# Houston Area COVID-19 School Introduction Risks

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## Summary

Houston Independent School District (HISD) is the eighth largest school district in the United States and comprises 284 schools, nearly 215,000 students, and 40,000 staff members. The feasibility and risks of restarting in-person activities on school campuses will partially depend on the changing prevalence of SARS-CoV-2 in the Houston Metropolitan Area. As community prevalence decreases, the chance that students or staff arrive at school infected should also decrease. In this report, we provide simple calculations to help school leadership, students, families and teachers gauge risks in the weeks ahead.

The Harvard Global Health Initiative suggests that communities can begin to relax *stay-home* restrictions when the number of new confirmed cases each day has dropped below 25 per 100,000, but only if the community has sufficient viral testing and contact tracing capacity[1] [2]. While this provides a benchmark for community-wide relaxation of measures, it does not directly indicate when schools should reopen. In this brief report, we provide recommendations for determining the risks of reopening schools based on the size of the school and key indicators of COVID-19 transmission in the local community.

As of August 27, 2020, COVID-19 confirmed case data suggest that the prevalence of COVID-19 in Harris County is between 400 and 1400 cases per 100,000 people. If the largest schools in HISD, with over 3,000 students, reopened under these conditions, it is likely that several students and teachers would arrive infected in the first week. One possible threshold for cautiously bringing students back to campus is when the chance of even one person arriving infected in the first week is below 50%. For a school with 3,000 students and staff, this threshold is 24 cases per 100,000 people. The estimated COVID-19 prevalence in the Houston area has been decreasing but is still far above this threshold and not projected to fall below this threshold by the end of September.

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[1] The Harvard Global Health Initiative provides key performance indicators for testing and tracing, including at least 30 tracers per 100,000 people and the ability to trace at least 75% of cases and reach over 80% of contacts within 24 hours [1].

# Calculating the risks of COVID-19 introductions into schools

We present a simple two step method to calculating risk that involves first estimating the total prevalence of COVID-19 in the community (rather than the daily number of reported cases) and then determining the likelihood that students and teachers will arrive at schools infected.

**Step 1: Estimate the prevalence of COVID-19 in the community.**

- **Look up the number of confirmed cases per 100,000 over the last seven days.** The New York Times database provides this key indicator for all counties in the US [3].
- **Account for unreported cases.** Many COVID-19 cases go unreported because they are asymptomatic or do not seek testing for other reasons. Depending on the county, we estimate that between 10% and 33% of all cases are reported. To account for these undetected cases, we recommend multiplying the number of confirmed cases by both 3 and 10. This provides a plausible range for the true prevalence of the virus.
- **An example.** On August 27, 2020, the New York Times database reported a seven-day incidence of 136 new cases per 100,000 in Harris County [3]. We would thus estimate that the current prevalence of COVID-19 in Harris County is somewhere between 414 and 1380 cases per 100,000 people.

**Step 2: Determine school introduction risks.** We suggest three complementary strategies for quantifying risk that depend on the current prevalence in the community and the size of the school.

- **Expected number of COVID-19 introductions.** This is simply the current prevalence times the number of people who will be coming to campus. Table 1 provides this quantity over a range of prevalence (from 5 to 1500 infections per 100,000 people) and a range of school sizes (from 100 to 3000 people on campus).
- **Probability that at least one student or teacher will arrive infected.** The equation for this[2] also depends on the current prevalence and the number of people who will be coming to campus. Table 2 provides this quantity over a range of prevalence (from 5 to 1500 infections per 100,000 people) and a range of school sizes (from 100 to 3000 people on campus).
- **Comparing current prevalence to specific risk threshold.** A possible criterion for a threshold would be *ensuring that the risk of an introduction is under 50%*[3]. Table 3 recommends thresholds for reopening schools for a range of risk tolerance levels (from

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[2] The probability of at least one introduction is given by $1-(1-P)^S$ where $P$ denotes the community-wide prevalence of COVID-19 and $S$ denotes the number of people returning to school.

[3] The equation for this threshold is given by $-\log(1-R)/S$ where $R$ denotes a specific risk tolerance (e.g., setting $R = 0.1$ means a 10% chance of an introduction or a 90% chance of no introductions) and $S$ denotes the number of people returning to school. Multiply by 100,000 to translate this threshold into a number of cases per 100,000.

5% to 75% chance of an introduction) and a range of school sizes (from 100 to 3000 people on campus).

- **An example.** Based on the estimated current prevalence of 404-1380 cases per 100,000 people, we would calculate the following for a school with **1000** students and teachers returning to campus:
    - Expected introductions: 4.0-13.8 people would arrive infected.
    - Probability of at least one introduction: 98-99% chance of at least one introduction.
    - Comparison to threshold: the threshold for limiting the probability of an introduction to 50% is 70 cases per 100,000; the threshold for limiting the risk to a more stringent 10% is 11 cases per 100,000. The current estimate of 404-1380 cases per 100,000 is far above both of these thresholds, indicating that the risks of bringing 1000 people onto a campus today are high.

**Table 1. Expected number of COVID-19 school introductions in a week.** The number of students and staff that would be expected to arrive at a school infected depends on the size of the school (that is, the total number of students and staff regularly coming to campus) and the current prevalence of SARS-CoV-2 in the community.

| | **Estimated prevalence (cases per 100,000 people)** | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **School Size** | **5** | **25** | **50** | **100** | **250** | **500** | **1000** | **1500** |
| **100** | <1 | <1 | <1 | <1 | <1 | <1 | 1 | 1.5 |
| **250** | <1 | <1 | <1 | <1 | <1 | 1.3 | 2.5 | 3.8 |
| **500** | <1 | <1 | <1 | <1 | 1.3 | 2.5 | 5 | 7.5 |
| **1000** | <1 | <1 | <1 | 1 | 2.5 | 5 | 10 | 15 |
| **2000** | <1 | <1 | 1 | 2 | 5 | 10 | 20 | 30 |
| **3000** | <1 | <1 | 1.5 | 3 | 7.5 | 15 | 30 | 45 |

**Table 2. Probability of at least one COVID-19 introduction in a week.** The risk depends on the size of the school (that is, the total number of students and staff regularly coming to campus) and the current prevalence of SARS-CoV-2 in the community.

| | Estimated prevalence (cases per 100,000 people) | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| **School Size** | **5** | **25** | **50** | **100** | **250** | **500** | **1000** | **1500** |
| **100** | <1% | 2.5% | 4.9% | 9.5% | 22.1% | 39.4% | 63.4% | 77.9% |
| **250** | 1.20% | 6.10% | 11.80% | 22.10% | 46.50% | 71.40% | 91.90% | 97.70% |
| **500** | 2.50% | 11.80% | 22.10% | 39.40% | 71.40% | 91.80% | 99.30% | 99.90% |
| **1000** | 4.90% | 22.10% | 39.40% | 63.20% | 91.80% | 99.30% | 100% | 100% |
| **2000** | 9.50% | 39.40% | 63.20% | 86.50% | 99.30% | 100% | 100% | 100% |
| **3000** | 13.90% | 52.80% | 77.70% | 95% | 99.90% | 100% | 100% | 100% |

**Table 3. Prevalence thresholds for reopening (current infections per 100,000).** The thresholds depend on the size of the school (that is, the total number of students and staff regularly coming to campus). They also depend on the risk tolerance, which is the probability that at least one introduction will occur in the first week. For example, a risk tolerance of 0.1 corresponds to a 10% chance of an introduction (i.e., a 90% guarantee of no introductions). The values in the table should be compared to estimates for total prevalence (rather than reported cases) as described above. If the estimated prevalence is below a threshold given in the table, then the expected risk of introductions would be below the specified risk tolerance.

| | Risk tolerance (probability of even one introduction) | | | | |
|---|---|---|---|---|---|
| **School Size** | **5%** | **10%** | **25%** | **50%** | **75%** |
| **100** | 52 | 106 | 288 | 694 | 1387 |
| **250** | 21 | 43 | 116 | 278 | 555 |
| **500** | 11 | 22 | 58 | 139 | 278 |
| **1000** | 6 | 11 | 29 | 70 | 139 |
| **2000** | 3 | 6 | 15 | 35 | 70 |
| **3000** | 2 | 4 | 10 | 24 | 47 |

## School Reopening Risks in Harris County

As depicted in Figure 1A reported cases climbed steeply in the summer and peaked in early August. Figure 1B shows the corresponding estimates for the total weekly prevalence of SARS-CoV-2. For the week ending on August 27, 2020, there were a total of 136 new cases reported per 100,000 in Harris County [3]. Assuming that somewhere between 10% and 33% of cases are reported, this corresponds to a total prevalence between 414 and 1380 infections per 100,000 people. We note that there is often at least a week-long delay between the date of infection and the date of case confirmation. The average time from exposure to first symptoms is roughly five days; several more days may pass by the time a case seeks testing and receives results. Thus, these prevalence estimates may correspond to the level of virus in the community one or more weeks prior to the date the cases are reported.

The feasibility of bringing students and teachers onto campuses depends on the size of the school. The largest schools in HISD, with enrollments over 3,000, have the highest risks for COVID-19 introductions. Figure 1 includes a threshold (red line) indicating the level of virus at which there is a 50% chance at least one person would arrive infected at a school with 3,000 people. We recommend waiting at least until local prevalence has dropped below this value (24 infections per 100,000 people) before bringing the full student body back to campus. For smaller groups of students and teachers, Tables 1-3 and the risk calculations described above can provide guideposts for reopening. Importantly, if schools are reopened when the risk of an introduction is 50%, we would still expect roughly one introduction every two weeks. Thus, school openings should be approached with an abundance of caution, including comprehensive measures to prevent transmission on campuses, such as mandatory face masks and strict cohorting, procedures to ensure early detection of cases, and clear plans for rapid and effective mitigation as cases arise.

Figure 2 presents alternative estimates for changing prevalence of COVID-19 in the Houston Area based on hospitalization data for Trauma Service Area Q (which includes Harris and 8 surrounding counties). The model and estimates are described in a recent UT COVID-19 Modeling Consortium report on COVID-19 healthcare trends in Texas [4]. As of August 28, 2020, this model suggests that the COVID-19 prevalence is somewhere between 430 and 1167 infections per 100,000, which is consistent with our estimate based on confirmed case data. The projections indicate that COVID-19 prevalence may continue to fall in the Houston area over the next few weeks. However, prevalence is unlikely to fall below the 24 infections per 100,000 threshold for safely opening schools over 3,000 students by the end of September.

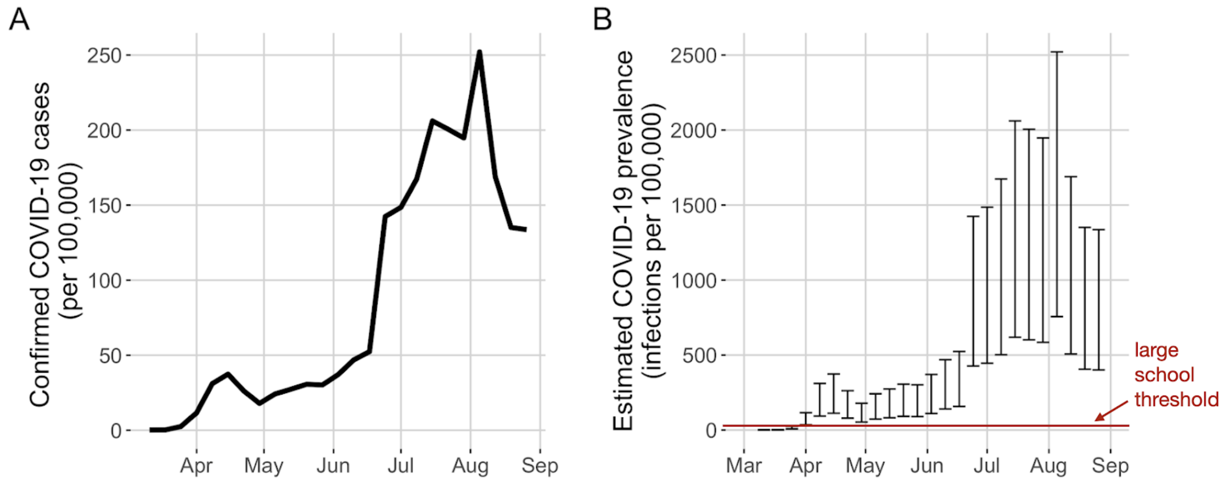


**Figure 1. Reported COVID-19 cases and estimated COVID-19 prevalence in Harris County.** (A) Weekly numbers of confirmed cases per 100,000 people in Harris County, from the New York Times [3]. (B) Estimated total number of people infected per 100,000 in Harris County, assuming a case reporting rate between 10% and 30%. The red *large school threshold* corresponds to a 50% chance that at least one person will arrive infected in a school with 3000 students and staff. Note, the estimate for any given week may reflect the level of COVID-19 in the community during the preceding week or two because of delays between exposure, symptom onset, testing and receiving results.

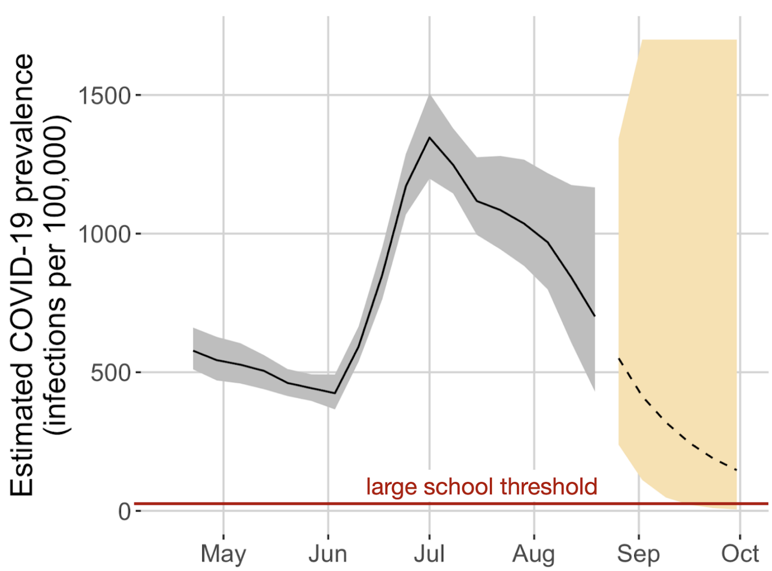


**Figure 2. Projected COVID-19 prevalence, based on COVID-19 hospitalization data for Trauma Service Area Q through August 20, 2020** [5]. We estimate the number of new COVID-19 cases per week per 100,000 people through September 30, 2020 using the methodology described in our recent Texas COVID-19 Healthcare Projections Report [4]. The gray shaded area represents the 95% prediction interval from our simulations for the period when hospitalization data were available, and the yellow shaded area represents the 95% prediction interval for the model projections. The solid and dashed black lines represent median estimates for the fitted model and model projections, respectively. The red *large school threshold* corresponds to a 50% chance that at least one person will arrive infected in a school with 3000 students and staff.

## Final considerations

To support school reopening efforts, the estimates provided herein should be revised to reflect the evolving state of the COVID-19 pandemic in the Houston area. To do so, we recommend making the calculations suggested above or using Georgia Tech's COVID-19 Event Risk Assessment Planning Tool, which uses similar equations to estimate introduction risks depending on US county and school size.

The guidance above makes a key assumption: the chance that a student or teacher 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 [6], more recent estimates suggest nearly equal susceptibility [7–9]. 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 [12].

Thus, decision-makers should recognize that this framework provides only a rough indication of importation risk 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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