# Operating Schools in a Pandemic: Predicted Effects of Opening, Quarantining, and Closure Strategies

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# We evaluated options for school operations using agent-based computational simulations to predict COVID-19 spread

- Schools are faced with wrenching trade-offs in reopening decisions—and need info about the magnitude of risks

- Pennsylvania wanted evidence-based guidance

- We conducted thousands of simulations under many different circumstances:

  - Low/moderate/high community infection rate

  - Full-time building operation vs. part-time hybrid with small groups

  - Approach to detected infection: partial quarantine vs. temporary school closure

- Report includes **108 combinations of scenarios**, so that any school can find info relevant to its own circumstances

Grade K    Grade 1st    Teacher Contacts    Grade 5th

Lunch Contacts

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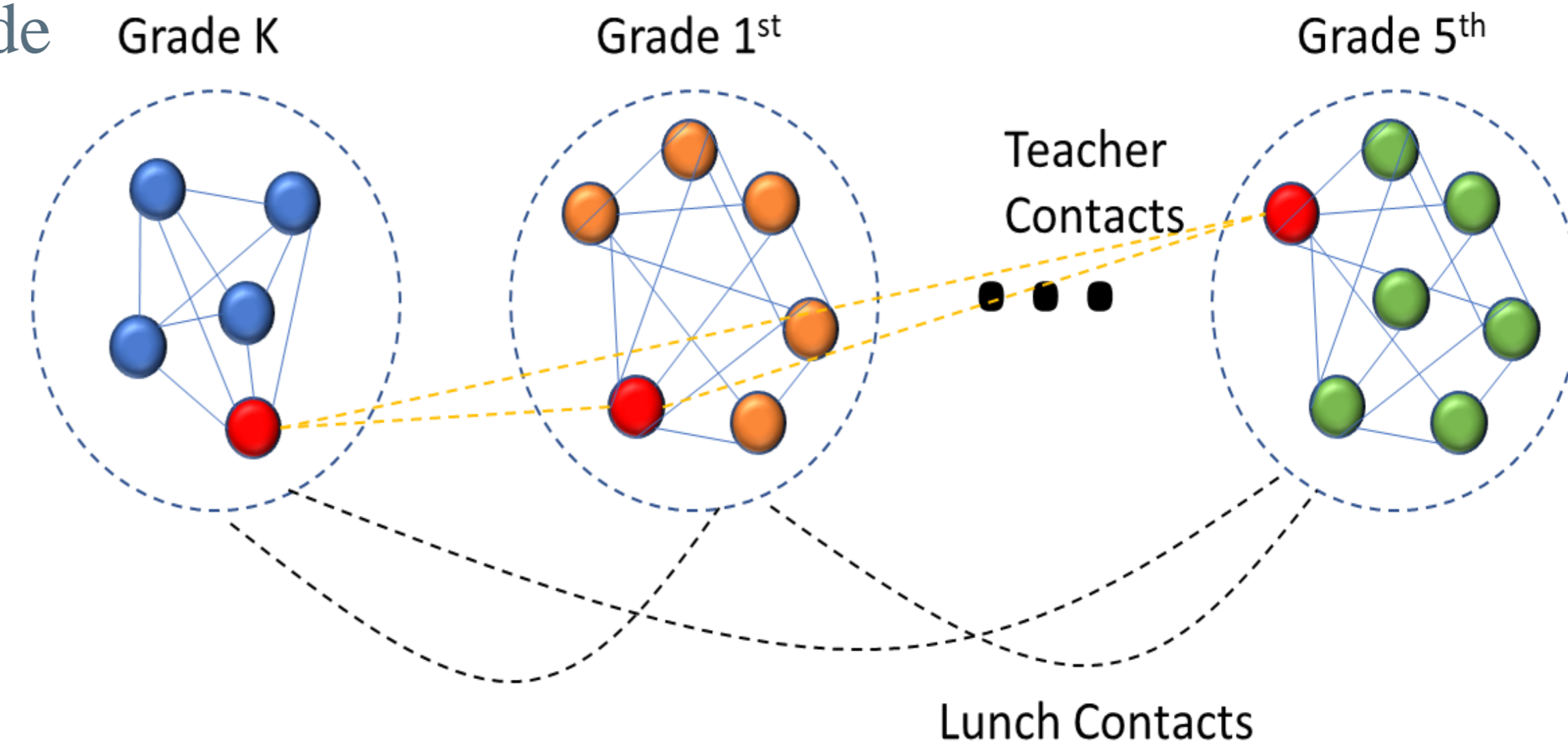
# Caveat: We don't have a crystal ball

- Agent-based model simulates infection spread among students and staff in schools, using the best information available from emerging research on transmission of SARS-Cov-2
  - To capture random variation, we conducted 200 simulations of every variant (approx. 400k simulations in total), and showed variation in output graphs
- But much remains unknown about the disease
- And much remains uncertain about human behavior in schools
- We conducted sensitivity analyses to test assumptions, where possible

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# We examined operating scenarios informed by evidence review and interviews

**Scenario A**. Operate as if the pandemic had not occurred

**Scenario B**. Daily attendance with precautions (restrictions on interclass mixing, students and staff wear masks)

**Scenario C**. Daily attendance with precautions and block scheduling

**Scenario D**. Daily attendance with precautions and students podded in one classroom

**Scenario E**. Students divided into 2 groups, rotating 2 days per week, with 6 feet of physical distance in class, plus precautions

**Scenario F**. Students divided into 2 groups, with weekly 4-day rotations, with 6 feet of physical distance in class, plus precautions

**Scenario G**. Students divided into 5 groups, rotating 1 day per week, with 6 feet of physical distance in class and on school bus, plus precautions

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# Simulations suggested that with precautions, many schools can operate without substantially increasing infection spread

- Elementary schools have lower infection spread than secondary schools

- Precautions (masks, distance) and part-time hybrid operation reduce infections with less need for disruptive quarantines and school closures

- Rapid turnaround of COVID-19 test results not necessary to limit infection spread in schools

- Transmission of the virus has a large random element, outside schools' control: Any school must be prepared for having an infection
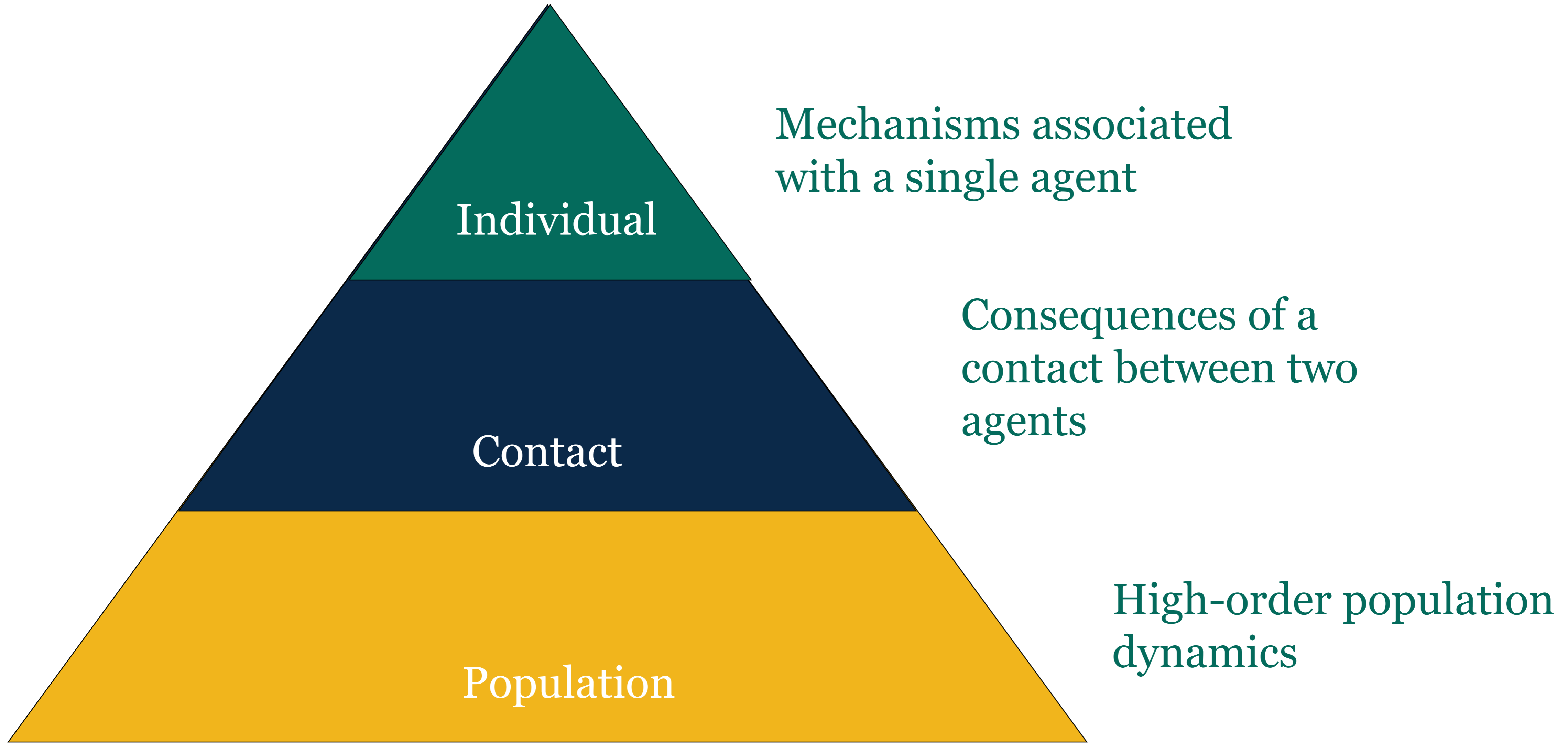
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# Precautions and hybrid operation dramatically reduce the likelihood that schools will contribute to outbreaks

**Figure 3.** *Average number of additional infections among students and staff for each infection coming from outside the school, by operating scenario, in a typical Pennsylvania secondary school*
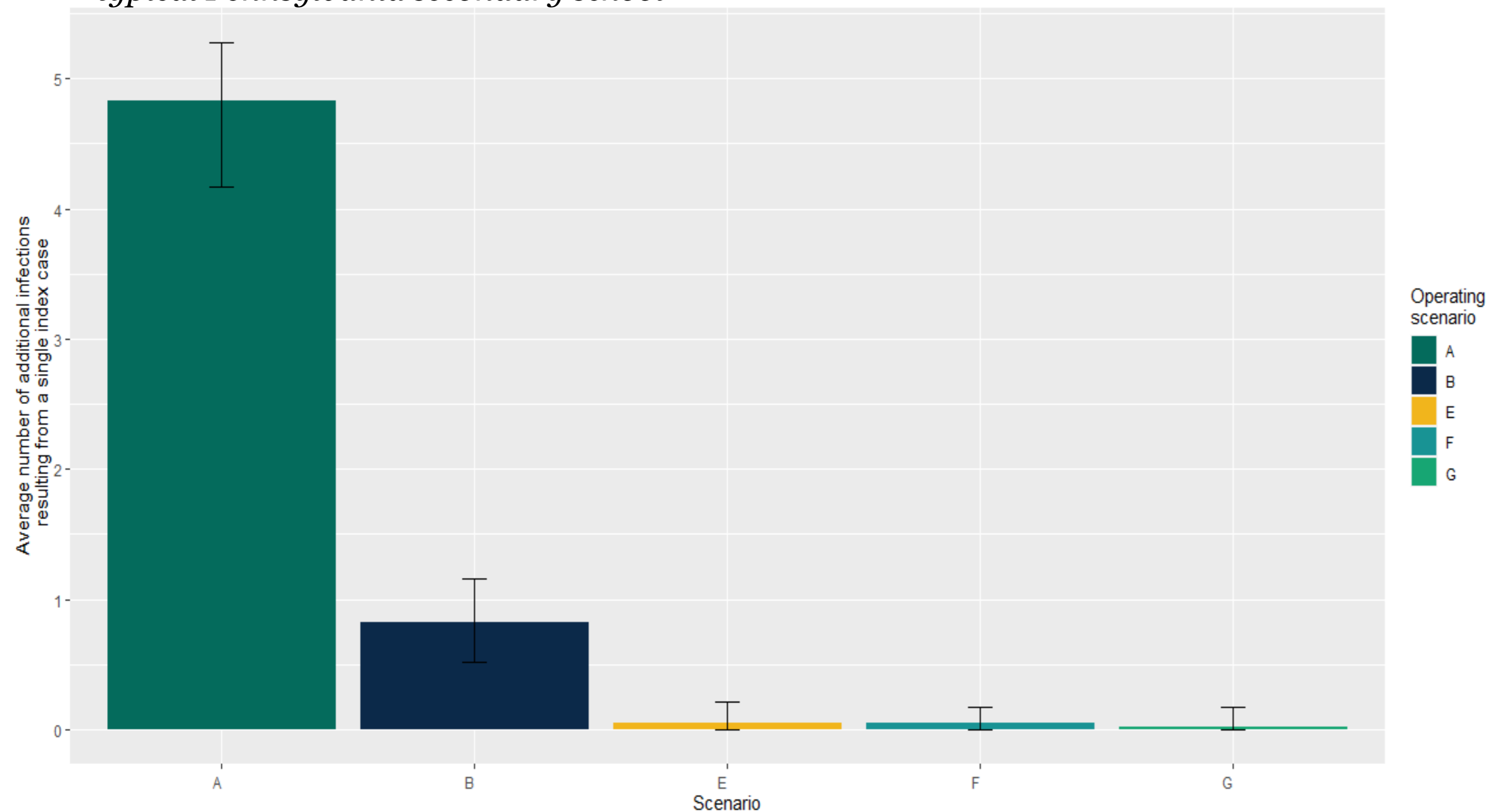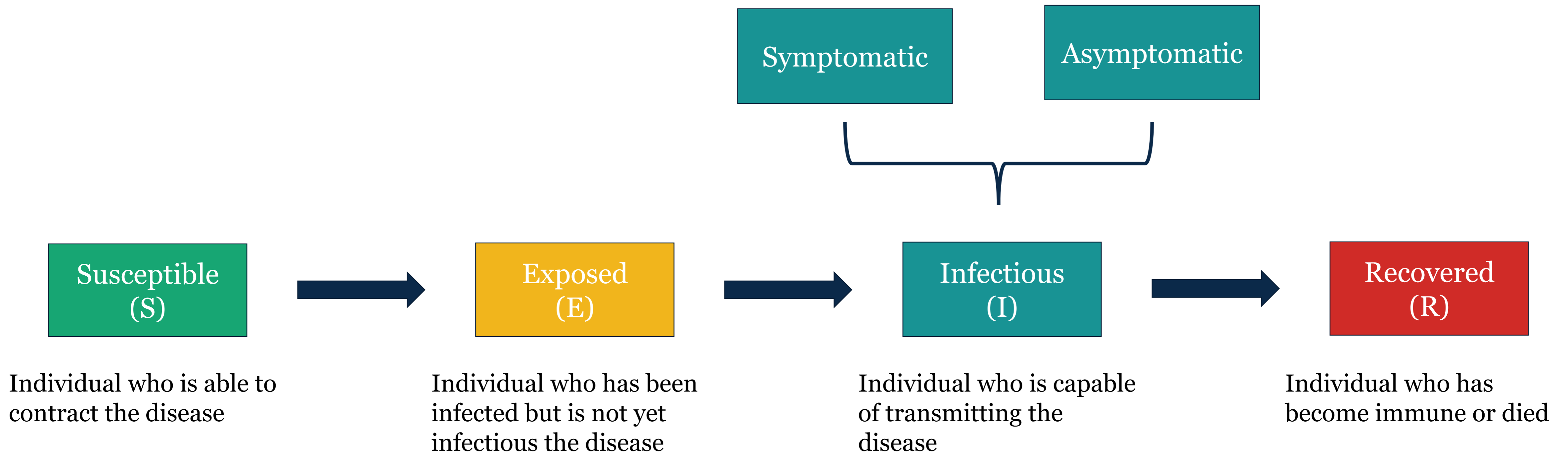


- Secondary schools that try to run full-time without precautions are likely to seed additional infections

- In schools operating in part-time hybrid mode with precautions, most infections from outside lead to zero additional infections in school

  - *Emerging evidence from schools appears consistent with this prediction*

# Categorization of agent-based model parameters

Individual

Contact

Population

Mechanisms associated with a single agent

Consequences of a contact between two agents

High-order population dynamics

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# Disease progression



**Individual**

Symptomatic    Asymptomatic

| Susceptible (S) | → | Exposed (E) | → | Infectious (I) | → | Recovered (R) |

Individual who is able to contract the disease

Individual who has been infected but is not yet infectious the disease

Individual who is capable of transmitting the disease

Individual who has become immune or died

## We based values for disease progression parameters from published literature
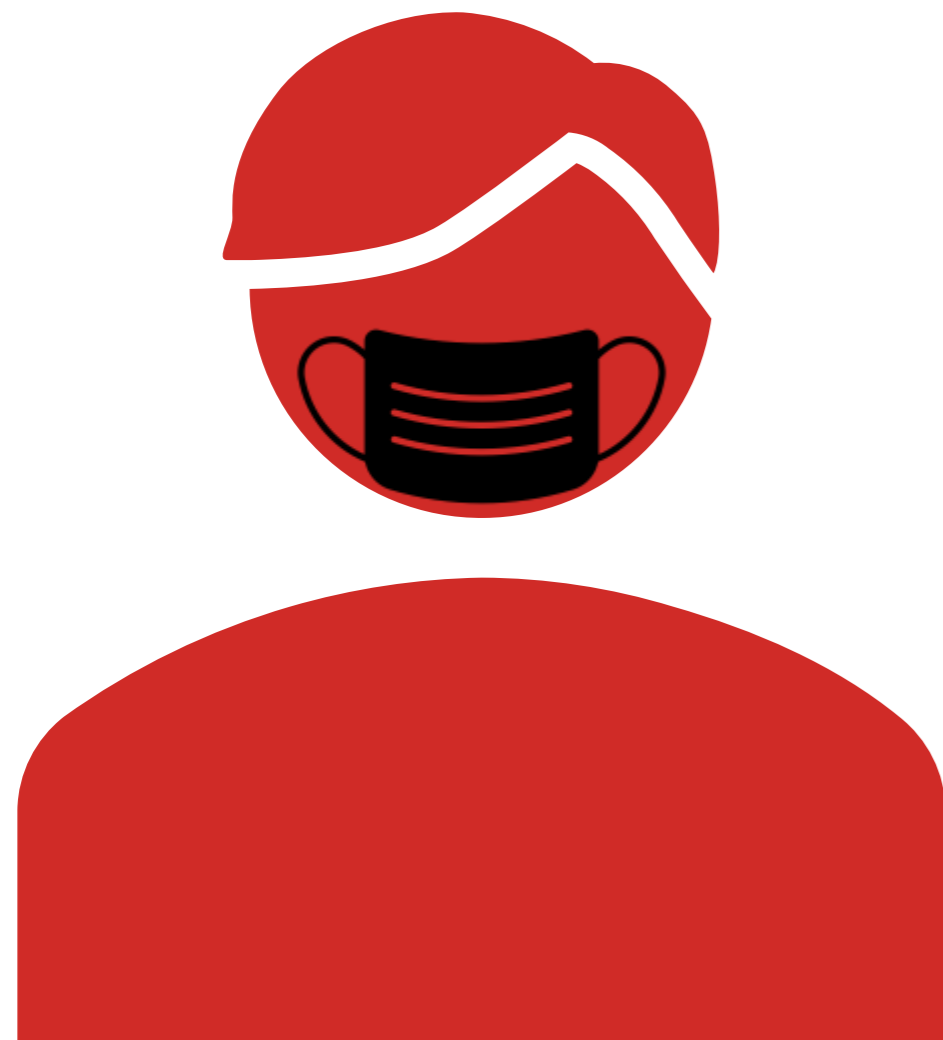
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# Transcription probabilities

**What is the probability that an infected individual spreads to another person at a school?**

Contact
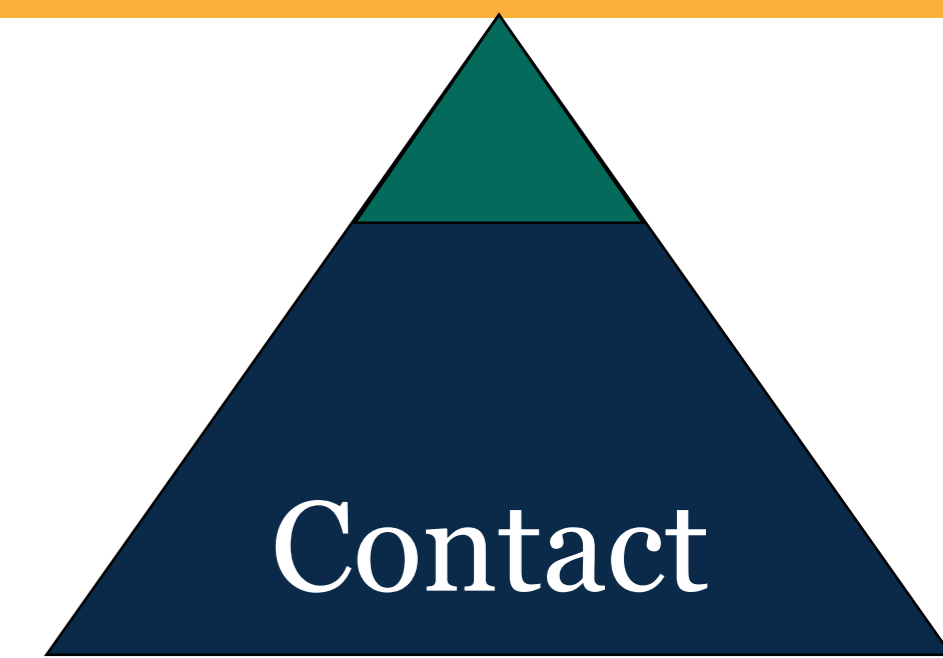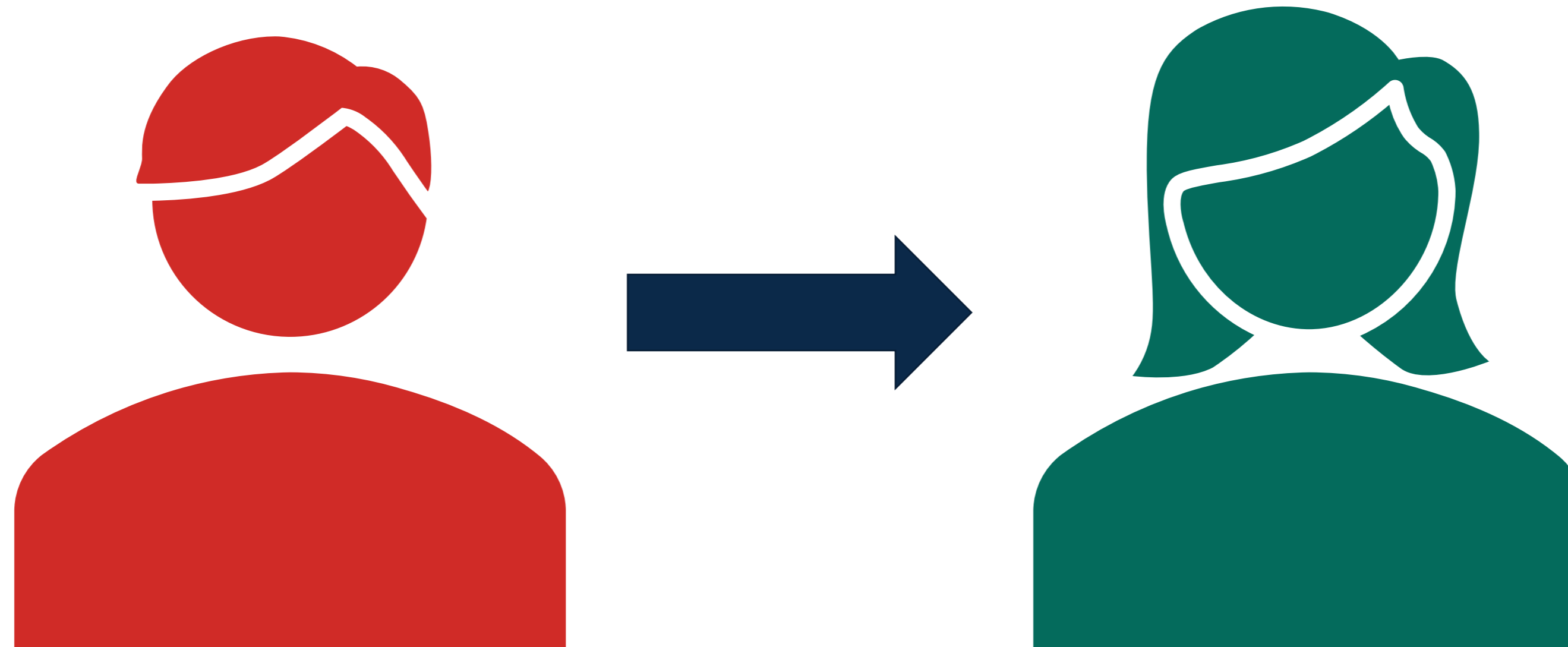
# Transmission probabilities

What if they are practicing social distancing and masking?

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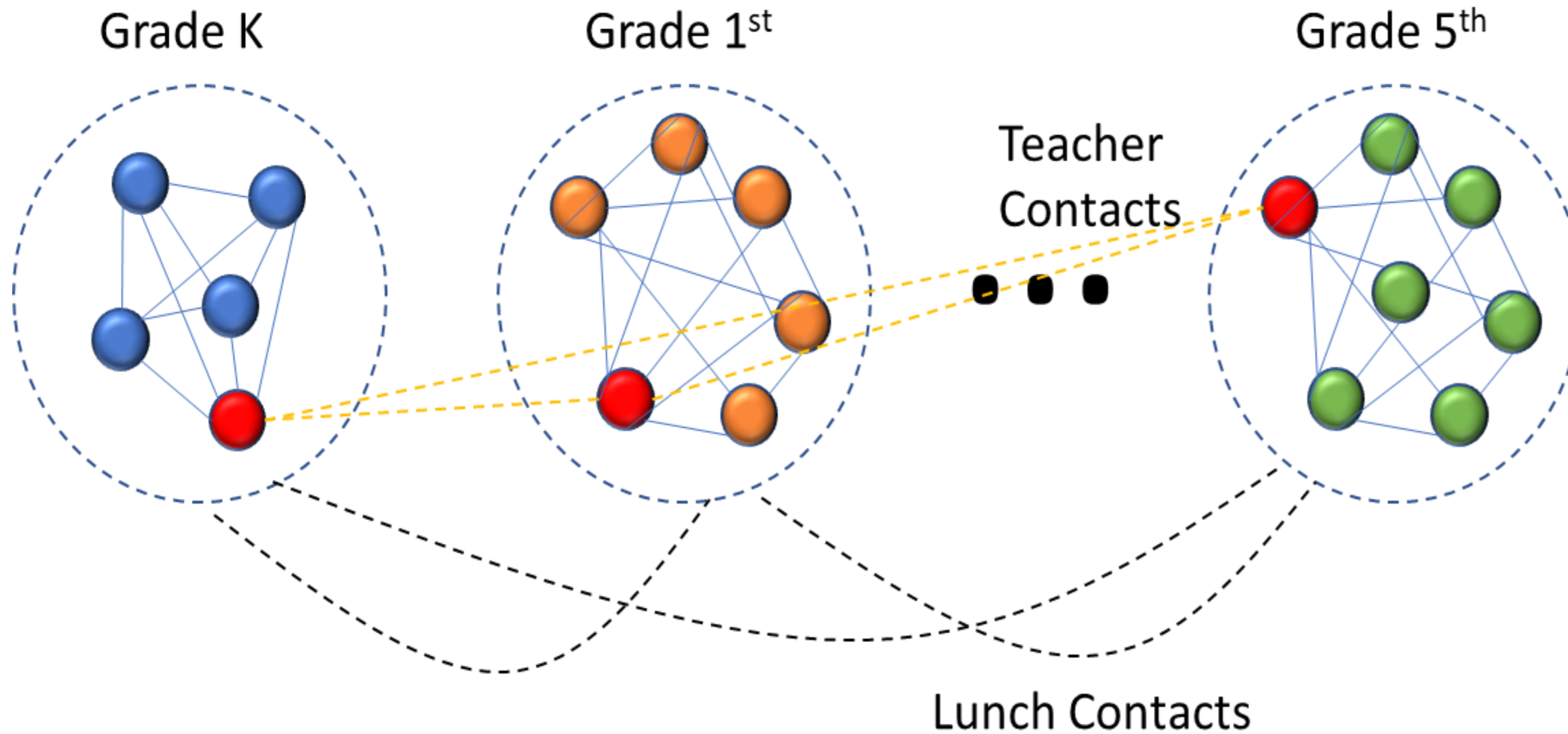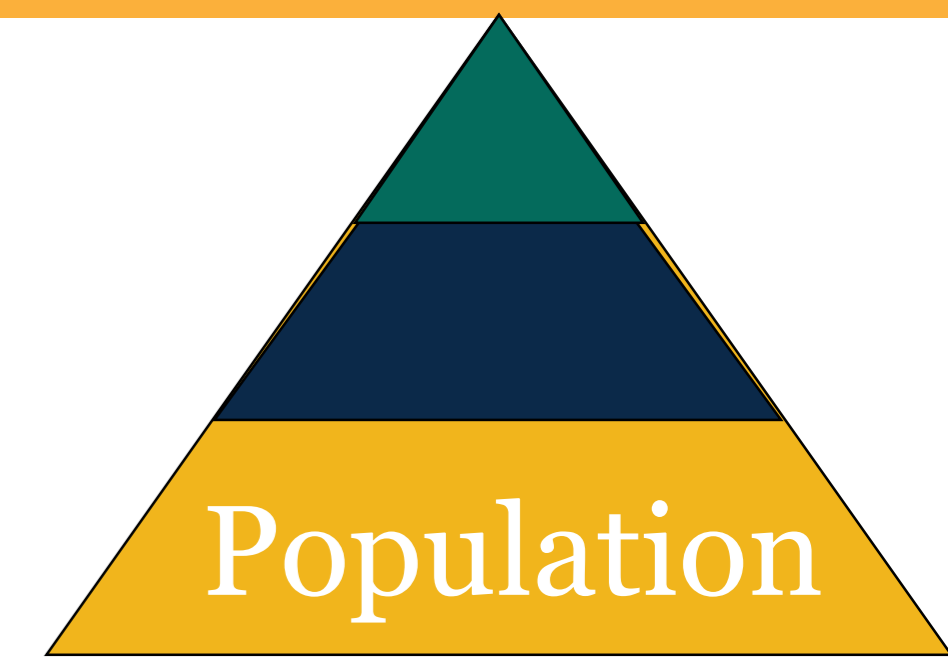
# Transcription probabilities

How does the transmission probability change if
the infected individual is a child

Contact

Many combinations!

We assumed a base transmission probability and used multipliers

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# Contact network



Structure of contact network impacts disease spread and effectiveness of strategies to mitigate its spread

Known: Students teachers are assigned to classes

Unknown: Interaction of teachers and staff as well as Students during lunch/recess