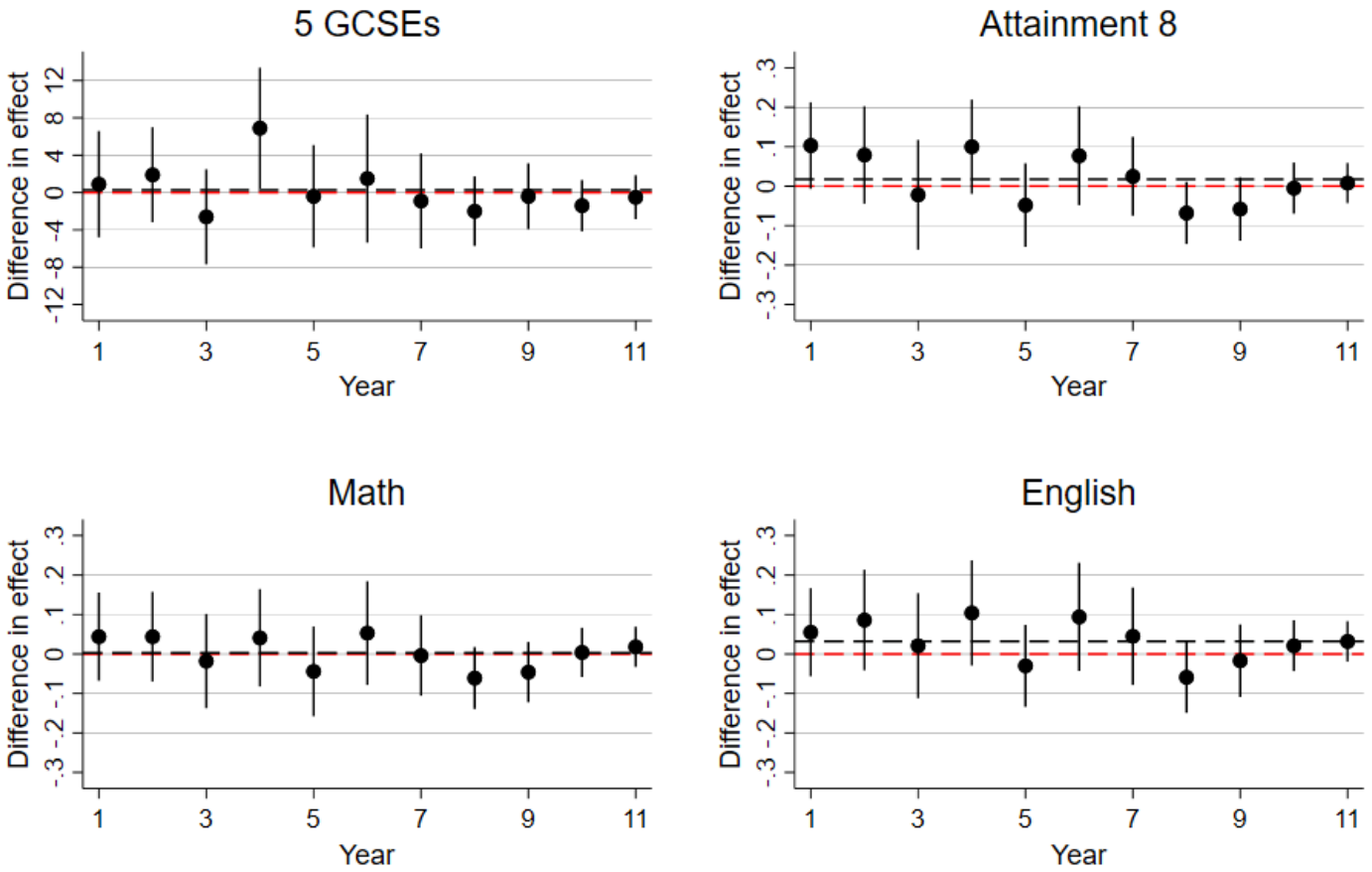
Note: Effects adjusted by confounders. Black dots: effects of overall absences, blue dots: effects of authorized absences, red dots: effects of unauthorized absences. Five or more GCSEs is measured on a binary scale and Attainment 8 on a continuous scale. The thin vertical lines represent the 95%-confidence intervals for determining whether effects differ statistically significantly from zero. The thick vertical lines indicate the 84%-confidence intervals to visually determine whether the effects of absences in different school years significantly differ from the effects of absences in other years (MacGregor-Fors & Payton, 2013). The dashed horizontal lines show the average effect across all years.

Fig 3. Effect of school absences on Math and English GCSE grade by timing of absences in England. *Source:* Linked MCS-NPD data. N=8,139. Multiple Imputed and weighted.



Note: Effects adjusted by confounders. Black dots: effects of overall absences, blue dots: effects of authorized absences, red dots: effects of unauthorized absences. The thin vertical lines represent the 95%-confidence intervals for determining whether effects differ statistically significantly from zero. The thick vertical lines indicate the 84%-confidence intervals to visually determine whether the effects of absences in different school years significantly differ from the effects of absences in other years (MacGregor-Fors & Payton, 2013). The dashed horizontal lines show the average effect across all years.

Fig 4. Difference in the effect of authorized and unauthorized absences for each school year in England. N=8,139. Multiple Imputed and weighted.



Note: Positive values indicate that unauthorized absences have larger effects. The dashed vertical line shows the average difference in the effect of authorized and unauthorized absences across all years. Thin vertical lines indicate the 95%-confidence intervals.

Online Appendix: Does the impact of pupil absences on achievement depend on their timing?

A. Estimation of weights

Table A1. Logistic regression of membership in the analysis sample on baseline covariates. Source: Linked MCS-NPD data. N=8,986. Multiple Imputed and weighted.

Reference categories: Ethnicity: White, Complications at birth: None, Child long-lasting illness: None, NVQ: None, NSSEC: 1, Housing tenure: Owned outright, Region: Northeast. *** p<0.01, ** p<0.05, * p<0.1

	Coef	SE
Date of Birth	0.001	(0.011)
Boy	-0.081	(0.075)
Ethnicity		
Mixed	-0.430**	(0.170)
Indian	-0.201	(0.204)
Pakistani/Bangladeshi	-0.591***	(0.158)
Black	-0.733***	(0.161)
Other	-0.118	(0.274)
Family Structure		
Stepfamily	-0.039	(0.188)
Single parent	-0.176	(0.129)
Other	-0.166	(0.566)
HH size	-0.098*	(0.056)
Children in HH	0.147**	(0.066)
Parental Education		
NVQ 1	-0.034	(0.178)
NVQ 2	0.149	(0.134)
NVQ 3	-0.084	(0.153)
NVQ 4	-0.196	(0.143)
NVQ 5	-0.504***	(0.189)
Class		
NS-SEC 1	0.250**	(0.122)
NS-SEC 2	0.429**	(0.167)
NS-SEC 3	0.226	(0.178)
NS-SEC 4	0.450**	(0.193)
NS-SEC 5	0.237	(0.167)
NS-SEC 6	0.403**	(0.193)
Neighborhood Deprivation	0.004	(0.018)
Housing Tenure		
Owned with mortgage	0.149	(0.171)
Rent - Local authority	-0.225	(0.199)
Rent - Housing association or private	-0.305	(0.191)
Other	0.027	(0.285)

Income	0.000	(0.000)
Region		
Northwest	-0.131	(0.237)
Yorkshire and the Humber	-0.133	(0.241)
East Midlands	-0.150	(0.254)
West Midlands	-0.493**	(0.234)
East of England	-0.144	(0.244)
London	-0.458*	(0.234)
Southeast	-0.395*	(0.234)
Southwest	-0.389	(0.247)
Residential mobility	-0.300***	(0.106)
Birthweight	0.067	(0.067)
Complications at birth		
Complications, not in special care	-0.145*	(0.084)
Complications, in special care	-0.128	(0.140)
Alcohol during pregnancy	-0.003	(0.039)
Smoking during pregnancy	-0.128	(0.110)
Parental depression	0.020	(0.013)
General child health	-0.020	(0.048)
Long-lasting illness		
Yes, a little bit affected	0.093	(0.118)
Yes, strongly affected	0.067	(0.170)
Bracken (Age 3)	0.005*	(0.003)
BAS vocabulary (Age 3)	-0.002	(0.005)
Externalizing behavior (Age 3)	0.010	(0.012)
Internalizing behavior (Age 3)	0.012	(0.018)
Importance of child independence	-0.031	(0.037)
Importance of child obedience	0.028	(0.040)
Constant	1.606	(5.259)

B. Distribution of absences and correlations over time and across type of absences

Tab B1. Distribution of absences by year. Source: Linked MCS-NPD data. N=8,139. Multiple Imputed and weighted.

Note: "p50" shows the 50th percentile, "p10" the 10th percentile, and "p90" the 90th percentile of absences. The columns "Overall", "Auth", and "Unauth" show the correlation of different types of absences in consecutive years. The rightmost column shows the correlation between authorized and unauthorized absences in the same year.

Year	Overall absences				Authorized absences				Unauthorized absences				Correlations			
	Mean	p50	p10	p90	Mean	p50	p10	p90	Mean	p50	p10	p90	Overall	Auth	Unauth	Auth-Unauth
1	0.055	0.042	0.006	0.121	0.050	0.039	0.006	0.110	0.005	0.000	0.000	0.013				0.156
2	0.051	0.039	0.006	0.111	0.046	0.036	0.006	0.100	0.005	0.000	0.000	0.013	0.545	0.481	0.331	0.147
3	0.048	0.036	0.006	0.106	0.043	0.032	0.006	0.095	0.006	0.000	0.000	0.013	0.509	0.439	0.327	0.152
4	0.048	0.036	0.006	0.106	0.043	0.032	0.006	0.092	0.006	0.000	0.000	0.013	0.544	0.451	0.417	0.135
5	0.046	0.033	0.006	0.101	0.040	0.029	0.003	0.088	0.006	0.000	0.000	0.017	0.541	0.471	0.406	0.068
6	0.040	0.028	0.003	0.091	0.035	0.025	0.000	0.080	0.005	0.000	0.000	0.013	0.550	0.479	0.302	0.096
7	0.047	0.032	0.003	0.103	0.041	0.029	0.003	0.090	0.006	0.000	0.000	0.013	0.545	0.450	0.243	0.193
8	0.047	0.030	0.003	0.103	0.039	0.026	0.000	0.086	0.009	0.000	0.000	0.020	0.621	0.501	0.518	0.122
9	0.055	0.035	0.003	0.116	0.043	0.030	0.003	0.092	0.012	0.000	0.000	0.026	0.613	0.527	0.477	0.163
10	0.058	0.034	0.003	0.120	0.043	0.028	0.000	0.091	0.016	0.000	0.000	0.038	0.618	0.470	0.420	0.207
11	0.067	0.038	0.003	0.139	0.046	0.029	0.000	0.098	0.021	0.000	0.000	0.048	0.655	0.462	0.552	0.183

C. Distribution of outcomes and covariates

Table C1. Distribution of outcomes and confounders. Source: Linked MCS-NPD data. N=8,139. Multiple Imputed and weighted.

	Mean	SD
Outcomes		
5 or more GCSEs	0.540	-
Attainment 8	45.101	19.991
English	9.417	4.651
Math	8.539	4.704
Baseline confounders		
Education[1]		
None	0.122	-
NVQ 1	0.066	-
NVQ 2	0.258	-
NVQ 3	0.151	-
NVQ 4	0.336	-
NVQ 5	0.066	-
Class[2]		
NS-SEC 1	0.153	-
NS-SEC 2	0.287	-
NS-SEC 3	0.142	-
NS-SEC 4	0.085	-
NS-SEC 5	0.084	-
NS-SEC 6	0.151	-
NS-SEC 7	0.098	-
Housing Tenure		
Owned outright	0.048	-
Owned with mortgage	0.578	-
Rent - Local authority	0.156	-
Rent - Housing association or private	0.192	-
Other	0.026	-
Region		
Northeast	0.045	-
Northwest	0.131	-
Yorkshire and the Humber	0.106	-
East Midlands	0.088	-
West Midlands	0.100	-
East of England	0.118	-
London	0.135	-
Southeast	0.177	-
Southwest	0.100	-

Complications at birth		
No complications	0.535	-
Complications, not in special care	0.378	-
Complications, in special care	0.087	-
Ethnicity		
White	0.829	-
Mixed	0.040	-
Indian	0.023	-
Pakistani/Bangladeshi	0.055	-
Black	0.039	-
Other	0.015	-
Family structure		
Two natural parents	0.737	-
Stepfamily	0.057	-
Single parent	0.201	-
Other	0.004	-
Long-standing illness		
No	0.802	-
Yes, a little bit affected	0.138	-
Yes, strongly affected	0.060	-
Date of Birth[3]	493.467	3.487
Boy	0.513	-
HH size	4.297	1.249
Children in HH	2.390	1.049
Neighborhood Depriv.[4]	5.354	2.961
HH income[5]	360.137	228.683
Residential Moves[6]	0.134	-
Birthweight	3.335	0.593
Alcohol during pregnancy[7]	6.374	1.081
Smoking during pregnancy[8]	0.222	-
Parental depression[9]	3.388	3.368
Child general health[10]	1.729	0.858
Bracken (Age 3)[11]	103.397	16.421
BAS vocabulary (Age 3)[12]	48.708	11.426
Externalizing (Age 3)[13]	6.940	3.856
Internalizing (Age 3)[14]	3.009	2.558
Importance of child independence[15]	2.055	1.230
Importance of child obedience	3.229	1.133
BAS picture (Age 5)[16]	54.839	10.728
BAS vocabulary (Age 5)	53.796	11.703
BAS pattern (Age 5)[17]	50.132	10.500
Externalizing (Age 5)	4.902	3.430
Internalizing (Age 5)	2.600	2.563

Educational motivation (Age 5, reported by parents)	1.596	0.725
Parents met teacher (Age 5)[18]	0.918	-
Joint activities (Age 5)	4.301	0.848
School Fees (Age 5)	0.958	-
School change (Age 5)	0.033	-
Confounders for absences in years 3-11		
BAS reading (Age 7)[19]	112.036	18.011
BAS pattern (Age 7)	52.488	11.094
NFER math (Age 7)[20]	97.449	15.709
Externalizing (Age 7)	4.898	3.615
Internalizing (Age 7)	2.889	2.878
Educational motivation (Age 7)	2.347	.384
Parents met teacher (Age 7)	0.948	-
Reading score in KS 1[21]	15.827	4.286
Writing score in KS 1	14.410	4.031
Math score in KS 1	15.989	3.763
Parents' educational aspiration (Age 7)[22]	0.978	-
Joint activities (Age 7)	3.936	0.916
School Fees (Age 7)	0.960	-
School change (Age 7)	0.119	-
Top Stream (Age 7)[23]	0.070	-
Top English set (Age 7)	0.113	-
Top Math set (Age 7)[24]	0.148	-
Bottom Stream (Age 7)	0.044	-
Bottom English set (Age 7)	0.074	-
Bottom Math set (Age 7)	0.088	-
Confounders for absences in years 7-11		
BAS Verbal similarities (Age 11)[25]	58.332	9.862
Externalizing (Age 11)	6.545	1.964
Internalizing (Age 11)	6.710	2.662
Educational motivation (Age 11)	3.181	0.481
Parents met teacher (Age 11)	0.955	-
Reading score in KS 2[26]	28.426	4.751
Math score in KS 2	28.612	5.152
Parents' educational aspiration (Age 11)	0.884	-
School Fees (Age 11)	0.950	-
School change (Age 11)	0.228	-
Top Stream (Age 11)	0.098	-
Top English set (Age 11)	0.195	-

Top Math set (Age 11)	0.302	-
Bottom Stream (Age 11)	0.040	-
Bottom English set (Age 11)	0.094	-
Bottom Math set (Age 11)	0.145	-
Confounders for absences in years 10-11		
Vocabulary (Age 14)[27]	6.981	2.606
Externalizing (Age 14)	4.563	3.664
Internalizing (Age 14)	3.841	3.443
Educational motivation (Age 14)	2.895	0.493
Parents met teacher (Age 14)	0.901	-
Educational aspiration (Age 14)[28]	86.507	20.525
School Fees (Age 14)	0.936	-
School change (Age 14)	0.078	-

Note:
1 Parental education: National Vocational Qualification (NVQ)
NVQ 5: Higher Degree and Postgraduate qualifications or vocational equivalent
NVQ 4: First Degree, diploma in higher education or vocational equivalent
NVQ 3: A/AS/S Levels/SCE Higher or vocational equivalent
NVQ 2: O Level or GCSE grade A-C or vocational equivalent
NVQ 1: CSE below grade 1/GCSE or O Level below grade C or vocational equivalent
2 Social class: National Statistics Socio-economic classification (NS-SEC)
NS-SEC 1: Higher managerial, administrative, and professional occupations
NS-SEC 2: Lower managerial, administrative, and professional occupations
NS-SEC 3: Intermediate occupations
NS-SEC 4: Small employers and own account workers
NS-SEC 5: Lower supervisory and technical occupations
NS-SEC 6: Semi-routine occupations
NS-SEC 7: Routine occupations
3 Date of birth: In months since January 1960.
4 Neighborhood deprivation: Decile of the index of multiple deprivation at Lower Super Output Area Level.
5 HH income: OECD equivalized income. Provided by MCS.
6 Residential moves: Whether the child moved residence in 2005 or 2006 (1) or not (0).
7 Alcohol during pregnancy: Frequency of alcohol consumption during pregnancy (1 "Every day", 2 "5-6 times per week", 3 "3-4 times per week", 4 "1-2 times per week", 5 "1-2 times per months", 6 "Less than once a month", 7 "Never").
8 Smoking during pregnancy: Whether mother smoked during pregnancy (1) or not (0).
9 Parental depression: Score on Kessler scale, range 0-24, provided by MCS, averaged over parents.
10 Child general health: Child's general level of health as reported by parents (1 "excellent" 2 "very good" 3 "good" 4 "fair or poor")
11 Bracken (Age 3): Measures basic knowledge in preparation for school. The test includes 88 items, belonging to 6 different sub-set (colors, letters, numbers/counting sizes, comparisons, shapes). Ability adjusted scores. Range: 56-149. Provided by MCS (see Hansen, 2017).
12 BAS Vocabulary (Age 3, Age 5): Measures expressive verbal ability. Children are shown up to 36 pictures of objects and are asked to name them. Ability and age adjusted. Range 20-80. Provided by MCS (see Hansen, 2017).
13 Externalizing (Age 3, 5, 7, 11, 14): Raw score of the conduct problems subscale plus the hyperactivity subscale of the strengths and difficulties questionnaire (Goodman, 1997). Range 0-20.
14 Internalizing (Age 3, 5, 7, 11, 14): Raw score of the emotion symptoms subscale plus the peer problems subscale of the strengths and difficulties questionnaire (Goodman, 1997). Range 0-20.
15 Parents value child independence/obedience: Parents were asked about the most, second most, third most, and least important value to install in their child. They could choose from: 1 "To be well liked or popular", 2 "To think for himself or herself" (child independence), 3 "To work hard", 4 "To help others when they need help", 5 "To obey

his or her parents" (obedience), 6 "To learn religious values". If independence or obedience were mentioned as most important, they were coded as 1, second-most important as 2, third most-important as 3, and least important as 5. When independence and obedience were not mentioned as any of the aforementioned options, they were coded as 4.
16 BAS picture (Age 5): Measures children's problem-solving skills. Children are shown a row of four pictures and are asked to choose a fifth picture that matches the other pictures best. Ability and age adjusted. Range 20-80. Provided by MCS (see Hansen, 2017).
17 BAS pattern (Age 5, 7): Children were presented different patterns and are asked to replicate the pattern. 23 Items. Ability and age adjusted. Range 20-80. Provided by MCS (see Hansen, 2017).
18 Parents met teacher (Age 5): Whether parents have attended the parent evening in school.
19 BAS reading (Age 7): Measures English reading ability. Children are asked to read words to the interviewer. Ability and age adjusted. Range 55-145. Provided by MCS (see Hansen, 2017).
20 NFER math (Age 7): Measures mathematical skills and knowledge. Covers numbers, shapes and data handling. Ability and age adjusted. Range 69-136. Provided by MCS (see Hansen, 2017).
21 Reading/Writing/Math score in KS 1: Teacher assigned reading score at the end of year 2. Range 3-39.
22 Parents' educational aspiration (Age 7, 11): Whether parents want to child to continue full-time education at age 16 (i.e., after mandatory school attendance).
23 Bottom/Top Stream (Age 7, 11): Whether the child attends the bottom or top stream if the child is streamed. Reported by teachers.
24 Bottom/Top English/Math set (Age 7, 11): Whether the child is in the bottom or top set in English and Math if there are sets in English and Math. Reported by teachers.
25 BAS Verbal similarities (Age 11): Assess verbal reasoning and verbal knowledge. The interviewer reads out three words to the child and the child is asked to say what these words have in common. Ability and age adjusted. Range 20-80. Provided by MCS (see Hansen, 2017).
26 Reading/Math score in KS 2: Fine graded score of standardized tests at the end of year 6. Range 3-39.
27 Vocabulary (Age 14): Children were presented words and are then offered a multiple-choice list of 5 words from which they should pick the word with the same meaning. Raw scores. Range 0-19. Provided by MCS.
28 Child's educational aspiration (Age 14): How likely the child thinks that they will remain in school at the end of year 11 on a scale from 0 to 100.

D. Measurement of latent factors

Table D1. Measurement of latent factors not provided by the MCS.

Construct	Items	Method
Attitude towards school Reported by parent. Age 5	Whether CM enjoys school How often CM talks about school How often reluctant to go to school	Sum score Cronbachs alpha=0.49
Attitude towards school Reported by child. Age 7	How often do you try to do your best at school? How often is school interesting? How often do you feel unhappy at school? How often do you get tired at school? How often do you get fed up at school?	Sum score Cronbachs alpha=0.56
Attitude towards school Reported by child. Age 11	How often do you try your best at school? How often do you find school interesting? How often do you feel unhappy at school? How often do you get tired at school? How often do you feel school is a waste of time?	Sum score Cronbachs alpha=0.71
Attitude towards school Reported by child. Age 14	How often do you try your best at school? How often do you find school interesting? How often do you feel unhappy at school? How often do you get tired at school? How often do you feel school is a waste of time? How often difficult to keep mind on work at school?	Sum score Cronbachs alpha=0.75
Joint Activities Age 5	How often do you read to CM? How often tells stories to CM? How often does musical activities with CM? How often does CM paint/draw at home?	Sum score Cronbachs alpha=0.58
Joint Activities Age 7	How often do you read to CM? How often tells stories to CM? How often does musical activities with CM? How often does CM paint/draw at home?	Sum score Cronbachs alpha=0.57

E. Adjustment of confounders by estimating year-specific absence effect

Table E1. Adjusted confounders for the association between absences in year 1 to 11 and GCSE achievement.

Effect of absences in year	Confounders measured in MCS	Previous absences	Previous achievement	Number of covariates
1	Sweeps 1-3	-	-	36
2	Sweeps 1-3	Absences in Year 1	-	37
3	Sweeps 1-4	Absences in Years 1-2	Achievement in KS1	54
4	Sweeps 1-4	Absences in Years 1-3	Achievement in KS1	55
5	Sweeps 1-4	Absences in Years 1-4	Achievement in KS1	56
6	Sweeps 1-4	Absences in Years 1-5	Achievement in KS1	57
7	Sweeps 1-5	Absences in Years 1-6	Achievement in KS1+2	67
8	Sweeps 1-5	Absences in Years 1-7	Achievement in KS1+2	68
9	Sweeps 1-5	Absences in Years 1-8	Achievement in KS1+2	69
10	Sweeps 1-6	Absences in Years 1-9	Achievement in KS1+2	75
11	Sweeps 1-6	Absences in Years 1-10	Achievement in KS1+2	76

F. Regression estimates for Figures 2-4

Tab F1. Regression estimates for Figures 2, 3, and 4. Source: Linked MCS-NPD data. N=8,139. Multiple Imputed and weighted.

Note: Based on separate linear regressions for each outcome and each year. The column "*Average*" is the average of the effects across the 11 years (no standard errors). The column "*Difference between authorized and unauthorized*" was calculated as the effect of authorized absences minus the effect of unauthorized absences, i.e., positive values indicate larger effects of unauthorized absences (in line with Figure 4 in the manuscript).

Year	Overall absences		Authorized		Unauthorized		Difference between authorized and unauthorized	
	b	SE	b	SE	b	SE	b	SE
5 GCSEs or more								
1	-0.053	0.010	-0.054	0.012	-0.063	0.025	0.009	0.029
2	-0.049	0.012	-0.042	0.015	-0.062	0.022	0.019	0.026
3	-0.023	0.012	-0.034	0.014	-0.007	0.023	-0.026	0.026
4	-0.021	0.013	-0.005	0.014	-0.074	0.030	0.069	0.033
5	-0.022	0.014	-0.023	0.017	-0.019	0.023	-0.004	0.028
6	-0.065	0.014	-0.062	0.016	-0.077	0.031	0.015	0.035
7	-0.060	0.011	-0.068	0.014	-0.059	0.022	-0.009	0.026
8	-0.062	0.010	-0.067	0.012	-0.047	0.015	-0.020	0.019
9	-0.057	0.008	-0.056	0.014	-0.052	0.012	-0.004	0.018
10	-0.050	0.007	-0.052	0.010	-0.038	0.010	-0.014	0.014
11	-0.045	0.006	-0.041	0.009	-0.036	0.007	-0.005	0.012
Average	-0.046		-0.046		-0.049		0.003	
Attainment 8								
1	-0.132	0.019	-0.112	0.022	-0.214	0.048	0.103	0.056
2	-0.111	0.022	-0.083	0.027	-0.162	0.056	0.079	0.063
3	-0.110	0.026	-0.108	0.027	-0.086	0.065	-0.022	0.071
4	-0.088	0.026	-0.056	0.028	-0.156	0.055	0.100	0.061
5	-0.093	0.027	-0.089	0.033	-0.041	0.044	-0.048	0.054
6	-0.163	0.024	-0.139	0.031	-0.216	0.056	0.077	0.064
7	-0.185	0.022	-0.165	0.026	-0.190	0.046	0.025	0.051
8	-0.199	0.020	-0.200	0.024	-0.132	0.035	-0.068	0.040
9	-0.193	0.020	-0.199	0.027	-0.141	0.030	-0.058	0.041
10	-0.212	0.015	-0.186	0.023	-0.182	0.022	-0.005	0.033
11	-0.158	0.012	-0.127	0.020	-0.135	0.016	0.008	0.026
Average	-0.149		-0.133		-0.150		0.017	
Math								
1	-0.120	0.019	-0.115	0.024	-0.158	0.048	0.044	0.057
2	-0.093	0.022	-0.075	0.029	-0.119	0.049	0.044	0.058
3	-0.101	0.022	-0.105	0.031	-0.087	0.052	-0.018	0.061
4	-0.077	0.025	-0.054	0.031	-0.095	0.054	0.041	0.063
5	-0.082	0.026	-0.074	0.034	-0.030	0.048	-0.044	0.058
6	-0.153	0.024	-0.139	0.034	-0.191	0.055	0.053	0.067

7	-0.152	0.019	-0.150	0.030	-0.146	0.044	-0.004	0.052
8	-0.157	0.018	-0.167	0.023	-0.106	0.034	-0.061	0.040
9	-0.154	0.017	-0.157	0.029	-0.111	0.029	-0.046	0.039
10	-0.158	0.014	-0.143	0.023	-0.147	0.022	0.004	0.032
11	-0.119	0.011	-0.091	0.022	-0.109	0.017	0.018	0.026
Average	-0.124		-0.115		-0.118		0.003	
English								
1	-0.114	0.019	-0.105	0.025	-0.159	0.050	0.055	0.057
2	-0.083	0.022	-0.056	0.031	-0.142	0.055	0.086	0.065
3	-0.063	0.024	-0.059	0.031	-0.080	0.060	0.021	0.068
4	-0.069	0.026	-0.036	0.032	-0.140	0.062	0.104	0.068
5	-0.057	0.026	-0.055	0.036	-0.025	0.041	-0.030	0.053
6	-0.134	0.026	-0.106	0.036	-0.201	0.059	0.094	0.070
7	-0.147	0.024	-0.130	0.029	-0.175	0.054	0.045	0.063
8	-0.161	0.021	-0.163	0.029	-0.103	0.038	-0.059	0.046
9	-0.155	0.021	-0.144	0.032	-0.127	0.034	-0.017	0.047
10	-0.181	0.015	-0.153	0.023	-0.173	0.023	0.021	0.033
11	-0.148	0.012	-0.105	0.021	-0.137	0.018	0.032	0.026
Average	-0.119		-0.101		-0.133		0.032	

G. Timing of absences and GCSE achievement in Wales

Data, variables, and methods

Out of the total of 1,995 families residing in Wales and taking part in sweep 4, a majority of 1,898 families provided consent for the linkage of education data. The data of 1,735 pupils was effectively linked to administrative data. After excluding all pupils with incomplete achievement measures in key stage 4, the remaining sample size consists of 1,730 pupils.

The analysis of the English and Welsh data exhibits several disparities, primarily attributed to data limitations and the comparatively smaller sample size in Wales. Significantly, the dataset exclusively encompasses data pertaining to absences occurring within the academic years spanning from year 2 to year 11 in Wales. To assess the comprehensive KS4 achievement, we employed the Capped 9 point score (for more information see https://www.gov.wales/sites/default/files/publications/2019-07/guidance-on-the-calculation-of-the-capped-9-points-score-interim.pdf), which is used in Wales as an alternative to the Attainment 8 score. Additionally, we were required to consolidate the classifications of ethnicity and family structure and omit the data regarding whether students are required to pay school tuition due to limited sample sizes. Finally, the survey weights for sweep 4 are unavailable. Instead, we used sweep 1 weights and multiplied these with the inverse of the probability that families gave consent to data linkage and that children have complete information on KS4 achievement measures. Other than that, we performed an exact replication of the analysis for England.

Fig G1. Mean absences by type and year. N=1,730. Multiple imputed and weighted.

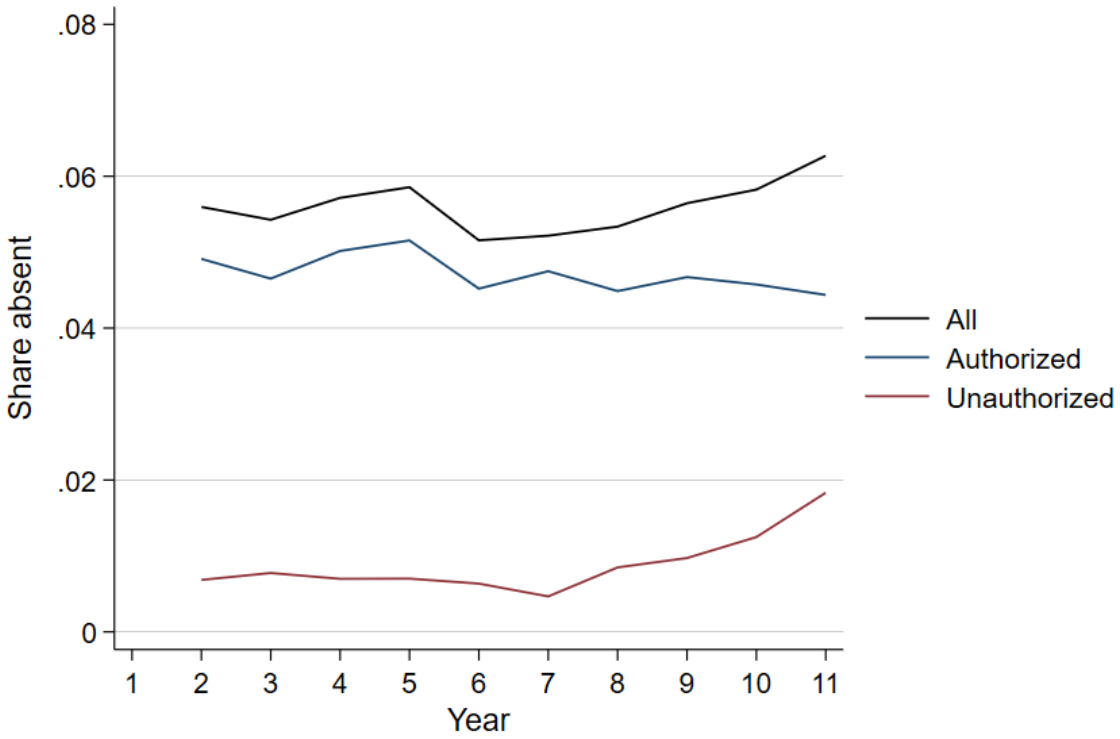
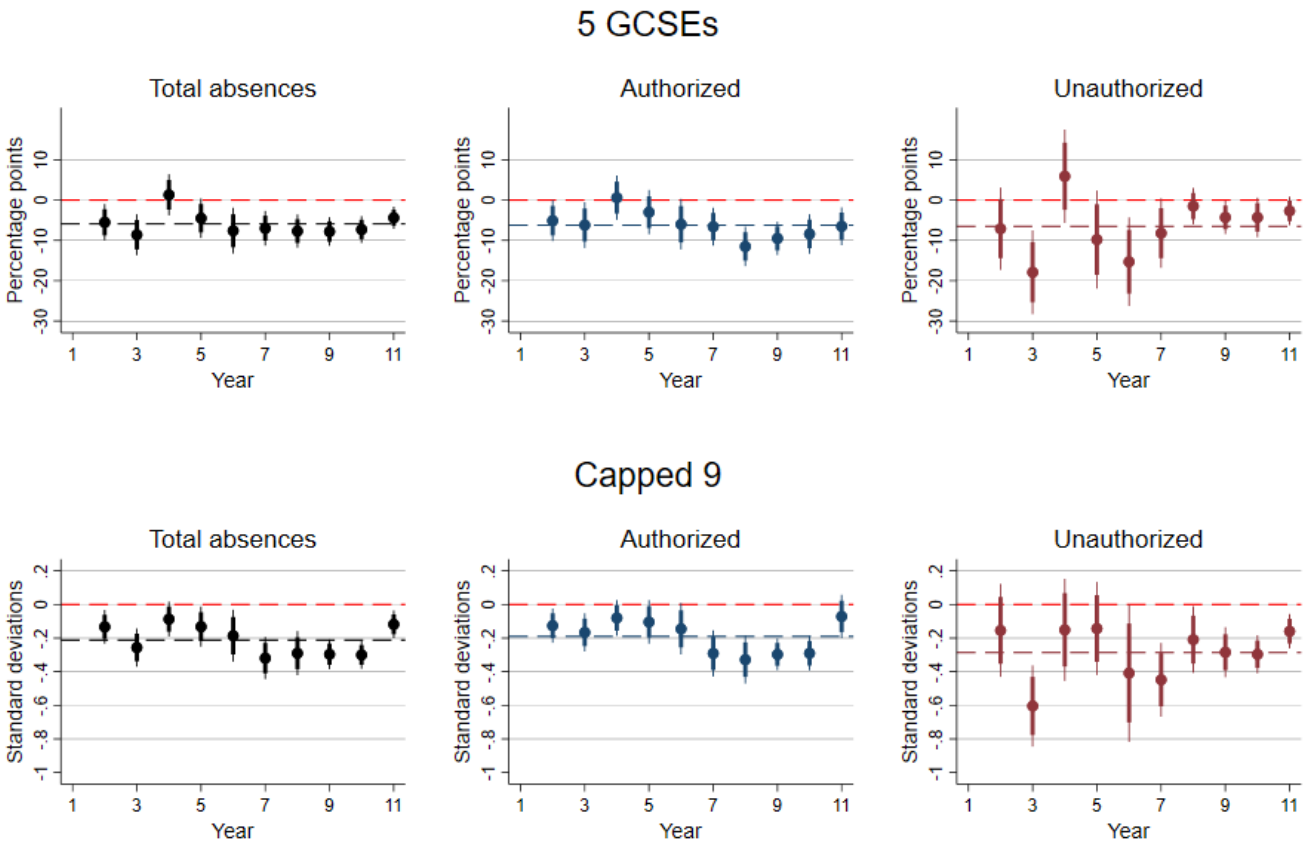


Table G1. Distribution of absences by year. N=1,730. Multiple imputed and weighted.

Note: "p50" shows the 50th percentile, "p10" the 10th percentile, and "p90" the 90th percentile of absences. The rightmost column shows the correlation between authorized and unauthorized absences in the same year. The columns "Overall", "Auth", and "Unauth" show the correlation of different types of absences in consecutive years.

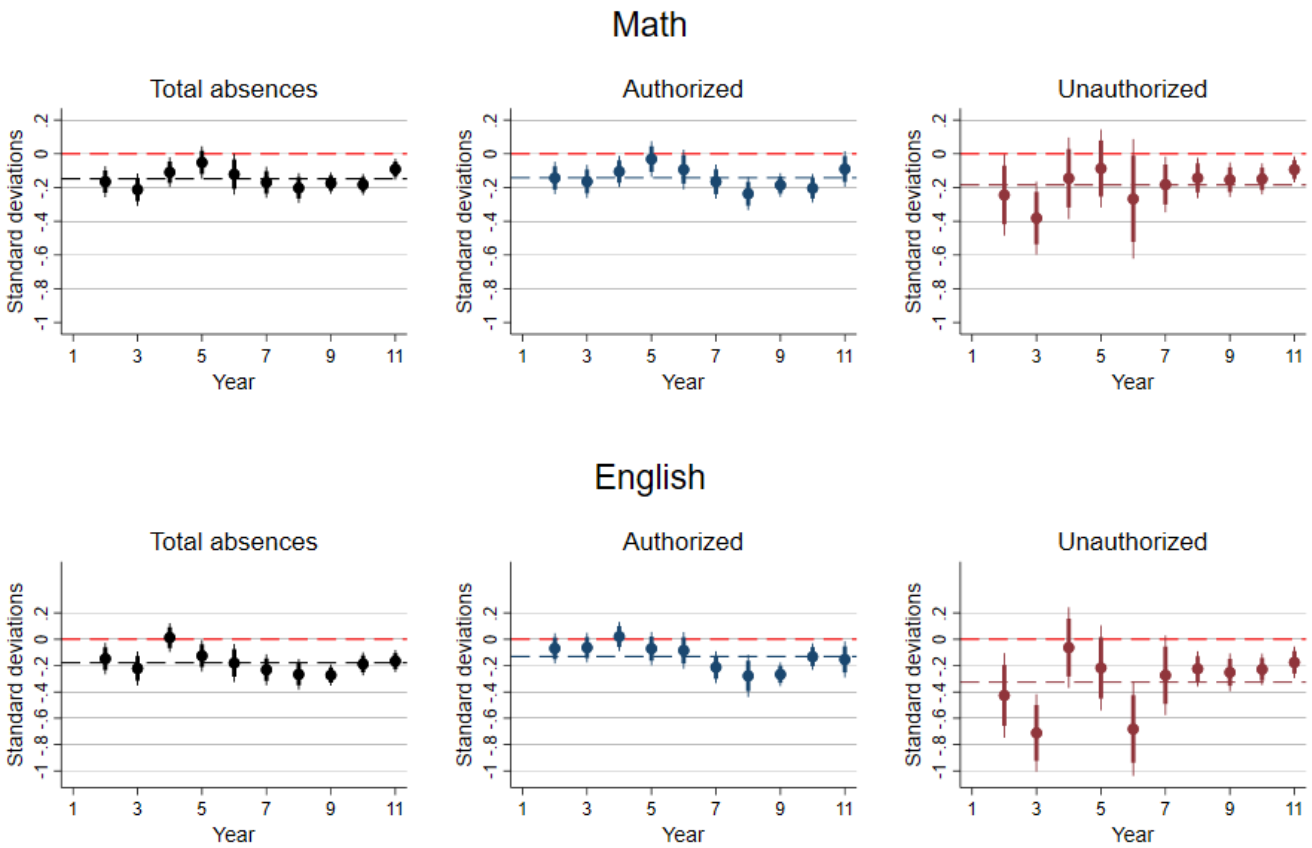
Year	Overall absences				Authorized absences				Unauthorized absences				Correlations			
	Mean	p50	p10	p90	Mean	p50	p10	p90	Mean	p50	p10	p90	Overall	Auth	Unauth	Auth-Unauth
2	0.056	0.043	0.008	0.116	0.049	0.040	0.005	0.103	0.007	0.000	0.000	0.016				0.105
3	0.054	0.041	0.006	0.116	0.047	0.037	0.005	0.096	0.008	0.000	0.000	0.021	0.668	0.573	0.570	0.150
4	0.057	0.043	0.008	0.122	0.050	0.038	0.005	0.108	0.007	0.000	0.000	0.020	0.679	0.608	0.721	0.144
5	0.059	0.045	0.008	0.124	0.052	0.040	0.005	0.108	0.007	0.000	0.000	0.021	0.663	0.589	0.647	0.144
6	0.052	0.038	0.005	0.114	0.045	0.035	0.005	0.097	0.006	0.000	0.000	0.016	0.685	0.591	0.646	0.192
7	0.052	0.036	0.007	0.114	0.047	0.033	0.006	0.105	0.005	0.000	0.000	0.013	0.629	0.527	0.353	0.149
8	0.053	0.037	0.003	0.119	0.045	0.032	0.003	0.102	0.008	0.000	0.000	0.023	0.626	0.554	0.500	0.097
9	0.056	0.039	0.003	0.123	0.047	0.032	0.003	0.103	0.010	0.000	0.000	0.026	0.695	0.580	0.644	0.072
10	0.058	0.035	0.003	0.134	0.046	0.032	0.003	0.104	0.012	0.000	0.000	0.028	0.654	0.588	0.584	0.188
11	0.063	0.038	0.003	0.143	0.044	0.029	0.000	0.100	0.018	0.000	0.000	0.039	0.654	0.532	0.643	0.128

Fig G2. Effect of absences on five or more GCSEs and Capped 9 by timing and reason for absence in Wales. N=1,730. Multiple imputed and weighted.



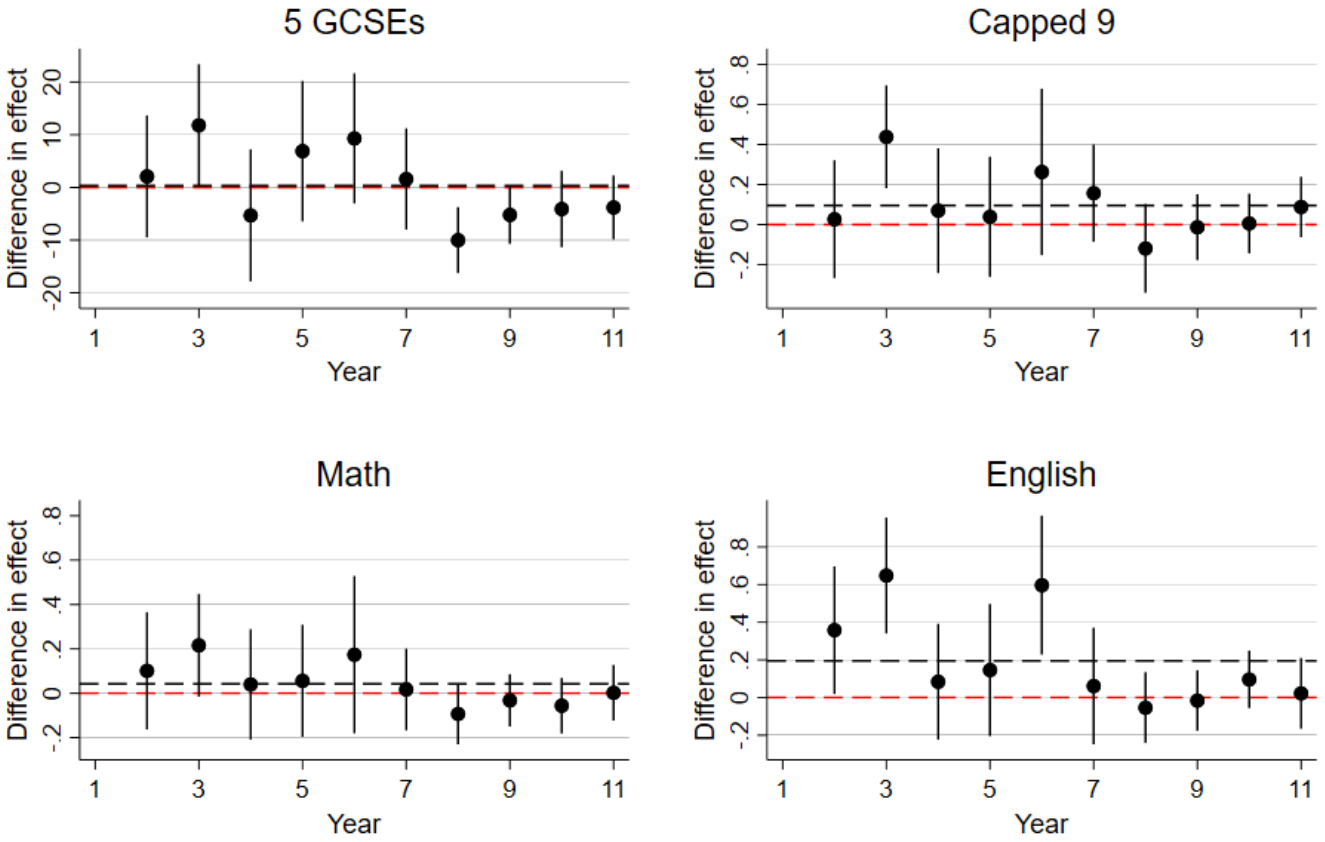
Note: Effects adjusted by confounders. Black dots: effects of overall absences, blue dots: effects of authorized absences, red dots: effects of unauthorized absences. 5 or more GCSEs is measured on a binary scale and Capped 9 on a continuous scale. The thin vertical lines represent the 95%-confidence intervals for determining whether effects differ statistically significantly from zero. The thick vertical lines indicate the 84%-confidence intervals to visually determine whether the effects of absences in different school years significantly differ from the effects of absences in other years (MacGregor-Fors & Payton, 2013). The dashed horizontal lines show the average effect across all years.

Fig G3. Effect of absences on math and English scores by timing and reason for absence in Wales. N=1,730. Multiple imputed and weighted.



Note: Effects adjusted by confounders. Black dots: effects of overall absences, blue dots: effects of authorized absences, red dots: effects of unauthorized absences. The thin vertical lines represent the 95%-confidence intervals for determining whether effects differ statistically significantly from zero. The thick vertical lines indicate the 84%-confidence intervals to visually determine whether the effects of absences in different school years significantly differ from the effects of absences in other years (MacGregor-Fors & Payton, 2013). The dashed horizontal lines show the average effect across all years.

Fig G4. Difference in the effect of authorized and unauthorized absences in Wales. N=1,730. Multiple imputed and weighted.



Note: Positive values indicate that unauthorized absences have larger effects. The dashed vertical line shows the average difference in the effect of authorized and unauthorized absences across all years. Thin vertical lines indicate the 95%-confidence intervals.

Table G2. Regression estimates for figures G2-G4.

Year	Overall absences		Authorized		Unauthorized		Difference between authorized and unauthorized	
	b	SE	b	SE	b	SE	b	SE
5 GCSEs								
2	-0.055	0.023	-0.051	0.026	-0.071	0.052	0.021	0.059
3	-0.086	0.026	-0.062	0.029	-0.179	0.053	0.118	0.059
4	0.013	0.026	0.006	0.028	0.059	0.059	-0.053	0.064
5	-0.045	0.025	-0.030	0.028	-0.098	0.062	0.069	0.068
6	-0.076	0.029	-0.060	0.032	-0.153	0.056	0.093	0.063
7	-0.070	0.022	-0.066	0.024	-0.082	0.044	0.016	0.049
8	-0.077	0.021	-0.115	0.025	-0.015	0.023	-0.100	0.032
9	-0.078	0.018	-0.095	0.021	-0.043	0.021	-0.052	0.028
10	-0.073	0.017	-0.084	0.025	-0.043	0.025	-0.041	0.037
11	-0.044	0.014	-0.065	0.024	-0.027	0.018	-0.038	0.031
Average	-0.059		-0.062		-0.065		0.003	
Capped 9 score								
2	-0.133	0.051	-0.126	0.052	-0.154	0.141	0.027	0.150
3	-0.256	0.058	-0.166	0.058	-0.604	0.123	0.438	0.131
4	-0.087	0.053	-0.080	0.054	-0.151	0.155	0.070	0.159
5	-0.132	0.061	-0.104	0.066	-0.143	0.141	0.039	0.153
6	-0.186	0.079	-0.145	0.078	-0.408	0.209	0.263	0.212
7	-0.319	0.064	-0.291	0.070	-0.448	0.112	0.157	0.124
8	-0.290	0.067	-0.328	0.073	-0.209	0.101	-0.119	0.113
9	-0.296	0.045	-0.297	0.048	-0.284	0.076	-0.013	0.084
10	-0.300	0.042	-0.290	0.052	-0.296	0.058	0.006	0.076
11	-0.118	0.042	-0.071	0.066	-0.159	0.052	0.088	0.077
Average	-0.212		-0.190		-0.286		0.096	
Math								
2	-0.165	0.047	-0.143	0.049	-0.244	0.123	0.101	0.135
3	-0.212	0.049	-0.164	0.050	-0.381	0.110	0.216	0.118
4	-0.109	0.045	-0.105	0.047	-0.145	0.123	0.040	0.127
5	-0.051	0.049	-0.031	0.054	-0.087	0.118	0.056	0.129
6	-0.121	0.062	-0.093	0.060	-0.267	0.181	0.174	0.181
7	-0.169	0.047	-0.165	0.052	-0.182	0.084	0.017	0.094
8	-0.202	0.045	-0.236	0.050	-0.143	0.061	-0.093	0.070
9	-0.174	0.032	-0.185	0.036	-0.153	0.052	-0.032	0.060
10	-0.182	0.032	-0.204	0.043	-0.149	0.047	-0.056	0.064
11	-0.091	0.032	-0.090	0.054	-0.093	0.039	0.002	0.064
Average	-0.148		-0.142		-0.184		0.043	
English								
2	-0.147	0.061	-0.069	0.059	-0.426	0.164	0.358	0.173
3	-0.221	0.066	-0.063	0.057	-0.711	0.150	0.648	0.157
4	0.013	0.056	0.021	0.056	-0.063	0.156	0.084	0.157
5	-0.125	0.061	-0.071	0.065	-0.217	0.165	0.146	0.179
6	-0.180	0.074	-0.084	0.071	-0.681	0.182	0.597	0.188

7	-0.231	0.060	-0.212	0.062	-0.273	0.154	0.061	0.158
8	-0.266	0.059	-0.278	0.082	-0.224	0.068	-0.054	0.096
9	-0.272	0.041	-0.266	0.046	-0.251	0.073	-0.016	0.082
10	-0.187	0.045	-0.132	0.051	-0.228	0.061	0.096	0.078
11	-0.165	0.043	-0.153	0.070	-0.175	0.061	0.022	0.096
Average	-0.178		-0.131		-0.325		0.194	