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DISCUSSION PAPER SERIES

IZA DP No. 12396

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ABSTRACT

Neighbourhood and School Poverty Simultaneously Predicting Educational Achievement, Taking into Account Timing and Duration of Exposure

Research on neighbourhood effects indicates that neighbourhood poverty is related to educational outcomes of youth, however, much less attention is spend on studying neighbourhood and school effects simultaneously. Because the demographic composition of both contexts likely overlaps to some extent, it is possible that the effect both contexts have is not independent of each other. Throughout the early teenage years the neighbourhood and school contexts can vary, advocating for a life-course approach, including how the timing and duration of exposure to either contexts affect educational achievement. Using the Avon Longitudinal Study of Parents and Children (ALSPAC) birth cohort (N=4,502), we employed cross-classified multilevel models to examine the timing and duration of exposure to poverty in neighbourhood and school contexts between ages 10 and 16, to predict educational achievement of adolescents at age 16. Our results indicate that neighbourhood poverty impacts on educational achievement, independent of school poverty. Furthermore, we found that for neighbourhood poverty, especially enduring exposure impacts on educational achievement, while the timing of exposure does not play a role. However, for school poverty, both timing and duration play a role: longer exposure is related to lower achievement, but also exposure at an earlier age has a stronger impact than exposure at a later age. Finally, the lowest educational achievement was observed in adolescents who were exposed to poverty in both contexts for the full observation period. In sum, our analyses indicate that, when studying contextual disadvantage, it is crucial to consider how variations over time in different contexts might be related and how they might influence the study.

JEL Classification: I24, R23

Keywords: neighbourhoods, schools, poverty, educational achievement, ALSPAC

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Introduction

Researchers of urban poverty have for a long time acknowledged the importance of studying the effects of neighbourhood poverty on educational outcomes for children and adolescents (for reviews, see Dietz, 2002; Jencks & Mayer, 1990; Leventhal & Brooks-Gunn, 2000; Nieuwenhuis & Hooimeijer, 2016). However, when it comes to the educational development of adolescents, the school context is very likely to play an important role as well (Bronfenbrenner, 1979; Nieuwenhuis, 2018). With a few notable exceptions (e.g., Ainsworth, 2002; Kauppinen, 2008; Sykes & Musterd, 2011; Wodtke & Parbst, 2017), the field of neighbourhood effects not often explicitly studies both the neighbourhood and school context simultaneously. At the same time, studies focussing on school effects on children, often do not take into account possible neighbourhood effects (Gaias et al., 2017). There are many reasons to suspect that neighbourhood and school effects may overlap, intersect, or even reinforce each other. Not in the least because schools are often located within or near neighbourhoods where people live and where people have the same information about educational opportunities. Therefore, the demographic composition of both contexts is likely to overlap to some extent. But each might also have its own independent effect on individual outcomes. In this study we argue that to fully understand the influence of either neighbourhood poverty or school poverty on educational achievement of adolescence, it is crucial to study them in tandem.

Like many other fields, the field of neighbourhood effects studies has seen a surge in longitudinal studies in recent years, due to increased data availability. This has led to an increased understanding of the role of time when studying neighbourhood effects (e.g., Alvarado, 2016; Kleinepier et al., 2018; Nieuwenhuis et al., 2016; Wodtke, 2013; Wodtke et al., 2011). What we learn from these studies is that to measure contextual effects, a cross-sectional approach is often not sufficient, and that the duration and the timing of exposure to a poor context matters. First, longer exposure to poverty is likely to have a stronger impact on outcomes than short-term exposure. And second, exposure to poverty at an early, more formative age, is likely to have a stronger impact than exposure at a later age. Therefore, in this study, besides examining the combined effects of schools and neighbourhoods, we study the effects of duration and timing of exposure to poverty in both contexts as well.

In this study, we examine the effects of neighbourhood poverty and school poverty on adolescents' educational achievement in the United Kingdom simultaneously by employing cross-classified multilevel models, to account for the clustering of individuals in both neighbourhoods and schools. Additionally, we examine duration and timing of exposure to neighbourhood and school poverty by studying the exposure to either at three different ages in the adolescents' lives: 10/11, 13/14, and 15/16. This approach allows us to examine both the importance of schools when studying neighbourhoods, as well as to examine the importance of time when studying neighbourhoods and schools simultaneously.

Neighbourhood effects and/or school effects

Neighbourhoods and schools can be regarded as competing contexts when explaining educational outcomes of adolescents. Both are considered to exert an influence on adolescents' educational development, however, because they can often not be seen independent from each other, it is important to study them simultaneously. Neighbourhood effects researchers often argue for a relation between neighbourhood poverty and educational achievement because of a variety of proposed mechanisms. For example, levels of adult role models, supervision and social control may differ between neighbourhoods; neighbourhood-based social networks may provide different sources of information and resources pertaining to educational opportunities; and the exposure to deviant peers can depend on the quality of the neighbourhood (for an overview, see Galster, 2012). All these mechanisms deal with the demographic composition of neighbourhoods and predict that the behaviour of other residents influences the education-related behaviour of adolescents in these neighbourhoods. However, it is very likely that the demographic composition of the neighbourhood is also represented in the school. School catchment areas determine which schools parents can choose from, and these catchment areas are the same for neighbours, meaning that their children will end up within the same limited set of schools in the area. Poor neighbourhoods are often faced with poor schools that have more problems attracting good teaching staff because of a lack of resources and a bad reputation (Jencks & Mayer, 1990; Wacquant, 2008). In catchment areas where schools are of low quality, parents may want to overcome this problem by sending their children to private schools, however, especially in the poorer neighbourhoods, most parents will not have the resources to be able to afford the private school tuitions. Besides catchment areas, geographical proximity in general affects the choice between institutions, because traveling time should remain manageable. Because of the strong link between poverty and the demographic composition of neighbourhoods and schools, it has been argued that schools are a pathway through which neighbourhood effects transpire (Galster, 2012; Nieuwenhuis & Hooimeijer, 2016; Wodtke & Parbst, 2017).

Despite the relevance of school context for neighbourhood effects studies, only about one quarter of studies that examine the relation between neighbourhood poverty and educational outcomes take into account school-related control variables (Nieuwenhuis & Hooimeijer, 2016). Those studies that do take into account school-related control variables find a much weaker neighbourhood effect, compared to those studies that do not take this into account (Nieuwenhuis & Hooimeijer, 2016). The studies that specifically study the combined effects of neighbourhoods and school on educational outcomes find mixed results. Sykes and Musterd (2008) find that the neighbourhood effect disappears all together after modelling the neighbourhood and school together, while Bowen and Bowen (1999) find that it remains. Others find partial mediation of the neighbourhood effect through school factors (Ainsworth, 2002), no mediation by school poverty (Wodtke & Parbst, 2017), that the results depend on how the neighbourhood and school characteristics are measured (Owens, 2010; Pong & Hao, 2007), and that the neighbourhood-level variance decreases after taking schools into account (Brännström, 2008; Kauppinen, 2008). Although the relation between neighbourhood poverty and school poverty is not evident, most of the above mentioned studies do seem to suggest that they are not independent of each other.

If neighbourhood poverty and school poverty are indeed not independent from each other, it is important to take both into account simultaneously, in order not to overestimate the importance of one or the other. When schools are indeed a pathway through which neighbourhood effects are expressed, school poverty will (partly) explain the effect of neighbourhood poverty. This leads to the following two hypotheses:

- The effect of neighbourhood poverty on educational achievement will be smaller when taking into account school poverty (H1).
- The neighbourhood-level variance of educational achievement will be less when taking into account school poverty (H2).

Duration of exposure

The neighbourhoods in which people live and the schools they attend during their life are often not fixed. People move and transfer, leading to divergent neighbourhood and school histories over the life-time between people. Some adolescents may grow up their whole childhood in a disadvantaged neighbourhood, while others may only live shortly in such a neighbourhood (Kleinepier & van Ham, 2017). Many of the mechanisms through which neighbourhoods and schools are hypothesised to impact on educational achievement are based on community characteristics (see Galster, 2012). Poor neighbourhoods and schools have few social resources and poorer social organisation. Children in such deprived contexts will be less stimulated to perform well in school. However, if adolescents are exposed to a deprived context for only a brief period, the impact it may have is arguably smaller compared to being exposed to poverty for the duration of the childhood. Moreover, the exposure to non-deprived contexts may even buffer the negative impact of the deprived context, because adolescents and their parents may retain resources and social networks from previous non-deprived contexts. This notion is important, because many studies of contextual poverty have studied a point-in-time measure of poverty, rather than take a longitudinal perspective. This has the disadvantage of only studying one certain moment in the life of adolescents, while two adolescents who live in a poor neighbourhood at the time of measurement may have had a very different unmeasured neighbourhood history up until that point. Several studies already found that a longitudinal approach to contextual poverty has more predictive power than a cross-sectional approach, suggesting that long-term exposure has more impact on educational outcomes than short-term exposure (Hicks et al., 2018; Wodtke et al., 2011). This idea leads to the following hypotheses:

- The longer adolescents are exposed to neighbourhood poverty, the lower their educational achievement (H3a).
- The longer adolescents are exposed to school poverty, the lower their educational achievement (H3b).

Timing of exposure

In contrast to the increased attention for duration of exposure to neighbourhood/school poverty in recent years, the developmental timing of exposure has received much less attention thus far.

Previous studies that do take the timing of exposure into account have typically made a two-fold distinction between early/middle childhood on the one hand (ages 0-10 years) and adolescence on the other (ages 11-20 years). These studies have consistently reported that exposure to poor neighbourhoods during adolescence has stronger effects on individual outcomes than exposure to neighbourhood poverty in early and/or middle childhood (e.g., Kleinepier & van Ham, 2018; Wodtke, 2013; Wodtke et al., 2016). An explanation for these findings has been sought in other studies showing that adolescents are more susceptible to peer pressure than are children or (young) adults (Prinstein & Dodge, 2008). Indeed, during adolescence, there is sharp increase in the amount of time spent with peers (Brown, 2004). Moreover, this coincides with heightened sensation-seeking, risky behaviour, and a growing contrast between peer and family values, for example regarding the importance of doing well in school (Gardner & Steinberg, 2005).

Given the importance of adolescent exposure to contextual poverty, we specifically focus on this developmental stage in the current study. Importantly, susceptibility to peer socialization has also been found to change over the course of adolescence itself. Several studies have shown that susceptibility to peer pressure follows a curvilinear trend, increasing during early adolescence, peaking around age 13-14, and declining thereafter (Steinberg, 2010; Steinberg & Monahan, 2007; Zohar et al., 2018). The period around ages 13-14 has been viewed as impulsive and rebellious as young teenagers experiments with new ways of behaving as they develop autonomy from their parents. At the same time that early teens become more independent from their parents, they also become more receptive to the norms favored by their peers. Once a person has begun to internalize his/her own identity around age 14, the person gradually becomes less and less susceptible to either parental or peer influence (Zohar et al., 2018).

Because peer socialization is widely regarded one of the key mechanisms through which the neighbourhood and school contexts may affect adolescents' outcomes (Galster, 2012; Jencks & Mayer, 1990), we come to the following hypotheses:

- The relation between exposure to neighbourhood poverty and educational achievement is stronger during middle adolescence (ages 13-14 years) than earlier (ages 10-11 years) and later in adolescence (ages 15-16 years) (H4a).
- The relation between exposure to school poverty and educational achievement is stronger during middle adolescence (ages 13-14 years) than earlier (ages 10-11 years) and later in adolescence (ages 15-16 years) (H4b).

Cumulative contextual poverty

Growing up in a poor neighbourhood and attending a poor school both may have their separate negative impact on adolescents' educational achievement. However, being exposed to poverty in both contexts effectively increases the overall exposure to poverty. Exposure to poverty in multiple contexts potentially has a larger impact on educational achievement than experiencing poverty at only one context (Mijs & Nieuwenhuis, 2018; Whipple et al., 2010). Being exposed

to, for example, three periods of both school and neighbourhood poverty is likely to have a very different impact on educational achievement than being exposed to three periods of school poverty, but growing up in a middle-class or wealthy neighbourhood. We formulated two hypotheses, one for the duration of exposure, and one for the timing:

- The longer adolescents are exposed to poor neighbourhood and school contexts, the lower their educational achievement (H5).
- The relation between exposure to poor neighbourhood and school contexts and educational achievement is stronger during middle adolescence (ages 13-14 years) than earlier (ages 10-11 years) and later in adolescence (ages 15-16 years) (H6).

The current study

In the current study we aim to examine the relevance of school poverty when studying the effect of neighbourhood poverty on educational achievement, using data from a study from south-west England, United Kingdom. First, we study the relative importance of both neighbourhood and school contexts by using cross-classified multilevel models. Such models can account for the clustering of individuals within different non-nested contexts, in this case neighbourhoods and schools. We examine the importance of both contexts for educational achievement in general, by studying a comprehensive measure of educational achievement that includes scores from the Key Stage 4 tests on reading, math, and science (taken at age 15/16). Second, we aim to assess the importance of time within this neighbourhood-school framework by specifically modelling the duration and timing of exposure to neighbourhood and school poverty. This allows us to understand differences between short-term and long-term exposure, as well as between exposure at early ages compared to later ages in adolescence. To do this we measured neighbourhood and school poverty at three different ages in the adolescents' lives (i.e., at 10/11, 13/14, and 15/16). Third, building on the previous points, we combine neighbourhood and school poverty to study more general cumulative poverty during adolescence. With this cumulative measure we will again study the importance of duration and timing of exposure to poverty. Studying neighbourhoods and school simultaneously and cumulatively, while including duration and timing, will give a more comprehensive understanding of the importance of schools when studying neighbourhoods.

Data and methods

Participants

To test our hypotheses, we used the Avon Longitudinal Study of Parents and Children (ALSPAC), an ongoing population based cohort study that recruited 14,541 pregnant women living in the county of Avon, UK, and who were expected to give birth between April 1st, 1991 and December 31st, 1992. There was an additional enrolment of 713 children. The total sample consisted of 15,458 fetuses, of which 14,701 were alive at age 1 (Boyd et al., 2013; Fraser et al., 2013). We obtained educational test results and aggregated neighbourhood and school

information by linking ALSPAC data on children's school and neighbourhood histories to national databases, such as the Annual School Census and the National Pupil Database. Our study sample consisted of 4,502 adolescents, for whom information was available about their neighbourhood and school contexts, as well as their educational results. Please note that the study website contains details of all the data that is available through a fully searchable data dictionary at <http://www.bris.ac.uk/alspac/researchers/data-access/data-dictionary/>.

Variables

Our dependent variable is a factor score of three standardised test results (reading, math, and science) taken for the Key Stage 4 test at age 15/16. These results were linked in through the National Pupil Database (NPD). The factor analysis showed a clear indication of one factor, with factor loadings of .82 (reading), .88 (math), and .89 (science). Descriptive statistics for this and other variables can be found in Table 1.

--- Table 1 about here ---

To measure exposure to contextual poverty, we looked at two contexts, the neighbourhood and the school, and at three time points, ages 10/11, 13/14, and 15/16. Neighbourhood poverty was measured using government issued Indices of Multiple Deprivation (IMD) for the neighbourhood in which the adolescents lived during the three measurement periods (Payne & Abel, 2012). The IMD consists of the following characteristics: income; employment; health and disability; education, skills and training; barriers to housing and services; living environment; and crime. The IMD comes in deciles, ranging from the 1st (least deprived) to the 10th (most deprived). To measure exposure to neighbourhood poverty, we marked those adolescents that lived in the two most deprived deciles of the IMD.

As a commonly used proxy for school poverty (Gorard, 2012), we used the proportion of children eligible for school meals in the schools that adolescents attended at the three measurement periods. This measure was available from the Annual School Census. To measure exposure to school poverty, we marked those adolescents that attended the poorest 10% of schools. To give insight in the percentage of adolescents who experience poverty at different time points and for multiple time point, we show these percentages for both contexts in Tables 2 and 3.

--- Table 2 about here ---

--- Table 3 about here ---

We control for parents' highest education, gender, previous educational achievement, and moving. Parents' highest education was measured as the highest education received by either of the parents, divided into five categories: 1) Certificate of Secondary Education (CSE) or General Certificate of Secondary Education (GCSE) levels D, E, F, or G; 2) vocational; 3) Ordinary Level (O Level) or GCSE levels A, B, or C; 4) Advanced Level (A Level); and 5)

university degree. Gender was included into the models as a female = 1 and male = 0. Previous educational achievement was measured as the summary score of the adolescents' Key Stage 1 test results, a test administered around age 7. Moving was measured as whether the adolescents' had moved to a different neighbourhood between the three measurement periods.

Analyses

To study the combined effects of neighbourhoods and schools, we used cross-classified multilevel models. The structure of the data is such that individuals are nested in neighbourhoods (defined as Lower layer Super Output Areas (LSOAs) and schools, but schools are not nested within in neighbourhoods. This represents a cross-classified data structure, which can be taken into account with cross-classified multilevel models, and thus does not ignore the interdependencies between individuals within both contexts. To run these models, we used MlwiN 2.35 through Stata 15.1 using the user written runmlwin command (Leckie & Charlton, 2013). MlwiN uses Markov Chain Monte Carlo (MCMC) methods to calculate these models. We used Iterative Generalized Least Squares (IGLS) estimates of our models as initial values for the MCMC model parameters.

We performed three sets of analyses to test our different sets of hypotheses. First, to examine the role of duration, we studied count variables of years of exposure to school poverty and neighbourhood poverty. Because we had three measurement periods, focussed on the time of the Key Stage 2-4 tests, these variables ran from (0) no exposure to (1) three periods of exposure to poverty. We ran the model first with neighbourhood poverty only, and then we included school poverty as well.

Second, to test the timing hypotheses, we used dummy variables of whether respondents had been exposed to poverty in the neighbourhood or school context, at the three different measurement periods. Again, we first ran a model with only neighbourhood, and then with both neighbourhood and school poverty.

Finally, we combined neighbourhood and school poverty in a measure for cumulative contextual poverty. We first ran a model for the duration hypothesis, where respondents could be exposed to zero through six instances of either school or neighbourhood poverty. Next, for the timing hypothesis, we looked at each measurement period whether respondents were (0) not exposed to poverty, (1) exposed to either school or neighbourhood poverty, or (2) to both school and neighbourhood poverty. This final set of analyses has the downside that we cannot analyses the differences between neighbourhood and school effects, but these were already present in the previous models. The upside is that they allow for a better cumulative measure of experienced poverty than the models with separate contexts.

To deal with potential selection bias arising from children with a certain educational advantage going to different schools or living in different neighbourhoods than children with a certain educational disadvantage, we include a pre-treatment control variable in the models, which is previous educational achievement, as measured about three years before the first measurement

period for neighbourhood and school poverty. This (partly) takes care of the variance potentially introduced by heritability or the different learning environments parents from different socio-economic backgrounds are able to provide for their children. All models were run without previous educational achievement as well (see Appendix A), and this indeed indicates selection bias, as these models have larger and more often significant coefficients.

Results

To gain insight into the combination of adolescents' exposures to neighbourhood and school poverty, we cross-tabulated both to see how many people experience how much poverty each context separately and combined (Table 4). The results show that most adolescents were not exposed to poverty in either context. What also stands out is that most adolescents who were exposed to neighbourhood poverty were exposed for the maximum of three periods, while exposure to school poverty shows a decreasing number of individuals. Most adolescents who experienced school poverty were exposed for only one period, and the least were exposed to three periods of school poverty. This suggests that neighbourhood poverty is more persisting than school poverty, and also that neighbourhood and school poverty are not perfectly correlated. Adolescents who were exposed to three periods of neighbourhood poverty also had higher rates of exposure to school poverty and the highest rate of exposure to three periods of school poverty.

--- Table 4 about here ---

Model 1 of Table 5 examines the influence of the duration of exposure to neighbourhood poverty on educational achievement. We see that one or two periods of exposure to neighbourhood poverty shows no difference from not being exposed to neighbourhood poverty. Adolescents who were exposed for three periods had lower levels of educational achievement than adolescents who were not exposed to neighbourhood poverty, which is in support of hypothesis 3a. Model 2 of Table 5 includes the duration of exposure to school poverty. Although the coefficient of being exposed to three periods of neighbourhood poverty and the proportion of variance explained by the neighbourhood level both decrease, the decrease is not significant, thus we find no support for hypotheses 1 and 2. In line with hypothesis 3b, we also find that the duration of exposure to school poverty predicts educational achievement: adolescents who were exposed for two or three periods of school poverty had lower levels of educational achievement. Furthermore, previous educational achievement and parental education both positively predict educational achievement. Also, the more times adolescents moved, the lower their educational achievement.

--- Table 5 about here ---

Model 1 of Table 6 includes the timing of exposure to neighbourhood poverty, but we find no effects for the three different periods of exposure to neighbourhood poverty, suggesting that cumulative exposure (see Table 5) is more important when predicting educational achievement.

Thus we find no support for the hypothesis that the timing of exposure to neighbourhood poverty is differentially related to educational achievement (H4a). Model 2 of Table 6 includes the timing of exposure to school poverty, and in line with hypothesis 4b we find that exposure to school poverty at age 13/14 is strongest related to educational achievement compared to earlier or later ages. Additionally, we find that adolescents who moved in a later period had lower educational achievement than adolescents who moved in an earlier period.

--- Table 6 about here ---

Model 1 of Table 7 includes the duration of exposure to contextual poverty, which includes both exposure to neighbourhood poverty and to school poverty. Adolescents who were exposed to contextual poverty once or twice showed no differences in educational achievement to those who were never exposed, however, adolescents who were exposed three times or more had lower levels of educational achievement. The number of exposures is incremental with the effect size, suggesting that increased exposure to multiple contexts of poverty is related to lower levels of educational achievement compared to lower numbers of exposure. Using different reference categories, we find that being exposed to six instances of contextual poverty was related to lower educational achievement than being exposed four times ($b = .28$, s.e. = .09, $p = .002$) or lower, and being exposed to five instances of poverty was related to lower educational achievement than two times ($b = .33$, s.e. = .08, $p < .001$) or lower. This is in line with hypothesis 5, which predicts that longer exposure is related with lower achievement. Model 2 of Table 7 examines the importance of timing of exposure to contextual poverty. We find that being exposed to contextual poverty at ages 10/11 and 13/14 was related to educational achievement, albeit only with a significance level of 10% for age 10/11. Exposure at age 15/16 was not related to educational achievement. This finding is in line with hypothesis 6, that exposure to contextual poverty at age 13/14 is stronger related to educational achievement than at other ages.

--- Table 7 about here ---

Discussion

To study the combined effects of neighbourhood poverty and school poverty on adolescents' educational achievement is of crucial importance when trying to understand how context relates to adolescents chances in life. Therefore, we studied how educational achievement at age 16 in England is affected by the simultaneous exposure to three periods of neighbourhood poverty and school poverty. By studying three different periods of exposure to poverty, we could also disentangle differential effects of early vs. late exposure, and prolonged exposure vs. short spells of exposure to contextual poverty.

We expected that the effect of exposure to neighbourhood poverty would be diminished by including school poverty (H1 and H2), however, we did not find support for this expectation. This suggests that neighbourhood poverty in itself impacts on adolescents' educational achievement, independent of school poverty. This is in line with a recent study that did not find

a mediating effect of school poverty on the relation between neighbourhood poverty and educational achievement in the US (Wodtke & Parbst, 2017), however, not in line with a study from the Netherlands which found that neighbourhood effects disappear after including school characteristics (Sykes & Musterd, 2008). It is not unlikely that the much steeper levels of segregation in the UK and the US also result in a higher likelihood of finding neighbourhood effects, whereas in a country like the Netherlands, with much lower levels of segregation and fewer neighbourhoods with high poverty concentrations, neighbourhoods are of less importance when predicting educational achievement (Nieuwenhuis & Hooimeijer, 2016; Nieuwenhuis et al., 2019). The lack of support for hypotheses 1 and 2 therefore may be due to the higher comparability of UK's segregation levels to those of the US, as compared to those of the Netherlands. In the UK, neighbourhood effects are not explained through school effects, but neighbourhood poverty leads to lower educational achievement, despite of the school adolescents attend.

Next, we examined duration and timing effects. First, in line with hypotheses 3a and 3b, we found that longer exposure to either neighbourhood (H3a) or school poverty (H3b) relates to lower educational achievement. Adolescents who were exposed for only one period to school poverty or one or two periods to neighbourhood poverty did not have different educational achievement compared to unexposed adolescents. However, exposure to two or three periods of school poverty or three periods of neighbourhood poverty did lead to lower educational achievement. This corroborates other studies (Hicks et al., 2018; Wodtke et al., 2011) that find that prolonged exposure has a more severe impact on adolescents' educational outcomes than short-term exposure. This finding highlights again the importance of studying enduring exposure to contextual poverty, rather than the often seen cross-sectional approach of studying exposure and outcomes at the same point in time.

Second, we studied the effect of timing of exposure to poverty. We hypothesised that exposure to neighbourhood (H4a) and school poverty (H4b) at age 13/14 is stronger related to educational achievement than at earlier (10/11) or later ages (15/16). For neighbourhood poverty we find no differences in adolescents' educational achievement dependent on whether they were exposed at an early age or a later age, thus finding no support for hypothesis 4a. When not taking into account prior educational achievement, we find that exposure to neighbourhood poverty at a later age has a stronger effect than neighbourhood poverty at an earlier age. However, this finding seems to be driven by selection only. Furthermore, in line with hypothesis 4b we do find that exposure to school poverty at age 13/14 is stronger related to educational achievement than exposure at ages 10/11 and 15/16. For neighbourhood poverty this suggests that especially enduring exposure is important, but within the timeframe of our study, the timing of this exposure does not play an important role. However, for school poverty both timing and duration seem to play a role when predicting educational achievement. Earlier exposure has a stronger impact on educational achievement than later exposure. In a recent paper, Chetty and colleagues (2015) argue that interventions in early-age contextual poverty are more beneficial for later life income, compared to interventions during ages late in adolescence. Our finding that exposure to school poverty at age 13/14 has a stronger impact on educational achievement than exposure at other ages supports the finding that interventions with young people are most

beneficial when targeting issues of educational stratification in a school context. But our results also nuance this finding by pointing out that at different ages interventions will have a different impact.

Finally, we studied the cumulative exposure to either neighbourhood and/or school poverty. In line with the separate hypotheses for neighbourhood and school, we found here as well that the longer the exposure to several contexts of poverty, the lower adolescents' educational achievement (H5), and exposure at age 13/14 is stronger related to educational achievement than exposure at other ages (H6). Combining the contextual measures of poverty showed that a cumulative perspective on contextual poverty adds an additional explanatory perspective to the study of educational achievement and poverty. Exposure to one or two periods of contextual poverty does not affect educational achievement, however, the more exposure to neighbourhood and school poverty, the lower adolescents' educational achievement. The strongest impact was observed for adolescents who were exposed to poverty for the maximum of three periods in both the neighbourhood and the school context.

Selection bias

Parental socio-economic status normally strongly influences the type of neighbourhoods in which adolescents grow up and the quality of the schools they attend. Not properly taking this selection into account can lead to spurious contextual effects that could be explained by the sorting of families with different SES sorting into different neighbourhoods and schools. We tried to overcome this first by using a cross-classified multilevel model which takes into account the multiple membership structure of adolescents in neighbourhoods and schools. This serves the better estimation of standard errors of the higher level predictor variables, therewith not overestimating the significance of contextual predictors. Second, we controlled for parental education and adolescents' own previously achieved educational results. Parental education partly deals with the potential bias that can arise by parental selection into neighbourhood based on their educational background. Adolescents' previous educational achievement was measured pre-treatment, that is, just before the periods of exposure to contextual poverty that we studied. This partly controls for confounding introduced through the parents. For example, selection due to heritability of educational achievement (Okbay et al., 2016) is partly captured by this measure: if parents who have a higher education also have higher educated children as well as better paying jobs that can buy them into wealthier neighbourhoods and better schools, this could introduce a bias. The same argument applies to higher educated parents being able to provide their children with the appropriate cultural capital to succeed in education (Bourdieu & Passeron, 1990), as well as having jobs with better salaries that allow them access to low-poverty contexts. By controlling for educational achievement just before our study-period, we take out much of this variance. The models that did not include prior educational achievement indeed showed stronger neighbourhood and school effects. This suggests that the models that take prior educational achievement into account take care of some of the selection bias and are more indicative of the influence of neighbourhoods and schools on educational achievement.

Conclusion

To conclude, we argue that it is important to examine both neighbourhood and school effects simultaneously, when studying educational achievement. However, institutional context is likely to play an important role in how much both contexts are interdependent. Places with high levels of socio-economic segregation may not see much interaction between the two contexts, because growing up in a poor neighbourhood will likely also mean attending a poor school. While in places with more egalitarian educational policies, neighbourhood poverty and school poverty may not be strongly related, and negative influences from the neighbourhood may be buffered by a good school environment. Finally, since prolonged and early exposure to contextual poverty seem most harmful, when interventions are considered, it is important to implement them early on in the life-course.

Ethical approval

Ethical approval for the study was obtained from the ALSPAC Ethics and Law Committee and the Local Research Ethics Committees.

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Tables

Table 1. Descriptive statistics (N = 4,502)

Variable	Mean	SD	Min.	Max.
Educational achievement (factor score)	.02	.90	-3.70	1.92
Previous educational achievement	9.53	3.50	0	15
	%			
Parental education: CSE or GCSE (D, E, F)	14.68			
- Vocational	7.26			
- O level or GCSE (A, B, C)	30.61			
- A level	32.92			
- University degree	14.53			
Gender (female)	49.27			
Times moved: 0	87.32			
- 1	11.99			
- 2	.69			
Moved between period 10/11 and 13/14	10.93			
Moved between period 13/14 and 15/16	2.44			

Table 2. Periods of exposure to poverty (%) (N = 4,502)

Context	0	1	2	3	4	5	6
Neighbourhood	83.90	2.78	2.02	11.31			
School	85.36	7.29	4.51	2.84			
Both	78.28	5.04	3.71	5.35	3.22	2.22	2.18

Table 3. Exposure to poverty at different periods (%) (N = 4,502)

Context	No	Yes/One	Both
Neighbourhood at age 10/11	86.38	13.62	
Neighbourhood at age 13/14	86.58	13.42	
Neighbourhood at age 15/16	86.29	13.71	
School at age 10/11	91.23	8.77	
School at age 13/14	92.63	7.37	
School at age 15/16	91.31	8.69	
Both at age 10/11	84.18	9.24	6.57
Both at age 13/14	83.21	12.79	4.00
Both at age 15/16	82.30	13.02	4.69

Table 4. Individuals in sample with periods of exposure to neighbourhood poverty by periods of exposure to school poverty

	Periods of exposure to school poverty				
Periods of exposure to neighbourhood poverty	0	1	2	3	Total
0	3,524	151	87	15	3,777
1	76	26	17	6	125
2	54	20	8	9	91
3	189	131	91	98	509
Total	3,843	328	203	128	4,502

Table 5. Cross-classified multilevel analyses for educational achievement: Duration of exposure to neighbourhood and school poverty (N = 4,502)

	M1			M2		
	B	SE	p	B	SE	p
Periods of exposure to neighbourhood poverty (ref.=0)						
- 1	-.03	.06	.632	-.01	.06	.909
- 2	-.10	.07	.144	-.07	.07	.274
- 3	-.21	.04	<.001	-.15	.04	<.001
Periods of exposure to school poverty (ref.=0)						
- 1				-.02	.04	.579
- 2				-.14	.05	.009
- 3				-.39	.08	<.001
Previous educational achievement	.15	.00	<.001	.15	.00	<.001
Parental educ. (ref.=CSE or GCSE (D, E, F))						
- Vocational	.05	.04	.267	.04	.04	.317
- O level or GCSE (A, B, C)	.18	.03	<.001	.18	.03	<.001
- A level	.33	.03	<.001	.33	.03	<.001
- University degree	.62	.04	<.001	.62	.04	<.001
Gender (female)	-.03	.02	.147	-.03	.02	.124
Times moved (ref.=0)						
- 1	-.06	.03	.047	-.06	.03	.035
- 2	-.31	.11	.005	-.33	.11	.004
Intercept	-1.64	.04	<.001	-1.61	.04	<.001
Neighbourhood-level variance	.01	.00		.01	.00	
School-level variance	.02	.01		.01	.00	
Individual-level variance	.37	.01		.37	.01	
Proportion neighbourhood-level variance	.03			.02		
Proportion school-level variance	.04			.03		
Proportion individual-level variance	.93			.95		

Table 6. Cross-classified multilevel analyses for educational achievement: timing of exposure to neighbourhood and school poverty (N = 4,502)

	M1			M2		
	B	SE	p	B	SE	p
Exposure to neighbourhood poverty at age 10/11	-.03	.05	.543	.01	.05	.908
Exposure to neighbourhood poverty at age 13/14	-.05	.09	.571	-.05	.09	.582
Exposure to neighbourhood poverty at age 15/16	-.12	.08	.147	-.09	.08	.250
Exposure to school poverty at age 10/11				-.11	.04	.006
Exposure to school poverty at age 13/14				-.21	.06	.001
Exposure to school poverty at age 15/16				.04	.06	.496
Previous educational achievement	.15	.00	<.001	.15	.00	<.001
Parental educ. (ref.=CSE or GCSE (D, E, F))						
- Vocational	.05	.04	.263	.04	.04	.301
- O level or GCSE (A, B, C)	.18	.03	<.001	.18	.03	<.001
- A level	.33	.03	<.001	.33	.03	<.001
- University degree	.62	.04	<.001	.62	.04	<.001
Gender (female)	-.03	.02	.162	-.03	.02	.149
Moved between age 10/11 and 13/14	-.06	.03	.056	-.06	.03	.048
Moved between age 13/14 and 15/16	-.14	.06	.018	-.15	.06	.016
Intercept	-1.64	.04	<.001	-1.61	.04	<.001
Neighbourhood-level variance	.01	.00		.01	.00	
School-level variance	.02	.01		.01	.00	
Individual-level variance	.37	.01		.37	.01	
Proportion neighbourhood-level variance	.03			.02		
Proportion school-level variance	.04			.03		
Proportion individual-level variance	.93			.95		

Table 7. Cross-classified multilevel analyses for educational achievement: cumulative contextual poverty (N = 4,502)

	M1			M2		
	B	SE	p	B	SE	p
Periods of exposure to contextual poverty (ref.=0)						
- 1	-.06	.05	.192			
- 2	.02	.05	.772			
- 3	-.18	.04	<.001			
- 4	-.19	.06	.001			
- 5	-.32	.07	<.001			
- 6	-.47	.08	<.001			
Cumulative exposure at age 10/11 (ref.=no)						
- one context				-.08	.04	.057
- two contexts				-.10	.06	.080
Cumulative exposure at age 13/14 (ref.=no)						
- one context				-.05	.06	.384
- two contexts				-.34	.11	.001
Cumulative exposure at age 15/16 (ref.=no)						
- one context				-.02	.06	.728
- two contexts				-.02	.10	.841
Previous educational achievement	.15	.00	<.001	.15	.00	<.001
Parental educ. (ref.=CSE or GCSE (D, E, F))						
- Vocational	.04	.04	.302	.04	.04	.287
- O level or GCSE (A, B, C)	.18	.03	<.001	.18	.03	<.001
- A level	.33	.03	<.001	.33	.03	<.001
- University degree	.62	.04	<.001	.62	.04	<.001
Gender (female)	-.03	.02	.132	-.03	.02	.142
Times moved (ref.=0)						
- 1	-.06	.03	.036			
- 2	-.32	.11	.004			
Moved between age 10/11 and 13/14				-.05	.03	.068
Moved between age 13/14 and 15/16				-.14	.06	.016
Intercept	-1.62	.04	<.001	-1.61	.04	<.001
Neighbourhood-level variance	.01	.00		.01	.00	
School-level variance	.01	.00		.01	.00	
Individual-level variance	.37	.01		.37	.01	
Proportion neighbourhood-level variance	.03			.02		
Proportion school-level variance	.03			.03		
Proportion individual-level variance	.94			.95		

Appendix A

This appendix shows the results of Tables 5 through 7 without including previous educational achievement (Tables A1 through A3). The coefficients of exposure to neighbourhood and school poverty in the tables below are larger and more often significant compared to the coefficients in Tables 5 through 7, which include previous educational achievement. This indicates that neighbourhood and school effects are partly explained by selection.

Table A1. Cross-classified multilevel analyses for educational achievement: Duration of exposure to neighbourhood and school poverty (N = 4,502)

	M1			M2		
	B	SE	p	B	SE	p
Periods of exposure to neighbourhood poverty (ref.=0)						
- 1	-.14	.08	.061	-.11	.08	.161
- 2	-.26	.09	.002	-.22	.09	.012
- 3	-.38	.04	<.001	-.29	.05	<.001
Periods of exposure to school poverty (ref.=0)						
- 1				-.07	.05	.208
- 2				-.25	.07	<.001
- 3				-.54	.10	<.001
Parental educ. (ref.=CSE or GCSE (D, E, F))						
- Vocational	.06	.05	.237	.06	.05	.251
- O level or GCSE (A, B, C)	.40	.04	<.001	.39	.04	<.001
- A level	.60	.04	<.001	.60	.04	<.001
- University degree	1.12	.05	<.001	1.12	.05	<.001
Gender (female)	.12	.02	<.001	.12	.02	<.001
Times moved (ref.=0)						
- 1	-.06	.04	.088	-.07	.04	.069
- 2	-.23	.14	.098	-.26	.14	.070
Intercept	-.50	.05	<.001	-.45	.05	<.001
Neighbourhood-level variance	.02	.01		.02	.01	
School-level variance	.03	.01		.02	.01	
Individual-level variance	.60	.01		.60	.01	
Proportion neighbourhood-level variance	.03			.03		
Proportion school-level variance	.05			.03		
Proportion individual-level variance	.93			.94		

Table A2. Cross-classified multilevel analyses for educational achievement: timing of exposure to neighbourhood and school poverty (N = 4,502)

	M1			M2		
	B	SE	p	B	SE	p
Exposure to neighbourhood poverty at age 10/11	-.07	.07	.280	-.02	.07	.771
Exposure to neighbourhood poverty at age 13/14	-.05	.11	.665	-.04	.11	.742
Exposure to neighbourhood poverty at age 15/16	-.26	.10	.012	-.22	.10	.029
Exposure to school poverty at age 10/11				-.17	.05	.002
Exposure to school poverty at age 13/14				-.22	.08	.007
Exposure to school poverty at age 15/16				-.05	.08	.507
Parental educ. (ref.=CSE or GCSE (D, E, F))						
- Vocational	.06	.05	.239	.06	.05	.246
- O level or GCSE (A, B, C)	.40	.04	<.001	.39	.04	<.001
- A level	.60	.04	<.001	.60	.04	<.001
- University degree	1.12	.05	<.001	1.12	.05	<.001
Gender (female)	.12	.02	<.001	.12	.03	<.001
Moved between age 10/11 and 13/14	-.08	.04	.031	-.09	.04	.024
Moved between age 13/14 and 15/16	-.07	.08	.351	-.08	.08	.306
Intercept	-.50	.05	<.001	-.45	.05	<.001
Neighbourhood-level variance	.02	.01		.02	.01	
School-level variance	.03	.01		.02	.01	
Individual-level variance	.60	.01		.60	.01	
Proportion neighbourhood-level variance	.03			.03		
Proportion school-level variance	.05			.03		
Proportion individual-level variance	.93			.94		

Table A3. Cross-classified multilevel analyses for educational achievement: cumulative contextual poverty (N = 4,502)

	M1			M2		
	B	SE	p	B	SE	p
Periods of exposure to contextual poverty (ref.=0)						
- 1	-.13	.06	.037			
- 2	-.08	.07	.242			
- 3	-.31	.05	<.001			
- 4	-.42	.07	<.001			
- 5	-.58	.09	<.001			
- 6	-.74	.10	<.001			
Cumulative exposure at age 10/11 (ref.=no)						
- one context				-.08	.06	.166
- two contexts				-.19	.07	.007
Cumulative exposure at age 13/14 (ref.=no)						
- one context				-.07	.07	.363
- two contexts				-.35	.13	.006
Cumulative exposure at age 15/16 (ref.=no)						
- one context				-.12	.07	.092
- two contexts				-.23	.13	.073
Parental educ. (ref.=CSE or GCSE (D, E, F))						
- Vocational	.06	.05	.250	.06	.05	.252
- O level or GCSE (A, B, C)	.39	.04	<.001	.39	.04	<.001
- A level	.60	.04	<.001	.60	.04	<.001
- University degree	1.11	.05	<.001	1.12	.05	<.001
Gender (female)	.12	.02	<.001	.12	.02	<.001
Times moved (ref.=0)						
- 1	-.07	.04	.049			
- 2	-.26	.14	.066			
Moved between age 10/11 and 13/14				-.08	.04	.031
Moved between age 13/14 and 15/16				-.08	.08	.300
Intercept	-.46	.05	<.001	-.46	.05	<.001
Neighbourhood-level variance	.02	.01		.02	.01	
School-level variance	.02	.01		.02	.01	
Individual-level variance	.60	.01		.60	.01	
Proportion neighbourhood-level variance	.03			.03		
Proportion school-level variance	.03			.03		
Proportion individual-level variance	.94			.94		