



Safe Blues

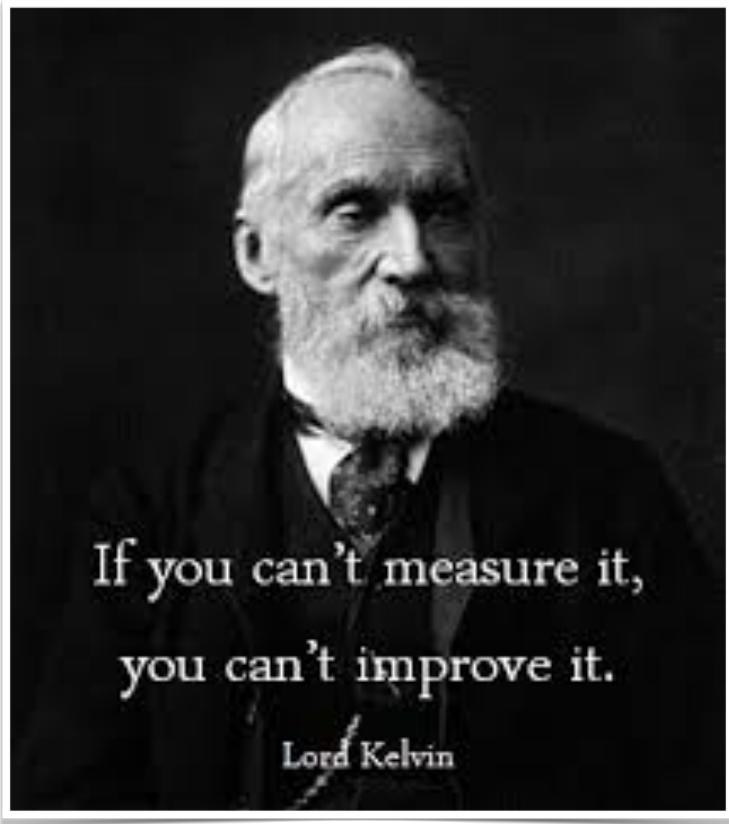
A Method for Estimation and Control in the Fight Against COVID-19

Yoni Nazarathy, The University of Queensland

Joint work with Raj Dandekar (MIT), Shane Henderson (Cornell), Marijn Jansen (UQ), Sarat Moka (UQ), Chris Rackauckas (MIT), Peter Taylor (Melbourne), and Aapeli Vuorinen (UQ, Melbourne)

Visit: safeblues.org

Presented at The University of Queensland, Online Pandemic Seminar, May 4, 2020

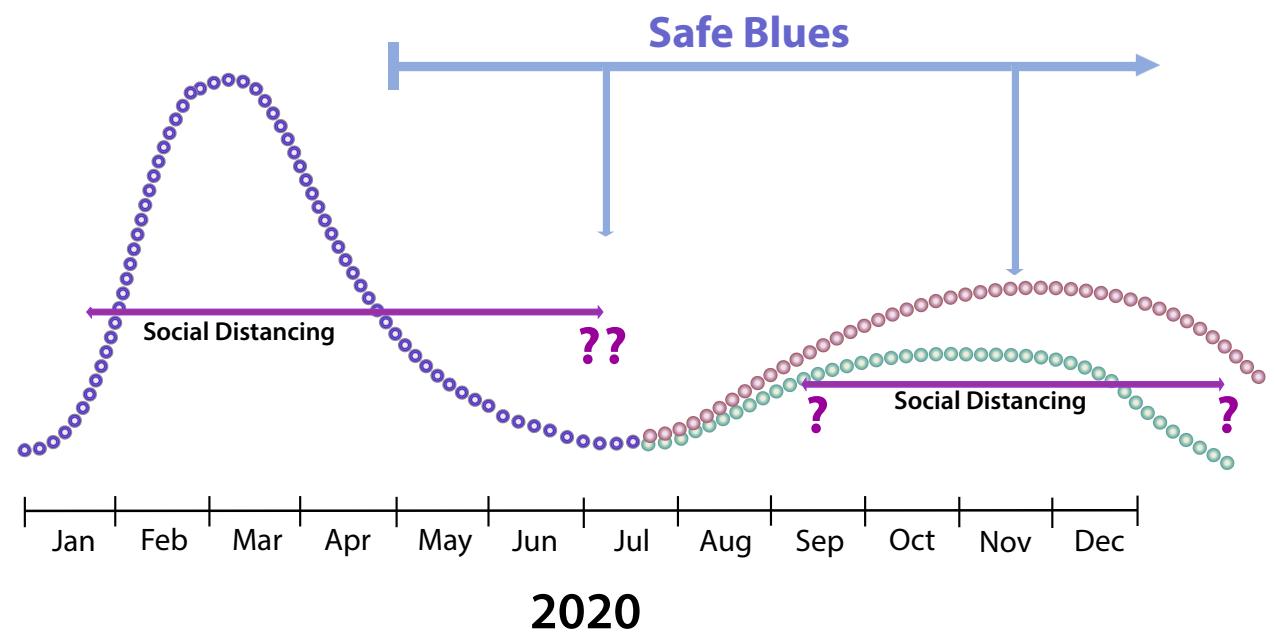
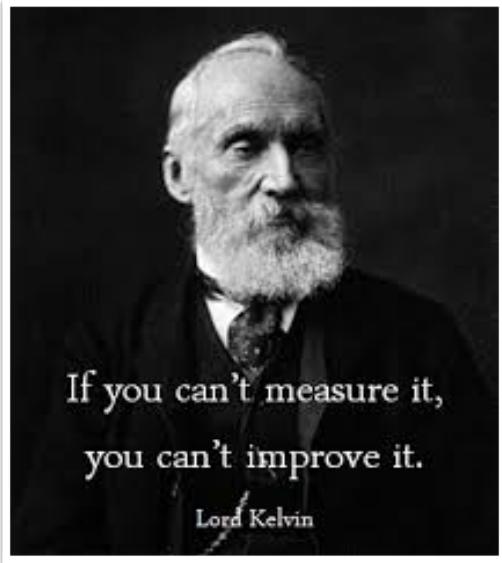


If you can't measure it,
you can't improve it.

Lord Kelvin



Leaders around the world are grappling with decisions around how and when to reopen their economies.



What affects the basic reproduction number?

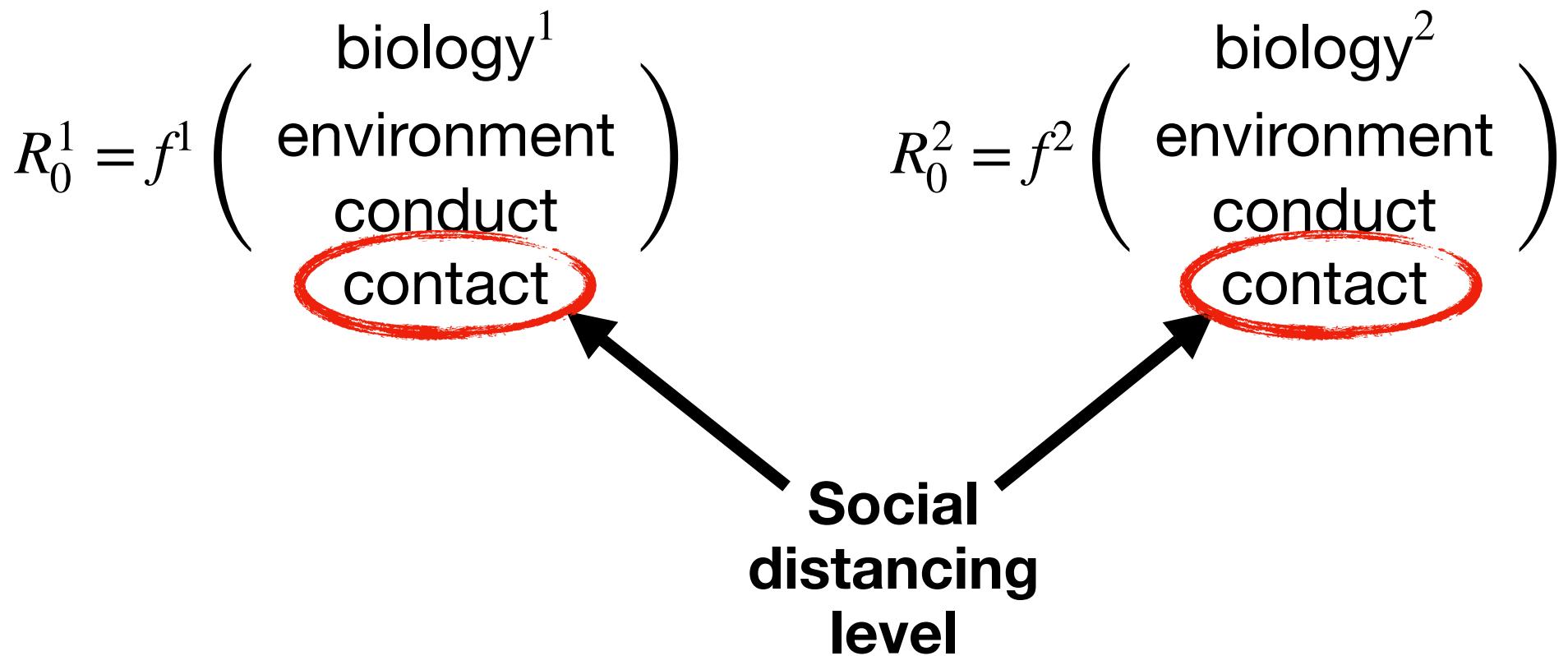
$$R_0 = f \left(\begin{array}{l} \text{biology} \\ \text{environment} \\ \text{conduct} \\ \text{contact} \end{array} \right)$$

Social distancing level

```
graph TD; R0["R₀ = f((biology, environment, conduct, contact))"]; SDL["Social distancing level"]; SDL --> Contact["contact"]; SDL --> Conduct["conduct"];
```

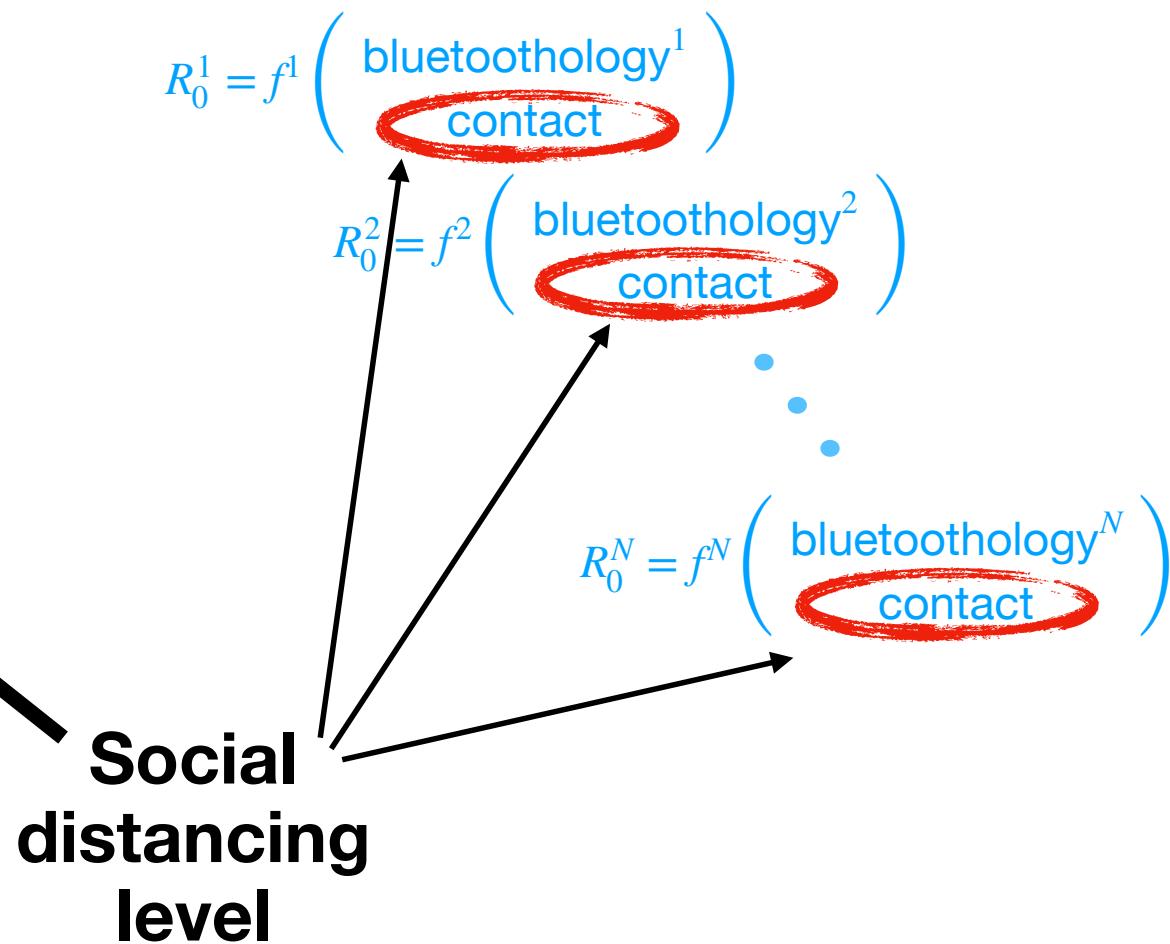


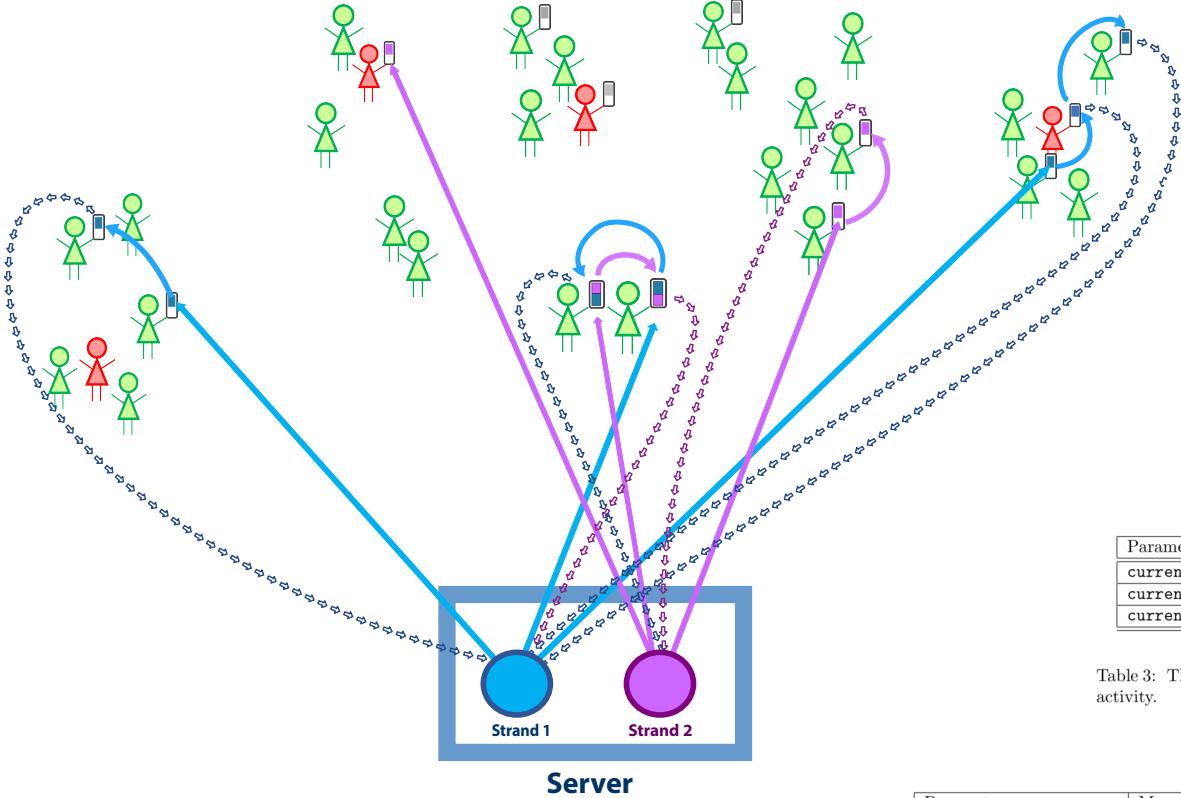
What if you had two types of viruses?



Safe Blues is about injecting many virtual safe viruses

$$R_0^C = f^C \left(\begin{array}{l} \text{biology}^C \\ \text{environment} \\ \text{conduct} \\ \text{contact} \end{array} \right)$$





Parameter	Name	Value Type
s	strandID	Unique identifier.
t_{start}	startTime	Date and time at which the Strand begins.
t_{end}	endTime	Date and time at which the Strand ends.
p_0	seedingProbability	Seeding probability.
$I(D, \tau)$	infectionProbabilityMap	Mapping infection probability as distance (cm) and exposure (min).
F_I	incubationPeriodDistribution	The distribution of the incubation period in hours.
F_R	infectiousPeriodDistribution	The distribution of the infection period in hours.

Table 2: The parameters that define a single Strand.

Parameter	Meaning
currentIncubatingStrands	List of current Strands with state <i>INCUBATING</i> on the Host.
currentInfectedStrands	List of current Strands with state <i>INFECTED</i> on the Host.
currentRemovedStrands	List of current Strands with state <i>REMOVED</i> on the Host.

Table 3: The daily information pushed to the Database from each Host via the **PUSH-INFECTATION-REPORT** activity.

Parameter	Meaning
strandID	The unique identifier of the Strand.
date	The date.
totalHosts	An estimate of the total number of participating Hosts.
totalHostsSusceptible	The estimated number of Hosts in state <i>SUSCEPTIBLE</i> for strandID on date .
totalHostsIncubating	The number of Hosts in state <i>INCUBATING</i> for strandID on date .
totalHostsInfected	The number of Hosts in state <i>INFECTED</i> for strandID on date .
totalHostsRemoved	The number of Hosts in state <i>REMOVED</i> for strandID on date .

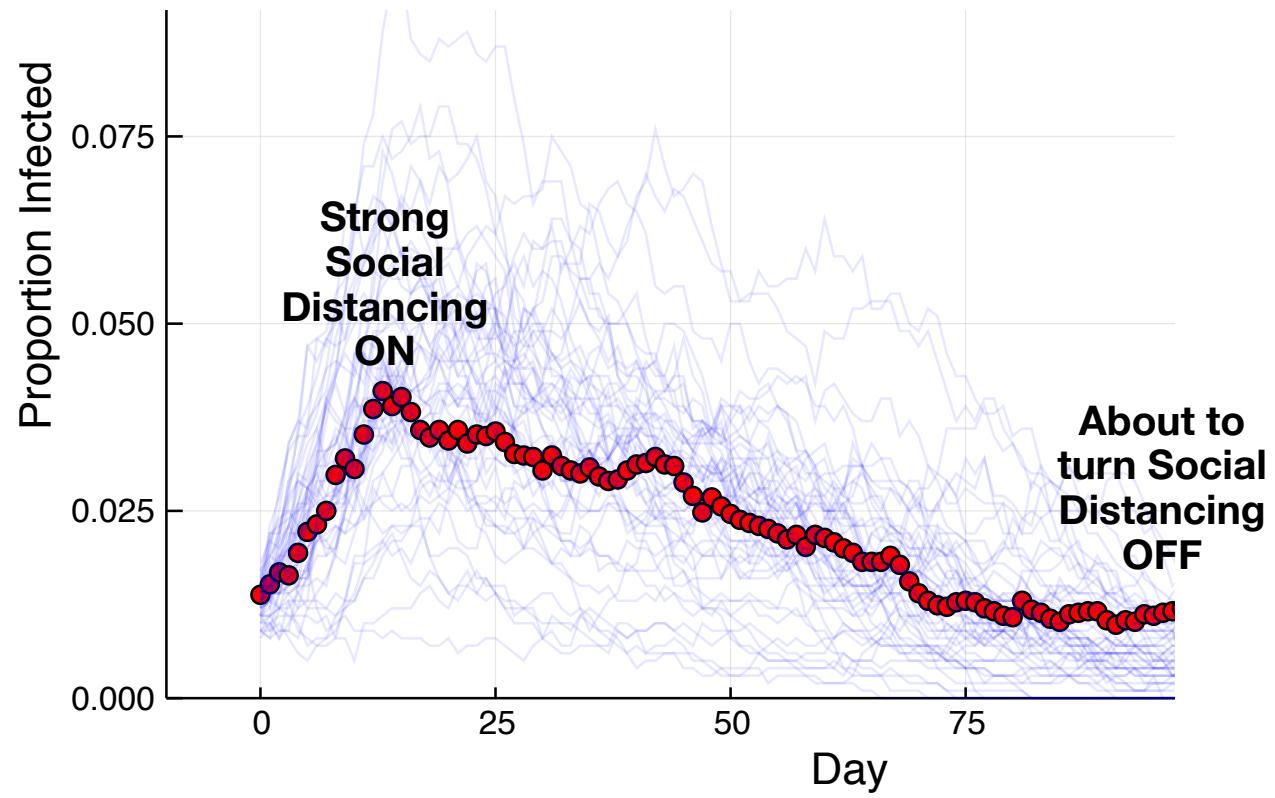
Table 4: Aggregate information publically available via the Database.

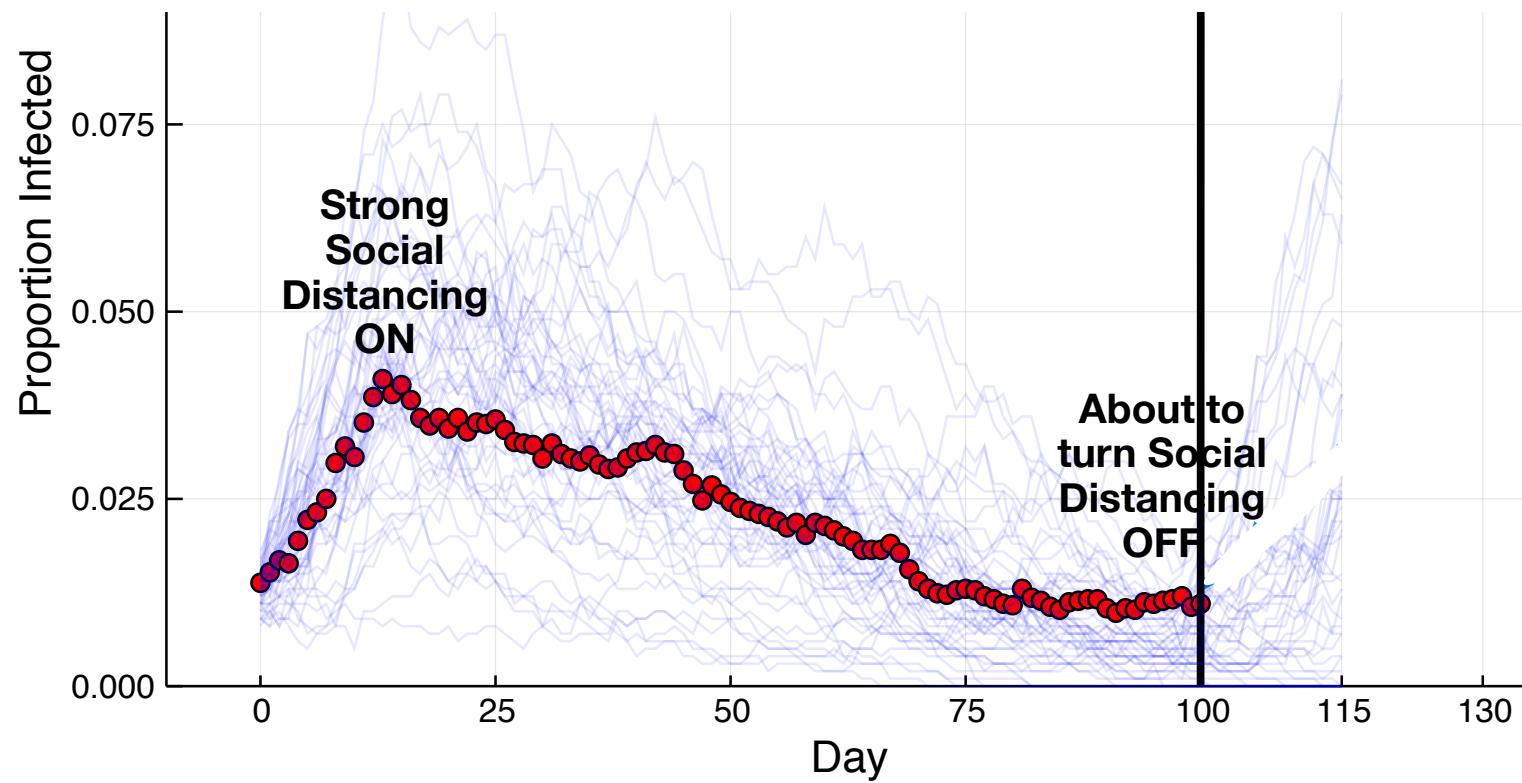
Safe Blues is not Contact Tracing

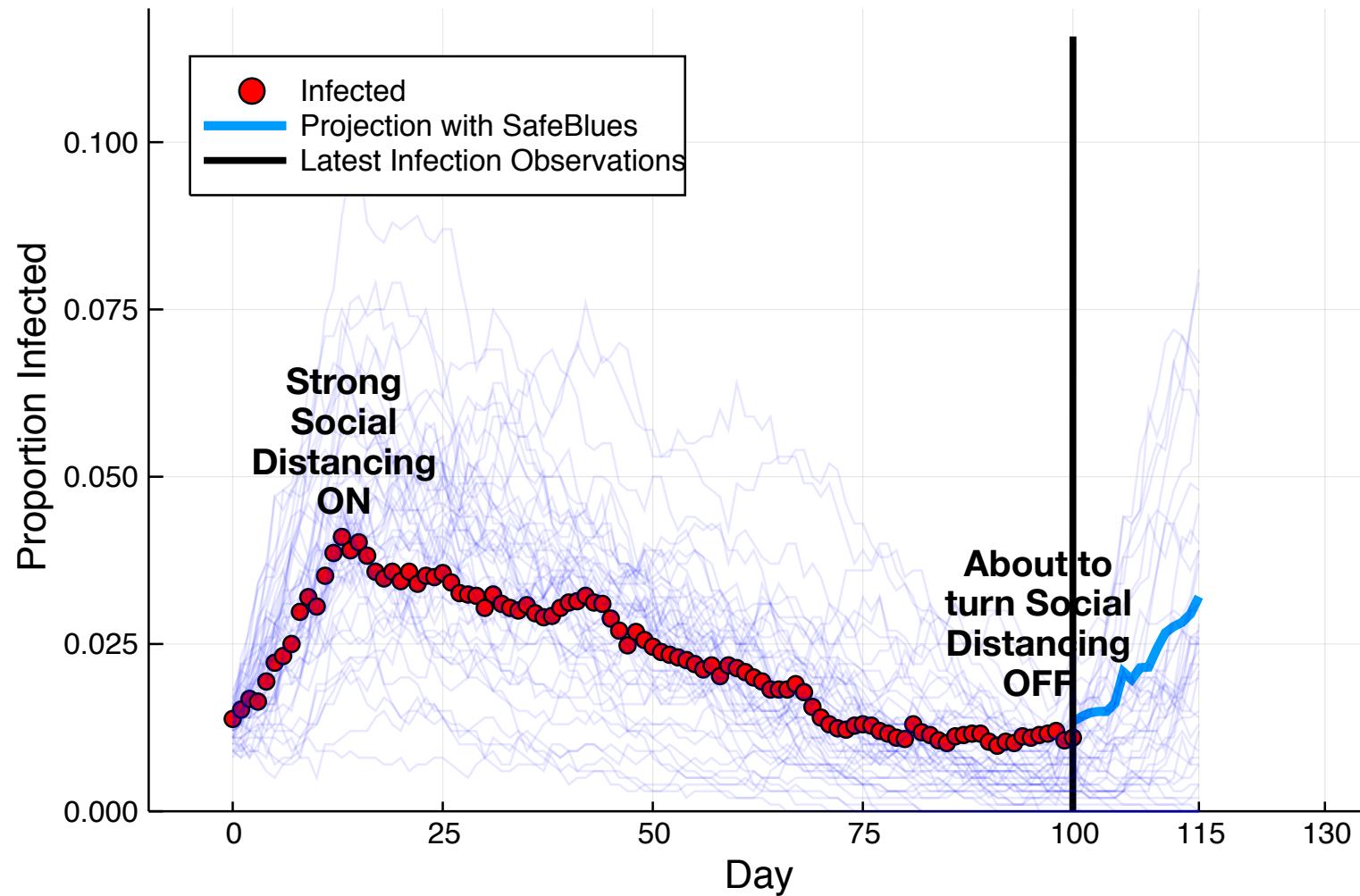
Country	App Name and reference	Source Code	Comments
Australia	CovidSafe [19]	Not released	A clone of TraceTogether [29]
Czech Republic	eRouska [20]	[21]	
Germany	ITO [22]	N/A	Only on Android at this time
India	Aarogyasetu App [23]	N/A	Also uses GPS
Israel	Hamagen [24]	[25]	Also uses GPS
North Macedonia	StopKorona! [26]	N/A	
Poland	ProteGO! [27]	[28]	Not available at this time
Singapore	TraceTogether [29]	OpenTrace [30]	BlueTrace specification at [1]

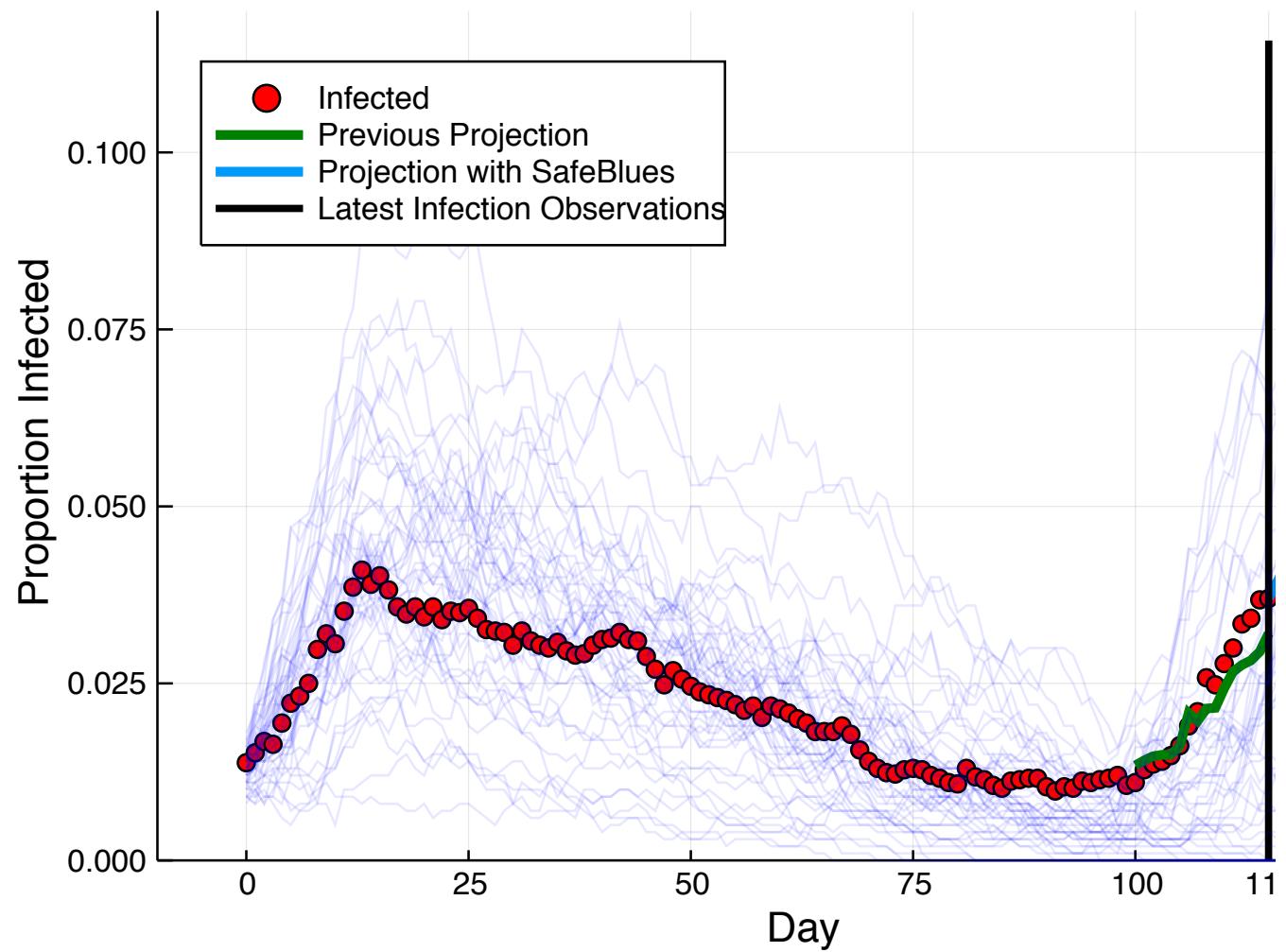
Table 1: Current contact-tracing apps that use Bluetooth.

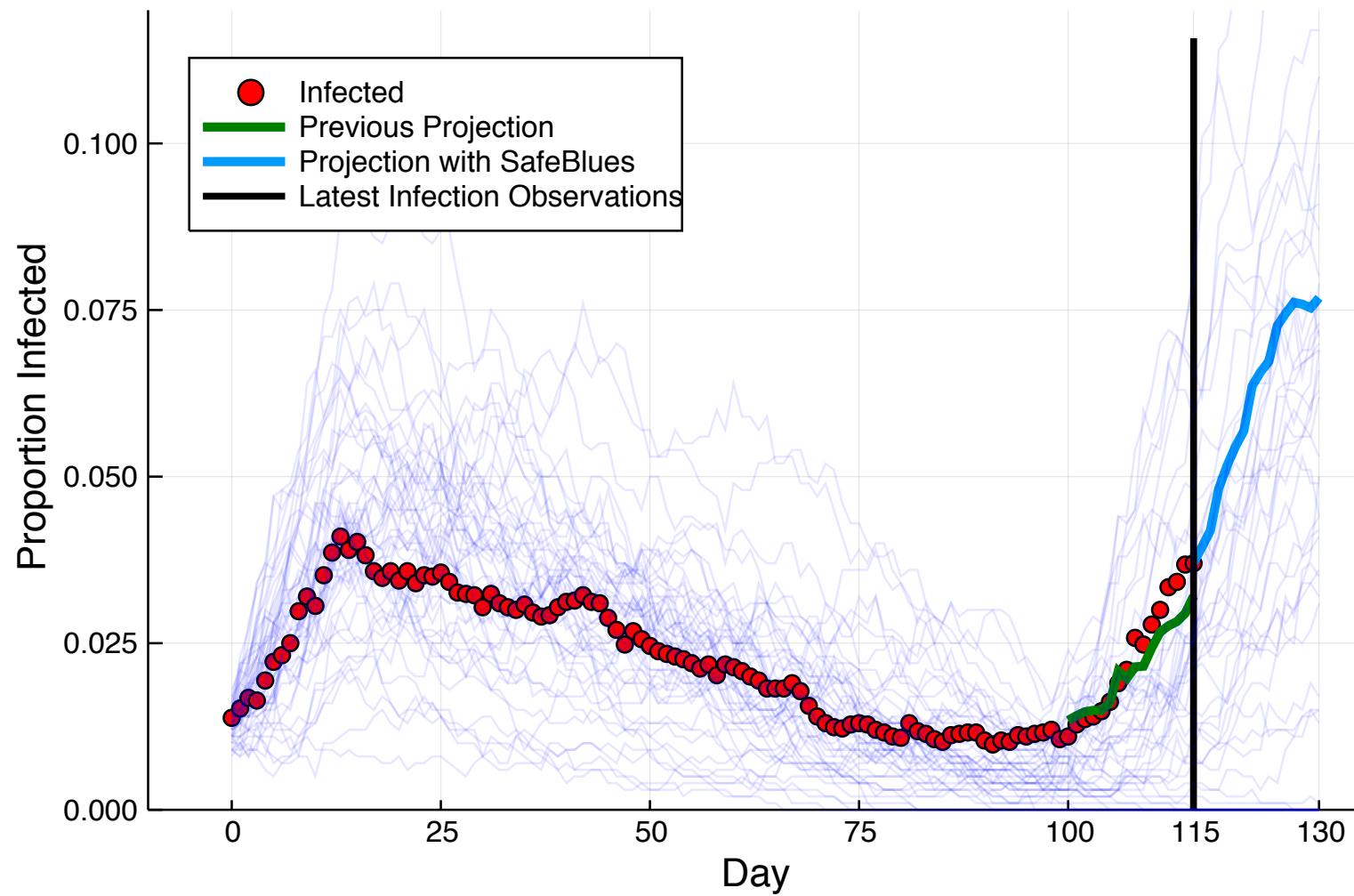
... but can be added to such apps









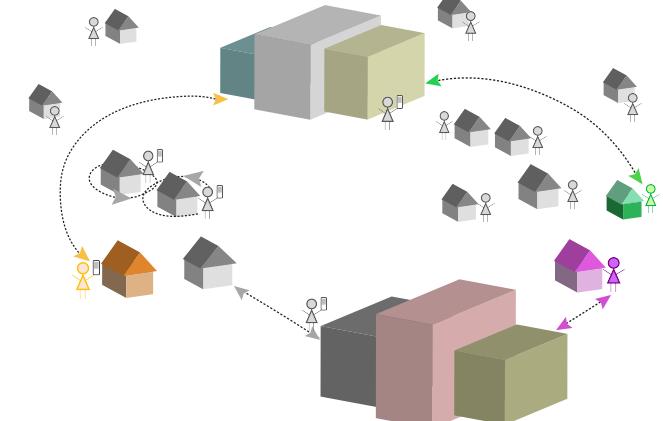
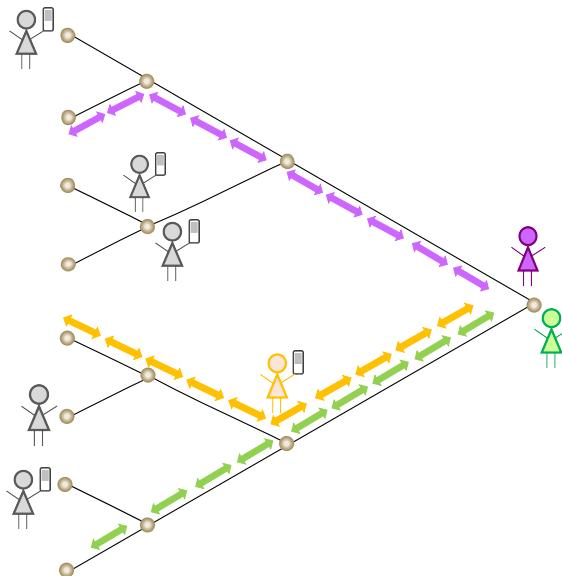
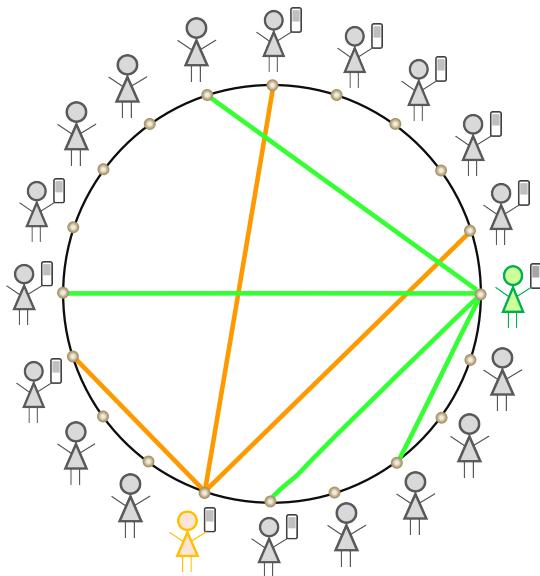


Estimation and Control with Safe Blues

Some Goals:

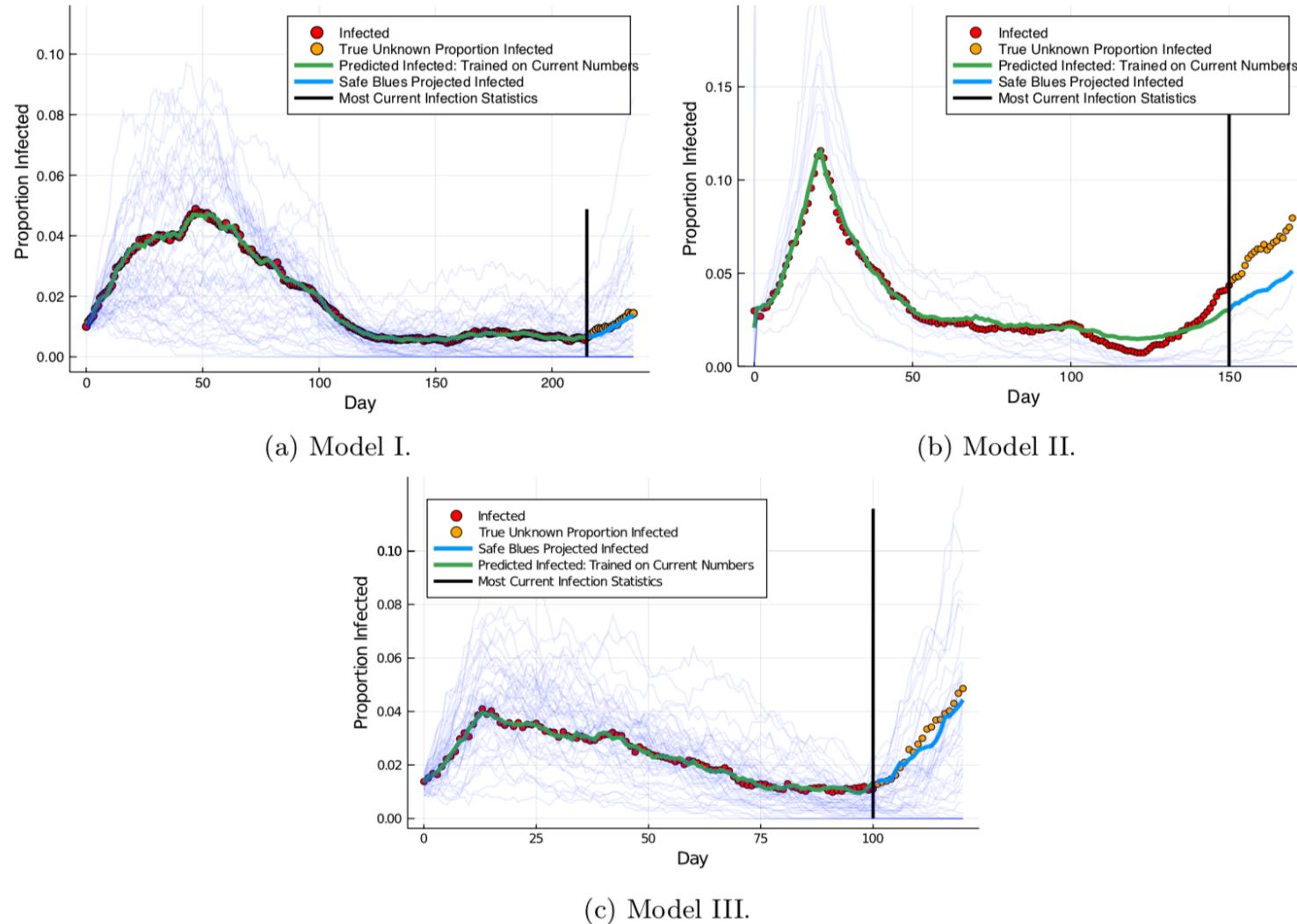
1. Early warning of a rise towards a “second wave”.
2. Understanding the effect of various social distancing regimes on $R_{\text{eff}}(t)$.
3. Designing optimal control policies for fine tuning social distancing measures towards the end game of COVID-19.
4. Projecting the course of the epidemic in the medium and long run.
5. Estimating the proportion of asymptomatic carriers of COVID-19.
6. Computing uncertainty bounds for projections.
7. Optimally choosing parameters and timing for newly created Safe Blues Strands.

Models for basic evaluation of the Safe Blues idea

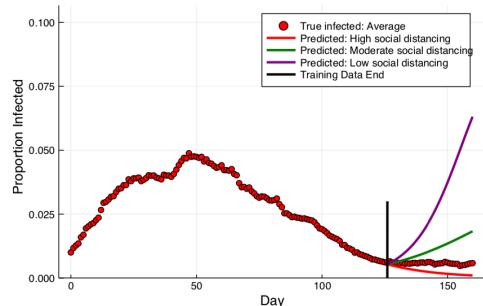


Important: Safe Blues is NOT about model fitting

Early warning towards a second wave



Understanding the effect of various social distancing regimes

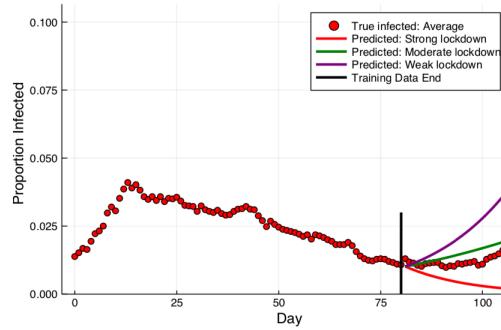
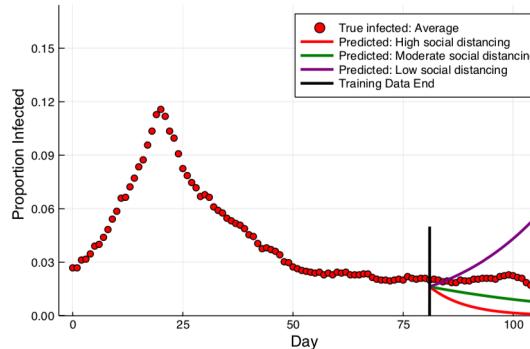


(a) Model I.

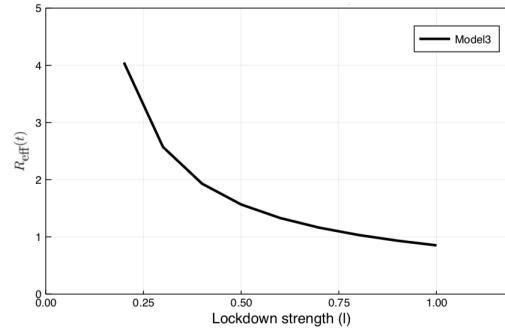
$$\begin{aligned} S' &= -C\beta(p)\delta SI, \\ I' &= C\beta(p)\delta SI - \gamma(p)\delta_\gamma I, \\ R' &= \gamma(p)\delta_\gamma I, \end{aligned}$$

$$\begin{aligned} \tilde{S}' &= -C\beta(p)\tilde{S}\tilde{I}, \\ \tilde{I}' &= C\beta(p)\tilde{S}\tilde{I} - \gamma(p)\tilde{I}, \\ \tilde{R}' &= \gamma(p)\tilde{I}. \end{aligned}$$

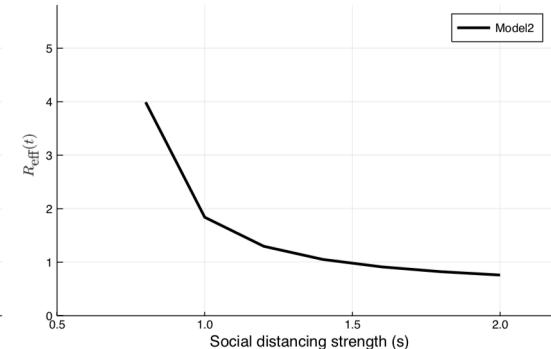
Model1



(c) Model III.



Model2



(b) Model II.

Where to?

Discussion....