Agent-based models for investigating SARS-CoV-2 in K-12 Schools

Agent-based models (ABMs) are computational models that imitate how interactions of individuals ("agents") contribute to community-level outcomes. Over the past 50 years, ABMs have been used to evaluate the effectiveness of efforts to control spread of disease, reduce teenage smoking, diffuse technology, and update agricultural policies. For The Rockefeller Foundation's COVID-19 testing protocol demonstration project in six schools, we use an ABM to understand the impact of COVID-19 screening testing on the spread of COVID among students, teachers, administrators, and other school staff.

How do ABMs work? ABMs use available data on infection spread, people's behaviors (such as increasing physical distance, wearing masks, and testing), and people's characteristics to predict the likely spread of disease in a school.

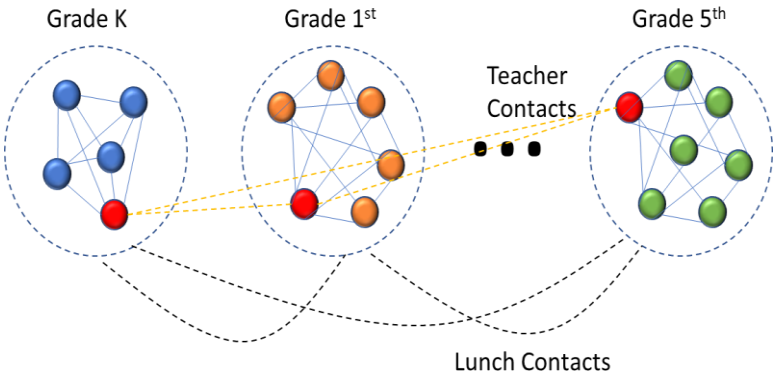
What can ABMs tell us? An ABM can:

- Provide an early indication of whether a screening program can help reduce infections in schools and keep schools open
- Help decision-makers decide whether their screening program should be modified (e.g. if the current program does not seem likely to produce desired results)

Key outcomes from the ABM are compared across varying screening testing strategies to assess the potential effectiveness of the screening program, answering questions such as:

- Does screening result in fewer infections, greater or similar number of days open, or increased attendance in schools?
- Do other COVID-19 precautions implemented at schools impact effectiveness of screening?
- Should pilot sites make any changes or course corrections to their screening program?

Figure 1. *Illustration of a potential contact network for a K–5 school*



How is the ABM tailored for a school? Figure 1 shows an illustration of interactions that could spread COVID for a K–5 school for the classroom, lunch/recess, and teacher contacts in a typical school. Those interactions can vary depending on the specific conditions within schools and communities, including class sizes, community prevalence, and screening strategies. We can specify the parameters of the model to each community's

context to develop results for how screening is helping specific schools, cities or other settings to mitigate the spread of COVID.[1]

ABMs can account for mechanics that vary the macro structure of interactions, such as students eating lunch with just their classmates (which would eliminate any additional lunch contacts), and the micro structure of interactions, such as requiring masking (which would decrease transmission probability for all interactions). The number of students, teachers, and staff that arrive for the first day of school already COVID positive can be modified to match estimates of community prevalence. When localized data is unavailable, best estimates from the COVID-19 literature and data aggregations for larger geographic regions (e.g. county, state, or national COVID-19 dashboards) can be used.

Have ABMs been used to model COVID-19 in schools? Mathematica researchers have already developed and used ABMs that simulate the spread of SARS-CoV-2 for K-12 schools (Gill et al, 2020a, Gill et al, 2020b) to help them make data-driven re-opening and operating policy decisions tailored to their communities. Over the two studies referenced above, Mathematica investigated 108 different school situations, including urban, suburban, and rural settings.

[1] The ABM work proposed here serves a different purpose from initial modeling used to inform this project (Larremore et al. 2020). The initial modeling work was used to develop the range of testing strategies to be used by schools. In contrast, ABM will provide insights into how the strategies play out given actual on-the-ground conditions in schools, including in the context of other mitigation strategies being implemented.