The Paradox of Neglecting Changes in Behavior

A two-minute version

1 Motivation

In epidemics, as perceived risk rises, people reduce contacts. Standard SEIRD models usually do not represent this feedback. They assume fixed transmission, and we then use the fitted model to estimate quantities such as the basic reproduction number, $\mathcal{R}_0$, and the final epidemic size, A.

2 Models

The models are deliberately simple. Both use the same SEIRD equations. The only difference is the transmission rate.

In the baseline model, transmission is constant, $\beta(t) = \beta_0$.

In the behavioral mixed model, transmission decreases with mortality:

$$\beta(t) = \frac{\beta_0 e^{-\zeta\delta I(t)}}{1 + \zeta\delta I(t)}.$$

Here, $\delta I(t)$ is the instantaneous mortality rate, and ζ controls the strength of behavioral feedback. Larger ζ means a stronger reduction in transmission as mortality rises. When $\zeta = 0$, the behavioral model reduces exactly to the baseline model.

The poster shows the mixed behavioral model, in the paper we also tested exponential and rational forms.

3 Synthetic validation

For synthetic validation, we generated mortality data from the behavioral mixed model with known parameters and increasing feedback strength ζ. We then fitted both the baseline and behavioral models using ABC–SMC, Approximate Bayesian Computation with Sequential Monte Carlo.

Because the data-generating parameters are known, bias is directly observable.

We observe that as behavioral feedback becomes stronger, the baseline model fits the mortality data worse.

It underestimates $\mathcal{R}_0$ and overestimates the final epidemic size A.

With behavioral model we can recover the parameter values, the mortality trajectory and the two estimands accurately.

4 Empirical evidence

We then fitted both models to first-wave COVID-19 mortality data across 30 U.S. locations.

We observe a similar pattern in the real data. The behavioral mixed model usually fits better, estimates larger $\mathcal{R}_0$, and predicts smaller final epidemic size A.

Using ABC–SMC model selection with equal model priors, we estimated posterior probabilities over the two models: baseline versus behavioral. This is not just a comparison of best-fit curves. The algorithm samples jointly over model identity and parameters, so the behavioral model is favored only when its extra feedback mechanism is supported by the data.

The Bayes factors favored the behavioral model in 28 out of 30 locations.

5 Takeaway

When transmission falls because people reduce contacts, a standard SEIRD model explains the downturn by susceptible depletion, pushing $\mathcal{R}_0$ too low and final epidemic size A too high.

This is the paradox mentioned in the title, ignoring behavior makes the pathogen look less transmissible, but the epidemic look larger.