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Risks of COVID-19 Introductions as Schools Reopen

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Summary

The COVID-19 pandemic continues to threaten the United States, though the risks vary widely across regions. School districts are developing plans to offer in-person instruction that meets the social and educational needs of students while mitigating the risk COVID-19 to students, staff, faculty, their families and the surrounding communities. The level of risk for a particular school or school system will stem from three factors:

1. *Introduction risks*: the chance that students and staff will be infected outside of school and arrive at school while infected.
2. *On-campus transmission risks*: the chance that transmission will occur within schools if and when students or staff arrive infected.
3. *Community amplification risks:* the chance that individuals infected within schools will subsequently transmit the virus to individuals in the surrounding community.

To address the first of these three components, this report provides a simple calculation for estimating the rate at which COVID-19 may appear on school campuses depending on the background prevalence of the virus in the surrounding community. This analysis was featured as an interactive map in the *New York Times* on July 31, 2020 and can be accessed here [1].

Background

COVID-19 emerged in China in late 2019, and quickly spread around the world in early 2020. Given its rapid spread and large numbers of hospitalizations and deaths, most regions made the difficult decision to suspend in-person teaching almost immediately upon detecting local cases. These decisions were based partly on research suggesting that schools accelerate community transmission of respiratory viruses like influenza and milder seasonal coronaviruses. Given that schools throughout the US have largely remained closed since mid-March and other countries have sporadically opened schools with highly variable strategies and success, there is still uncertainty regarding the risks of reopening schools.

The National Academy of Sciences, Engineering, and Medicine published an in depth analysis of the challenges and priorities for opening schools during the COVID-19 pandemic, entitled *Reopening K-12 Schools During the COVID-19 Pandemic: Prioritizing Health, Equity, and Communities (2020) [2]*. It notes that “School systems will need to take local epidemiology into account when making decisions about whether and how to open and close.” Regions that have mostly eliminated COVID-19 may be able to offer in-person schooling with sensible precautions, whereas others fighting COVID-19 surges may find it infeasible to reopen safely regardless of precautionary measures.

Here, we provide a simple approach to help decision-makers and educators gauge the feasibility of bringing students and staff to campus. Based on the prevalence of the virus in a given community, we calculate the school *introduction risk*—that is, the number of students and staff we would expect to arrive at school during the first week of the school year.

Methodology

1. Calculating school introduction risk

The number of students and staff that would arrive infected in a given week can be estimated from the following two quantities:

N: the size of the school (number of students and staff)

P: the probability a student or staff member recently became infected outside of school

The expected number of students and staff that will arrive infected during that week is then the product of these two quantities ($N \cdot P$). While *N* is straightforward–simply the total number of students and staff that will come to campus during the first week–*P* must be approximated. We assume that it is equal to the prevalence of COVID-19 in the surrounding community. For

example, if 3% of people in the surrounding community are infected during a given week, then we would assume that 3 out of every 100 students and staff are likewise infected.

Table 1 gives the expected number of students and staff that will arrive at school infected during a given week, for different levels of COVID-19 prevalence (ranging from 1 in 1000 to 5 in 100 infected) and school size (ranging from 25 to 2000 students and staff on campus). Regardless of school size, if local prevalence is high, schools should expect to have many infected students and staff introducing the virus. The following section provides a simple method for estimating local prevalence from reported numbers of confirmed COVID-19 cases.

Table 1: Number of students and staff that will arrive infected during one week of the school year depending on the size of the school and the background prevalence of COVID-19 in the community. Gray cells indicate prevalence and school size scenarios in which we would not even expect one student or staff to be infected.

	School size – total students and teachers on campus							
COVID-19 Prevalence	**25**	**50**	**75**	**100**	**200**	**500**	**1000**	**2000**
1 in 1000 (0.1%)	<1	<1	<1	<1	<1	<1	1	2
5 in 1000 (0.5%)	<1	<1	<1	<1	1	2.5	5	10
1 in 100 (1%)	<1	<1	<1	1	2	5	10	20
2 in 100 (2%)	<1	1	1.5	2	4	10	20	40
3 in 100 (3%)	<1	1.5	2.25	3	6	15	30	60
4 in 100 (4%)	1	2	3	4	8	20	40	80
5 in 100 (5%)	1.25	2.5	3.75	5	10	25	50	100

2. Estimating the local prevalence of COVID-19

To approximate the chance that a given student or staff member may be infected, we suggest that decision-makers use the local prevalence of COVID-19, that is, the fraction of the population who are currently infected and capable of infecting others.

These three quantities are used to estimate the fraction of the population that is infectious:

1. The number of new infections each day
2. How long each case remains infectious
3. The total population size

Confirmed COVID-19 case data can be used to estimate the total number of new infections in a community. However, such data typically does not account for all cases in a community. A large fraction of infected cases may never develop symptoms or only feel mildly ill. Even cases with clear symptoms may never seek or may not have adequate access to testing. In some counties, as few as 10% of total infections are reported [3].

Using COVID-19 hospitalization data from Texas, we estimated the case reporting rates across the 22 Trauma Service Areas that cover the entire state. As of mid-July, case reporting rates ranged from one in ten infections reported in the Lower Rio Grande Valley to one in three in Austin, with a median of one in five. Thus, we suggest estimating COVID-19 incidence assuming that confirmed case counts represent somewhere between one third and one tenth of all infections, as follows:

1. Obtain case data for the focal counties from the New York Times [4] datasets.
2. Sum up the number of new infections over the past 7 days[1].
3. Multiply that sum by three, five, and ten to get a lower, median, and upper estimate for the current number of infectious cases.
4. Divide by the population size in the focal counties.

Example: COVID-19 school introduction risks in counties across the United States in August 2020

To demonstrate the method, we have estimated the risks of introductions if schools were opened the week of August 17-21, 2020 in each US county. This spreadsheet provides the full set of estimates. As an example, Figure 1 provides estimates for four large counties with different levels of COVID-19 spread: King county in Washington, Los Angeles county in California, Travis county in Texas, and Miami-Dade county in Florida. This is **not** meant to indicate the long-term feasibility of school openings in these communities, but rather to highlight the heterogeneous and rapidly changing risks throughout the country. As communities succeed in slowing transmission and reducing prevalence, the introduction risks will decline.

The expected number of COVID-19 introductions for a school with 500 students and staff ranges from 0-3 in King county to 10-22 in Miami-Dade county (Figure 1). As described above,

[1] This assumes that cases remain infectious for seven days following infection [5,6] and that prevalence is relatively stable from one week to the next. This will underestimate risk if counties are experiencing rapid epidemic growth and overestimate risk if counties are experiencing declining epidemics.

we assume that the local prevalence of COVID-19 can be estimated by tallying the number of cases reported over the preceding week and correcting for the large proportion of unreported cases.

As of August 17, 2020, the estimated prevalence of COVID-19 varies widely across US counties. Figures 2 and 3 shows the corresponding range of school introduction risks for schools with 100 staff and students. The number of people expected to arrive infected in the first week ranges from zero to nine (Figure 2). Furthermore, 12.3% (CI: 3.3%-39%) of US counties covering 8.8% (CI: 3.1%-42%) of the US population would expect at least one COVID-19 introduction (Figure 3).

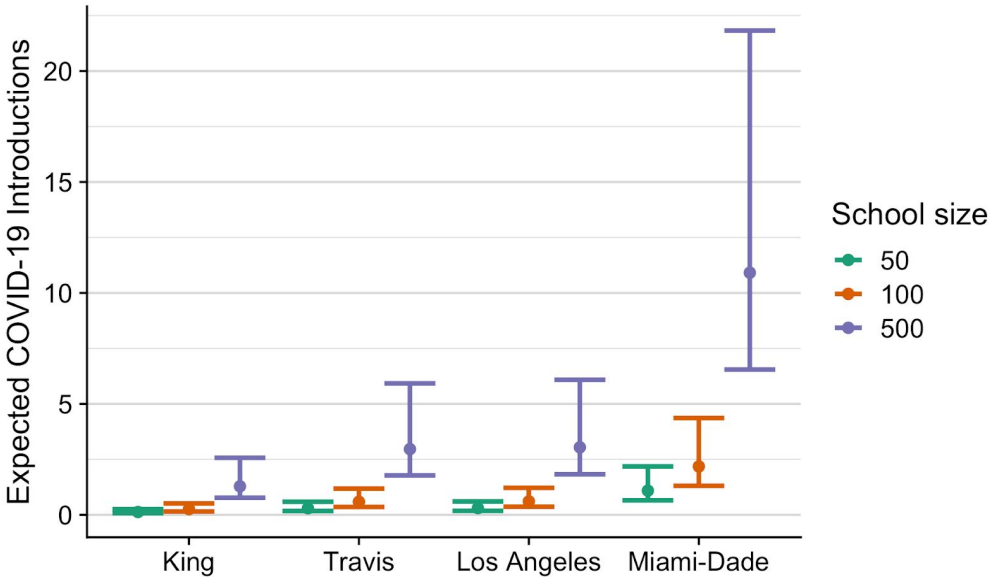

Figure 1: Expected number of infected students and staff arriving the week of August 17-21, 2020 in King county (Washington), Travis county (Texas), Los Angeles county (California), and Miami-Dade county (Florida). These large counties were selected to cover the wide range of COVID-19 risks across the US in early-August. The colors correspond to school sizes, that is, the total number of students and staff on campus. The points assume that COVID-19 prevalence is five times the reported cases; the bottoms and tops of the bars assume that prevalence is three and ten times the reported cases, respectively.

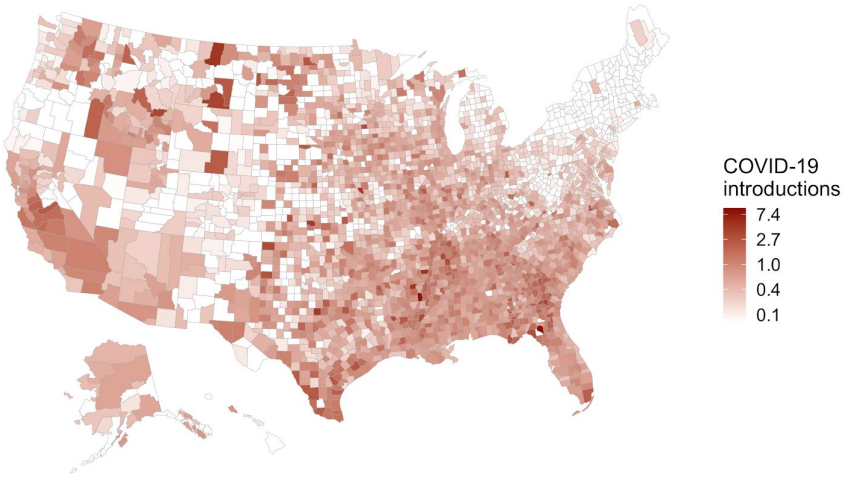

Figure 2: County-level estimates for the number of COVID-19 introductions during the first week of school, assuming 100 students and staff on campus, based prevalence estimated for the week of August 17-21, 2020. Shading indicates the expected number of introductions in a week. Note that colors are on a log-scale given the nearly 100-fold range in estimated risk. Prevalence is estimated by five times the number of newly reported cases over the preceding seven days. Lafayette county in Florida is omitted as an outlier with an estimated 50 school introductions; the recent spike in reported cases may stem from a prison outbreak.

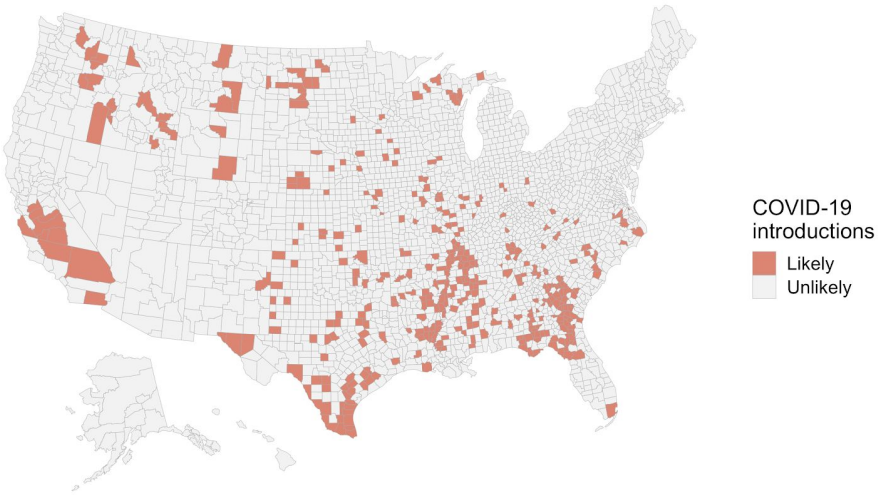

Figure 3: County-level risk of at least one COVID-19 introduction during the first week of school, assuming 100 students and staff on campus, based prevalence estimated for August 17-21, 2020. Prevalence is estimated by five times the number of newly reported cases over the preceding seven days. Red indicates counties in which at least one student or staff would be expected to arrive infected during the first week of school.

Interactive online Maps and Table (*New York Times*)

On August 2, 2020, the front page of the New York Times featured maps derived from this model. The newspaper also published an interactive online version that allows readers to look up specific counties and toggle between groups of 10, 100, 500 and 1,000 students [1]. Table 2 and Figure 4 provide screenshots from this online tool.

Table 2. Image of New York Times interactive table [1] providing the expected number of COVID-19 introductions during the first week of school, based on data through July 2020. Values have been rounded to the nearest whole number with zeros indicating low, but not non-zero risk for COVID-19 introductions.

	POD OF 10	SCHOOL OF 100	SCHOOL OF 500	SCHOOL OF 1,000
New York, N.Y.	0	0	1	1
Philadelphia County, Pa.	0	0	2	4
Cook County, Ill.	0	0	2	4
Travis County, Texas	0	1	3	6
Los Angeles County, Calif.	0	1	4	8
Harris County, Texas	0	1	5	10
Maricopa County, Ariz.	0	1	7	14
Clark County, Nev.	0	1	7	14
Davidson County, Tenn.	0	2	9	18
Broward County, Fla.	0	2	12	23
Miami-Dade County, Fla.	0	4	19	38

Note: Estimates show potential infected people arriving during the first week of instruction. A zero indicates a low probability that an infected person will show up in the school or pod during that week.

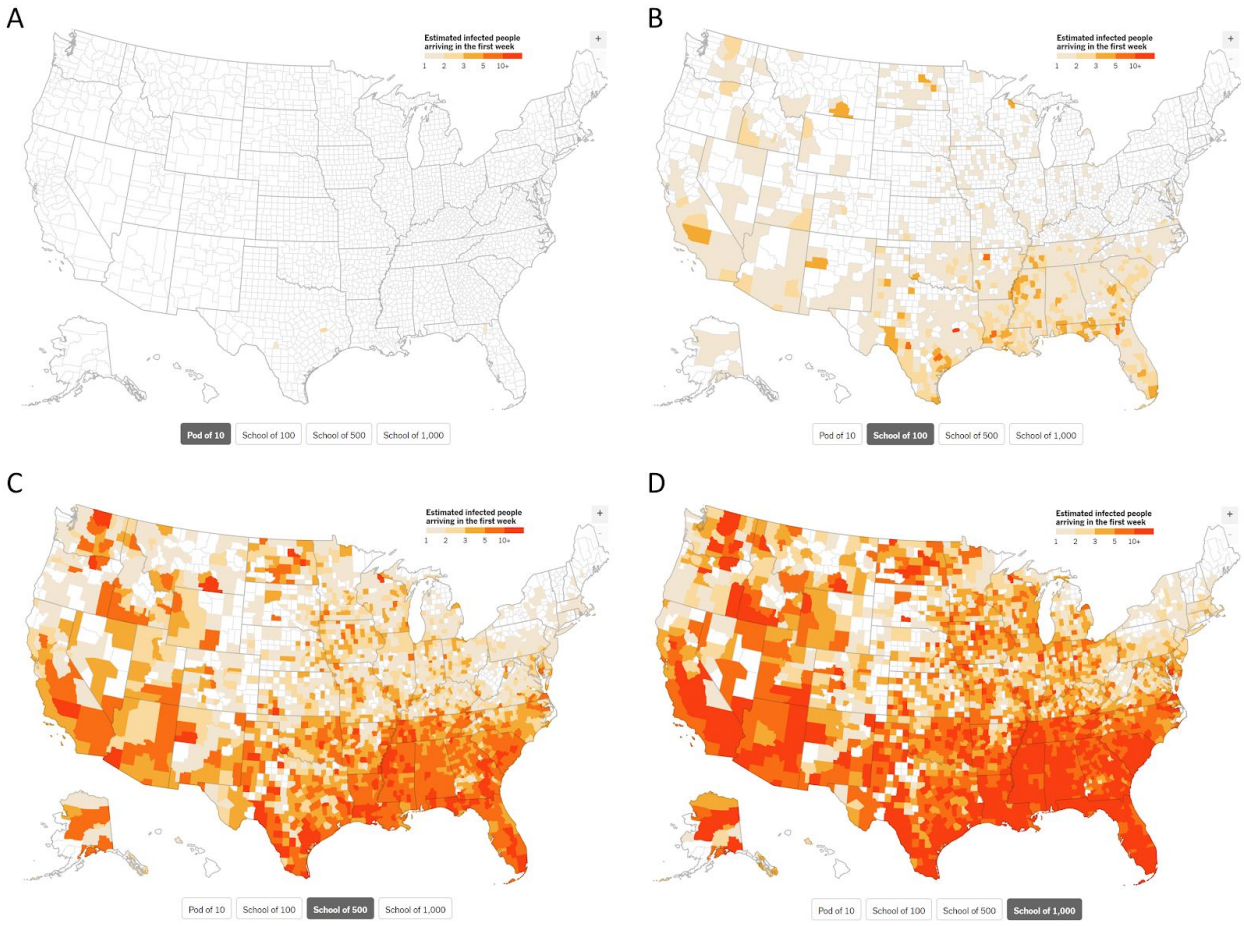

Figure 4: Screenshot from New York Times interactive maps [1] providing the expected number of COVID-19 introductions during the first week of school, based on prevalence estimates for the last week of July 2020. For each US county, the shading corresponds to the estimated number of COVID-19 introductions for (A) a pod of 10 students; (B) a school of 100 students; (C) a school of 500 students; (D) a school of 1,000 students.

Final considerations

To support school planning in the months ahead, the estimates provided herein should be revised to reflect the evolving state of the COVID-19 pandemic across the United States. Our approach can be broadly applied to provide situational awareness in communities across the US and closely resembles the methodology used by Georgia Tech's COVID-19 Event Risk Assessment Planning Tool.

The guidance above makes a key assumption: the chance that a student will arrive at school infected can be approximated by the overall prevalence of COVID-19 in the surrounding

community. However, there are two important issues that could lead to underestimating or overestimating a school's risk:

1. The prevalence of COVID-19 among school-aged children may differ from the overall prevalence in a community. If children have lower susceptibility to the virus or fewer daily contacts than adults, then the chance that they are infected in any given week may be lower than the overall prevalence in the community. While early reports suggested that children could be 55% (95% CI: 35-70%) less susceptible to infection than adults [7], more recent estimates suggest nearly equal susceptibility [8,9]. These guidelines should be updated as we gain more insight into the spread of COVID-19 to, from and among school-aged children.

2. Schools within the same county may have different levels of risk. If infections are occurring in localized *hot spots*, then schools in those neighborhoods will have higher risks than suggested by the overall prevalence while schools in less affected neighborhoods will have lower risk. Importantly, COVID-19 is disproportionately impacting vulnerable communities [10,11]. Socioeconomic and racial disparities in COVID-19 burden drive heterogeneity in local risks, with unfortunate overlap between high disease risk and the greatest need for the educational and social services provided by schools [2].

Thus, decision-makers should recognize that this framework provides only a rough indication of school introduction risks and should also consider local information regarding the variation in COVID-19 burden within their communities.

Importantly, these calculations only consider the risk that infections will be *introduced into schools* by students and staff who are infected outside of school. They do not consider the subsequent risks of transmission within and beyond the school community. Those risks will depend on precautionary measures taken by schools, individuals and families. Nonetheless, these estimates can provide insight into the feasibility of in-person schooling. If schools plan to suspend classes, grades, or entire programs upon detection of a single infection, then it may be infeasible to bring students and staff to campus until the current waves of COVID-19 subside.

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