Testing the waters: is it time to go back to school?
Daniel Klein, Cliff Kerr, Dina Mistry, Niket Thakkar, Jamie Cohen on behalf of the IDM COVID-19 modeling team

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Introduction to IDM

The Institute for Disease Modeling (IDM) aims to support global efforts to eradicate infectious diseases and achieve permanent improvements in health by developing, using, and sharing computational modeling tools and promoting quantitative decision-making.

Size: ~90 people, 50% research + 50% software

Emphasis: Polio, malaria, HIV, measles, etc - now COVID

COVID-19 workstreams:

- Epidemiology: prevalence, reproduction number
- Complex scenarios: contact tracing, schools, vaccines
- Low- & middle-income country modeling

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Sr. Research Manager at IDM
Joined IDM in 2010, HIV focus
Kids in 4th & 6th grade, LWSD

Please visit idmod.org to learn more about our institute.
Primer on disease modeling

“Essentially all models are wrong, but some are useful.” – George Box

Models help us understand trends, explore what-if questions, and make predictions.

### Statistical model

\[ y \sim mx + b + \varepsilon \]


### Compartmental model

Researchers can use compartmental models to understand the spread of diseases by dividing the population into different compartments, such as susceptible, infectious, and recovered.


### Agent-based model

Agent-based models represent individual people, infections, networks, and other relevant features.
Glossary of epidemiology terms

**Screening**: Filtering applied to everyone (diagnostic uses a test, symptom doesn’t)

**Prevalence**: Percent of the population that is currently infected

**Case diagnosis rate**: New diagnoses in the past 14 days, per 100k people

**Infection vs. case**: 1 in 10 up to 1 in 2 infections are diagnosed as a case

**Reproduction number**: Number of onward infections caused by each infection

**Diagnostics**: PCR, antigen, or antibody tests

**Diagnostic test sensitivity**: Probability of a positive result in an infected individual

**Diagnostic test specificity**: Probability of a negative result in a healthy individual

**Non-pharmaceutical interventions (NPI)**: masks, distancing, hygiene, ventilation

**Countermeasures**: NPI, symptom screening, and contact tracing

**Attack rate**: Percent acquiring infection in a specified period
**Infections**: Age-specific COVID-19 dynamics

**Person-to-person contacts**:  
- Depends on age and setting‡  
- Contacts can change day-by-day

**Interventions**:  
- Setting-specific countermeasures  
- Testing, tracing, diagnosis & quarantine  
- Configurable delays in test & trace

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**Covasim is an agent-based COVID-19 model purpose-built to explore reopening scenarios**

- Non-pharmaceutical interventions (NPI): physical distancing, hand hygiene, masks, and ventilation.
- † Model code available at: [covasim.org](http://covasim.org)
- ‡ A contact network of agents was constructed using data on age, households, and activity patterns from census and BLS statistics for King County from 2015-2019.  
  Age-mixing patterns are used for the US to construct contacts within households, schools, workplaces, long-term care facilities, and the general community.
IDM school modeling results to date

Schools are not islands

Risk of in-person learning is non-zero, and depends primarily on:

1. Countermeasures implemented in and around schools
2. Incidence of COVID-19 infections in the community

Maximize education, minimize risk

While worst-case outcomes could result in many infections, we found:

1. K-5 phase-in or hybrid scheduling, combined with countermeasures, dramatically reduces risks
2. Lower risk reopening scenarios result in fewer in-person days

Testing the waters: is it time to go back to school?

*Diagnostic screening as a risk-mitigation strategy for reopening K-12 schools*

**Setting:** King County, WA as of mid. October

**Analysis period:** Nov. 2\textsuperscript{nd} → Jan. 31\textsuperscript{st} (no holidays)

<table>
<thead>
<tr>
<th>Indicator</th>
<th>Modeled</th>
<th>10/26-11/8 coronavirus.wa.gov</th>
</tr>
</thead>
<tbody>
<tr>
<td>Case incidence (14d total per 100k)</td>
<td>75</td>
<td>~200</td>
</tr>
<tr>
<td>Testing volume</td>
<td>225</td>
<td>306</td>
</tr>
<tr>
<td>Test positivity</td>
<td>2.5%</td>
<td>3.7%</td>
</tr>
<tr>
<td>Reproduction #</td>
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<td>1.2*</td>
</tr>
<tr>
<td>Prevalence</td>
<td>0.2%</td>
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</tr>
</tbody>
</table>

* Current value is higher

[https://coronavirus.wa.gov](https://coronavirus.wa.gov), accessed November 10\textsuperscript{th}, 2020

From Oct 26 through Nov 08, there was a rate of 197.2 cases per 100K in King County.
School reopening scenarios

1. Full schedule, no countermeasures
   ➢ 5d in-person, unchecked growth

2. Full schedule
   ➢ 5d in-person

3. Hybrid scheduling
   ➢ A & B groups in-person 2d per week

4. Phased-in scheduling
   ➢ K-5† 5d in-person, others remote

5. All remote
   ➢ Continued remote learning for all

With countermeasures

1. NPI
2. Symptom screening
3. Contact tracing

Diagnostic screening scenarios

- No diagnostic screening
- PCR one week prior, 1d delay
- Weekly antigen for teachers & staff, PCR f/u
- Fortnightly antigen, no f/u
- Fortnightly antigen, PCR f/u
- Fortnightly PCR, 1d delay
- Weekly antigen, PCR f/u
- Weekly PCR, 1d delay
- Daily PCR, no delay

Scenarios outlined in black are included in these slides, see report for others.

* Antigen tests are less reliable. Positives can isolate without PCR follow-up (f/u) or seek PCR confirmation with 3-day lag.

† Compared to adults 20-64, children 0-9 and 10-19 are assumed to be 33% and 66% as susceptible, see Zhang, Science, 2020.
Bars indicate % of school populations acquiring COVID-19 from any source during first 3 months of school

Key Findings

1. No zero-risk scenario
2. Countermeasures are effective
3. Hybrid & K-5 phase-in are not much riskier than all remote
4. Dx screening is helpful only when there are infections to catch

Countermeasures include symptom screening, NPIs (25% reduction), and contact tracing.
Bar height represents the reproduction number in all of King County, averaged over the 3 month period.

Key Findings

1. In-person learning with countermeasures does not dramatically increase population wide transmission in this analysis.

2. Screening shifts $R_e$ below 1.0 for the full schedule.
Percent of schools with an infectious individual present on the first day*, after symptom screening

Key Findings
1. Probability increases with school size, but risk might not be due to cohorting

* To make the point here, all students, teachers, and staff are screened on the same day
Percent of schools with an infectious individual present on the first day*, after symptom screening

Key Findings
1. Probability increases with school size, but risk might not due to cohorting
2. Dx screening one-week prior results in marginal improvement
3. Dx screening a few days prior reduces the day-one probability

* To make the point here, all students, teachers, and staff are screened on the same day
Bar height indicates the percentage of the 65† possible in-person days that are remote.

Key Findings
1. Remote learning days are dominated by scheduling
2. Smaller contribution from health concerns (false positives tests* and symptom screening†)

† Our modeling accounts for day-of-week, but not holidays.
* Assumed 90% specificity and 3 days at home per false positive
+ We model ~12% will experience influenza-like symptoms in 3 months
Key modeling assumptions

- School starts on November 2\textsuperscript{nd}, evaluated through January 31\textsuperscript{st}
- $R_0$ of 1.6 in schools “as normal” without countermeasures - \textit{high uncertainty}
- \textbf{Not including reactive closures at this time, just contact tracing}
- Symptom screening coverage is 90%, follow-up testing coverage is 50%
- Children 0-9 and 10-19 are 33% and 66% as susceptible compared to 20-64
- Of newly-diagnosed school cases, 75% will be indices for contact tracing
- Of contacts, 75% will be reached and will quarantine
- Daily ILI probability of 0.2\% (~10\% per season) creates false screen positives
- PCR test assumed to have 100\% sensitivity and specificity
- Antigen test is has 97.1\% sensitivity within 7-days of symptom onset and 90\% otherwise, 98.5\% specificity, and no delay*. PCR follow-up resulted in 3 days.

\textit{Please refer to the report for a complete list of modeling assumptions}

* New data on the Abbott BinaxNOW\textsuperscript{TM} Covid-19 rapid antigen test shows even higher specificity, see Pilarowski et al, medRxiv.
Takeaways & discussion

• In-person learning is not zero-risk, but symptom screening and other countermeasures are highly effective in this analysis

• Routine diagnostic screening will have more impact if countermeasures are not fully implemented or community prevalence is higher

• A single PCR test the week before school, small test numbers, or infrequent testing may have limited lasting impact beyond surveillance

• Scheduling dominates proportion of remote learning days, but symptom screening and low-specificity diagnostics contribute

• Sensitivity analysis reinforces emphasis on reducing community transmission outside of schools

• Many uncertainties remain, but we hope these results are helpful