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Budget Model

COVID: Trade-offs in School Reopening

Summary: We estimate that each month of school closures in response to the COVID pandemic cost current students between $12,000 and $15,000 in future earnings due to lower educational quality. We also estimate total value-of-life, medical, and productivity costs per infection at $38,315 for September 2020. Using these costs, we calculate the cost-benefit threshold to keeping schools closed for October at over 0.355 new expected infections in the community per student kept out of school.

Key Points

- Using data on mortality and hospitalization from COVID, we estimate a cost per infection which accounts for value-of-life and other costs, peaking at $329,942 in March and declining to $38,315 in September.

- We also estimate that lower-quality education during school closures costs current students between $12,000 and $15,000 in future earnings, varying by age. By October 1, 2020, we project students in grades 1-12 had lost between $43,000 and $57,000, or 4 to 5 percent of their lifetime wage earnings.

- Using these trade-offs, we calculate approximate thresholds for school closure from expected new infections. Based on September's cost per COVID case, the threshold to close schools for October (using the high end of educational harm to children) is over 0.355 new expected infections per student.

Introduction

The COVID pandemic has led many school districts to close schools to in-person learning as a way to reduce spread of the virus. Schools have operated with various distance learning approaches and have been debating how and when to reopen.

School closures and virtual schooling can be costly to 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 care-givers, and other negative effects. Health policy guidance for school reopening has focused on establishing thresholds for infection incidence rates and positivity rates to suggest when various levels of reopening may be safe. These thresholds imply a trade-off analysis between public health costs of increased infections and the harm to students and parents.

In this brief, we attempt to quantify some of these trade-offs. Using data on mortality and illness from COVID along with value-of-life estimates, we calculate the average cost of a new COVID infection. While research on education losses does not offer definitive assessments, we provide some high-end estimates of learning loss on lifetime income.

School reopening undoubtedly will cause some increase in the infection rate as students, teachers, and staff gather in indoor spaces. Research on transmission of COVID in school settings is ongoing, but we note empirical studies of influenza-like illnesses have found that closing schools can reduce influenza transmission by 7-15%.[1] Since 'school reopening' is a very broad concept that includes different mitigation measures and approaches applied in a wide range of ways across varying school districts, we do not attempt to quantify potential increases in COVID incidence from school reopening. Instead, we estimate the number of new infections in the community for the benefit of a school closure to exceed its costs, and we leave the estimation of infection rates to local public health experts who are best familiar with local circumstances.

Cost per case

Some COVID infected individuals are asymptomatic, others recover quickly without any serious symptoms, a portion suffer debilitating effects for a lengthy period, and some die from the illness. The infection rate and fatality rate vary across age groups. Using CDC's COVID-19 Case Surveillance Public Use Data from February to September,[2] we construct a frequency distribution across age groups of three severity levels: non-hospitalization, hospitalization without ICU admission, and hospitalization with ICU admission. Each severity level in each age group has a different probability of a fatal outcome. We estimate the following three costs:

Life cost

The value-of-life cost uses the QALY (quality-adjusted life year)-based dollar value of the economic loss for a fatality. Using the Census Bureau's Population Estimates, we calculate the average life expectancy for each age group[3] and the mortality rate. The estimate of each QALY's value ($155,837)[4] is converted into present value using a discount rate (1.50 percent over the first 30 years, 1.29 percent over the next 45 years and 1.07 percent over the following 50 years).[5] This measure does not account for the disease's potential impact on the length and quality of life for non-fatal cases, as there is very little understanding yet of these longer-term effects.

Medical cost

The medical cost is the amount charged for hospitalization, where we have used the amounts associated with one hospitalized patient from FAIR Health[6] and combined with our severity distribution to get the expected medical cost for one COVID case. This measure does not account for medical costs for individuals who are not hospitalized.

Productivity cost

We measure the productivity cost as wages lost due to infection. Due to a lack of data, we set expected time off work to the average hospitalization stay duration plus 2 weeks quarantine. Although the hospitalization stay is probably an underestimate of total days lost for those severe cases, adding the quarantine period to every case may be an overestimate since many workers can work remotely if they are not actually ill (and the full quarantine period does not apply in all cases). Nonetheless, we are not able to estimate all days lost from non-hospitalization illness. We calculate an age-specific average length of hospital stay using the severity distribution and the healthcare usage-related parameters in

CDC's COVID-19 Pandemic Planning Scenarios.[7] The employment rates and the weekly wage of both full-time and part-time employed workers are the 2020 Q1 and Q2 averages from the Bureau of Labor Statistics.[8]

Figure 1 shows estimated monthly costs.[9] For the period from February to September 2020, the average life cost per COVID case is $110,522, the average medical cost is $6,102, and the average productivity cost is $905, giving a total cost of $117,529 per case. The cost has a strong downward time trend, which is mainly the result of decreasing mortality rates. In March, the cost was $329,942 and has since dropped to $38,315 for September.

Figure 1: COVID Case Costs by Month and Category

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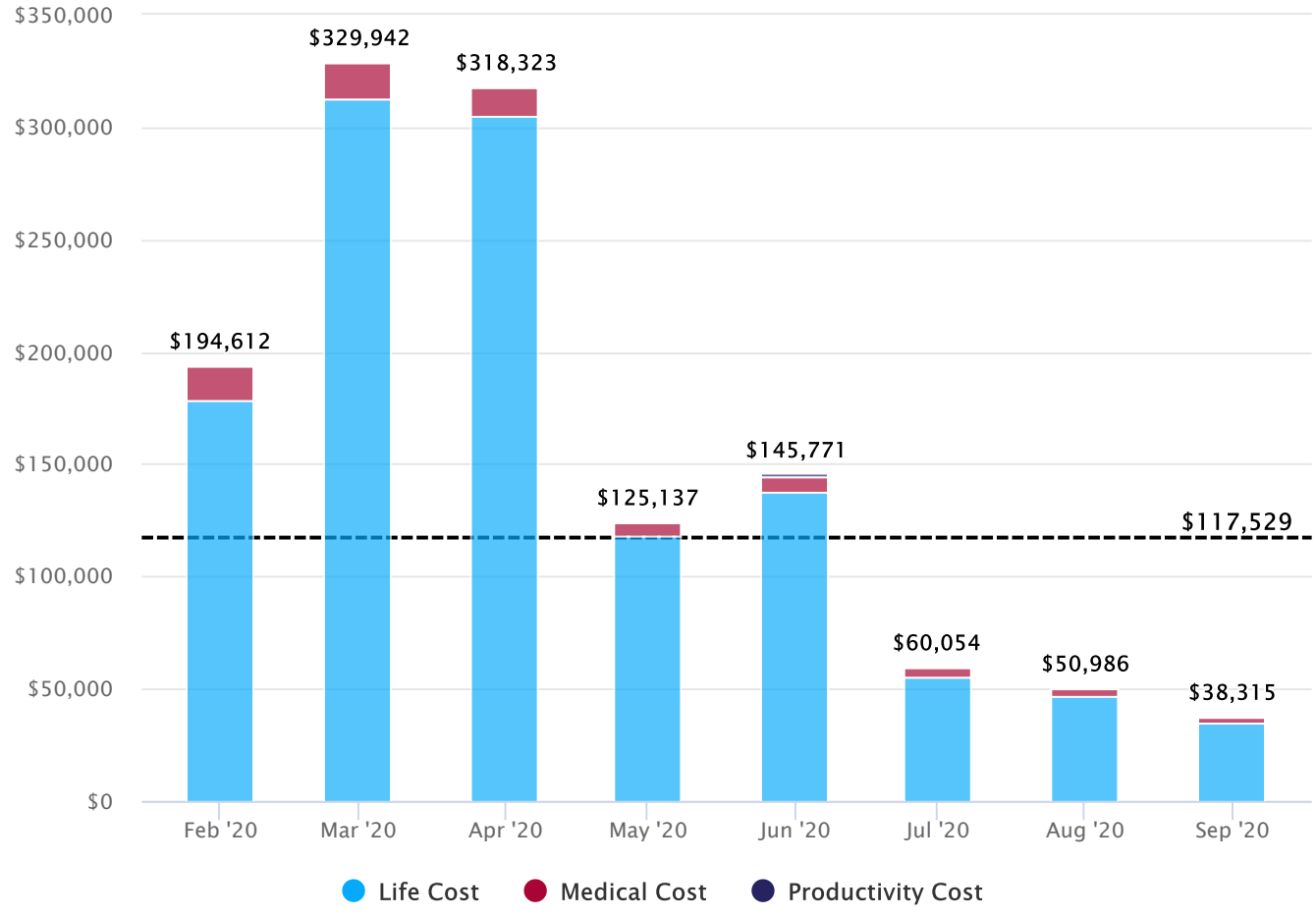

Table 1 shows the average total cost for the eight month period by age group separated into the life, medical, and productivity components. Life and medical costs are generally increasing with age, due to greater severity and higher mortality rates, reaching $450,638 and $17,076, respectively, for 70-79 year olds. Average productivity costs peak at $1,437 for 40-49 year olds.

Table 1: Average COVID Case Cost by Age Group for Feb-Aug 2020

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	0-9	10-19	20-29	30-39	40-49	50-59	60-69	70-79	80+
Life Cost ($)	4,657	2,801	9,039	25,593	56,558	122,172	266,262	450,638	433,359
Medical Cost ($)	1,423	879	1,506	2,966	4,802	8,424	13,261	17,076	15,164
Productivity Cost ($)	0	45	825	1,287	1,437	1,302	762	271	228
Total Cost ($)	6,081	3,725	11,370	29,846	62,797	131,898	280,285	467,985	448,750

Table 2 shows the average total cost by age group for each month. Costs generally increase with age, but decrease across all age groups from the March-April peak.

Table 2: Monthly COVID Case Cost by Age Group

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Month	0-9	10-19	20-29	30-39	40-49	50-59	60-69	70-79	80+
February	14,701	7,878	9,686	83,650	166,192	153,812	287,286	260,507	475,846
March	44,401	33,977	51,729	131,344	217,929	352,298	563,302	807,685	655,177
April	4,141	16,470	30,616	70,994	157,997	311,498	594,040	849,307	629,611
May	5,225	4,352	13,100	24,901	50,347	108,857	238,841	468,921	436,654
June	8,244	5,435	14,735	37,904	80,374	171,677	366,291	552,165	478,731
July	4,693	2,399	6,550	18,402	37,898	80,333	171,792	283,330	320,273
August	2,864	2,615	6,684	14,787	28,045	54,492	123,561	246,012	291,111
September	7,338	1,869	6,256	12,464	22,477	39,591	98,745	192,825	249,798

Figure 2 shows the monthly mortality rates and hospitalization rates, which have all been declining. These declines likely imply that treatment and care for those more seriously ill has been improving. It may also be the case that individuals most susceptible to severe effects from the disease were infected early.

Figure 2: Monthly Mortality Rates and Hospitalization Rates by Age Group

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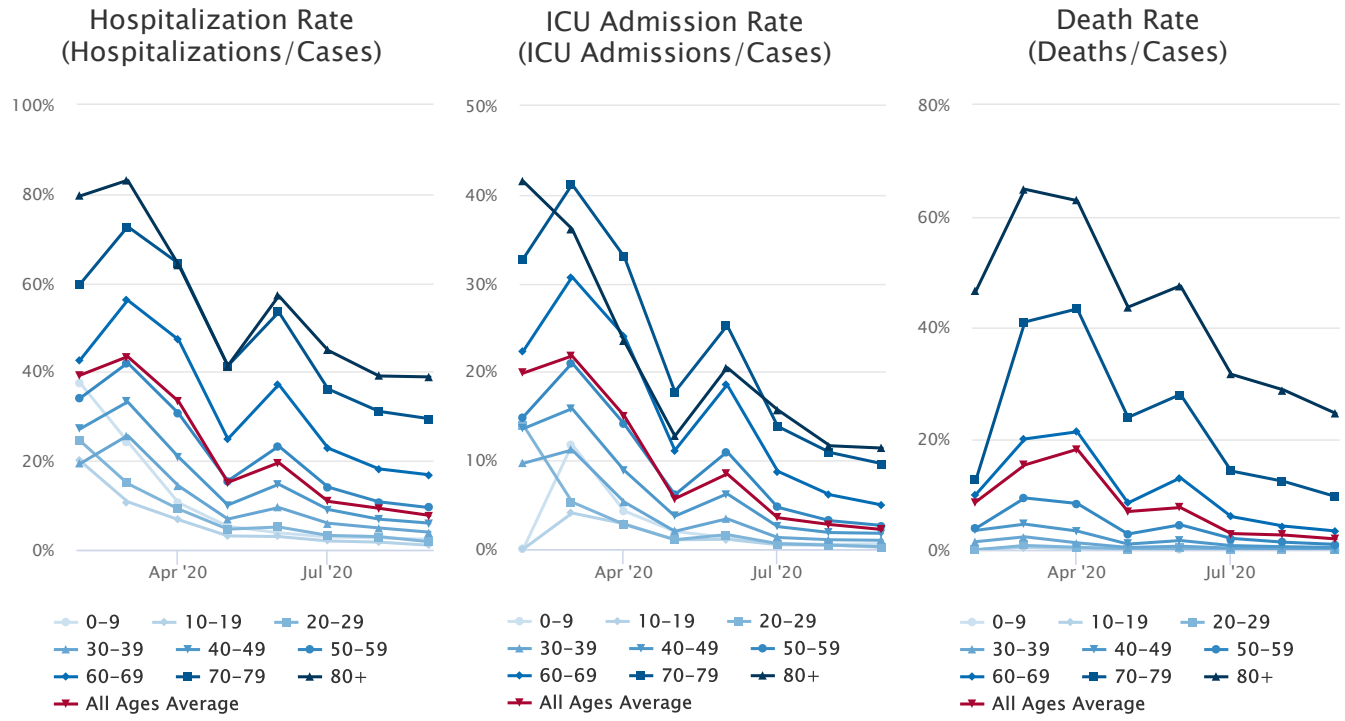

Schools Under COVID

As of fall 2020, there are approximately 56.4 million primary and secondary students in the U.S. (U.S. Department of Education 2019) and 89.9 percent of the school age population is enrolled in public schools.[10] The vast majority of public schools have been or are currently engaging in distance learning or a hybrid education model as a result of the COVID-19 pandemic.[11] Most educators, parents, and researchers agree[12] that children are getting a lower level of education online than in the classroom.[13] Most teachers are unfamiliar with how to conduct classes online, which further lowers education quality. In addition, many educators report that student engagement in distance schooling has been low,[14] particularly for students from disadvantaged backgrounds, including low-income families, single parent households, and already low-achieving students.[15]

Education quality not only affects student test scores, it also has long term effects on the rate at which students attend college and students' lifetime earnings.[16] The COVID-19 school closures are unprecedented, but literature on other school closures provides some estimates of long term impacts of learning disruptions on students' achievement, grade retention, and college enrollment.[17] According to a recent study,[18] children who have been out of the classroom due to COVID-19 closures will likely suffer permanent learning losses unless education quality is improved substantially, meaning students will not be able to catch up on lost learning when they return to the classroom.

We do not attempt to quantify other benefits of in-person schooling to children's mental, social, and emotional wellbeing, including interaction with peers and learning cooperative skills. Another cost we do not quantify is the potential lack of child supervision amidst school closures, particularly for lower income and single-headed families. Unsupervised children are more likely to engage in negative behaviors, such as

substance abuse and criminality, thus incurring additional social and individual costs beyond lack of education. A 2004 study shows decreased crime, violence, and incarceration when children are in school and estimates that a one percent decrease in the male high school graduation rate costs the U.S. approximately $1.9 billion.[19] A recent 2020 study[20] predicts a two to nine percent decline in graduation rates from the COVID school closures.

Value of Education

The question of to what extent schooling provides educational value or is merely a signal of ability is a long-standing debate.[21] If COVID school closures and distance learning do not result in lower graduation rates, as students are promoted without regard to actual learning, and if school is mostly a signal rather than an acquisition of human capital, then effects on children's lifetime earnings may be fairly small. However, many researchers document a causal relationship between education, skill development, and earnings,[22] in which case declines in education quality under school closure and distance learning policies may have significant consequences for current students' future earnings.

We use PWBM's microsimulation model to project lifetime wage earnings for population cohorts currently in school and calculate these earnings' present value using a 3.5 percent discount rate.[23] Wage earnings are not the only source of lifetime earnings, so this estimate underestimates costs to lifetime income. Because of the dearth of evidence on distance learning outcomes, we project lifetime wage earnings lost under the assumption that distance learning under school closures is lost class time.[24] As such, these estimates are likely too high. While measures of returns to schooling are fairly consistent across the literature, with a 7 to 13 percent increase in lifetime income for each additional year of schooling,[25] these historical measures may understate the value of education in an increasingly knowledge-based economy.[26] We apply returns of 13 percent to primary school (K-5), and 10 percent to secondary school (grades 6-12), since some researchers have documented the relative importance of primary school and early childhood education.[27] Further, younger students are less self-sufficient and bear more of the costs of distance learning than older students.[28]

As of October 1, 2020, we project students in grades 1-12 have lost between $43,000 and $57,000, or 4 to 5 percent of their lifetime wage earnings, with younger children losing more than older children. For each additional month schools remain closed, K-12 students forgo an additional $12,000 to $15,000 of their future earnings. Table 3 shows projections on the present value of lost lifetime wage earnings by grade cohort dependent on months of school closure.

Table 3: Projections of lifetime wage earning losses from school closure

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Approximate Grade Level in 20-21 SY	Projected Lifetime Earnings Prior to School Closures	Return to Schooling	Reduction in Earnings from 1 month of DL	Cumulative Losses - Oct 1, 2020	Cumulative Losses - Jan 1, 2021	Cumulative Losses - Apr 1, 2021	Cumula Losse Jun 1 202
Graduated - 12 in 19-20 SY	$1,408,368.87	10%	$14,824.94	$44,474.81	$44,474.81	$44,474.81	$44,47
12	$1,360,420.18	10%	$14,320.21	$57,280.85	$100,241.49	$143,202.12	$179,00
11	$1,332,538.97	10%	$14,026.73	$56,106.90	$98,187.08	$140,267.26	$175,33
10	$1,302,062.00	10%	$13,705.92	$54,823.66	$95,941.41	$137,059.16	$171,32
9	$1,245,189.30	10%	$13,107.26	$52,429.02	$91,750.79	$131,072.56	$163,84
8	$1,229,343.52	10%	$12,940.46	$51,761.83	$90,583.21	$129,404.58	$161,75
7	$1,187,046.92	10%	$12,495.23	$49,980.92	$87,466.62	$124,952.31	$156,19
6	$1,029,238.93	10%	$10,834.09	$53,087.06	$85,589.34	$118,091.62	$145,17
5	$964,122.82	13%	$13,193.26	$52,773.04	$92,352.82	$131,932.60	$164,91
4	$980,216.25	13%	$13,413.49	$53,653.94	$93,894.40	$134,134.86	$167,66
3	$925,992.59	13%	$12,671.48	$50,685.91	$88,700.34	$126,714.78	$158,39
2	$911,572.39	13%	$12,474.15	$49,896.59	$87,319.04	$124,741.48	$155,92
1	$878,709.22	13%	$12,024.44	$48,097.77	$84,171.09	$120,244.42	$150,30
K	$858,874.98	13%	$11,753.03	$11,753.03	$47,012.10	$82,271.18	$111,65

These projections are high estimates of education losses because (1) distance learning likely provides some benefit over complete school closure, (2) educators and students may improve distance learning outcomes with more experience, and (3) schooling may have some signaling component which is not reduced if students are promoted regardless of education losses.

Trade-offs and Policy

By our projections on the high-end, U.S. K-12 students have already lost $2.8 trillion in future wage earnings from school closures in Spring 2020 and September 2020. If schools do not reopen until January, American students may lose another $2 trillion. These losses must be balanced against reducing the spread of COVID and the resulting costs on life and health.

Taking the current cost of COVID as approximately $38,000 per new infection and our estimates of lifetime wage income loss to students from one month of school shutdown as roughly $13,500, we approximate a threshold for school closure versus reopening for October. If school reopening leads to an increased COVID incidence of greater than 0.355 new community cases per month for each student, then schools should remain closed. As a numerical example, suppose a school district has a school age population of 4,000. Economic benefits of reopening schools in this district outweigh the public health costs if additional COVID cases from reopening would be fewer than 355 per week. Assuming distance learning losses are only 10 percent of our estimates (or about $1350 per month), then the threshold is 35.5 additional cases per week. Back in March, when the average cost of a COVID case was about $330,000, the public health benefits of closing schools in that district would have outweighed the costs to students if closing reduced new infections by more than 40.9 per week (or more than 4.1 per week, using one-tenth of our estimate of wage income loss).

It is likely that health outcomes from COVID infection will continue to improve as new treatments and vaccines become available. These improvements will drive down the average cost of a COVID case and will, consequently, raise the threshold of the number of expected new infections at which schools should remain closed.

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

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2. The patient-level data from CDC's COVID-19 Case Surveillance database includes demographic characteristics, disease severity indicators and outcomes; the categorization scheme used in our calculation is also from this database. ↩

3. Assuming a uniform distribution within each age group. ↩

4. The value of an additional QALY ($155,837 in 2020 dollars) is the inflation-adjusted result based on the $129,090 value suggested by a Stanford and Wharton research team in the year of 2008.
C. P. Lee, G. M. Chertow, and S. A. Zenios. (2009). "An Empiric Estimate of the Value of Life: Updating the Renal Dialysis Cost-Effectiveness Standard." *Value in Health*, 12 (1): 80-87. doi:10.1111/j.1524-4733.2008.00401.x ↩

5. The declining long term discount rate is recommended by the UK Treasury's 2018 Guidance on Appraisal and Evaluation for health-related cost evaluation.
Her Majesty's Treasury. (2018). "The Green Book: Central Government Guidance on Appraisal and Evaluation." *Her Majesty's Treasury*. ↩

6. FAIR Health's estimates are based on the COVID-related claims from Jan. to May in its repository, which records claims for health plans covering about 75 percent of the nation's privately insured population. We use their median cost as an average cost in our calculations.

FAIR Health. (2020). "Key Characteristics of COVID-19 Patients." https://s3.amazonaws.com/media2.fairhealth.org/brief/asset/Key%20Characteristics%20of%20COVID-19%20Patients%20-%20Profiles%20Based%20on%20Analysis%20of%20Private%20Healthcare%20Claims%20-%20A%20FAIR%20Health%20Brief.pdf. ↩

7. CDC provides estimates of the 18-49, 50-64 and 65+ groups for the median number of days of hospitalization among those admitted to ICU and those not admitted to ICU. We assume: (1) the 0-17 group has the same as the 18-49 group and (2) the median is used as the average. ↩

8. We assume the median wage as the average. ↩

9. Although infections resulting from school reopening are more likely to be concentrated on students, students (in addition to teachers and staff) may transmit the virus to other people in the community. Therefore, we assume that new infections will occur according to the current age distribution and use this weighted average for the trade-off analysis. Our cost may thus be an overestimate since younger people have a lower rate of negative outcomes from infection. ↩

10. U.S. Department of Education, National Center for Education Statistics, Common Core of Data (CCD). (2019). "State Nonfiscal Survey of Public Elementary and Secondary Education," 1990-91 through 2017-18; Private School Universe Survey (PSS), 1995-96 through 2017-18; National Elementary and Secondary Enrollment Projection Model, 1972 through 2029; Integrated Postsecondary Education Data System (IPEDS), "Fall Enrollment Survey" (IPEDS-EF:90-99); IPEDS Spring 2001 through Spring 2019, Fall Enrollment component; and Enrollment in Degree-Granting Institutions Projection Model, 2000 through 2029. https://nces.ed.gov/programs/digest/d19/tables/dt19_105.20.asp. ↩

11. Barnum, M. and C. Bryan. (2020). "America's Great Remote-Learning Experiment: What Surveys of Teachers and Parents Tell us About How it Went." *Chalkbeat*.
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13. According to a 2015 study of online charter schools by Stanford University's Center for Research on Education Outcomes, students derived little to no benefits from distance learning.
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23. The present value of lifetime earnings as calculated by the United States' Social Security Administration utilizes a discount rate of four percent. Since interest rates have been declining over the past few decades, we assume this trend is likely to continue, so we use a lower discount rate, in line with that of the UK's Green Book.
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27. Some researchers, including Montenegro and Patrinos (2014) study the relative labor market returns to different levels of schooling and find relatively higher returns to lower levels of schooling and interventions at earlier ages (Heckman 2006). A recent paper by Rea and Burton (2019) has challenged this assumption by concluding policy interventions are not necessarily more beneficial for younger children than their older peers. While this may be true for some types of policy, we proceed with our assumption of higher relative returns to schooling for younger children since education literature in the U.S. context documents higher achievement growth at lower grade levels where the amount of achievement growth decreases with nearly every increasing grade level (Kuhfeld et al. 2020; LoGerfo, Nichols, and Reardon 2006). Learning gains from a specific grade level are not exactly the same as labor market returns; however, given that schooling is compulsory until at least age 16 in most U.S. states, directly measuring labor market returns of a specific grade level poses a challenge, but learning gains from a specific grade level are measurable. Further, work by Hampf, Wiederhold, and Woessman (2017) and Card and Krueger (2002) has tied skill development (through schooling) to earnings.
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