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Pandemic Modeling: Lessons from COVID-19 and Seasonal Influenza forecasting

Avian influenza has the potential to cause a global pandemic once a mutation leads to human-to-human transmission. In such a pandemic scenario, model forecasting will be heavily relied on to inform public health interventions. Many of the models used for the COVID-19 pandemic can be expected to be heavily leveraged. The assessment of the National Science Foundation of the overall performance of COVID-19 mathematical models during the COVID-19 pandemic is "insufficient" and "far less useful than possible" in aiding the development of measures to mitigate ongoing pandemics (NSF-IHBEM). Mathematically, some fundamental questions remain: are there mathematical reasons for the collective under-performance of COVID-19 models? Are there mathematical benchmarks that can be used to evaluate model performance or quantify improvements in model performance when applied to real-world epidemics or a pandemic?

In this talk, I will demonstrate three key reasons that impact the performance of mathematical models for real-world epidemics: (1) mismatches of model outputs with data; (2) nonidentifiability of model parameters in model fitting to data; and (3) the final-size formula that dictates that models will over-project the epidemic size. Collectively, I call these three challenges the "final-size trap." To break the trap, new and improved models should be able to produce a good fitting between model output and the correct data and produce an epidemic size that can be validated by seroprevalence data. I will present some modeling experiences during COVID-19 and for seasonal influenza forecasting to show that non-autonomous models offer a dependable solution for the final-size trap.