

2021 DMDU Webinar Series

Nov 29th, 2021

Reopening Under Uncertainty ***Stress-Testing COVID-19 Reopening Policies*** Pedro Nascimento de Lima

Presented at the DMDU Webinar:
“Informing COVID-19 Policy Under Uncertainty”

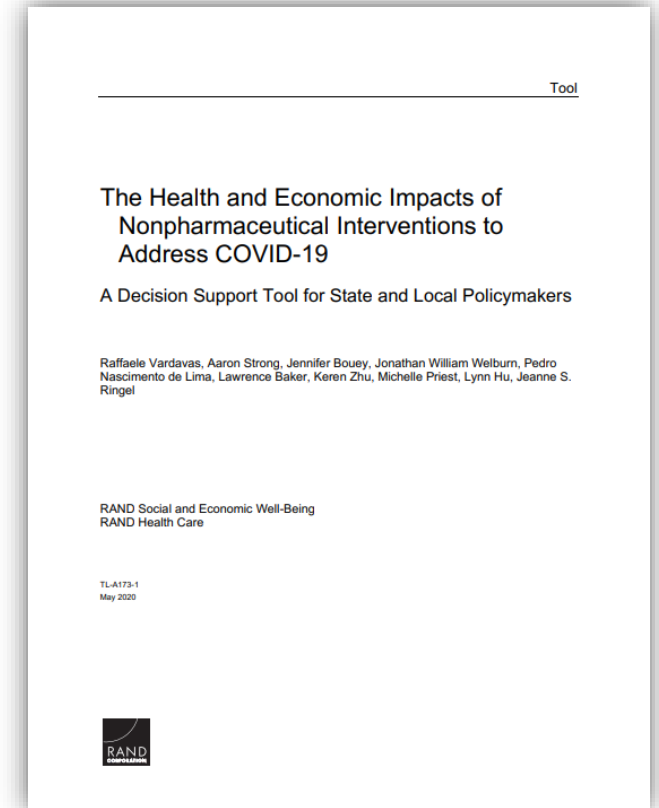
In this talk

Key findings from recent papers:

1. Nascimento de Lima, et al. 2021. "Reopening California: Seeking Robust, Non-Dominated COVID-19 Exit Strategies.". *PLOS ONE* 16 (10): e0259166.
<https://doi.org/10.1371/journal.pone.0259166>
2. Nascimento de Lima, Pedro, et al. 2021. "Reopening Under Uncertainty: Stress-Testing California's COVID-19 Exit Strategy." Santa Monica, CA.
<https://doi.org/10.7249/PEA1080-1>
3. Nowak, Sarah A, Pedro Nascimento de Lima, and Raffaele Vardavas. 2021. "Should We Mitigate or Suppress the Next Pandemic? Time-Horizons and Costs Shape Optimal Social Distancing Strategies." *MedRxiv*.
<https://doi.org/10.1101/2021.11.14.21266322>

Prior Work:

The Health and Economic Impacts of Nonpharmaceutical Interventions to Address COVID-19



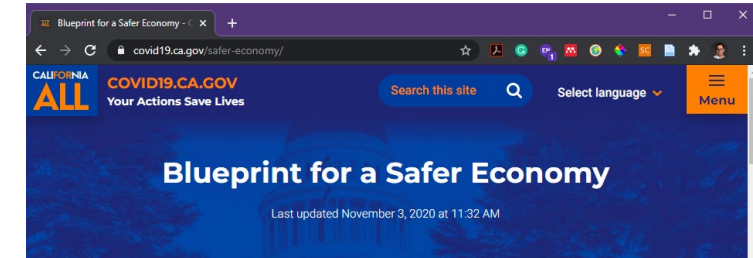
<https://www.rand.org/pubs/tools/TLA173-1.html>

Motivation and Policy Question:

How to manage NPIs in 2021 amidst uncertainty?

- A. Reopening thresholds were defined at the county level in California.
- B. California's Blueprint for a Safer Economy plan was highly detailed and contained restrictions on capacity and detailed regulations on *how to reopen*
- C. Three types of decisions are involved in any reopening plan:
 - A. How **stringent** should the plan be?
 - B. What restrictions should apply **to each level**?
 - C. How (A) and (B) should be managed **over time** *contingent on other conditions*?
- D. Key policy questions:
 - A. Are we following a **robust** exit strategy?
 - B. Is our strategy **pareto-efficient**?

<https://covid19.ca.gov/safer-economy/>



County risk level	Adjusted case rate* 7-day average of daily COVID-19 cases per 100K with 7-day lag, adjusted for number of tests performed	Positivity rate** 7-day average of all COVID-19 tests performed that are positive	
		Entire county	Healthy equity quartile
WIDESPREAD Many non-essential indoor business operations are closed	More than 7.0 Daily new cases (per 100k)	More than 8.0% Positive tests	
SUBSTANTIAL Some non-essential indoor business operations are closed	4.0 – 7.0 Daily new cases (per 100k)	5.0 – 8.0% Positive tests	5.3 – 8.0% Positive tests
MODERATE Some indoor business operations are open with modifications	1.0 – 3.9 Daily new cases (per 100k)	2.0 – 4.9% Positive tests	2.2 – 5.2% Positive tests
MINIMAL Most indoor business operations are open with modifications	Less than 1.0 Daily new cases (per 100k)	Less than 2.0% Positive tests	Less than 2.2% Positive tests

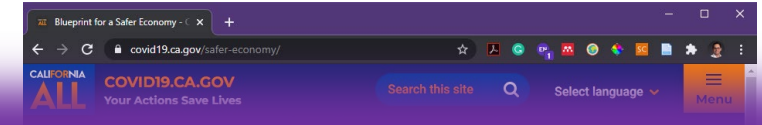
*Small counties (those with a population less than 106,000) may be subject to alternate case assessment measures for purposes of tier assignment.

**Health equity metric is not applied for small counties. The health equity metric is used to move to a less restrictive tier.

Motivation and Policy Question:

How to manage NPIs in 2021 amidst uncertainty?

- A. Reopening thresholds were defined at the county level in California.



What is our **long-term strategy**?

Are **there any dominated strategies**?

Can we find **robust strategies** given the problem structure

(**as opposed to good predictions** given assumptions)?

<https://covid19.ca.gov/safer-economy/>

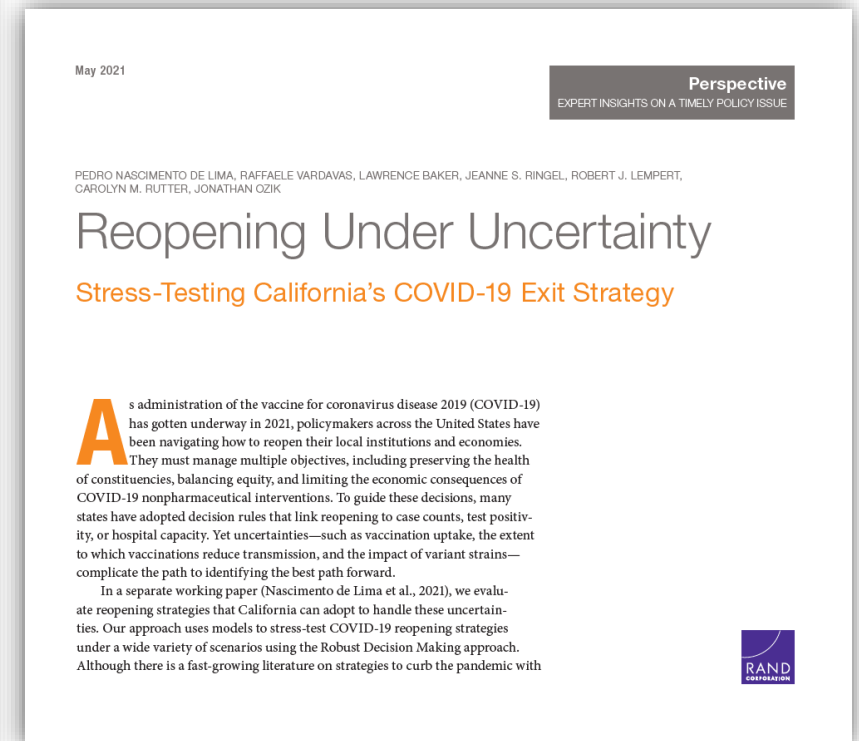
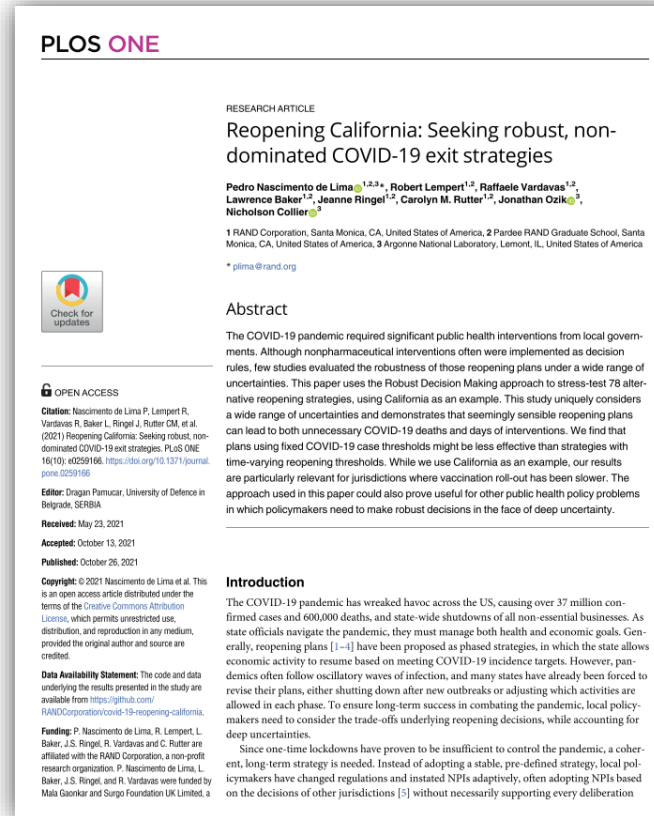
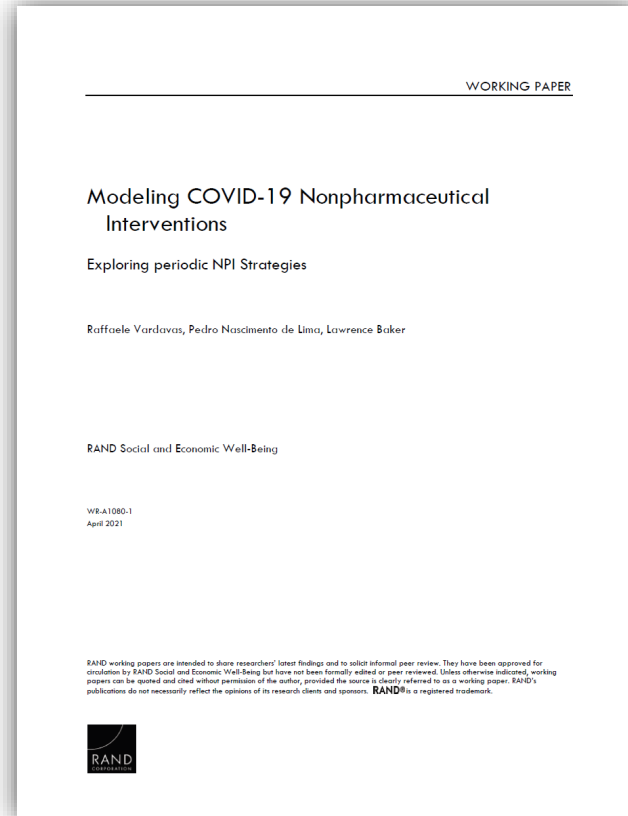
A partial view of a table from the COVID19.CA.GOV website. The table has four columns. The first column contains the text 'Most indoor business operations are open with modifications'. The other three columns are empty.

*Small counties (those with a population less than 106,000) may be subject to alternate case assessment measures for purposes of tier assignment.

**Health equity metric is not applied for small counties. The health equity metric is used to move to a less restrictive tier.

Policy Question

How California and other jurisdictions should approach reopening in the wake of vaccination?



https://www.rand.org/pubs/working_papers/WRA1080-1.html

<https://journals.plos.org/plosone/article?id=10.1371/journal.pone.0259166>

<https://www.rand.org/pubs/perspectives/PEA1080-1.html>

slides & references: bit.ly/covid19dmd

Approach

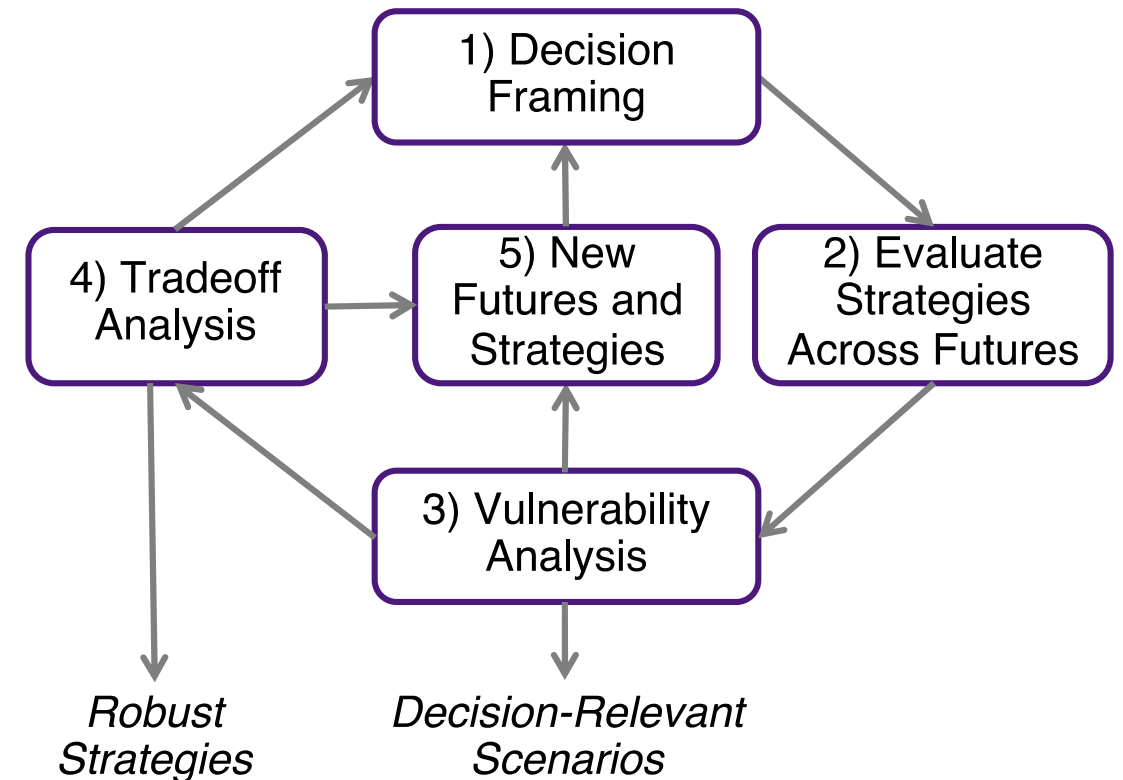
Stress-testing reopening strategies with the Robust Decision Making (RDM) approach

1. RDM provides an **iterative framework** for evaluating policies while accounting for *deep uncertainty*
2. Uses *models* to **stress-test policies across wide range of futures**, reflecting uncertainties
3. Quantitative **vulnerability analysis** identifies the **assumptions that lead policies to be successful and unsuccessful**, and informs development of *adaptive strategies*
4. Tradeoff analysis helps balance across **multiple objectives** and identify *robust strategies*
5. RDM Is part of a family of **Decision making Under Deep Uncertainty (DMDU)** methods.

More information on RDM:

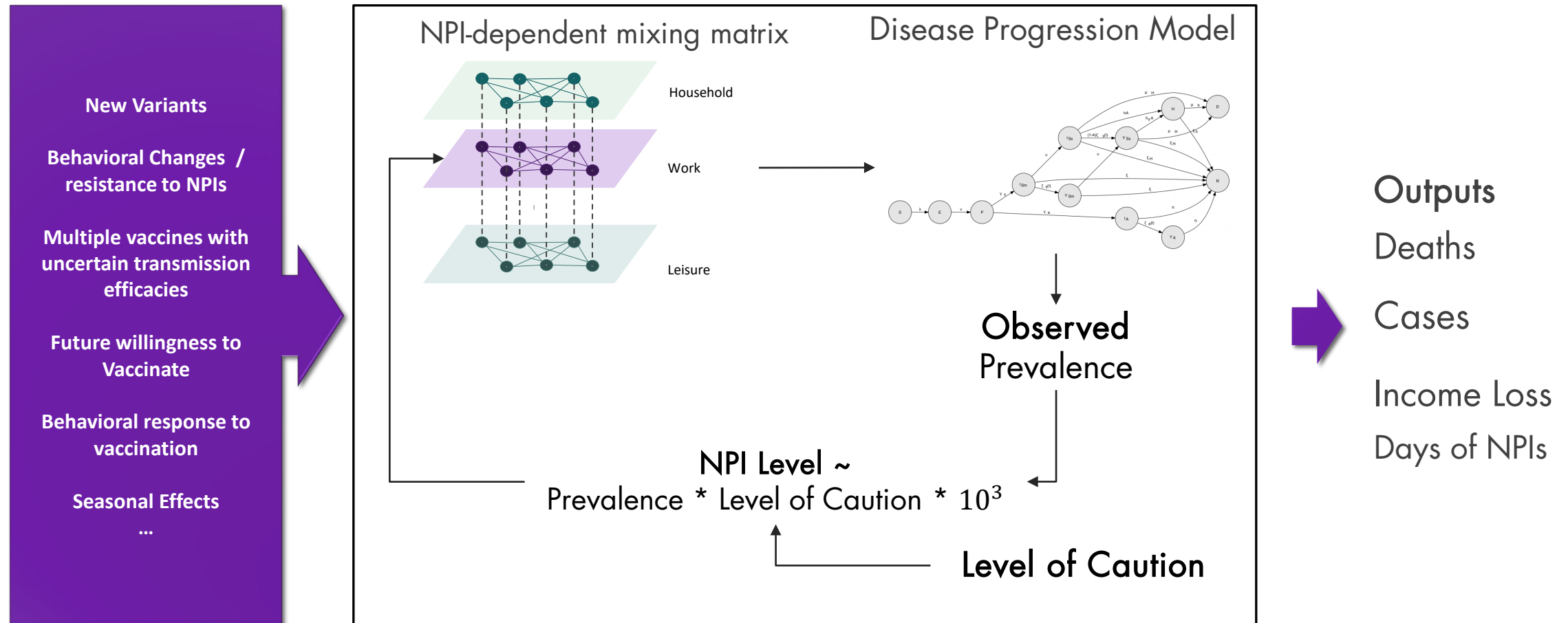
<https://www.rand.org/methods/rdmlab.html>

Robust Decision Making (RDM)

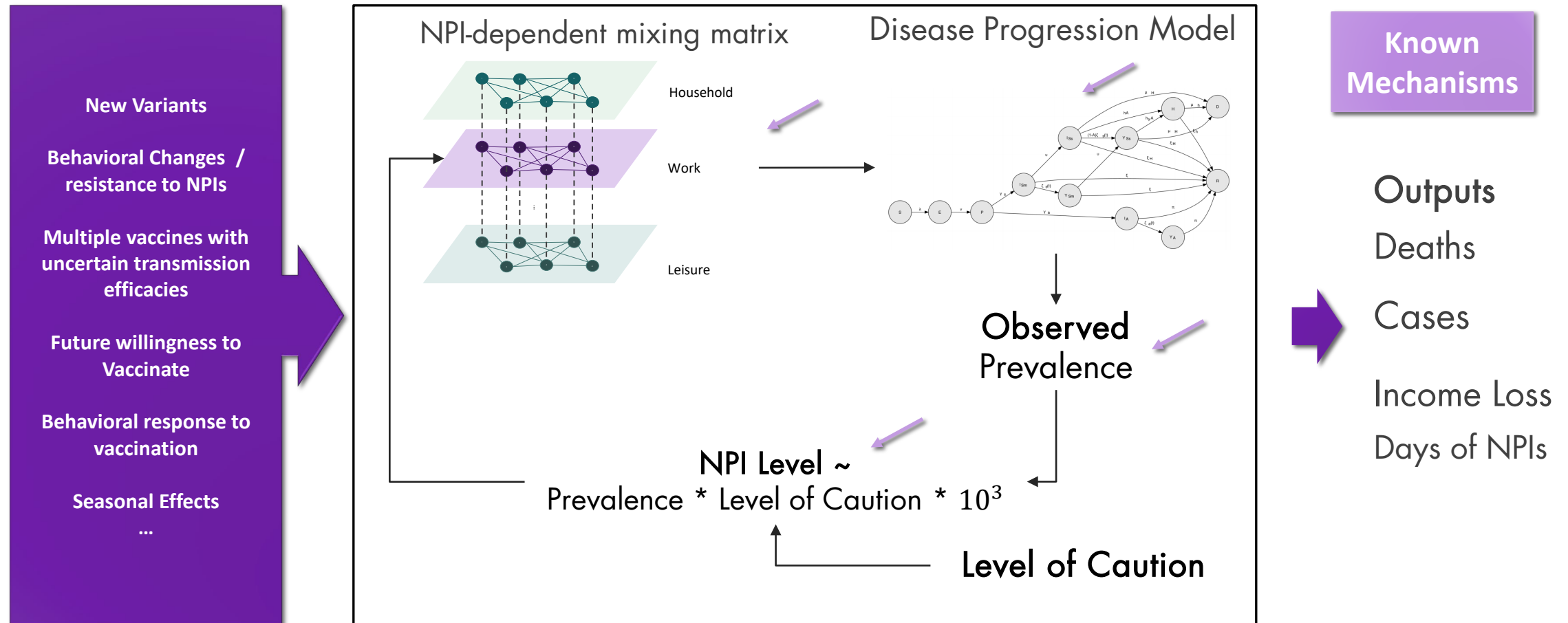


Decision Framing:

Stress-testing a pandemic “control loop”

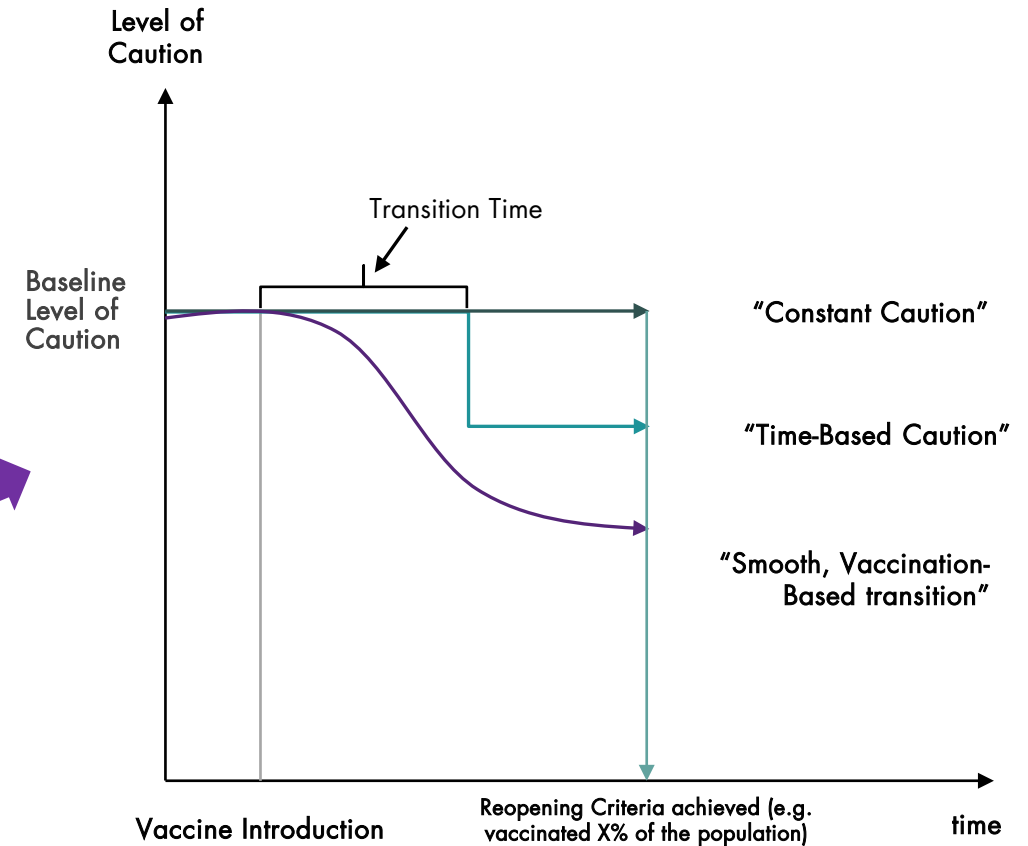
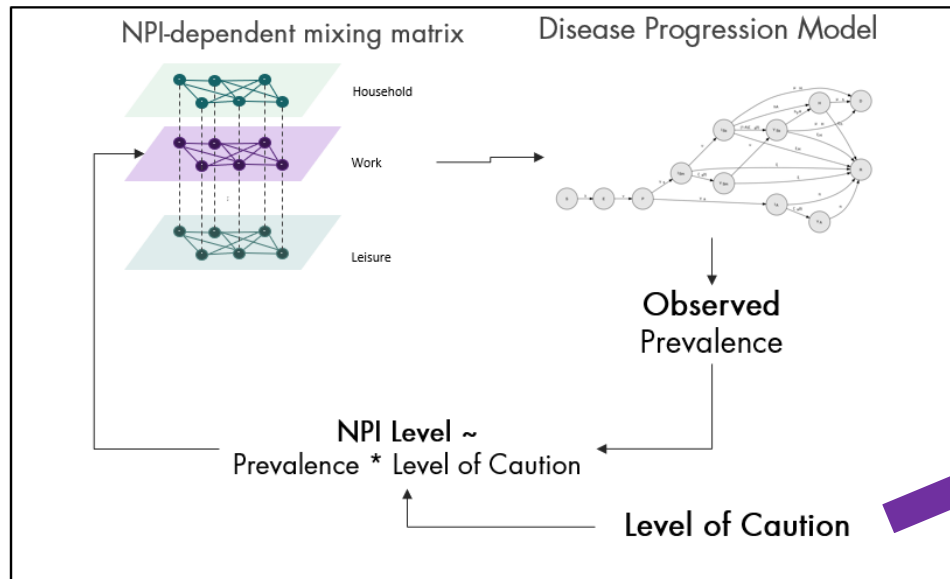


Mechanistic models are still useful for computational experimentation (even when prediction is out of reach)



Decision Framing:

Policy question: How to manage this level of caution over time?



XLRM framework helps by framing the decision under uncertainty problem

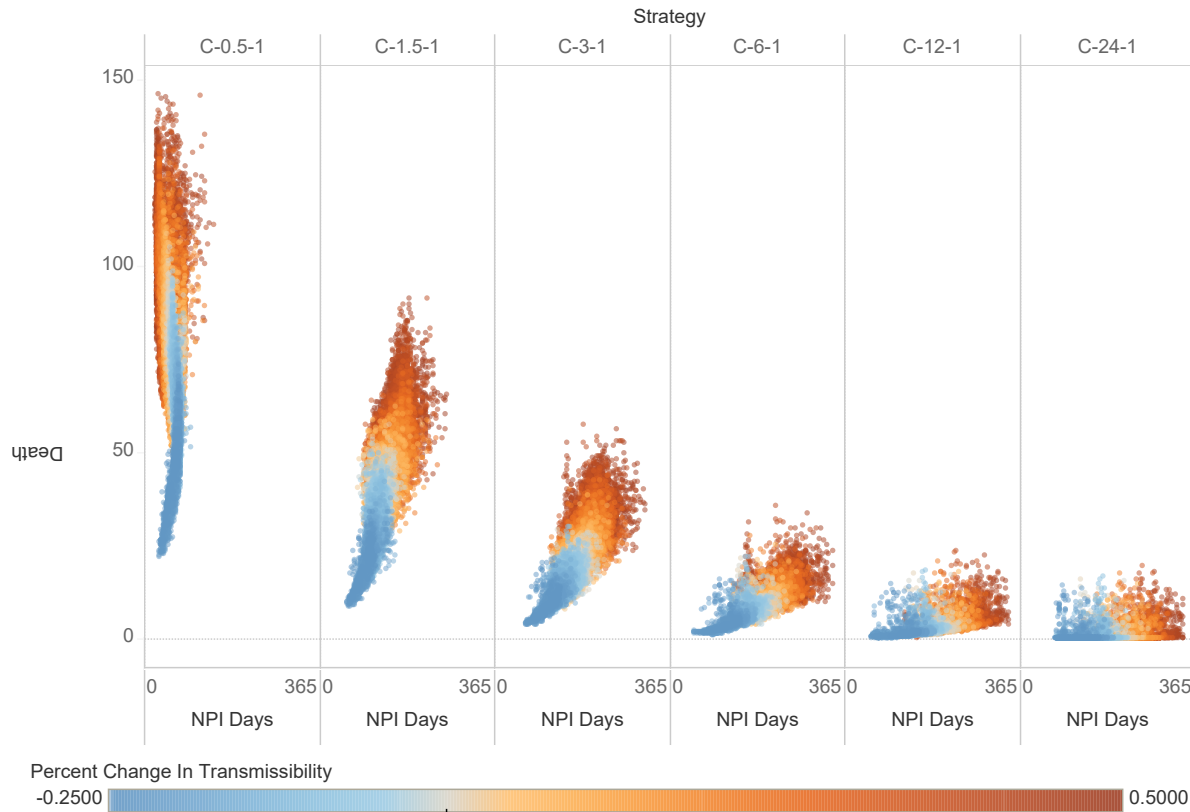
Failing to consider some of those elements can lead to incomplete or misleading advice:

1. **Not enough levers** -> Results in a **menu of potentially dominated options**.
2. **Not enough uncertainties** -> Plans can be **fragile** and break.
3. **Ignore important outcomes** -> Can result in **dominated policies (likely ignores precarious values)**

X - Uncertainties	L - Policy levers
<ul style="list-style-type: none">• Vaccine efficacy to prevent transmission• Loss of immunity• Behavioral response to vaccination• Willingness to vaccinate• Changes in transmissibility (i.e., induced by variant strains)• Actual vaccination Rate	<ul style="list-style-type: none">• Baseline level of caution x_b• NPI strategy $s \in \{C, T, V\}$• Time-based strategies $s = T$<ul style="list-style-type: none">– Level of caution factor α– Transition date T_α• Vaccination-based strategies $s = V$<ul style="list-style-type: none">– Vaccination reference point V_{mid}– Relaxation rate k_c
R - Relationships (models)	M - Metrics
Meta-population deterministic ODE [10, 33]	75 th Regret percentile of deaths / 100 k people, years of life lost, cases, income loss, and days under NPIs
Computable general equilibrium model [36]	

Reopening policies matter: They determine how we confront uncertainties

A - fixed-threshold strategies



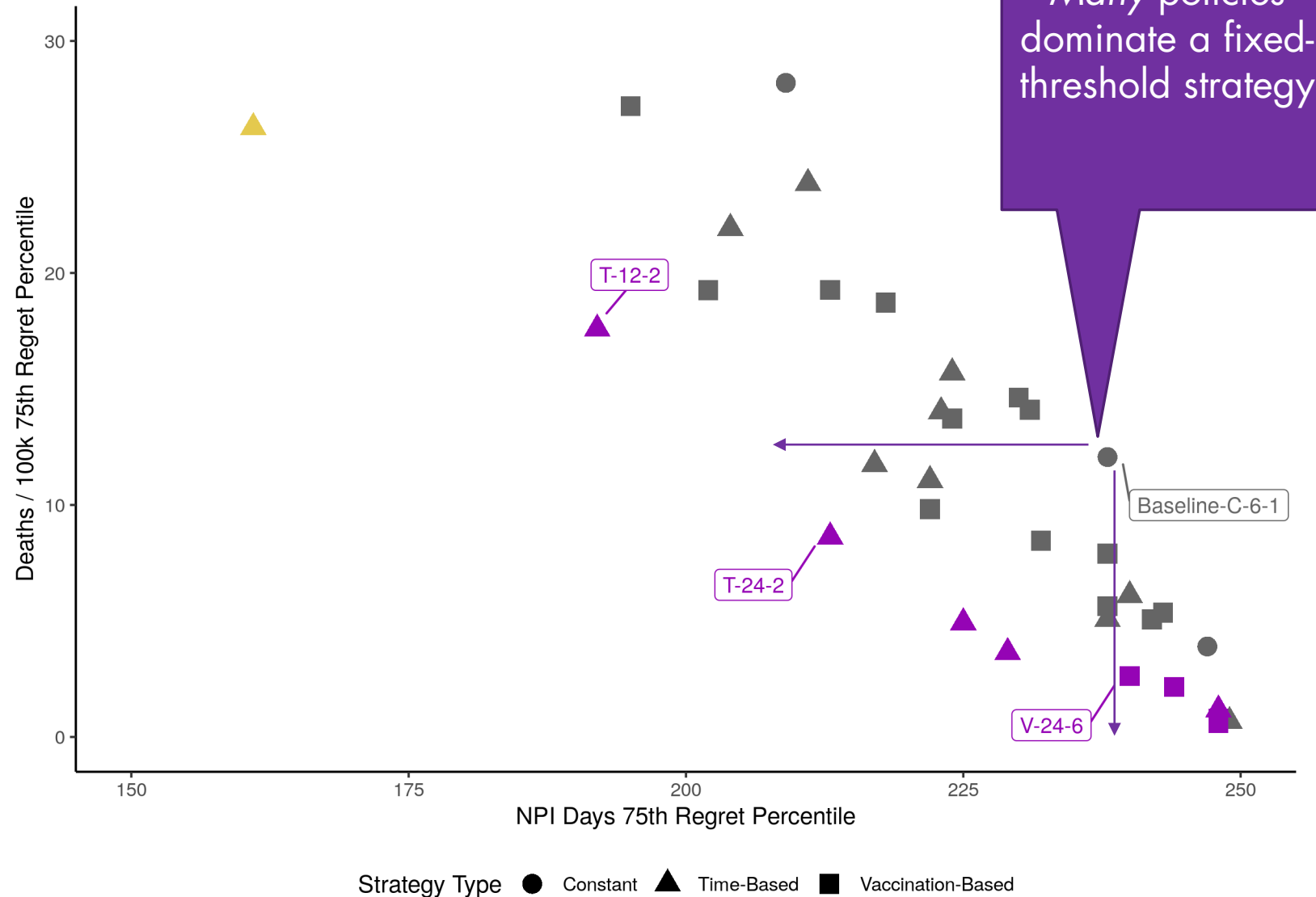
Yes, the future is uncertain, but we have agency over where we land in this outcome space

In more challenging futures, we can choose more stringent policies and avoid COVID-19 deaths, and that requires more days under NPIS.

California's original policy was close to C-6-1, if left unchanged.

Vaccination-Based or Time-based policies dominate constant-threshold strategies

- I. Constant-caution strategies were always dominated.
- II. The best strategies combined a high initial level of caution with an adaptive component – either time or vaccination-based strategies worked
- III. The only constant-caution policy in the pareto-front is the most-stringent, and the current policy was dominated.
- IV. We stop the model in Feb 2022. If we ran the model for more time, these differences could increase.



Vaccination-Based or Time-based policies dominate constant-threshold strategies

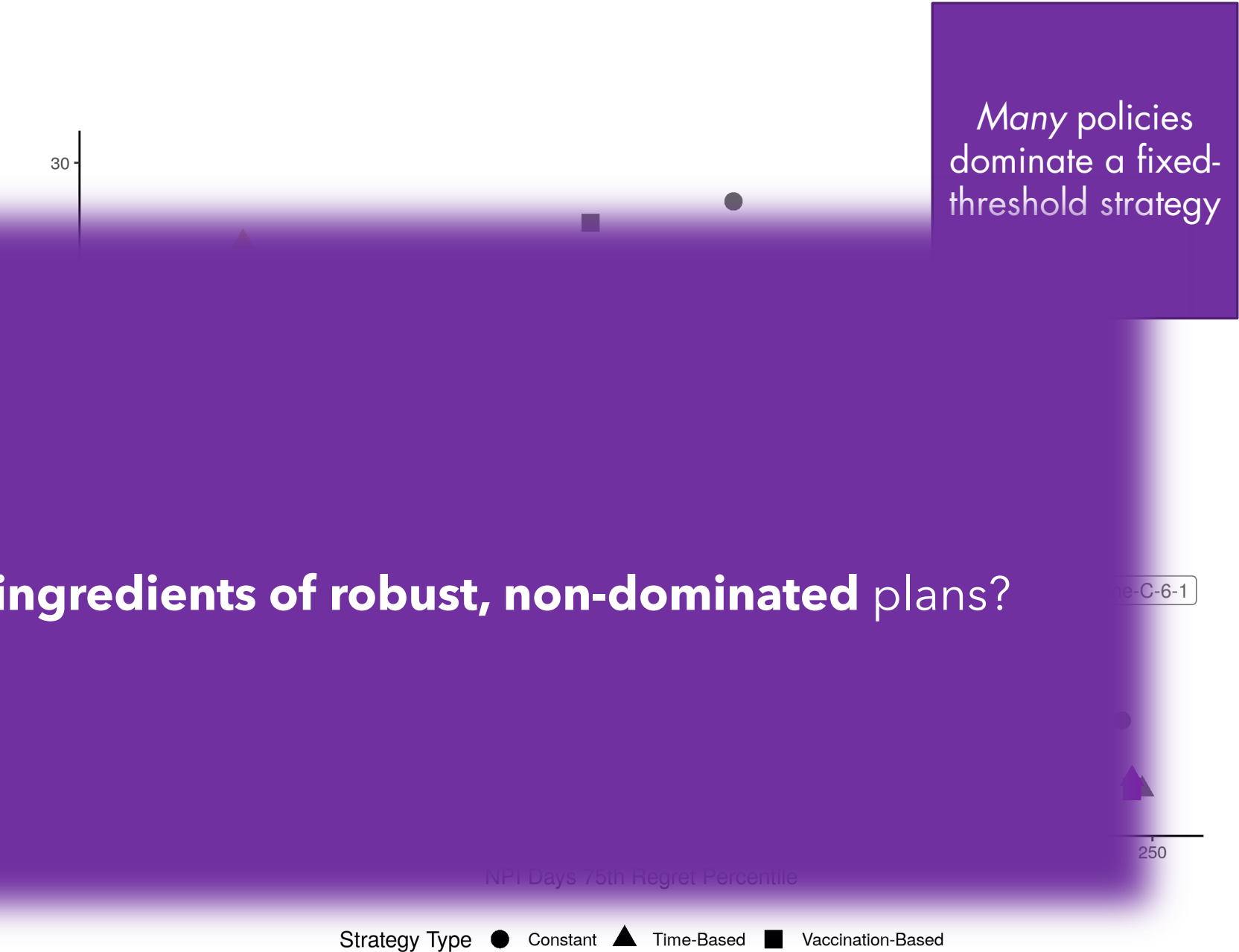
I. Constant strategies dominate

II. The best initial policy is computer based

III. The optimal policy is pareto current

IV. We stop the model in Feb 2022. If we ran the model for more time, these differences could increase.

What **were the ingredients of robust, non-dominated** plans?



Back to the Policy Question:

Characteristics of Robust, Non-Dominated Strategies

1. **Encourage Inexpensive Adaptation Measures:** Every increase in transmissibility that could be avoided with inexpensive measures makes society systematic worse off.
2. **Begin Cautiously:** Only the initially cautious strategies were robust.
3. **Adapt as People are Vaccinated:** Strategies that did not adapt reopening thresholds based on vaccination were systematically dominated.
4. **Avoid abrupt changes:** Strategies that abruptly relaxed all interventions invited resurgences and were dominated.

All these characteristics are necessary in robust, non-dominated plans.

Should we Mitigate or Suppress the Next Pandemic?

In a new paper, we set out to “solve” the social distancing dilemma as a boundary value problem:



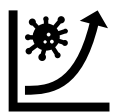
Hyper-rational society: Everyone has an SIR model in their heads and behaves rationally.



Society minimizes the “pandemic cost” = Cost of Infection + Cost of NPIs.



Fixed Time-Horizon: We know when the pandemic will “end” and strategize accordingly.



Standard SIR dynamics: SIR dynamics constrain the problem. Sterilizing immunity lasts during the decision-making time-frame.

Should we Mitigate or Suppress the Next Pandemic?

In a new paper, we set out to “solve” the social distancing problem under a set of structural assumptions:

Which strategies **emerge from the problem** under those structural assumptions?

Are they like those **stress-tested for COVID-19**?

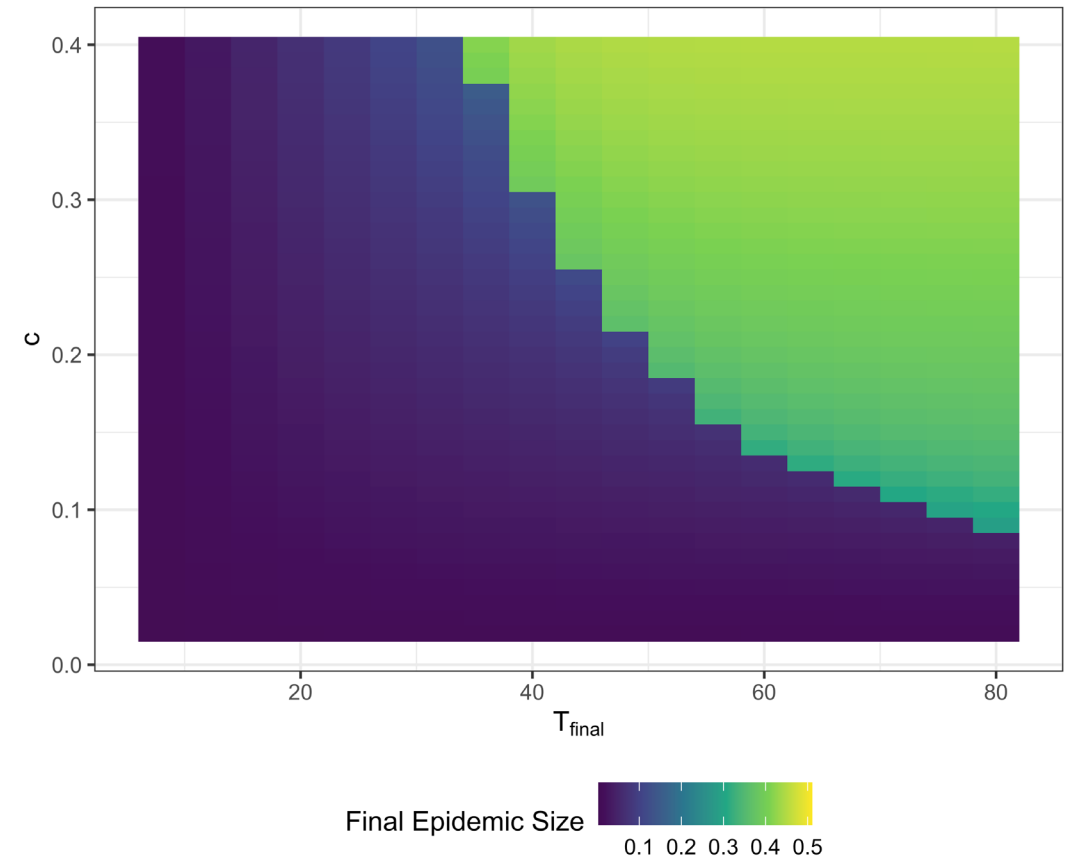
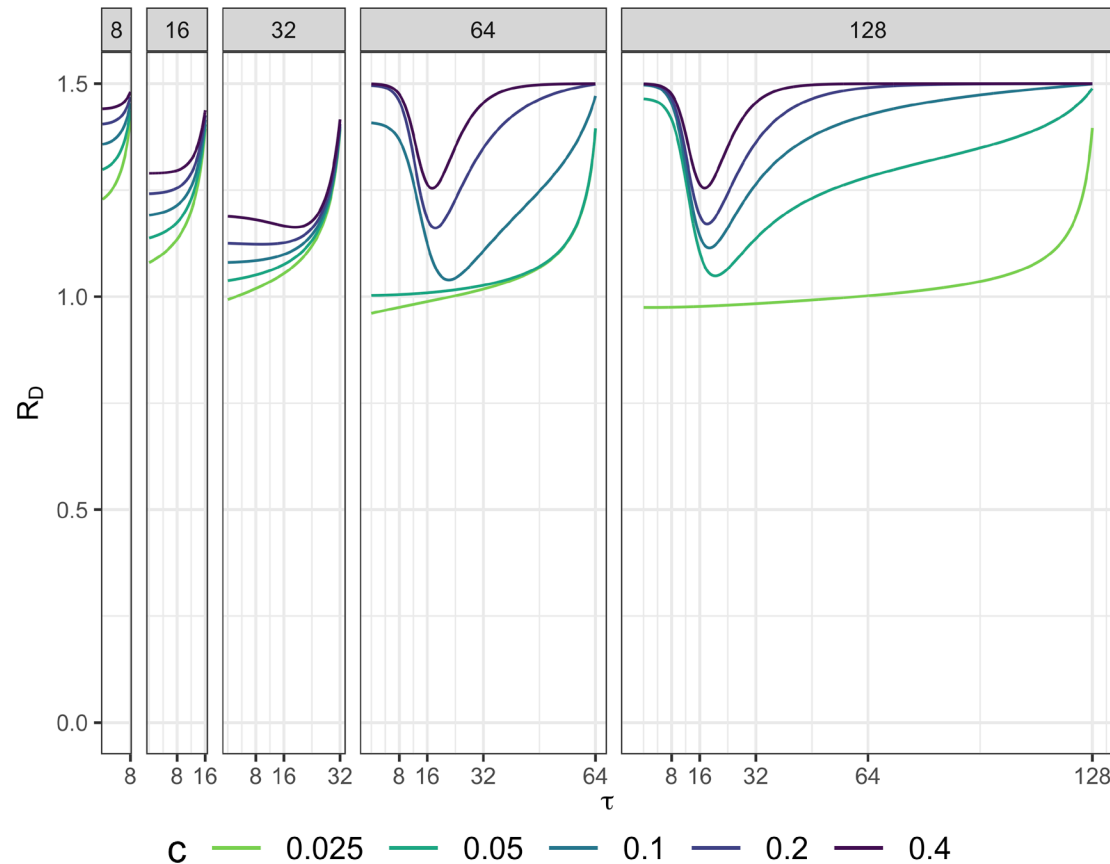
Under which conditions do we sustain a strict suppression strategy?



Standard SIR dynamics: SIR dynamics constrain the problem. Sterilizing immunity lasts during the decision-making time-frame.

Should we Mitigate or Suppress the Next Pandemic?

Time-Horizons and (relative) costs shape optimal distancing strategies



Conclusions

- A. We used models to stress-test policies over long time ranges – focus was not to predict but to understand the benefits of long-term strategies.
- B. Simple models can also be used to understand the fundamental structure of the problem.
- C. These approaches complement approaches used for the short-term, but are better used preemptively.

Thanks!

And thanks to the awesome people who contributed to this work



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