HHS Public Access

Author manuscript

*Policy Insights Behav Brain Sci*. Author manuscript; available in PMC 2022 November 14.

Published in final edited form as:

*Policy Insights Behav Brain Sci*. 2021 October ; 8(2): 111–118. doi:10.1177/23727322211032248.

# Potential Socioeconomic Effects of the COVID-19 Pandemic on Neural Development, Mental Health, and K-12 Educational Achievement

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## Abstract

The Novel Coronavirus (COVID-19) pandemic can affect more than a child's biological health. Lack of in-person schooling and increased stress can affect neurodevelopment, mental health, and later life outcomes, especially for students who are from low socioeconomic status (SES) households. Insights from neuroscience on child development reveal potential neural mechanisms and educational outcomes likely disrupted by the pandemic—and how this will disproportionally affect low-SES children. Three policies can combat these educational and emotional effects: increased access to online resources, investments in social-emotional health, and increased access to summer/out-of-school learning. Integrating the traditionally separate fields of neuroscience and educational research will be critical for developing and assessing the most impactful policies to improve the well-being and educational achievement of our most disadvantaged children.

## Tweet

The pandemic likely affected educational outcomes due to stress, especially for low-SES students. Insights from neuroscience indicate three high-yield mitigating policies: access to online resources, investments in social-emotional health, and increased summer learning.

### Keywords

COVID-19; education; neuroscience; adolescents; socioeconomic status

COVID-19 infiltrated every state in the United States, and at its peak, averaged around 250,000 cases with just over 3,000 deaths a day (Centers for Disease Control and Prevention, 2020). At the end of the 2019–2020 school year, almost every U.S. state closed schools to protect students and teachers from COVID-19 (Chavez & Moshtaghian, 2020). To aid states in responding to COVID-19 and combat the economic effects of the pandemic, the United States Congress passed the CARES (Coronavirus Aid, Relief, and Economic Security) Act (2020), which allocated approximately $13 billion to K-12 schools. This Act



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Declaration of Conflicting Interests

The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

gave flexible spending to help stabilize schools and help foster reopening, including money for sanitation, meals, purchasing of educational technology, and mental health services. The pandemic persisted into the 2020–2021 year and in December of 2020, a $1.4 trillion relief funding package was passed to fund government activities and provide additional relief to education among other provisions (National Conference of State Legislatures [NCSL], 2021). For K-12 schools, $54.3 billion were allocated to address similar problems described in the original CARES Act. In March 2021, the American Rescue Plan apportioned $195 billion to K-12 education (Ujifusa, 2021). The vague language within all these packages allowed states and school districts flexibility to allocate based on their needs. This article focuses on policy implications for brain development and educational outcomes, how to address potential inequalities that may stem from differences in funding appropriation, and potential interventions which could mitigate these detrimental effects.

## Schools' Response

For the end of the 2019–2020 school year, states adopted varying methods of continuing education. Some, like Kentucky, mandated that every school switch over to already state-created distant learning instruction. Other states, such as Montana, did not recommend or require any distant or online learning, leading school districts to adopt divergent policies within state ("Coronavirus and Learning: What's Happening in Each State," 2020). This variability in policy inherently creates educational disparities between states and even between school districts within states. For example, some schools attempted to restart the 2020–2021 school year in person, yet subsequently moved to online-only learning after drastic increases in cases (Nierenberg & Pasick, 2020). Other schools started online and continued with online schooling for the majority of the 2020–2021 school year.

In 2020, and recently updated in 2021, The American Academy of Pediatrics advised schools to reopen, if possible, to mitigate adverse social and educational effects (COVID-19 Guidance for Safe Schools, 2020). Local governments, in turn, were continually tasked with preventing illness and death among students, teachers, and their families, while also teaching children who spent the last year without in-person schooling (Richards, 2020). Regardless of how each district moved forward, schools needed more resources to combat pandemic stress, adapt instructional plans, enact safety measures, and compensate for the lack of in-person schooling (American Federation of Teachers, 2020; Lee, 2020). The months-long break from school and substituting online/distance learning may work for some students with the privileges of stable internet access, secure housing, and available caregivers. However, others will likely continue to struggle emotionally and academically because of the pandemic for years to come. Lack of stability and increased chronic stress due to the pandemic disproportionately affects students from households defined as low socioeconomic status (SES) prior to the pandemic, as well as those who then found themselves in those households as a result of the pandemic.

Insights from neuroscience research can help inform predictions of the pandemic's likely impact on neurodevelopmental and educational outcomes. Factors such as poverty and pre-existing stress may predict differences in academic achievement and further pandemic-related stress. Children of essential workers, for example, continued to cope with potential

illness and navigate stressors such as parental job loss, death of a family member, or food insecurity. These types of acute and chronic stressors can change neurodevelopment. Although all children are at risk of falling behind, students from low-SES backgrounds will fall even further behind educationally, with accompanying emotional and behavioral problems due to ripple effects of the COVID pandemic. Specifically, stress and poverty undermine emotional, neurological, and academic health. Although schools acknowledge achievement gaps, few take a neurodevelopmental approach. This more nuanced integration of emotional, physical, and educational health helps understand child development.

This article will briefly review how stress from a low-SES household affects relevant brain areas, and how this may translate to emotional health and educational outcomes. Then we will propose an accentuated Summer Slide and Chronic Stress model: Neurodevelopmental and educational impacts on children in poverty- and near poverty-level households (identified in research from prior off-school periods) likely amplifies under the high-stress conditions of the COVID-19 pandemic. In addition, the current relief bills' shortcomings require policy makers to adapt the funds provided for the best outcomes. Integrating the traditionally separate fields of neuroscience and educational research enables developing and assessing policies for the greatest impact on improving the well-being and educational achievement of our most disadvantaged children.

## Neural Mechanisms of Stress and Low-SES

SES, or the combination measure of education, income, and occupation, has been critical in assessing differences in many types of behavioral, physical, mental, and cognitive outcomes (Conger & Donnellan, 2007). Low-SES is associated with higher levels of stress, including more daily stressors, and can interfere with normal, healthy stress responses (Evans & English, 2002). Such daily stressors include feeling unsafe in one's neighborhood, inadequate access to food or water, inadequate family support, housing insecurity, and domestic violence, among others (Graves & Nowakowski, 2017). These repeated chronic stressors affect normal biological functioning, such as the stress pathway (hypothalamic-pituitary-adrenal [HPA] axis) which, in turn, can affect the immune system and cognitive processes leading to poor mental and physical health (Kudielka & Kirschbaum, 2005).

Although stress is necessary for navigating life effectively, chronic stress can harm the brain (Kokubun et al., 2018). Stress-related damage to the critical HPA axis in childhood may have significant, negative long-term effects. Chronic stress can worsen psychopathology symptoms, like anxiety or depression, that can manifest in the classroom; furthermore, it can cause other adverse health effects that decrease stress-coping mechanisms and increase insulin resistance (Condon, 2018). Together, stress affects children's functioning in school and overall health post-pandemic.

Stress and low-SES relate to differences in brain volume, particularly in the prefrontal cortex (PFC) and hippocampus. These brain areas support social health, mental health, and educational achievement (Hackman & Farah, 2009; Hair et al., 2015; Kokubun et al., 2018). American children's stress increased during the pandemic and was worse for children and adolescents who already had financial hardships (Fegert et al., 2020; Lee, 2020; Zhou et

al., 2020). These findings indicate the importance of understanding the effect of stress and mental health on other aspects of children's lives including education. Next, this article will highlight the role of the PFC and hippocampus in learning and memory and discuss how the effects of chronic stress on these brain circuits may compromise educational development in children.

## PFC and Hippocampus

The PFC and the hippocampus are crucial for school achievement (Gogtay et al., 2004; Montagrin et al., 2018). The PFC, located at the front of the brain, over the eyes, serves as the hub for many crucial processes, including executive control, which allows children to pay attention in class and complete important tasks like homework (Miyake et al., 2000; Sheridan et al., 2012). The hippocampus, a small region deep within the brain, is important for formation and retrieval of memory and accordingly has many implications for educational achievement (Leutgeb & Leutgeb, 2007; Staresina & Davachi, 2009). The PFC and hippocampus are sensitive—especially susceptible during development— to stress caused by poverty. Even brief stress can disrupt basic memory and attention performance (Akirav & Richter-Levin, 1999; Farah, 2017; Qin et al., 2009). Reduction in volume of PFC and hippocampus have been shown to be related to poverty and stress and these differences are related to worse academic outcomes in literacy and math (Clark et al., 2010; Kim et al., 2013; Noble et al., 2012). Without healthy development of the PFC and hippocampus, children have difficulty working flexibly and self-regulating behaviors related to school achievement and readiness (Blair & Razza, 2007; Montagrin et al., 2018).

However, not all stress is created equal. Namely, perceived control over psychological stress can help mitigate the adverse effects on brain development (Shors et al., 1989). Children who have higher perceived stress show lower hippocampal volume compared with those who have less perceived stress (Piccolo et al., 2018). During this current pandemic, however, many students have lost their sense of control and are likely facing increased psychological stress as a result (Fegert et al., 2020; Lee, 2020; Zhou et al., 2020). The ability to succeed in school relies in part on the ability of the PFC and hippocampus to work effectively; crucially, chronic stress can change the developmental trajectory of these brain areas. Chronic stress can come from many sources that can compound each other; for example, instability of food and housing, lack of educational stimulation, increased violence, and lack of healthy social engagement. These stressors are being accentuated during the COVID-19 pandemic and could potentially affect PFC and hippocampal development of children currently in the school system; therefore, it is necessary to consider this development in predicting educational outcomes.

## Stress, the Brain, and Emotion

As previously discussed, the PFC and hippocampus are implicated in educational achievement. However, the brain is multifaceted, and each region has multiple functions as well as many regions concurrently working together to achieve behavioral outputs. Both the PFC and hippocampus, as well as their functional and structural interactions, are involved in emotion, memory, and attention. Accordingly, mood has been linked to children's school

performance and therefore needs to be centered in the conversation of academic achievement (Gumora & Arsenio, 2002). Stress can cause emotion dysregulation over time which can lead to more aggressive behavior and potentially worse later life outcomes (Fite et al., 2010; Herts et al., 2012).

The PFC and hippocampus together enable memory and specifically contextual and emotional memories (Jin & Maren, 2015; Preston & Eichenbaum, 2013). Emotions themselves influence how the hippocampus forms and this formation affects memory systems (Pessoa, 2008). In the context of the COVID-19 pandemic, youth could have a difficult time in school due to losing loved ones, their homes, or not being able to see friends. Therefore, detrimental effects of low-SES and increased stress on these brain regions do not just affect educational performance by itself, but also decrease emotion regulation and emotional memory accuracy, leading to additional harmful effects on educational achievement. Thus, both educators and policy makers must take emotional well-being and development into account to help counteract deficits caused by stress.

## Summer Slide + Chronic Stress Model

"Summer Slide" refers to a reduction in academic achievement during the summer months due to not being in school (Alexander et al., 2001). The effect of this lost school time occurs predominantly among children who live in poverty or near-poverty (Alexander et al., 2001; Kuhfeld et al., 2020). Summer learning loss can project deficits in learning for different groups of children because of the pandemic. In one projection, students on average were to only gain between 37% and 50% of normal gains in math and 63% and 68% of gains in reading at the end of the 2019–2020 school year (Kuhfeld et al., 2020). Here, extrapolating into the fall semester projected students to learn less than 30% of their typical gains. Typically, SES per se did not widen achievement gaps, but the availability of technology did, indicating its role in mitigating poverty's effects. Granted, this study does not account for the increased stress and mental health effects due to the pandemic that will likely disproportionately affect low-income students.

Student achievements in the fall 2020 semester provide additional support for the Summer Slide and Chronic Stress model. Reportedly, students learned only about 67% of math and 87% of reading they would have typically learned (Dorn et al., 2020). Low-SES and students of color, which there is some overlap, are expected to lag behind these projections, with one study projecting that students of color may have lost 12 to 16 months, while White students lagged 5 to 9 months from March 2020 to June 2021 (Dorn et al., 2020; Olneck-Brown, 2021). Although preliminary data estimates these large deficits in learning will continue once students return to school and normal learning trajectories will likely not go back to a normal. Moving forward, low-SES and students of color may consistently stay about 1 to 2 years behind where they should be, while high-SES and White students will move closer to their typical trajectory within a few years. High-SES students are more likely to get back on track due to availability of learning resources and greater stability in life, while low-SES students will not have those privileges. Below are some recommendations to mitigate these effects in order to get low-SES students back on a healthy trajectory of emotional and educational development.

## Policy Recommendations

To combat the economic effects of the pandemic, Congress passed both the CARES Act and the economic relief package, giving approximately $67 billion for K-12 schools in flexible funds to help stabilize schools and foster reopening (Coronavirus Aid, Relief, and Economic Security Act, 2020; NCSL, 2021). According to the American Federation of Teachers, this was still around $62 billion dollars short to safely and effectively open schools (American Federation of Teachers, 2020). Even with the financial stimulus behind opening schools safely, low-SES students will continue to lag behind their peers, without immediate action to combat the mental health and academic effects of the pandemic (Roza, 2020). Below are three high-yield areas of investment to combat these disparities for low-SES students: increased access to online resources, investments in social-emotional health, and increased access to summer/out-of-school learning.

### Increased Access to Online Resources

The Pew Research Center estimates that only around 50% of poor households have a home computer and broadband internet while 95% of high-earning households have access to these technologies (Anderson & Kumar, 2019). If most schools implement distance/online learning, those students who lack access will struggle with their work as well as not have access to virtual mental health resources (Ali et al., 2019). While most schools have provided devices such as laptops, providing adequate internet to rural and poor urban areas has been difficult, although arguably a necessary utility for everyone in the United States. In future funding bills, Congress, as well as local and state governments, should allocate funding to create expanded avenues for internet access—such as community hotspots or citywide Wi-Fi— and subsidize internet costs. Without congressional budget and direction, states or communities themselves may not build sound broadband internet infrastructure. Without it, online learning may not keep students on track for success. Furthermore, if additional schooling or homework is needed to try to regain learning lost from the pandemic, having equitable internet access is imperative. Creating accessible broadband internet would also give a return on investment in as little as a year (Blandin Foundation, 2017). It also creates and stabilizes jobs, increases real estate value, which together will likely decrease stress of the families who need it and increase funding for local schools through real estate taxes. However, some young students (first grade and under) or some children with disabilities may not be able to do online learning no matter how accessible it is. For these children, school districts should provide special consideration for in-school learning programs. In sum, increasing internet access and affordability will help mitigate stress due to the pandemic and further help children learn.

### Investments in Social-Emotional Health

Even with schools reopening, telehealth and mental health resources need funding. Mississippi recently allocated money to include schools in the Mississippi Division of Medicaid, thereby giving telehealth coverage to any student (Alsup, 2020). Telehealth can support both mental and physical health for families that otherwise would not have access to health care, specifically in low-SES households (Khwaja, 2020). Telehealth demonstrably helps mental health in numerous emotional disorders and would be applicable to any school

district (Kennedy et al., 2020). Although the CARES Act allowed for more discretionary funding of mental health resources, each state or school district should use their own funding to start, expand, and maintain telehealth services. These investments may combat potential mental health difficulties and in turn help mitigate deficits in brain development due to the pandemic (Lee, 2020).

Social and emotional learning (SEL) is a curriculum that helps children manage their emotions, create and achieve goals, and practice empathy and positive relationships (Ross & Tolan, 2018). One validated framework (Collaborative for Academic, Social, and Emotional Learning; CASEL) uses a five-pronged SEL model to increase social, emotional, and personal skills (see Ross & Tolan, 2018). This program focuses on childhood and early adolescence, which have generally been the most impactful developmental points for SEL interventions. In a study of fifth to seventh graders, CASEL's SEL intervention decreased risky behaviors, decreased delinquency, and improved academic performance. Adding SEL programming would likely help mitigate the impacts of COVID-19 stressors and lost educational opportunities for low-SES youth. States should consider adding SEL curriculum moving forward with discretionary funding from Congress. Many SEL curriculums are available, and each district should consider which one is most appropriate for their demographics and cultural values.

Another possible direction is to adopt trauma-informed schooling, which is shown to increase resilience and decrease problematic behaviors (Fondren et al., 2020). Emotion-based learning may become especially necessary for children who have post-traumatic stress disorder (PTSD) or show increased stress symptoms due to the pandemic. Without knowing how these interventions affect the brain, many interventions nevertheless lead to better symptom outcomes (Wiest-Stevenson & Lee, 2016).

### Increased Access to Summer/Out-of-School Learning

Most students, but especially those who have higher stress and poverty due to the pandemic, will need increased support and year-round schooling to combat these effects. It will likely take years to put students back on their original academic trajectory. There should be adequate funding for summer school for any student that needs it, based on the district funding distribution laid out in the CARES Act (funding is given per pupil, but also % low income of the district), and should continue for years to come to make up for lost months or years of inadequate schooling due to the pandemic (Coronavirus Aid, Relief, and Economic Security Act, 2020). While enriched learning opportunities will be important for low-SES students, as shown in some interventions (McEachin et al., 2018), it will be vital to similarly address other disparities accentuating the SES learning gap, including access to adequate nutrition, housing, and stable incomes for parents, to fully combat the effects of poverty and stress on child behavioral and neural development (Sheridan et al., 2017).

## Limitations

Education and student success are complicated issues. Although educational policy and research has increased knowledge on neurodivergent children or children who have experienced trauma, there are still many unknowns. Furthermore, the SES construct does

not include constructions of neurodiversity or trauma, so it is difficult to know how their intersection with SES will affect children's learning. Neurodivergent children who have attention-deficit hyperactivity disorder (ADHD), Autism, or Down Syndrome will likely have a more difficult time catching up to their peers or participating in distant or online learning. Furthermore, students who have pre-existing mental health disorders like anxiety, depression, or PTSD are also unlikely to be as successful during or after the COVID-19 pandemic as their neurotypical peers. Many school districts need to understand each individual student's capabilities and journey.

Each child's brain also has a unique developmental trajectory depending on genetics and environment. Decreasing stress and increasing academic interventions will help remediate some losses due to pre-existing health conditions, exposure to environmental pollutants, and inadequate sleep (Senut et al., 2012; Shonkoff et al., 2009; Telzer et al., 2013). Furthermore, ensuring that each child is fed nutritious meals and has adequate exercise increases academic achievement (Edwards et al., 2011). Thus, understanding the comprehensive picture of a child's environment and how it affects outcomes and brain development is imperative for the child's success. The policy interventions proposed in this article address some of the acute challenges posed by COVID-19. However, these interventions alone will not address enduring disparities in neurological development and educational achievement for students experiencing adverse environmental conditions.

## Future Directions

Neuroscientists have the potential to help shape education policy and make schooling more accessible and effective for disadvantaged students. Although few research studies directly combine neuroscience with educational interventions and outcomes, this growing field will be useful for future policy decisions. Incorporating biology and behavior can inform policy recommendations that address disparities. This article serves as a starting point for policy makers, educators, and scientists to understand the larger picture of child development and to create science-based policy designed to reduce the vast inequities in social, emotional, and educational outcomes facing our most disadvantaged children.

## Funding

The author(s) disclosed receipt of the following financial support for the research, authorship, and/or publication of this article: Funding for this study was provided by the National Institute of Mental Health (R01MH117141 and Ro1MH115910, to RJH), the National Institute of Mental Health Diversity Supplement (R01MH115910, to GCG).

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**Key Points**

- The COVID-19 pandemic has increased stress on some of our most vulnerable youth, likely prolonging their disadvantages in school.
- Stress caused by poverty and the pandemic may interfere with healthy brain development including executive functioning, memory systems, and emotion regulation.
- Low-SES students are expected to lag behind their high-SES peers.
- Policies can combat educational effects: increased access to online resources, investments in social-emotional health, and increased access to summer/out-of-school learning.