Understanding Ethical Dilemmas in Infectious Disease Interventions through Modeling

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Evolution of Social Complexity

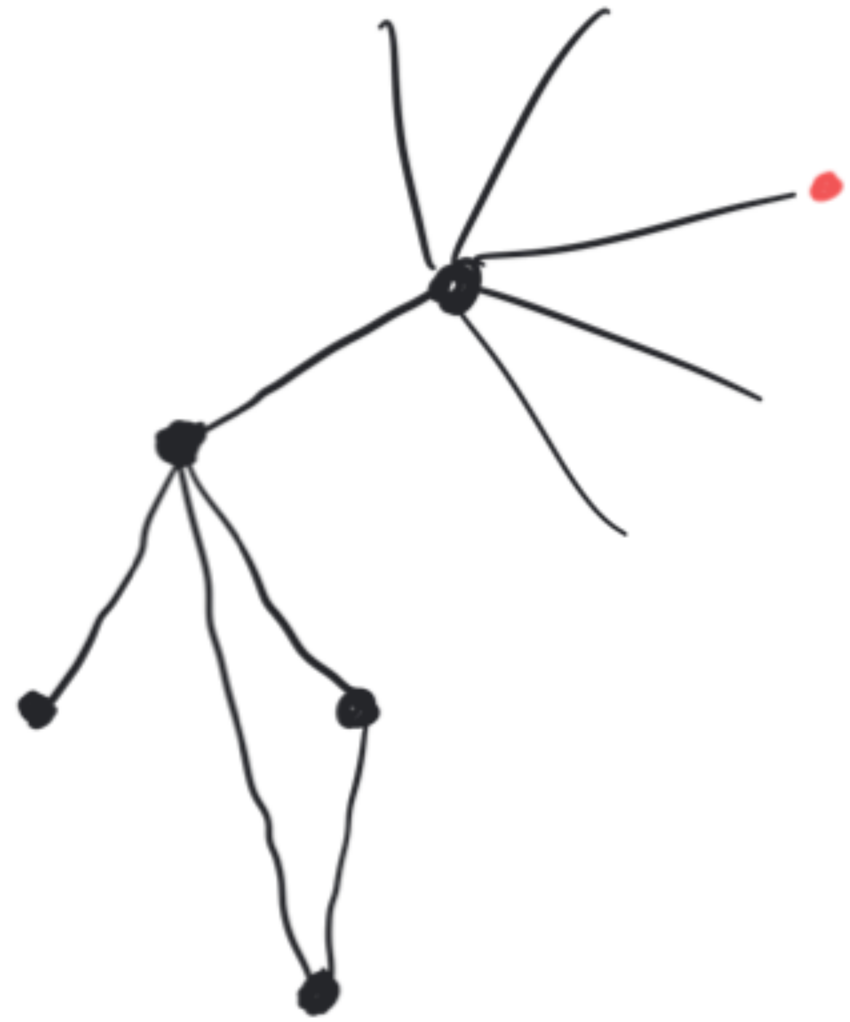
Acknowledgment

This work was performed on the traditional lands of the Wurundjeri people of the Kulin Nation. I acknowledge their elders past, present, and emerging. I extend the same respect to the traditional custodians of the land here and to all Indigenous people in the audience today.

Outline

- Why are ethical infectious disease interventions hard?
- Can we see an example of an ethical dilemma?
- What is the role of one individual?

Infection and Ethics as a complex system



The choices of one individual can expose others to risk they have not "consented" to.

Mathematically this shows up as a nonlinearity in the governing equations.

Impact of nonlinearity – Ethical Dilemmas:

If we make optimal ethical decisions at the individual scale..
(ignoring an individual's impacts on others)
(Medical/Clinical Ethics)

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We get ethical dilemmas

How do we resolve them?

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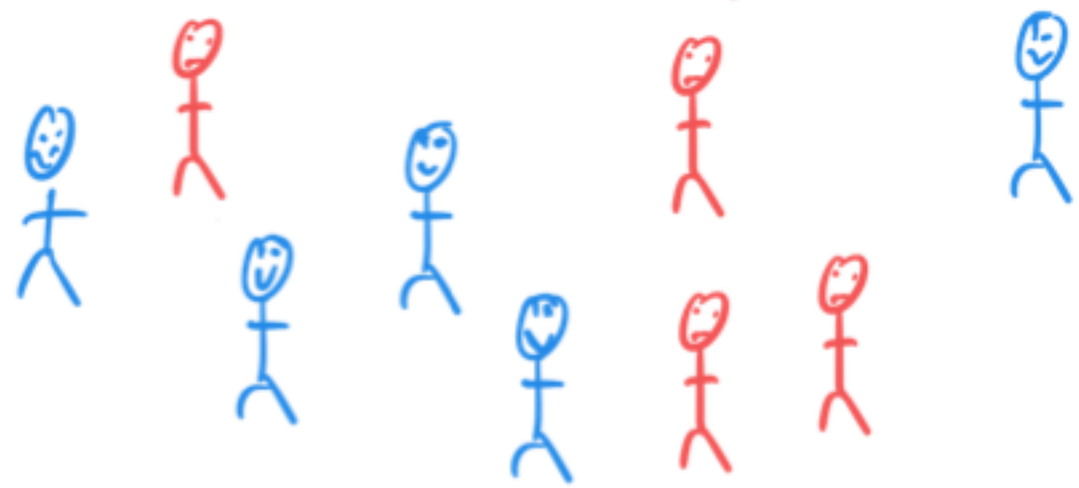


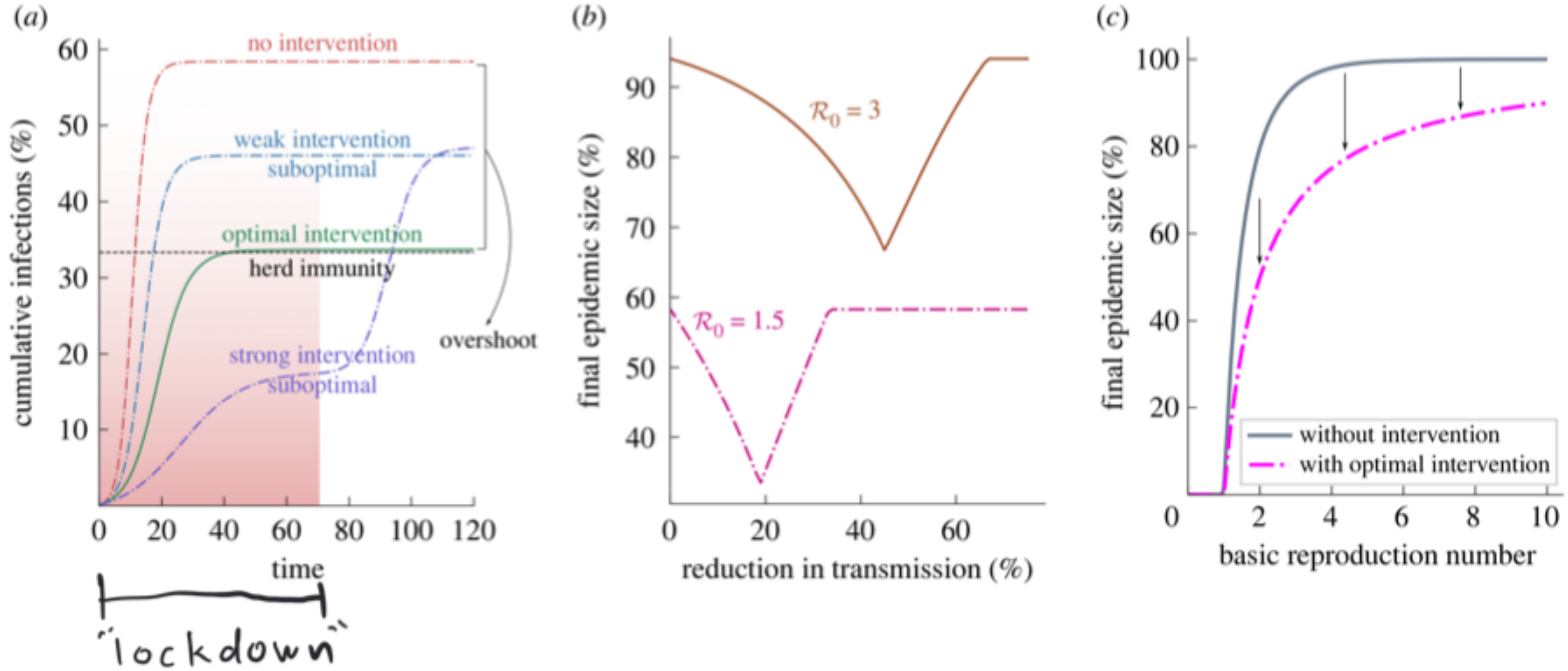
We get ethical dilemmas

How do we resolve them?

I don't know - right now let's focus on identifying + quantifying the problem.

Example - multiple risk groups

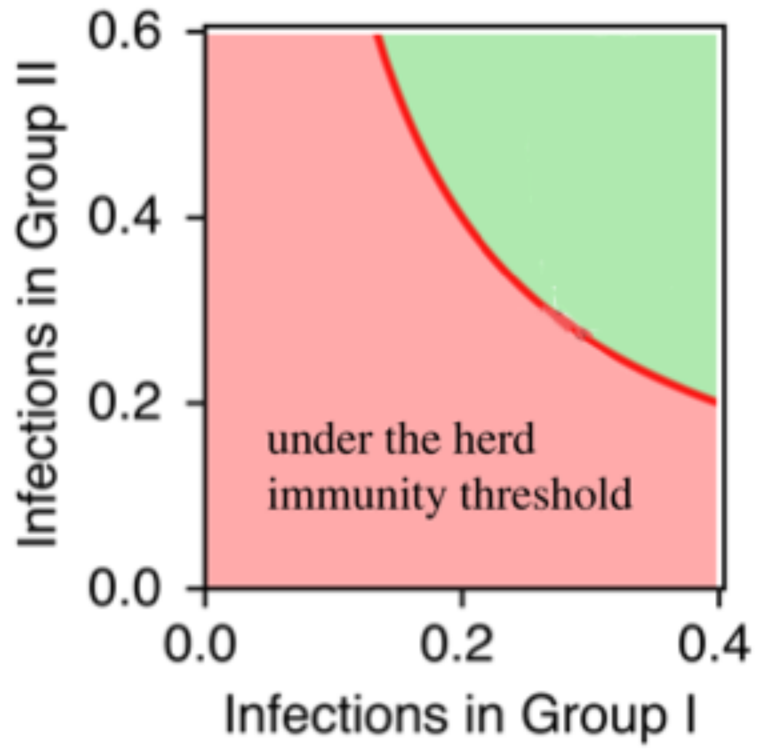
Consider a homogeneous population with a lockdown-like intervention for a limited period (70 days)



The optimal strength of intervention produces an epidemic that leaves the population at the herd immunity threshold.

Example - multiple risk groups

Now consider a multigroup population with a heterogeneous intermediate duration intervention



Possible "intermediate final states" during intervention.

Example - multiple risk groups

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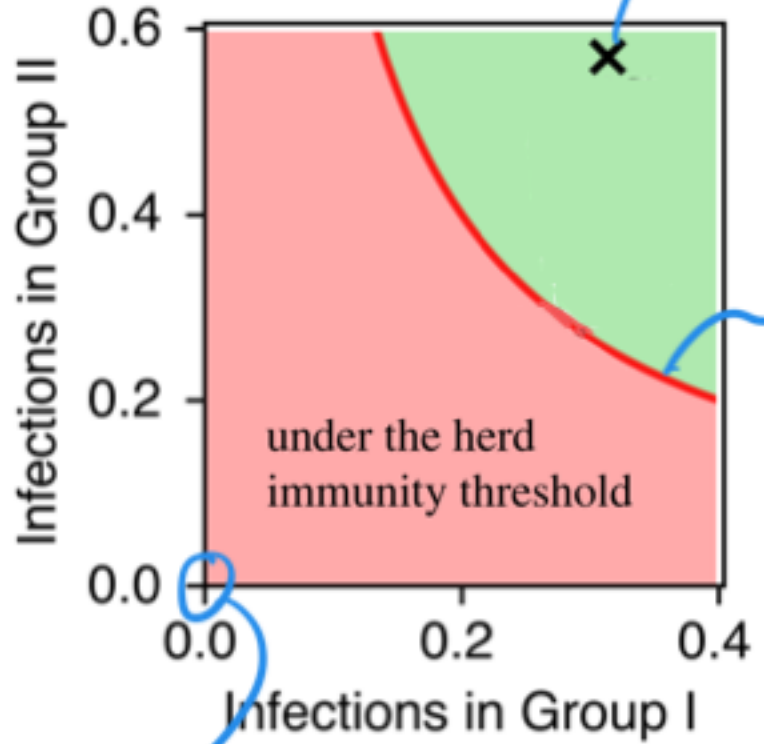


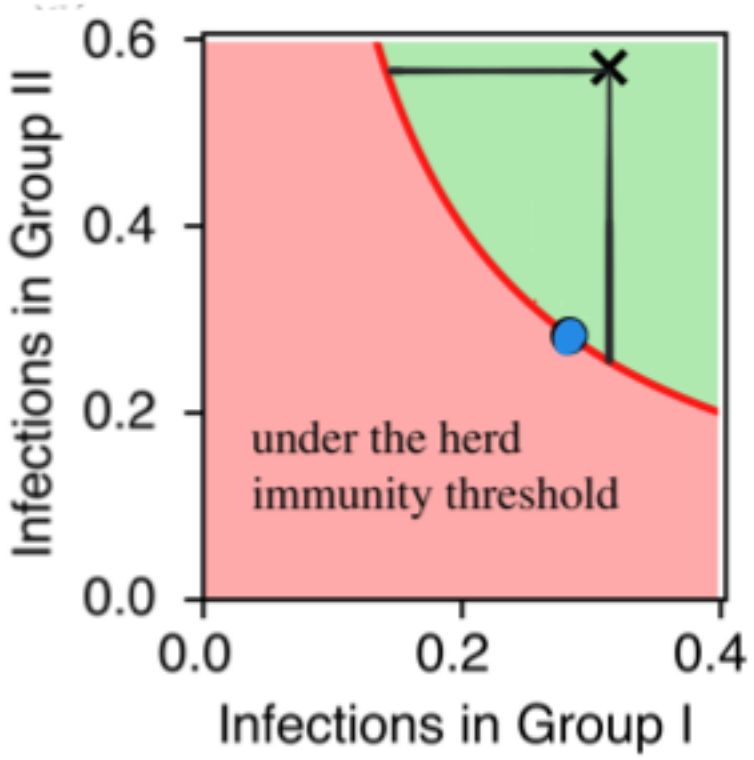
end of epidemic without intervention

possible herd immunity states

initial state at start

Possible "intermediate final states" during intervention.

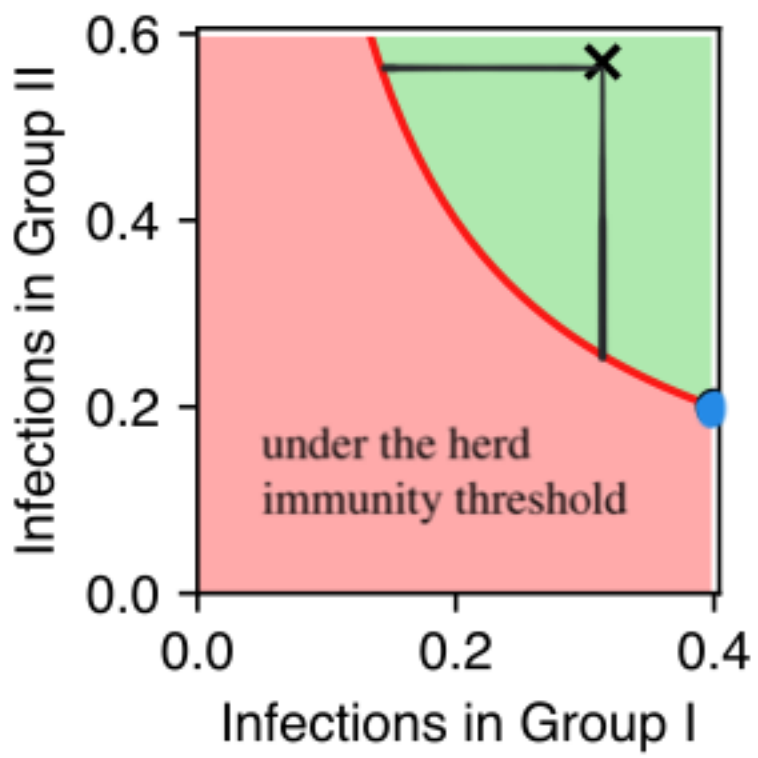
minimizing infection $r_1 + r_2$



both groups better off.

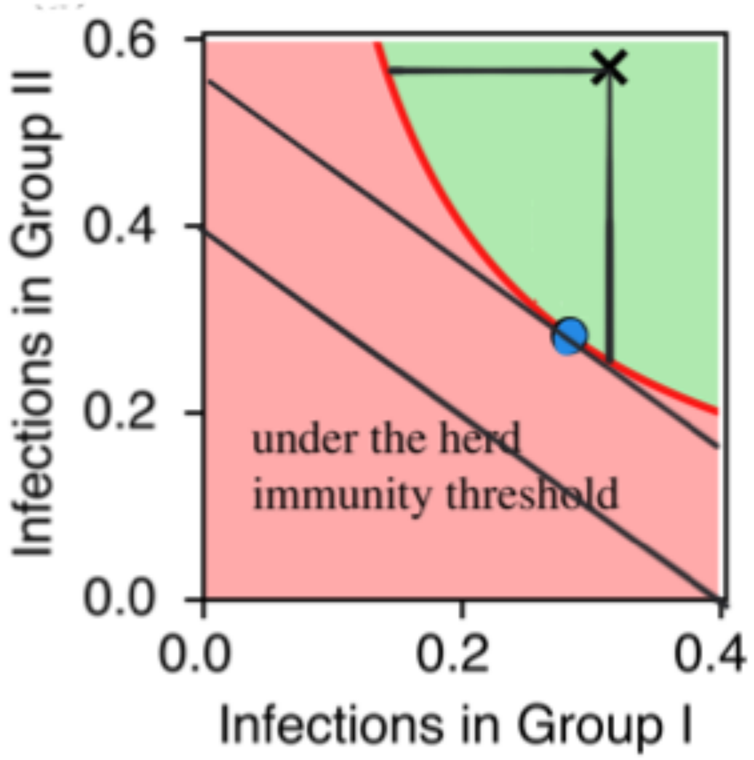
Ethically sound

minimizing infection in Group II (or just minimizing $2r_2 + r_1$)



Group I is worse off → we've forced them to party during intervention

minimizing infection
$r_1 + r_2$



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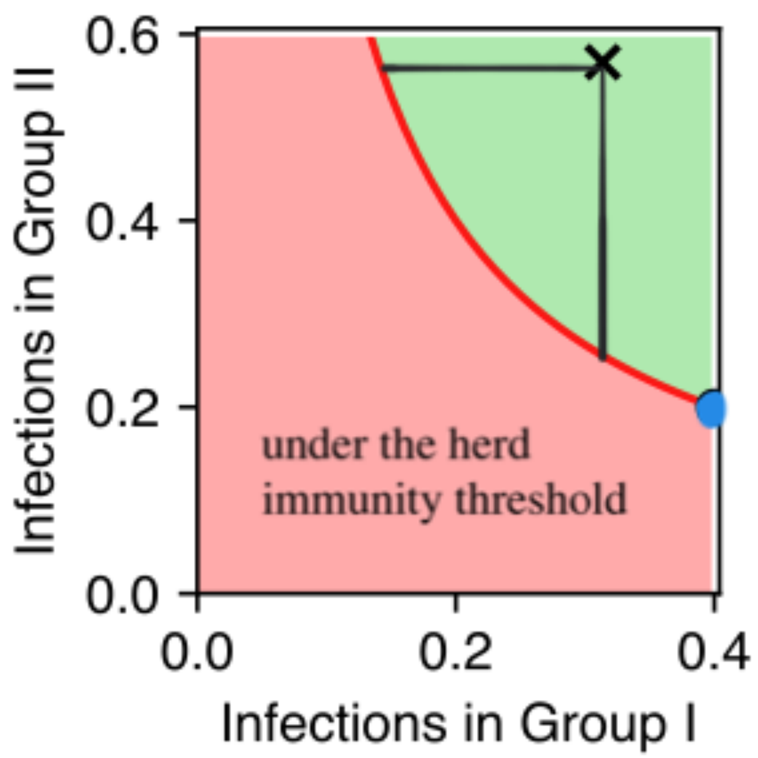

Group I is worse off → we've forced them to party during intervention

Ethical dilemma arises from optimizing interventions for epidemics in heterogeneous populations

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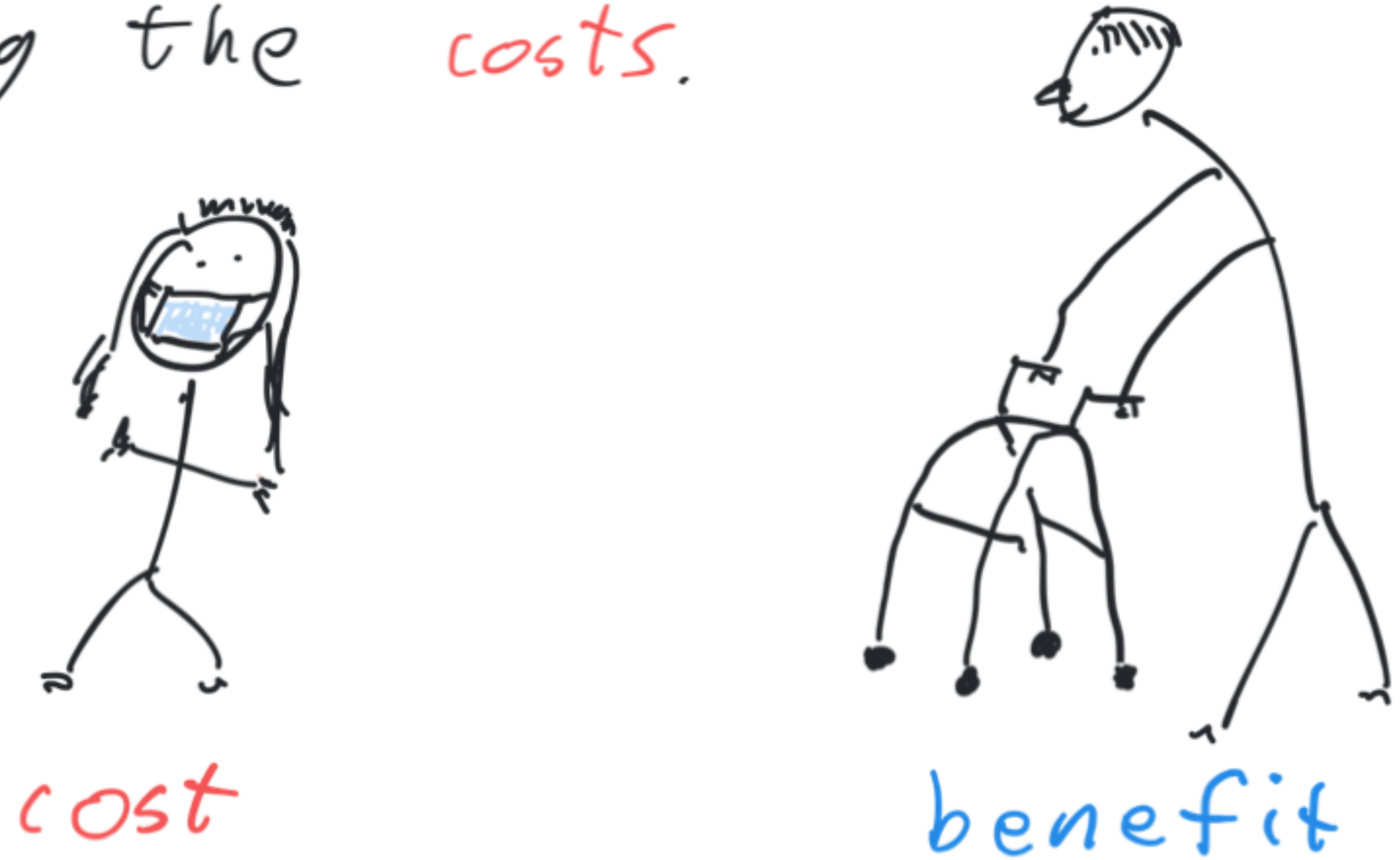
Understanding the impact of 1 person:

The benefits of an intervention may not be experienced by the person paying the costs.



What is the impact of 1 individual changing behavior?

Reference Case:

Drunk driving / Seatbelt laws

There are penalties for behaviors that put others or even oneself at risk.

Should vaccine mandates (e.g.) have stronger penalties than drunk driving?

Australia's 'No Jab No Play' policies: history, design and rationales

Katie Attwell,[1] Shevaun Drislane[1]

Abstract

Objective: Since 2014, five Australian states have enacted 'No Jab, No Play' policies requiring children to be fully vaccinated to attend childcare and early education services. We review the five policies and their implications for implementers – including healthcare and childcare service providers – and analyse factors that shaped the design of state policies.

Methods: We employed documentary analysis and analysed key informant interviews in NVivo 12.

Results: Our findings reveal similarities and differences between state provisions regarding exemptions, grace periods, responsibilities of service providers and sanctions for non-compliance. We elaborate on five factors of influence that have shaped No Jab, No Play policies: i) impetus for change; ii) policy normalisation, growing concurrence and stringency; iii) increased co-optation of childcare providers into vaccination governance; iv) policy influence and lessons; and v) partisan politics and the development of party ideologies over time.

Conclusion: A range of factors contribute to how and why Australia's NJNPlay policies have taken their current forms.

Implications for public health: NJNPlay policies impact families and healthcare providers as part of the broader policy ecosystem concerned with maintaining high immunisation rates in Australia. Increased coercion of parents over time has been tempered by partisan positions on exemptions for disadvantage.

Key words: vaccination, vaccination policy, public health policy design, vaccine mandates

Governments globally are introducing or tightening childhood vaccine mandates to address parental vaccine refusal.[1] Australia's state-level 'No Jab, No Play' ('NJNPlay') policies limit enrolment in childcare and early learning facilities. While the Federal 'No Jab, No Play' policy has been closely analysed,[2-4] there is less analysis on how state-based vaccine mandates operate, particularly compared to work on American state policies.[5-9]

This article reviews how Australian state policies differ from each other and the political and governance factors underpinning these differences. First, we provide a comparative overview of NJNPlay provisions with regard to: i) exemptions, ii) grace periods, iii) duties and responsibilities of childcare providers, and iv) sanctions for non-compliance. We then discuss how key actors or contexts, disciplinary perspectives and (shifting) partisan norms, and policy learning and expectations have shaped the introduction and design of NJNPlay policies.

The Federal 'No Jab, No Pay' ('NJNPay') policy requires families to vaccinate their children in line with the national immunisation schedule to be eligible for certain family support (Centrelink) payments, including childcare subsidies that range from 20–85% of total childcare costs.[10] NJNPay came into effect on 1 January 2016. Previous policies linked Centrelink payments to childhood vaccination, however, families could lodge a conscientious objection (CO) to vaccination and still receive benefits.[2] NJNPay ended COs, meaning to receive payments families now need to vaccinate their children unless they have an approved medical exemption[2] or qualify for an additional narrow set of exemptions.[11] Medical exemptions are recorded through the Australian Immunisation Register (AIR). Approved healthcare providers can grant temporary or permanent exemptions where a child has a contraindication to a vaccine (for example, anaphylaxis reaction to a previous dose or component of a vaccine, or is significantly immunocompromised and unable to receive a live vaccine), or has natural immunity.[12]

State-level 'No Jab, No Play' (NJNPlay) policies focus on enrolment in childcare and early learning facilities. Five Australian states (New South Wales, Victoria, Queensland, Western Australia, and South Australia) have NJNPlay policies (Figure 1), with provisions varying between them as to how they operate (Table 1).

Methods

We analysed academic publications, grey literature, policy documents, news reports

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Consider:

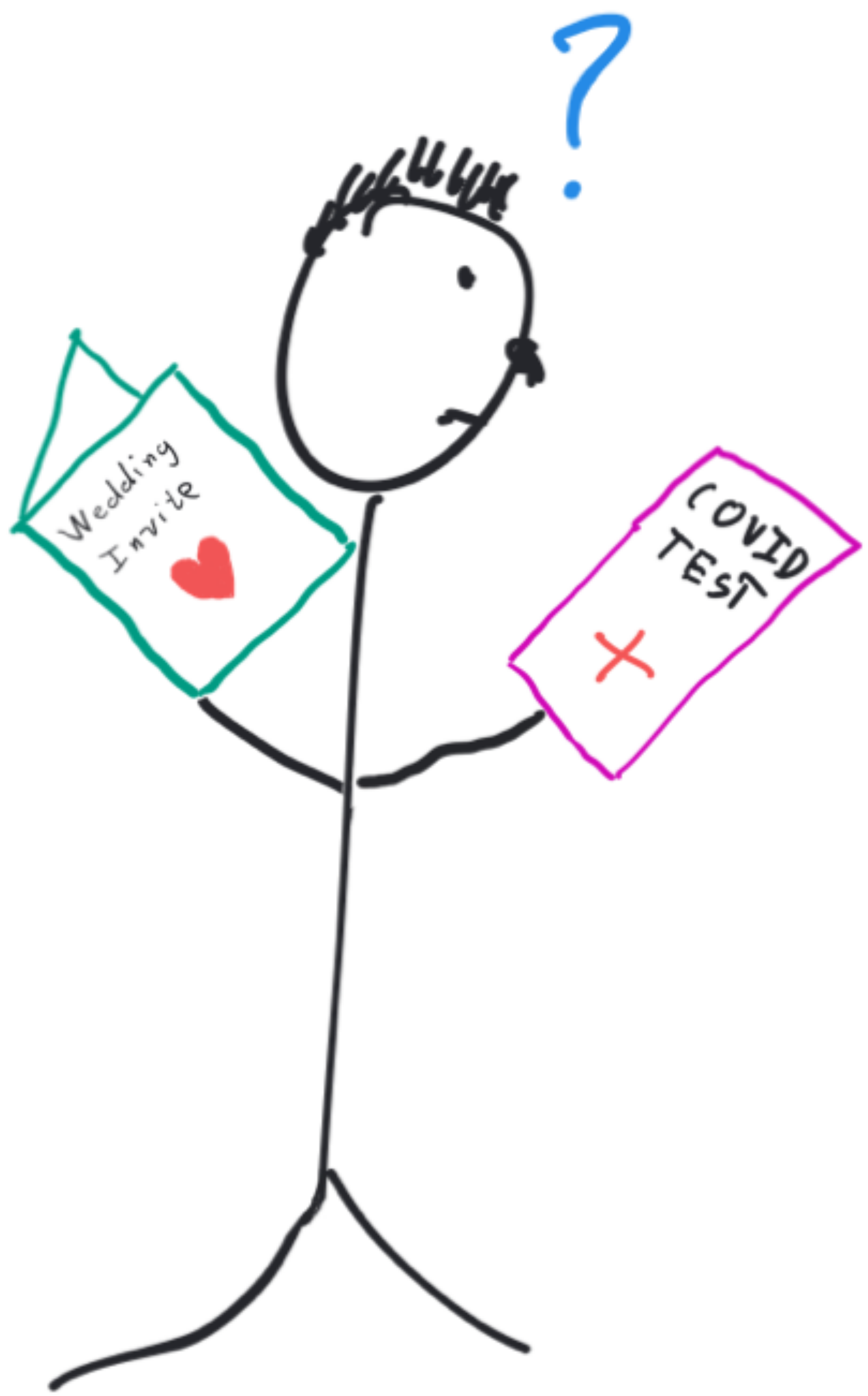
- Well mixed population
- Constant intervention effort
- SIR disease (Recovered = immune)
- Offspring distribution, mean = R_0

Consider:

- Well mixed population
- Constant intervention effort
- SIR disease (Recovered = immune)
- Offspring distribution, mean = R_0

What is the impact of:

- One newly infected individual deciding whether to isolate
- One uninfected individual deciding whether to get vaccinated / take prophylaxis / etc


Wedding Invite
COVID TEST

Caveat:

I could get most of my answers by differentiating the "final size relation"

$$r(\infty) = 1 - s(0)\, e^{-r(\infty) R_0}$$

with respect to $s(0)$.

Caveat:

I could get most of my answers by differentiating

depends on $s(0)$ ↙   depends on $s(0)$ ↓

$$r(\infty) = 1 - s(0)e^{-r(\infty)R_0}$$

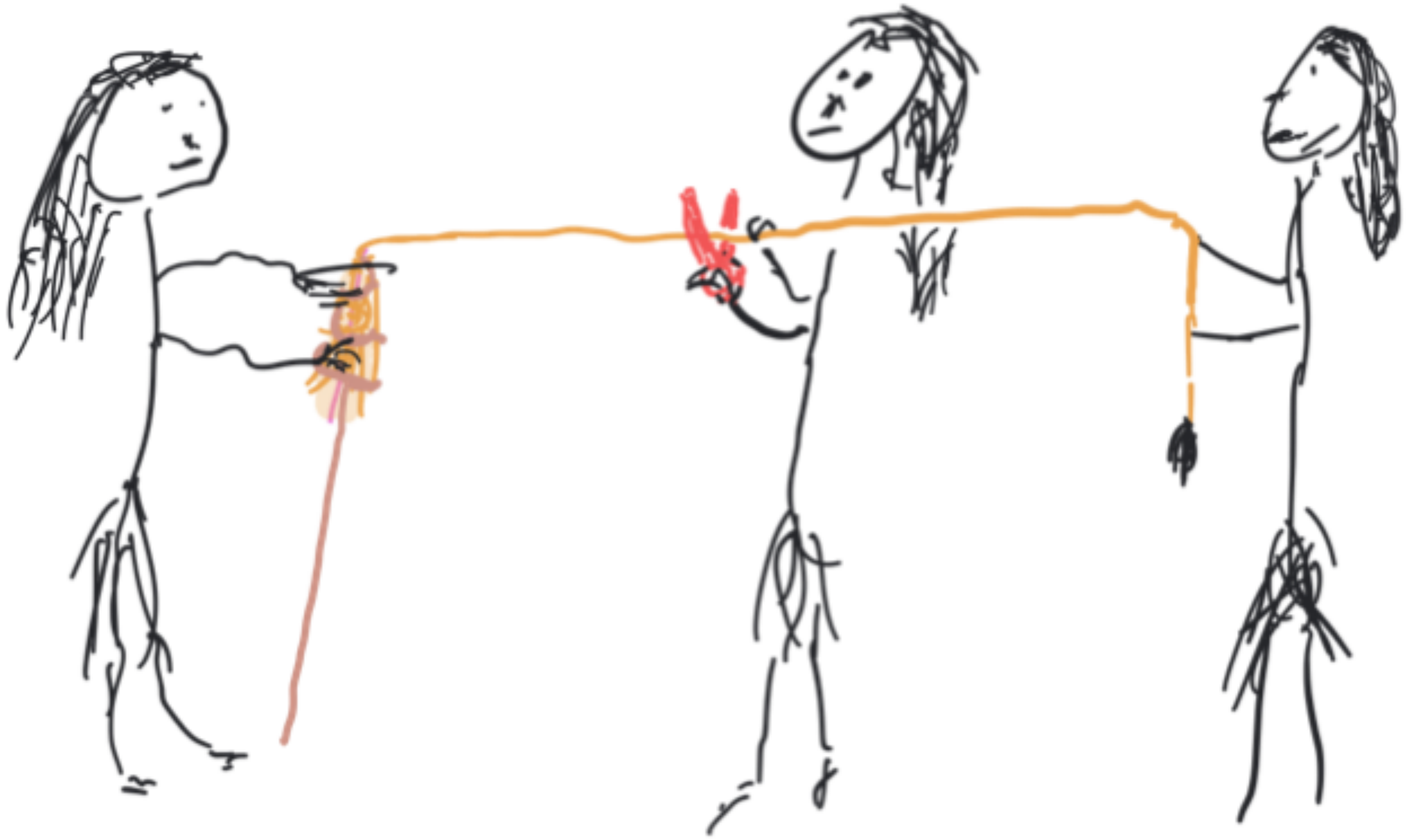
with respect to $s(0)$.

But result does not tell us about distribution of impacts (just expected impact)

& not illuminating

Conceptualizing the SIR epidemic

A Fatalistic Interpretation



If

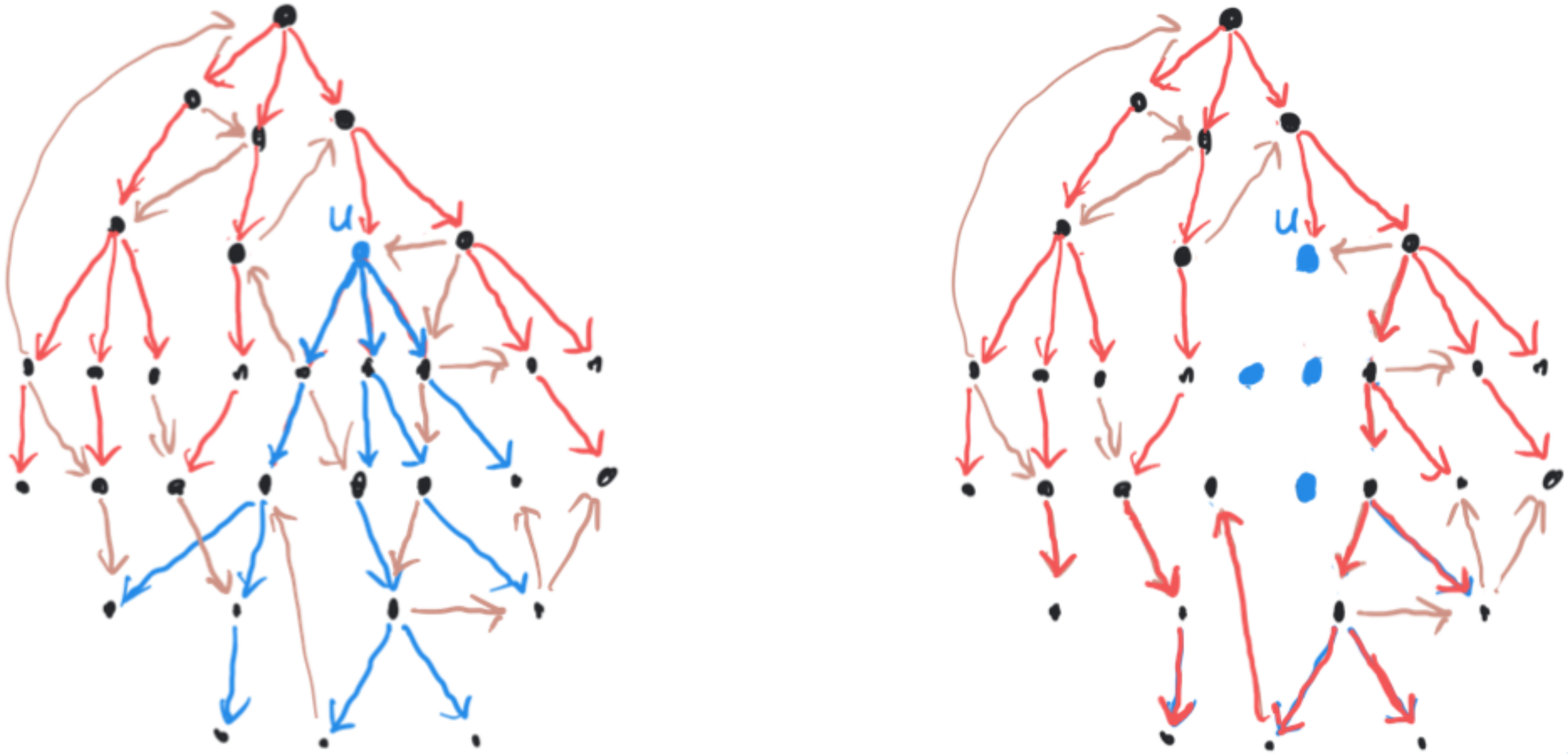
- duration of my infection &
- who I would transmit to (& how long it would take)

are independent of when I become infected

Then

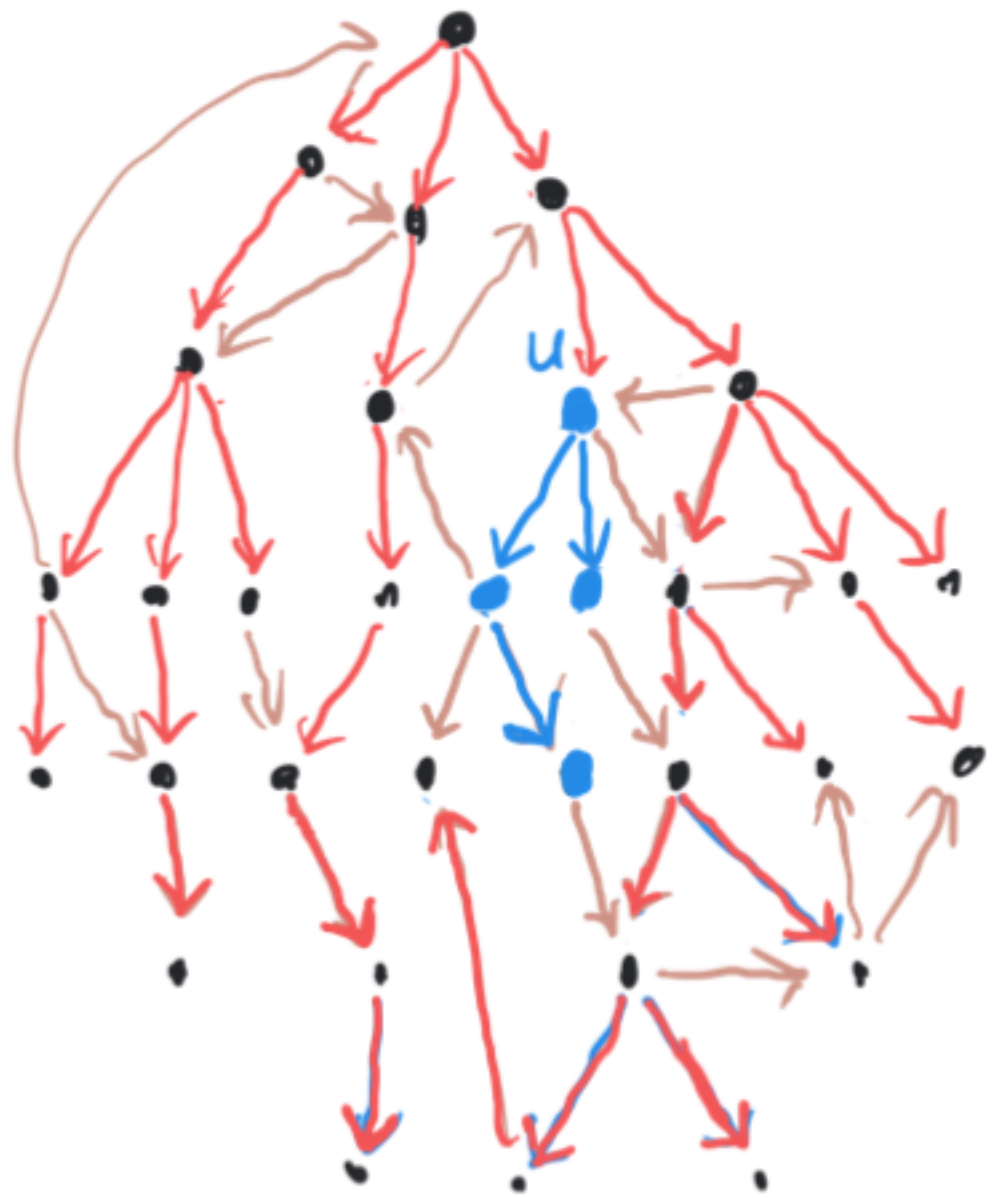
we can make these decisions before choosing the index case(s)

Impact of infected individual u not transmitting (isolation)



Individuals escape only if all paths from index case pass through u.

How many escape if u changes behavior?



Freeze node u and wait for the rest of the epidemic to finish.

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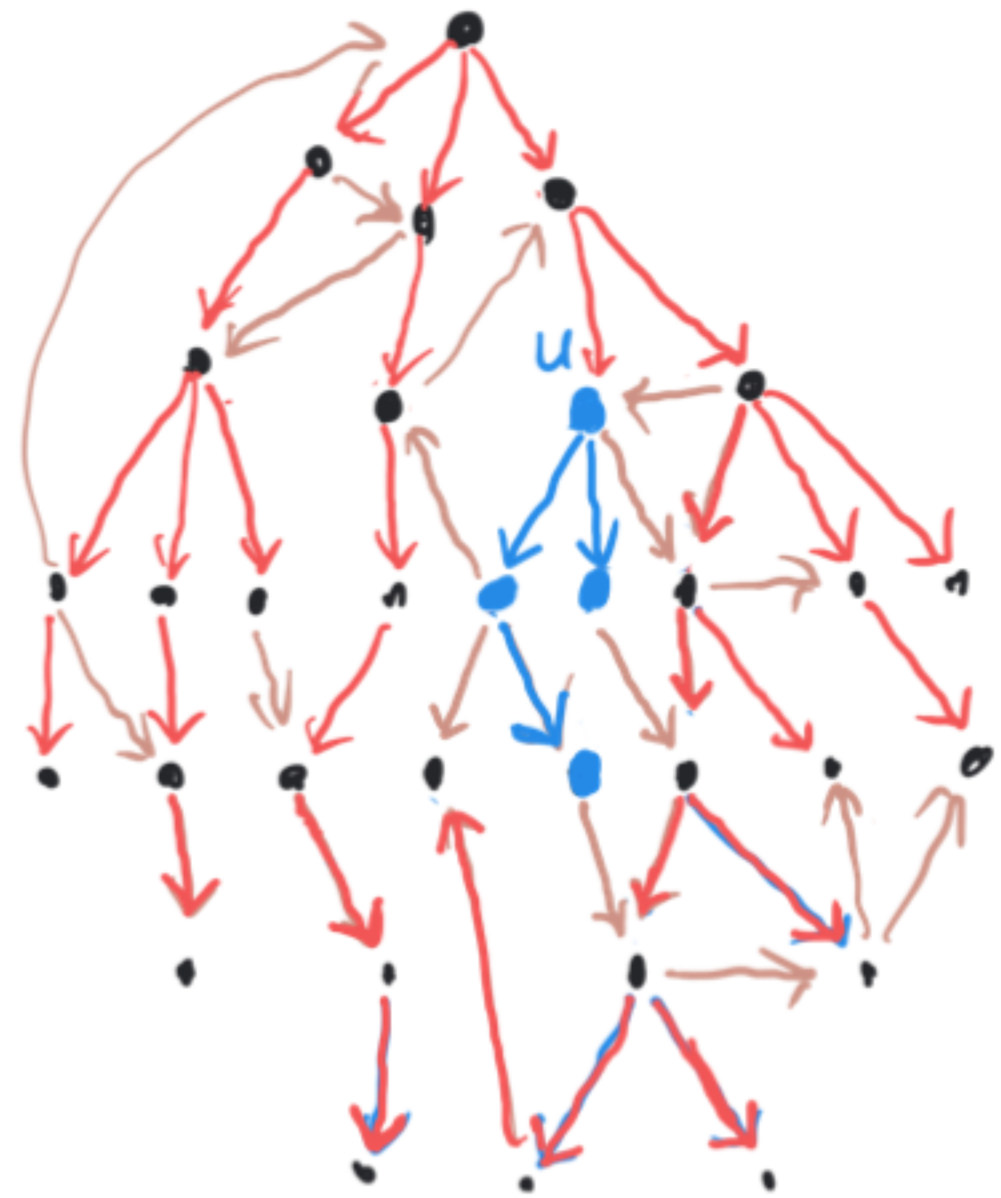


Freeze node u and wait for the rest of the epidemic to finish.

Equivalent to introducing infection in population after epidemic is done

Impact on total number of infections from a single infected individual isolating (Expected value)

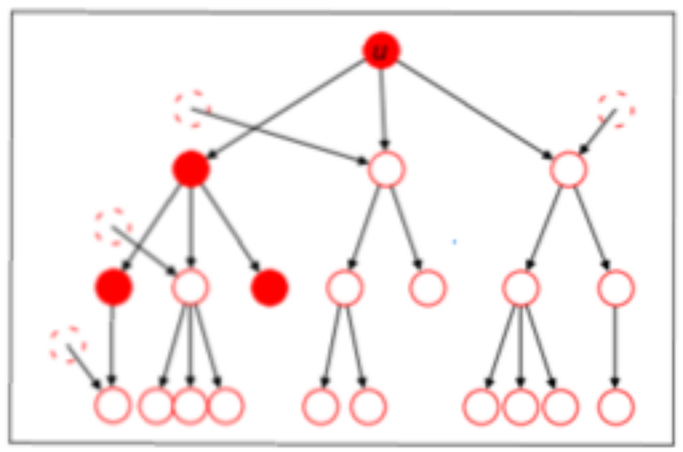
$R_0 < 1$: $\quad R_0 + R_0^2 + R_0^3 + \cdots = \dfrac{R_0}{1-R_0}$

large if R_0 close to 1

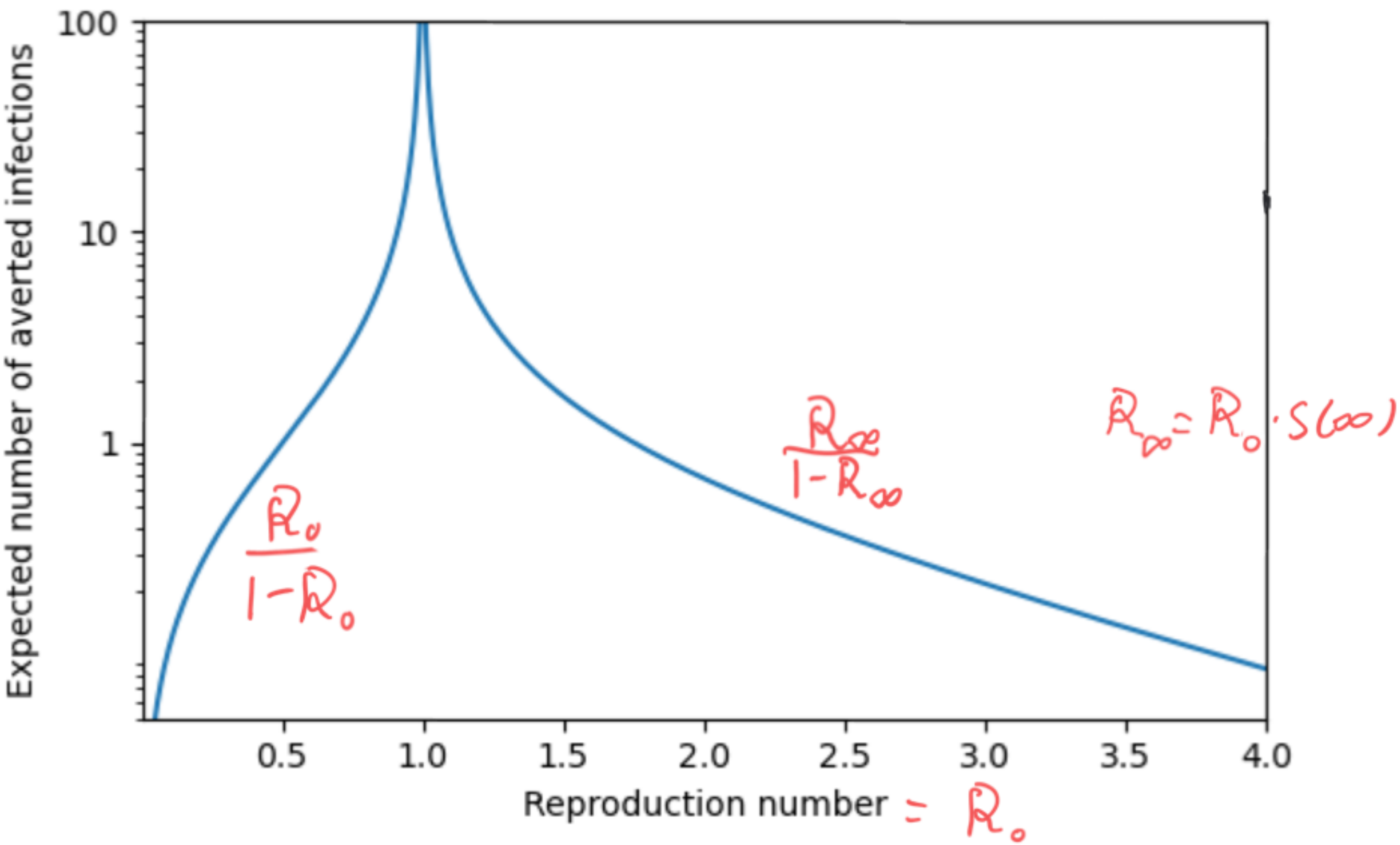
small if R_0 close to 0

$R_0 > 1$: We put individual in stasis, let rest of epidemic spread, Then release individual at final value $R_\infty = R_{eff}(\infty) = R_0 \cdot S(\infty) < 1$

$$R_\infty + R_\infty^2 + R_\infty^3 + \cdots = \frac{R_\infty}{1-R_\infty}$$



large if R_0 close to 1, small if R_0 large.



Key observations:

Even if contact tracing can't bring R_0 below 1, if R_0 is close to 1, a single infection traced and isolated has a large relative impact.

Offspring-distribution independent [offspring dist affects how # averted is distributed]

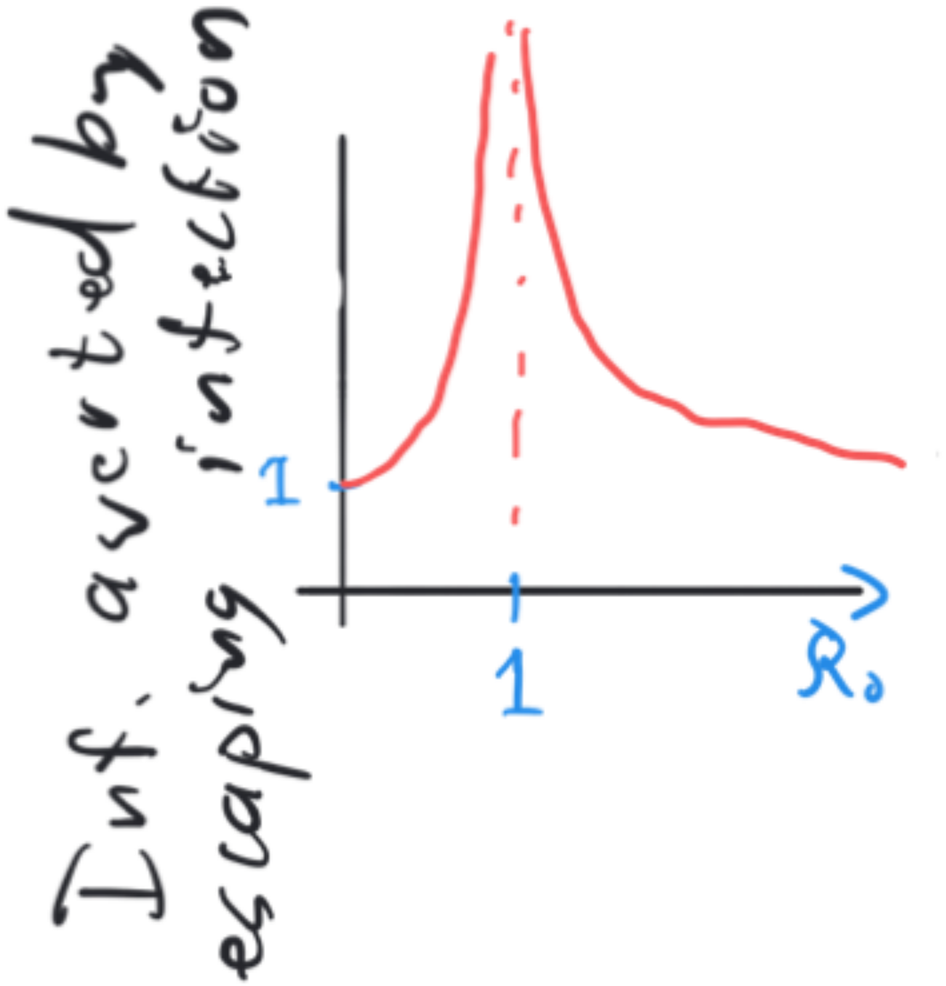
What about vaccination/ prophylaxis?

If individual avoids infection through vaccine the number of infections averted is

1 + (number averted by post-infection isolation)

Of course maybe vaccine has no impact b/c not the vaccinee wouldn't have been infected

So scale by probability infected (= attack rate)



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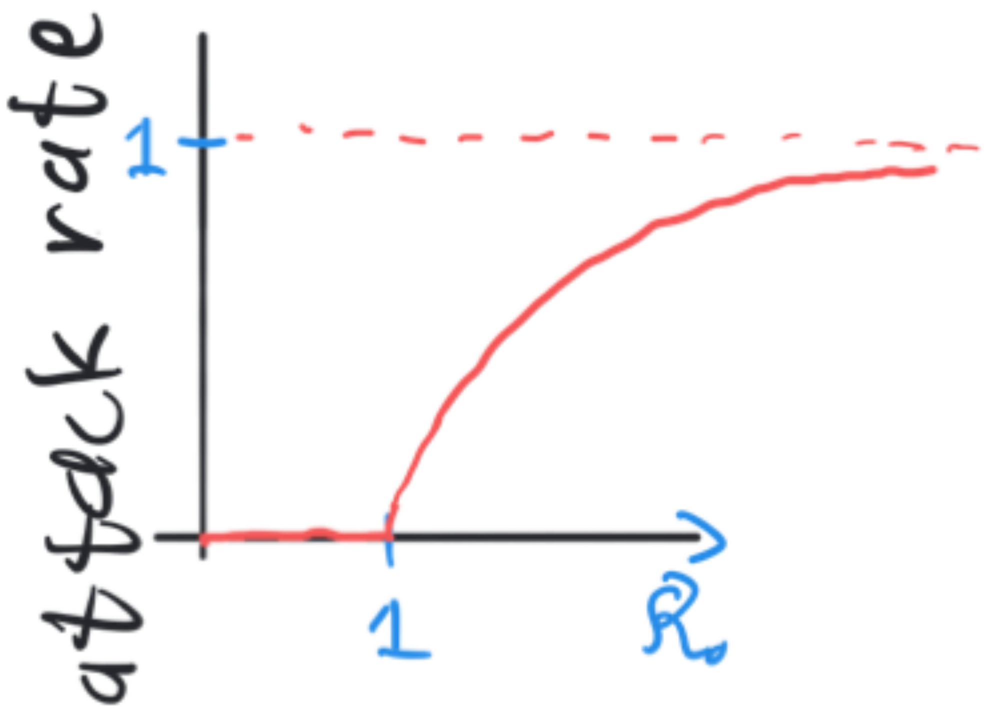

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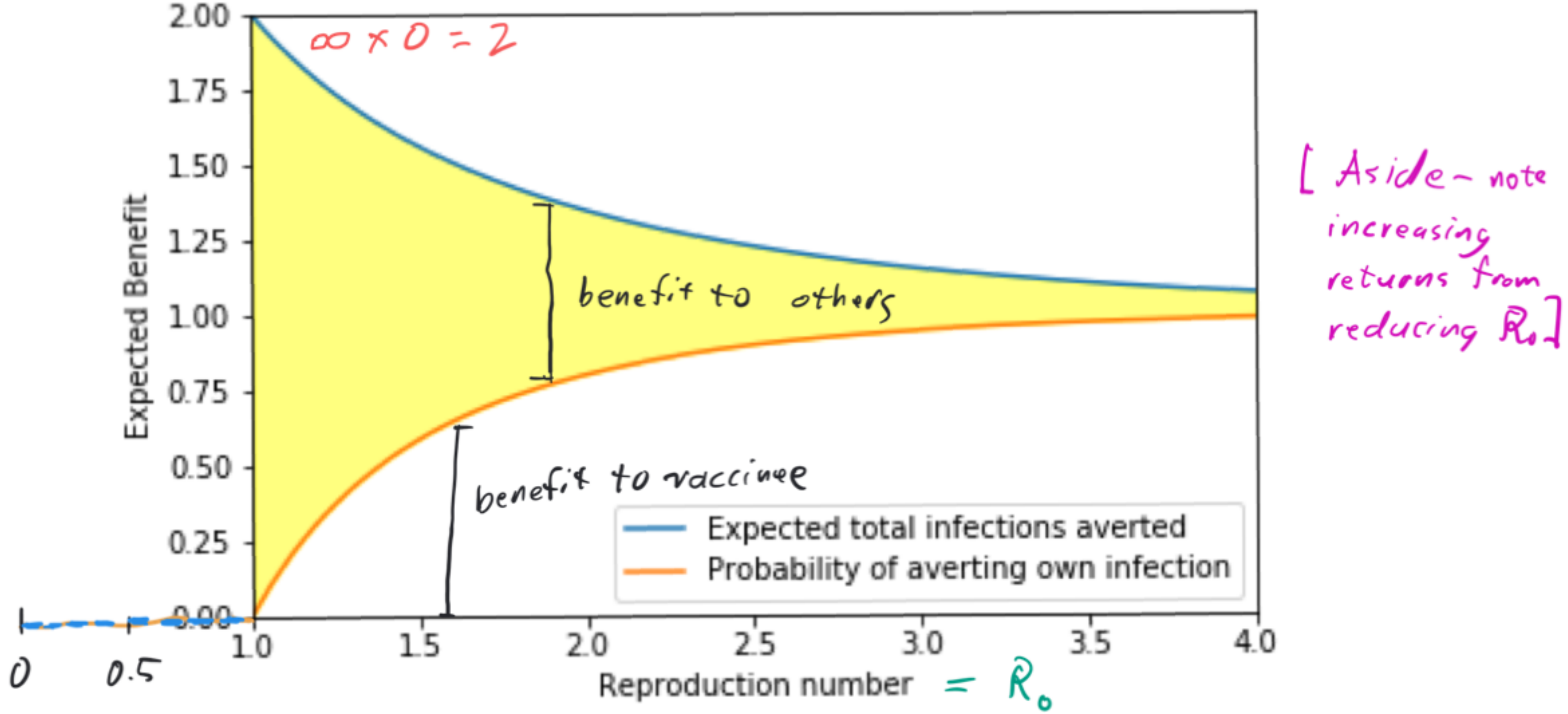


Key observations: (For $R_0 > 1$)

On average each vaccination prevents >1 infection.

biggest population-wide impact when p(infection) → 0.

Largest (expected) population benefit occurs when expected individual benefit is 0.

Implications for eradication.

SCIENCE ADVANCES | RESEARCH ARTICLE

DISEASES AND DISORDERS

Quantifying the impact of individual and collective compliance with infection control measures for ethical public health policy

Daniel Roberts[1], Euzebiusz Jamrozik[2,3,4]*, George S. Heriot[4], Anja C. Slim[3], Michael J. Selgelid[5], Joel C. Miller[6]

[Probability Generating Functions
+ Contour Integration on
Complex Plane]

Discussion

Many optimal individual decisions may not yield an optimal global decision.

Ethical dilemmas may occur in heterogeneous populations or close to the epidemic threshold.

Need to do a more complete survey of intervention types to characterise such scenarios.

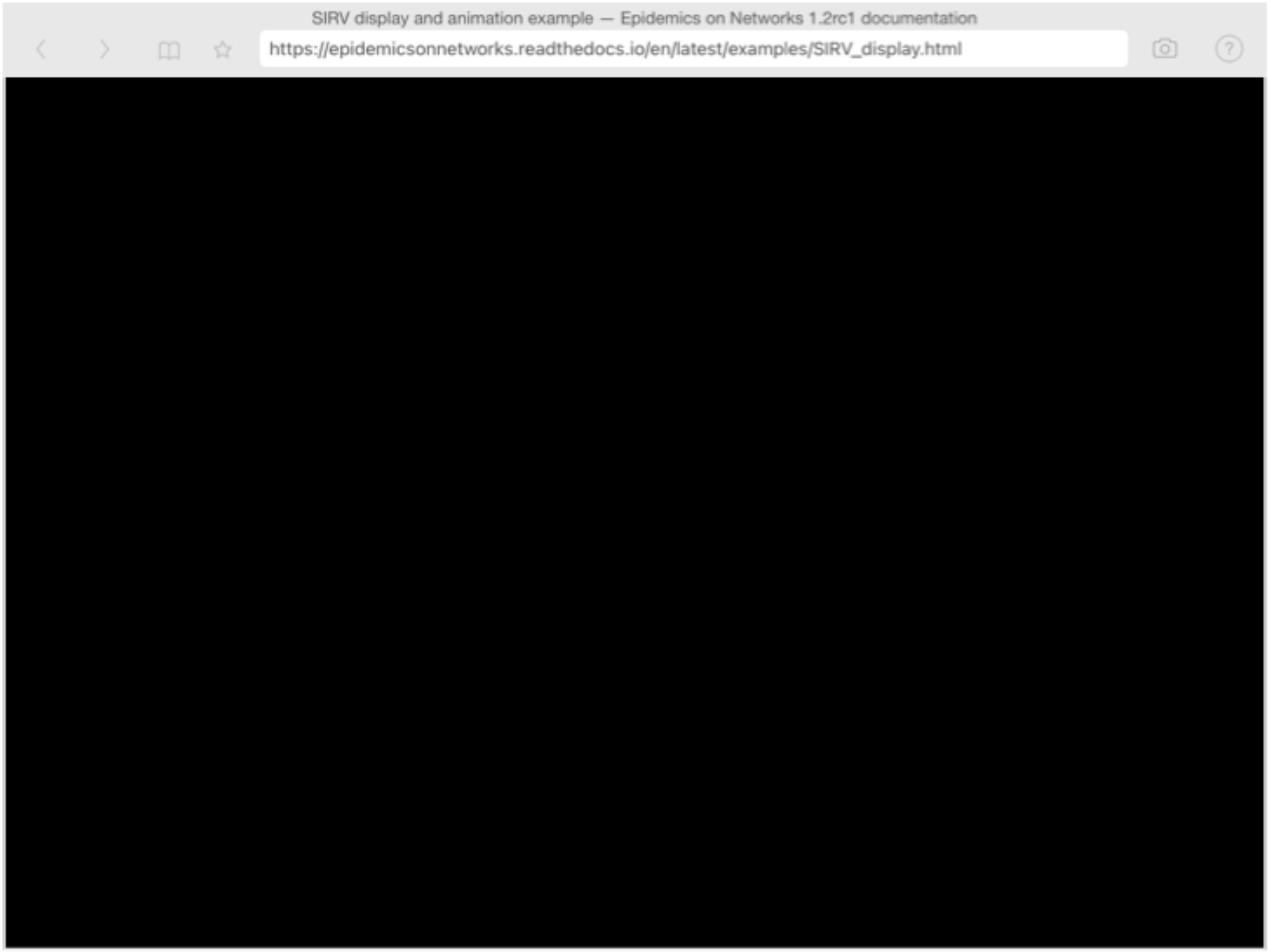
Need new modeling tools that provide policy-maker with information needed to evaluate ethical dilemmas.

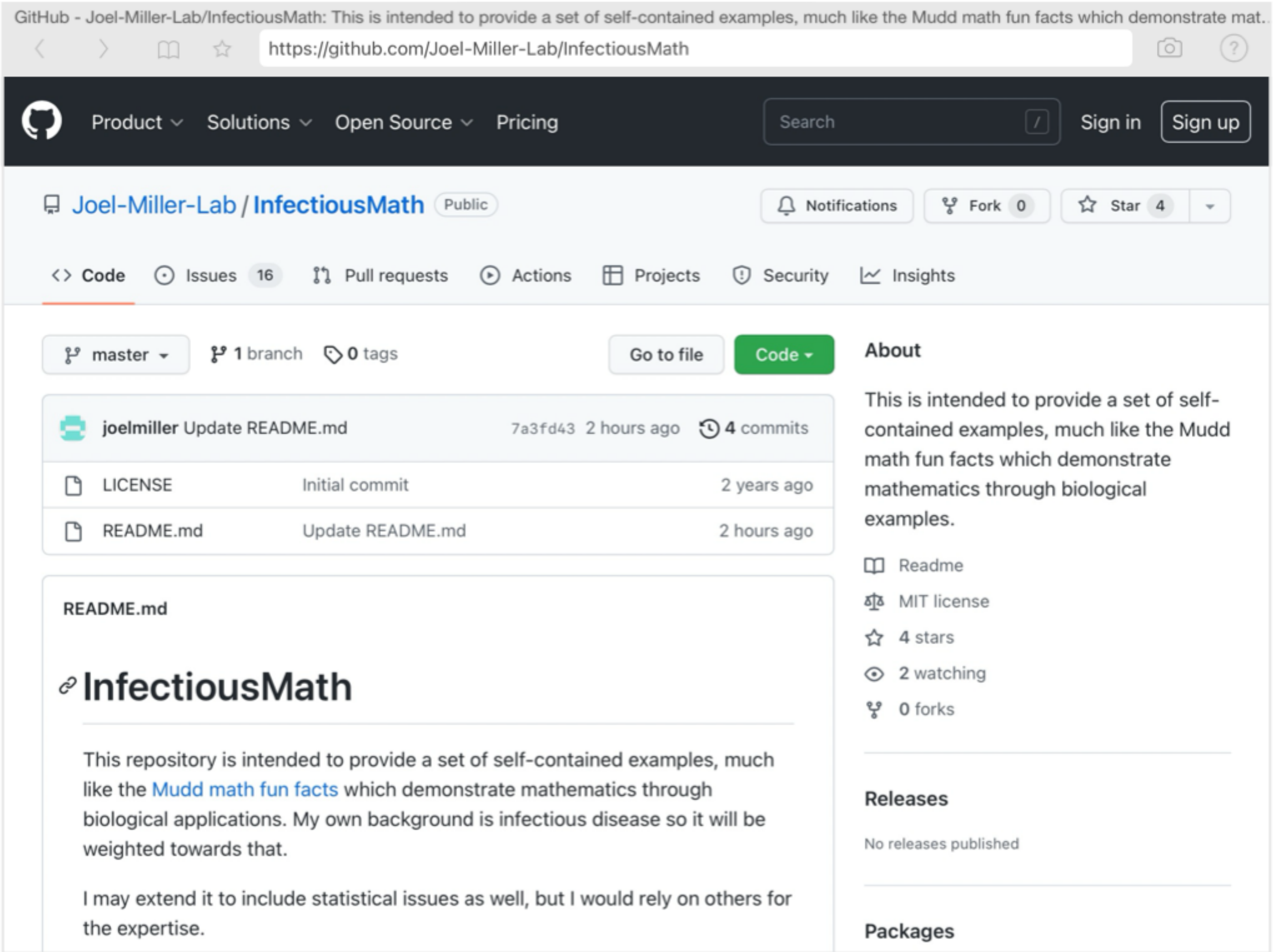
Acknowledgments / shameless plugs / requests for help

Daniel Roberts

Zeb Jamrozik

Pratyush Kollepara





GitHub - Joel-Miller-Lab/InfectiousMath: This is intended to provide a set of self-contained examples, much like the Mudd math fun facts which demonstrate mat...

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joelmiller Update README.md 7a3fd43 2 hours ago 4 commits

LICENSE	Initial commit	2 years ago
README.md	Update README.md	2 hours ago

README.md

InfectiousMath

This repository is intended to provide a set of self-contained examples, much like the Mudd math fun facts which demonstrate mathematics through biological applications. My own background is infectious disease so it will be weighted towards that.

I may extend it to include statistical issues as well, but I would rely on others for the expertise.

About

This is intended to provide a set of self-contained examples, much like the Mudd math fun facts which demonstrate mathematics through biological examples.

Readme

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4 stars

2 watching

0 forks

Releases

No releases published

Packages