



Budget Model

COVID-19: Cost of virtual schooling by race and income

Summary: PWBM estimates that schools in the Philadelphia and surrounding suburb districts with more Black students are less likely to reopen with in-person instruction relative to schools with more White students, even after controlling for differences in income by district. By March 2021, Black students in grades K-5 have incurred a 11.9 percent loss in lifetime income from school closures while White students have lost 10.4 percent. Students educated in the city face larger losses than students educated in the surrounding suburbs.

Key Points

- Using data from the Philadelphia school district and 63 neighboring suburban school districts, we find that schools in districts with more White students are more likely to reopen, even after accounting for differences in income. A 10-percentage point increase in a school district's White population share is associated with at least a 5-percentage point increase in school openness.
- By March 2021, Black students in grades K-5 have lost about 11.9 percent of lifetime income while White students in K-5 have lost 10.4 percent. Students in K-5 in the lowest family income quintile have lost about 11.3 percent of lifetime income compared to 10.7 percent for students in the highest income quintile.
- Schools located in Philadelphia are less likely to reopen relative to suburban districts, indicating an urban-suburban divide.

Introduction

March 2021 marks one year since schools in the United States substantially reduced in-person learning to control infection spread during the COVID-19 pandemic. School closures and virtual schooling are costly to many students and parents in terms of reduced learning outcomes, mental health and emotional costs, increased incidence of substance abuse and physical abuse, time and productivity costs to parents and caregivers, and other negative effects. Of course, bringing students, teachers, and staff together may increase the risk of COVID-19 spread. [Recent work](#) has found no statistically significant increase in infections for most

districts from reopening schools, with an increase in infections of up to 20 per 100,000 people for districts already experiencing high levels of infection.¹

We previously analyzed the trade-off between average costs of a new COVID-19 infection and future income losses to students from missed education with a [national average](#) study and a [case study](#) for Philadelphia suburbs. Our estimated average cost of COVID-19 infection accounts for value-of-life lost, hospitalization costs, and lost productivity. Our newest estimates indicate that the average cost of a new infection is \$41,180 through January 2021²—roughly 8 times the average estimated \$4,972 cost of an influenza infection.³

In this brief, we estimate a relationship between the level of school openness and educational loss. Lower education is correlated with lower labor income, so the 13 cohorts of children in grades K-12 who have been distance learning for the past year are likely to suffer permanent reductions in lifetime income.

We use data for 63 school districts in four Philadelphia-area counties and the school district of Philadelphia to investigate the correlations between school district level average openness in the fall 2020 semester and local demographic and economic characteristics. On average, for the past year, White students in our sample experienced an openness level of 19 percent (about one in-person school day per week), resulting in a predicted loss of between 8.0 percent and 10.4 percent to their lifetime income. The average openness level faced by Black students was 8.0 percent (less than half of one in-person school day per week), which decreases their expected lifetime earnings by between 9.2 percent and 11.9 percent.

Previous Studies

Since many school districts in our dataset implemented various forms of hybrid learning (varying from one to four in-person days per school week), we investigate the relationship between days of in-person schooling and educational outcomes as measured by standardized test scores in math and reading. Several previous studies have examined various factors that help inform our modeling of this relationship.

Research on the effects of hybrid instruction is still preliminary, so we use [studies on full virtual schooling](#) and on [shortened school-weeks](#) to model educational losses.⁴ Though distance learning may have increased in effectiveness over the course of the pandemic, we derive our initial data points of learning loss under completely virtual schooling from empirical evidence from a [Stanford University study](#) on the effectiveness of online K-12 charter schools. The study found complete learning loss in math, but only partial learning loss in reading when instruction is fully online. Consistently, [an OECD study published in fall 2020](#) projects that current [students in 18 states and Washington, D.C. have lost between 6 to 9 percent of future lifetime labor income](#) from the school shutdowns.

When school is virtual, students lose the documented benefits of in-person instruction, but they also lose interaction with friends and peers—specifically, schools allow low-income students to expand their social circles to include higher-income students. [A recent study](#) estimates that these peer effects are nearly twice as important as the direct effect of school closures on students' learning. That study projects that the lack of mixing of students from different socioeconomic groups in public schools will lead to a stratification in post-pandemic learning outcomes, where students from the lowest income families experience the greatest learning losses, while those from the highest income families may not fall behind at all. Peer effects may be nonlinear in number of in-person days. For instance, though a school can be partially open, students may require a critical mass of friends and peers to be in school on the same days in order to benefit from peer effects.

Virtual schooling also likely does disproportionate harm to disadvantaged students, who are more likely to lack access to suitable study spaces, sufficient access to internet connectivity and computer equipment (especially in households with multiple children), and caregivers at home to supervise and assist with remote learning. Differences in attendance and engagement with in-person school, even when available, are [related to race](#) and to different attitudes to risk as shown in a [50 state survey](#) conducted between December 2020 and January 2021. A [recent study](#) found that most subgroups of students in fall 2020 had stable reading test performance compared to same-grade students in fall 2019. However, Black and Hispanic students in upper elementary grades had lower test scores than their same-grade peers from a year prior. [Other studies](#) have found that lower-performing students have suffered greater learning loss than higher-performing students during the COVID-19 pandemic.

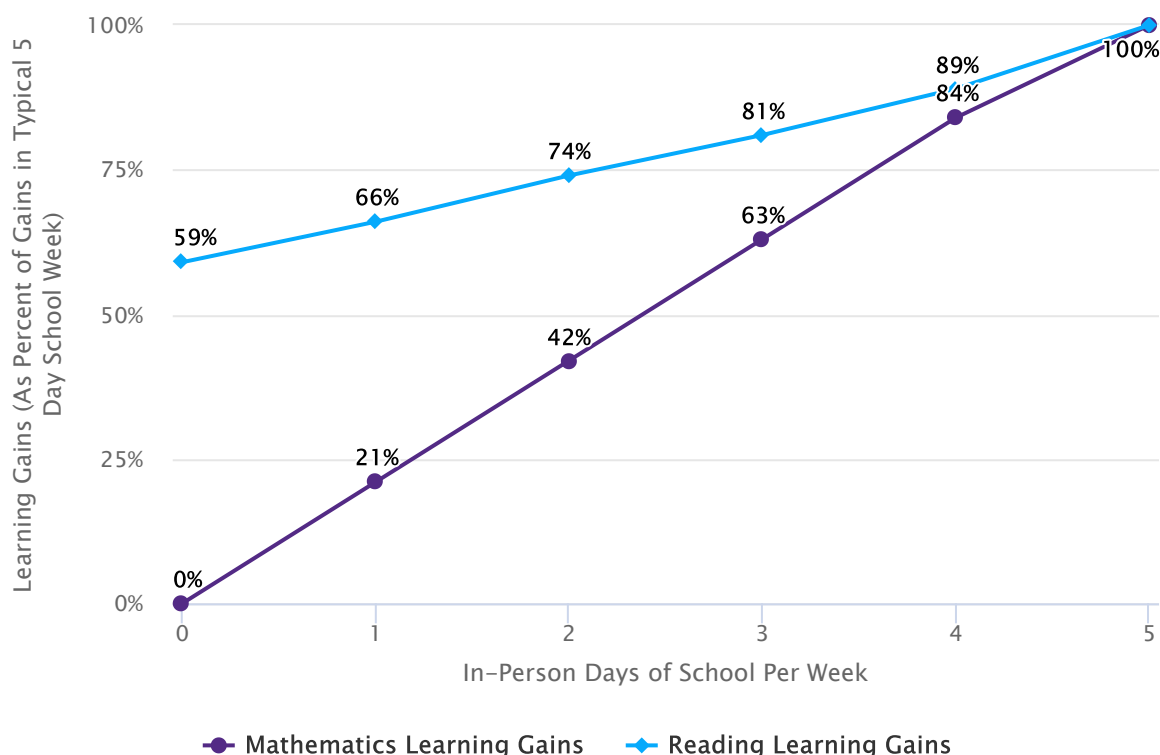
Of course, the “average” results reported in many previous studies do not account for heterogeneous differences in learning styles or school delivery. For example, some students may benefit from remote learning due to differences in preferred learning styles. Furthermore, students in schools which are less safe or lacking in classroom discipline may benefit from a more stable learning environment even if the quality of remote instruction is inferior. A better understanding of the consequences of remote learning will be developed over the coming years as more data is gathered that allows us to consider heterogeneity in learning styles and schools.

Modeling the Effects of Virtual Schooling on Learning

Figure 1 shows estimates of learning in math and reading by the number of days per week that students attend school in person. Our estimates combine results from studies of [fully virtual learning](#) and [4 day school weeks](#), assuming a linear relationship between learning loss and openness for less than 4 in-person school days per week, in line with studies on [student absences and snow days](#). Going from 5 days of in-person schooling to 4 days results in an 11-percentage point loss in reading learning and a 16-percentage point loss to math learning. Each additional day less of in-person schooling is estimated to reduce reading learning by an additional 8 percentage points and math learning by an additional 21 percentage points. Actual realized learning losses may differ and may vary widely depending on the student and specific mode of hybrid education.

Figure 1: Predicted Learning as a Function of In-Person School Days

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The above estimates represent projected average learning losses from virtual schooling. But, as noted previously, actual learning losses likely fall more heavily on already disadvantaged students.

Each year of schooling is estimated to increase future labor income by 7 percent to 13 percent.⁵ The US economy is increasingly knowledge-based, which makes education even more important and potentially raises the returns to schooling above historical levels. Consistent with [our previous post](#), we apply a 13 percent return to in-person schooling for grades K-5 and 10 percent return to grades 6-12, since younger children likely gain less from virtual schooling than their older peers and some researchers have found there are higher relative returns to the primary grades than the upper grades.

Modeling the Relationship between School Openness and Income and Race

Using the school openness index we developed in our [previous work](#), we compile a dataset consisting of the large Philadelphia city school district, which has been fully virtual since March 2020, and 63 school districts in the neighboring suburban area. We examine three relationships (regression analysis) of district-level data for the fall 2020 semester, weighted by each district’s K-12 enrollment:

1. Relationship of school openness on White population share,
2. Relationship of school openness on mean income,
3. Relationship of school openness on both race and income.

To understand if Philadelphia school openings are different than its suburbs, we consider each of these relationships using two different versions of the data: first, using data with just suburban school districts (without Philadelphia) and, second, using the full dataset that includes the Philadelphia school district.

Looking only at the 63 suburban school districts, relationship (1) finds that a 10 percentage point increase in a school district's White population share predicts a 5 percentage point increase in school openness. Relationship (2) finds a positive but not statistically significant correlation between school openness and mean incomes for those suburban school districts. Relationship (3), however, finds that a 10 percentage point increase in White population share predicts an 8 percentage point increase in school openness but with the correlation between openness and mean income now *negative* and statistically insignificant.

Looking instead at the full sample—the 63 suburban school districts plus the Philadelphia school district, relationship (1) is unchanged, with a 10 percentage point increase in White population share predicting a 5 percentage point increase in openness. Relationship (2) finds that a \$100 increase in mean weekly income predicts a 2 percentage point increase in school openness. Relationship (3) finds that 10 percentage point increase in White population share still predicts an 8 percentage point increase in openness, with a negative and statistically insignificant correlation between openness and mean income.

In both the suburban sample and the full sample, the correlation between race and school openness remains even when adjusting for local income levels. In contrast, the correlation between income and openness disappears when controlling for race. The lack of a clear relationship between district-level income and school openness is potentially consistent with [recent work](#) that finds no significant relationship between openness and school funding. Additionally, the larger income disparity when including the Philadelphia school district suggests that disparities in school openness are more strongly related to urban versus non-urban policy differences rather than solely race or income factors.

Using our model presented above, we calculate learning loss for both mathematics and reading in terms of lost school days per month (where one month is an average of 20 instructional days) and lost school days per year (where one year is 180 instructional days). Using learning loss and rates of return on schooling, we calculate the lifetime income loss from one year of school at each student group's average openness exposure.⁶

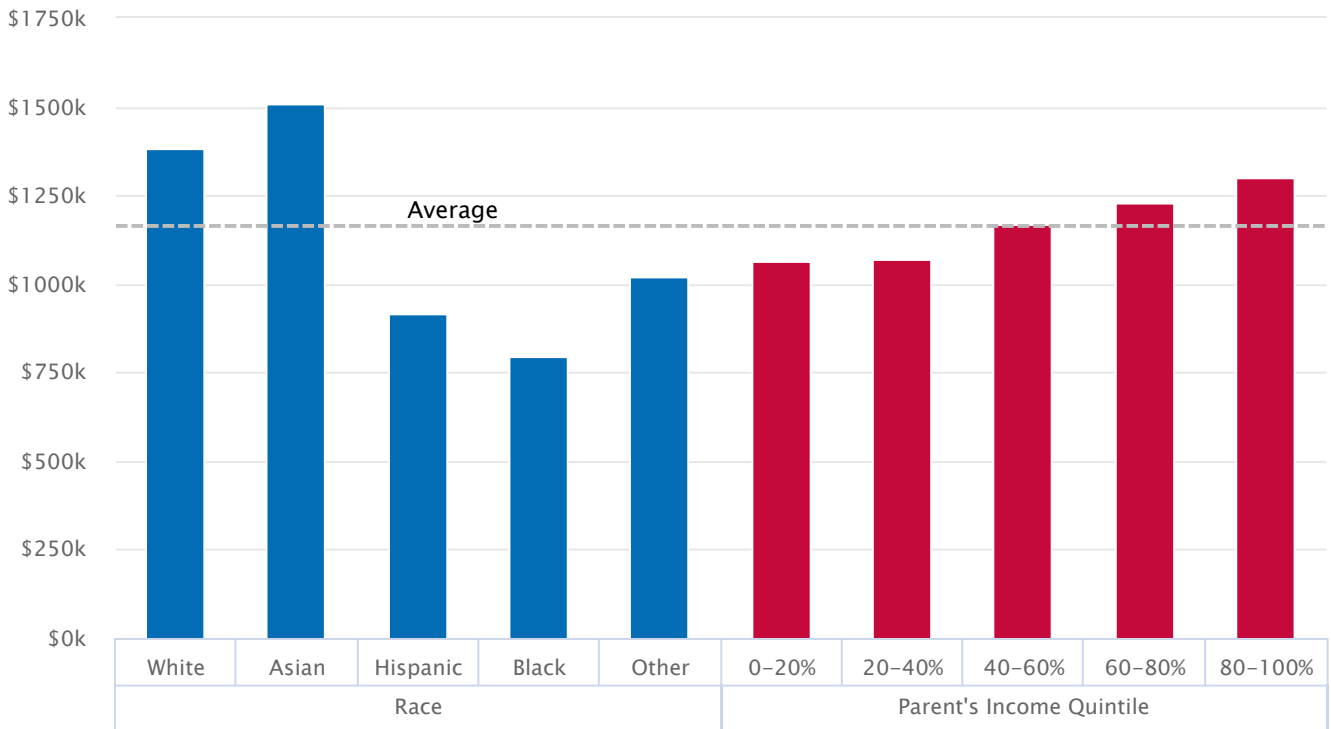
Estimating the Impact of School Closures on Lifetime Income

To examine the impact of school closures on lifetime income, we first use the PWBM microsimulation model to estimate "baseline" lifetime incomes for current students without COVID-19 and school closures. We then compute lifetime incomes of these same students with the school closures, and we report the differences in lost lifetime incomes.

For the baseline without school closures, the projected future path of wages for simulated individuals ages 5 to 18 in 2020 is discounted and summed to produce a net present value (NPV) of labor income for each modelled individual. Figure 2 shows the NPV of average expected lifetime wage income by race and parents' income quintile.

Figure 2: Net Present Value of Expected Lifetime Earnings by Race and Parent’s Income Quintile

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The average NPV of lifetime income across subgroups is \$1.16 million. Income varies by race, with White and Asian students earning a NPV of \$1.38 million and \$1.51 million, respectively, while Hispanic students earn \$0.91 million and Black students earn \$0.80 million over their lifetime. Student predicted income also increases with parental income, ranging from \$1.06 million for the bottom quintile to \$1.30 million for the top quintile.

Table 1 reports the loss in lifetime incomes from school closures. The learning and income loss estimates are presented for both 1 month or 1 year of schooling at the average openness level. The table shows results for the 63 suburban school districts separately and for the full dataset and displays lifetime income losses in both dollars and percentage terms (see interactive toggles).

Table 1: Projections of Students’ Learning and Future Income Losses by Race and Parents’ Income

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Suburban School Districts ▼

Present Value of Income Losses in 2020 dollars ▼

1-1 Results for Suburban School Districts, Present Value of Income Losses in 2020 dollars

	Average Openness Calculated with Suburbs Data (2020 Sept-Dec)	Estimated Learning & Income Losses due to 1 Month of Schooling at the Average Openness				Estimated Learning & Year of Schooling at		
		Mathematics LL (school days)	Reading LL (school days)	Grades K-5 (present value in 2020 dollars)	Grades 6-12 (present value in 2020 dollars)	Mathematics LL (school days)	Reading LL (school days)	
All	0.20	15.8	6.7	\$10,534	\$11,282	142	61	
Race	White	0.22	15.4	6.6	\$12,089	\$13,057	138	59
	Asian	0.19	16.0	6.8	\$13,349	\$14,920	144	61
	Hispanic	0.18	16.2	6.9	\$8,860	\$9,955	146	62
	Black	0.17	16.4	7.0	\$7,616	\$8,028	148	63
	Other	0.17	16.4	7.0	\$9,822	\$10,078	148	63
Parents' Income Quintile	0-20%	0.20	15.8	6.7	\$9,348	\$10,234	142	61
	20-40%	0.20	15.8	6.7	\$9,806	\$10,391	142	61
	40-60%	0.21	15.6	6.7	\$10,398	\$11,183	140	60
	60-80%	0.21	15.6	6.7	\$10,955	\$11,707	140	60
	80-100%	0.20	15.8	6.7	\$11,766	\$12,547	142	61

1-2 Results for Suburban School Districts, Income Losses in Percentage

	Average Openness Calculated with Suburbs Data (2020 Sept-Dec)	Estimated Learning & Income Losses due to 1 Month of Schooling at the Average Openness				Estimated Learning & Income Losses due to 1 Year of Schooling at the Average Openness		
		Mathematics LL (school days)	Reading LL (school days)	Grades K-5	Grades 6-12	Mathematics LL (school days)	Reading LL (school days)	
All	0.20	15.8	6.7	1.14%	0.88%	142	61	
Race	White	0.22	15.4	6.6	1.11%	0.86%	138	59
	Asian	0.19	16.0	6.8	1.16%	0.89%	144	61
	Hispanic	0.18	16.2	6.9	1.17%	0.90%	146	62
	Black	0.17	16.4	7.0	1.18%	0.91%	148	63
	Other	0.17	16.4	7.0	1.18%	0.91%	148	63
Parents' Income Quintile	0-20%	0.20	15.8	6.7	1.14%	0.88%	142	61
	20-40%	0.20	15.8	6.7	1.14%	0.88%	142	61
	40-60%	0.21	15.6	6.7	1.13%	0.87%	140	60
	60-80%	0.21	15.6	6.7	1.13%	0.87%	140	60
	80-100%	0.20	15.8	6.7	1.14%	0.88%	142	61

1-3 Results for Suburban and Philadelphia School Districts, Present Value of Income Losses in 2020 dollars

	Average Openness Calculated with Suburbs and Philadelphia Data (2020 Sept-Dec)	Estimated Learning & Income Losses due to 1 Month of Schooling at the Average Openness				Estimated Learning & Income Losses due to 1 Year of Schooling at the Average Openness		
		Mathematics LL (school days)	Reading LL (school days)	Grades K-5 (present value in 2020 dollars)	Grades 6-12 (present value in 2020 dollars)	Mathematics LL (school days)	Reading LL (school days)	
All	0.15	16.9	7.1	\$11,267	\$12,068	152	64	
Race	White	0.19	16.0	6.8	\$12,560	\$13,566	144	61
	Asian	0.13	17.3	7.3	\$14,434	\$16,133	155	65
	Hispanic	0.10	17.9	7.5	\$9,790	\$11,000	161	67
	Black	0.08	18.3	7.6	\$8,498	\$8,958	165	69
	Other	0.11	17.7	7.4	\$10,600	\$10,877	159	67
Parents' Income Quintile	0-20%	0.12	17.5	7.3	\$10,353	\$11,335	157	66
	20-40%	0.13	17.3	7.3	\$10,737	\$11,378	155	65
	40-60%	0.15	16.9	7.1	\$11,264	\$12,115	152	64
	60-80%	0.16	16.6	7.0	\$11,657	\$12,457	150	63
	80-100%	0.17	16.4	7.0	\$12,213	\$13,023	148	63

1-4 Results for Suburban and Philadelphia School Districts, Income Losses in Percentage

	Average Openness Calculated with Suburbs and Philadelphia Data (2020 Sept-Dec)	Estimated Learning & Income Losses due to 1 Month of Schooling at the Average Openness				Estimated Learning & Income Losses due to 1 Year of Schooling at the Average Openness		
		Mathematics LL (school days)	Reading LL (school days)	Grades K-5	Grades 6-12	Mathematics LL (school days)	Reading LL (school days)	
All	0.15	16.9	7.1	1.22%	0.94%	152	64	
Race	White	0.19	16.0	6.8	1.16%	0.89%	144	61
	Asian	0.13	17.3	7.3	1.25%	0.96%	155	65
	Hispanic	0.10	17.9	7.5	1.29%	0.99%	161	67
	Black	0.08	18.3	7.6	1.32%	1.02%	165	69
	Other	0.11	17.7	7.4	1.28%	0.98%	159	67
Parents' Income Quintile	0-20%	0.12	17.5	7.3	1.26%	0.97%	157	66
	20-40%	0.13	17.3	7.3	1.25%	0.96%	155	65
	40-60%	0.15	16.9	7.1	1.22%	0.94%	152	64
	60-80%	0.16	16.6	7.0	1.20%	0.92%	150	63
	80-100%	0.17	16.4	7.0	1.18%	0.91%	148	63

These results show that openness disparity by income is primarily due to the closure of schools in the lower-income district of the city of Philadelphia and that, in the suburbs, there is little relationship between a school district's average income and openness. Disparity by race is also larger when including the city schools, with Black students having the opportunity for in-person education 0.4 days per week while White students have about 140 percent more in-person time available. However, in the suburbs, Black students still experience levels of school openness which are on average five percentage points lower than White students, implying White students have about 30 percent more in-person education opportunity. Across all subgroups and age cohorts, average losses from the past year range between \$76,600 and \$144,500 per student in present value of lifetime wage income. Although the predicted learning losses are higher in dollar terms for White students as compared to Black students, Black students in K-5 have lost about 11.9 percent of lifetime income while White students in K-5 have lost 10.4 percent.

This analysis was conducted by Maddison Erbabian and Youran Wu under the direction of Efraim Berkovich. Prepared for the website by Mariko Paulson.

1. A February 2021 [brief by the Centers for Disease Control](#) concludes that: "Based on the data available, in-person learning in schools has not been associated with substantial community transmission." ↩
2. The U.S. Center for Disease Control issues updates to COVID-19 mortality rates. Based on the 2020/02/28 data release, our cost of infection estimate is \$56,292 for November 2020 and \$54,792 for December 2020. ↩
3. Morlinari et al. <https://pubmed.ncbi.nlm.nih.gov/17544181/> ↩
4. Most learning loss literature measures learning gains and losses in terms of standard deviations of achievement. Using [methodology from Stanford University's Center for Research on Education Outcomes](#), we [convert learning loss estimates into lost years and days of schooling](#), assuming a typical school year has 180 school days—one standard deviation of learning is estimated to equate to 3.22 years of schooling, so in one typical school year (or 180 days), students gain approximately 0.31 standard deviations of learning (as measured by achievement on standardized tests). ↩
5. Becker, G.S. (1963). *Human Capital: A Theoretical and Empirical Analysis, with Special Reference to Education*, New York: NBER.
Mincer, J. (1974). *Schooling, Experience, and Earnings*. New York: NBER.
Card, D. (1994). "Earnings, Schooling, and Ability Revisited." *NBER Working Paper 4832*.
Card, D. (2001). "Estimating the Return to Schooling: Progress on Some Persistent Econometric Problems." *Econometrica*, 69 (5): 1127-1160.
Hanushek, E.A. and L. Woessmann. (2020). "The Economic Impacts of Learning Losses." *OECD*. <http://www.oecd.org/education/The-economic-impacts-of-coronavirus-covid-19-learning-losses.pdf>.
Kuhfeld, M., J. Soland, B. Tarasawa, A. Johnson, E. Ruzek, and J. Liu. (2020). "Projecting the Potential Impacts of COVID-19 School Closures on Academic Achievement." *Brown University Annenberg EdWorkingPaper No. 20-226*. <https://edworkingpapers.com/ai20-226>.
Psacharopoulos, G. and H.A. Patrinos. (2004). "Returns to Investment in Education: A Further Update." *Education Economics*, 12 (2): 111-134. ↩
6. The learning loss input we use to estimate future income losses is based on learning losses in mathematics, consistent with the methodology of our [previous posts](#). We make this choice since mathematics learning is documented to be more closely linked to income and will likely grow in relative importance as the prevalence of STEM (science, technology, engineering, and math) jobs continues to grow. ↩