May 18th, 3:30 PM - 4:00 PM

Optimal Allocation of Limited Testing Resources for Controlling Epidemic Outbreaks

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Inadequate testing capacity during the initial COVID-19 outbreak and the recent omicron surge exacerbated the worldwide struggle to limit disease spread. Faced with supply shortfalls, public health agencies initially advised to prioritize testing resources to the most severe symptomatic cases typically found in clinical settings, rather than to the mild or asymptomatic cases typically targeted by contact tracing and population monitoring programs. To evaluate the suitability of this advice, we construct a compartmental COVID-19 model with testing and quarantine control which flexibly accounts for resource-rich and resource-limited testing supply scenarios. Using this model, we calculate optimal policies for reducing disease spread by optimizing the allocation of resources between clinical and non-clinical testing strategies. We show that there exist threshold testing capacities, below which time-independent optimal polices call for clinical-only testing strategies and above which time-independent optimal policies are mixed, thus validating the advice of public health agencies. Threshold values depend on the degree to which non-clinical testing can be focused on infected individuals, e.g., through contact tracing, but are independent of the overall level of population accessibility. Time-dependent optimal strategies are shown to focus resources towards clinical testing during periods of peak infection and non-clinical testing during periods of low infection. Time-dependent protocols can simultaneously reduce peak height, reduce epidemic size, and delay peak time to a greater degree than any time-independent protocol.