
Executive Summary

Schools across Pennsylvania and around the country are beginning the 2020–2021 school year while COVID-19 remains a threat in widely varying degrees, in different communities, and at different times. Every school that is opening its building to students—part-time or full-time, starting now or later in the school year—needs to contemplate the possibility that a student or staff member will become infected with COVID-19. Our [previous work](#) (Gill et al., 2020) suggests that hybrid operating approaches, with part-time attendance in the school building, can substantially slow the spread of infections, but schools still need to have a plan for what to do when someone is infected.

The Pennsylvania Department of Education (PDE) asked Mathematica to extend our previous work by simulating COVID-19 spread in schools under a range of different scenarios that vary based on community infection rate, grade level, operating strategy, local COVID-19 testing capacity, and the school’s response to a confirmed infection—which is likely to include quarantining of close contacts of the infected person and may also include temporary closure of the school building.

This report provides the findings from those simulations. The simulations employed an agent-based computational model like the one used in our previous work, refined based on emerging evidence and extended to incorporate effects of quarantines and temporary school shutdowns in response to COVID-19 cases in the school community. We conducted approximately 400,000 simulations, predicting the spread of infections for hundreds of combinations of local circumstances and school operating and quarantine strategies.

Because we examined such a wide range of circumstances, the results of the simulations should be relevant well beyond Pennsylvania. Educators and policymakers elsewhere across the country can use these results to inform their own decisions about operating schools and setting policies for quarantining and/or closure in response to detecting COVID-19 cases among students or staff.

As with all simulations, the results depend on the validity of the assumptions informing the models, which are derived from emerging, uncertain science about the virus and from expectations about the behavior of students and school staff that involve a different kind of uncertainty. We model transmission of the virus in the school and on school buses—the places that are under the control of schools—but a rapid increase in infection rates outside the school can increase infections in the school (as is evident from our findings on schools in communities with higher infection rates). Educators and policymakers therefore should keep in mind the uncertainty of all predictions related to the pandemic.

The main body of this report presents results that describe general patterns related to school level, community infection rate, operating strategy, local COVID-19 testing capacity, and school policies for responding to detected infections. Appendix A provides detail on the agent-based model methods and assumptions underlying it. Appendix B provides customized results for sample schools with various particular characteristics using specific operating strategies and infection response policies. Specifically, Appendix B includes comparative results for 108 different school situations, so that any school can find a result relevant to its own circumstances. For each of these different circumstances, the appendix includes graphs showing the relative number of infections the school is likely to experience, the percentage of school days the typical student is likely to be able to attend in person, and the total number of likely infections in the school at the time the first infection is detected. Importantly, these graphs show not only the average results but also the range of random variation across schools in similar circumstances, which is important because no school can count on landing at the average.

Key findings from the main body of the report include the following:

- Cumulative infection rates in elementary schools are likely to be consistently lower than in secondary schools employing the same operating strategies, even if they are similar in size, because younger children are less likely to be infected.
- Precautions such as requiring masks can measurably reduce infection spread in schools.
- Hybrid operating approaches in which groups of students attend school in person part-time dramatically reduce the total number of likely infections in the school. Simulation results suggest that under a hybrid approach with precautions (including wearing masks, eliminating additional mixing of students outside of class, and putting six feet of distance between desks), most infections coming from outside the school will produce zero additional infections in the school.
- If all students are coming to school daily, temporarily closing the building every time an infection is detected modestly reduces the total number of infections. But temporary closures are far less effective in reducing infection spread than using a hybrid operating strategy from the start, and closures disrupt school schedules unpredictably.
- If the school is operating in part-time hybrid mode, quarantining the close contacts of individuals with detected infections is likely to keep the school's infection rate low; temporary closures reduce the number of days that students can attend with no demonstrable benefit in further reducing infections.
- Under part-time hybrid operating strategies, students come to school far fewer days by design, but because hybrid operation keeps infection rates low, the typical student in a secondary school using a hybrid approach (in a community with a low or moderate infection rate) is likely to experience little or no unplanned disruption in the days they can come to school. Students in school buildings operating full-time, in contrast, are more likely to be sent home for quarantine.
- At very low community infection rates (10 reported infections per 100,000 population over the last seven days), most students can expect to attend nearly every day even in schools operating full-time, as long as the schools implement precautions such as mask wearing.
- Delays in COVID-19 testing results are likely to increase infections in schools operating full-time without precautions. But faster turnaround of COVID-19 test results has no measurable impact on infection spread in schools operating on a part-time hybrid model, in which infections are likely to remain low regardless of the speed of receiving test results.
- Transmission of the virus has a large random element, which means that regardless of precautions taken, there is a chance that a school could have an infection on its first day of operation, underscoring the need for careful adherence to mitigation strategies to minimize the risk of spread in the school.
- Because many of those infected are asymptomatic or presymptomatic, all schools should expect that a single detected case may represent one or more additional undetected cases. In secondary schools operating with full-time attendance or in communities with high infection rates, there may be five or more infections in the school when the first case is detected.