School Reopening During COVID-19: A Cost-Benefit Analysis for Philadelphia Suburbs

Summary: We estimate the average cost of a COVID-19 infection for four Philadelphia-area counties at $8,000 to $13,000, less than half of our national average cost estimate ($27,230). We estimate a trade-off between cost of infections to the community from in-person schooling versus the lost future earnings to students from closing schools. For example, if Montgomery county had implemented full in-person school in the fall, we project the costs of infection would have been at most $429 million. However, closing schools costs students as much as $4.4 billion in present value of future wages.

Key Points

- Using the newest available data, we estimate that the average cost of a COVID-19 infection is $27,230— about five times more costly than a typical flu infection. These costs include expected cost for loss-of-life, medical costs, and productivity losses by age.

- Cost of COVID-19 measures for four Philadelphia-area counties are significantly lower than the national average and range from about $8,000 to $13,000. We also calculate a school openness index for these four counties. We do not find a statistically significant relationship between the cost of COVID-19 and the level of school openness, thereby suggesting that schools did not take these differential costs into account.

- We calculate an upper bound estimate of the cost of COVID-19 from school opening and compare against an upper bound of the present value loss to students' future earnings. For example, if Montgomery County had implemented full in-person school in the fall, we project the costs of infection would have been at most $429 million while closing schools would have cost students as much as $4.4 billion. Both these values decline under alternative assumptions: infection costs from school opening drop by attributing some COVID-19 cases to non-school transmission while education losses are lower from alternative methods of learning, including home and online schooling.

Introduction

Since the start of the 2020 school year, school districts have operated with various combinations of distance learning approaches and in-person schooling in order to balance the risk of the ongoing COVID-19 pandemic

against the costs to families and students of school closures. In response to the recent increase in infections across the country, policymakers have been adjusting their school re-opening plans.

We previously analyzed the trade-off between average costs of a new COVID-19 infection versus the future income losses to students from missed education. 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 caregivers, and other negative effects. At the same time, in-person schooling undoubtedly raises the risk of an increase in the community infection rate as students, teachers, and staff gather in indoor spaces. Although research is ongoing, recent empirical studies have tended to find that schools are not a major source of COVID-19 spread.[1]

A COVID-19 infection leads to a variety of health outcomes for the infected individual: asymptomatic, mild illness, severe illness, or sometimes death. Following our previous methodology, we calculate an expected cost for loss-of-life, medical costs, and productivity loss by using current data on COVID-19 effects by age group, value-of-life estimates, and wages. Similar methods have been applied to estimate the average cost of an influenza infection, such as a 2007 study[2] which finds the average cost of a new influenza infection to be $4,972, with death cost, medical expenditure and lost earnings taking up 69%, 12%, and 19% of the total cost, respectively. Our updated national average cost of a COVID-19 infection in November[3] is $27,230, implying that COVID-19 is about five times more costly per infection than influenza.

We localize the cost of COVID estimates by looking at age distribution, relative severity, and median wages at the county level for a select group of suburban counties north of the city of Philadelphia, Pennsylvania. Decisions made at the school district level implicitly account for trade-offs between the local cost of COVID-19 infections versus costs to students and families from school operating restrictions that limit in-person learning. We try to understand these trade-off decisions by looking at changes in COVID-19 costs as school districts changed their school opening policy. Although we do not find a statistically significant relationship between changes in school openness and the cost of COVID-19, we look at trade-offs school districts may have faced by assuming school opening was responsible for all new infections.

Local cost of COVID-19 infections

As in our prior post, we look at a weighted average of life-years lost, hospitalization costs, and lost labor income from a new COVID-19 infection, but we localize to data from Bucks, Chester, Delaware, and Montgomery counties in Pennsylvania.

We use the county level weekly fatality rate from Carnegie Mellon University's Real-time COVID-19 Indicators, the age composition of cases collected from each county's COVID-19 dashboard,[4] and the relative wage income calculated from the 2019 American Community Survey (ACS). Table 1 shows the national and county average cost per case.

Table 1: Dollar Cost per COVID-19 Infection by County

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| Region	August	September	October	November
Nationwide	$58,972	$58,481	$46,720	$27,230
Bucks County	$15,673	$31,894	$19,845	$12,726
Chester County	$21,510	$18,584	$13,879	$10,303
Delaware County	$42,179	$47,612	$11,513	$7,896
Montgomery County	$18,783	$23,805	$14,679	$10,104

The cost in all four Philadelphia-area counties has been lower than the national average, mainly due to a lower fatality rate. The primary trend, both nationally and within these counties, has been a declining cost per infection.

Using the cost per case, we multiply by the number of weekly new cases to calculate each county's additional weekly cost from COVID-19 infections as shown in Figure 1.

Figure 1: Cost of New Weekly COVID-19 Infections by County

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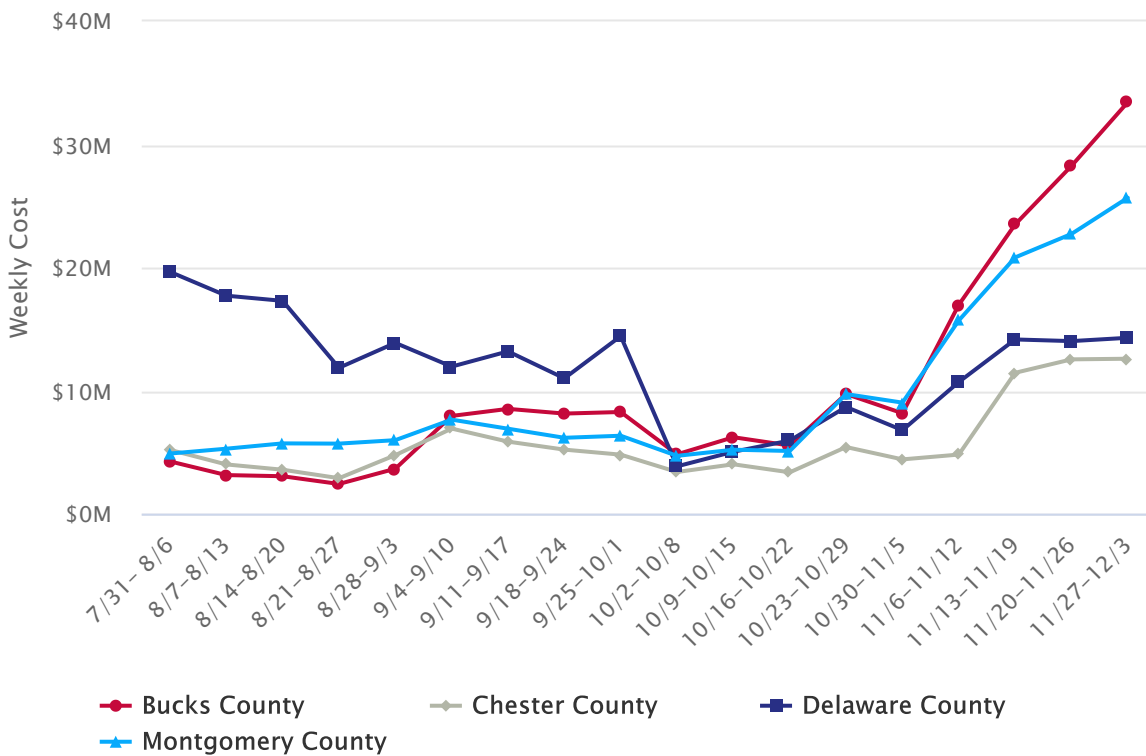
Weekly additional costs in all four counties have been surging recently with Bucks County and Montgomery County reaching highs since August. These higher weekly additional costs come from significantly higher

incidence rates in recent weeks, even as the local cost per case has been declining.

School re-openings

We classify the level of in-person learning according to an openness index, ranging from 0 to 100, where 0 represents completely virtual schooling and 100 represents completely in-person schooling. The index is calculated from the percentage of students (determined by grade level enrollment by county[5]) who are able to attend school and the number of days per week these students are able to attend school in person. (We do not measure realized openness, meaning the percentage of students who actually attended in-person school.) For instance, a school district with a hybrid reopening where K-12 students attend school on A/B days and everyone is remote on Fridays (two in-person school days per week per student) would have an openness index of 40.

Local and county-level policymakers make school re-opening decisions against the backdrop of COVID-19 infection rates in the area. County health departments in Bucks County, Chester County, and Montgomery County have provided guidance for moving to new phases of school openings based on predetermined threshold incidence rates. School boards take both county guidance and local conditions into account when making opening decisions.[6]

Figure 2: School Openness Index by School District and County, Fall 2020

DOWNLOAD DATA

◉ School District
◯ County

Please view online for additonal years.
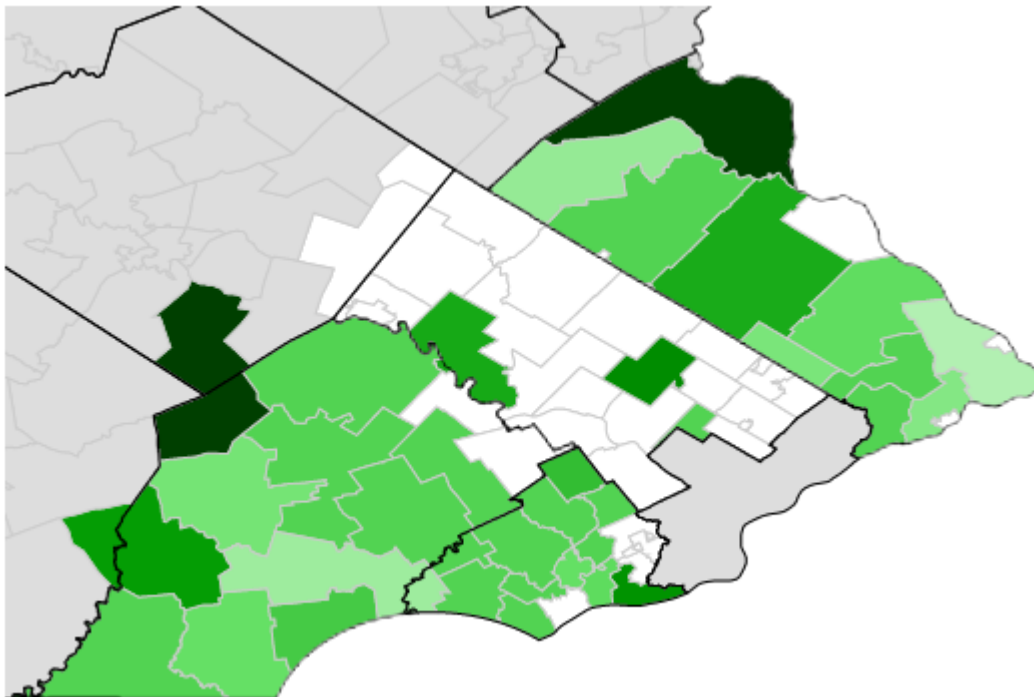
Estimating trade-offs

County health departments and school boards try to account for a variety of benefits, costs, and interests in their school opening guidance and decisions. There is uncertainty about the potential increase in community infections from a particular operating policy. There is also uncertainty about the resulting distribution of who gets infected. For our estimate, we assume that all increases and decreases in COVID-19 cost to the community are due to school opening policy. Clearly, this assumption is a gross overestimate of the effect of school policy on community infections (especially given the recent evidence that schools are not a significant source of infection spread), but it provides an upper bound.

We calculate the change in the average weekly total cost of COVID-19 divided by the change in school openness in each county. This provides an estimate of the cost effect of a one percentage point increase toward in-person schooling. If the community decides to open schools, this estimate is the resulting upper bound on cost. If the community decides to move toward virtual schooling, this is the cost that is avoided. Looking at this cost on a per capita basis gives the cost imposed (or avoided) on each person in the county by school opening (or closure).

If we think of the COVID cost avoided, then putting students into virtual school would presumably do less harm than the avoided cost. Policymakers implicitly compare these costs and their presumed harm on students and decide whether to impose the COVID cost on the wider community. We, therefore, calculate the cost of COVID on a per student basis in order to clarify this trade-off. As a simple example, suppose a community has 100 people and 10 students and the cost effect of school opening is estimated to be $1000. If policymakers decide to make schooling virtual, then each member of the community avoids $10 in cost. The additional harm to the ten students is not known in this example, but policymakers' decision to close schools implies that they considered the $1000 community cost (or $100 per student) to be greater than the harm to students.

Table 2 shows the upper bound weekly costs of COVID from a one percentage point increase in school openness. We show each county's average for the month and normalize these costs per capita (and per student). For Bucks, Chester, and Montgomery Counties, costs of school openness decline between September and October, then increase between October and November. For Delaware County, we find increasing costs of openness over time. Overall, school opening does not appear to have a consistent relationship with the cost of COVID, especially once we account for time trends. Various regression analyses (looking at lagged effects) find no statistical significance between school openness and the costs of COVID-19.

Table 2: Upper Bound Effects of a One Percentage Point Increase in School Openness on Weekly Cost of COVID-19

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Month		September	October	November
Bucks County	Per capita cost/wk	$0.85	-$0.13	$4.03
	Per student cost/wk	$6.42	-$0.97	$30.47
	Average in-person school days/wk	0.5	1.5	1.8
Chester County	Per capita cost/wk	$2.35	-$0.21	$0.53
	Per student cost/wk	$16.87	-$1.54	$3.80
	Average in-person school days/wk	0.2	0.9	1.8
Delaware County	Per capita cost/wk	-$1.48	-$0.66	$21.58
	Per student cost/wk	-$9.73	-$4.31	$141.90
	Average in-person school days/wk	0.2	1.1	1.1
Montgomery County	Per capita cost/wk	$0.22	-$0.08	$3.97
	Per student cost/wk	$1.63	-$0.59	$29.01
	Average in-person school days/wk	0.4	0.8	1.0

Note: Results are shown on a per capita and a per student basis along with average amount of in–person schooling per week.

Table 2 also shows the level of school openness increasing over time in all counties, reaching a peak in November in Bucks and Chester Counties. On average, Bucks and Chester County K-12 students attended in-person school just shy of two days a week in November. Montgomery County closed schools at the end of November. If the same cost of COVID-19 for November continues into December, then Montgomery County would avoid at most a $79.40[7] cost per person in the county by going from an openness index of 20 (one in-person school day per week on average) to zero. Meanwhile, harm per student from virtual school would presumably be less than $580 on average.[8]

In our previous post, we estimated an average upper bound loss to students' future earnings from school closure. Table 3 applies this metric to compare (a) cost of COVID-19 infections, assuming a full school re-opening where all new infections[9] are the result of school opening policy, versus (b) students' future wage earnings losses assuming full school closure. Both thresholds are upper bounds for their respective costs but serve as a basis to estimate total trade-offs taken during the fall semester to date in these four counties.

Table 3: Comparison of Costs to Full Reopening and to Full Closure

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	September-November	
County	Estimated Covid costs due to a full school reopening	Estimated wage earning losses due to a full school closure
Bucks County	$362.0m	$3,222.7m
Chester County	$133.8m	$2,841.4m
Delaware County	-$137.9m	$3,319.8m
Montgomery County	$429.2m	$4,418.9m

Note: Earnings losses are estimated by multiplying the per student earnings loss by the number of public school students in the county.

Projections of positive COVID-19 costs from a full school re-opening are no larger than 12% of the loss to future lifetime earnings associated with missed education from a full school closure. Delaware County has negative projected costs because its cost of COVID actually declined as its schools re-opened (see Figure 1) at the end of September (see Figure 2). Distance learning is likely less harmful to educational attainment (and therefore future earnings) than full school closure. However, our statistical analysis implies there is little correlation between the actual cost of COVID-19 and school re-opening, so the additional cost of COVID-19 from school opening is likely much closer to zero. Therefore, virtual schooling would have to be almost as effective as in-person schooling in order to justify restricting in-person schooling as a means to reduce the county's cost from COVID-19 infections.

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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1. https://pediatrics.aappublications.org/content/pediatrics/early/2020/10/16/peds.2020-031971.full.pdf
   https://biocomsc.upc.edu/en/shared/20201002_report_136.pdf
   https://www.theatlantic.com/ideas/archive/2020/10/schools-arent-superspreaders/616669/
   https://www.who.int/docs/default-source/coronaviruse/risk-comms-updates/update39-covid-and-schools.pdf?sfvrsn=320db233_2
   https://education.org/facts-and-insights#f09a6e46-8c5f-4d01-8297-d2a3f6c8f873 ↵

2. Morlinari et al. https://pubmed.ncbi.nlm.nih.gov/17544181/ ↵

3. Our cost of COVID estimates for previous months have been updated from our previous post due to additional and updated data from CDC and minor methodological changes. ↵

4. Bucks County:
   https://bucksgis.maps.arcgis.com/apps/opsdashboard/index.html#/a7e4f8a794a34bb5903813cdea584e

db

Chester County:

https://chesco.maps.arcgis.com/apps/opsdashboard/index.html#/975082d579454c3ca7877db0a44e61ca

Delaware

County: https://chesco.maps.arcgis.com/apps/opsdashboard/index.html#/bce5af8a6f454ee78e00b5adc67f4c4a

Montgomery County: https://data-montcopa.opendata.arcgis.com/pages/covid-19 ↵

5. Enrollment by grade level and county is from Open Data PA. The most recent data available is for the 2017-2018 school year, so we assume these counties exhibit the same trends as the national trends in grade level specific enrollment between the 2017-2018 school year and the 2020-2021 school year. National level enrollment data is obtained from the National Center for Education Statistics. ↵

6. Some examples of school boards making their reopening decision process clear include: The School District of Haverford Township, Hatboro-Horsham School District, Pennsbury School District, and Great Valley School District ↵

7. $3.97 * 20 = $79.40 weekly cost per capita from a change of openness index from 0 to 20. ↵

8. $29.01 * 20 = $580.20. ↵

9. The new infections are relative to the baseline level of infection cost as measured in the four weeks prior to the actual school re-opening. ↵