



Short communication

When the great equalizer shuts down: Schools, peers, and parents in pandemic times

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ABSTRACT

What are the effects of school closures during the Covid-19 pandemic on children's education? Online education is an imperfect substitute for in-person learning, particularly for children from low-income families. Peer effects also change: schools allow children from different socio-economic backgrounds to mix together, and this effect is lost when schools are closed. Another factor is the response of parents, some of whom compensate for the changed environment through their own efforts, while others are unable to do so. We examine the interaction of these factors with the aid of a structural model of skill formation. We find that school closures have a large, persistent, and unequal effect on human capital accumulation. High school students from low-income neighborhoods suffer a learning loss of 0.4 standard deviations after a one-year school closure, whereas children from high-income neighborhoods initially remain unscathed. The channels operating through schools, peers, and parents all contribute to growing educational inequality during the pandemic.

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Education, then, beyond all other divides of human origin, is a great equalizer of conditions of men—the balance wheel of the social machinery.

—Horace Mann, 1848.

1. Introduction

Of the many facets of the Covid-19 pandemic, the impact on children's education stands out for its particularly long-lasting consequences. Schools were closed for months in many countries, and early evidence suggests that online education that was offered as an alternative is a poor substitute. School closures threaten to widen inequality not only across cohorts but also across socio-economic groups, for a number of distinct reasons (Stantcheva, 2021). Online education relies on access to technology like computers and fast internet that not all families can afford. In addition, parents' ability to support their children's learning depends on their own knowledge and on whether they

can work from home during the crisis. Because learning is a cumulative process, part of the effects of the disruption will persist until children reach adulthood, thereby affecting their future economic prospects.

How large and persistent is the effect of the pandemic on children's learning? How should policies be designed to mitigate learning losses and their effects? And which groups of children are likely to be in particular need of help? For answering such questions, we need to understand the channels through which the crisis affects children. The fact that online learning is less effective than in-school learning is well recognized. But the accumulation of both cognitive and non-cognitive skills does not depend on school alone. Peer interactions are another crucial ingredient, and school closures and lockdown measures drastically changed children's social interactions and peer environment during the pandemic. The response of parents is equally important: they can spend more time with their children, step into the role of teachers, and influence their children in other ways, such as through reshaping their parenting style. Parents' ability to do all of this hinges on their own exposure to the crisis, for instance, whether they lost their job or could work from home during lockdowns.

In this paper, we provide a first assessment of how these channels interact during the pandemic and affect educational inequality. We focus on the effects on high school students, from grades

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9 to 12. We organize our analysis with a structural model of skill acquisition based on Agostinelli et al. (2020)—henceforth, ADSZ20.¹ The model captures how children's knowledge accumulation depends on educational inputs such as the quality of schools, parental inputs, and endogenously chosen peers.

We model the impact of the Covid-19 pandemic as a set of new constraints and temporary changes in the socio-economic environment. First, the switch to remote instruction curtails the overall productivity of the learning technology. Second, school closures change the peer environment: children lose contact with some friends, and new connections are shaped by the peer environment in the residential neighborhood rather than at school. We discipline our analysis using new evidence from the United States on the impact of losing peer connections on learning, and on differences in the peer environment at the level of neighborhoods and schools. Third, remote learning places greater demands on parents, who must supply some inputs usually provided by teachers and take a greater role in organizing and supporting their children's learning. This aspect of the model is matched to empirical evidence on the increase in the time parents spend on helping their children with learning activities during the Covid crisis. A critical factor is the heterogeneity in constraints different parents are subject to. For instance, some parents can telecommute and spend more time close to their children while others cannot.

Our quantitative model accurately replicates the effect of the pandemic on students' educational performance and on parents' time allocation. Multiple mechanisms related to children's skill acquisition contribute to widening educational inequality during the crisis. Beyond the direct impact of the switch from in-person to virtual schooling, children from low-income families are affected by a decline in positive peer spillovers. Parents in low-income families also face tighter constraints in supporting their children's learning, mostly because they are less likely to be able to work from home. In our baseline calibration, these channels jointly cause a skill loss of 0.4 standard deviations for children from a census block at the 20th percentile of the income distribution. This effect is quantitatively large. Translated into grades, the average loss for disadvantaged children is comparable to a change from a straight B to getting C in half of the subjects. Instead, the model predicts no losses at all for children living in the most affluent neighborhoods. The effect of school closures on educational inequality is persistent. While the resumption of in-person schooling induces some catch-up, our model predicts that only half of the gap is going to be closed by the end of high school.

The structural model allows us to decompose the relative importance of three different channels—schools, peers, and parents—for increasing educational inequality. While all factors are important, the effect of peers turns out to be the largest: in a counterfactual where the peer environment does not change while all other effects are there, the increase in skill inequality is dampened by more than 60 percent.

Our paper builds on three strands of literature. The first is the economic literature on children's skill formation, including the contributions by Cunha et al. (2010), Del Boca et al. (2014), Agostinelli and Wiswall (2016), Attanasio et al. (2020), and recent work considering the role of parenting styles that is summarized by Doepke et al. (2019). This literature provides information on the technology of skill formation and on the relative importance of inputs supplied by schools, parents, and peers; our model of skill formation builds directly on these findings. The second related literature considers neighborhood effects for children's skill acquisition, such as Chetty et al. (2016), Chetty and Raj (2018a,b), Eckert

and Kleineberg (2019), Fogli and Guerrieri (2018).² The findings from this literature motivate the emphasis on changing peer effects due to differences in neighborhood characteristics in our analysis. Finally, our work is part of the emerging literature on the consequences of the Covid-19 pandemic for families and children. Here related studies include Fuchs-Schündeln et al. (2020, 2021) and Jang and Yum (2020), who also use structural models to examine the impact of pandemic-induced school closures on educational inequality. These papers adopt a macroeconomic angle and focus mostly on the long-run repercussions of school closures, whereas our emphasis is on the interacting influences of schools, peers, and parents on educational inequality. In the empirical literature, Bacher-Hicks et al. (2021) show that early in the pandemic, internet searches for online learning resources rose much more quickly in high-income areas, which suggests that parents in affluent neighborhoods were more engaged with remote learning. Werner and Woessmann (2021) provide a comprehensive review of the literature on school closures during the pandemic, complemented by an empirical analysis based on a German longitudinal time-use survey. In line with our results, they document learning losses that are particularly severe for children from a disadvantaged background.

Section 2 discusses the empirical evidence about the effects of school closures. Section 3 describes the model. Section 4 describes the model estimation in normal and pandemic times. Section 5 describes our main results. A Supplementary Appendix contains a number of sensitivity analyses and policy counterfactuals.

2. Empirical Evidence: How School Closures Affect Children's Education

In this section, we review some empirical evidence that motivates and disciplines our model of the Covid shock. We focus on three issues: (i) the direct effect of replacing in-person teaching with online instruction; (ii) the change in the peer environment to which children are exposed when schools are closed; (iii) the parental response.

2.1. Direct Effect of School Closures

Some recent empirical studies assess the effects of Covid-induced school closures on children's learning. Maldonado and De Witte (2020) compare standardized test scores of Belgian students attending the last year of primary school who were affected by school closures (cohort of 2020) with those of previous cohorts. Students exposed to school closures experience a sizeable decay in mathematics and language scores by 0.19 and 0.29 standard deviations, respectively. Moreover, school closures deepen the gap between more and less disadvantaged children. Engzell et al. (2021) find similar results in the Netherlands.

Another benchmark to assess the effects of an interruption of in-person teaching is the impact on learning of the regular summer break.³ McCombs et al. (2014) use results for standardized MAP tests to measure the extent of summer learning losses. They document a 4-point drop in the average mathematics score on the RIT scale during each summer break, which amounts to one quarter of a standard deviation and can also be compared to an average 8-point gain that accrues during the regular school year for students from sixth to eighth grade. In English, students gain five points during the school year and lose two points during summer (14 percent of a standard

¹ A summary of the model and estimation results in ADSZ20 that are used in this paper is available from the authors' webpages.

² Within this literature, Calvó-Armengol et al. (2009) consider the role of a child's position in her local friendship network on school performance. List et al. (2019) have documented large spillover effects operating through children's social networks of programs targeting disadvantaged children.

³ The discussion in this paragraph follows Doepke and Zilibotti (2020). See also Downey et al. (2004).

deviation). If during school closures some families can fully make up for the lack of in-person teaching while in others learning is interrupted and children lose skills at the same rate as during the summer, in three months an achievement gap of seven points in math and four points in English would arise. This is larger than the typical learning gain during a school year.⁴

Time diaries for children's activities during the crisis also help us understand why the pandemic has unequal effects across the socio-economic ladder. The analysis of a sample of German parents in [Grewenig et al. \(2020\)](#) suggests that low-achieving students suffer more from the lack of educator support during school closures. Compared to high achievers, these students appear to disproportionately replace learning time with leisure activities such as watching TV or playing computer games. [Andrew et al. \(2020\)](#) reach a similar conclusion for a sample of English children.

2.2. Peer Effects

A burgeoning literature documents peer effects in education (see, e.g., [Durlauf and Ioannides, 2010](#); [Sacerdote, 2011](#); and [Epple and Romano, 2011](#)). When schools close down because of Covid, the peer environment in which children interact with each other changes. We focus on two aspects of this change. First, school closures change the set of peers that children are exposed to. Specifically, to the extent that peer interactions continue, they tend to be confined to the residential neighborhood, whereas connections with children who attend the same school but live far away become hard to maintain. Second, children's learning may also suffer from the psychological impact of losing daily contact with some friends at school. The salience of these two channels is in line with the survey evidence in [Werner and Woessmann \(2021\)](#). They document that children met substantially less often with their friends during the pandemic. Moreover, three quarters of parents think that it was a great burden for their children not to be able to meet friends as usual during the pandemic. Finally, a majority of the parents interviewed think that the school closures have had a negative effect on their children's social skills.

To gauge the quantitative importance of these peer interactions, we build on our previous research in ADSZ20, where we structurally estimate peer effects in the process of skill acquisition based on the Add Health data set. This survey follows a representative sample of high school students in the United States and includes information on the friendship network—see Appendix Section C for details. While estimated on an earlier period, the model enables us to make an educated guess on how the changes in the peer environment induced by school closures can affect peer formation and, ultimately, the learning process of children living in different neighborhoods.

In our analysis below, we model school closures as a shift in the peer environment from the school to the census block where each child resides. The Add Health data allows us to infer the characteristics of these census blocks.⁵ The extent of social segregation increases as children's peer interactions get confined to the block level. [Fig. 1](#) shows a bin scatter plot displaying the correlation between median family income at the census block level and the average GPA (grade point average) of children attending the same school (black line) or living in the same census block (gray line). Both

correlations are positive: children living in more affluent blocks are exposed to academically stronger peers. More importantly for us, the regression line is substantially steeper as we move from schools to blocks. This evidence indicates that schools provide the children of disadvantaged families with an opportunity to socialize with children from a stronger family background. Thus, in terms of the peer environment, schools operate as a social equalizer. This equalizer shuts down when schools remain closed.

While our assumptions about changes in the peer environment are consistent with the evidence from [Werner and Woessmann \(2021\)](#) reviewed above, quantifying the extent of the change necessarily entails some speculation. Arguably, even during the pandemic many children continue to interact with school friends through social media, although these interactions are less intense. Assuming that the census block defines the border of the peer environment during the pandemic could therefore overstate the intensity of the pandemic treatment. Conversely, there are reasons why our assumption could understate the change: a strict lockdown could limit peer interactions to the family and its closest circle. If so, social segregation could be even stronger than our assumption implies. To address this uncertainty, we study the sensitivity of our results to alternative scenarios.

The second effect of school closures is of a psychological nature. Separation from friends is a traumatic experience for adolescents. The Add Health data set allows us to assess the effect on academic performance of such a trauma in normal times. Parents and children are interviewed twice over two different school years (Wave I and Wave II In-Home). When some active respondents of the Wave I In-Home survey are not in the Wave II sample, they are likely to have left the school because either the family moved away or they switched to a different local school. We can then study the effect of these children's departure on the academic performance of the former friends who are still in the sample. We use this information to gauge the magnitude of the psychological effect of the physical distance from friends that the school closures impose on children during the pandemic.

[Table 1](#) provides regression results for the sample of children in Add Health entering 9th grade. Because 9th grade is the first grade of high school, these children are already experiencing a large change in their social environment (i.e., moving from middle to high school), similar to the one caused by school closures. For these children moving from 8th to 9th grade, the loss of one friend is associated with a deterioration of more than 10 percent in average GPA growth.⁶ The result is robust to controlling for other determinants of school performance and for school fixed effects, and is larger for boys than for girls (see Appendix Table B-1). The negative effect is twice as large for children who lose two or more friends instead of just one. [Table 2](#) shows the result of a specification where separation is interacted with the pre-separation GPA of the child. The negative effects are larger for low achievers. In other words, high achievers appear to be more resilient and cope better with losing contact with friends.⁷

The effect of being separated from friends is small and statistically insignificant in higher grades—see Appendix Table B-2. This finding suggests that children may be especially vulnerable to separation from friends when they are changing schools (i.e., entering high school in 9th grade after completing middle school). Older

⁴ [Kuhfeld et al. \(2020a\)](#) reach similar conclusions based on the effects of absenteeism, summer breaks, and weather-related school closures. [Kuhfeld et al. \(2020b\)](#) find smaller effects when comparing cohorts of students assessed in 2019 and 2020. However, the authors acknowledge they may underestimate the effect of the pandemic on learning due to selective attrition in the sample.

⁵ The contextual data section in Add Health includes information matched from the 1990 US Census. We use median household income at the census block to characterize the neighborhood where children live.

⁶ A caveat regarding the causal interpretation of this correlation is that a correlated shock may hit the families of two friends, inducing one of them to move. This shock (e.g., a job loss) could have direct effects on the performance of the stayer. Including school fixed effects reduces but does not eliminate this concern.

⁷ A possible confounder is the sample attrition that is unrelated to the school/residential choice. We test this hypothesis via a "placebo test," where we test the effect of losing a peer in each grade transition from 8th to 11th grades. In line with our hypothesis, we see negative and statistically significant effects only for the 8th to 9th grade transition (see Table B-3).

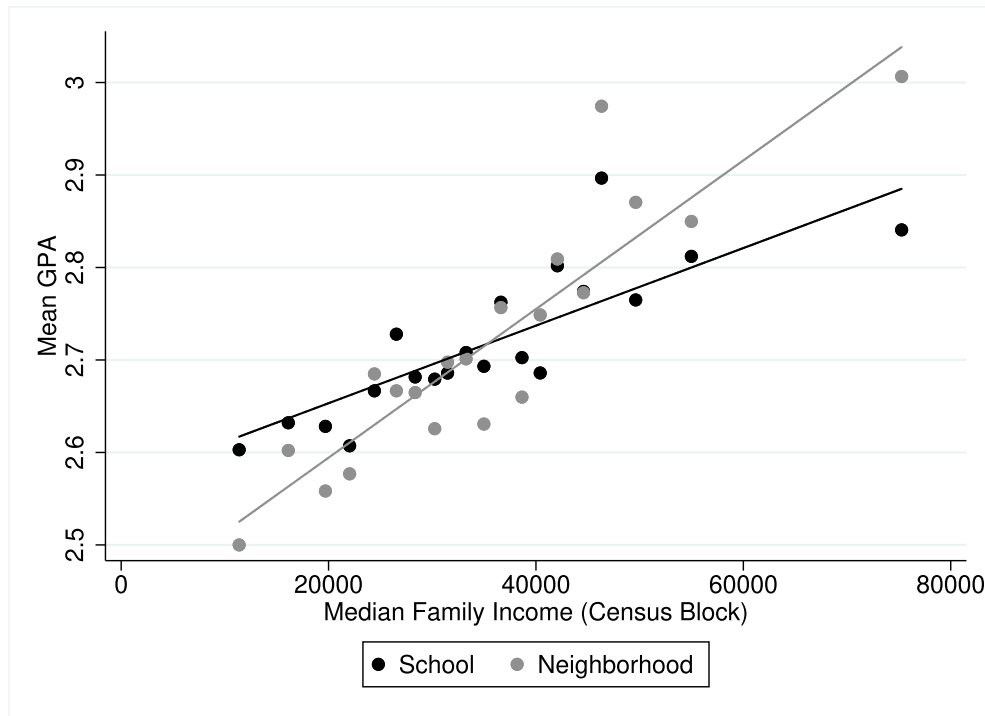


Fig. 1. Peer Quality: School vs Neighborhood. The figure shows the relationship (scatter plot) between peer quality, i.e., average GPA, and median family income at the census block level. The black dots represent peers' average GPA that children are exposed to at school by the median family income level of the census block where children live. The grey dots represent peers' average GPA of the census block (neighborhood) where children live by the median family income level of the census block where children live.

Table 1
Effect of Peer Separation on Child's GPA: Sample of Children Moving from 8th to 9th Grade.

	Change in GPA (from 8th Grade to 9th Grade)								
	(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)
One or More Peers Left	-0.123** (0.051)	-0.112** (0.051)	-0.107* (0.054)						
N. Peers who Left				-0.105** (0.040)		-0.096** (0.040)		-0.090** (0.043)	
1 Friend who Left					-0.102* (0.055)		-0.093* (0.055)		-0.095 (0.058)
2 Friends (or More) who Left					-0.218** (0.093)		-0.196** (0.092)		-0.172 (0.104)
N	1235	1235	1235	1235	1235	1235	1235	1235	1235
Controls	No	Yes	Yes	No	No	Yes	Yes	Yes	Yes
School F.E.	No	No	Yes	No	No	No	No	Yes	Yes

The table shows the effects of losing social ties in the transition from middle school to high school. The outcome variable is the change in a child's GPA between 8th grade (middle school) and 9th grade (high school). A GPA of 4.0 corresponds to a straight-A student, 3.0 to a straight-B student, and so on. In columns (1)-(3), the independent variable is whether a child lost at least one friend (indicator variable). In columns (4), (6), and (8), the independent variable is the number of friends that a child lost. In columns (5), (7), and (9), the independent variables are whether a child lost one friend or two (or more) friends between 8th grade and 9th grade (indicator variables). Control variables include mother's education, family income, and child's race (indicator variables). Standard errors are clustered at the school level. *, **, *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively.

children who continue in the same school may have already established a stable group of friends in their new environment.

In the baseline calibration of our model, we benchmark the psychological effect of separation from friends during Covid to the estimated effect of losing one friend in the Add Health regressions. This is a compromise between two factors. On the one hand, separation during Covid is often temporary and possibly less intense than a friend moving away. On the other hand, school closures simultaneously affect multiple peer connections rather than just severing the link to a single friend. For this reason, we perform sensitivity analyses in different directions.

2.3. Parental Responses to School Closures

Another channel through which school closures affect learning is changes in parents' behavior. Remote learning poses new challenges for parents, from making sure that their children have access to the technology they need to stepping in for some of the inputs usually provided by teachers. The severity of the challenge varies across the spectrum of families' socio-economic status. The first constraint is the parents' education level: not all parents can help children with high school math, for example. An even more important constraint is time. Most parents must earn a living in

Table 2
Effect of Peer Separation on Child's GPA: Heterogeneity.

	Change in GPA (from 8th Grade to 9th Grade)			
	(1)	(2)	(3)	(4)
N. Peers who Left	-0.314** (0.135)	-0.268** (0.131)	-0.576** (0.287)	-0.540* (0.296)
N. of Peers who Left × Child GPA (t-1)	0.086** (0.040)	0.067* (0.040)		
N. Peers who Left × Peers GPA (t-1)			0.166* (0.093)	0.155 (0.098)
N	1235	1235	1223	1223
Controls	Yes	Yes	Yes	Yes
School F.E.	No	Yes	No	Yes

The table shows the heterogeneity in the effects of losing social ties in the transition from middle school to high school. The outcome variable is the change in a child's GPA between 8th grade and 9th grade. Columns (1) and (2) include the interaction term between the number of friends that a child lost and the child's own GPA in 8th grade. Columns (3) and (4) include the interaction term between the number of friends that a child lost and the child's peer quality, i.e., average GPA, in 8th grade. Control variables include mother's education, family income, and child's race (indicator variables). Standard errors are clustered at the school level. *, **, *** indicate statistical significance at the 10%, 5%, and 1% levels, respectively.

addition to being substitute teachers. The problem is especially severe for single parents with limited resources—single parenthood is more common among less educated parents with low earnings prospects. During the pandemic, a key issue was the ability of parents to telecommute. The availability of telecommuting drastically varies across professions: during lockdowns, most academics and other office workers could work from home, while workers in manufacturing, healthcare, hospitality, and retail could not. Mongey et al. (2020) show that workers with less income and education were less likely to be able to work from home during the crisis than others. In our analysis below, we use survey evidence from Adams-Prassl et al. (2020a,b) to quantify the extent to which the ability to work from home varies with income.

Parenting style also responds to changes in the peer environment. Our previous research in ADSZ20 shows that parents become more authoritarian when their children are exposed to a more troublesome and unequal environment. In particular, more parents actively discourage their children from interacting with lower-achieving peers, especially when their children are low achievers themselves. In the Add Health data, the proportion of children answering affirmatively to the question “Do your parents let you make your own decisions about the people you hang around with?” is decreasing with median income and increasing with income inequality. That is, parents are more likely to interfere when there are more low-achieving children (who often come from a disadvantaged background) around. For the reasons discussed above, during the pandemic the peer environment deteriorated on average for children living in poorer areas while it did not change or even improved for children living in wealthier areas. According to the results of our previous research, this change in the peer environment is bound to induce more parents living in poorer neighborhoods to adopt an authoritarian parenting style.

3. A Model of Skill Acquisition during a Pandemic

We quantify the joint effect of the factors outlined in the previous section with the aid of the structural model in ADSZ20 augmented with the Covid shock. We focus on the skill acquisition of high school students from 9th grade through 12th grade. Families comprising one parent and one child live in different neighborhoods and children attend different schools. Parents decide how much time to spend on supporting their children's learning. Parents also choose whether to interfere in their children's peer group formation, which we refer to as adopting an *authoritarian parenting style*. Children decide who to be friends with, subject to the parental intervention in peer formation.

We model the Covid shock as affecting parameters in a single period—one year of school. Parents and children anticipate that

in-person schooling will resume in the following year. Even though the shock is temporary, it has persistent effects through the dynamics of skill accumulation. In addition, peer effects and parental responses will also exhibit persistence. The evolution of child *i*'s skills—denoted by $\theta_{i,t}$ —is governed by the following technology of skill formation:

$$\theta_{i,t+1} = A_{p,t} \times H_{p,t}(\theta_{i,t}, \bar{\theta}_{i,t}, I_{i,t}).$$

Here $A_{p,t}$ is total factor productivity, $\bar{\theta}_{i,t}$ denotes the average skills of the child's peers, $I_{i,t}$ denotes the investment in skill acquisition of *i*'s parent, and $P \in \{0, 1\}$ is an indicator for parenting style, where $P = 1$ corresponds to an authoritarian parenting style. The time index t denotes the grade, where $t = 1$ corresponds to 9th grade and $t = 4$ to 12th grade. The total factor productivity term—which among other things accounts for the inputs provided by schools—takes the following form:

$$A_{p,t} = -v_t + \kappa_t \cdot (\psi_0 + \psi_1 \cdot t) + \psi_2 \cdot P.$$

Here ψ_0 is a level parameter, and the parameters ψ_1 and ψ_2 allow productivity to vary across grades and parenting styles. In normal times, $v_t = 0$ and $\kappa_t = 1$; when schools close down (SC), $v_t = v_t^{SC} \geq 0$ and $\kappa_t = \kappa^{SC} < 1$. Hence, during the pandemic baseline productivity $\psi_0 + \psi_1 \cdot t$ falls by a factor $1 - \kappa^{SC}$. In addition, there is a grade-specific productivity loss v_t^{SC} .

The inputs to the technology of skill formation are average peer quality, skills at the beginning of the period, and parental effort. The technology is parameterized by a CES production function (cf. Equation 7 in ADSZ20):

$$H_{p,t}(\theta_{i,t}, \bar{\theta}_{i,t}, I_{i,t}) = \left[\alpha_{1,p} \theta_{i,t}^{\alpha_{1,p}} + (1 - \alpha_{1,p}) \left[\alpha_{2,p} \bar{\theta}_{i,t}^{\alpha_{2,p}} + (1 - \alpha_{2,p}) (I_{i,t} - \bar{I})^{\alpha_{2,p}} \right]^{\frac{\alpha_{1,p}}{\alpha_{1,p} - 1}} \right]^{\frac{\alpha_{1,p} - 1}{\alpha_{1,p}}}. \tag{1}$$

The parameters of the production function are allowed to vary with the parenting style P . Our estimation in ADSZ20 implies that parenting style changes the substitution relationships between different inputs in skill production. In particular, nonauthoritarian parents increase their time investments when the peer environment is weak (i.e., they substitute for the missing peer effects) and when their own children are academically strong (i.e., they complement the child's initial skills). We detect no such effects for authoritarian parents.

We assume that the pandemic alters two inputs in the production function. First, the Covid shock changes the quality of peers $\bar{\theta}_{i,t}$. When schools shut down, interactions turn more local, increasing the gap in the average quality of peers to which children from more and less affluent families are exposed. Second, the pandemic modifies the role of the parental investment through the variable \bar{I} . In

normal times, $\bar{I} = 0$, while during school closures, $\bar{I} = \bar{I}^{SC} > 0$. The term \bar{I}^{SC} is a minimum time requirement before the parental investment $I_{i,t}$ becomes productive, and captures the basic time cost required to manage learning at home during school closures. \bar{I}^{SC} can be thought of as consisting of inputs usually coming from teachers.

Parents choose their parenting style P and skill investments I in order to maximize a dynamic objective function that captures the utility cost of making these investments and the perceived future benefits for the child associated with acquiring skills. The value function for this problem is:

$$V_t^{n.s}(\theta_{i,t}, \bar{\theta}_{i,t}) = \max \left\{ E \left[U(I_{i,t}, P_{i,t}, \epsilon_{i,t}) + Z \times \tilde{V}_t^{n.s}(\theta_{i,t}, \bar{\theta}_{i,t}) \right] \right\} \quad (2)$$

$U(I_{i,t}, P_{i,t}, \epsilon_{i,t})$ is the parent's period utility, which captures the overall cost of child rearing and depends on parenting style and time investments ($P_{i,t}$ and $I_{i,t}$), both chosen optimally by the parent. Utility also depends on taste shocks $\epsilon_{i,t}$ (random utility), which ensures a smooth mapping from state variables into decisions. The parent cares about the child's future utility, where Z is the overall weight attached to the child's welfare. The continuation utility $\tilde{V}_t^{n.s}$ incorporates altruism toward the child, and a paternalistic concern about the child's skill acquisition. Importantly, the continuation utility hinges on the child's selection of friends, which the parent can influence through her choice of parenting style. The full decision problem of parent and child is provided in Section 3.1 of ADSZ20.

The pandemic affects the utility cost of investment. We assume that:

$$U(I_{i,t}, P_{i,t}, \epsilon_{i,t}, T) = \delta_1 \ln(T - I_{i,t}) + \delta_2 P_{i,t} + \epsilon_{i,t}(P_{i,t}). \quad (3)$$

Here T is a time endowment net of other activities (such as work and home production) that is available for investments $I_{i,t}$. In normal times, we normalize this endowment to $T = 1$ for all parents. In pandemic times, the time endowment is given by $T = T^{SC} \in \{\underline{T}^{SC}, \bar{T}^{SC}\}$, where $\bar{T}^{SC} > \underline{T}^{SC}$. Heterogeneity in the time endowment captures the different situations of parents who have a flexible work arrangement and are able to work from home during the pandemic (where they can help their children with school) versus those that cannot.

Children decide who to be friends with. This decision depends on their own skills, the skills of potential peers, a term that depends on the difference in skills between the two children (to capture homophily bias, i.e., the tendency to befriend others who are similar to oneself), the parental intervention in peer formation, and a taste shock for each particular potential friend (random utility). The pandemic affects this decision problem because when schools are closed, peer interactions are confined to the census block n rather than the school s . Hence, children draw their friends from a different set of potential peers. The functional forms that we impose on the choice problem of parent and child for the purpose of model estimation can be found in Section 3.5 of ADSZ20.

4. Model Estimation: Normal and Pandemic Times

We take the estimated model in ADSZ20 based on the Add Health data to represent skill accumulation in normal times when schools are open (see Table 5 in ADSZ20 for the parameter values used). Then, we introduce the shocks occurring during the Covid-19 crisis—disciplined by the empirical evidence discussed in Section 2 and by additional evidence discussed below.

We introduce the following changes in the model during the single school closure period:

Covid learning shock κ^{SC} : We calibrate the learning shock in our model based on the results in Maldonado and De Witte (2020), who use test score data from Belgium to estimate the

impact of the Covid crisis on learning. According to their analysis, the 2020 cohort of children leaving primary school (6th grade) experienced a learning loss of approximately 0.2 standard deviations compared to the previous cohort. This Covid-induced learning loss translates into a learning (TFP) shock of $\kappa^{SC} = 0.5$ in our framework. This TFP change matches the overall learning loss to the data after taking into account the changes to peer effects and parents' behavior during the pandemic. Given that Maldonado and De Witte (2020) consider the impact of school closures that lasted only a few months, this learning shock is a conservative estimate of the potential impact on learning of the entire pandemic. Erring on the conservative side is appropriate given that virtual instruction may have become more effective over time after the initial adjustment.

A potential concern is that the results for learning losses in Belgium documented by Maldonado and De Witte (2020) may not be representative for children in the United States. To address this concern, we can compare our assumptions with projections for learning loss in the United States that are already available. Kuhfeld et al. (2020a) develop projections based on evidence on summer learning loss in the United States, and estimate that under a three-month lockdown learning gains would be reduced to 37–50 percent of the usual progress for math and to 63–68 percent for reading. If we convert our 1-year lockdown effect into a 3-month effect, learning is reduced to 50 percent of the usual rate, which is right in the middle of these projections. Kuhfeld et al. (2020b) document actual learning loss among US students who took MAP tests in the fall of 2020, and find little learning loss in reading, but substantial learning loss in math in line with the projections based on summer learning loss. Given that relatively few students were tested in the fall of 2020 and that the sample of tested students likely underrepresents children from low-income families, these preliminary findings are likely to understate the size and inequality of the impact of the pandemic on learning. Overall, our assumptions on overall learning loss are broadly consistent with the emerging US evidence.

Changes in the peer environment during school closure: We calibrate the change in the peer environment based on the evidence in Fig. 1. We translate this evidence into the following income gradients for peer quality during the pandemic: $\bar{\theta}^{SC} = 0.1802 + 0.0198 \cdot \text{IncomePercentile}$.

Psychological effect of social ties disruption v^{SC} : We use the estimated effects in Table 2 (Column 1) of losing contact with peers in the transition from 8th grade to 9th grade. We divide children's skills during 9th grade into quartiles $Q(\theta) \in \{1, 2, 3, 4\}$ and then calibrate the disruptive effect as $v^{SC} = -0.314 + 0.086 \cdot Q(\theta)$. Hence, the baseline calibration assumes that the psychological impact of peer separation is comparable to the effect of losing one friend during normal times. We examine the sensitivity of our results to this assumption below.

Parental Time Investments: The Covid Inequality Project described in Adams-Prassl et al. (2020a) provides information on time spent on active childcare and homeschooling for a representative sample of US parents during the pandemic. For the pre-pandemic period, we use data on parental time use from the 2019 American Time Use Survey (2019 ATUS-CPS).⁸ We focus on two data moments to characterize the change in parental time inputs due to the outbreak of the pandemic. The first is the average

⁸ We classify as parental time inputs the following activities in ATUS: physical care of children, homework and other school related activities, homeschooling, reading, playing (including arts, crafts, and sports), other educational activities, talking and listening to children, organization of activities, looking after children, attending events, picking up, dropping off or waiting for/with children, providing medical or other health care to children. Parental time inputs refer to weekdays and to the sample of working parents.

number of hours parents spend with children. This has grown by a factor of 4.08, from average daily hours of 1.26 in 2019 to 5.15 during the pandemic in 2020. Second, we introduce a gradient relating family income to parental time inputs.⁹ Wealthier parents report spending more time on childcare than less affluent ones. This was already true in 2019, but the income gradient turns significantly steeper after the onset of the Covid-19 crisis. In 2020, the income gradient for parental time inputs is almost four times steeper than prior to the pandemic (an increase by a factor of 3.94). On average, a \$10,000 increase in family income is associated with about three and half extra minutes spent on child care per day.

The calibration matches the two data moments almost exactly: the ratio of mean investments is 4.04 in the model versus 4.08 in the data; and the ratio of the income gradient of parental investments from before to during the pandemic is 4.04 in the model versus 3.94 in the data. The calibration recovers two structural parameters associated with the Covid shock: the basic time cost $\bar{\tau}^{SC}$ required to manage learning at home—estimated to be 0.32—as well as the time endowment $\bar{\tau}^{SC}$ for parents who can work from home—estimated to be 2.42. This endowment is higher than the time endowment $\bar{\tau}^{SC} = 1$ for parents who cannot work from home (which we impose to be the same as before the crisis). The underlying assumption here is that parents who can work from home have some ability to work and supervise their children's learning at the same time, which increases their effective time endowment (see Alon et al., 2020).

5. The Effect of a Pandemic in the Estimated Model

In this section, we use the estimated model to assess how school, peers, and parents contribute to educational inequality during the pandemic.

Peer Effects. Fig. 2a shows the change in the average skills of friends broken down by the percentile of family income at the census block level. The average academic quality of peers falls for children from low-income census blocks and increases for children from high-income blocks. This is the result of two forces. First, school closures trigger a decay in the learning process through a fall in the total factor productivity of the skill formation technology, which lowers average peer quality across the board. Second, because the peer environment shifts from the school to the census block level, socio-economic segregation increases, causing children living in low-income census blocks to have lower-achieving peers than in normal times. This shift in the environment compensates for the overall decay in the learning process in high-income neighborhoods but amplifies the deterioration of peer quality in low-income census blocks. Inequality in peer effects is further exacerbated by the different time constraints faced by different parents across the socio-economic ladder. In low-income neighborhoods, fewer parents can work from home, and hence they have less time to help their children with learning activities. This feeds back into the peer environment.

⁹ To capture the role of work flexibility in shaping parental time inputs during the pandemic we rely on additional information provided by the Covid Inequality Project research team. We start with evidence of a positive and significant effect of work flexibility on parental time inputs during the pandemic. Then, we combine the information about the effect of work flexibility on parental time inputs with the positive relationship between labor income and work flexibility shown in Adams-Prassl et al. (2020b) (Figure 14-a). Finally, using the Current Population Survey (CPS) for 2019 we convert labor income into family income and estimate the relationship between family income and parental time inputs during the Covid-19 crisis. Based on this information, we impose a linear relationship between the fraction of parents with work flexibility and the quintile of neighborhood income. This linear function is calibrated in order to have 25 percent flexible parents in the lowest quintile and 75 percent flexible parents in the highest.

Parental Time Investments. Our model predicts that nonauthoritarian parents living in more disadvantaged areas have, in principle, a strong incentive to offset the deteriorating peer environment by spending more time on supporting their children's learning. Indeed, Appendix Figure B-1 shows that, absent other constraints, it is the parents living in low-income neighborhoods who would increase their time investments the most during the pandemic. However, the pandemic frees time selectively for parents working from home. The flexibility of work arrangements hinges on a parent's occupation, which in turn is highly correlated with income. Fig. 2b shows the response of time investments for parents of 9th graders, taking into account the different time constraints parents face. The time spent with children increases for all parents, largely because of the higher fixed time requirement \bar{l} during school closures. However, the response varies across the socio-economic ladder. While there are no major differences across the poorest 80 percent of neighborhoods, there is a steep income gradient for the parents living in the top 20 percent of neighborhoods by income. In the most affluent census blocks—where many parents can work from home—the response of parental time spent with children is 50 percent larger compared to average parents, and 70 percent larger compared to those living in the least affluent blocks.

Authoritarian Parenting. Another effect of the Covid shock is an increase in authoritarian parenting—which, recall, we define as parents trying to interfere in their children's choice of friends—in less affluent neighborhoods. In the baseline economy, authoritarian parenting is prevalent among low-income families whose children are on average less proficient, while it is almost entirely absent among high-income families. Fig. 2c shows that the pandemic exacerbates this divide. The authoritarian parenting style becomes more widespread in low-income neighborhoods, while remaining the exception in higher-income neighborhoods. For the parents in the lowest-income areas, the model predicts an increase in the prevalence of authoritarian parenting of 14 percentage points, which compares to a baseline of about 18 percent of authoritarian parents before the pandemic. To understand the skewed nature of the response, note that authoritarian parenting increases when peer effects deteriorate and when a child's own skills are lower. Both factors apply to low-income families during Covid: their children suffer a learning loss and they are more exposed to the influence of low-achieving peers. While adopting the authoritarian parenting style is an individually rational choice in the model, it has two negative consequences: first, it reduces the total factor productivity parameter in the technology of skill formation; second, it exerts a negative externality on other disadvantaged children by reducing their ability to benefit from peers effects, thereby exacerbating inequality.

Skill Accumulation. Fig. 3 shows the combined impact of schools, peers, and parents by displaying the effect of the Covid shock on the skill level of 9th graders when entering 10th grade along with the simulated effect for the same children at the end of high school (12th grade). The impact on the skills of 9th graders is large and skewed. For the top decile of census blocks, we actually observe a slight improvement relative to baseline. In affluent neighborhoods, the negative effect of school closures is offset by an increase in parental investments along with an improvement in the peer environment. For children living in a low-income neighborhood at the 20th percentile of the distribution, the skill loss when entering 10th grade amounts to 0.4 standard deviations, and in the lowest-income neighborhoods skill loss exceeds 0.6 standard deviations. In terms of the GPA scale, 0.4 standard deviations correspond to a decline of almost half a point; for example, a straight-B student before Covid would now be getting a C in almost half of their subjects. Many low-income working parents cannot

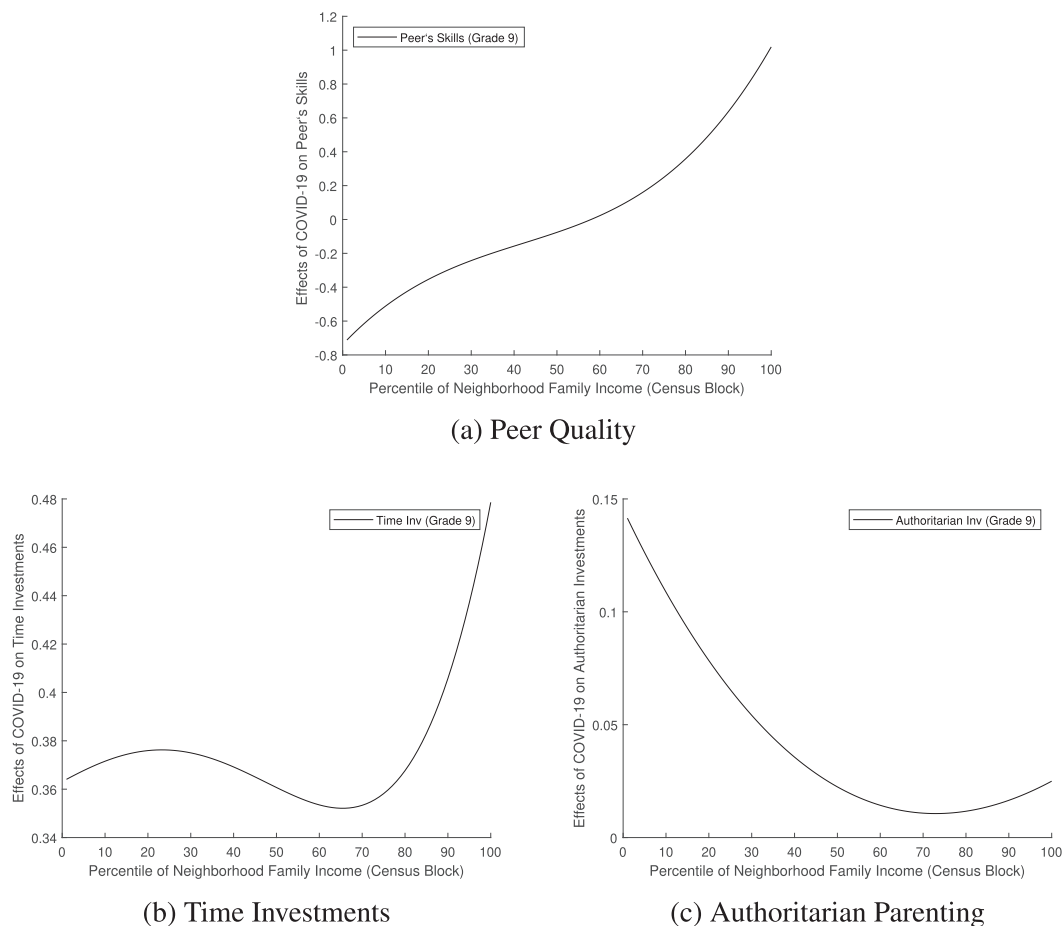


Fig. 2. Simulated Effects of Covid-19 on Peer Effects and Parenting. The figure shows the simulated effect of Covid-19 on peer quality (panel a), parental time investments (panel b), and authoritarian parenting (panel c) by neighborhood (census block) income. Neighborhood income is expressed in terms of income percentile of the neighborhood where children live. The y-axis displays changes in each variable relative to baseline.

respond to the lack of in-class teaching because they cannot work from home. In addition, more of them turn authoritarian, which imposes a further negative externality on the local environment.

We can also characterize how each of the three channels—schools, peers, and parents—contributes to learning losses and rising educational inequality. If we remove the peer effects channel, the average learning loss is 31 percent smaller compared to the baseline case, and if we remove changes to parental time constraints learning loss is 8 percent smaller. The bulk of average learning losses is accounted for by the remaining school channel (i.e., the downward shift in the total factor productivity of the skill accumulation technology associated with school closures). The results for educational inequality are markedly different. If we keep the productivity of the skill accumulation technology constant but keep the peers and parents channels, the income gradient falls by 33 percent compared to the baseline case. Restoring the learning shock but allowing all parents to work from home, regardless of income (i.e., all parents get the larger time endowment τ^{SC}), reduces the gradient by 22 percent. The change to the peer environment has the largest impact: if we hold peer influences on learning constant at the pre-crisis level, the gradient is reduced by 62 percent. Appendix Figure B-2 displays the full distribution of effects on children’s learning for the baseline case and for counterfactuals that remove changes to peer effects and changes to parental time constraints during the pandemic. Overall, we find that the schools channel is the most important driver of overall learning

losses, but the peers channel plays the biggest role for increasing educational inequality.

Our estimated model also allows us to trace out how children’s skills evolve over the remaining high school years. Changes in skills are persistent; existing skills are an input in the production of future skills, and additional persistence arises through peer effects and parental responses. Nevertheless, over time the negative impact on children’s skills becomes both smaller and less unequal. The children of wealthier families eventually suffer some losses because they interact with weaker peers as in-person schooling resumes. Conversely, as schools reopen the “Great Equalizer” starts working again, which reduces the loss of the most disadvantaged children over time. Yet, this is only a partial remedy: while children make up about half of the short-run losses, the long-run effects of Covid continues to be unequal. At the end of high school, the average human capital deficit is about 12 percent, ranging from 5 percent in the most affluent communities to 30 percent in the least affluent ones. These large long-run differences hit a society where gaps in opportunities were large to begin with.

Sensitivity Analysis. Our assumptions about changes in peer effects are largely based on extrapolation from pre-pandemic data. While lack of data prevents us from using more up-to-date information, we acknowledge that this makes our assumptions on changing peer effects somewhat speculative. For this reason, it is useful to check the sensitivity of our results to different assumptions about the size of changes in the peer environment.

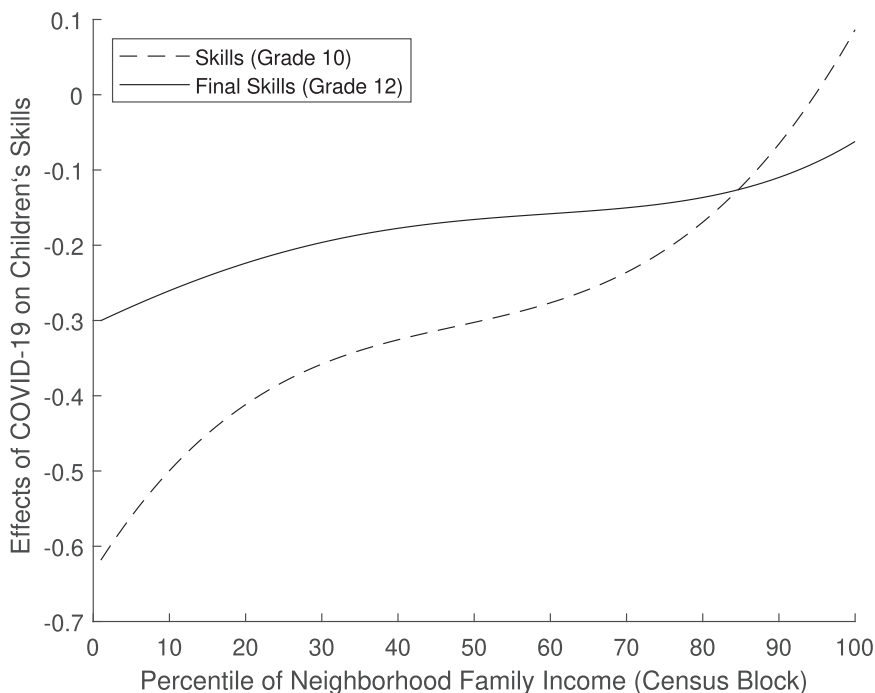


Fig. 3. Simulated Effects of Covid on a Child's Skills. The figure shows the simulated effect of Covid-19 on children's skills by neighborhood (census block) income. Neighborhood income is expressed in terms of income percentile of the neighborhood where children live. The y-axis displays changes in children's skills (expressed in standard deviations) relative to baseline.

To start with, we vary the intensity of the effect of separation from friends during school closures which, as discussed above, could be either over- or underestimated in our baseline experiment. Similarly, we consider alternative scenarios in which the change of the peer environment (from school to census block) is muted. As expected, in scenarios with smaller changes in the peer environment the predicted effect of Covid on skill accumulation is attenuated. For instance, in the most conservative scenario entailing the smallest change in peer effects, the skill loss for children in the least affluent neighborhood is 0.18 of a standard deviation by the end of high school, down from 0.30 in the baseline case. Yet, the effect is still sizeable. Moreover, even in the most conservative scenario, the skill loss suffered by the most disadvantaged children is approximately four times larger than for children living in high-income neighborhoods. We describe these sensitivity checks in more detail in Appendix A.1. Overall, in spite of some uncertainty about the quantitative effects, the unequal effects of Covid are robust.

Policy Interventions. In Appendix A.2, we also discuss stylized policy interventions that could be used to alleviate the unequal learning impacts of the pandemic on children. One policy is opening schools specifically for remedial schooling sessions targeting children below the median skill level. We find that this intervention could offset a large part of the disruption caused by peer effects during the pandemic for these children. We also consider a program that combines this policy with subsidies for parental investments in children's skills after the pandemic. These policies yield a sizeable improvement in children's learning, with the targeted component of the policy being especially successful in reducing inequality. Although these interventions are beneficial, neither policy fully eliminates the unequal effect on skills associated with the pandemic. This suggests that the effects of some dimensions of inequality during the pandemic, such as the more binding time constraints for low-income parents who often cannot work from home, are difficult to fully offset.

6. Conclusions

The Covid-19 pandemic has brought about the largest disruption to children's learning in many countries in generations. Learning losses, once accrued, are difficult to fully offset later on, suggesting that the current crisis will affect the economic opportunities of today's children for decades to come. An additional concern is the impact of the pandemic on educational inequality. As Horace Mann famously put it, in regular times schools play a role as a "Great Equalizer"—they provide a single learning environment and integrated peer groups for children from different backgrounds. The Covid-19 pandemic puts this role of schools at risk.

The main conclusion from our analysis is that channels running through schools, peers, and parents each contribute to higher educational inequality during the pandemic. Children from disadvantaged backgrounds do worse with virtual compared to regular schooling; they are less likely to benefit from positive peer spillovers during the crisis; and their parents are less likely to work from home and hence less likely to be able to provide them with maximum support for virtual schooling. The end result is that learning gaps grow during the pandemic.

Our findings suggest that policy measures that could counteract some of these changes, such as additional in-person instruction for at-risk children, should be considered. Our findings also call for more theoretical and empirical research on the education crisis brought about by the pandemic. There is now some direct evidence on changes in children's learning during the pandemic (Werner and Woessmann, 2021) but for other aspects such as changes to peer effects our analysis relies primarily on extrapolation from earlier evidence. Our analysis has also abstracted from monetary investments in children, which are particularly relevant for high school children (Del Boca et al., 2014). When monetary investments (in addition to time investments) matter, another link between economic inequality and educational inequality arises, which brings about additional channels of transmission given the

unequal economic impact of the pandemic. More comprehensive evidence on how children's peer environments, parental interactions, and parental investments change during the pandemic will put researchers and policymakers in a better position to evaluate possible countermeasures.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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Appendix A. Supplementary material

Supplementary data associated with this article can be found, in the online version, at <https://doi.org/10.1016/j.jpube.2021.104574>.

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