Swiss Re

Modelling Covid-19

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Infectious disease modelling – S I R (or S E I R) models

SARS-CoV-2: the virus & its characteristics

Modelling COVID-19

- the main components
- the process
- some key parameters
- the very beginning: the info-void
- challenges

Infectious Disease Modelling

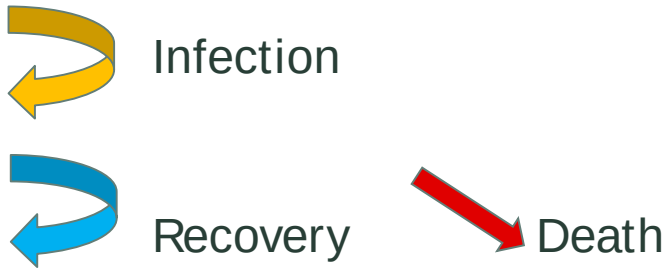
use of SIR to model SARS-CoV-2

STATES:

Susceptible

(immune)

PERHAPS MORE IMPORTANTLY : TRANSITIONS



Infection is affected by:

- number & infectiousness of the “infectors”
- number & susceptibility of the potential “infectees” (susceptibles)
- the number of opportunities for transmission – how these two groups mix
  - presence of the infectors - availability of potential infectees

Infectious Disease Modelling

use of SIR to model SARS-CoV-2

INITIALLY (period where Rt >1)

number of INFECTORS rises

while

number (& %) of SUSCEPTIBLES falls

and

number (& %) of IMMUNE rises

UNTIL (Rt =1)

depletion of SUSCEPTIBLES & population of IMMUNE

is such that

number of new INFECTORS flattens and starts to fall

LATER (Rt <1)

number of INFECTORS drops

while

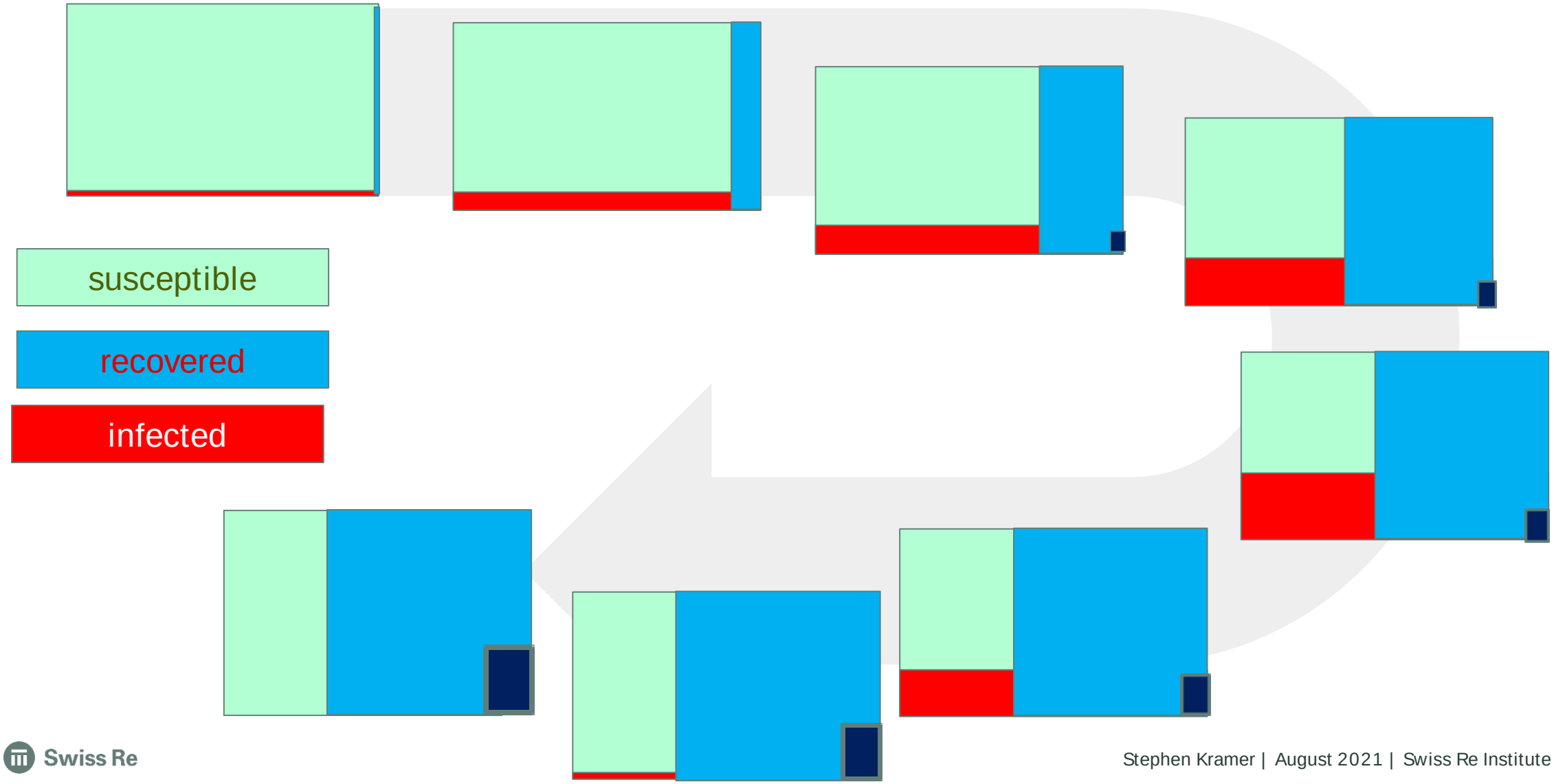
number (&%) of SUSCEPTIBLES also drops

quickly reducing NEW INFECTIONS ultimately ENDING transmission

Infectious Disease Modelling

use of SIR to model SARS-CoV-2

… DIAGRAMATICALLY…….



Modelling SARS-CoV-2 – main components & model uses

3 main aspects of modelling :

- timing, duration and **severity of illness -** determines **burden on health system**
- timing, duration and **level of infectiousness –** determines the **next generation of infections**
- rate of **lethality / IFR** (infection fatality rate) – the most adverse outcome & most important metric

Models: can estimate **attack rate** & **mortality** under various **scenarios**

BUT, more importantly - useful in **developing public health strategy**

- assess **whether containment/ suppression is feasible**
- assess **which interventions** would be **most effective**
  - rapid self-identification & isolation, contact tracing, social distancing, closures of schools or workplaces, etc
- **discovery** – when patterns emerge that are unexpected

modelled relationship between

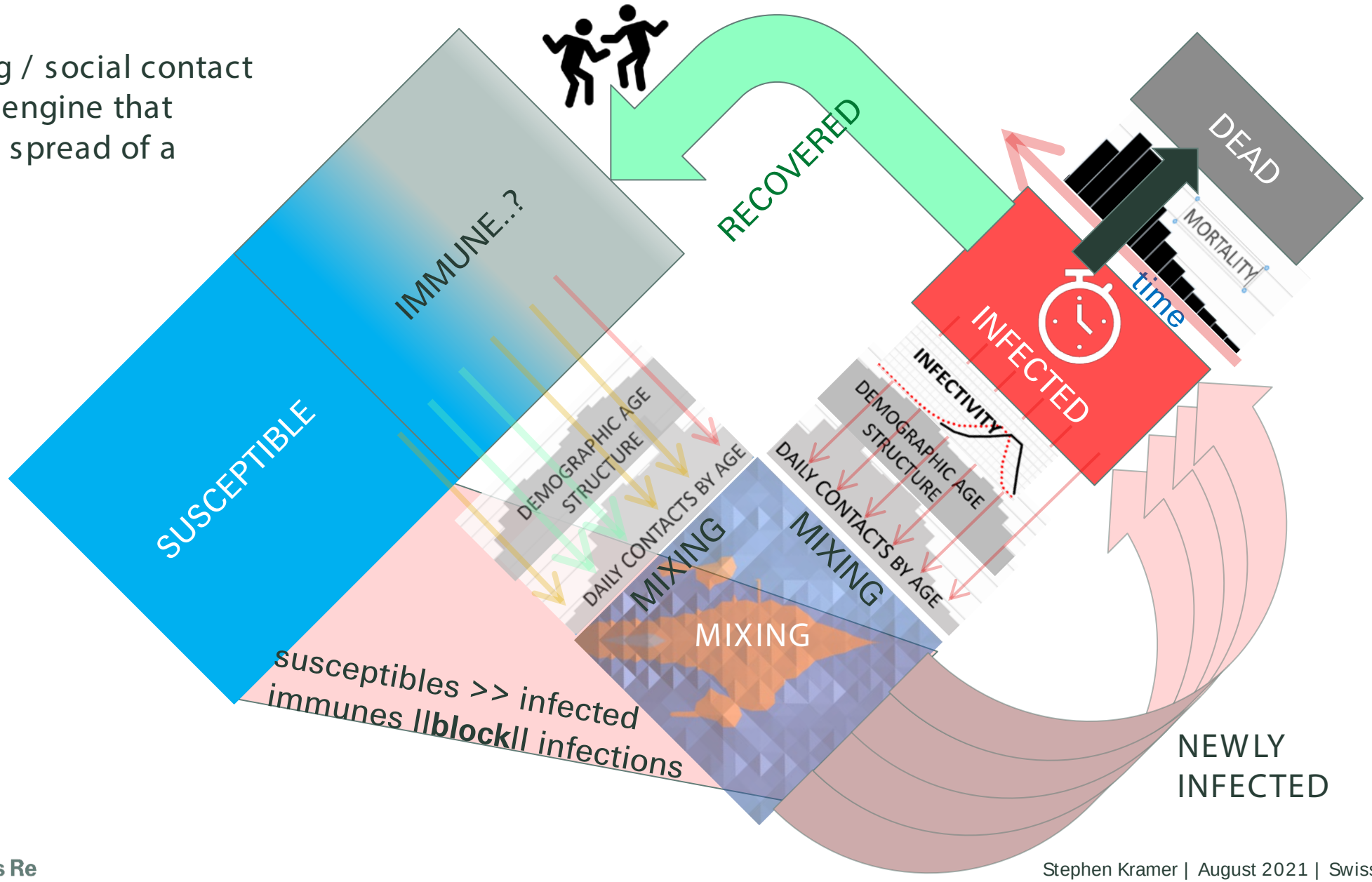
INFECTIOUSNESS & SYMPTOM EMERGENCE

is essential for developing

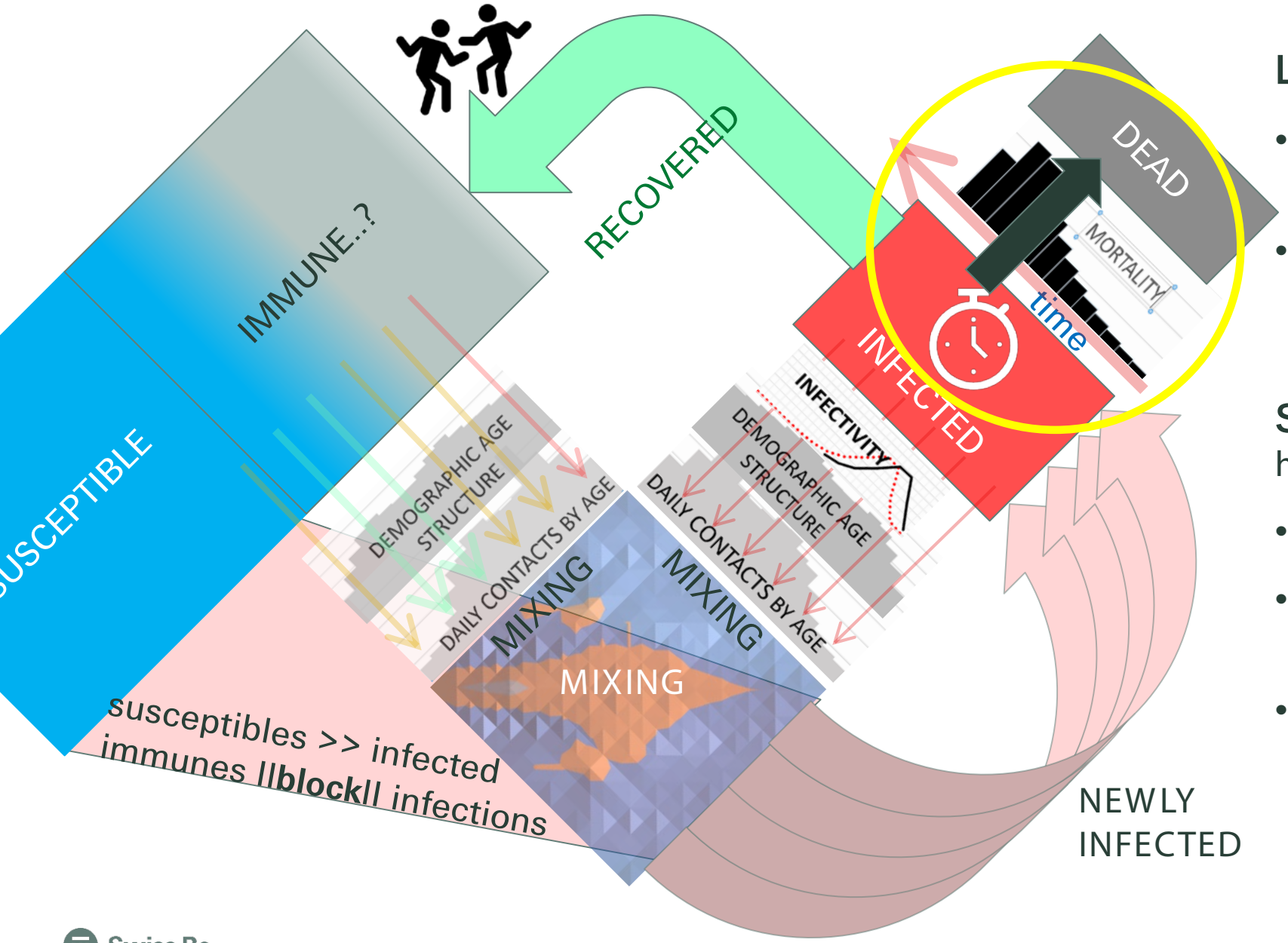
CONTAINMENT STRATEGY

MODELLING COVID-19 – states & transitions

Mixing / social contact is the engine that drives spread of a virus



MODELLING COVID-19 – lethality & severity



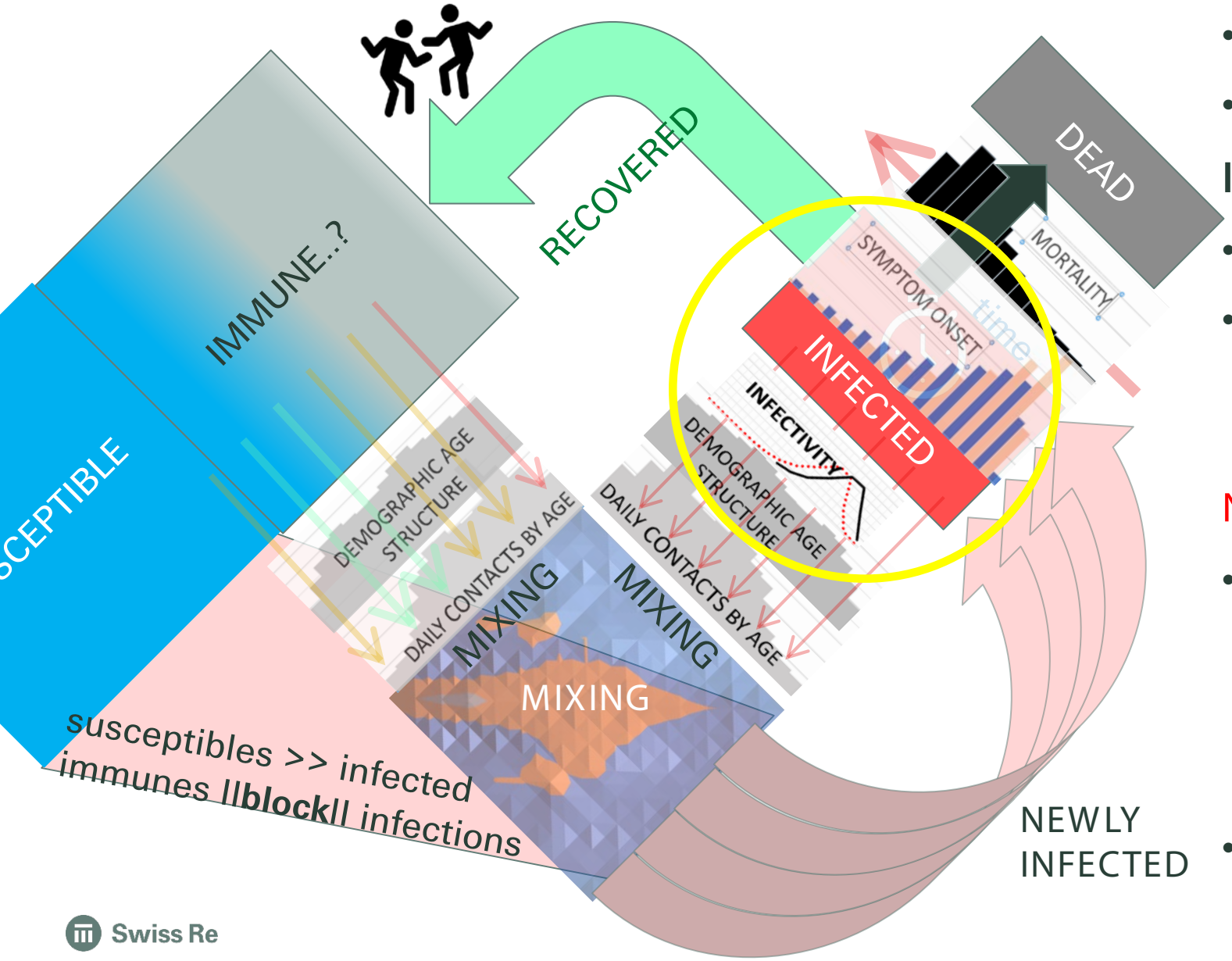
Lethality (death-per-infection)

- age-specific baseline rates across countries
- country-specific factors then added:
  - e.g. conditions which correlate with severe disease

Severity (asymptomatic, mild, hospital, ICU, dead)

- based largely on lethality patterns
- more severe passes less severe levels first
- i.e. all initially asymptomatic, some get symptoms, of which some are hospitalised, etc

MODELLING COVID-19 – incubation & infectivity



Incubation – time to symptoms

- mean of about 6, tail to the right
- for Delta may be closer to 4

Infectivity

- slightly later than incubation
- approx. 41% before symptoms (original virus)

NB for public health modelling

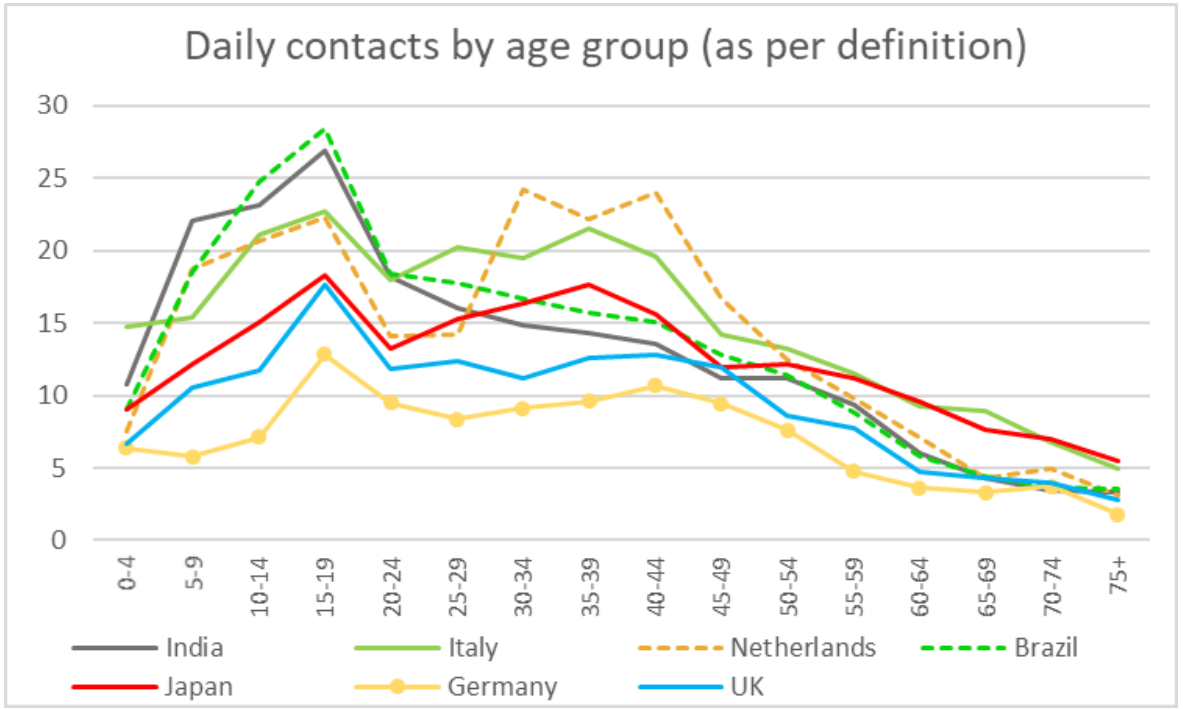
- test effect of interventions on transmission
  - model must be accurately set up
  - e.g. rapid self-identification & isolation
  - contact tracing
- important in assessing possibility of containment

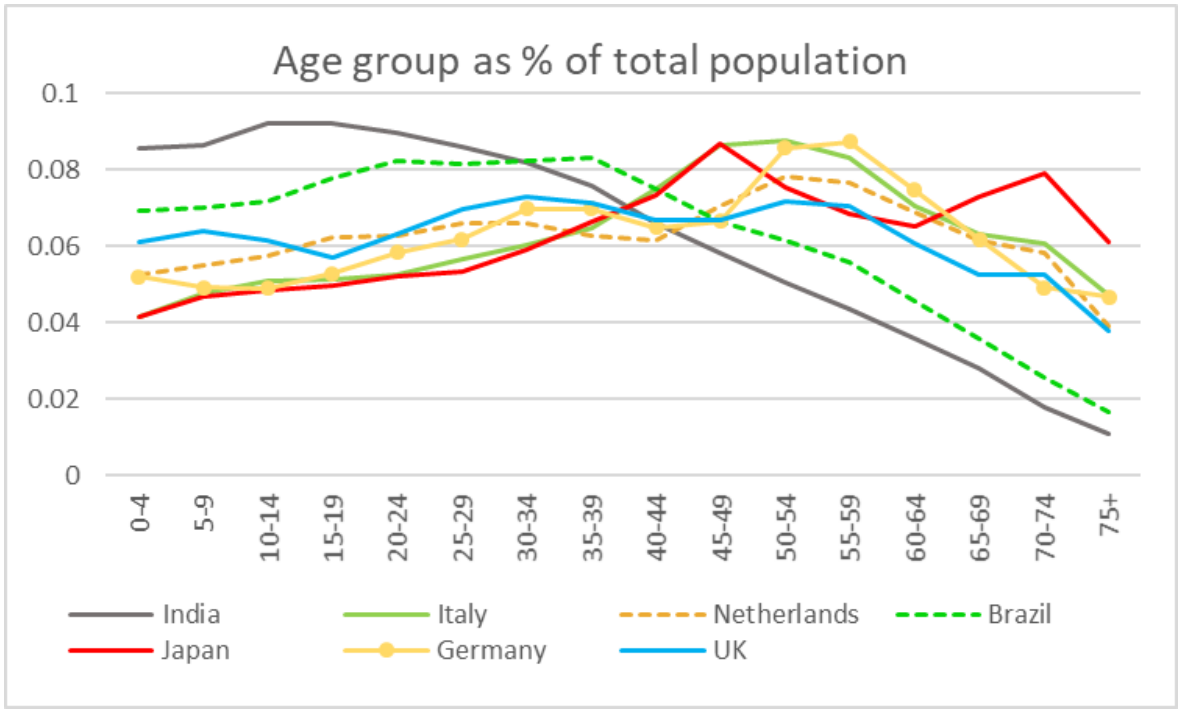
Modelling SARS-CoV-2: R_0

R0 is not a single number across countries

- mixing behaviours &
- demographic structure (age profile)
- for the Delta variant it's about 2X

est. R0 values – original strain		
Country	Age structure effect only	Age structure & mixing effects
USA	3.16	2.85
UK	3.13	2.16
Canada	3.10	2.85
China	3.10	3.10
India	3.44	3.48
Australia	3.17	2.91
Netherlands	3.07	3.18
Italy	3.04	3.31
South Africa	3.44	3.53
Japan	3.00	2.69
South Korea	3.11	2.92
France	3.09	2.69
Malaysia	3.41	3.42
Singapore	3.10	3.08
Germany	3.05	1.58





Modelling SARS-CoV-2 – the earliest days and weeks

Human or animal virus?

- Chinese authorities said it was zoonotic, despite some infected having no links to the market in Wuhan
- TRIGGER to model – cases with no links to zoonotic source, therefore a novel human virus

Will it spread globally, or can it be contained?

- at the time of discovery, this is practically the ONLY question
- CONTAINMENT depends on a few crucial factors:
  - pre-symptomatic transmission:
    - timing: is a person infectious before symptoms emerge
    - if so, how long before? & how infectious?
  - asymptomatic transmission:
    - is there, and if so what proportion of onward infection is asymptomatic?

WHAT VIRUSES ARE SIMILAR?

Closest known viruses: SARS1 & MERS

SARS: identified February 2003 (China)

- 8098 (known) cases ;774 deaths
- 9.6% CFR
- **infectious ONLY when symptomatic**
- **most infectious in the second week**

The hunt for reliable data begins, and never stops.

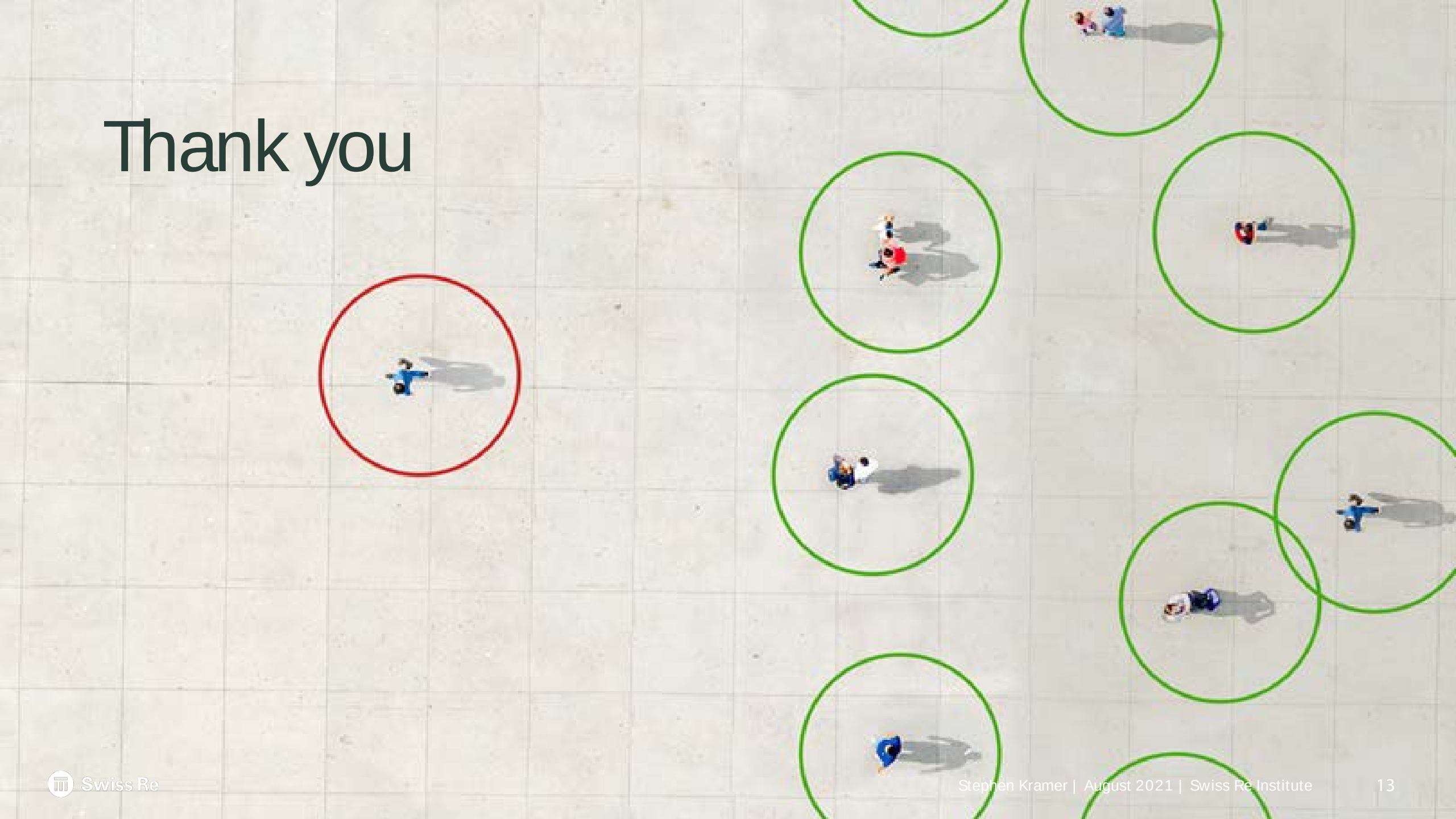
CHALLENGES

Communication with the public

- its widely know that models are used BUT they're not understood & not trusted
- the age-old public health problem
  - "… but there are so few deaths, so why all these severe measures…"
  - when its precisely the measures that lead "so few deaths"
  - the only way of knowing how bad it might have been is by modelling

When illness is averted and lives are spared, "nothing happens and all you have is the miracle of a normal, healthy day," says Howard Koh, a public-health professor at Harvard. "People take that for granted." Public-health departments are chronically underfunded because **the suffering they prevent is invisible**. Pandemic preparations are deprioritized in the peaceful years between outbreaks.

Thank you



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