Infectious disease epidemiology in principle

Prof. Sukhyun Ryu

1 September 2025

가톨릭대학교
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ONE HEALTH Lab
with Computational Epidemiology

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Surveillance

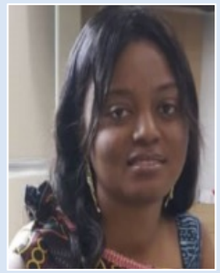
- Surveillance Medical Officer at the Korea Disease Control and Prevention

Control

- Field Epidemiologist at the Provincial Government

Research

- Research Fellow at the WHO CC, Infectious disease epidemiology and control, HKU



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1. Case study
2. Epidemiology
3. Infectious disease epidemiology
4. Parameters in ID epidemiology
5. Epidemics in theory

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1 Case-study

https://youtu.be/gByW9gtkIrI?si=vk4rAD_-gT95BWPp

1 Case-study

Scarlet fever is commonly known to affect children aged 2–8 years.

Recently, we have identified a larger number of cases of scarlet fever among school-aged children.

Clinicians

Are we currently observing a shift in the age distribution of scarlet fever?

1 Case-study

Epidemiologist

- Now, you collect the dataset between 2016 and 2025 from two regions where scarlet fever is designated as a notifiable disease.

1 Case-study

Epidemiologist

- Kindly explore the dataset and present the results at the next meeting with clinicians and the public.
- Your presentation should be less than 2 minutes.

1. Case study
2. **Epidemiology**
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2 Epidemiology

What is Epidemiology?

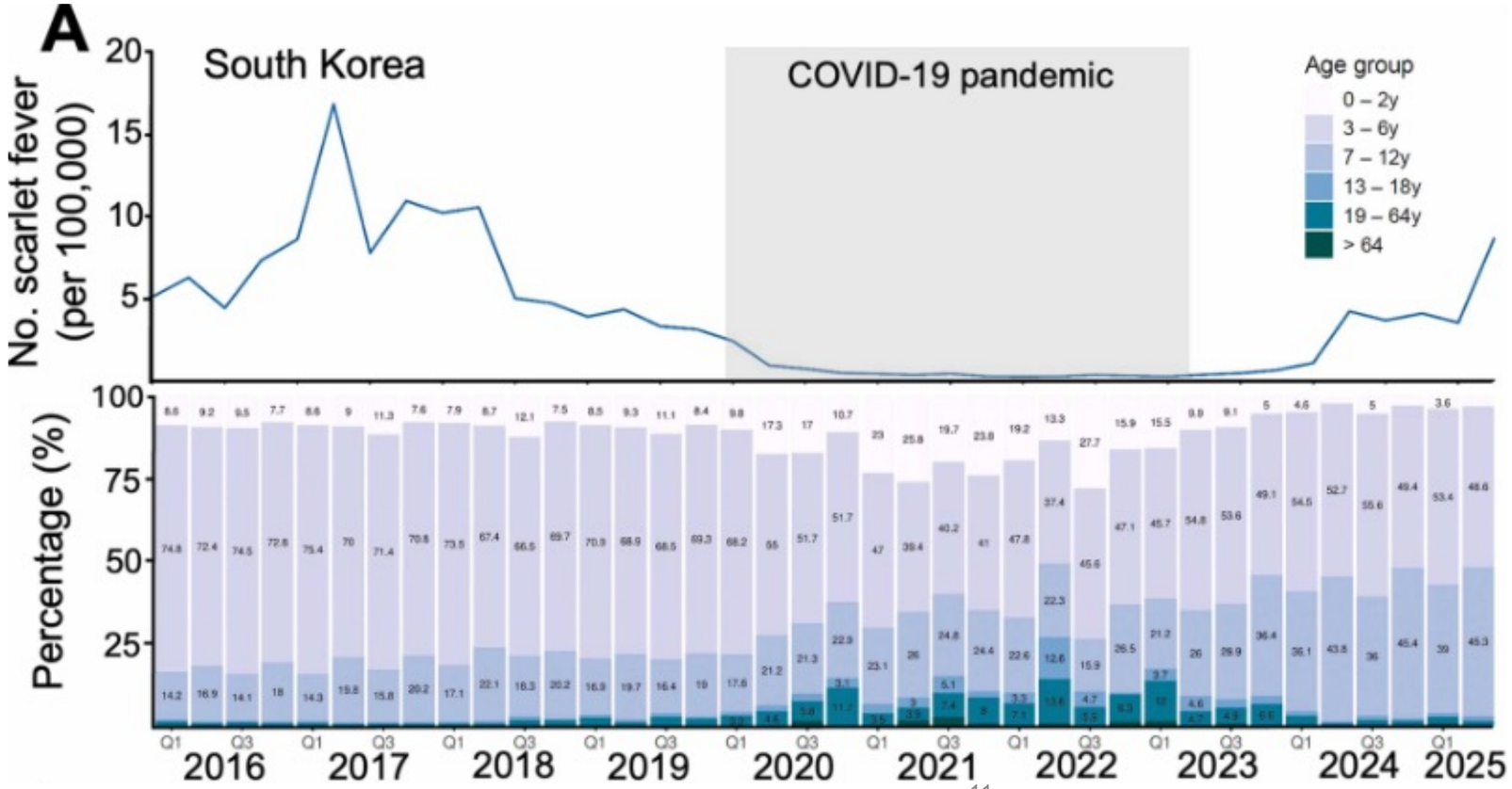
2 Epidemiology

The study of how disease is distributed in populations and the factors that influence or determine this distribution.

Gordis Epidemiology, 6th Ed. 2p

2 Epidemiology

The study of how disease is distributed in populations and the factors that influence or determine this distribution.



Lee EW, et al. *J Infect.* 2025.

2 Epidemiology

Epidemiology is a quantitative discipline that relies on

- probability,
- statistics,
- sound research methods.

Age group	0–2	3–6	7–12
South Korea			
2016–2019	9.1%	71.0%	17.7%
2024–2025	3.4%	52.4%	40.9%
P-value	<0.001†	<0.001†	<0.001†

†*t*-test

Lee EW, et al. J Infect 2025.

Field Epidemiology, 3rd Ed. 16p

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3 Infectious Disease Epidemiology

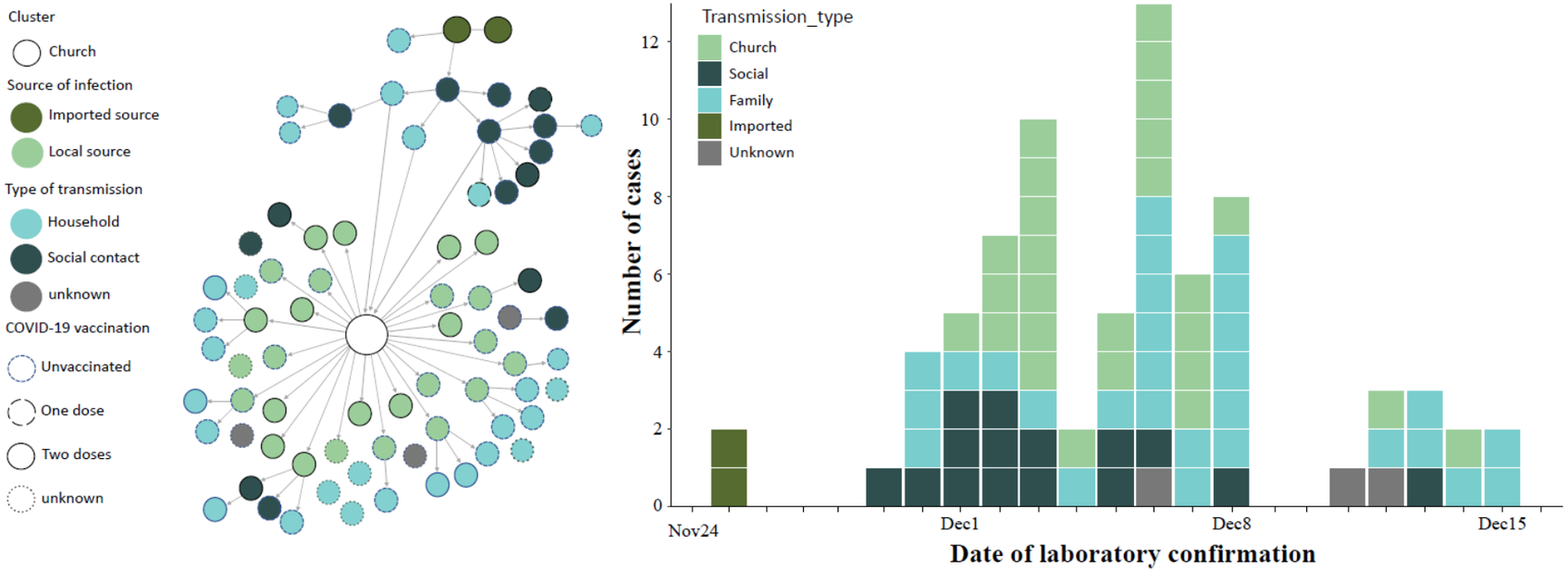
What is the special feature of ID epidemiology?

What makes ID epidemiology special?

1. Transmission

- A case may also be a risk factor

- A case may be a source without being recognized as a case

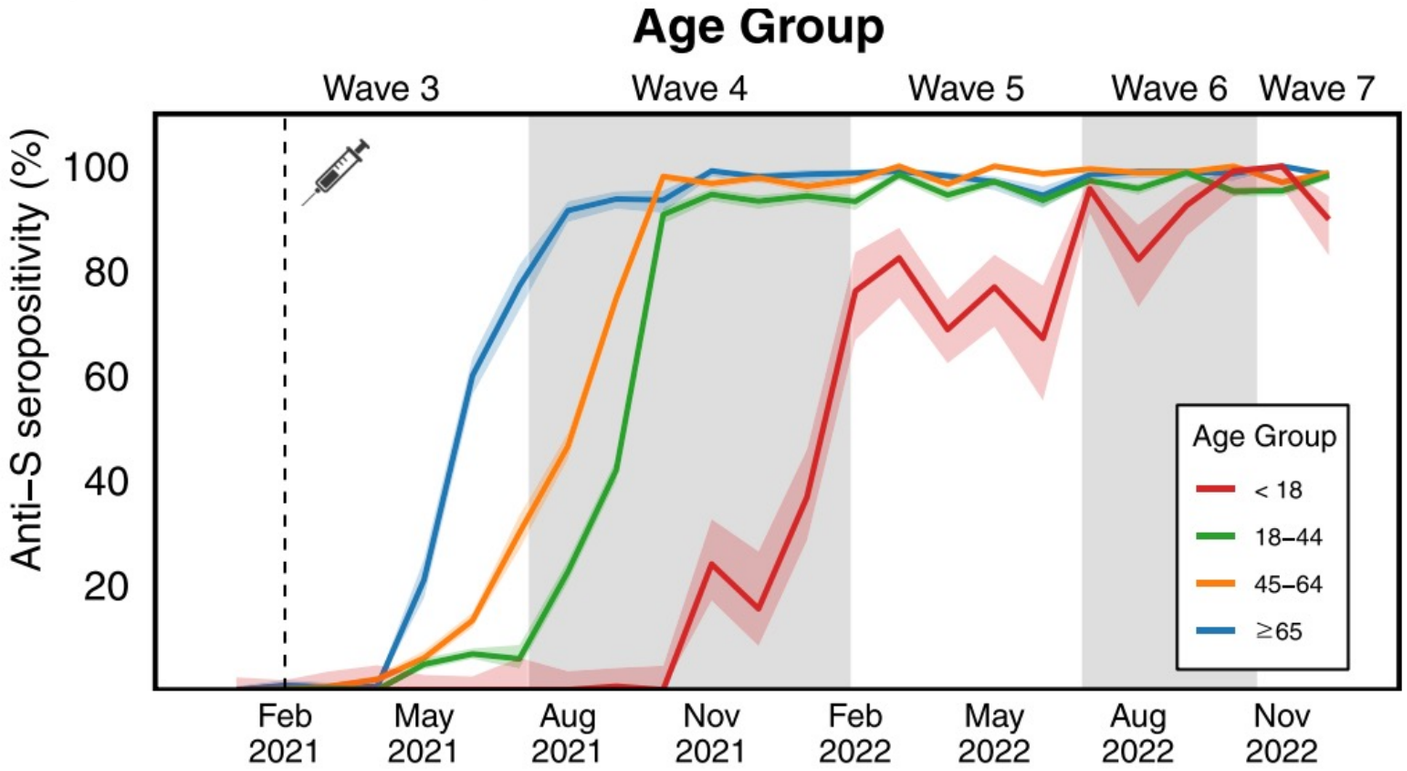


Kim D, et al. *Viruses.* 2023

What makes ID epidemiology special?

2. Immunity

- Dynamic susceptibles



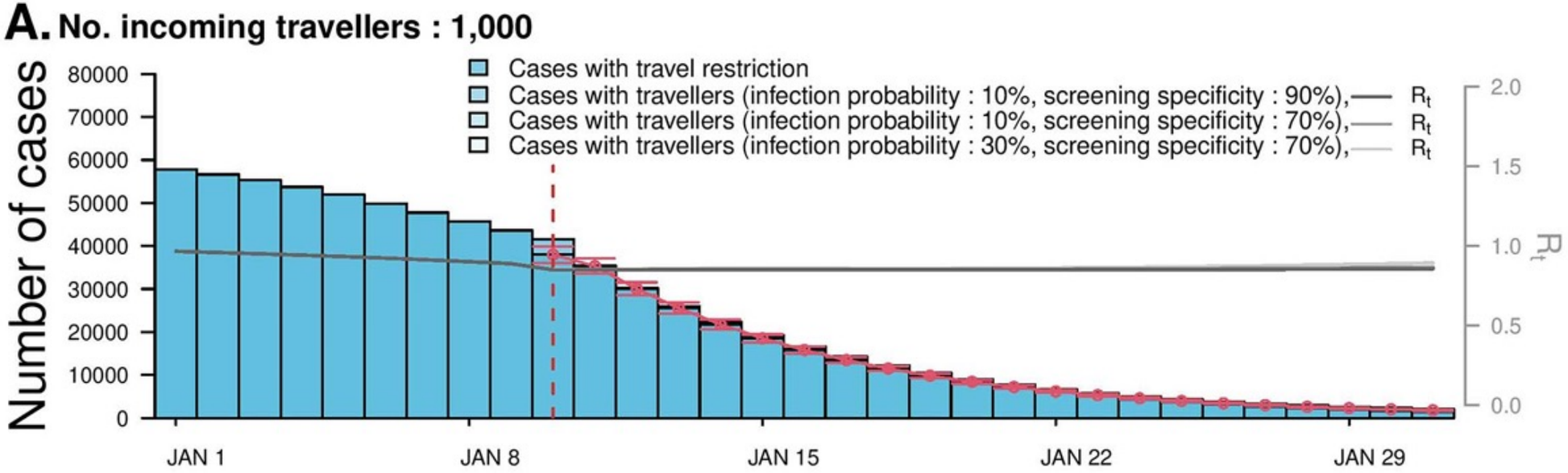
Kim AR, et al. *IORV*. 2025

What makes ID epidemiology special?

3. Urgency

Rapid Communication

Impact of travel restrictions for travellers from China on the internal spread of SARS-CoV-2 in South Korea



Han C, et al. *J Travel Med*. 2023

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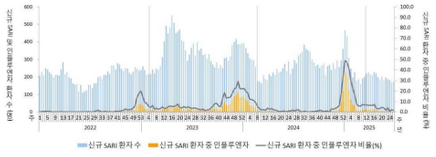
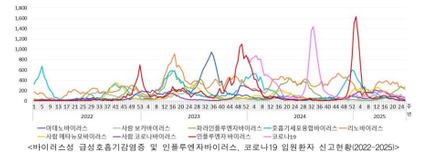
4 Parameters in Infectious Disease Epidemiology

Population-based data from sentinel surveillance

Hospitalization from SARI

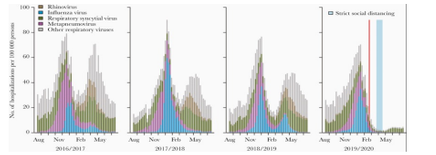


Hospitalization from ARI



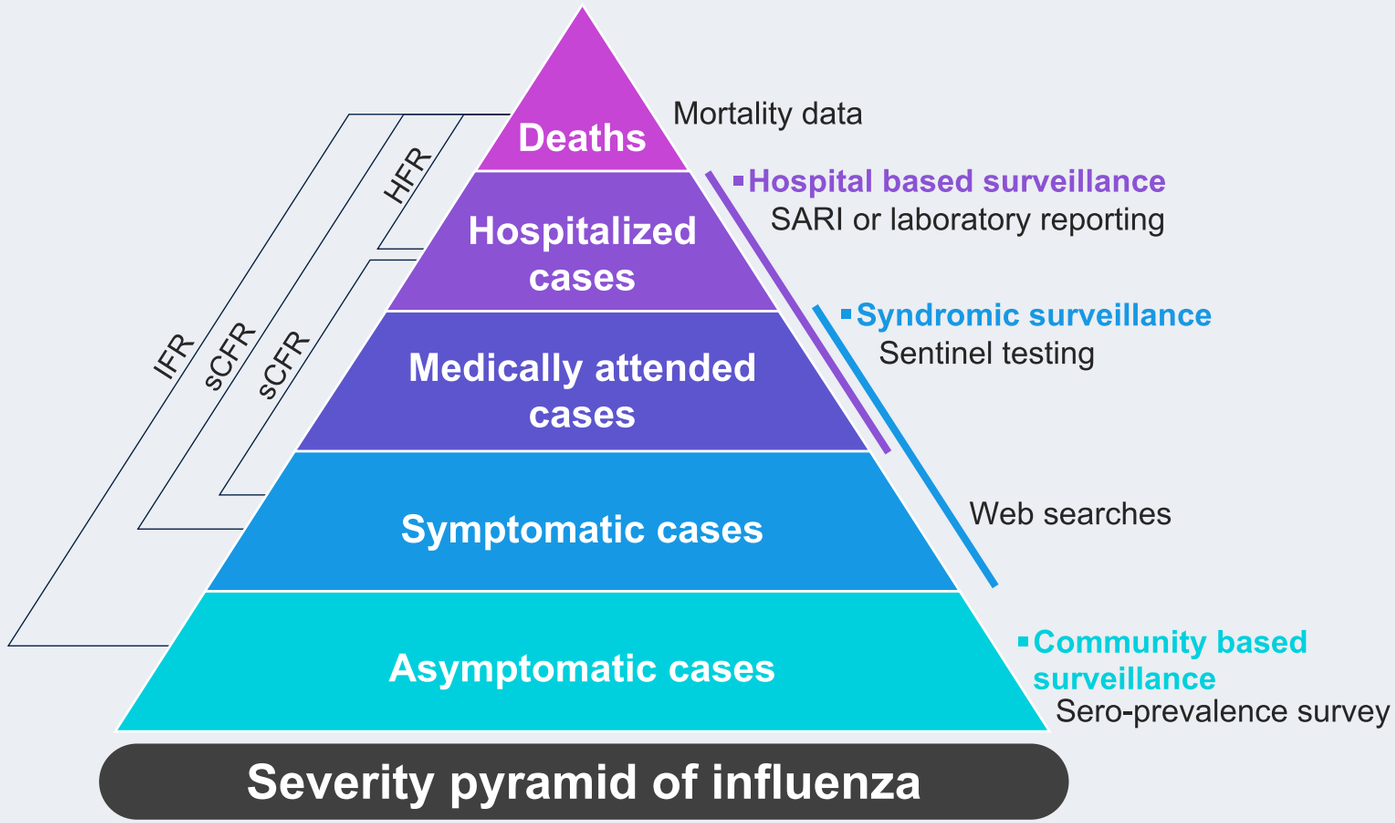
<바이러스성 급성호흡기감염증 및 인플루엔자바이러스, 코로나19 입원환자 신고현황(2022-2025)>

Hospitalization from ARI



Pathogen-based surveillance

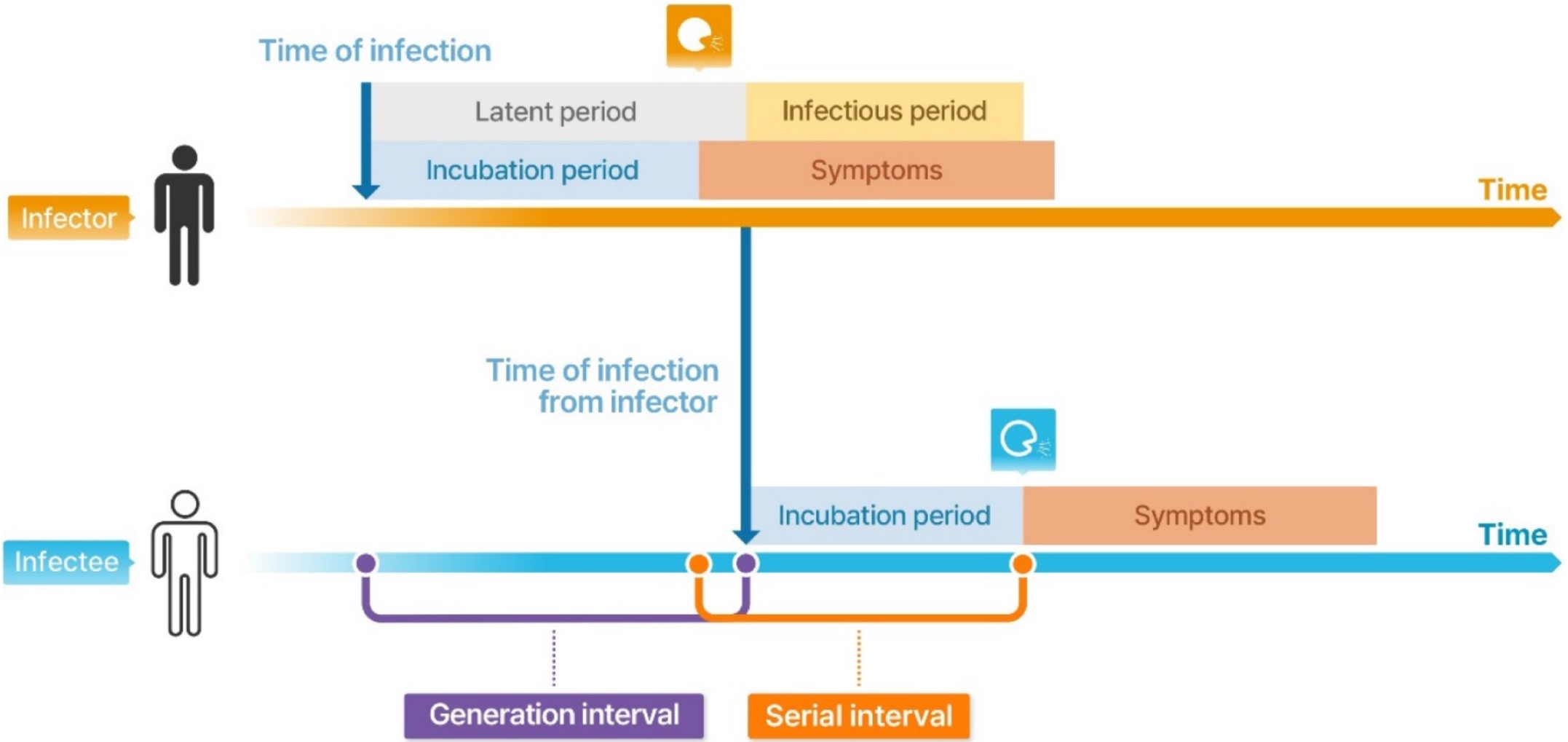
Parameters in ID epidemiology



Severity pyramid of influenza

※ 근거문헌: Ryu S et al, Cold Spring Harbor Perspectives in Medicine. 2020
Ryu S et al. Viruses 2022

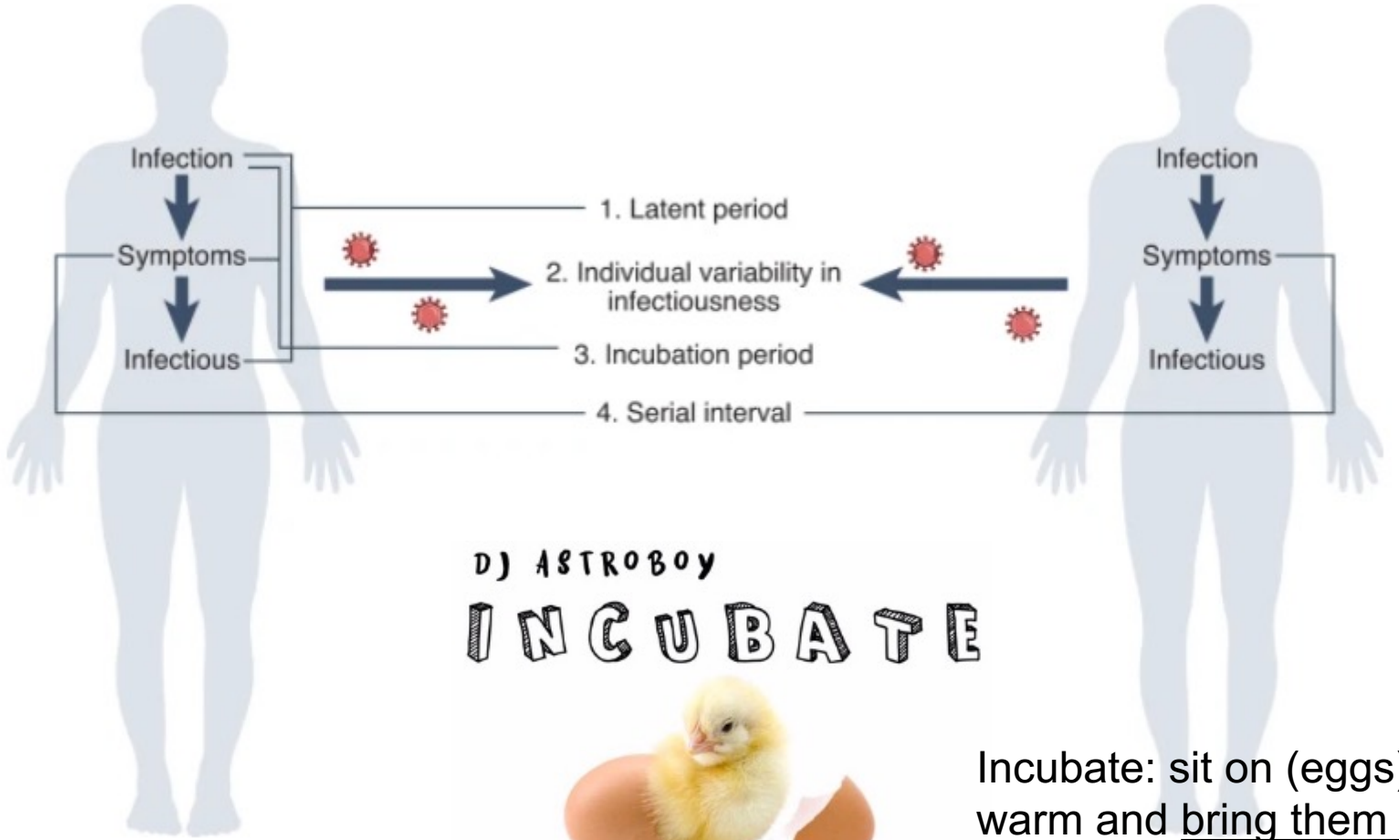
4 Parameters in Infectious Disease Epidemiology

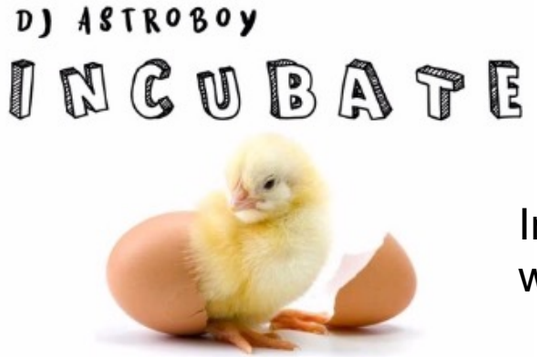


Incubation period

4 Parameters in Infectious Disease Epidemiology

Fig. 1: Epidemiological parameters of SARS-CoV-2 transmission.





Incubate: sit on (eggs) in order to keep them warm and bring them to hatching

Kraemer MUG et al., 2022 *Nat Med.*

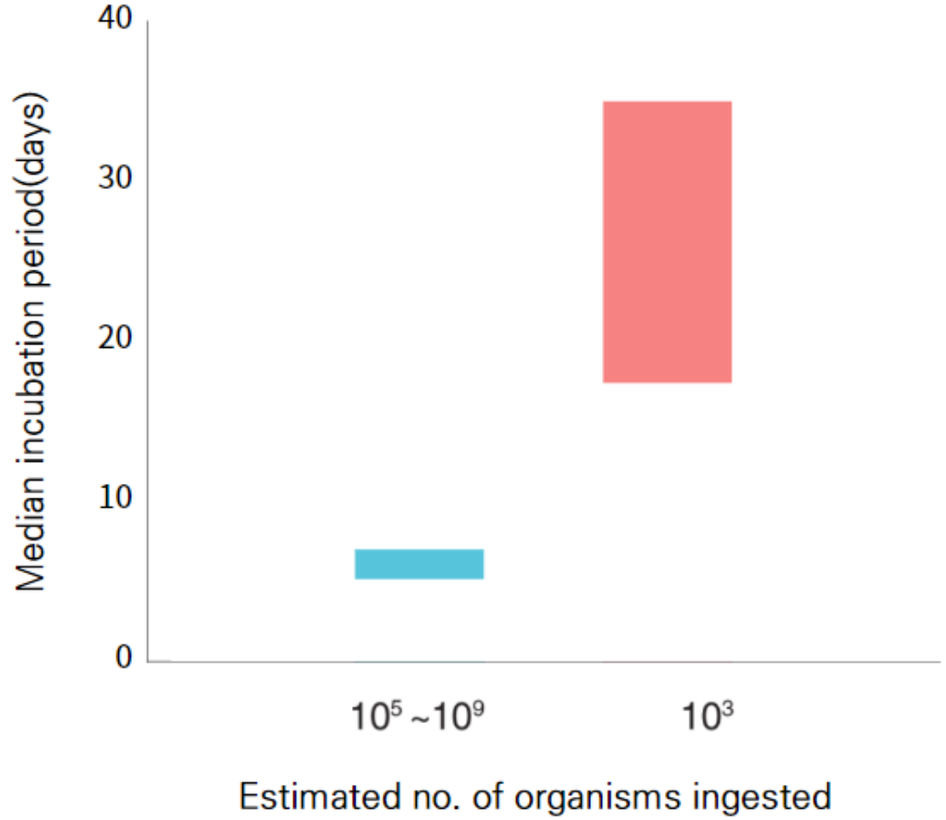
Is incubation period a constant across individuals or vary?

4 Parameters in Infectious Disease Epidemiology

The incubation period can vary substantially among individuals:

- Route of infection, dose of infection
- Host genetics, age, immunity
- Intervention (e.g. pharmacologic prophylaxis and treatment)

Larger dose of Salmonella typhi is associated with shorter incubation period



Blaser et al Review of Inf Dis 1982

4 Parameters in Infectious Disease Epidemiology

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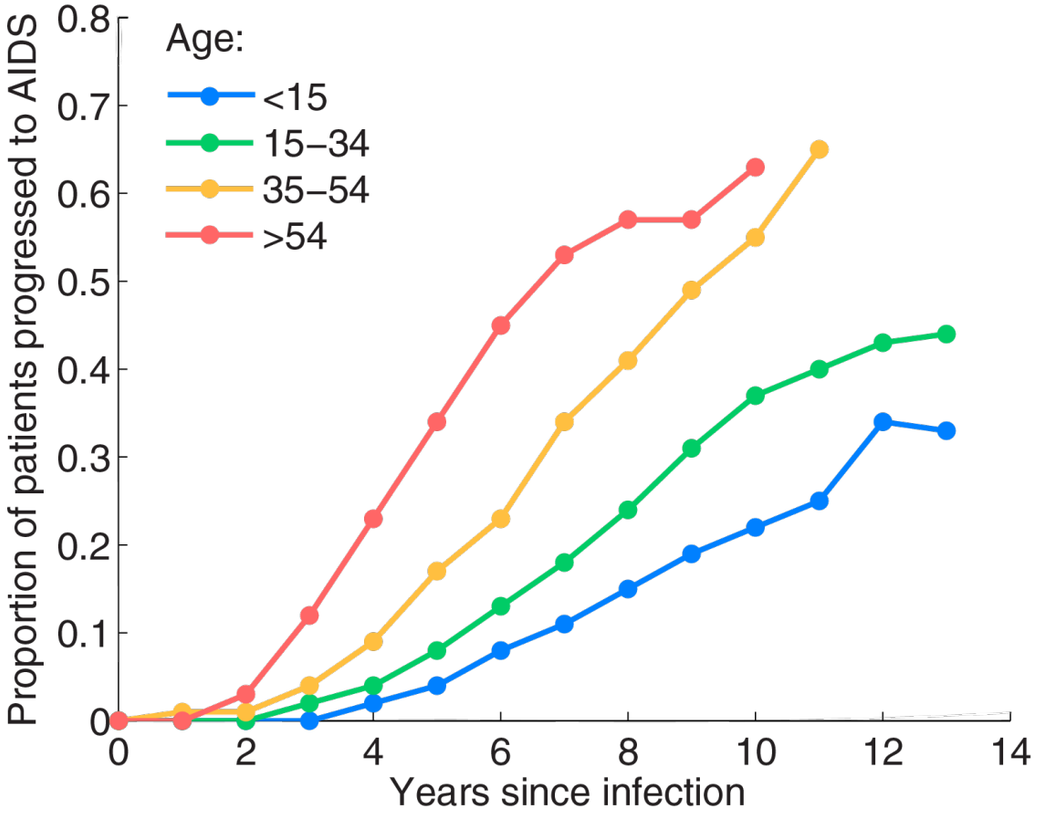
- Host genetics, age, immunity
- Intervention (e.g. pharmacologic prophylaxis and treatment)

Younger patients have longer incubation period for AIDS



Darby et al Lancet 1996

4 Parameters in Infectious Disease Epidemiology

The incubation period can vary substantially among individuals:

- Route of infection, dose of infection
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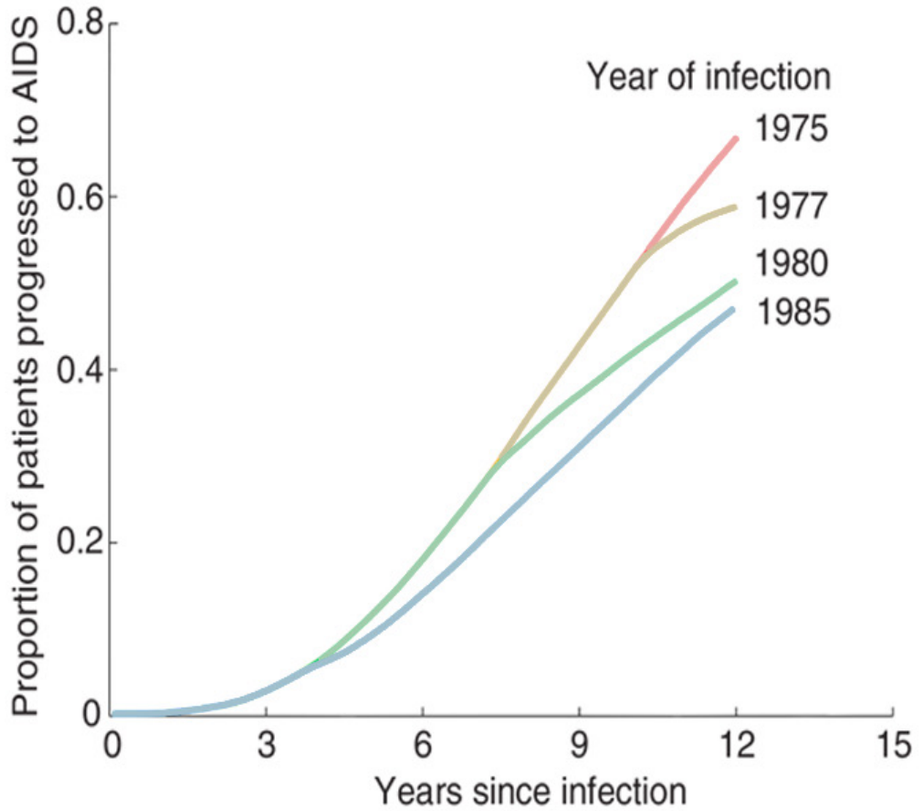
Antiretroviral therapies lengthen the incubation period of AIDS



Broomeyer et al Science 1991

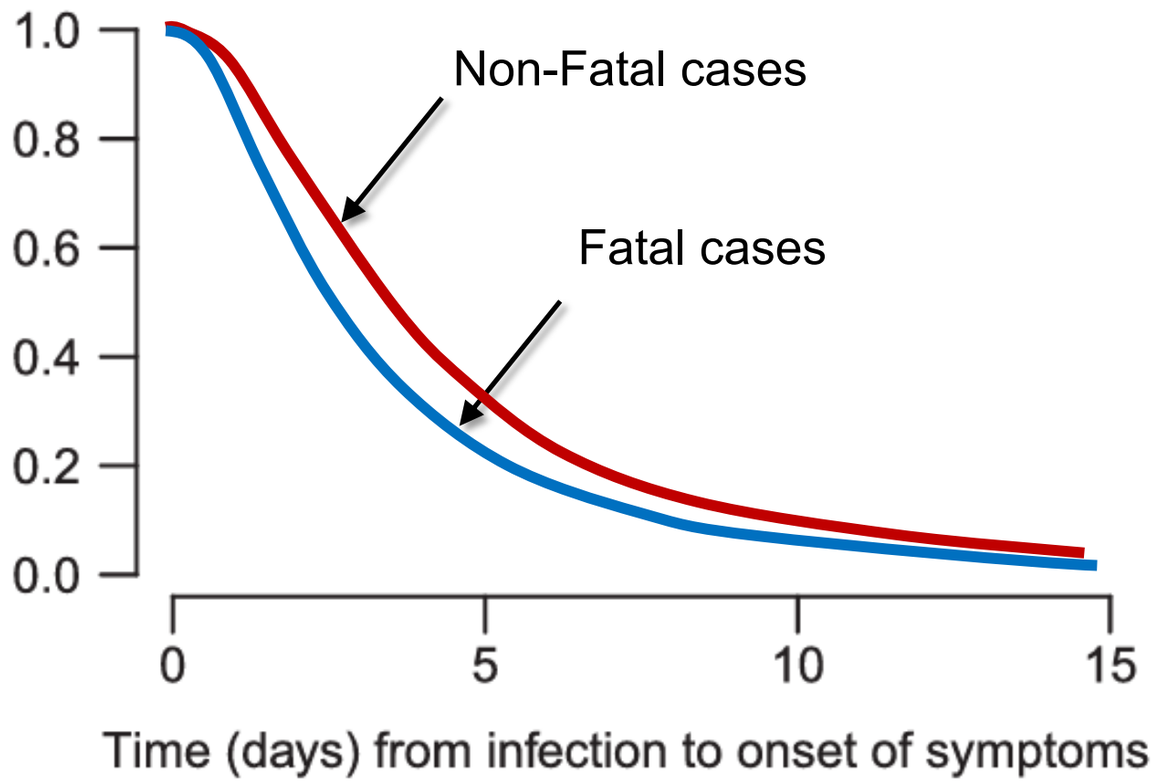
4 Parameters in Infectious Disease Epidemiology

How incubation period of individuals or population can be applied in the clinical or outbreak settings?

4 Parameters in Infectious Disease Epidemiology

For clinical management

- To predict disease severity, e.g. shorter incubation time is associated with more severe outcome

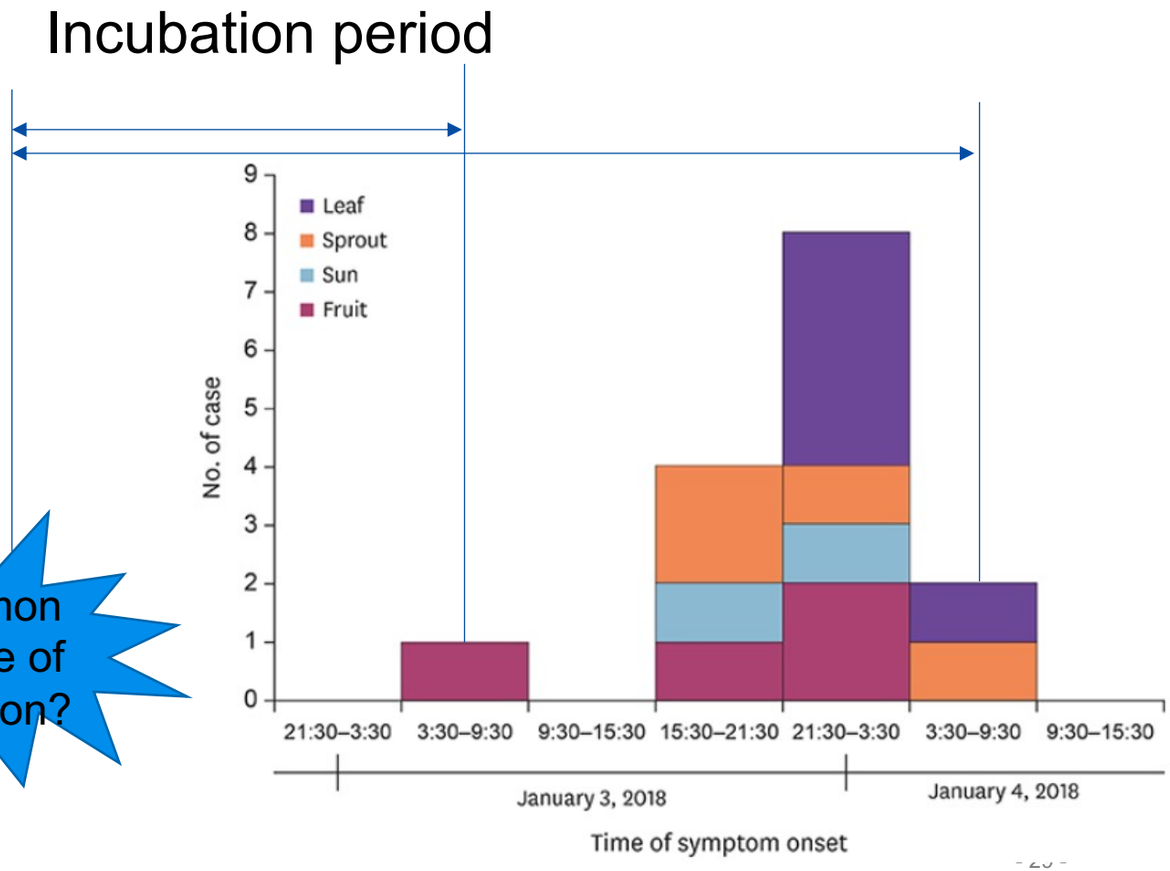


Virlogeux V, et al. Epidemiology 2015

4 Parameters in Infectious Disease Epidemiology

For public health control

- To identify the origin of common-source outbreaks



Common source of infection?

Kim S, et al. Infect Chemother 2019

4 Parameters in Infectious Disease Epidemiology

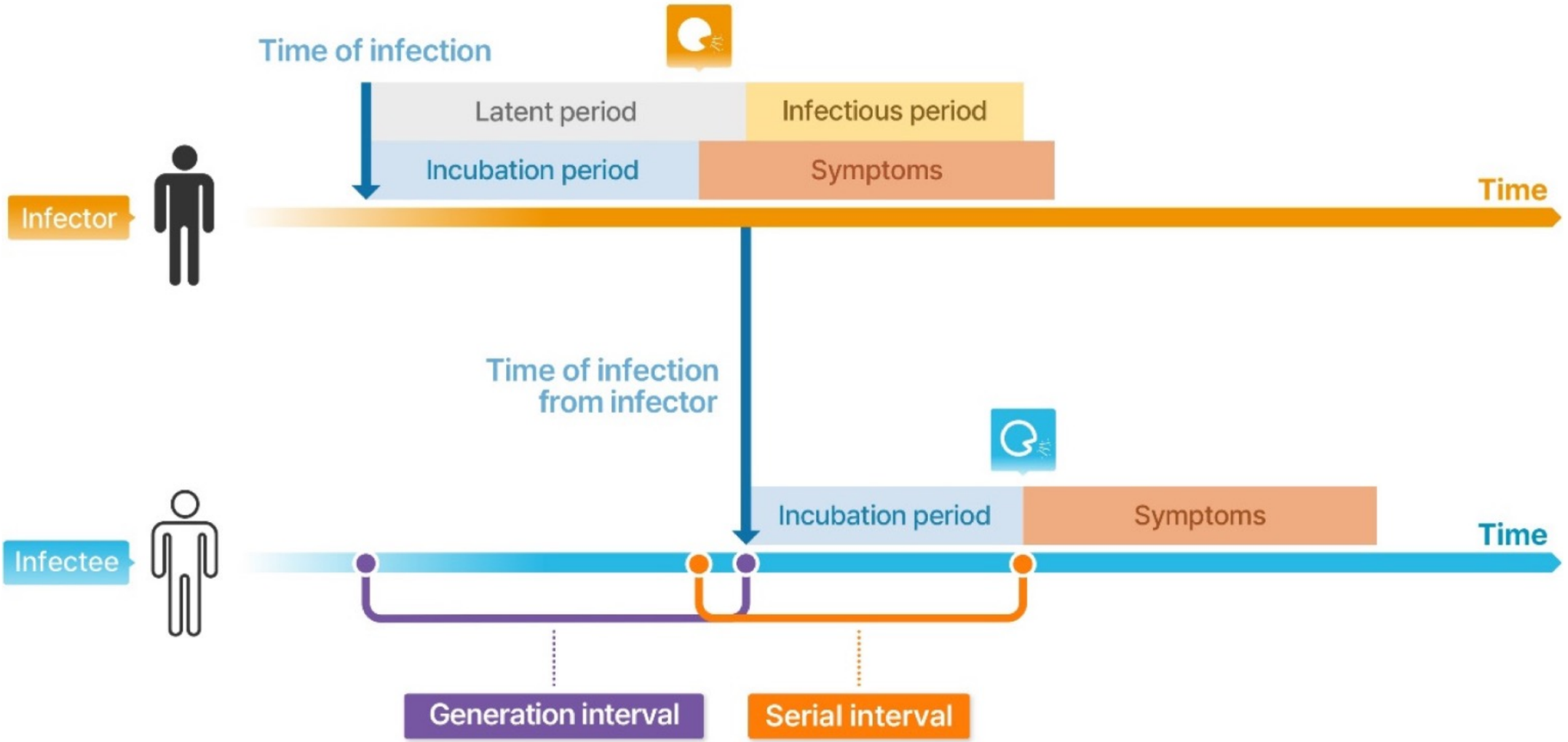
For public health control

- To estimate the duration necessary for quarantining suspected or contacts of cases to ensure that they are not infected upon release

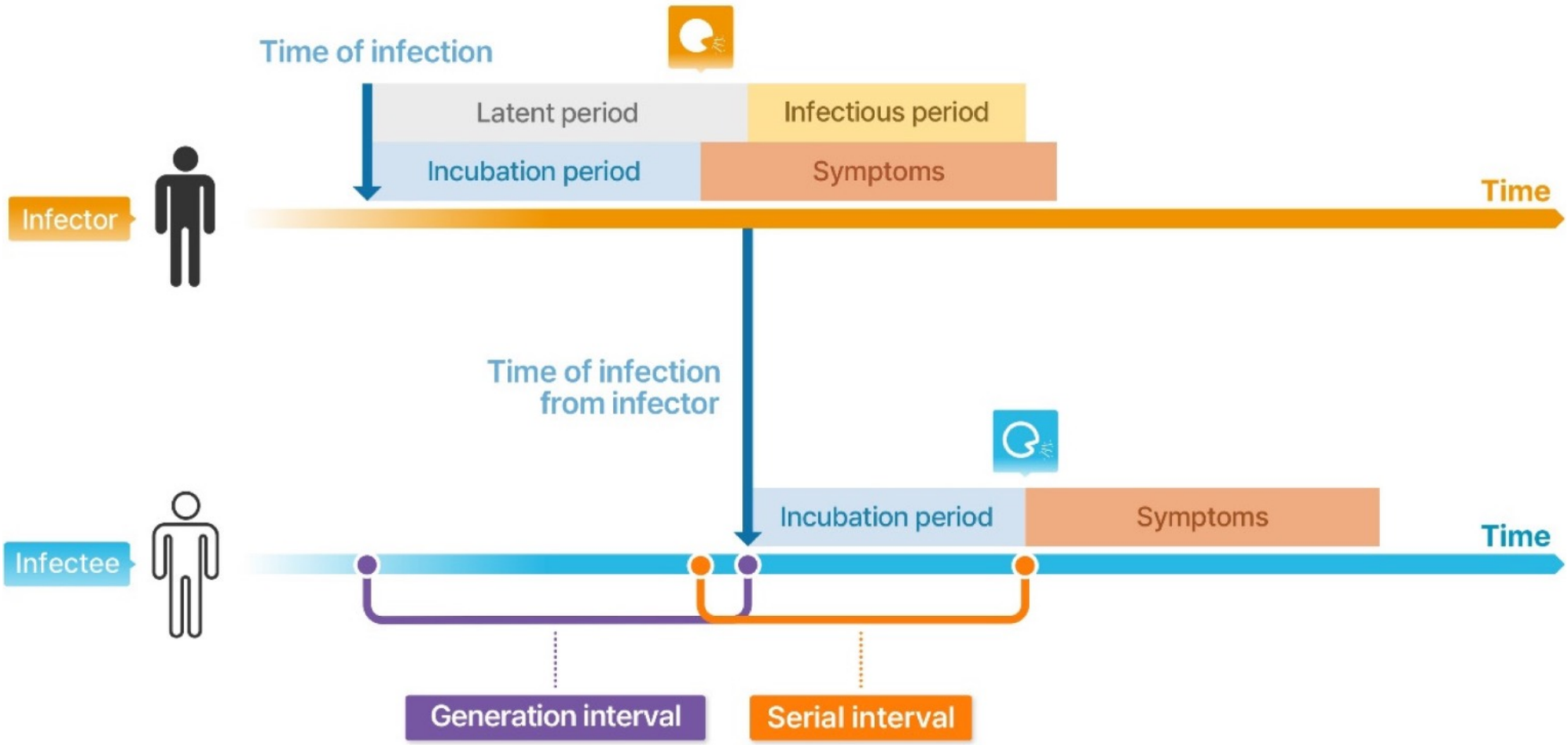
4 Parameters in Infectious Disease Epidemiology

- You collect the linelist from the outbreak investigation.
- Kindly explore the dataset and present the incubation period of the population (mean, median, and min-max) at the next meeting with clinicians and the public.
- Your presentation should be less than 2 minutes.

4 Parameters in Infectious Disease Epidemiology



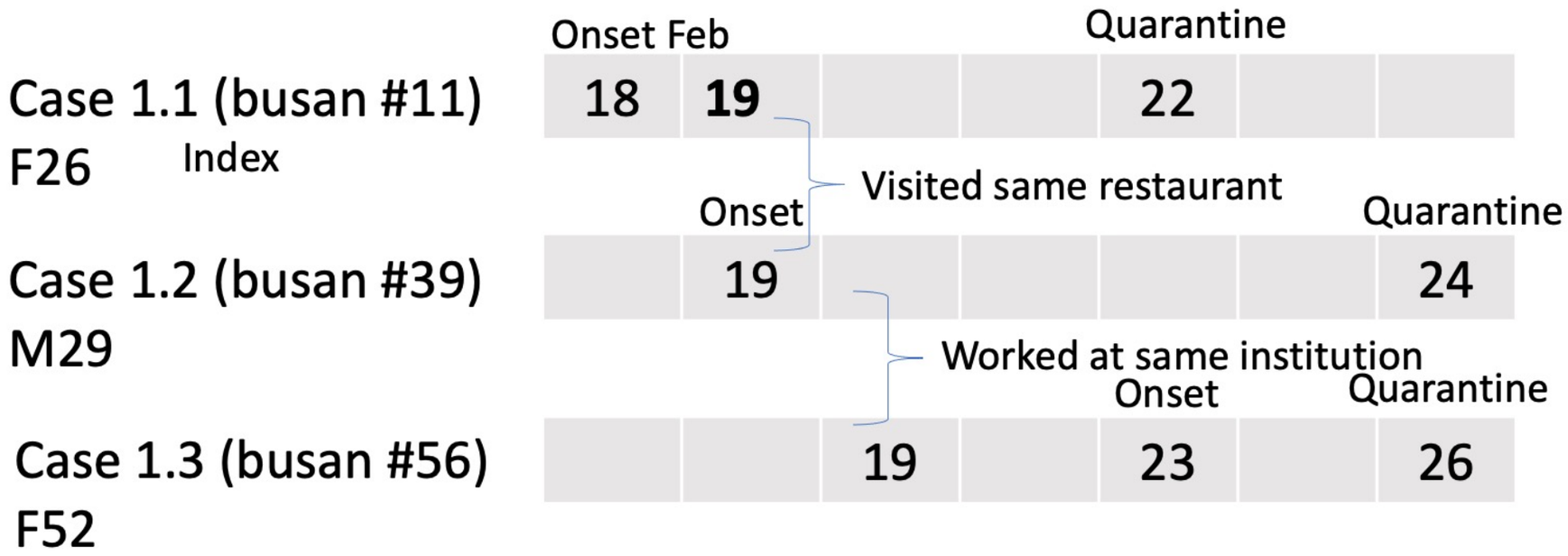
Serial Interval



Parameters in Infectious Disease Epidemiology

Serial interval

The time between successive cases in a chain of transmission.



Ryu S, et al. 2020 Emerg Infect Dis.

4 Parameters in Infectious Disease Epidemiology

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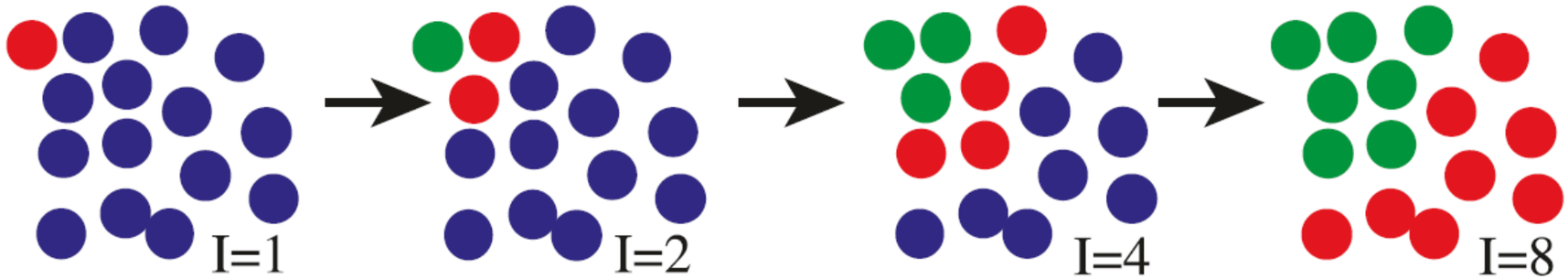
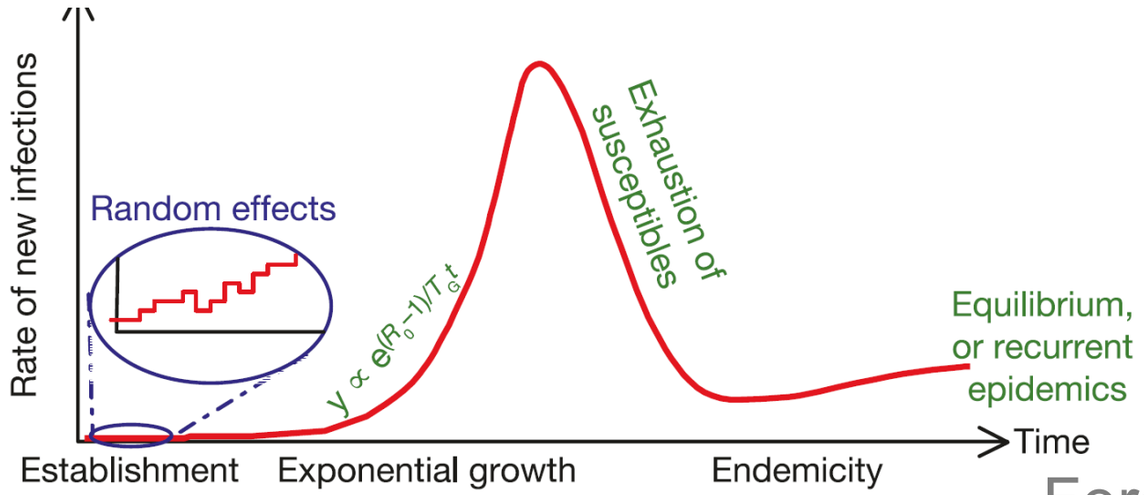
5 Epidemics: Basic theory

1. Individuals affected by an epidemic move through a no. of infection states

2. Epidemics are spread through contact



3. Chain reaction



4. Control

Ferguson, et al. 2003 Nature

5 Epidemics: Basic theory

1. Individuals affected by an epidemic move through a no. of infection states

Ferguson, et al. 2003 Nature

5 Epidemics: Basic theory

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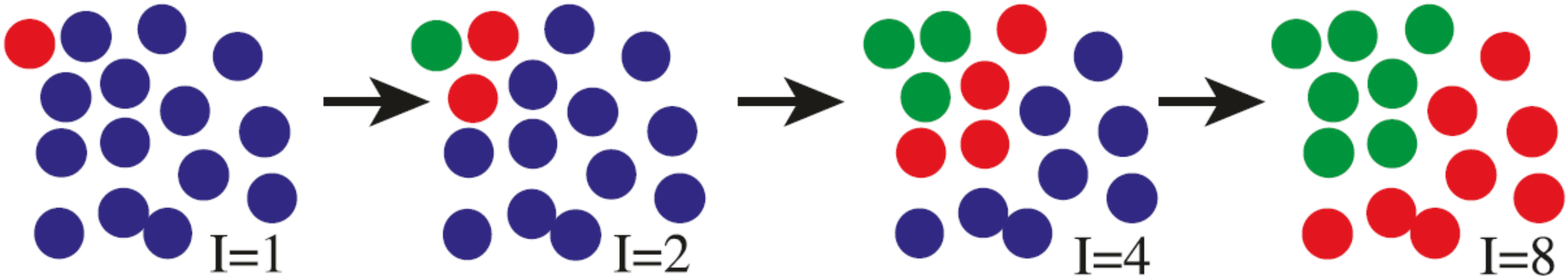
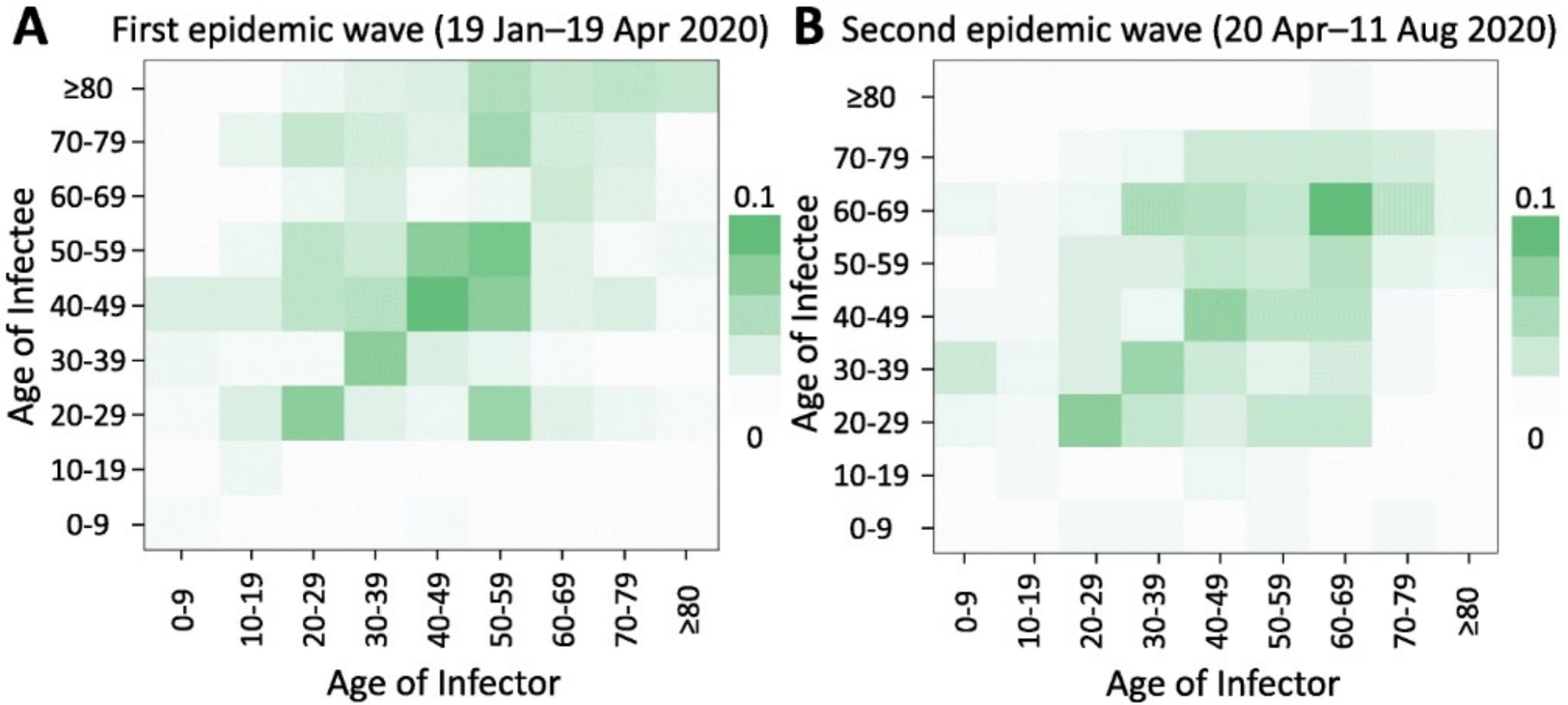


Ferguson, et al. 2003 Nature

5 Epidemics: Basic theory

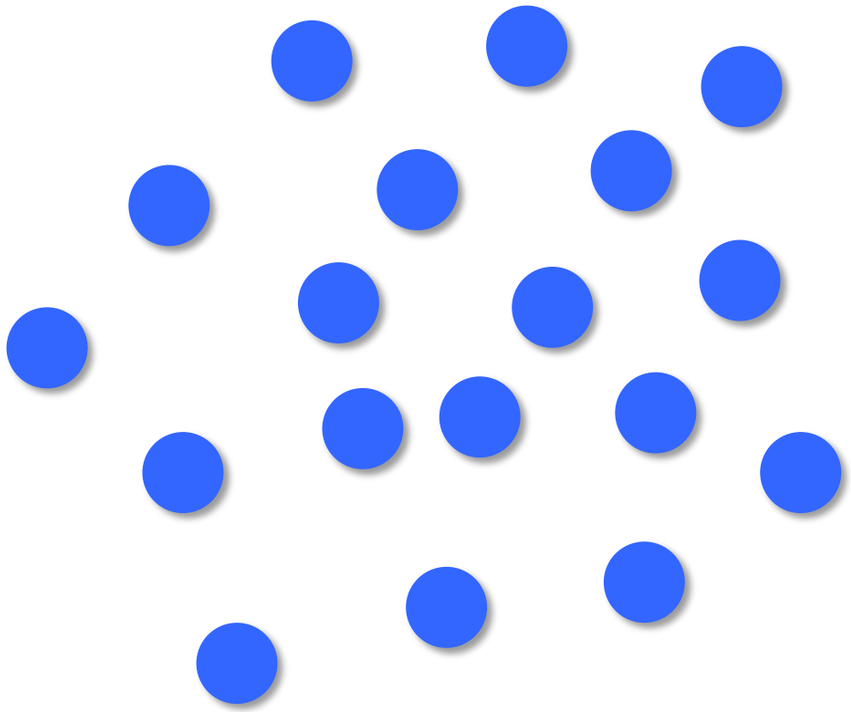
2. Epidemics are spread through contact



Ryu, et al. 2021 BMC Infect Dis.

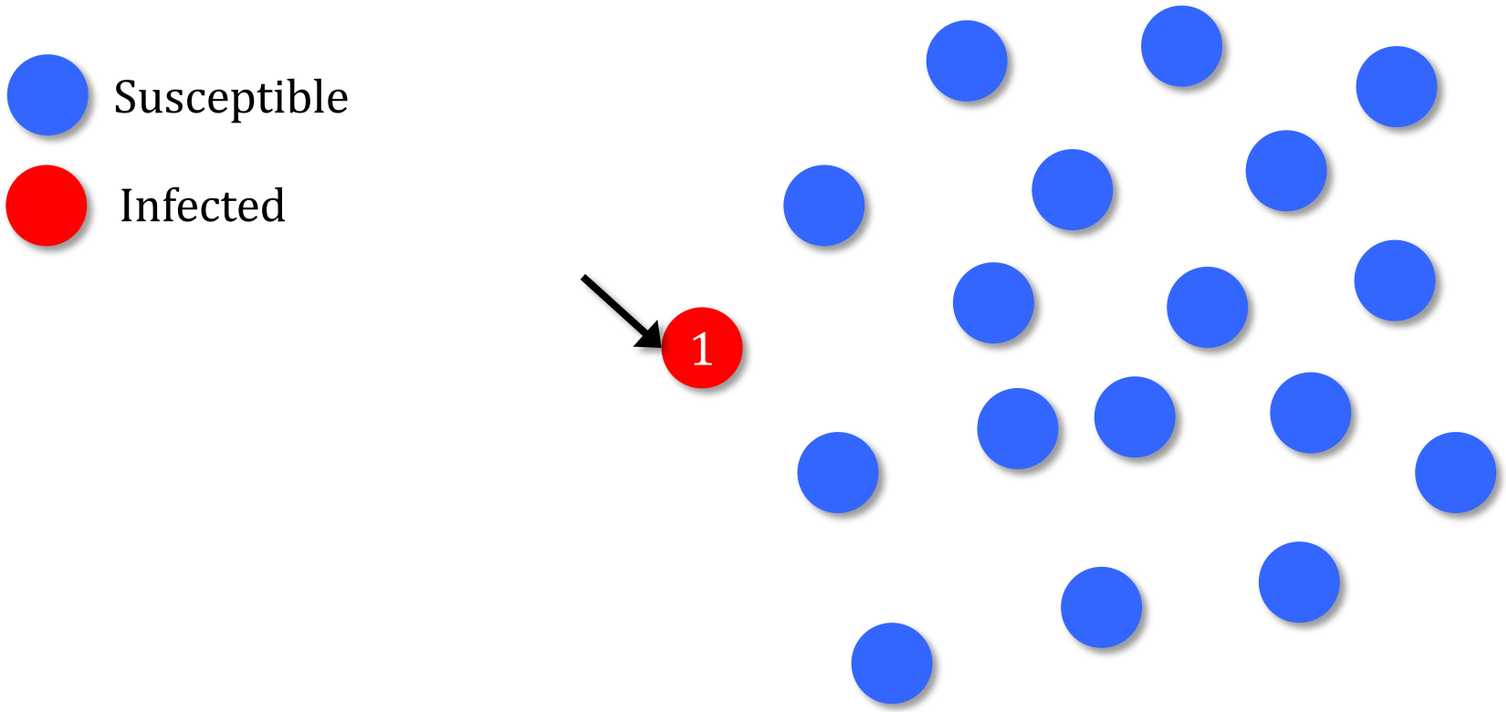
5 Epidemics: Basic theory

Susceptible



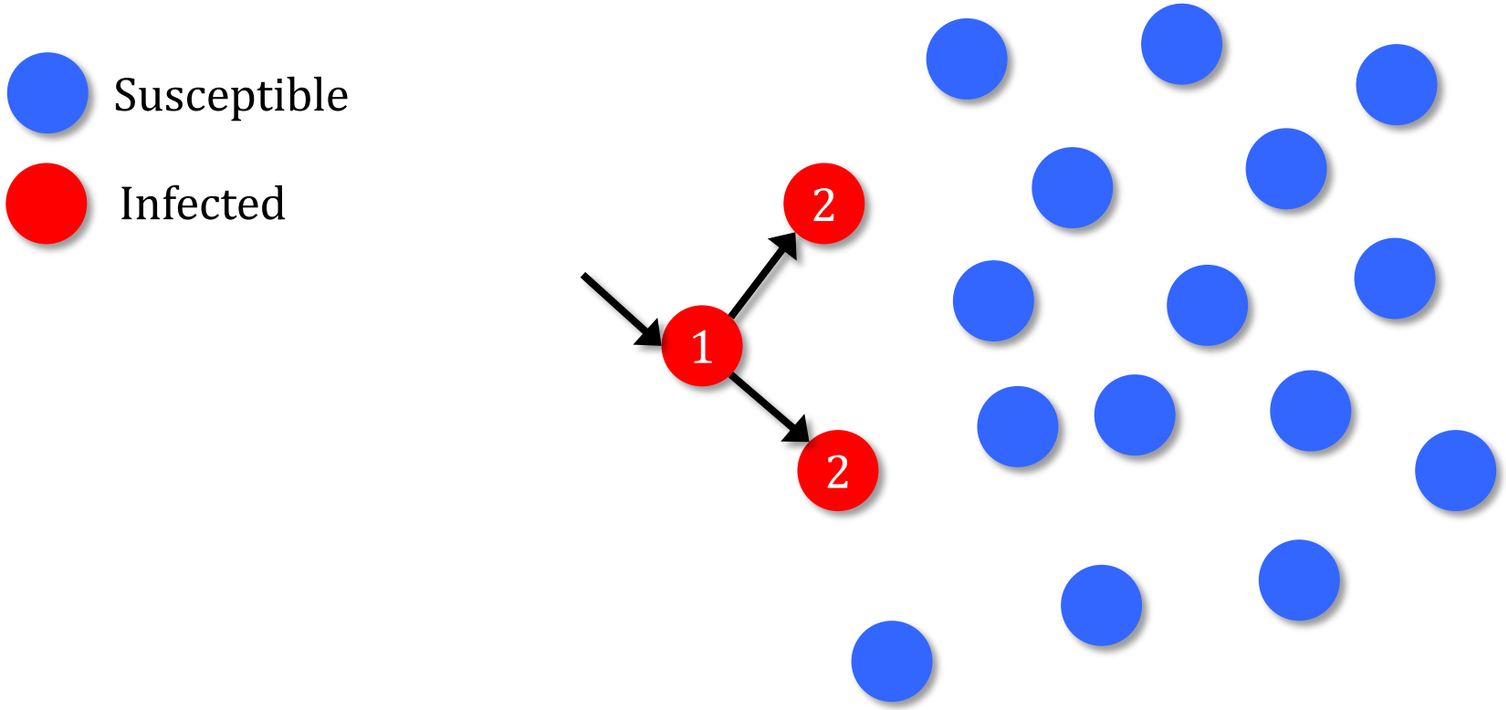
5 Epidemics: Basic theory

Primary cases – first infections in the population



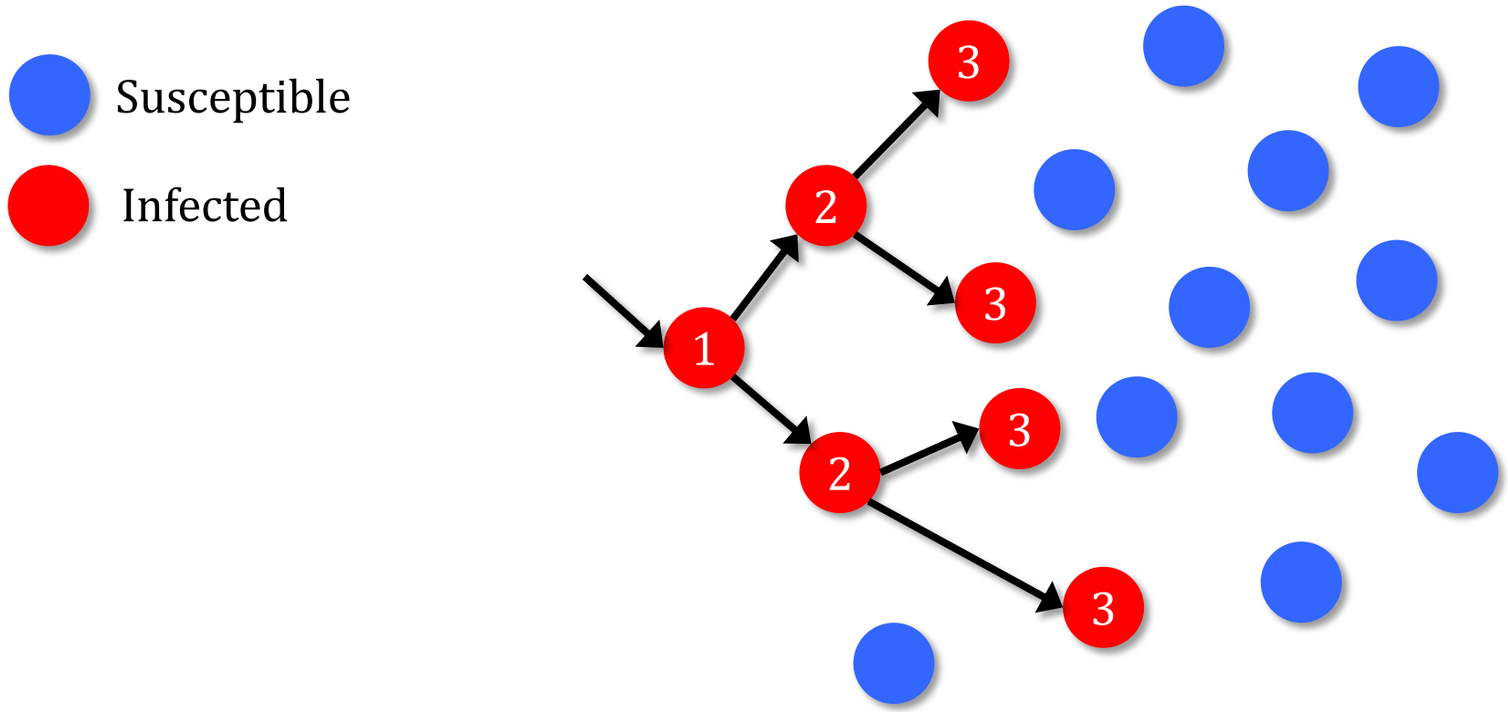
5 Epidemics: Basic theory

Primary cases – first infections in the population
Secondary cases – infections caused by the primary cases



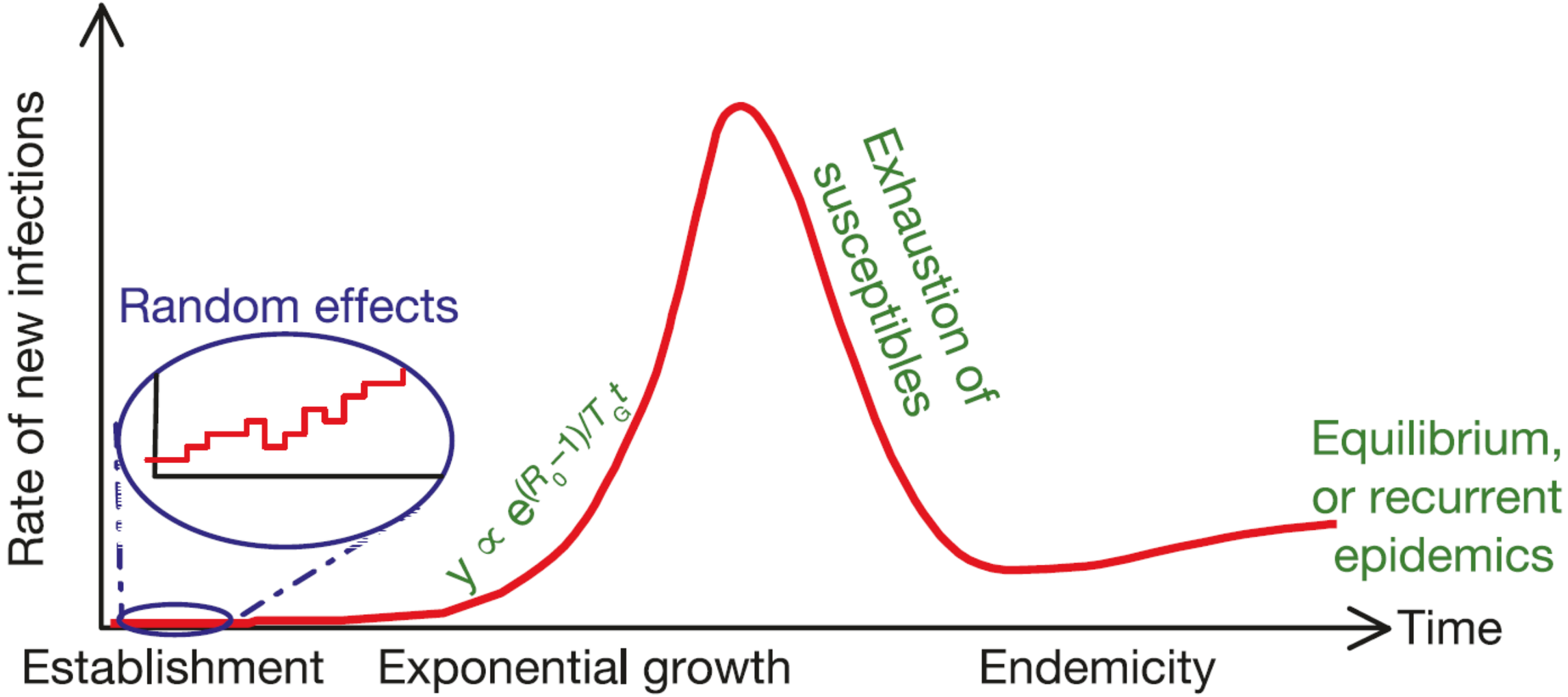
5 Epidemics: Basic theory

Primary cases – first infections in the population
Secondary cases – infections caused by the primary cases
Tertiary cases – infections caused by the secondary cases



5 Epidemics: Basic theory

3. Chain reaction (Exponential Phase)



Ferguson, et al. 2003 Nature

Epidemics: Basic theory

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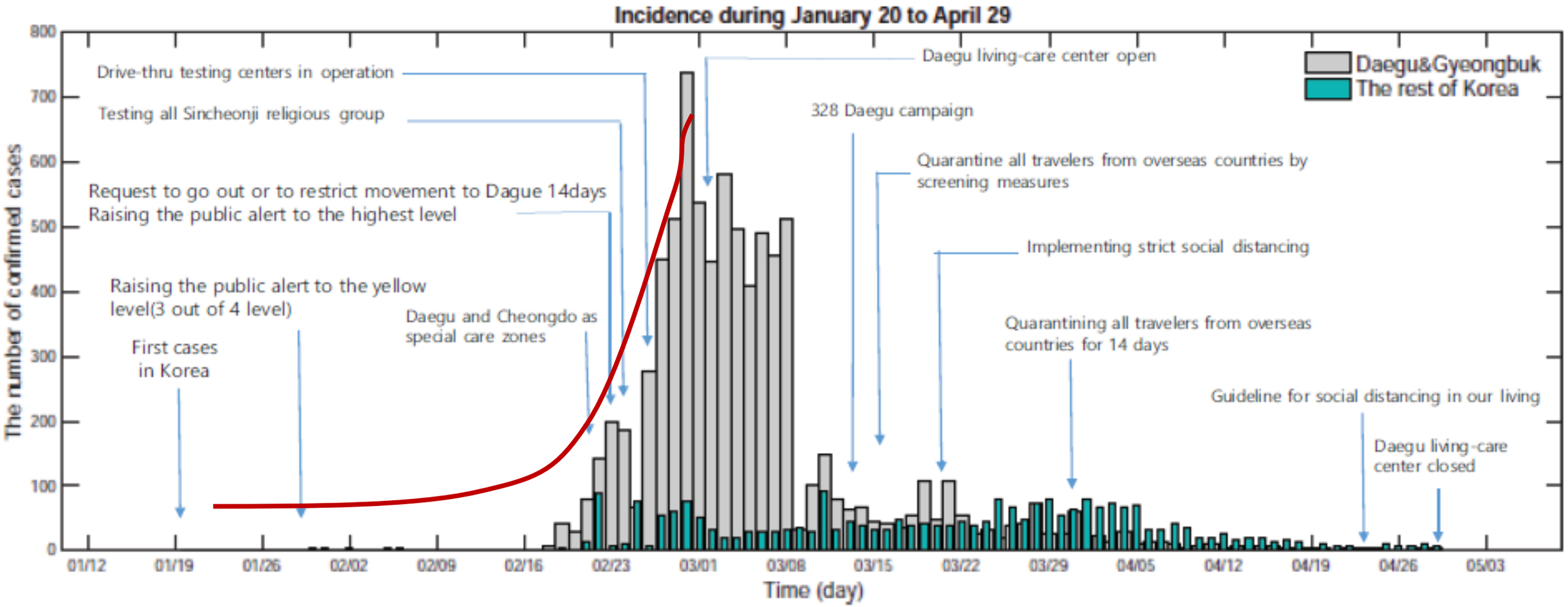
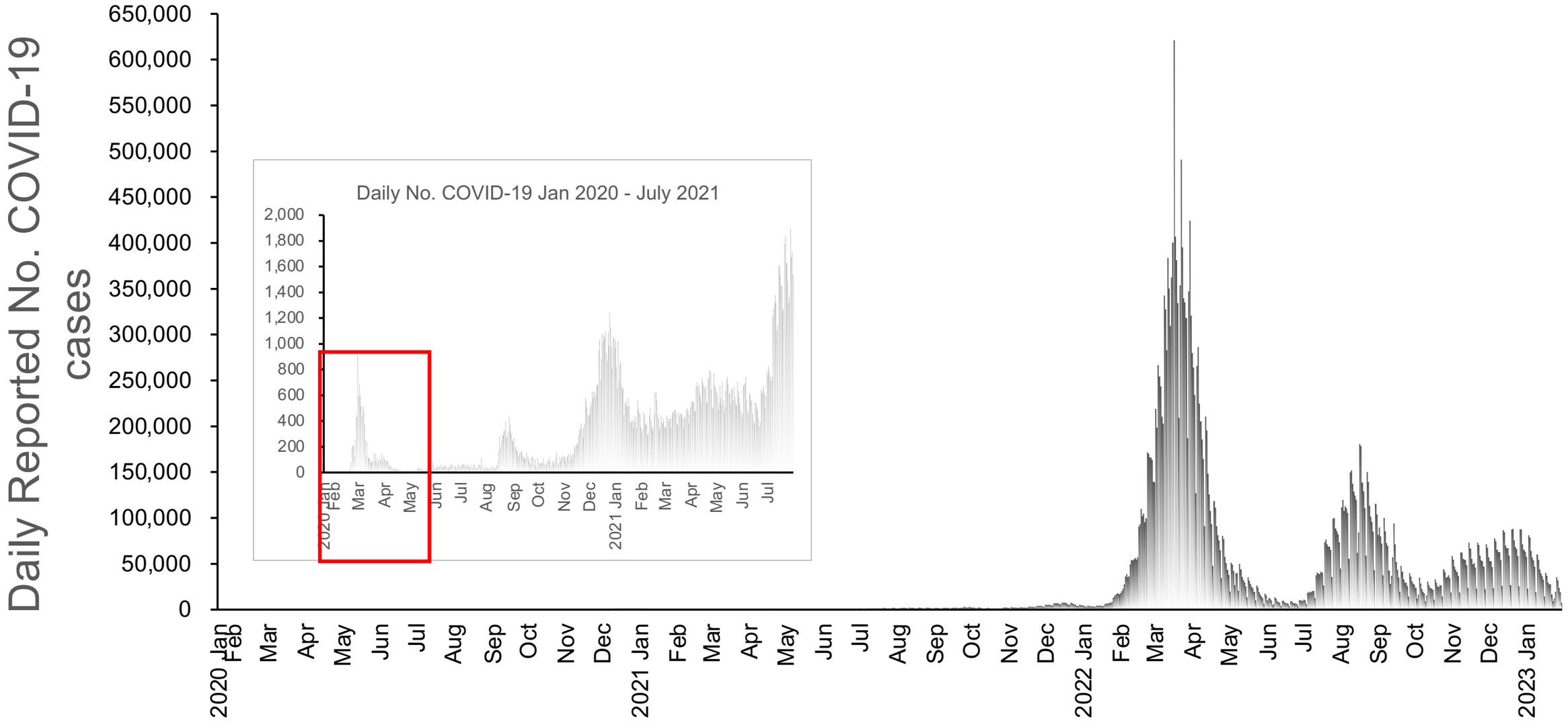


2020

Kim BN, et al. 2020 Processes

5 Epidemics: Basic theory



5 Epidemics: Basic theory

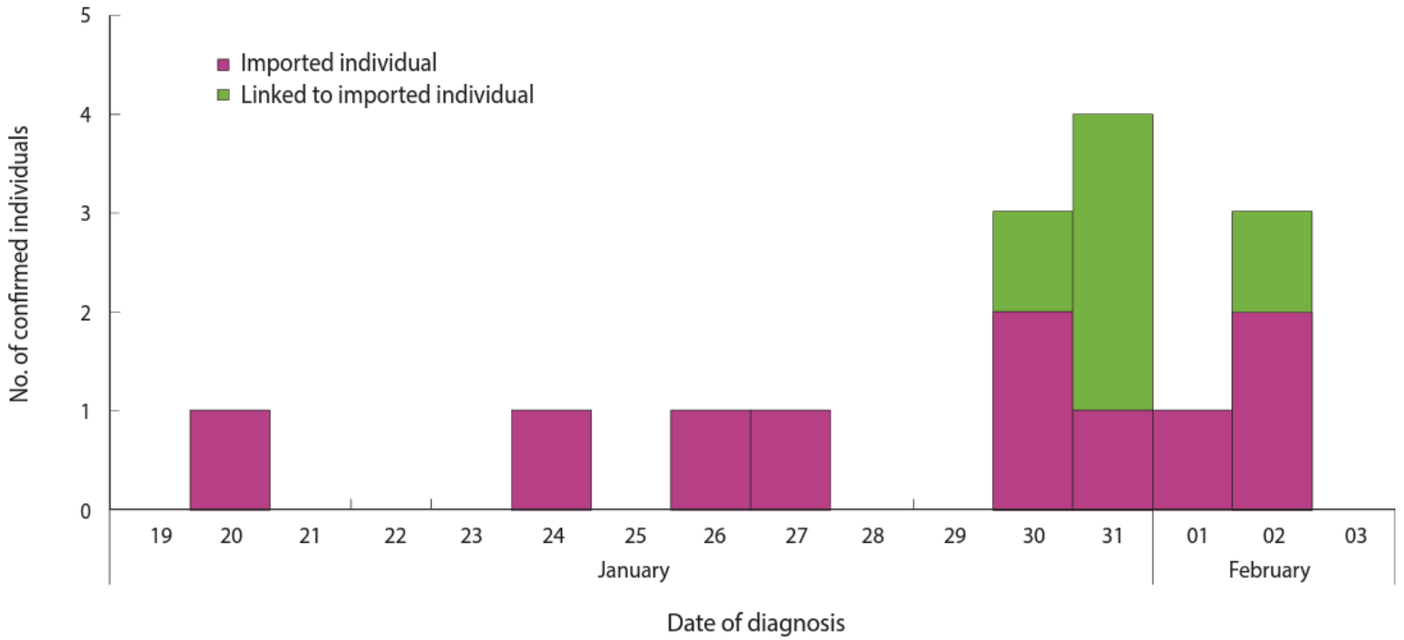


Figure 1. Timeline of individuals with laboratory-confirmed 2019 novel coronavirus infections in Korea, as of February 3, 2020.

Table 1. List of confirmed cases of 2019 novel coronavirus infection in Korea, as of February 3, 2020

Case No.	Age (yr)	Sex	Nationality	Date of entry to Korea	Suspected infection of place or origin
#1	35	Female	Chinese	Jan 19, 2020	Wuhan, China
#2	55	Male	Korean	Jan 22, 2020	Wuhan, China
#3	54	Male	Korean	Jan 20, 2020	Wuhan, China
#4	55	Male	Korean	Jan 20, 2020	Wuhan, China
#5	33	Male	Korean	Jan 24. 2020	Wuhan, China
#6	55	Male	Korean	-	Case #3

Ryu S, et al. 2020 Epi Health

Epidemics: Basic theory

4. Controls

- What will be the controls (i.e., public health measures) against epidemics?

Ryu S, et al. 2020 WHO Technical consultation meeting

5 Epidemics: Basic theory

4. Controls

Personal protective measures

- Hand hygiene
- Respiratory etiquette
- Facemasks

Environmental measures

- Surface and object cleaning
- UV light
- Ventilation
- Humidity

Social distancing measures

- Contact tracing
- Isolation of sick individuals
- Quarantine of exposed individuals
- School closures
- Workplace closures
- Workplace measures
- Avoiding crowding

Travel related measures

- Travel advice
- Entry and exit screening
- Internal travel restrictions
- Border closures

Public advice

- Risk communication

Ryu S, et al. 2020 WHO Technical consultation meeting

5 Epidemics: Basic theory

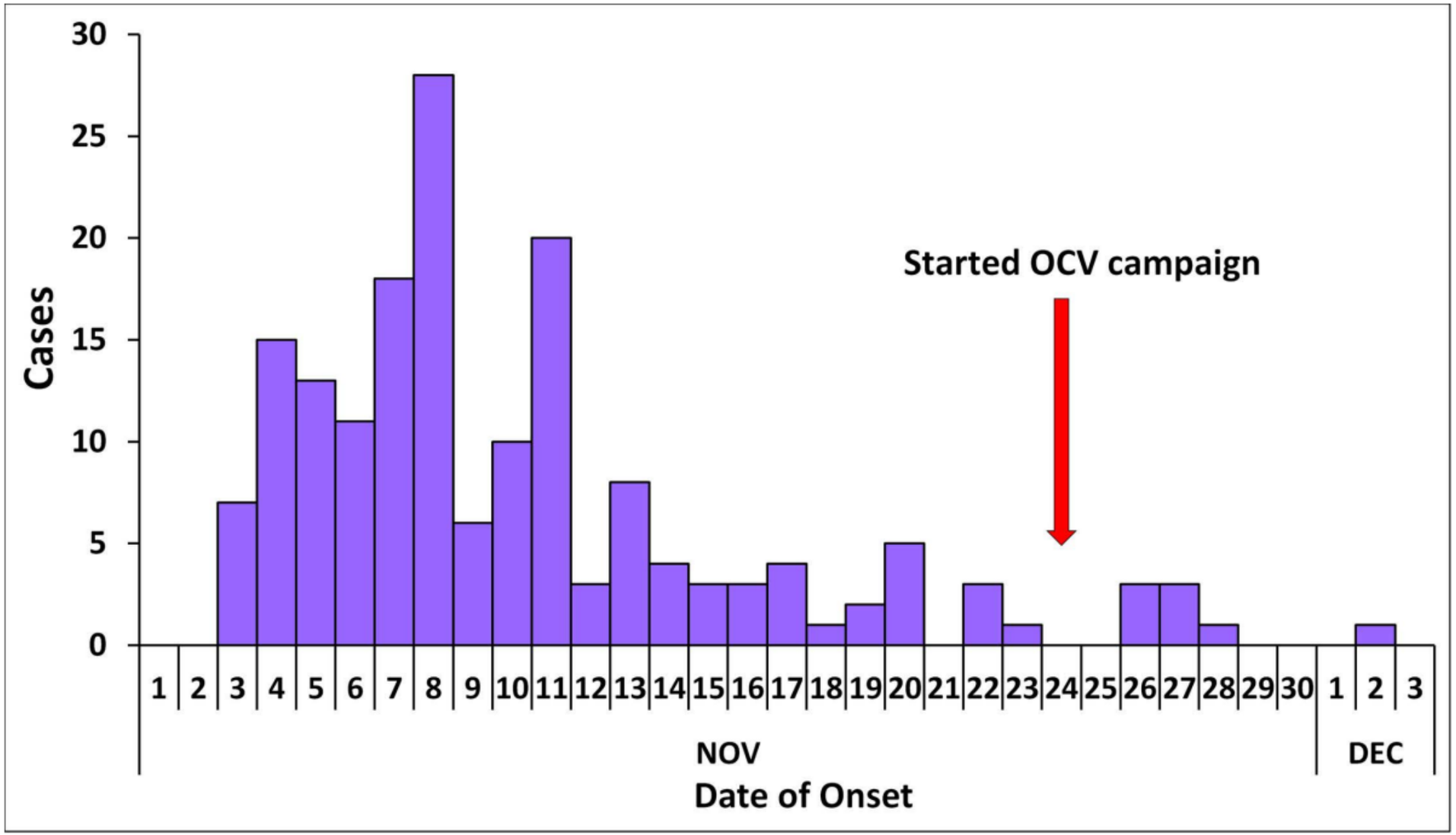
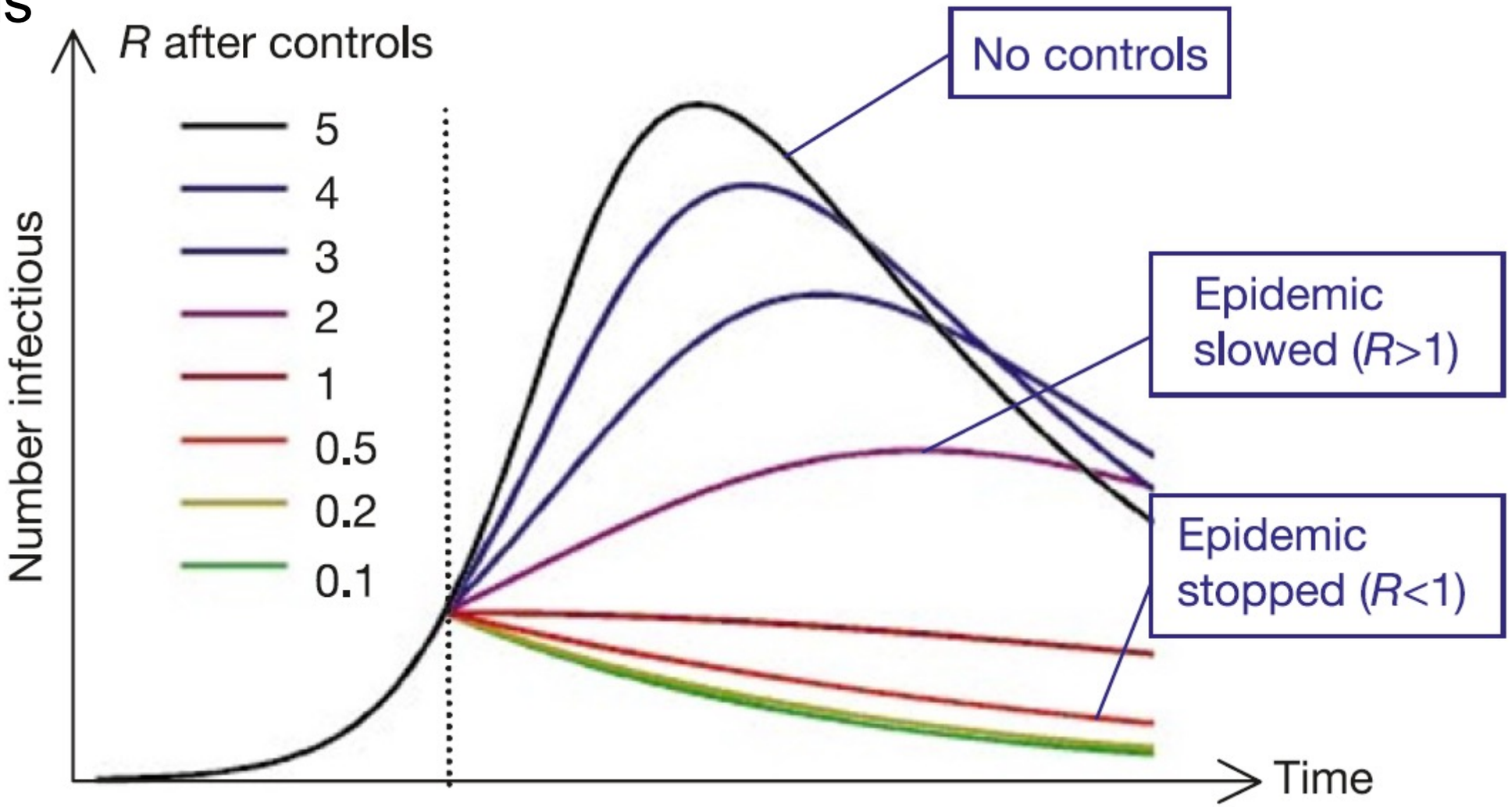


Fig 2. Epidemic curve showing symptom onset dates of persons with suspected and confirmed cholera: Isingiro District, Uganda, November to December 2021.

Aceng FL, et al. Plos Global Health. 2025

5 Epidemics: Basic theory

4. Controls



Ferguson, et al. 2003 Nature

4. Controls

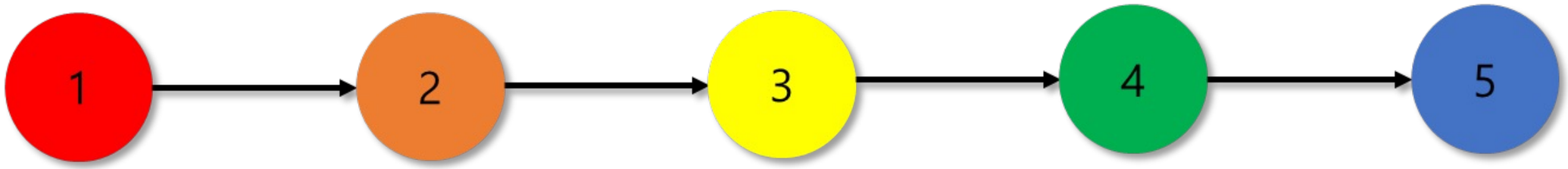
- **Basic reproductive number** (R_0)
  - The average number of secondary cases generated by an index case when an epidemic begins in a completely susceptible population

- **Effective reproduction number** (R_t)

5 Epidemics: Basic theory

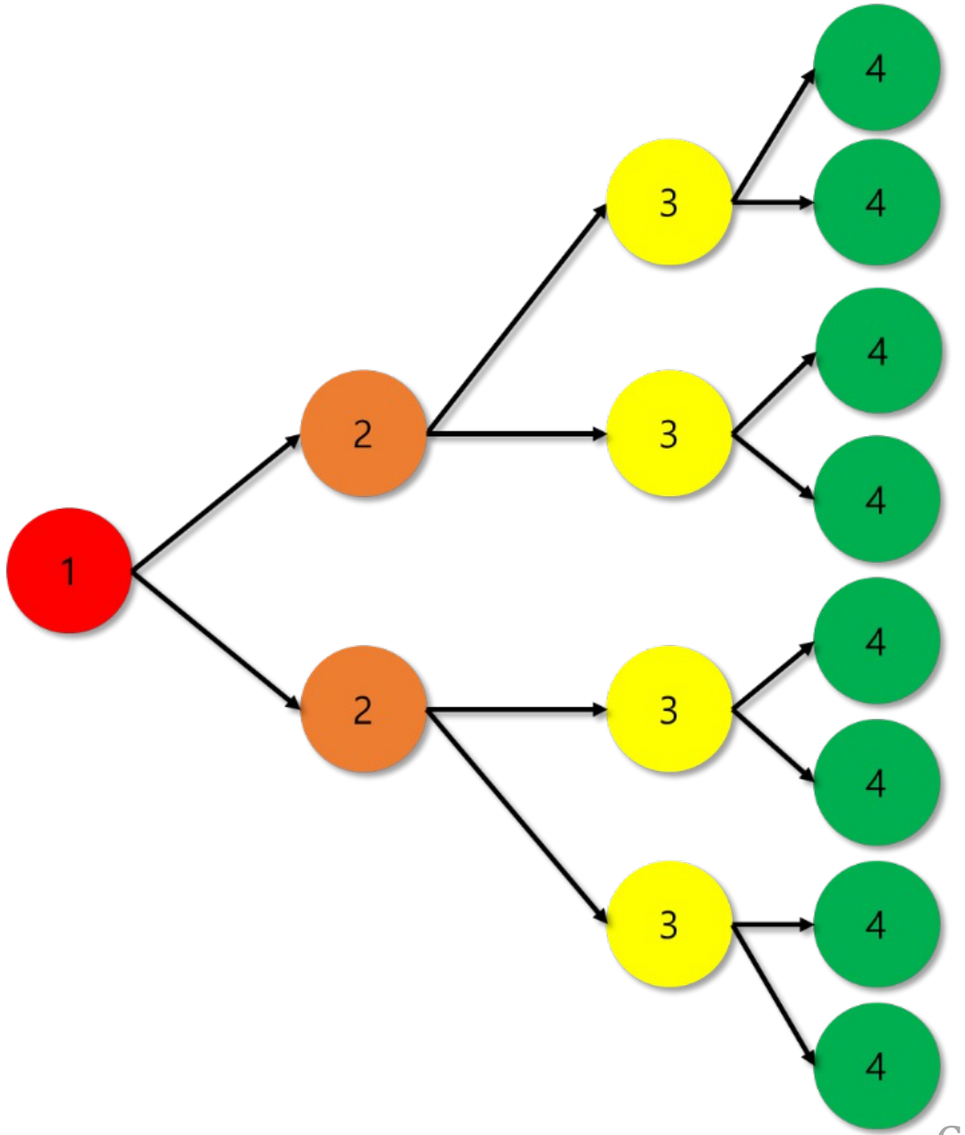
- **Basic reproductive number**

  - The average number of secondary cases generated by an index case when an epidemic begins in a completely susceptible population.



$R_0 = 1$

5 Epidemics: Basic theory



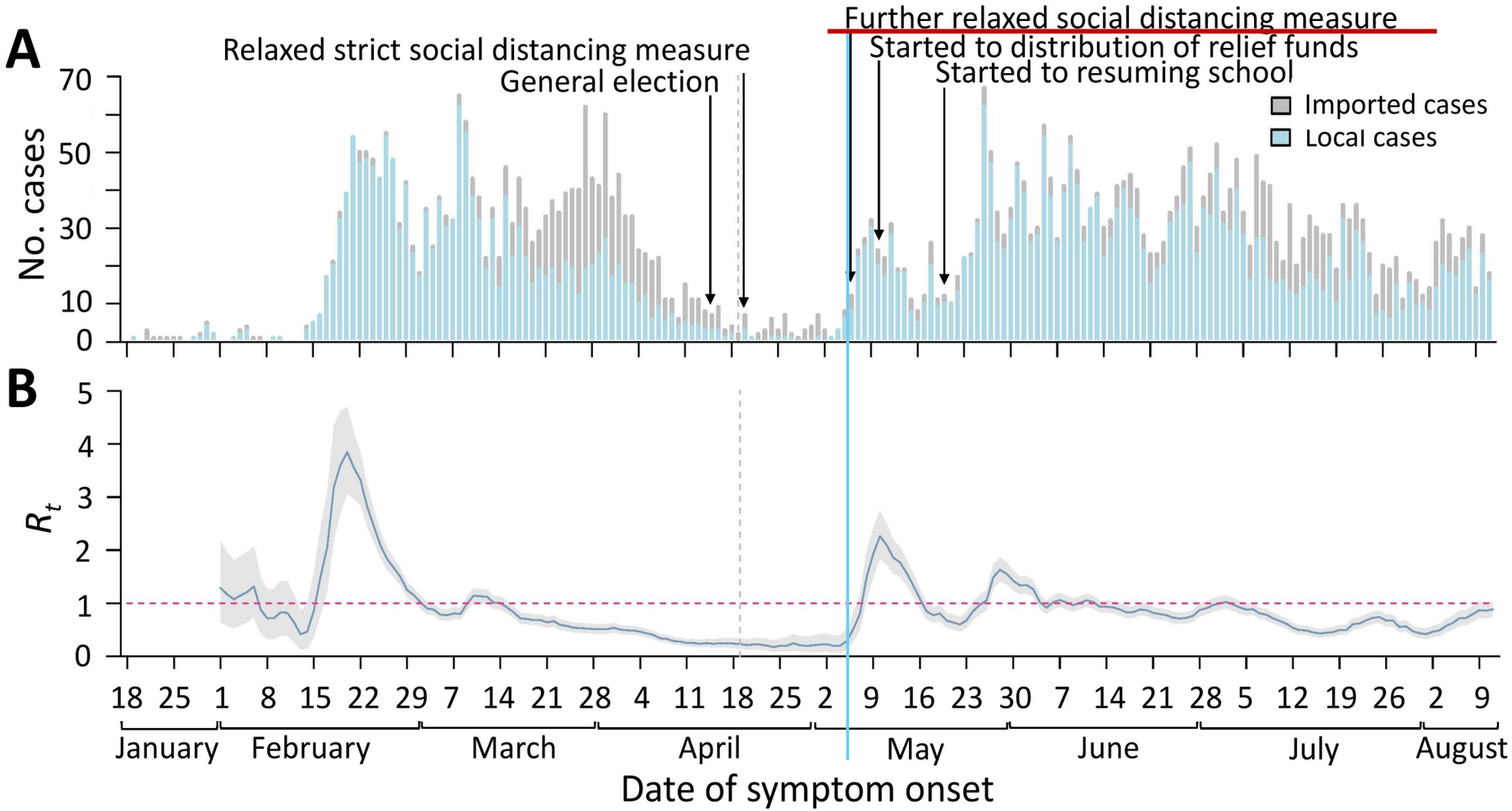
$R_0 > 1$

Ex) $R_0 = 2$

Giesecke J. Modern Infectious Disease Epidemiology. CRC press

5 Epidemics: Basic theory

- After relaxed social distancing, R_t was increased above 1

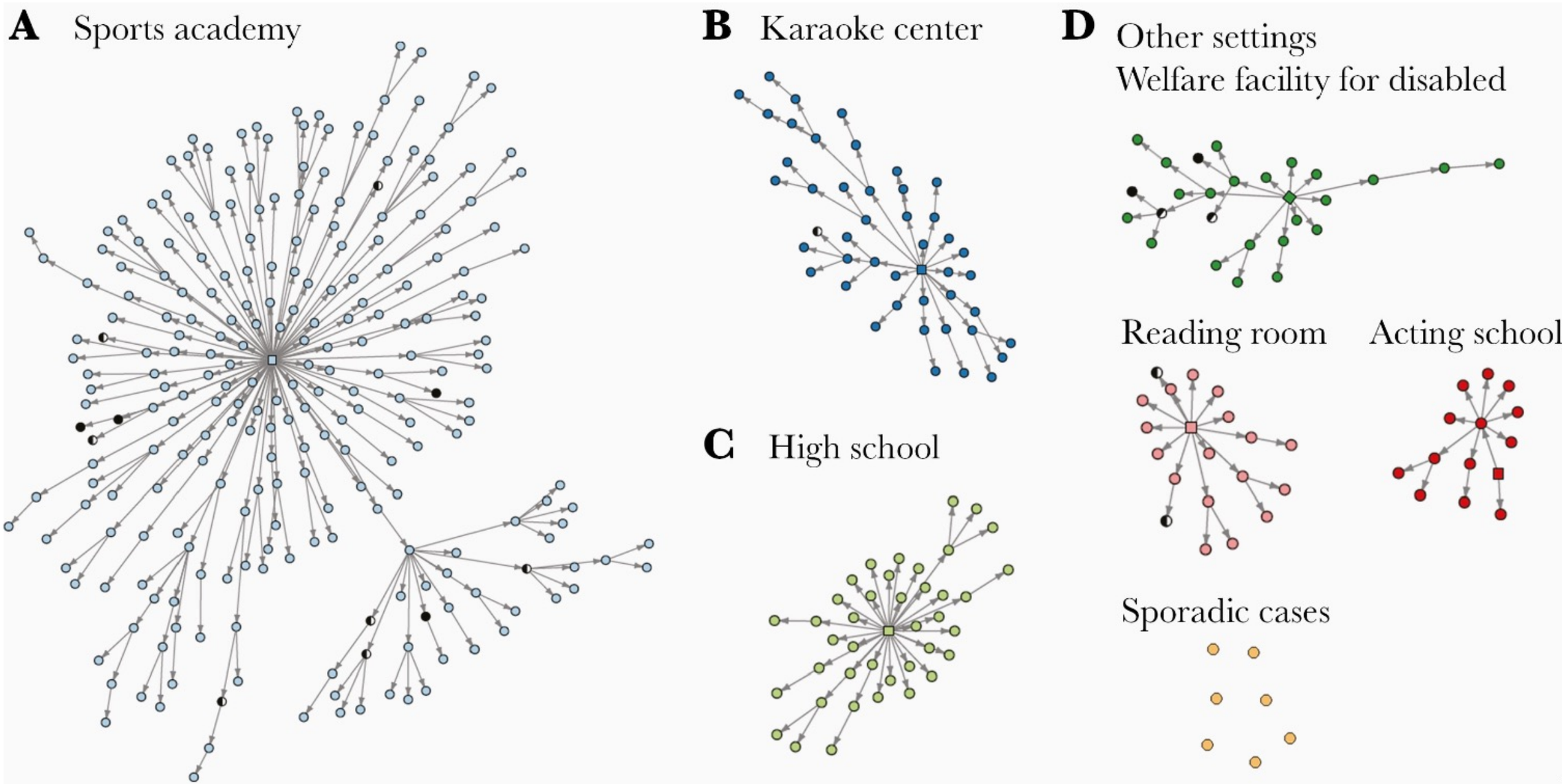


Ryu S, et al. 2021 BMC Infect Dis.

Sudan virus disease super-spreading, Uganda, 2022

Komakech *et al. BMC Infectious Diseases* (2024) 24:520
https://doi.org/10.1186/s12879-024-09391-0

5 Epidemics: Basic theory



Hwang H, et al. *J Inf Dis.* 2022

QnA

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ONE HEALTH Lab
with Computational Epidemiology

2 Epidemiology

What is epidemiology

Descriptive

(1) Description of the cases of a disease

- When do they appear? Where? What ages are they?
  Is there any group-defining characteristics that they have in common?

- Why were there so many cases in a certain area?
- Why are there more cases this year than last?
- Where were there no sick children?

Analytical

(2) Systematically compare the group of disease cases with another group of healthy people.

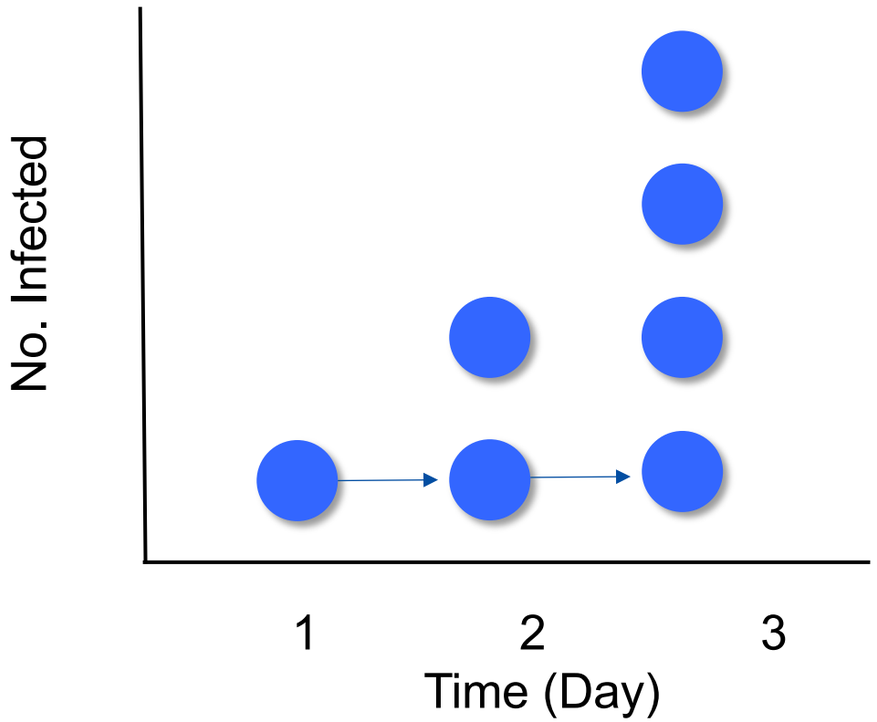
- Test clues offered by the descriptive study by exploring the differences in characteristics between the ill and the healthy.

Convert our knowledge about this disease into preventive action.

- Can we influence people's behavior to lessen their risk of falling ill?
- Is there any prophylactic treatment?

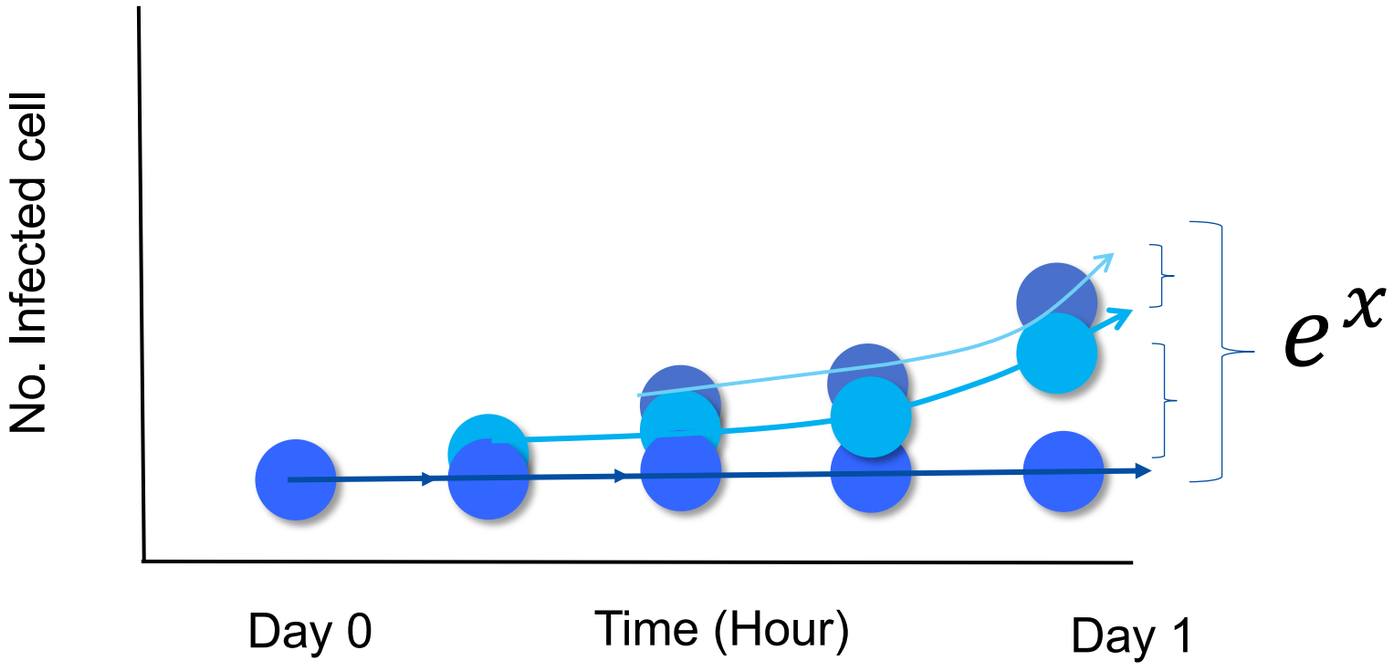
Modern Infectious Disease Epidemiology, 3rd Ed. 1-2p

5 Epidemics: Basic theory



5 Epidemics: Basic theory

$2^x \longrightarrow$ 100% growth



Growth in real observation i
not a discontinuous jump

5 Epidemics: Basic theory

① 100% growth
② Continuous
③ Flexible by time and rate of growth

$2.718\ldots = e^{x}$

$e^{(growth\ rate\ per\ unit\ of\ time)}$

$e^{\frac{(R_0-1)}{T_G\ t}}$