Scabies, who cares?

North West Seminar Series of Mathematical Biology and Data Science

Kylie Ainslie

National Institute for Public Health and the Environment
Ministry of Health, Welfare and Sport

What even is scabies?

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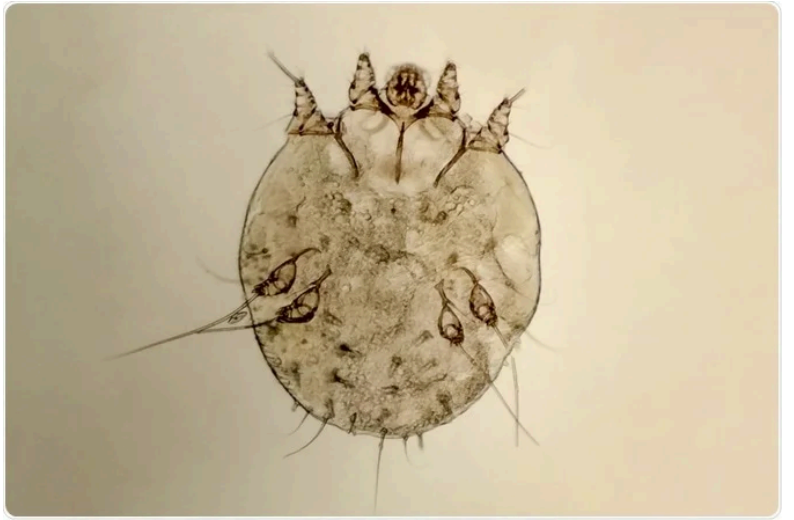
and the Environment
Ministry of Health, Welfare and Sport

Sarcoptes scabiei

- Scabies is a disease caused by infestation of the skin with a microscopic mite.
  - a.k.a. the Itch or seven-year itch
  - From the Latin *scabere*, meaning ‘to scratch’.
- Symptoms are characterized by itchiness and rash at the site of infestation.



Scabies mite. Image Credit: Aliaksei Marozau / Shutterstock.com

How does scabies spread?

- Direct, extended, skin-to-skin contact
- Sharing clothing, towels, or bedding used by an infected person
  - Less common

Do people still get scabies?

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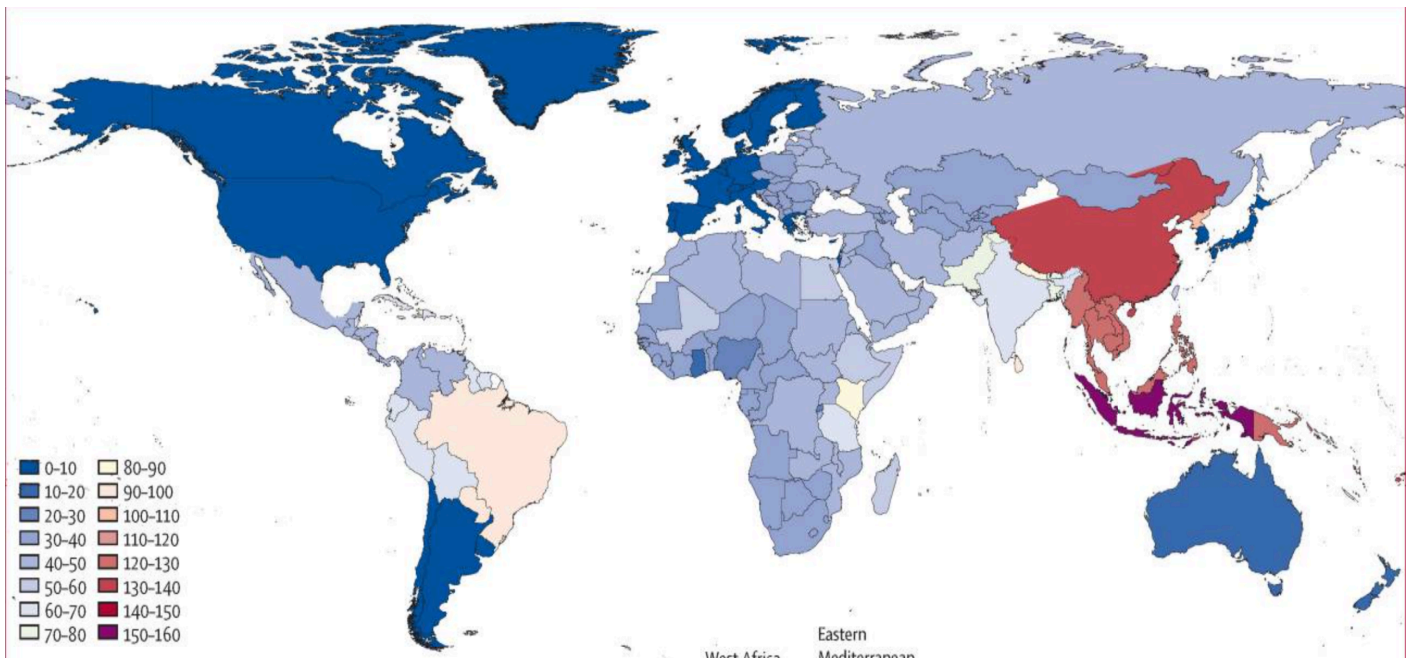
Scabies Worldwide

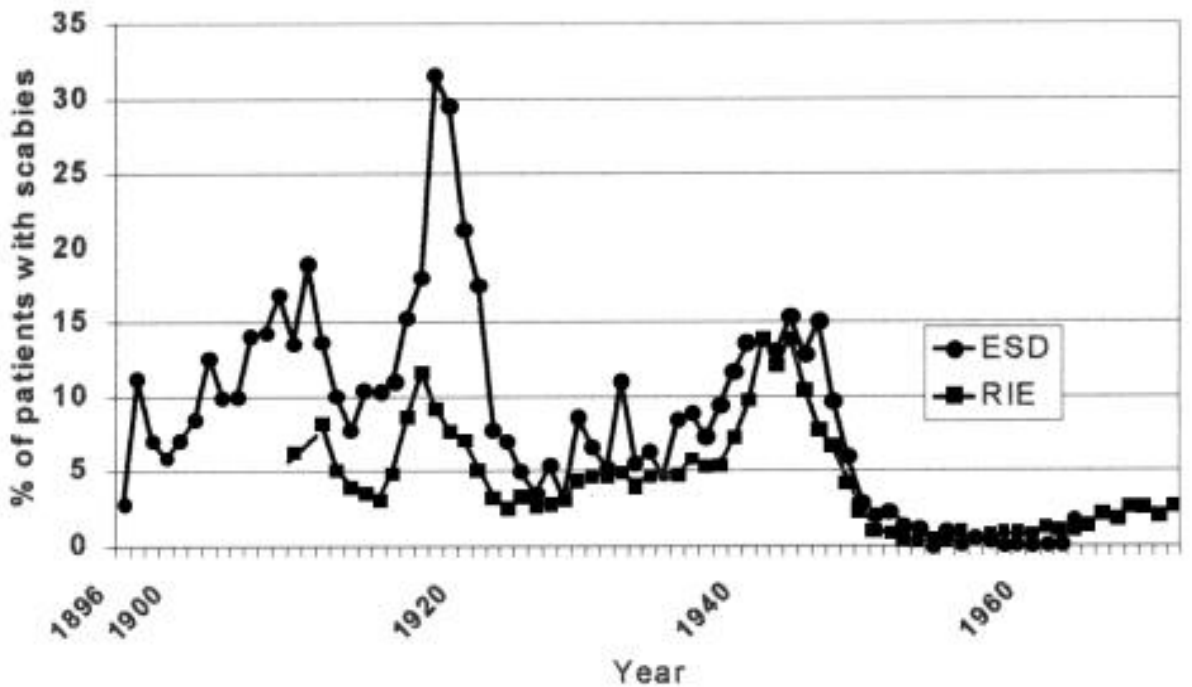
- Scabies affects around 400 million people per year.
- Accounts for a large proportion of skin disease in many low- and middle-income countries



Karimkhani et al. 2017. Lancet Infect. Dis. 17(12):1247 - 1254

Scabies in Europe (then)

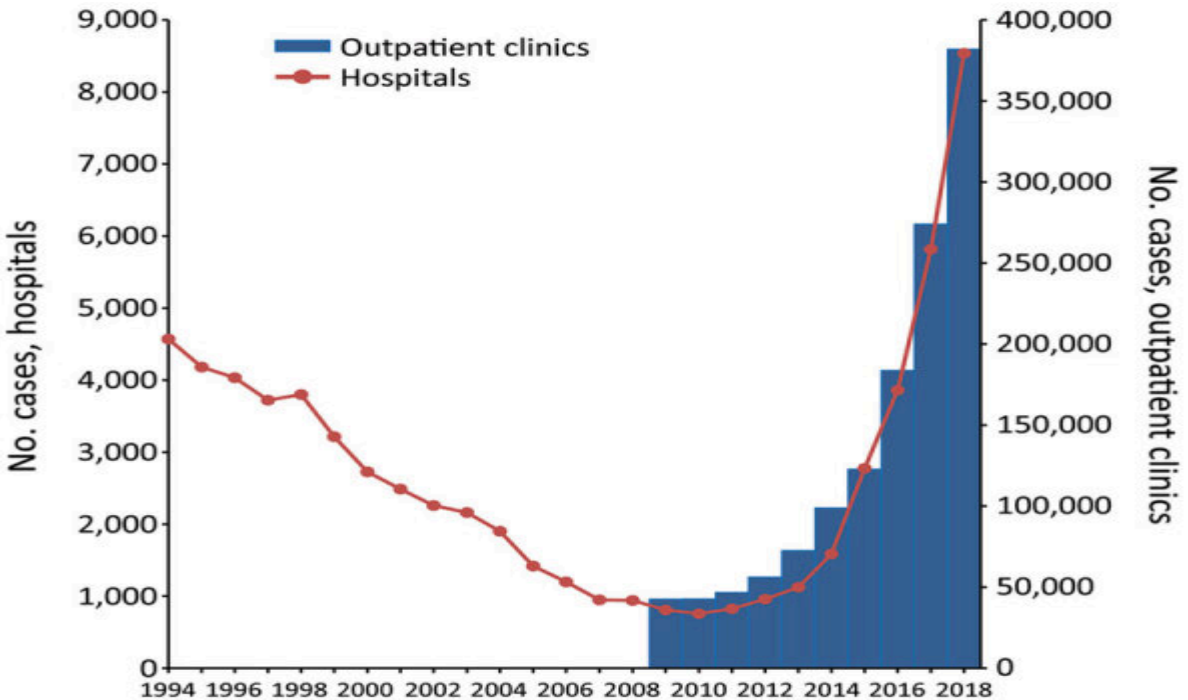
- Scabies infections were a common affliction in Europe in the late 1800s and early 1900s
  - Highest incidence seen in 1918 and 1945.



Savin 2005. J R Soc Med; 98(3):124–129.4

Scabies in Europe (now)

A rise in scabies cases has been observed through out Europe in recent years.



Reichert et al. 2021. Emerg Infect Dis.;27(6):1693–1696.

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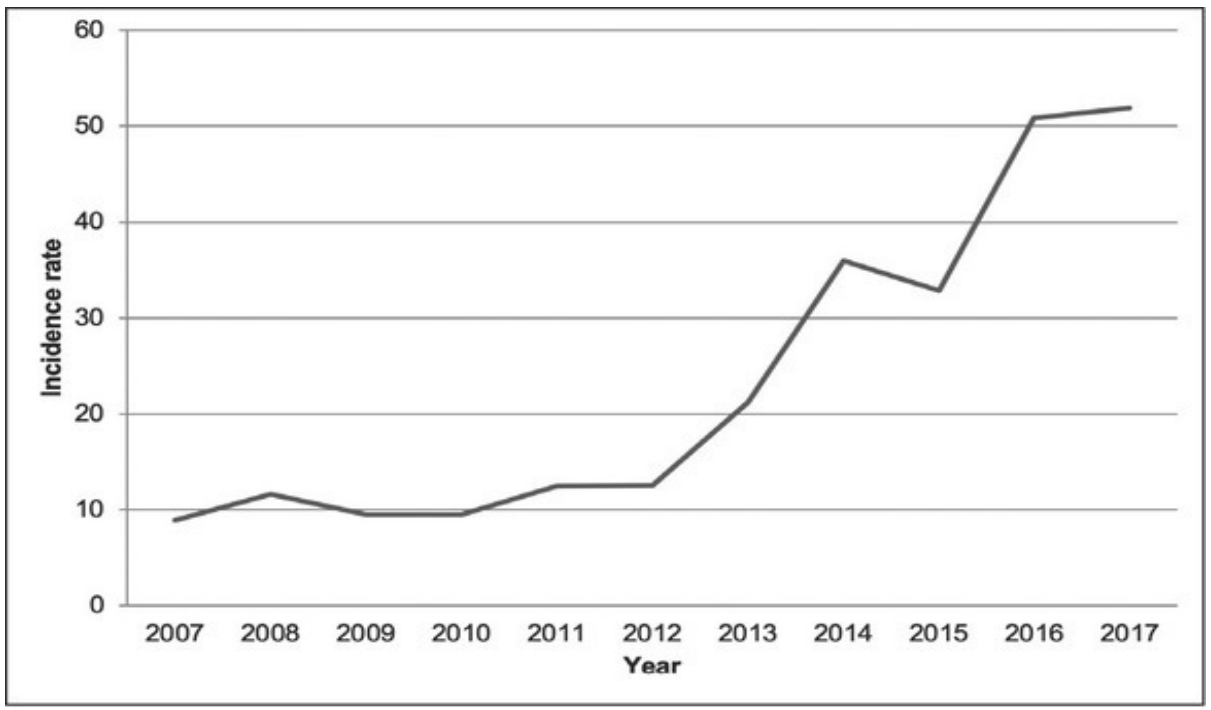

Lugović-Mihić et al. 2020. Zdravstveno Varstvo; 59(4):264-272.

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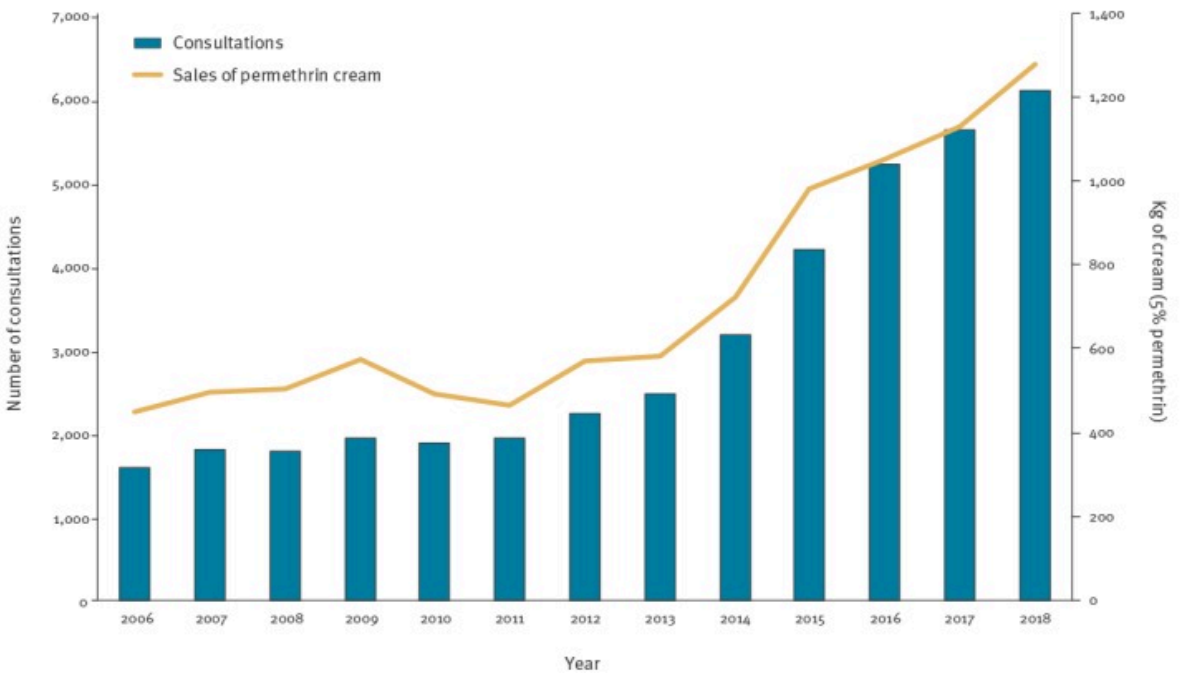

Amato et al. 2019. Eurosurveillance; 24(23):pii=190020.

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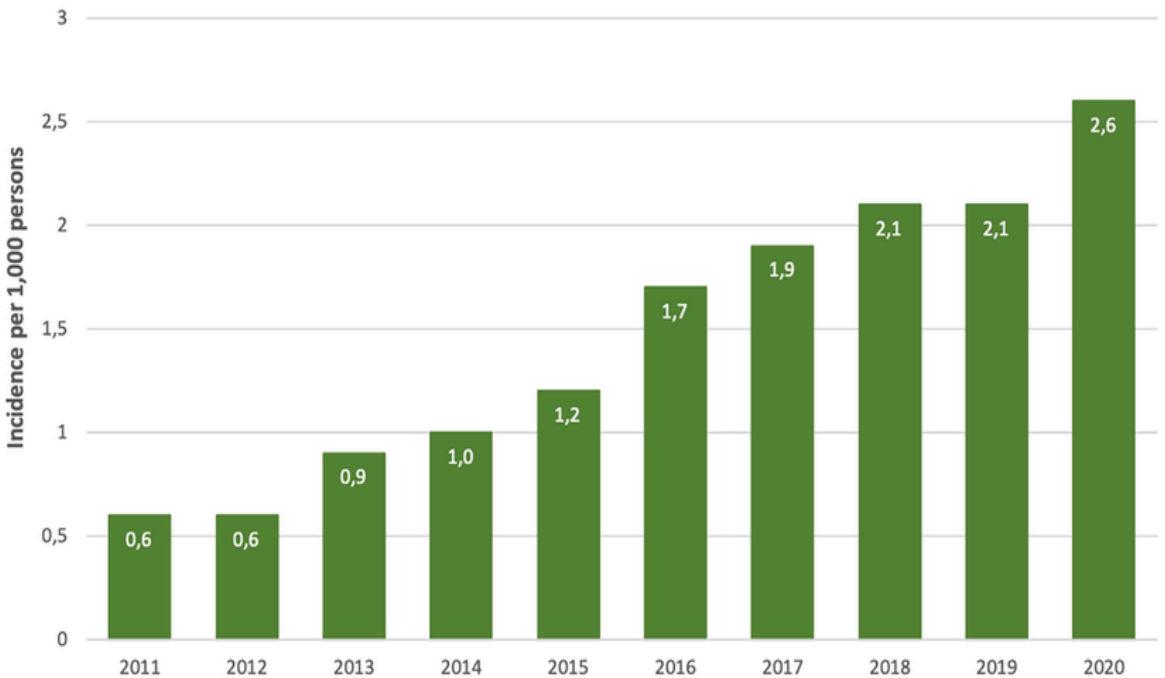


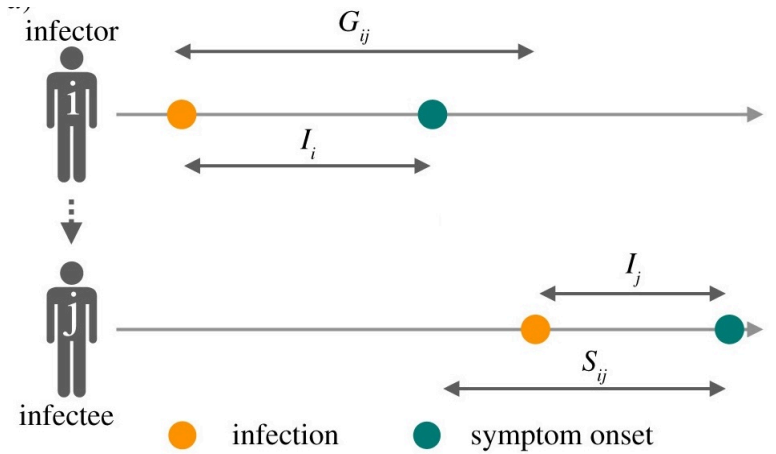
van Deursen et al. 2022. PLoS One; 17:e0268865

Ok, so what's the big deal?

- The global disease burden of scabies is low compared to other infectious diseases
- Disease severity is also low - you're not going to die
- BUT
- Secondary infections can lead to severe outcomes
- No simple diagnostic test for scabies
  - diagnoses rely on clinical assessment (more GP visits)
- scabies can have economic implications for both the patients and the healthcare system

What can we do about it?

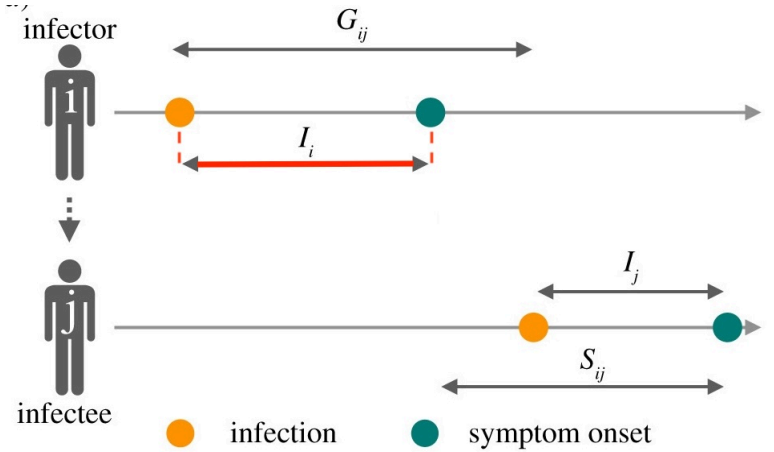
What we need to know



Adapted from: Lehtinen et al. 2021. J. R. Soc. Interface.1820200756

What we need to know

- the **incubation period:** time from infection to symptom onset



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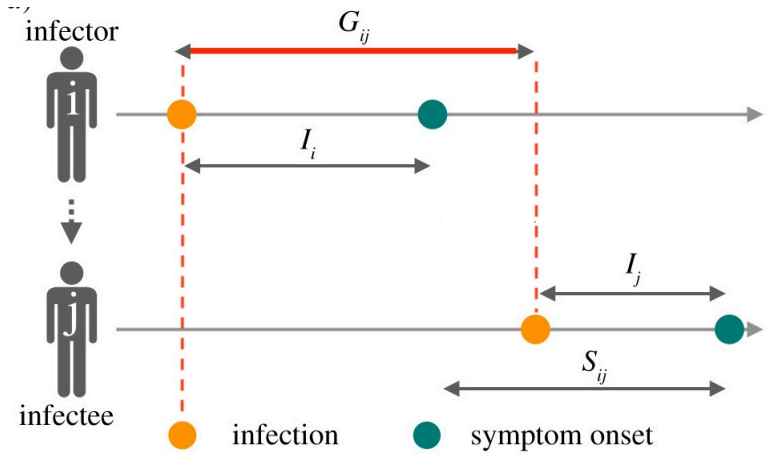

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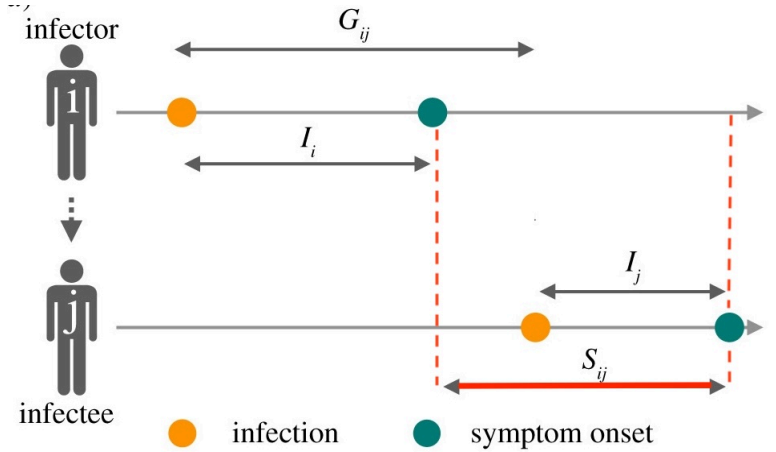

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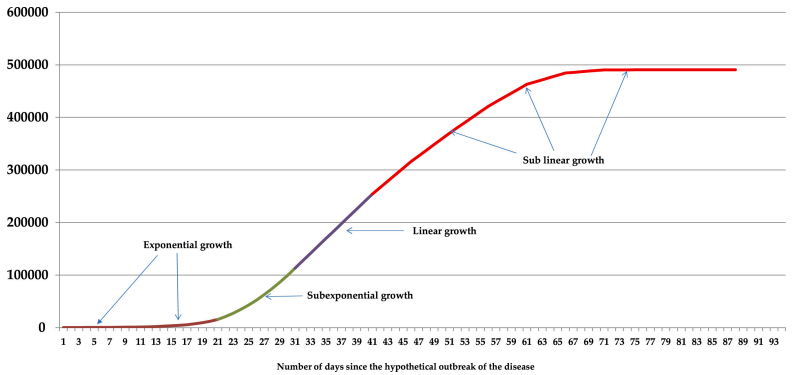

Picheira-Brown and Bentancor. 2021. Epidemics; 37:100486

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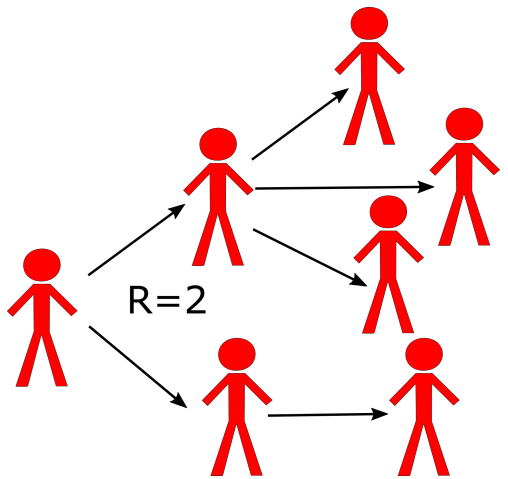
- **reproduction number:** the average number of secondary cases resulting from one index case



https://andreashandel.github.io/IDEMAbook/R0.html

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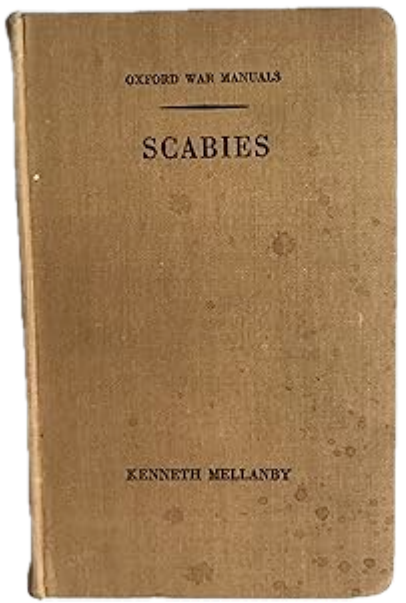
What we know

- Incubation period
  - 4-6 weeks after primary infection
  - 24 hours after post-primary infection
- A series of studies in the 1940s form much of the basis of our current understanding of scabies transmission.



THE DEVELOPMENT OF SYMPTOMS, PARASITIC INFECTION AND IMMUNITY IN HUMAN SCABIES

By KENNETH MELLANBY, *Sorby Research Fellow of the Royal Society*

Let’s dive in!

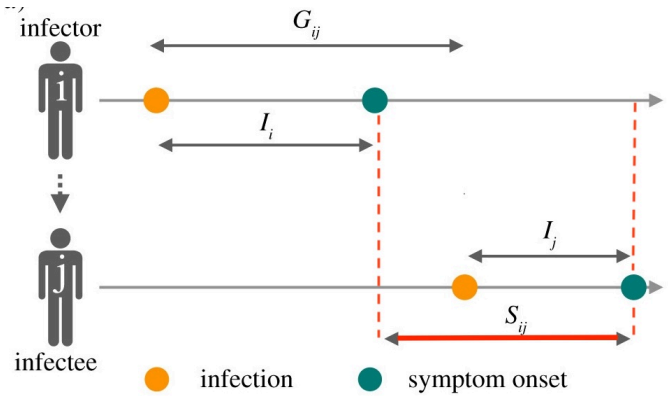
Our Roadmap

- What is the timescale of a typical scabies transmission event?
- How are the number of scabies cases changing over time?
- How many people will a scabies case go on to infect?
- How does scabies transmission change over time?

Our Roadmap

- What is the timescale of a typical scabies transmission event?

Serial Interval



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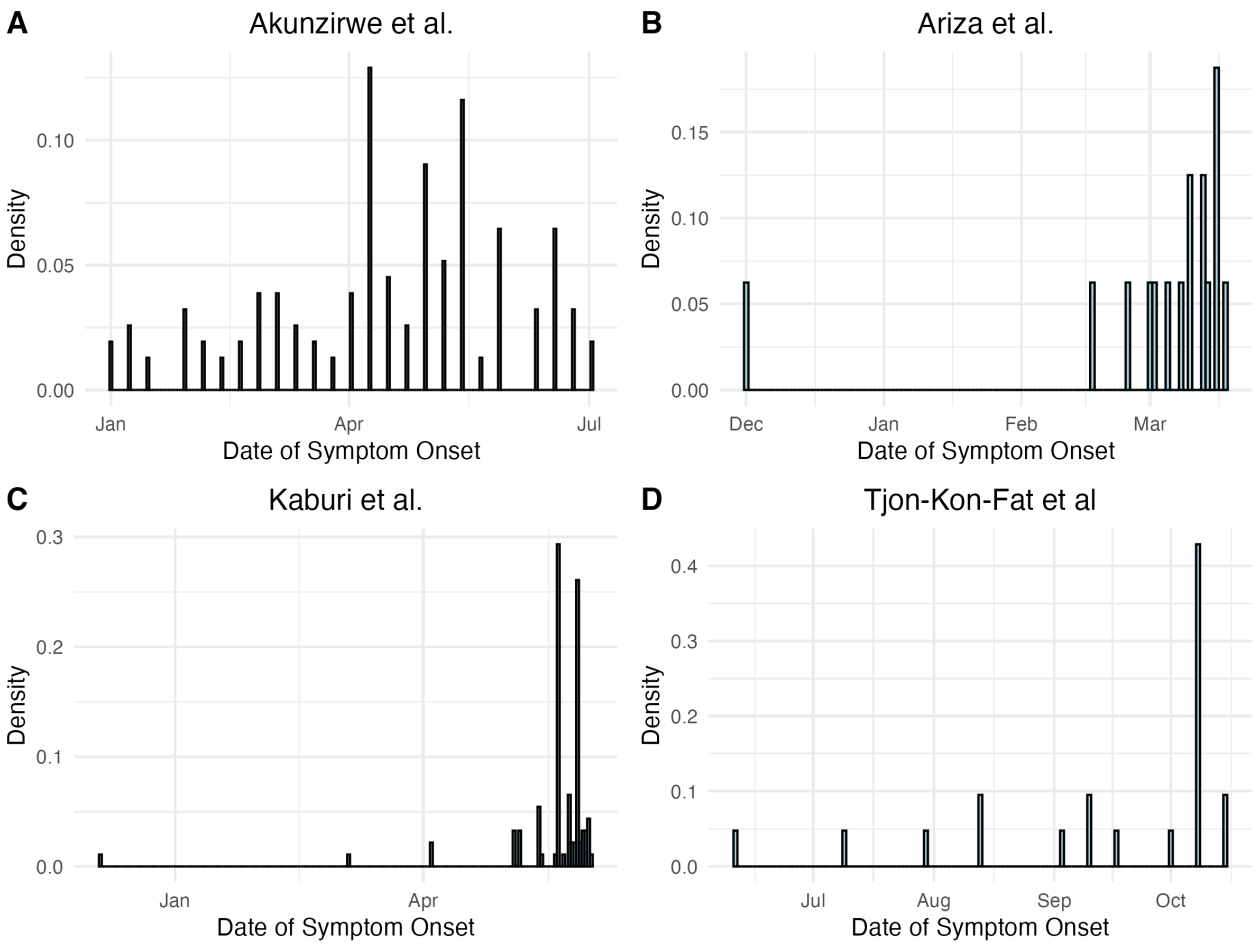


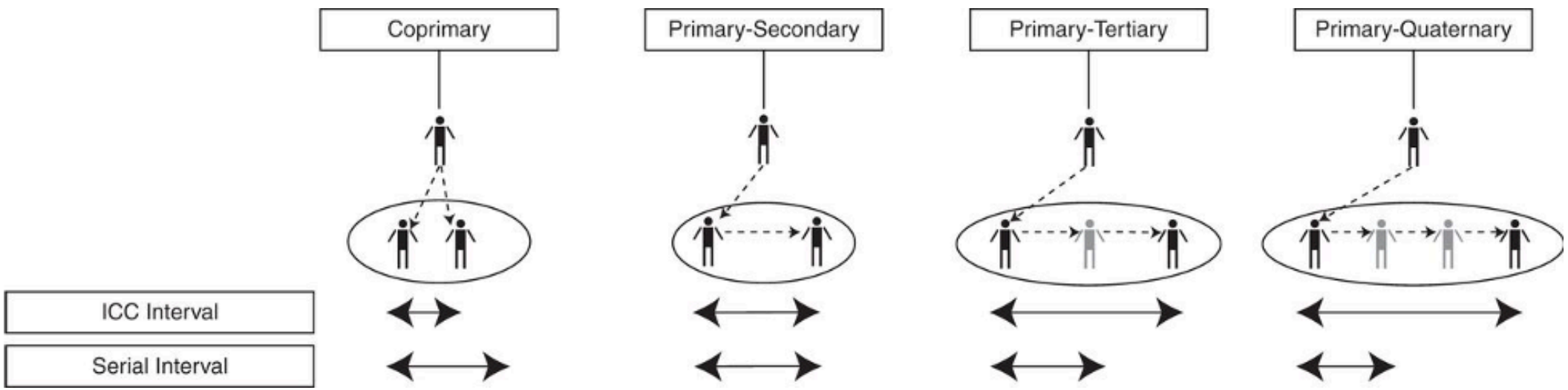
Date of symptom onset data from four scabies outbreaks.

Serial Interval

- We calculate the index case-to-case (ICC) interval for each person,
  - **index case:** the person with the greatest value for number of days since symptom onset.
  - **“secondary” cases:** have an ICC interval calculated as the number of days between their symptom onset day and the index case.

Serial Interval

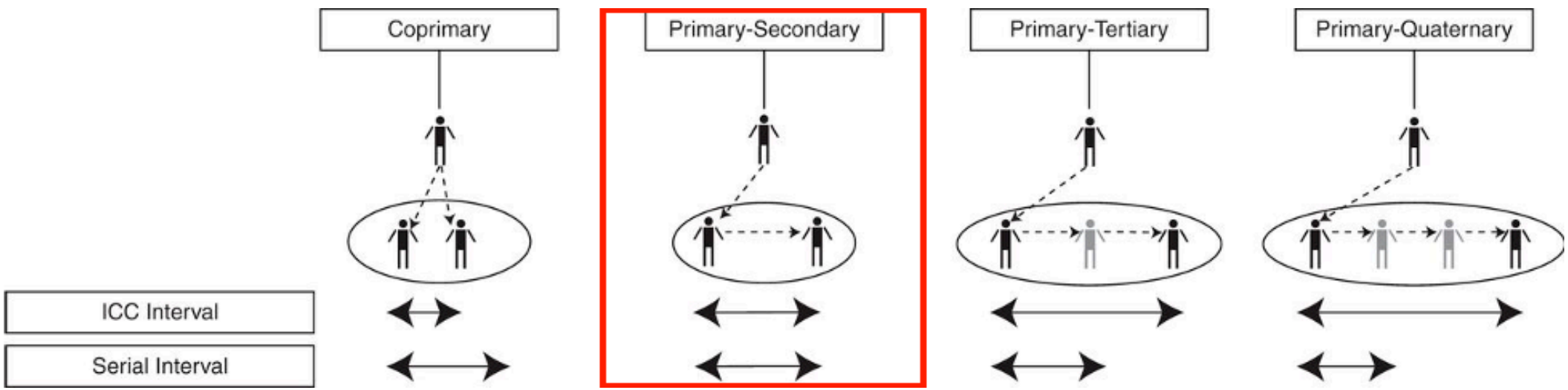
- We use a maximum likelihood framework to determine how likely each ICC interval can be attributed to each transmission route



Vink et al. 2014. Am J Epidemiol; 180(9):865–875

Serial Interval

- We use a maximum likelihood framework to determine how likely each ICC interval can be attributed to each transmission route
  - We then estimate serial interval using ICC intervals consistent with Primary-Secondary transmission



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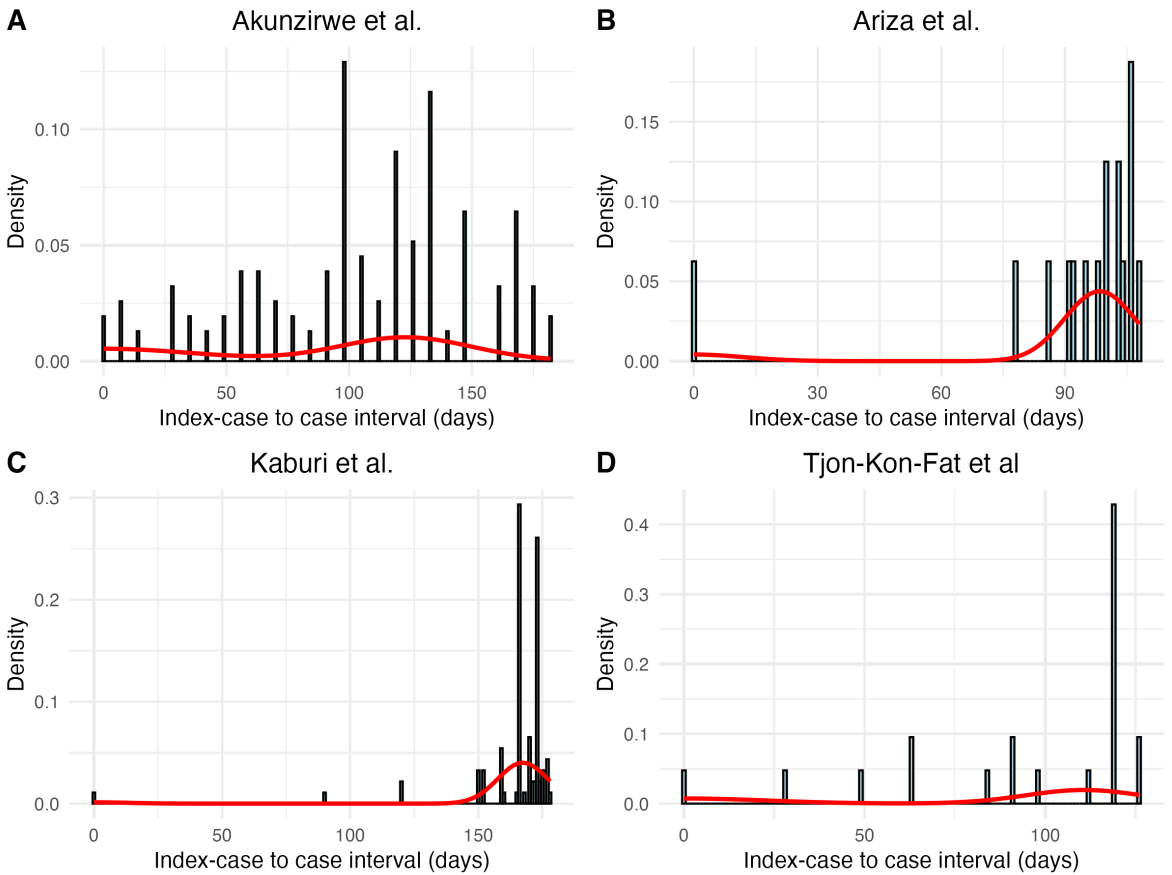
Serial Interval



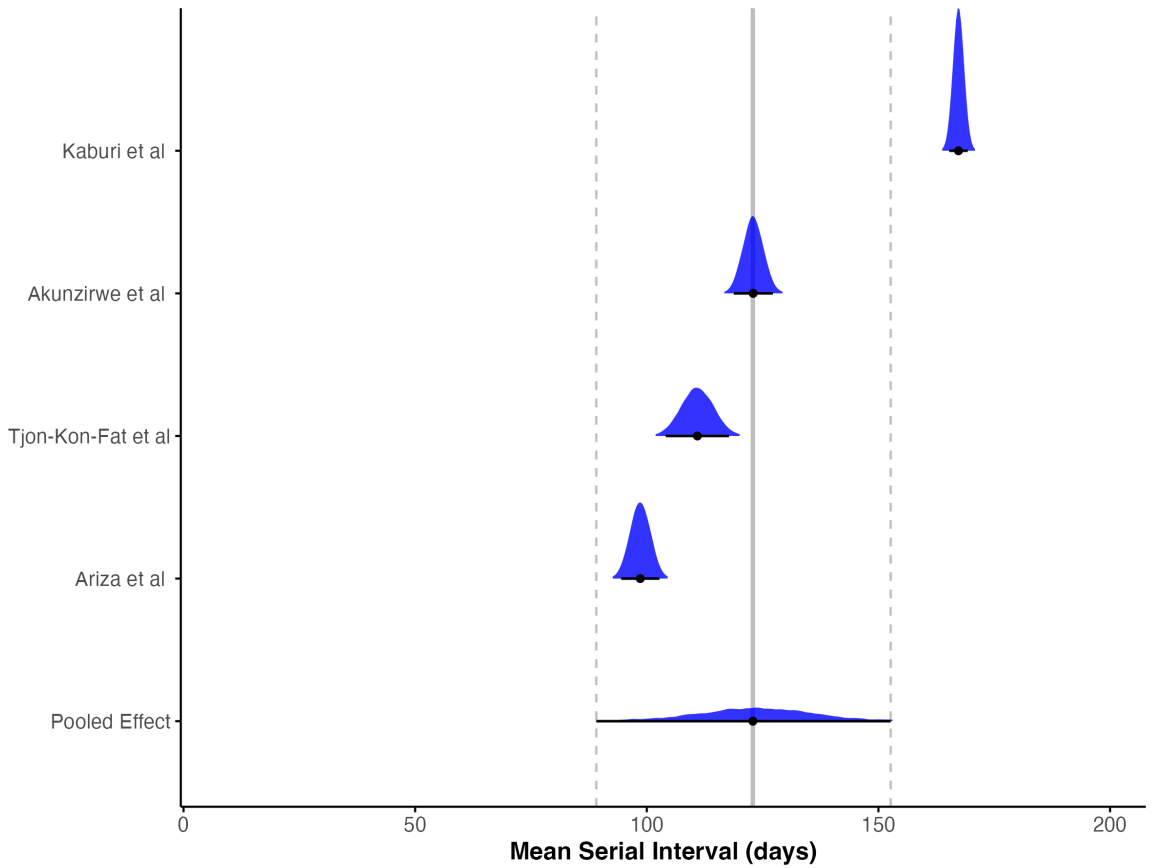
Study	Mean	Standard Deviation
Akunzirwe et al.	122.92	26.92
Ariza et al.	98.40	8.54
Kaburi et al.	167.34	9.72
Tjon-Kon-Fat et al	110.72	16.14

*unit is days

Epidemic curves and estimated serial interval distributions from four scabies outbreaks. Red line indicates estimated serial interval density assuming an underlying normal distribution.

Serial Interval

- We performed a meta-analysis.
- **Estimated pooled mean serial interval:**
  - 123.24 days (95% credible interval: 91.44, 153.41 days)



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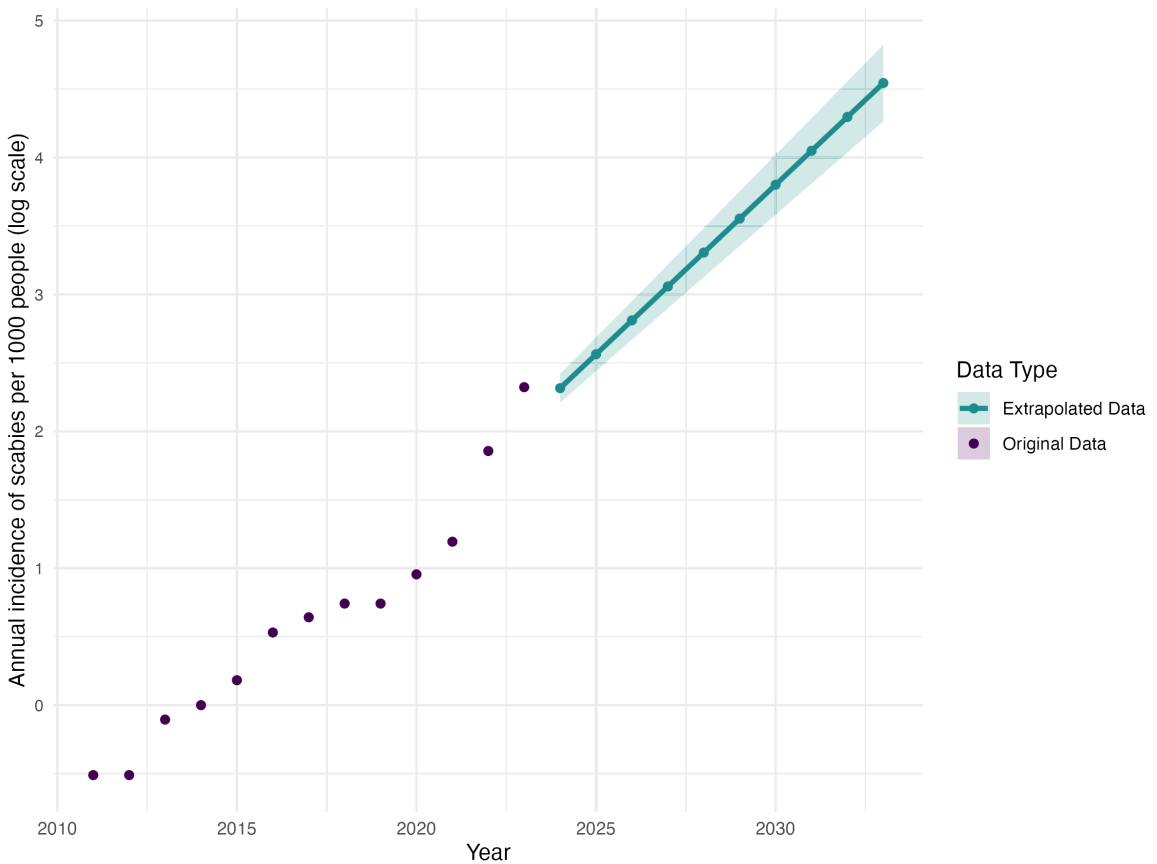
Growth Rate

- To determine how the number of scabies cases is changing each year in NL we estimated the *annual* growth rate
  - Fit GLM to the annual number of scabies diagnoses per 1000 people.
- **Estimated an annual growth rate:** 0.25 (95% CI: 0.2, 0.3)



Our Roadmap

- What is the timescale of a typical scabies transmission event?
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Basic Reproduction Number R_0

- We can relate the growth rate to the basic reproduction number as

$$R_0 = \exp(r * T - (1/2)r^2 s^2)$$

  - r is the annual growth rate,
  - T is the mean generation time (in years), and
  - s^2 is the variance of the generation time distribution.

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  - r is the annual growth rate,
  - T is the mean ~~generation time~~ serial interval (in years), and
  - s^2 is the variance of the ~~generation time~~ serial interval distribution.

- This gives us an $R_0 = 1.09\,(95\%\text{CI}: 1.07, 1.11)$

Our Roadmap

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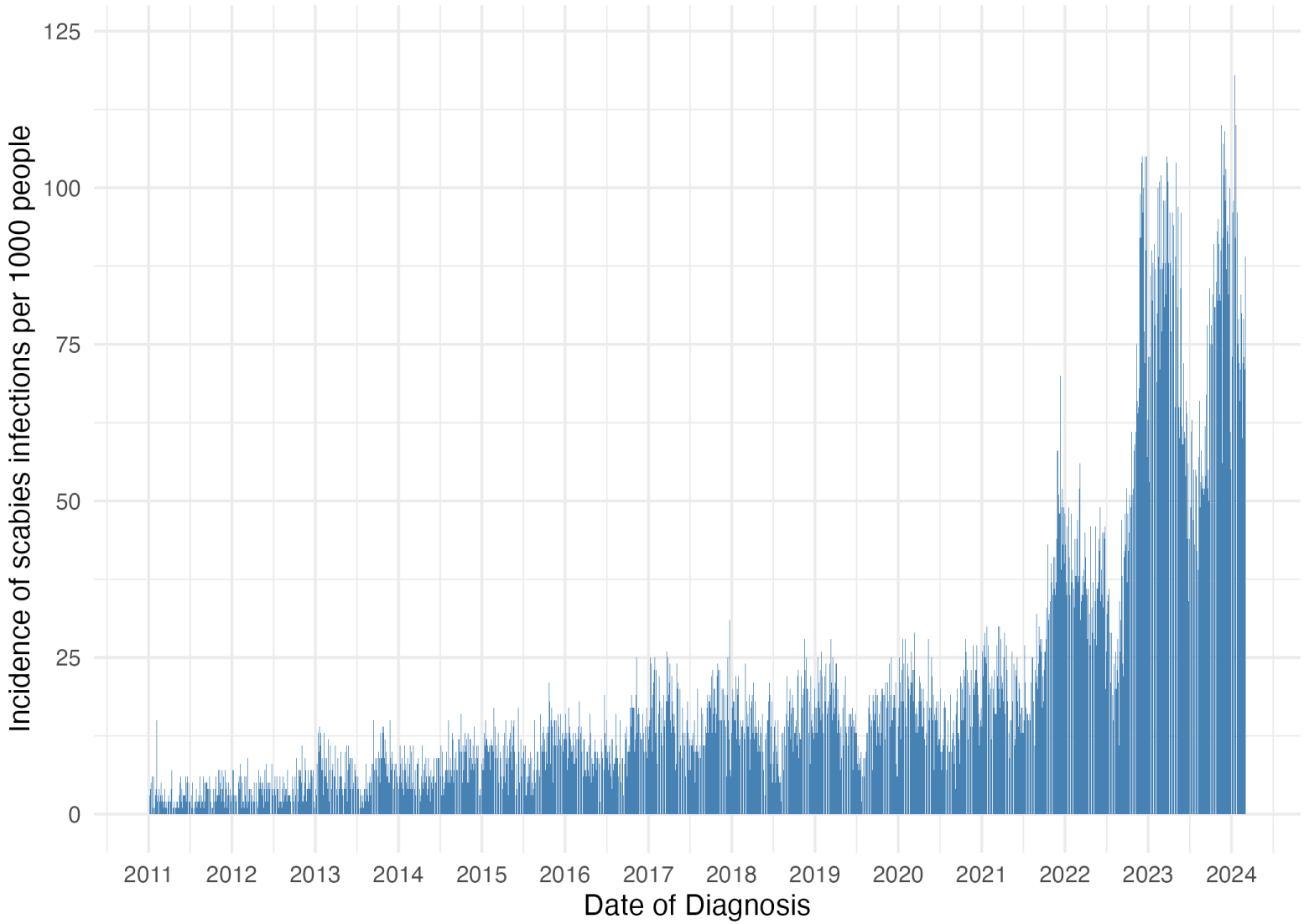
Time-varying Reproduction Number R_t



Incidence of scabies infections per 1000 people in the Netherlands by date of diagnosis.

National Institute for Public Health and the Environment
Ministry of Health, Welfare and Sport

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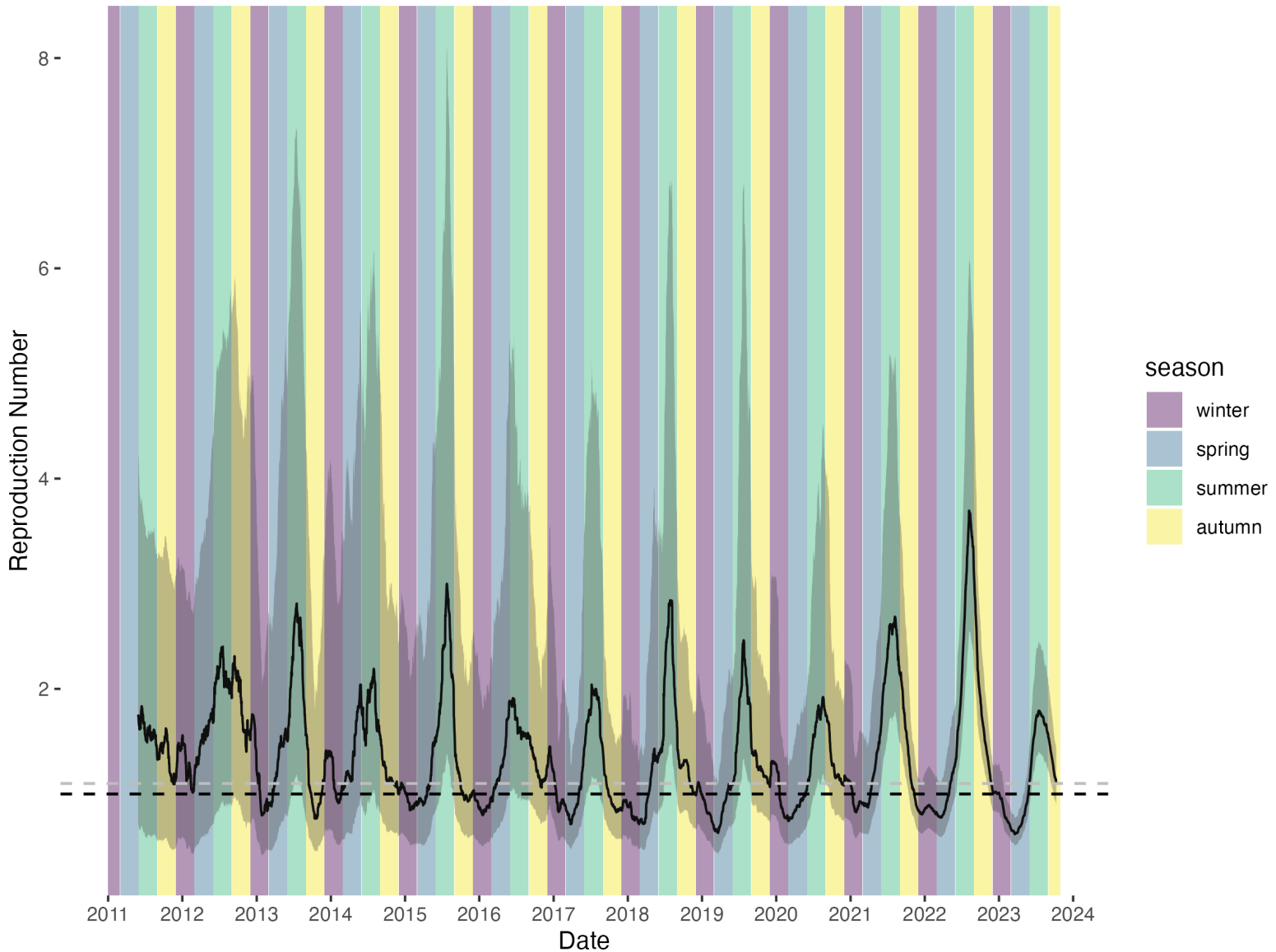

Now what?

Policy Implications

- Scabies cases are increasing in the Netherlands.
- Minimal control measures could decrease $R_0 < 1$, such as
  - educate age groups (adolescents and young adults) with highest prevalence of scabies about the causes and symptoms of scabies infections,
  - require a scabies check for university students prior to the school year, or
  - inform GPs about the higher risk of scabies in certain groups
    - could lead to quicker diagnoses

https://www.informedhealth.org/scabies-how-can-you-prevent-infection.html

This is only the beginning

- The epidemiological quantities estimated here can be used to parameterise mathematical models of scabies spread
- There is still a lot that we don’t know
  - Future work should focus on obtaining more precise estimates of the underlying quantities that govern scabies spread.

Your turn

`mitey` package

Wrapping up

Thank you

- Jacco Wallinga
- Mariette Hooiveld

Funding

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