Estimation of the basic reproduction number (R_0)

Karine Chalvet-Monfray

Estimation of R_0

R_0

1. Endemic equilibrium
2. Epidemic episode

   R_0 estimation

   β estimation

   -> (Rt) Estimation

Estimation of R_0

1. Endemic equilibrium

If homogenous population, born susceptible, no lost of immunity,…

$$R_0 = \frac{L}{A}$$

L ← Average life expectancy

A ← Average infection age

Average life expectancy 80 years and Average infection age 10 years, R_0=8

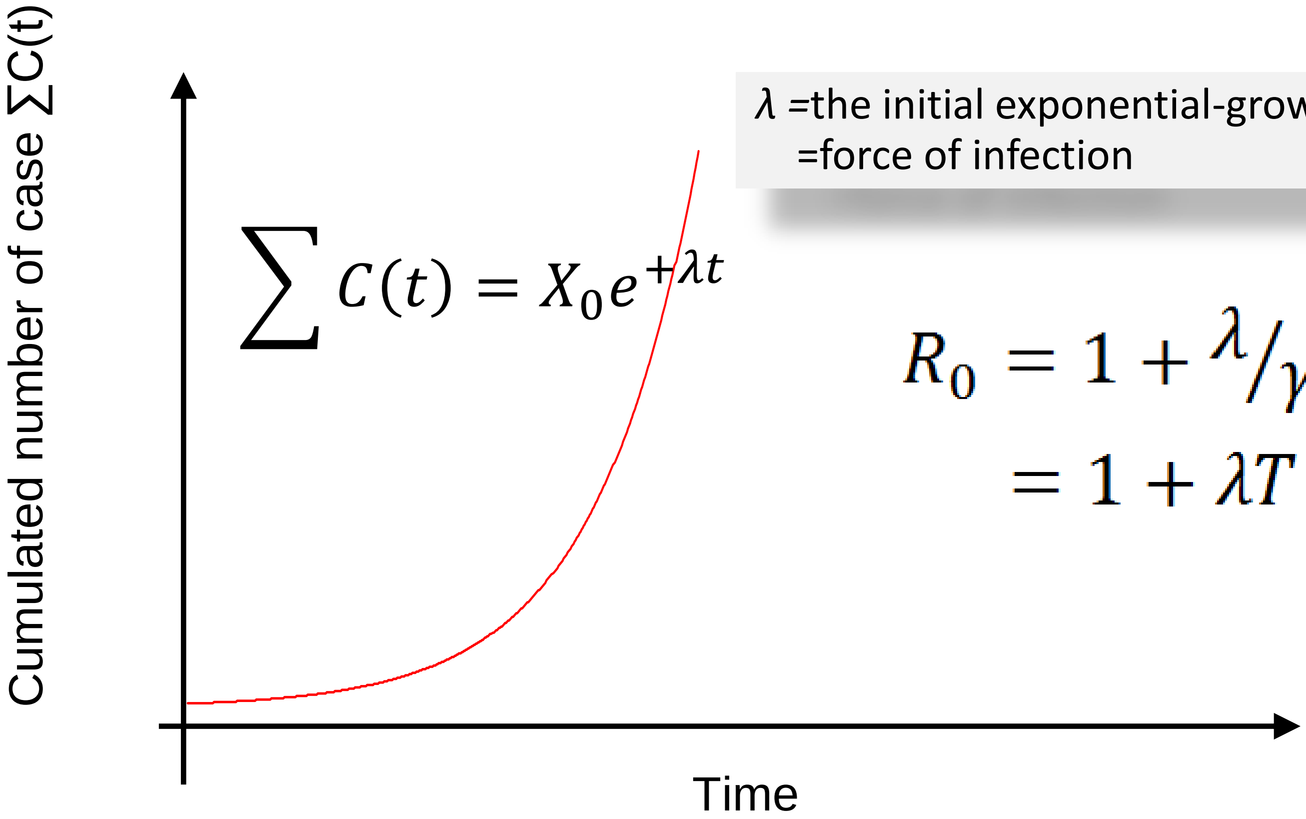
$$\lambda = \frac{1}{A}$$

Force of infection

Estimation of $\mathbf{R_0}$

1. Epidemic episode

R_0 estimation : exponential growth



$$\sum C(t) = X_0 e^{+\lambda t}$$

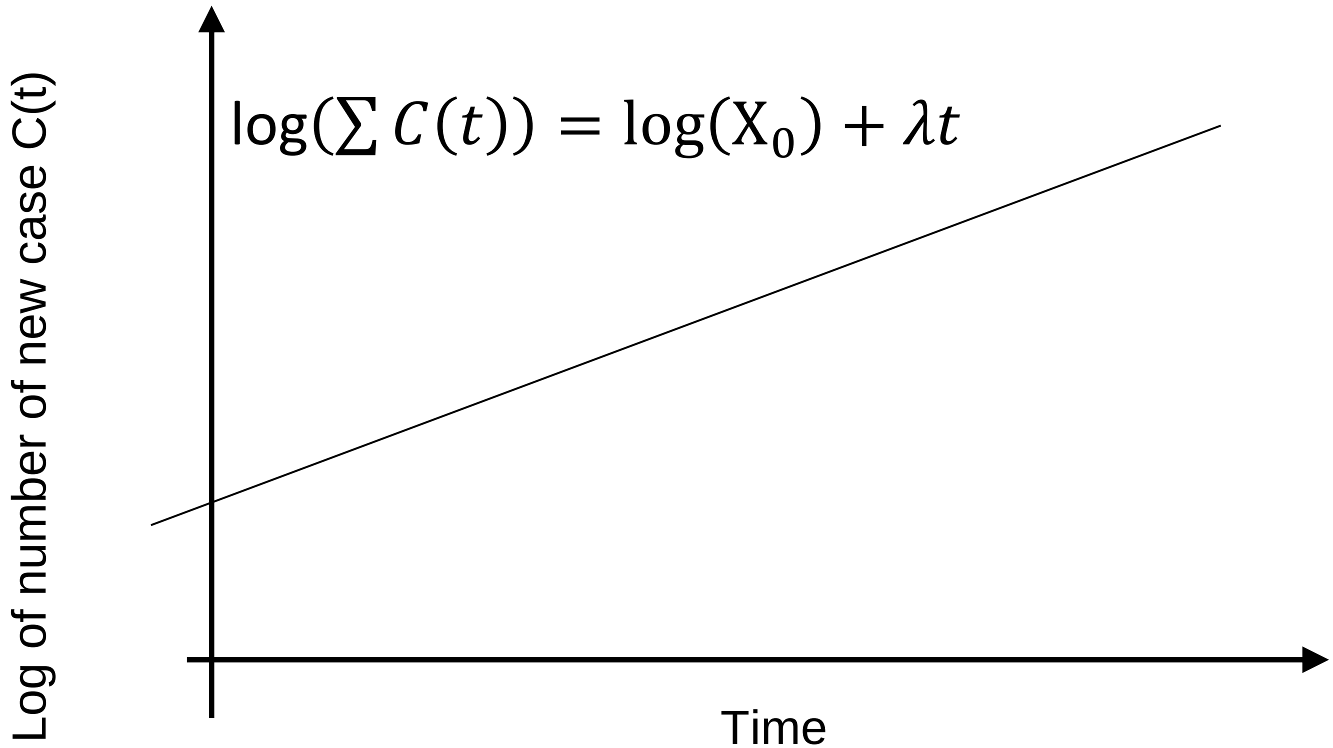
λ =the initial exponential-growth rate
=force of infection

$$R_0 = 1 + \lambda/\gamma$$
$$= 1 + \lambda T$$

Estimation of $\mathbf{R_0}$

1. Epidemic episode

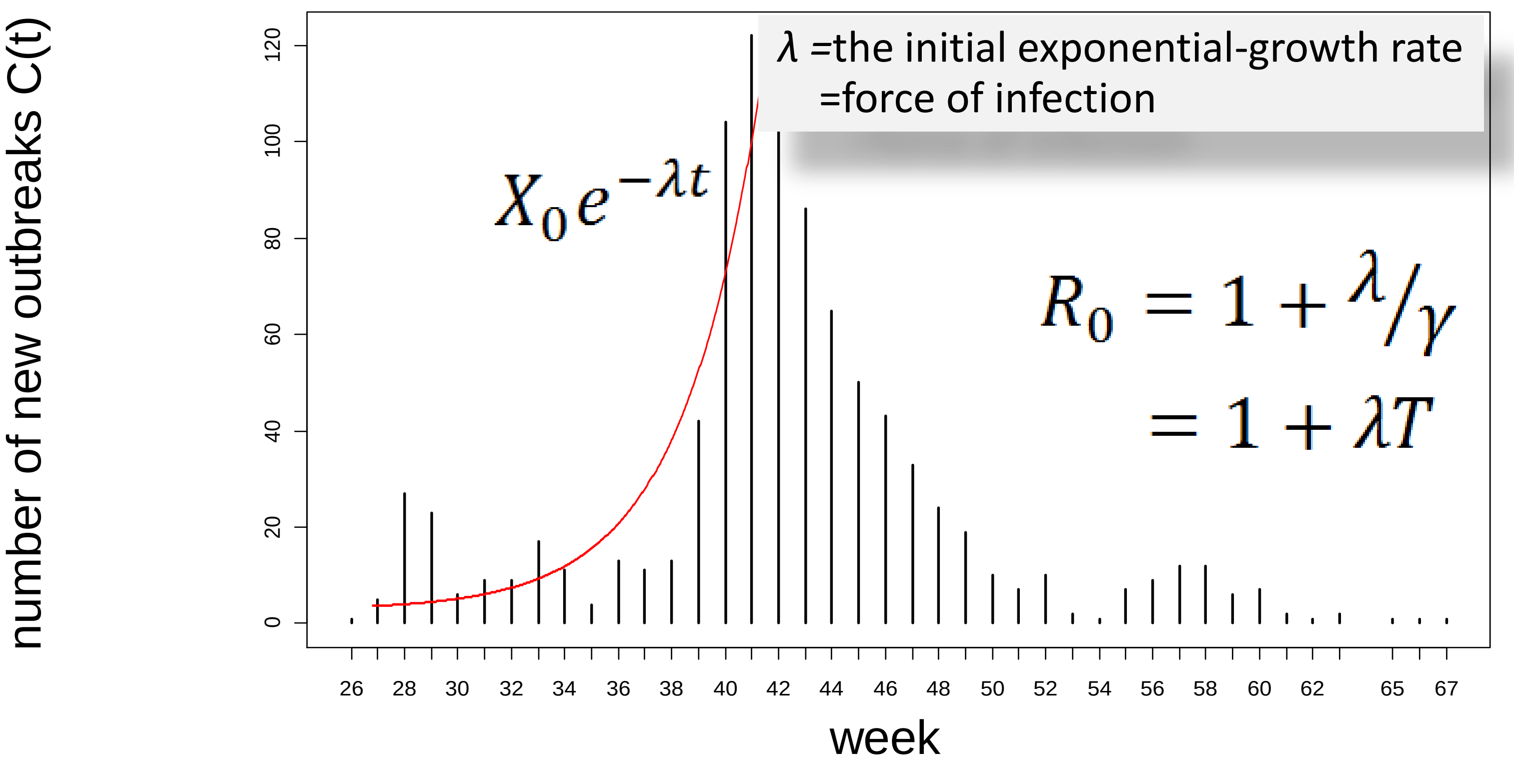
R_0 estimation : exponential growth



Estimation of R_0

1. Epidemic episode

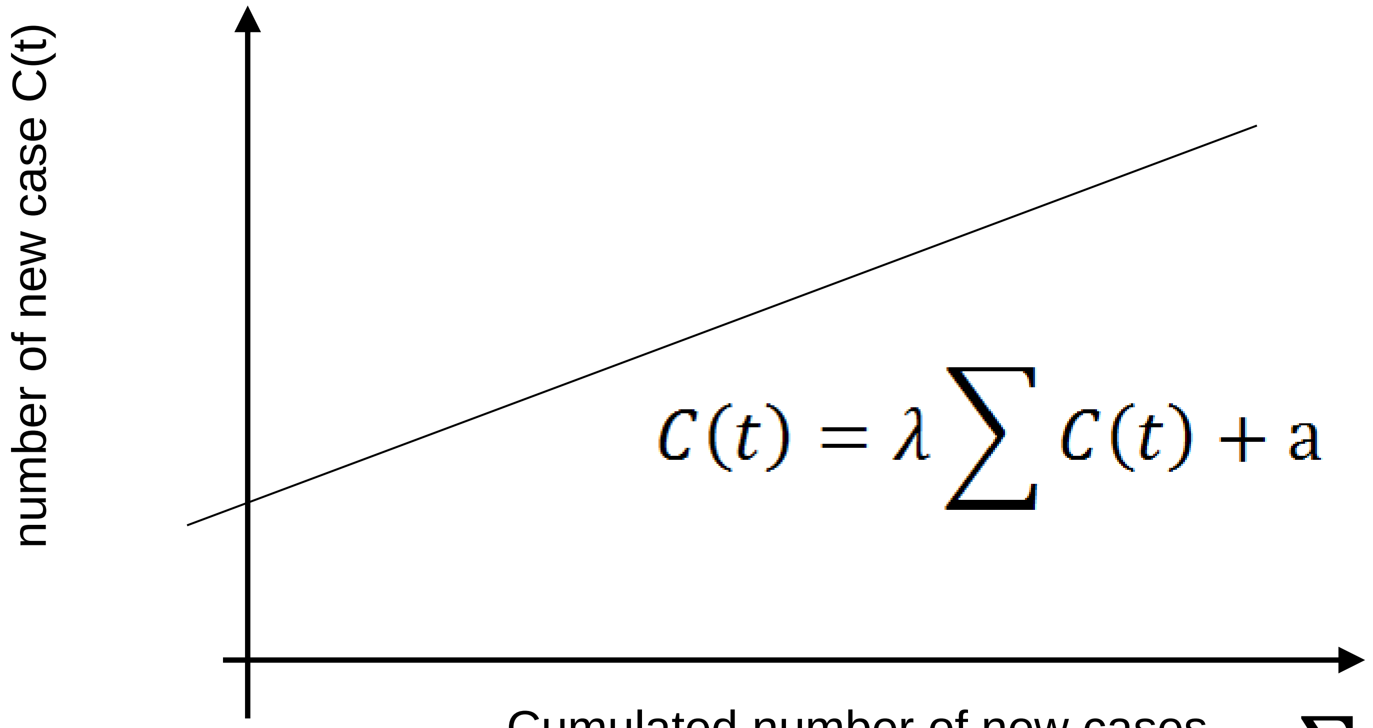
R_0 estimation : exponential growth



1. Only at the beginning
2. A global value
3. Not easy to define the limits of the phase

Estimation of R_0

R_0 estimation : exponential growth

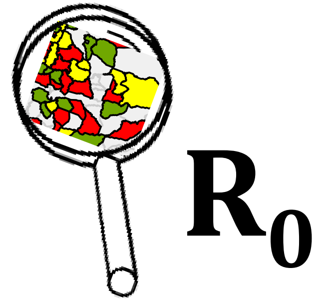


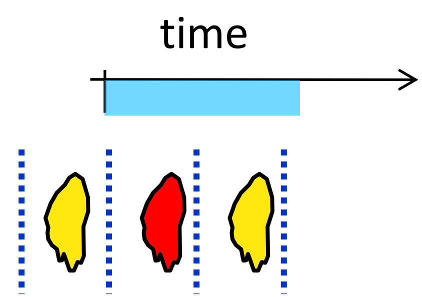
$$C(t) = \lambda \sum C(t) + a$$

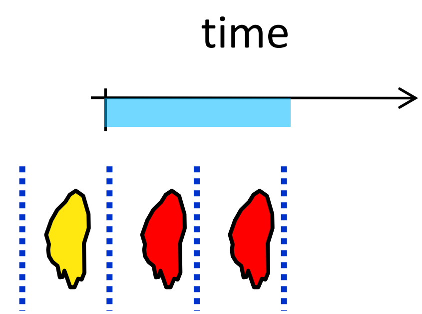
$$\sum C(t)$$

Method adapted from (Favier et al., 2006)

Estimated basic reproduction rate







	2 week refractory period and 1 week infectious period (T)		2 week refractory period of and 2 week infectious period (T)	
	Method adapted from (Vynnycky et al., 2007)	Method adapted from (Favier et al., 2006)	Method adapted from (Vynnycky et al., 2007)	Method adapted from (Favier et al., 2006)
Initial exponential-growth rate (SE)	λ=0.267 (SE=0.045)	λ=0.310 (SE=0.038)	λ=0.262 (SE=0.044)	λ=0.299 (SE=0.039)
R_0 [95% CI]	R_0=1.267 [1.180-1.355]	R_0=1.310 [1.234-1.385]	R_0=1.526 [1.352-1.670]	R_0=1.597 [1.444-1,750]

Estimation of R_0

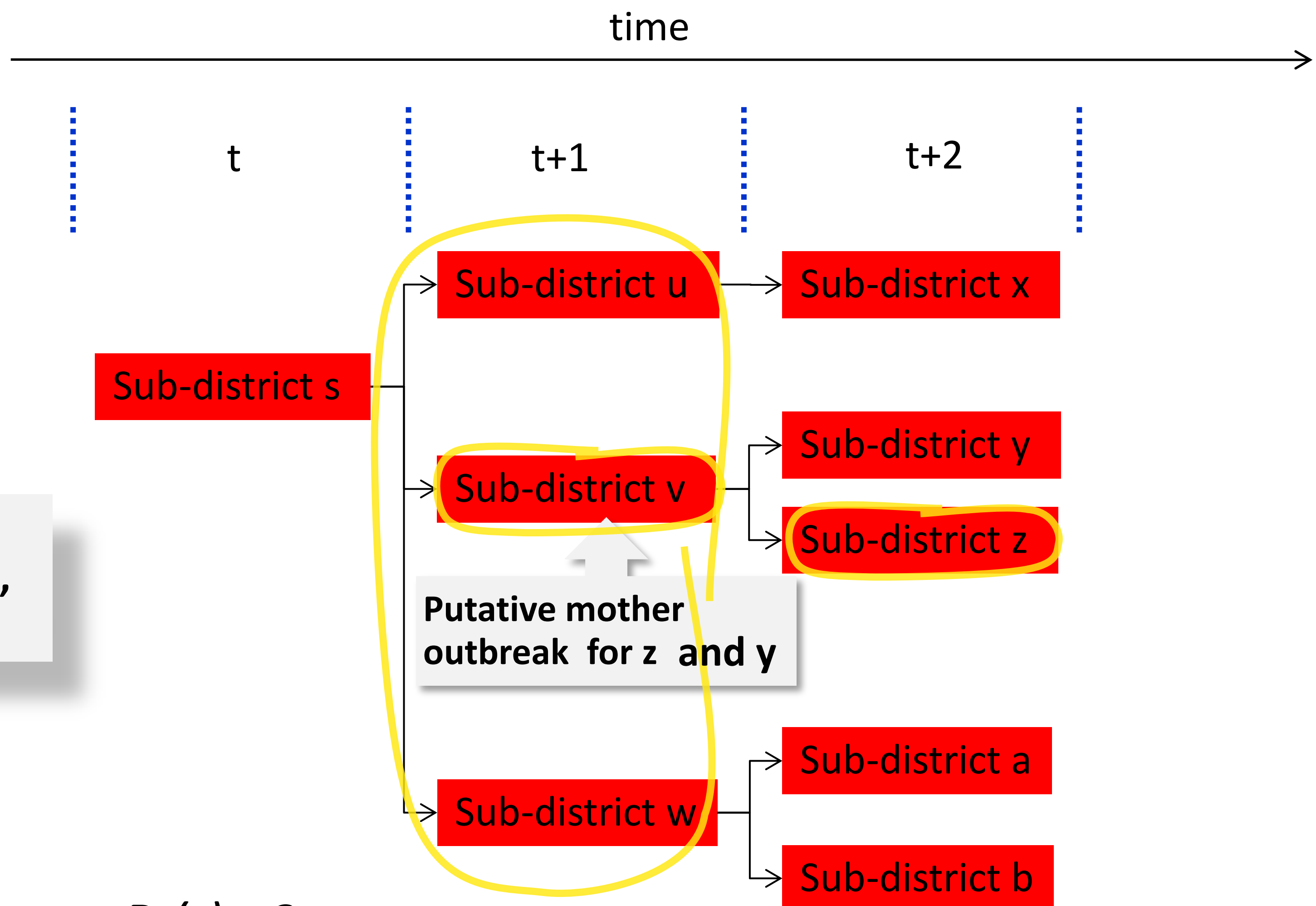
R_0 estimation : exponential growth

Nearest infectious neighbor method

-> Epidemic tree

R_0 estimation : exponential growth

Epidemic tree using the nearest infectious neighbor method



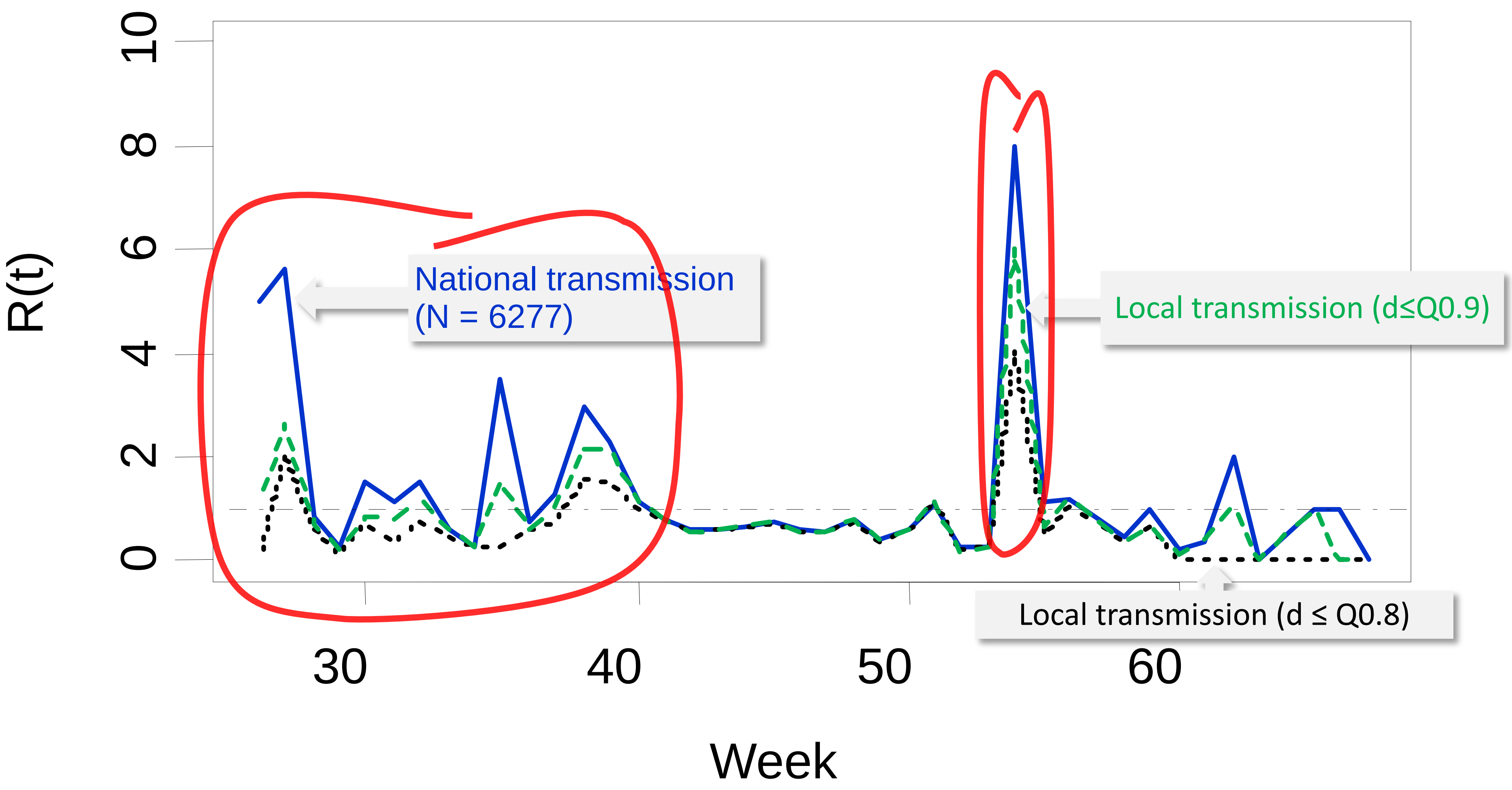
Method adapted from (Ward et al., 2009)

$R_s(t) = 3$

$R_u(t+1) = 1$

Estimations of the R(t)

2. Application to the estimation



Effective reproduction number R(t)

- When the population cannot be considered as being completely susceptible
- It represents the expected number of secondary cases issued from a primary case.

$$R \leq R_0$$

$$\mathrm{R} = \beta \mathrm{T}$$

-> Estimation de β

-> Estimation de T => Survival curve

Effective reproduction number R

-> Estimation de β

Method adapted from (Ward et al., 2009)

Susceptible S(t) → Infectious I(t)

$$N = S(t) + I(t)$$

$$\beta(t) S(t) I(t) / N = C(t)$$

$$R(t) = \beta(t) T$$

Effective reproduction number R

-> Estimation de β(t)

Method adapted from (Eblé et al., 2008)

$$\beta(t)S(t)I(t)/N = C(t)$$

$$P\,(not\ inf) = \ e^{-\beta I \Delta t/N}$$

$$P\,(inf) = \ 1 - e^{-\beta I \Delta t/N}$$

$$C(t) = S(t) * (1 - e^{-\beta I \Delta t/N})$$

$$1 - C(t)/S(t) = e^{-\beta I \Delta t/N}$$

$$\log(1 - C(t)/S(t)) = -\beta I \Delta t/N$$

$$\log\left(-\log\left(1 - \frac{C(t)}{S(t)}\right)\right) = \log(\beta) + \log(I \Delta t/N)$$

Estimation of R

-> Various methods
-> According data
-> According objective
->different values and different precisions

-> Let us practice