Modelling COVID-19 contact tracing in Illinois

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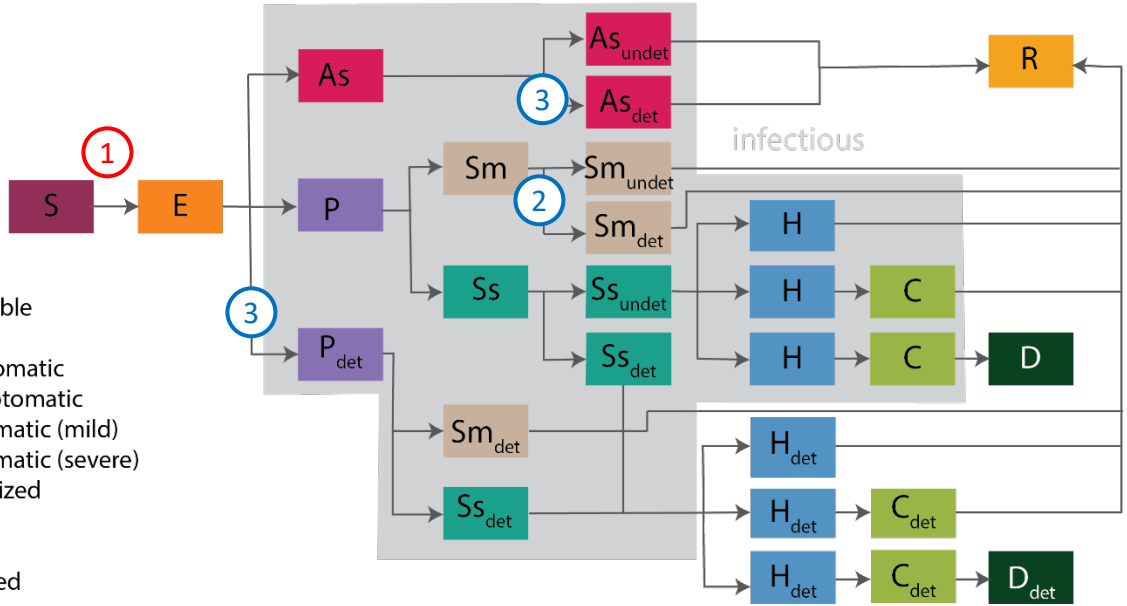
How do contact tracing thresholds for Illinois vary across different reopening scenarios and level of mild infection detections ?

- All areas have shown decreasing (or at least stable) case data over the past 30 days. Restaurants and recreational locations are open as of the end of June.
- To mitigate potential resurgence, increased testing is crucial. Contact tracing has been an effective intervention in other countries to reduce transmission by identifying and isolating non-symptomatic infectious cases
- We use a spatial compartmental model of COVID-19 transmission, calibrated to COVID-19 death data across Illinois, to **predict the impact of contact tracing under various reopening scenarios**. We identify testing and contact tracing performance thresholds needed to prevent exceeding heath capacity limits.
- We define contact tracing primarily as the detection of a- and presymptomatic infections, with additional increase in detecting mild infections

Modifying transition parameters between the compartments allows us to simulate various scenarios

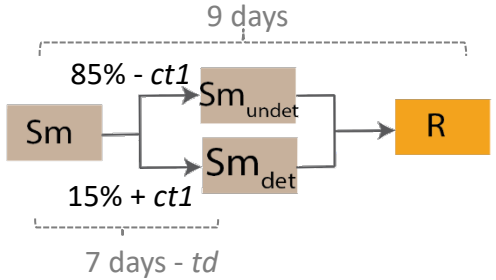


Susceptible
Exposed
Asymptomatic
Presymptomatic
Symptomatic (mild)
Symptomatic (severe)
Hospitalized
Critical
Dead
Recovered

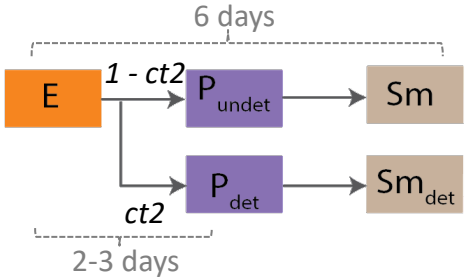
1. **Reopening** increases contact rates hence transmission
2. **Increased testing** results in more mild symptomatics to isolate
   Faster testing results in earlier isolation of mild symptomatics, hence reducing the time they can spread the infection
3. **Contact tracing** enables to identify infections that do not show symptoms and for these to isolate and quarantine appropriately

We can model both detection rates and time to positive diagnosis

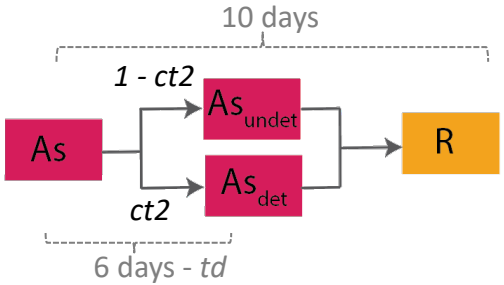
- We assume a fixed **symptomatic** period of 9 days and a detection rate of 15% for mild symptomatic cases.



- The period from exposed to become **pre-symptomatic** (or asymptomatic) was fixed to 2-3 days and to develop symptoms 3-4 days.

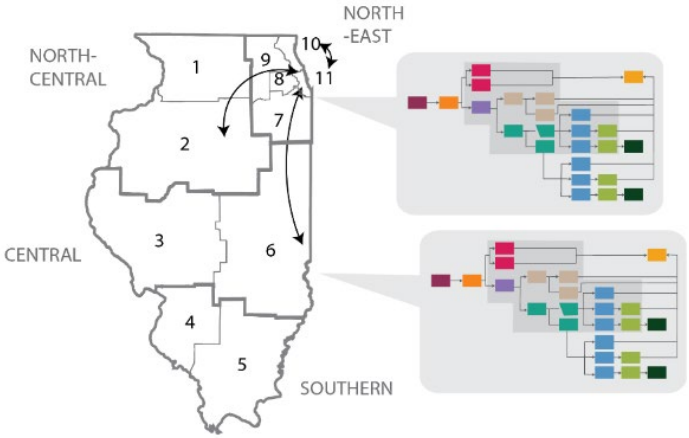


- **Asymptomatic** infections were assumed to last for 10 days and detections to happen at after 6 days.



We run simulations at the EMS level, then aggregate results up to IL

- The model includes ~30 parameters that are sampled from uniform distributions.
  - In this slide deck, we focus on only one sample
- Simulations ran for each EMS region assuming a closed population per EMS.
- Once detected, mild symptomatic cases isolate with an effectiveness of 70-100%, while the isolation effectiveness for pre- and asymptomatic ranges from 0 to 100%

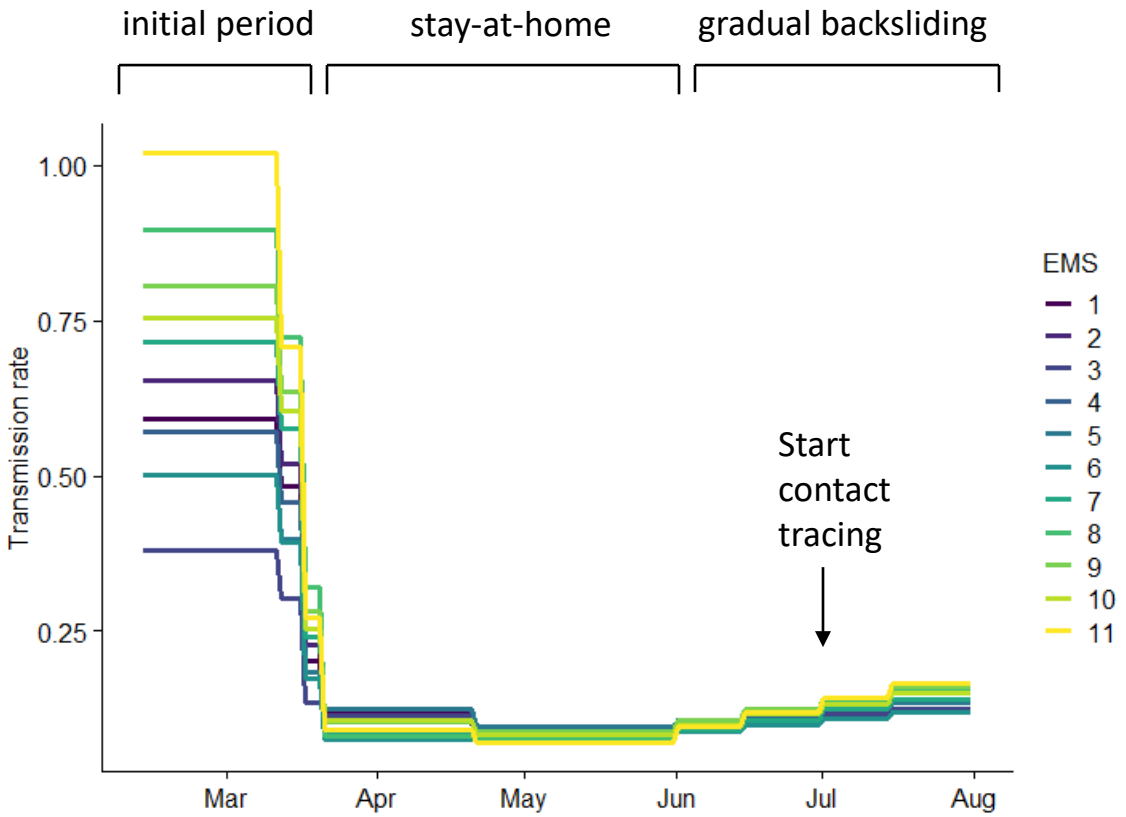


EMS areas are simulated as separate disconnected areas within the same model

 | Sym = mild infections, P = presymptomatic infections, As = asymptomatic infections

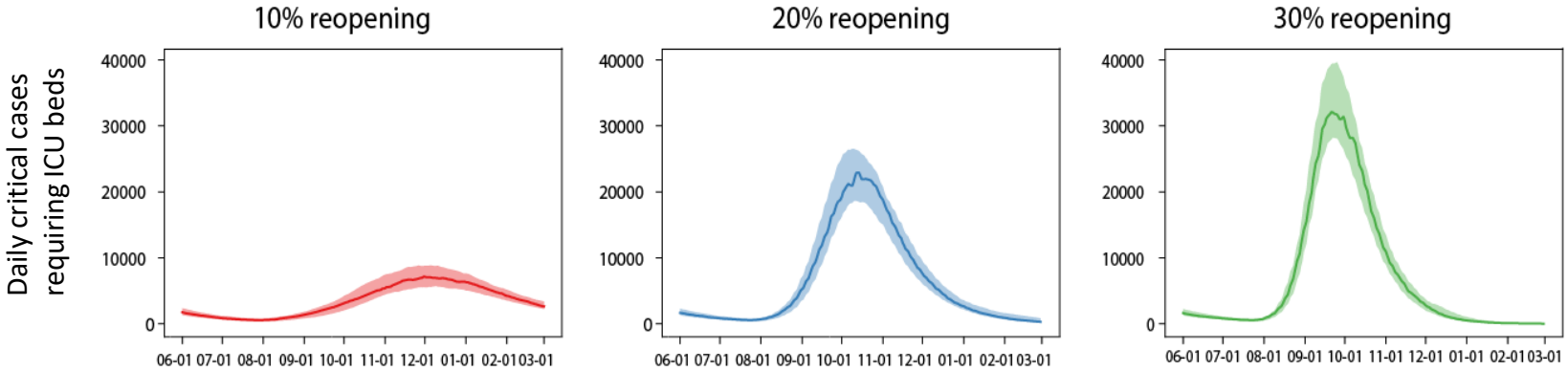
We try to capture each EMS's individual transmission trajectory

- Transmission intensity and lockdown effectiveness were fit to death data for each EMS
- Backsliding was simulated with gradual increase in transmission beginning June 1
- Assume contact tracing starts July 1



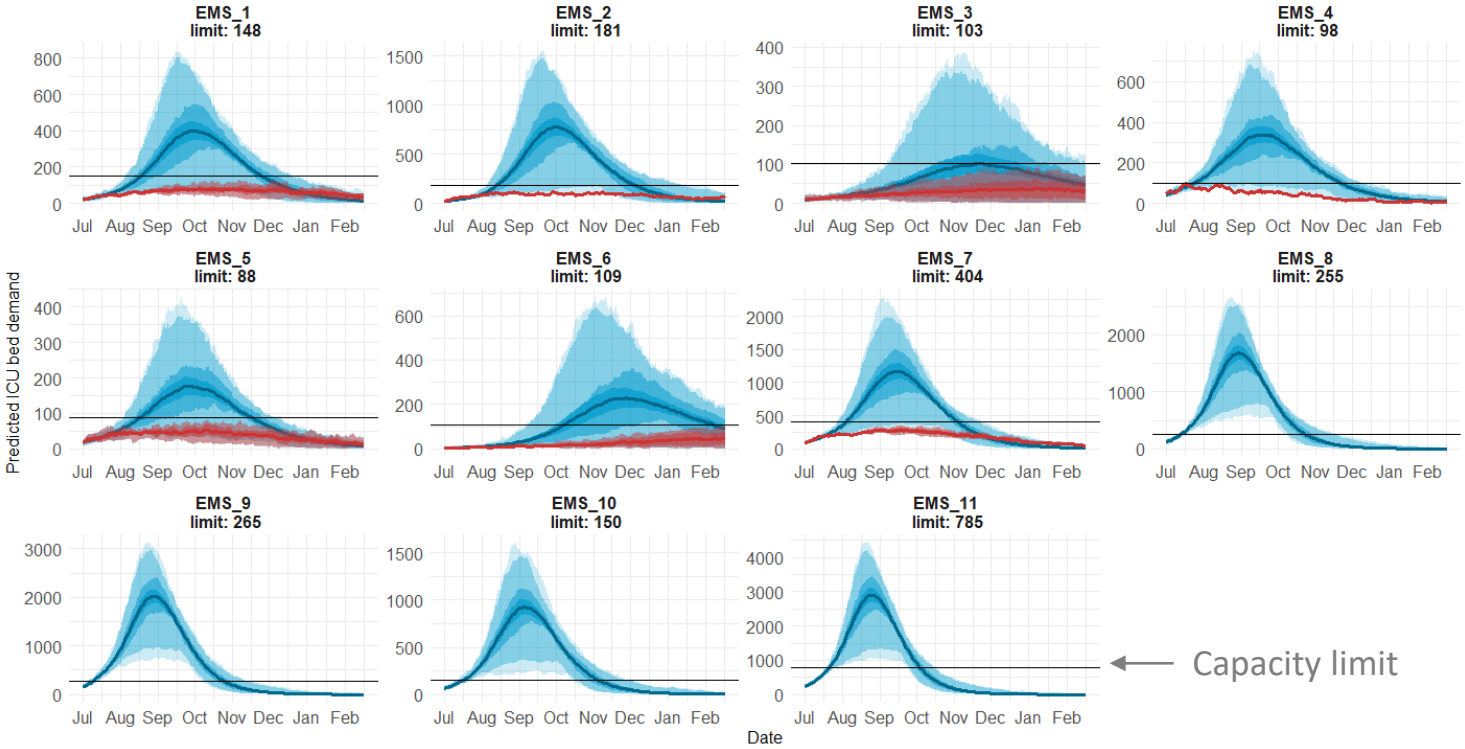
Since we don't know the impact of reopening, we consider transmission backsliding toward March rates by 10%, 20%, or 30%

- vary detection rate of and isolation performance for As, P (50 samples) grouped by
  - levels of increase in Sym
  - test delay reductions in a) Sym , b) As, and c) both
  - timing of contact tracing compared to reopening

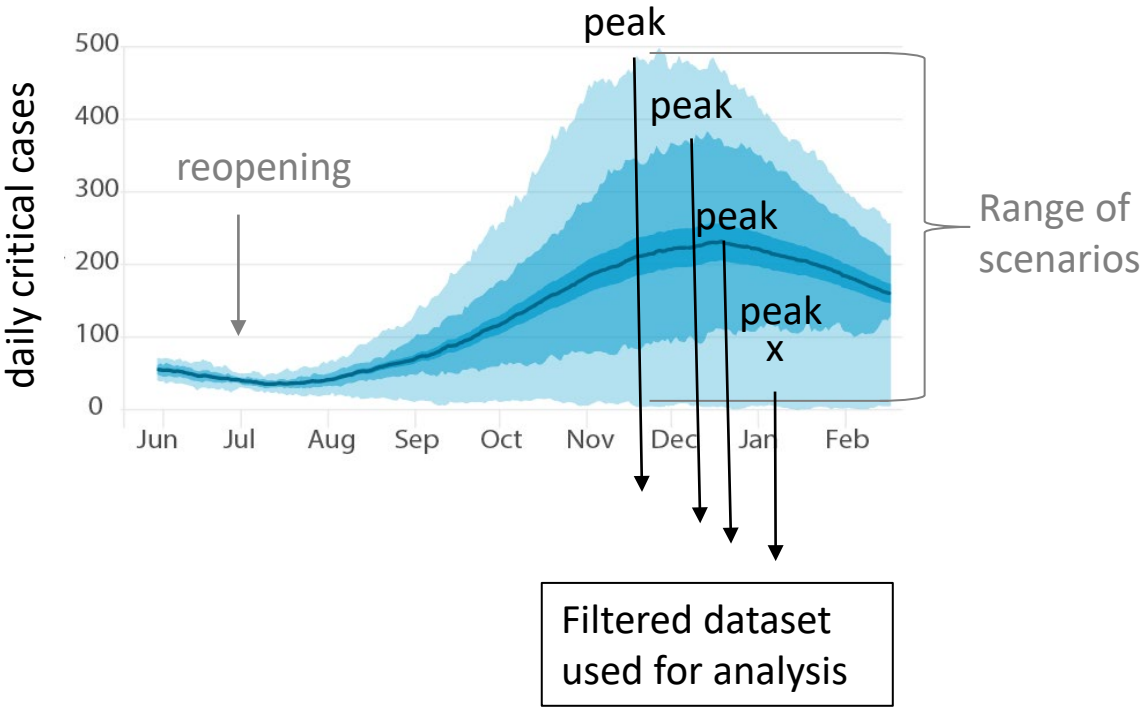


 | Sym = mild infections, P = presymptomatic infections, As = asymptomatic infections

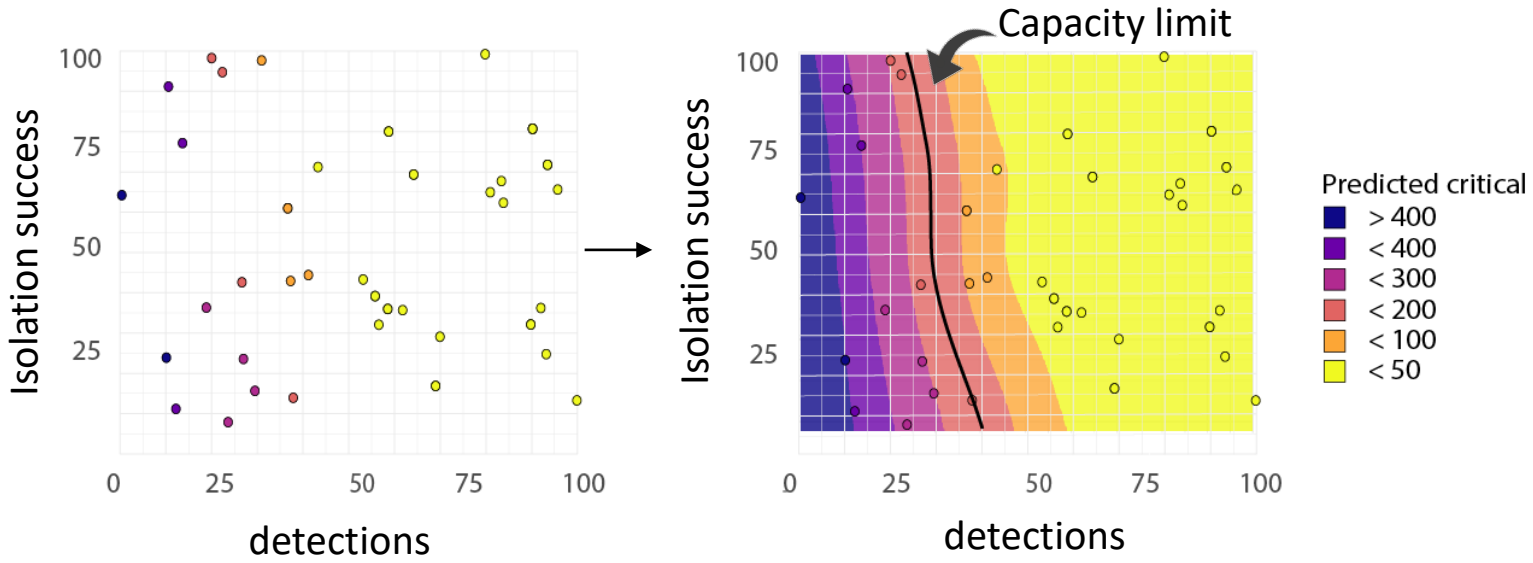
Out of all the detection level scenarios per EMS, we are interested in these that stay below the ICU bed capacity limit (red color)



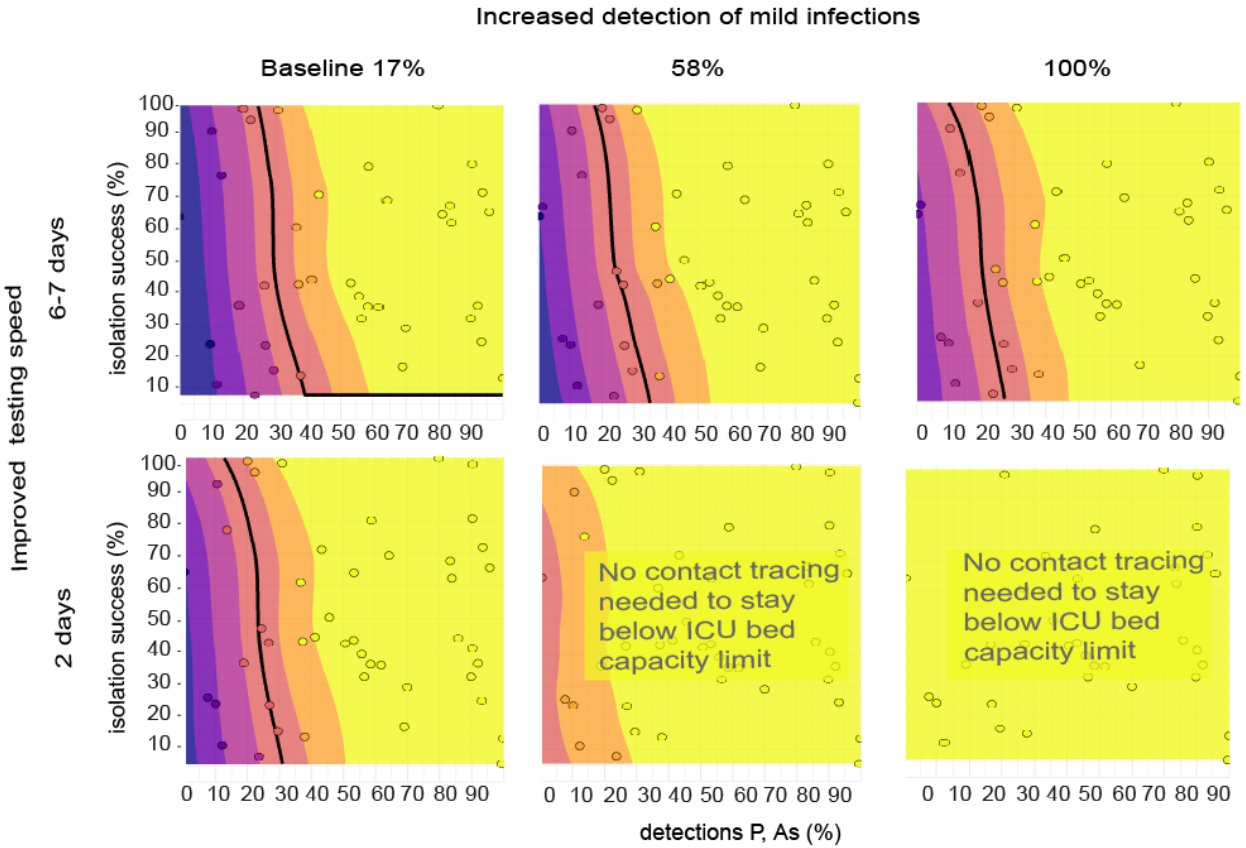
To **avoid exceeding capacity** limits at any time after reopening, we identified **the peak of the 'second wave'** for each simulated combination of intervention parameters



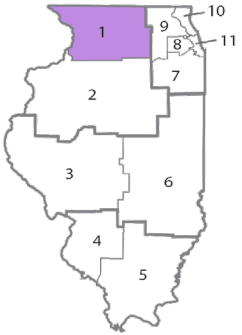
Detection and isolation coverage thresholds were identified after interpolating between simulation outputs and selecting the minimum values for which predicted ICU beds are below the capacity



Identifying thresholds for varying levels of detecting mild infections at 10% backsliding towards March transmission rates

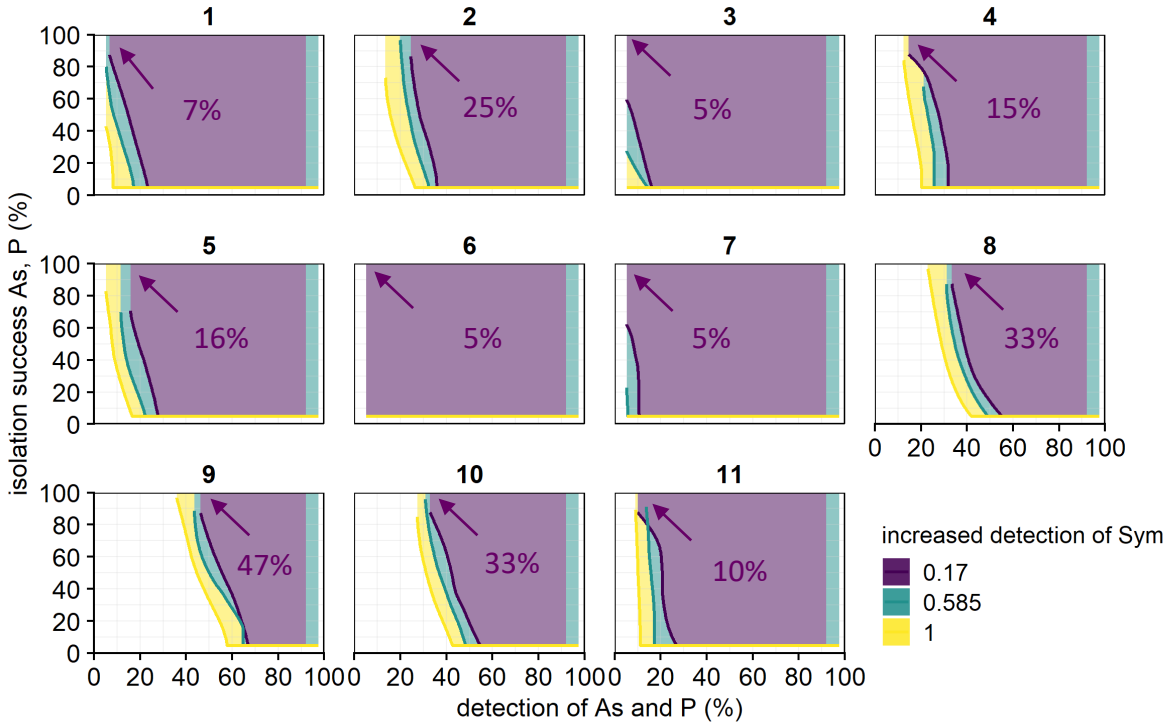


Example EMS 1

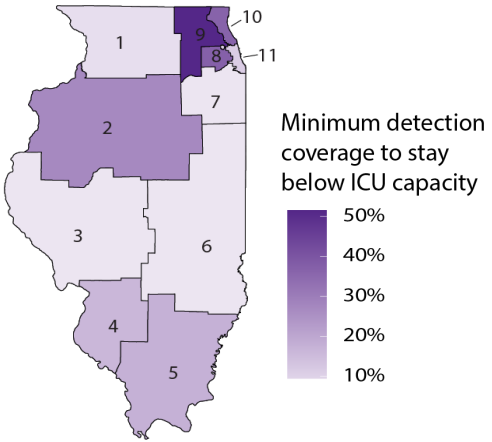


*Example from previous simulations

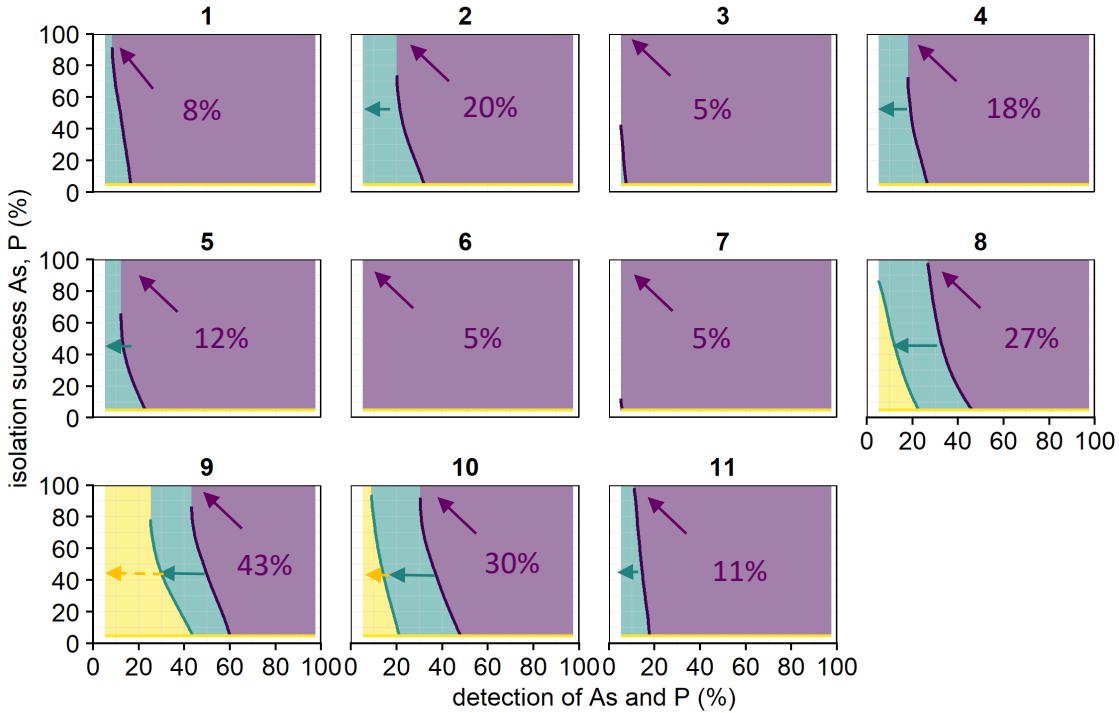
The contact tracing **thresholds vary per EMS** and depend on the detection level of mild symptomatic infections especially in southern EMS regions



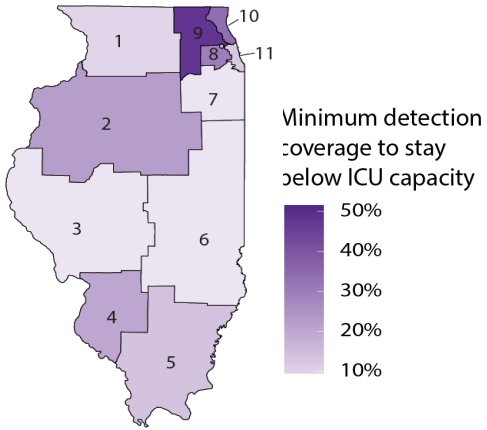
Scenario:
10% reopening keep baseline test delays to 7 days for mild infections



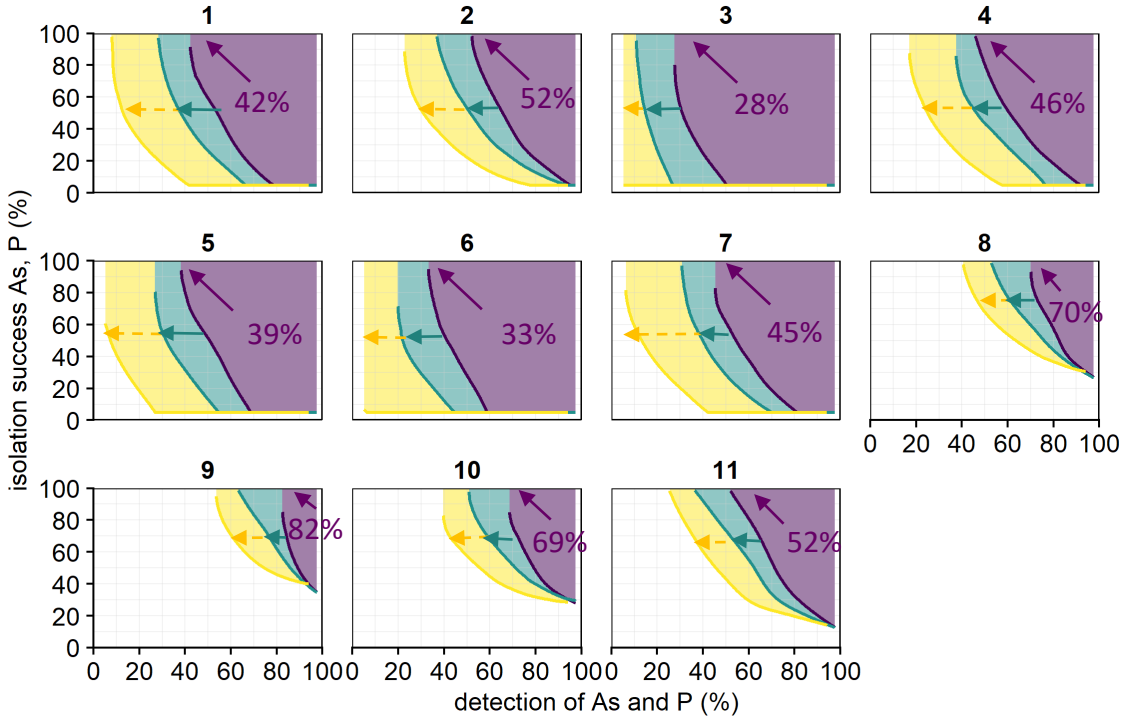
If mild infections can be **faster detected and sooner isolated**, detecting more mild infections can **substantially reduce detection thresholds for asymptomatic detection**



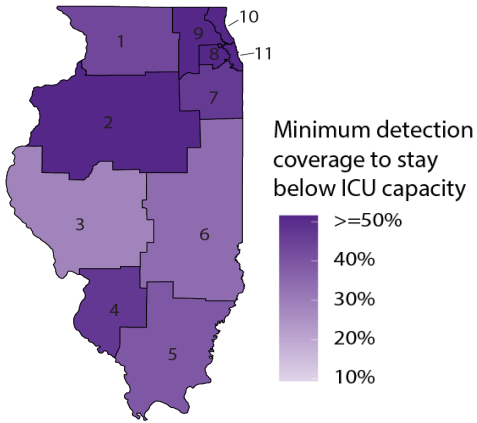
Scenario:
10% reopening shortening test delays to 2 days for mild infections only



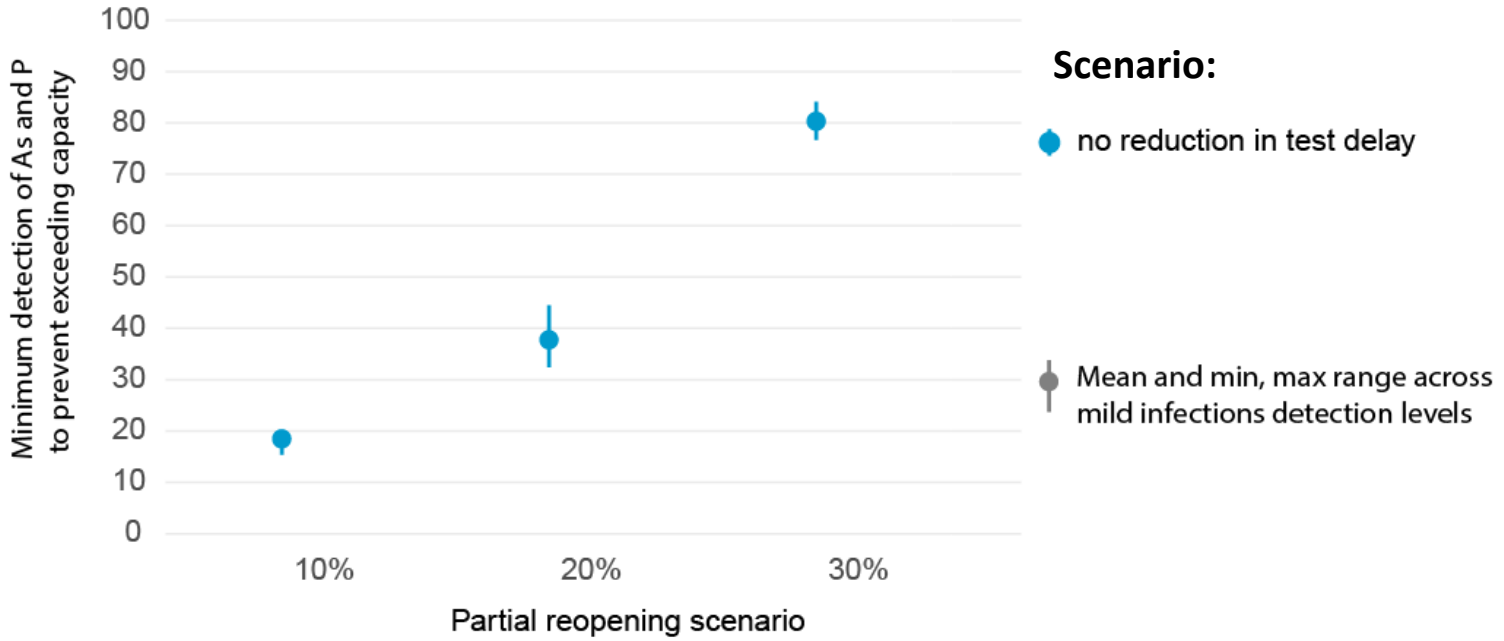
However, when **backsliding by 20%, detecting all mild infections** and high detection of a- and pre-symptomatic **would not be enough** in most EMS regions



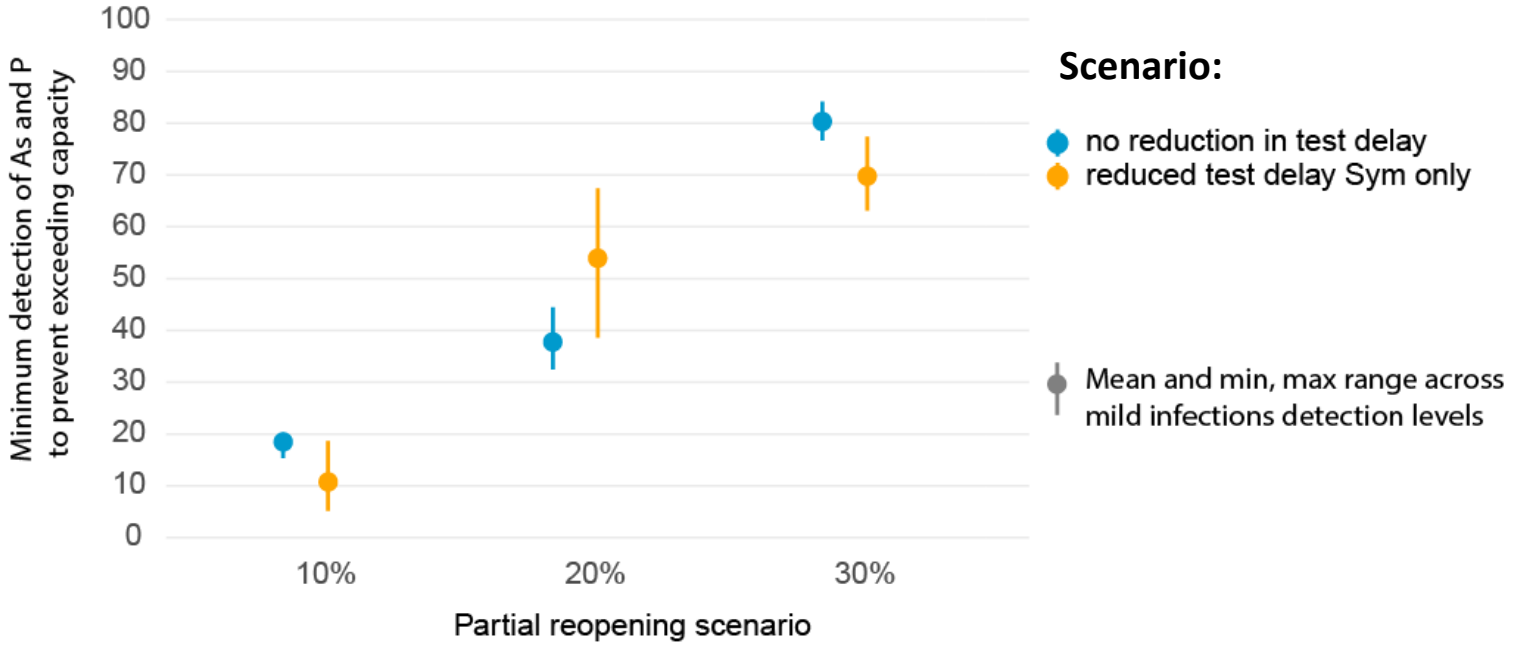
Scenario:
20% reopening shortening test delays to 2 days for all infections



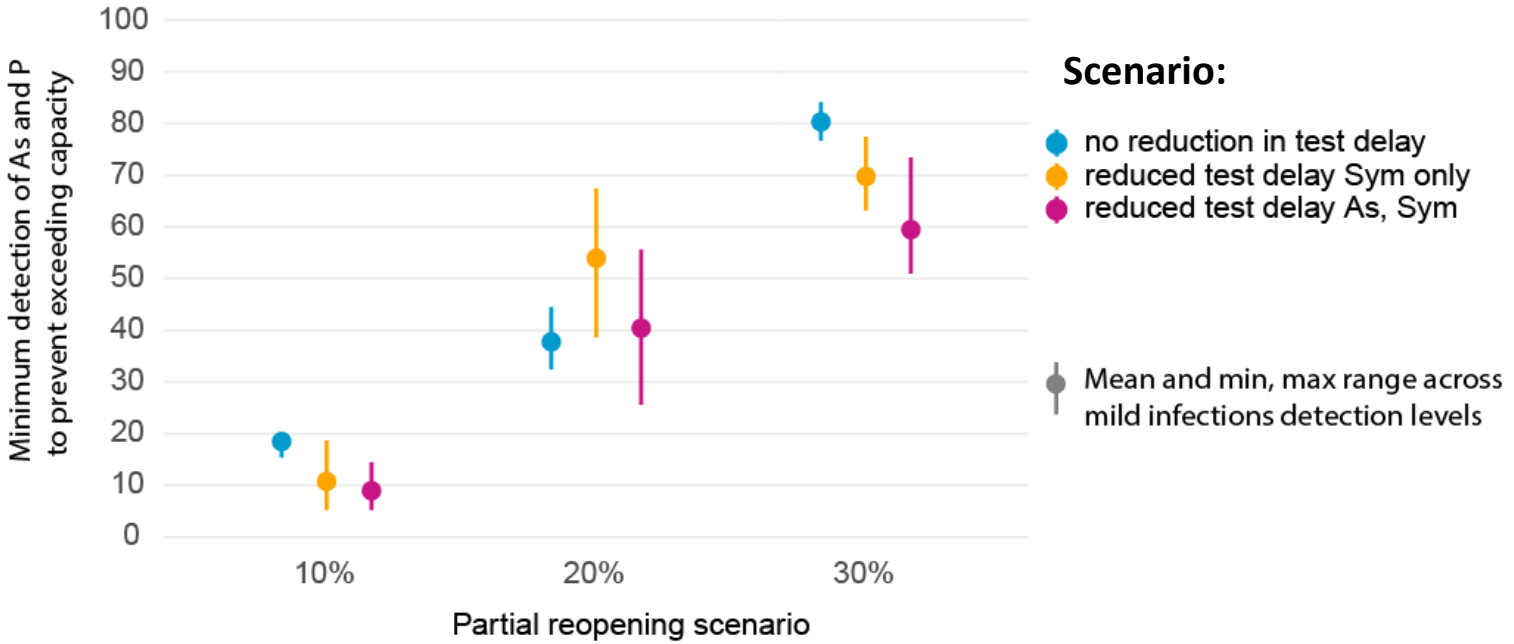
The higher the increase in contacts due to reopening, the higher the detection thresholds for contact tracing, **and unrealistically high detection rates** would need to be achieved



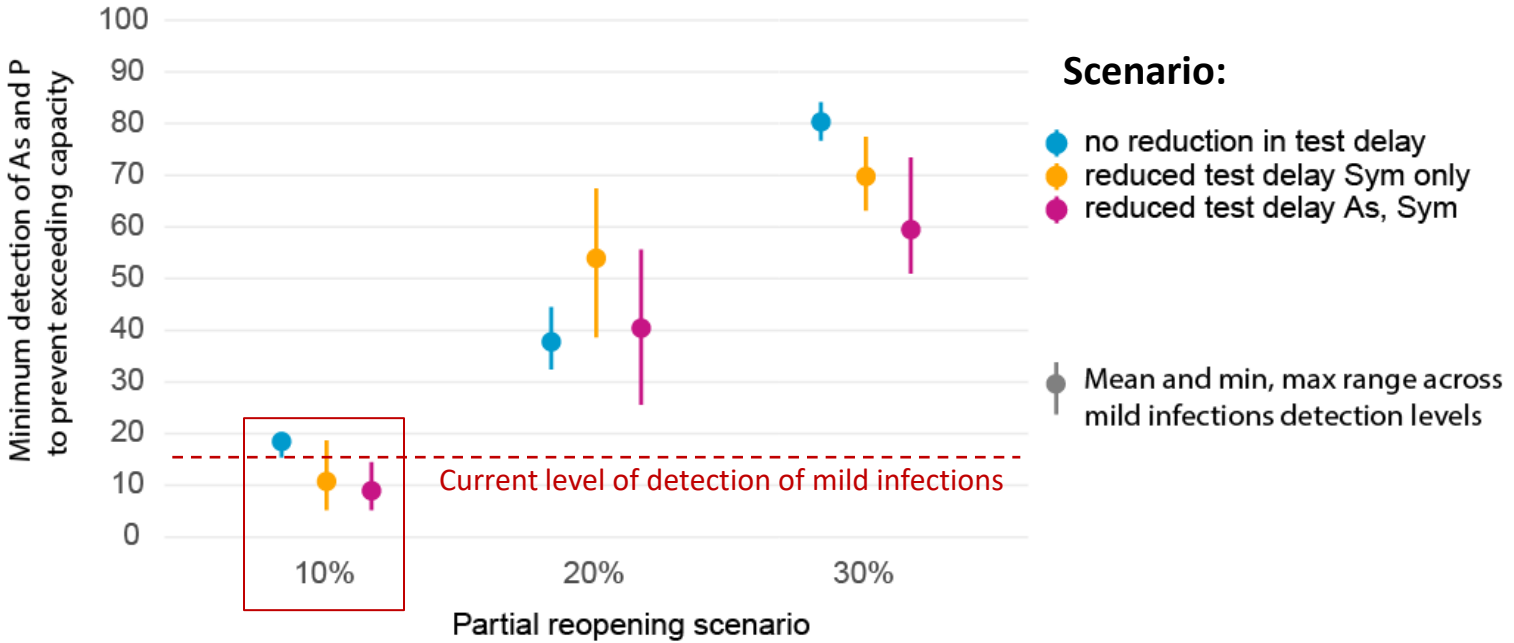
The detection of mild infections is more relevant at lower total case numbers (lower reopening) and when mild infections are detected faster



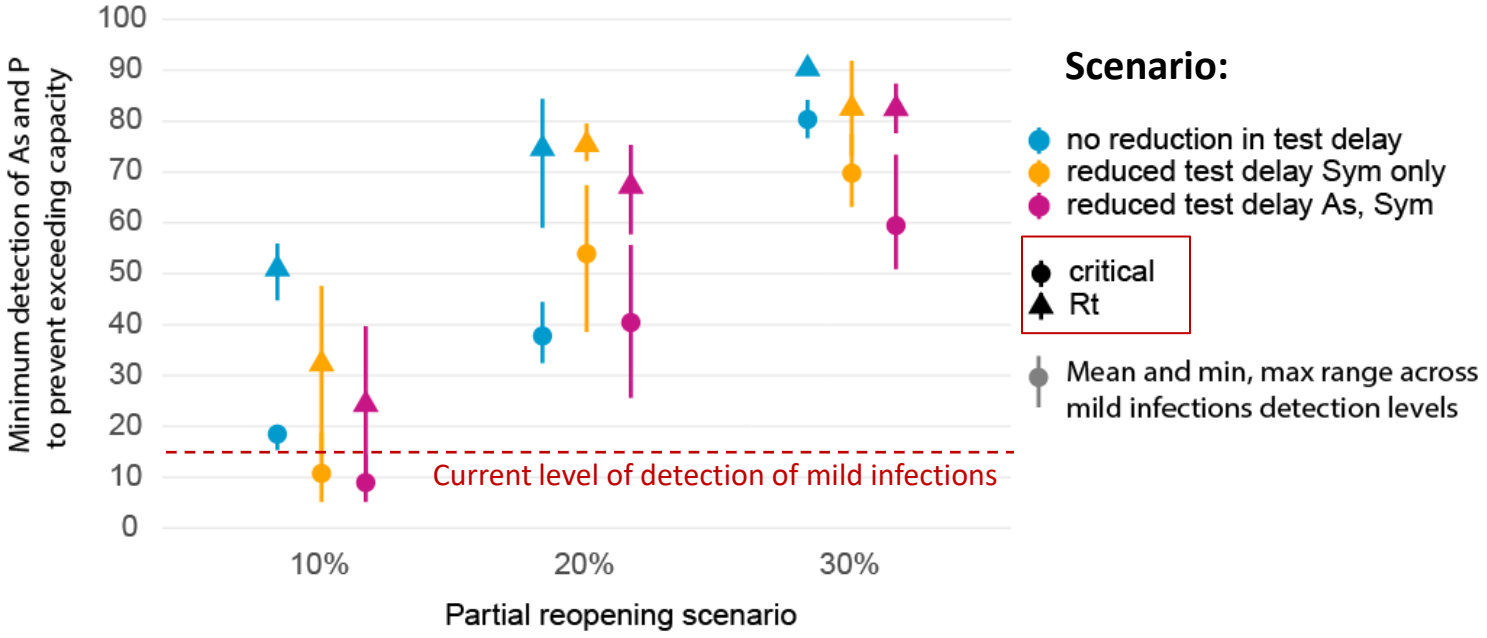
Reducing test delay in asymptomatic infections is not as important as reducing test delay in mild infections



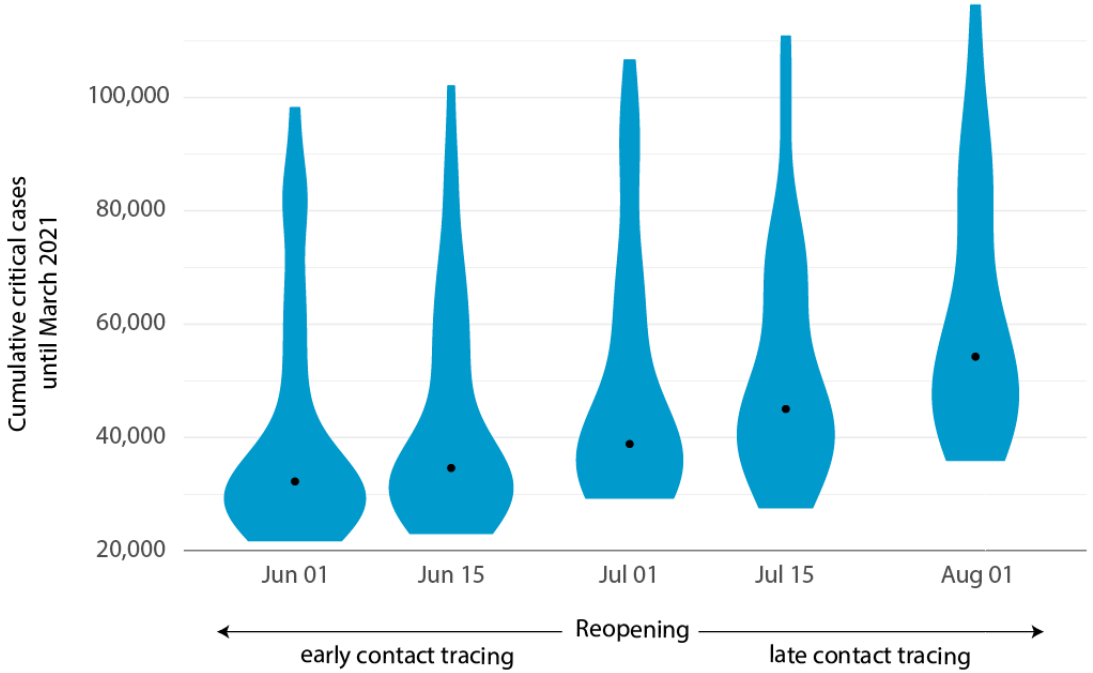
Considering current detection levels of mild infections, only when backsliding does not exceed 10% and with improved detection and isolation times would predicted ICU beds stay below capacity levels



The thresholds change depending on the indicator used and to keep the reproductive number below one **(prevent second wave), higher thresholds would be needed.**



The earlier contact tracing starts the more critical cases can be averted, **later** start date would not be able to prevent an **over proportional increase in critical cases**



Scenario:
10% immediate backsliding keeping baseline test delays and vary start date of contact tracing

*Simulation iteration without adjusted fraction critical and cumulative estimates are overestimated

Preliminary conclusions

- Performance requirements for CT vary across EMS regions and are lowest in the Southern and highest in the Northeastern regions.
- Minimum performance requirements for CT exceed feasibility if the transmission increases by more than 10% of the initial levels in March.
- Shorter test turnaround time for index cases substantially reduces detection and isolation thresholds and might be especially crucial before case counts rise and exceed testing capacities.
- Early contact tracing soon after reopening is crucial to prevent increase in critical cases