

# Ebola e H1N1

Lo studio della dinamica delle malattie infettive

STEFANO FINAZZI



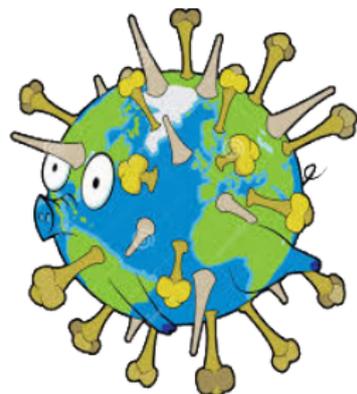
**GiViTi**

*Gruppo Italiano per la Valutazione degli Interventi in Terapia Intensiva*



**PESARO, 5 NOVEMBRE 2015**

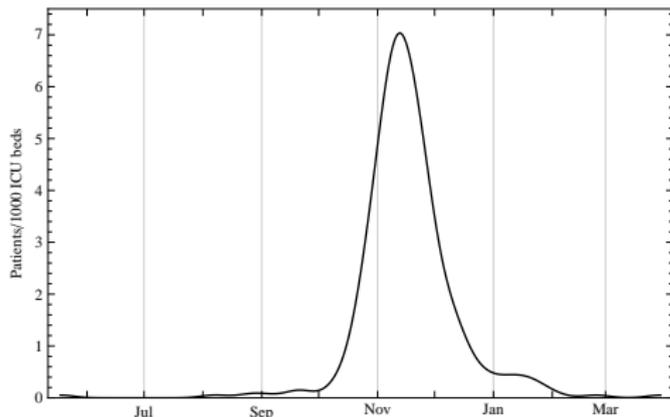
- Determinazione caratteristiche
  - contagiosità
  - mortalità
  - numero totale di contagiati
  - ...



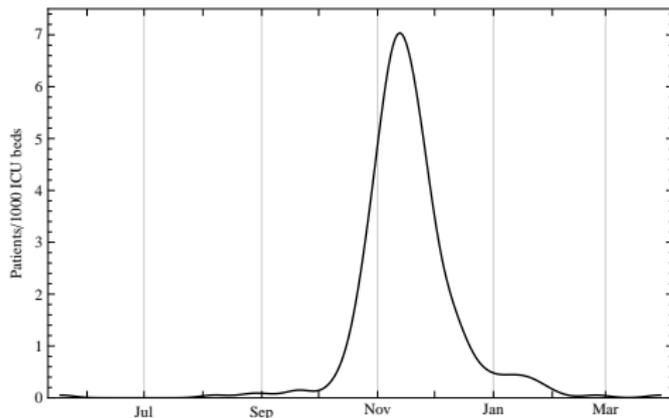
- Pianificazione interventi
  - controllo diffusione epidemia
  - allocazione ottimale risorse
  - contenimento costi sociali ed economici

sei anni fa

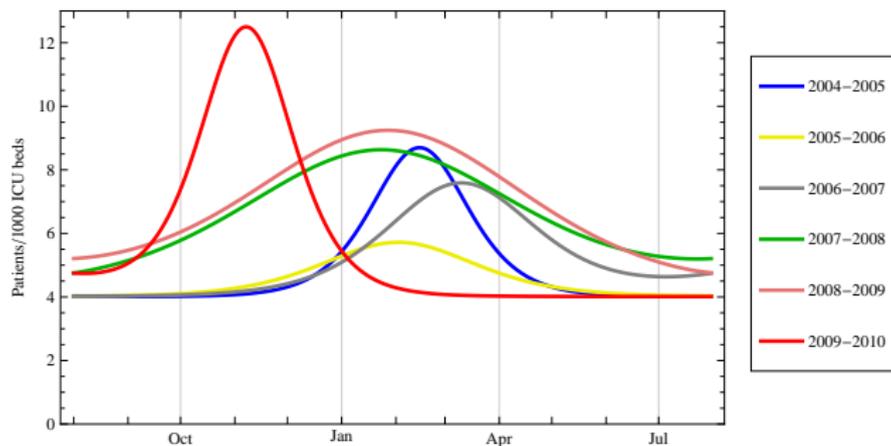
H1N1

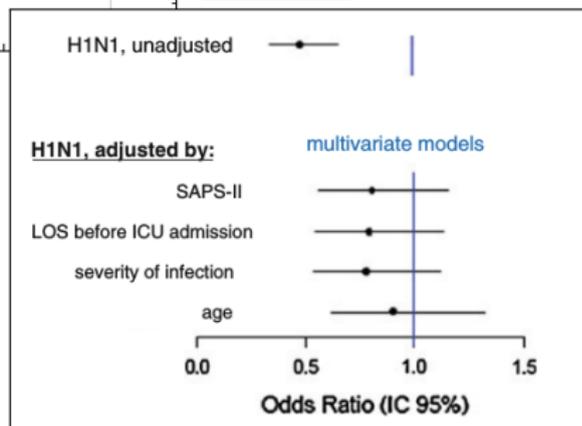
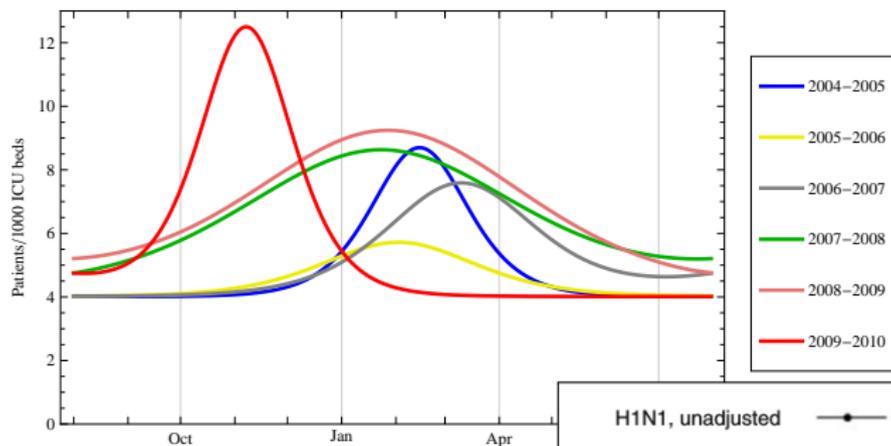


- Quale terapia? ECMO?
- Centralizzazione?
- Problemi logistici per TI?
- Mortalità maggiore?



- Quale terapia? ECMO?
- Centralizzazione?
- Problemi logistici per TI?
- Mortalità maggiore?





**S**uscettibili



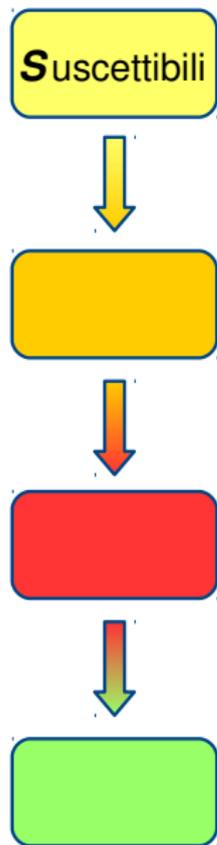
**I**nfettati



**C**ontagiosi



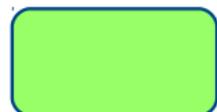
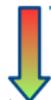
Guariti  
Morti



**S**uscettibili



**I**nfettati



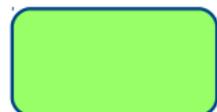
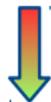
Nuovi infettati al giorno

$S$

**S**uscettibili

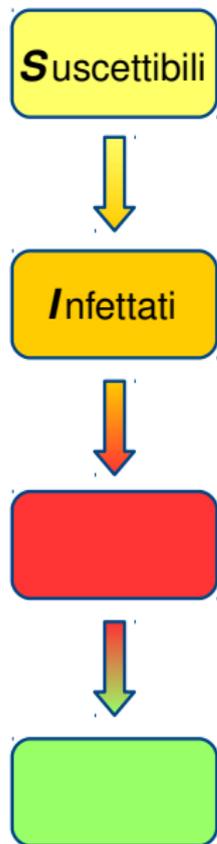


**I**nfettati



Nuovi infettati al giorno

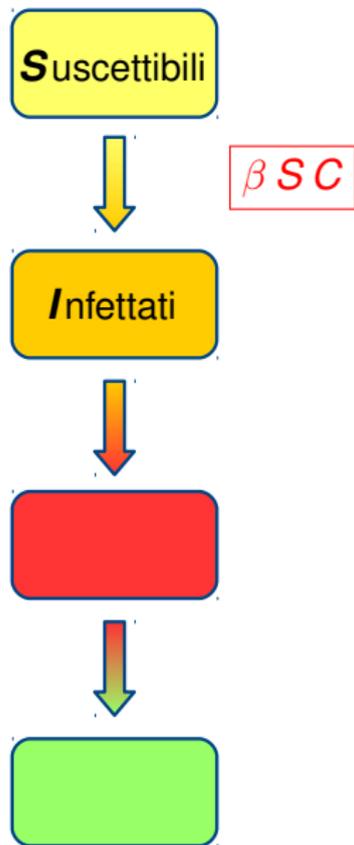
$$S \times C$$

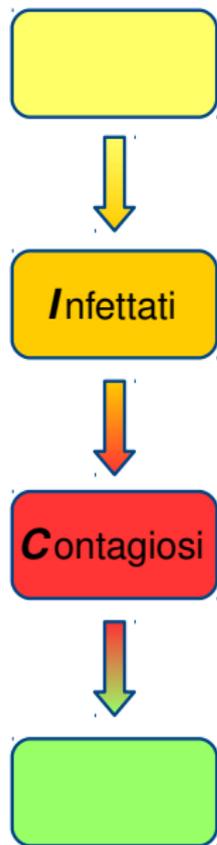


Nuovi infettati al giorno

$$S \times C \times \beta$$

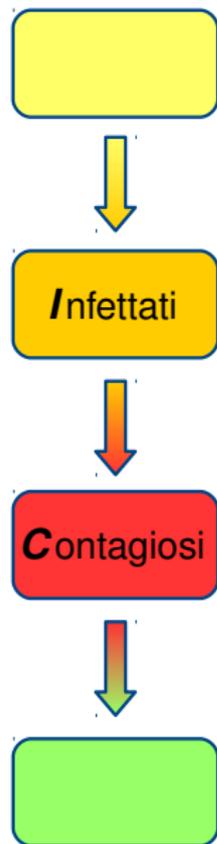
$\beta$  = Contagiosità





Nuovi contagiosi al giorno

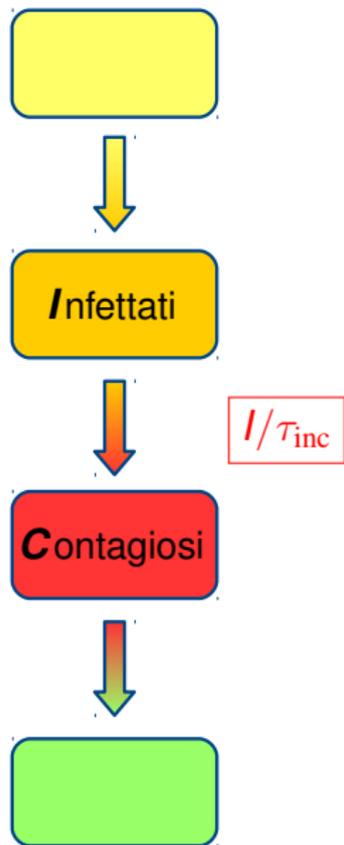
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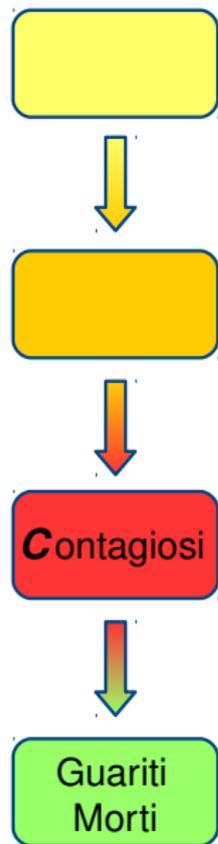


Nuovi contagiosi al giorno

$$I / \tau_{inc}$$

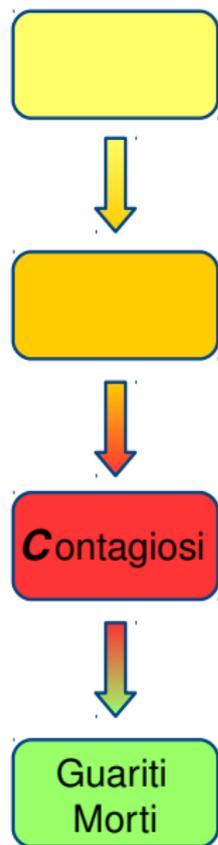
$\tau_{inc}$  = Tempo medio incubazione





Nuovi guariti/morti al giorno

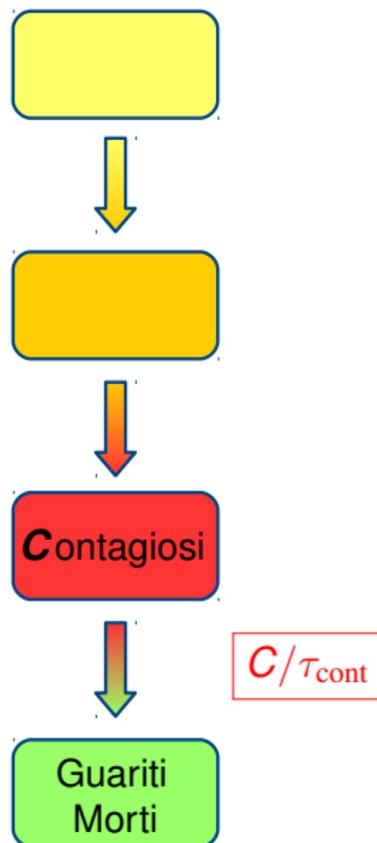
*C*

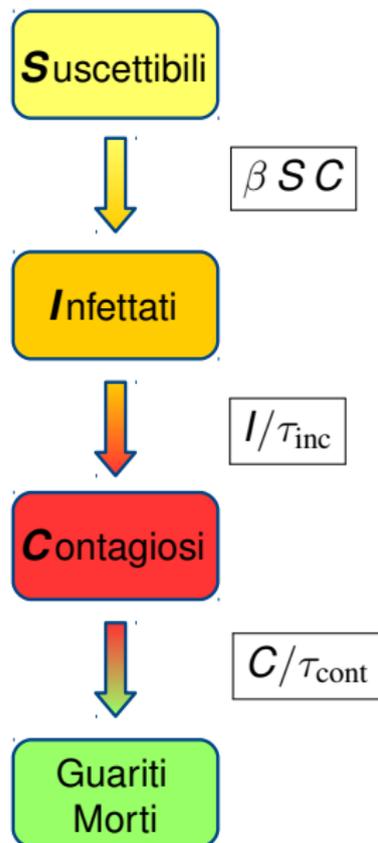


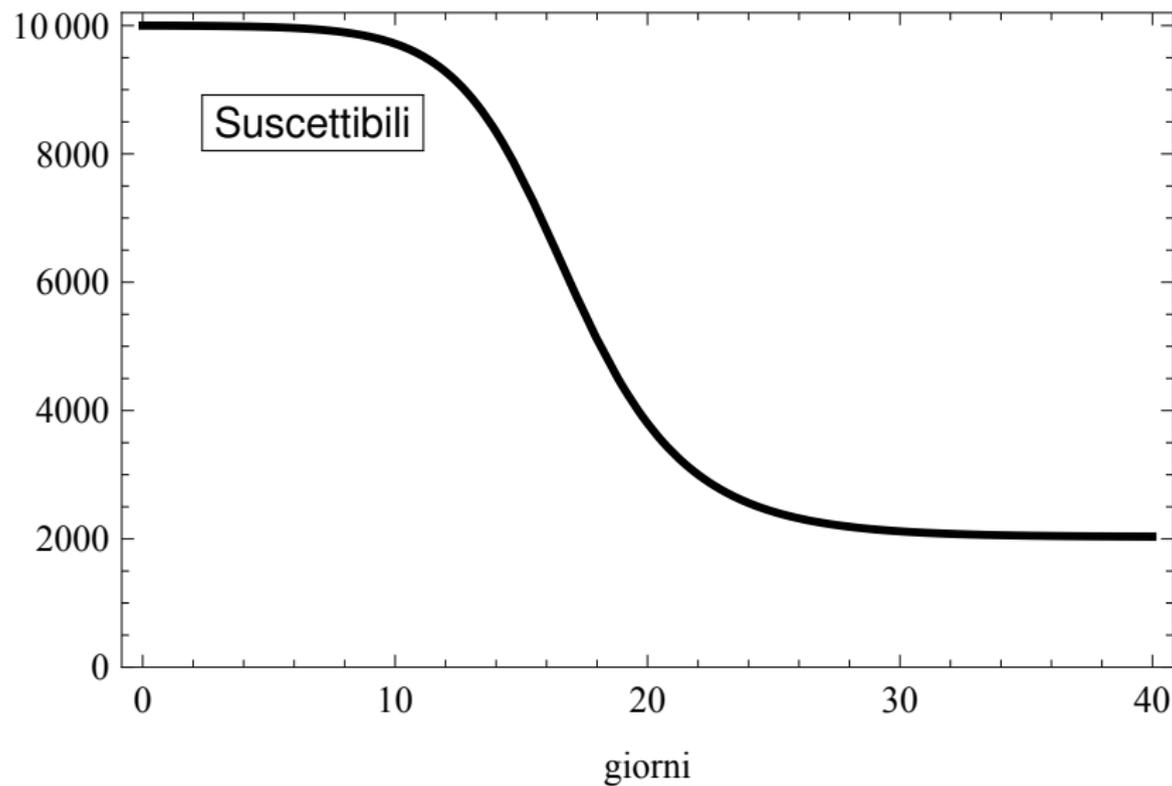
Nuovi guariti/morti al giorno

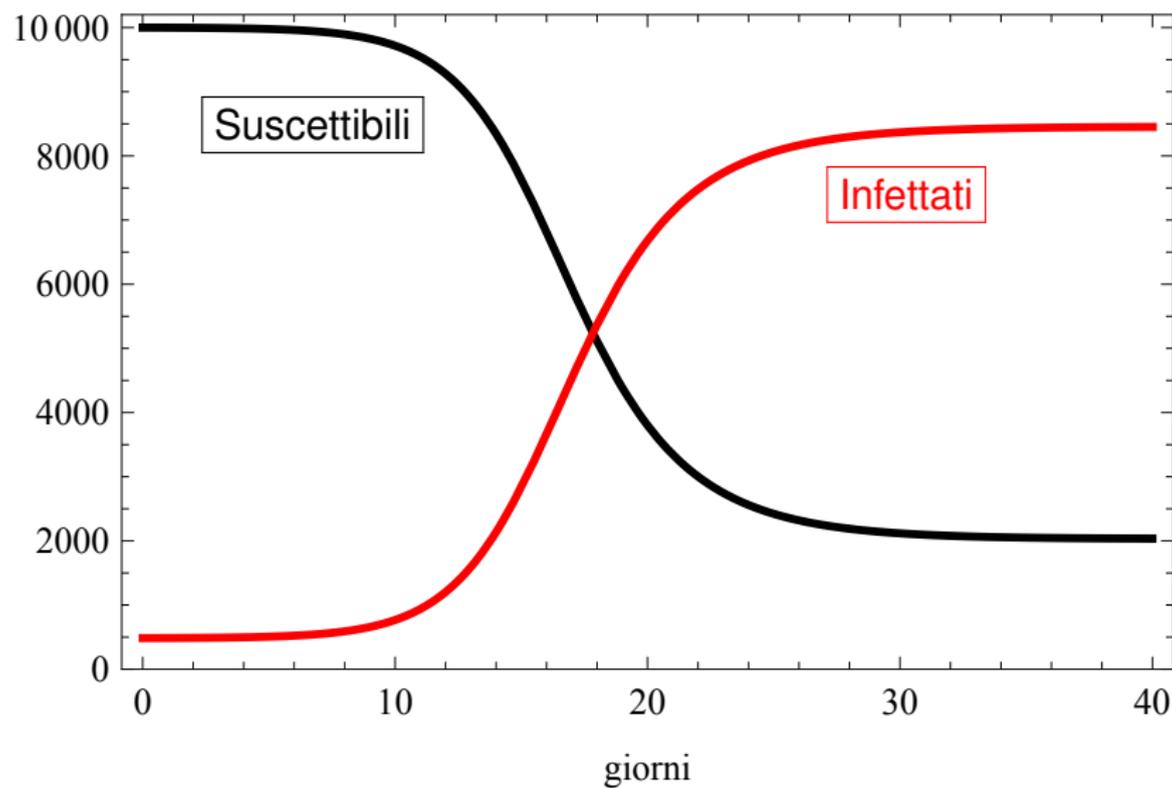
$$C/\tau_{\text{cont}}$$

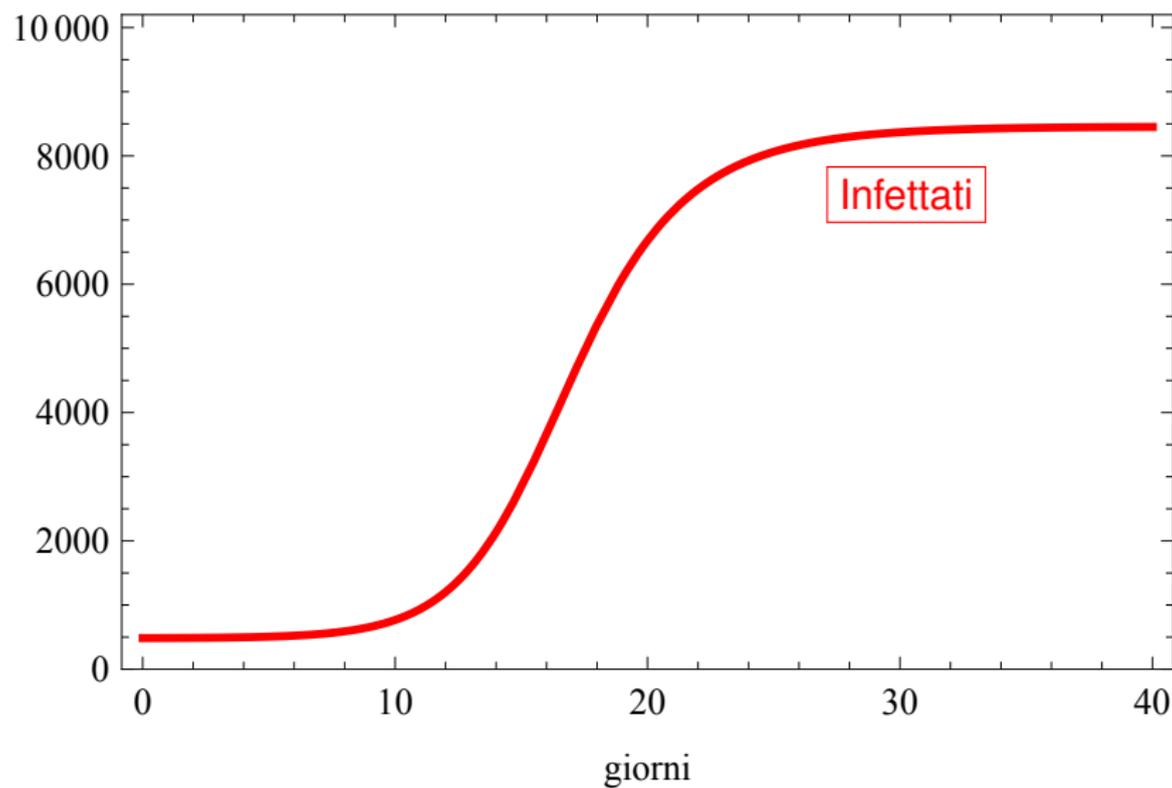
$\tau_{\text{cont}}$  = Tempo medio contagiosità

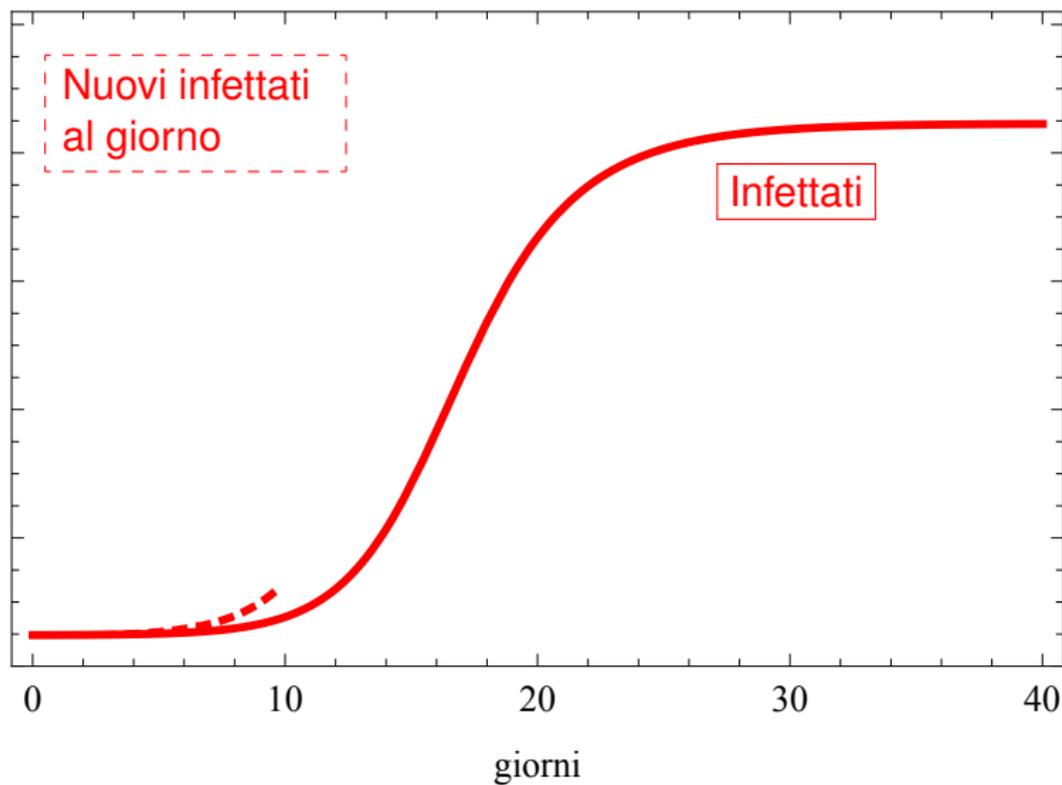


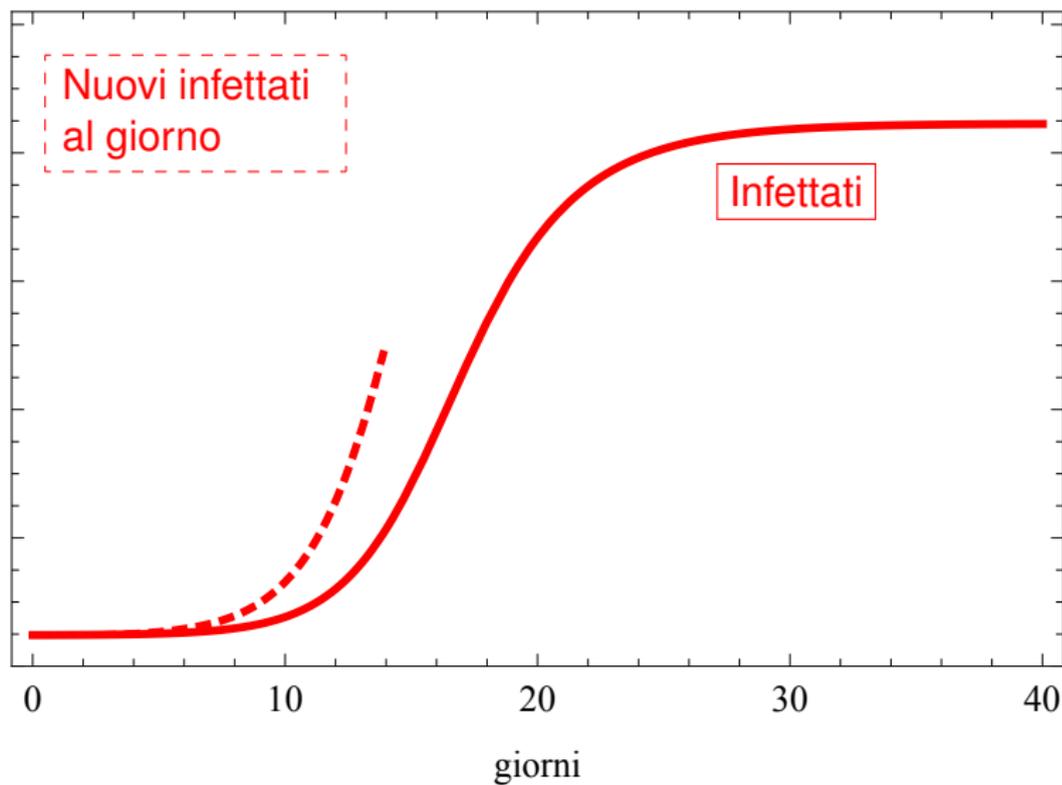


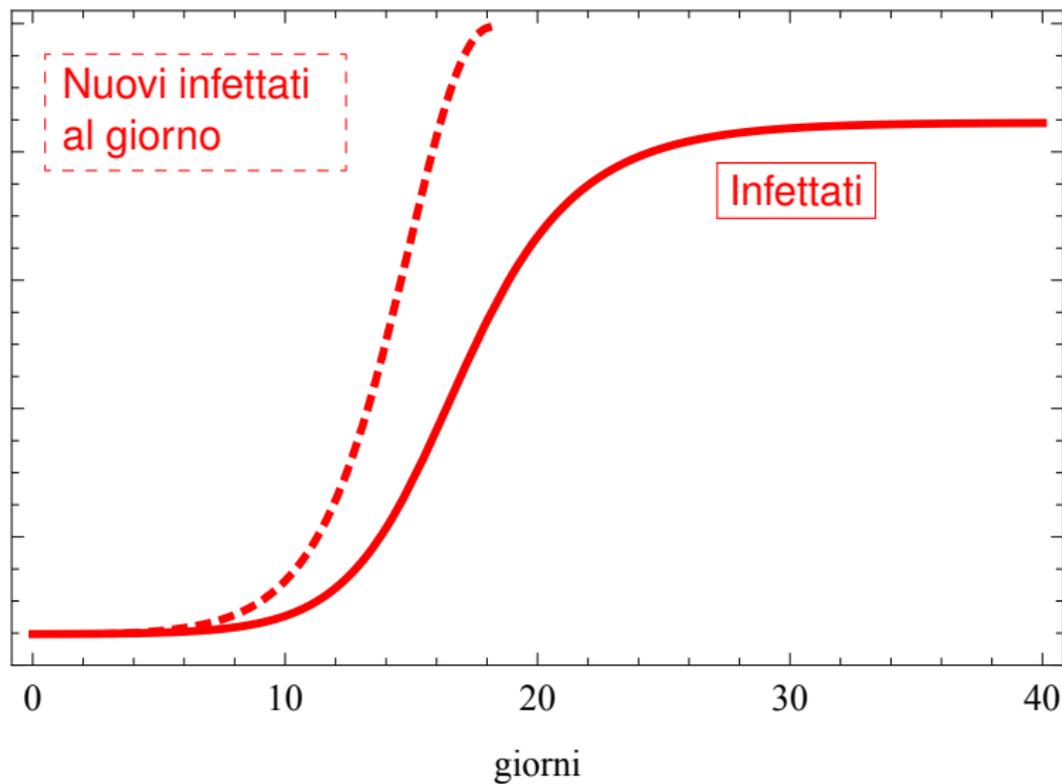


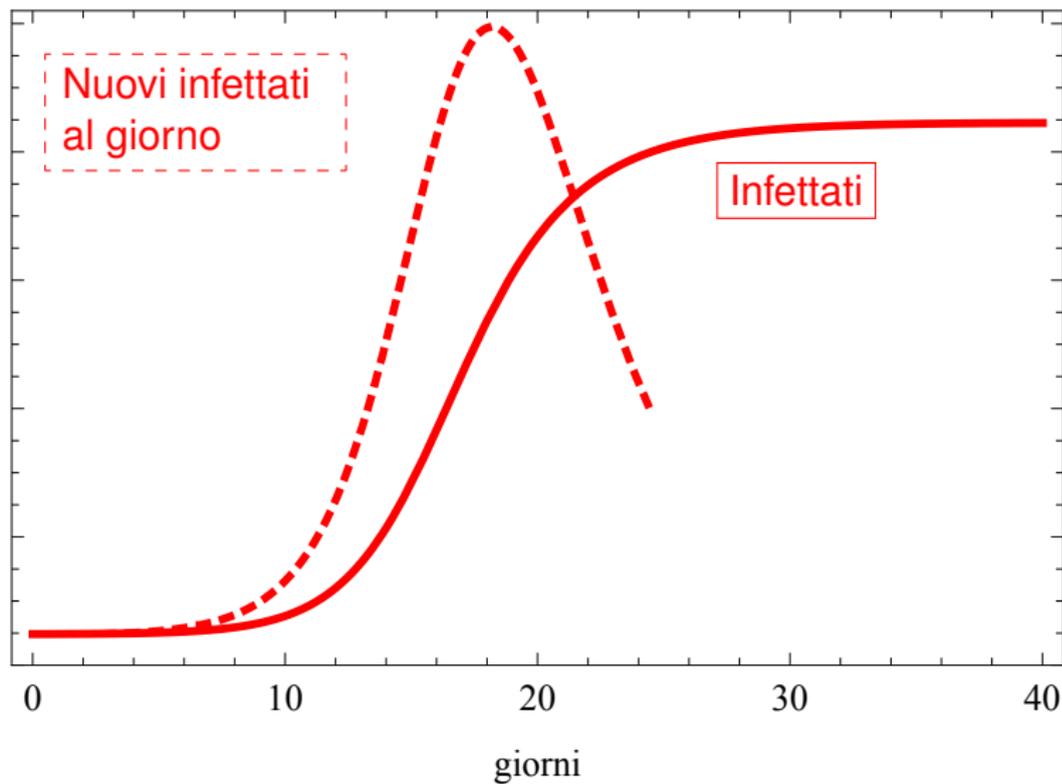


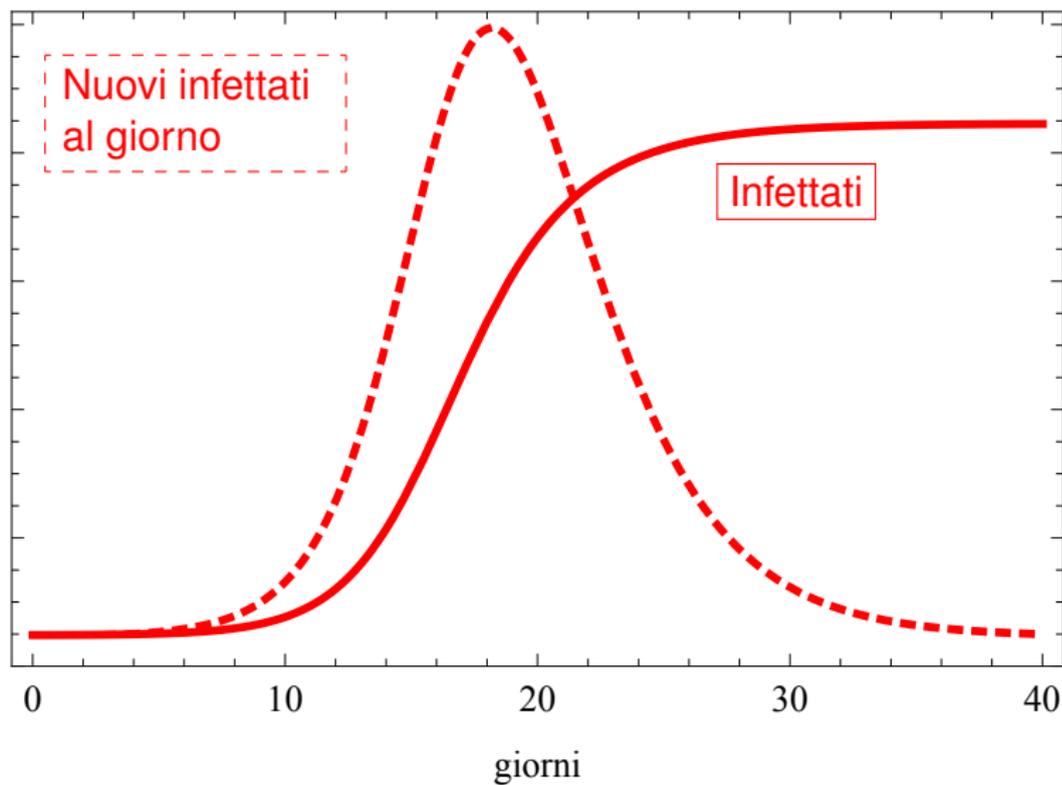


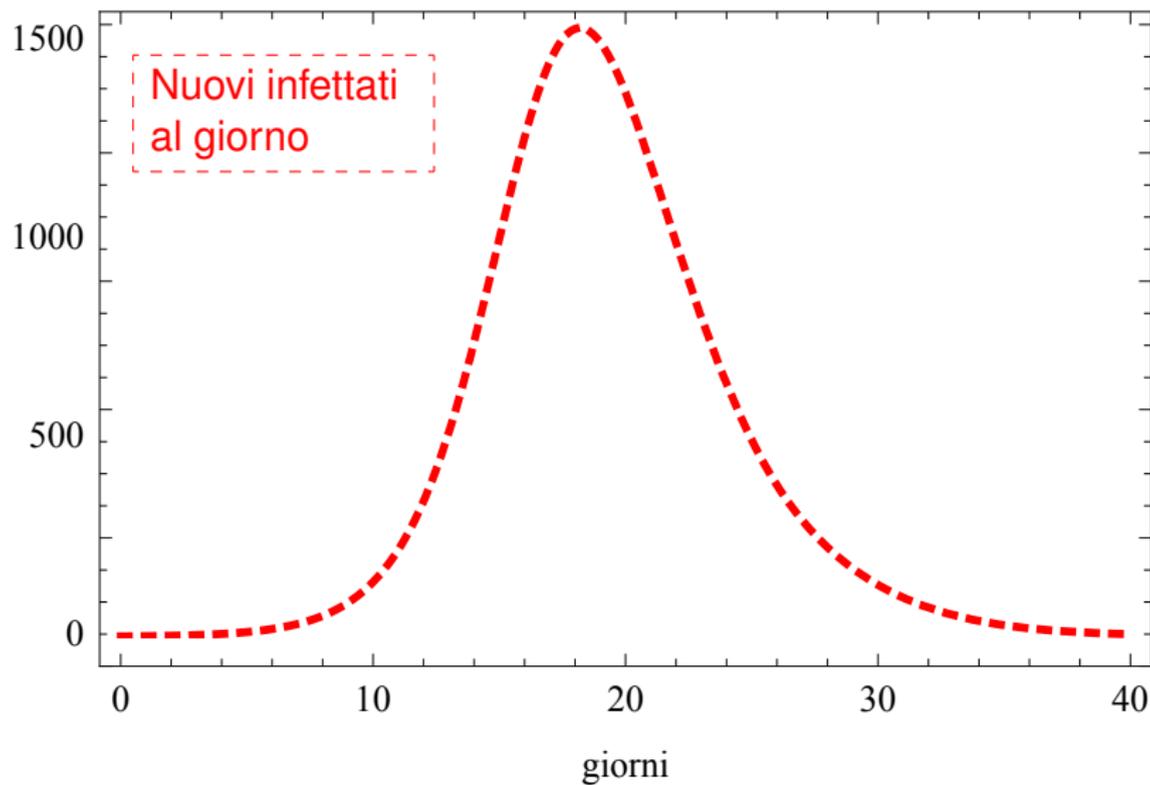


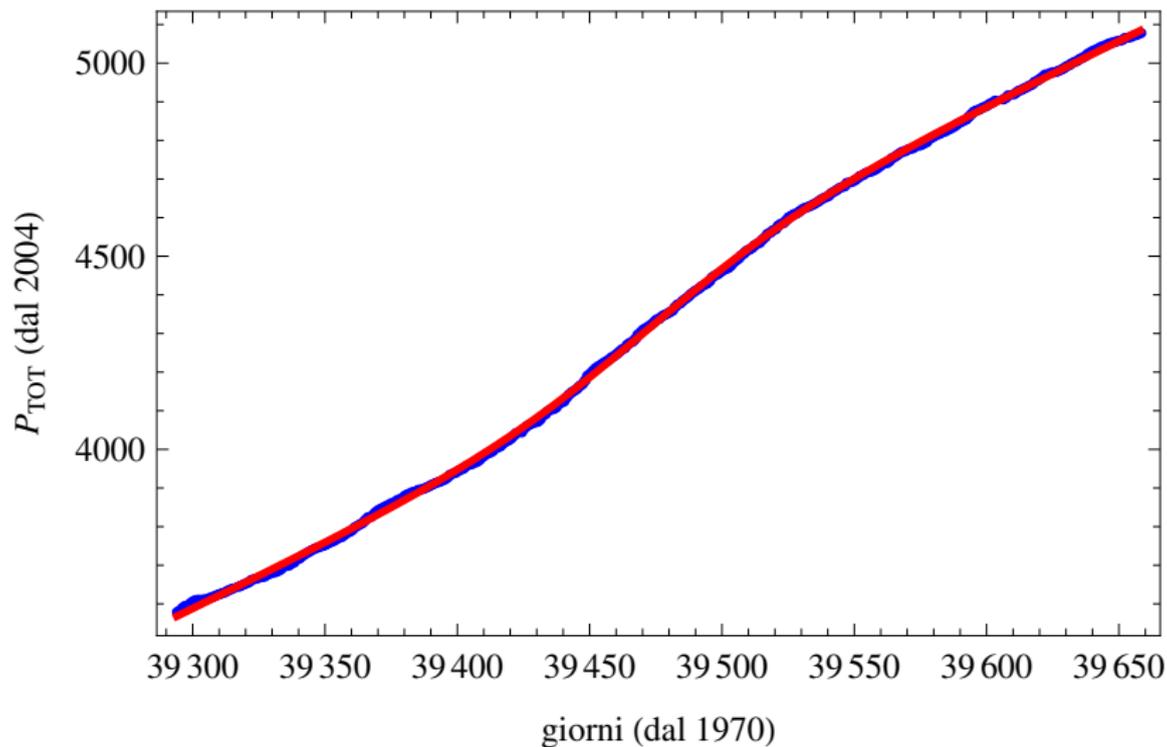


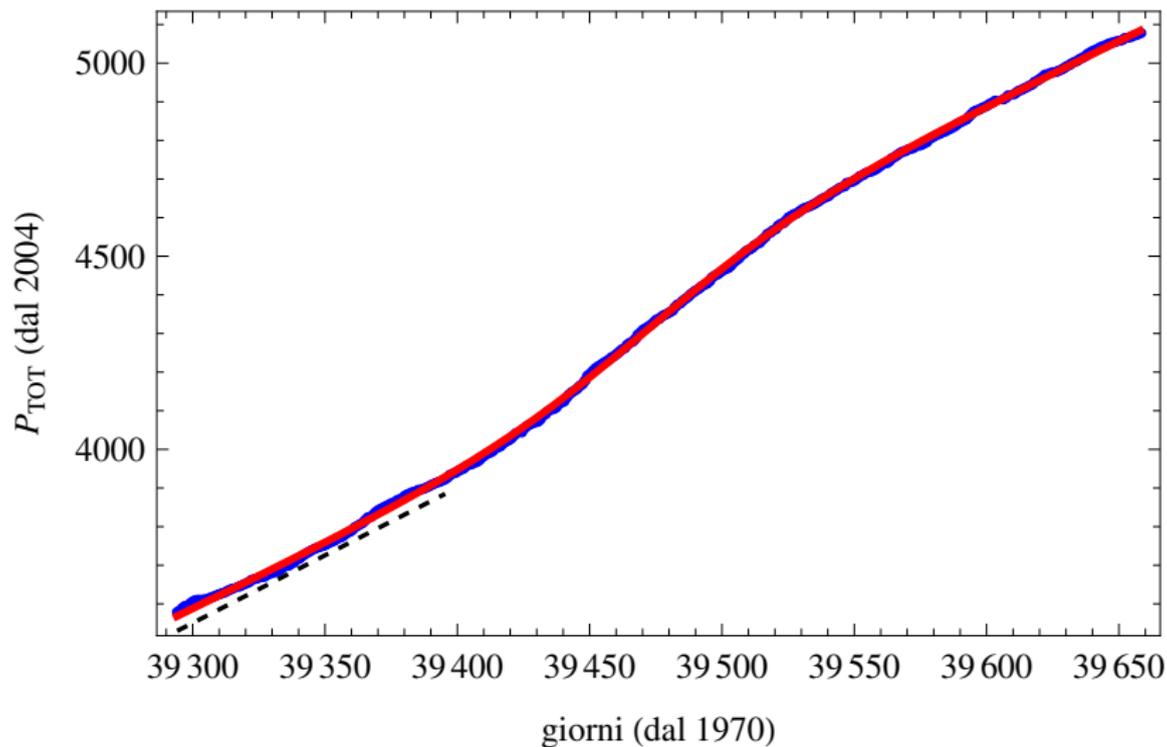


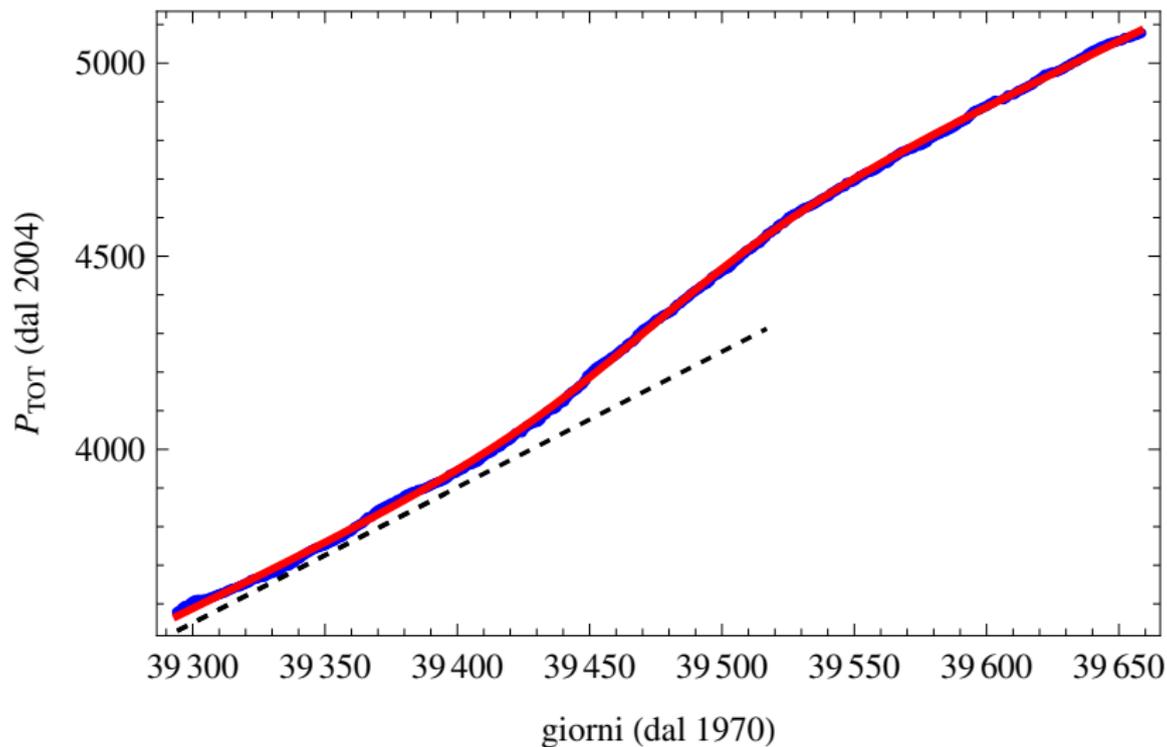


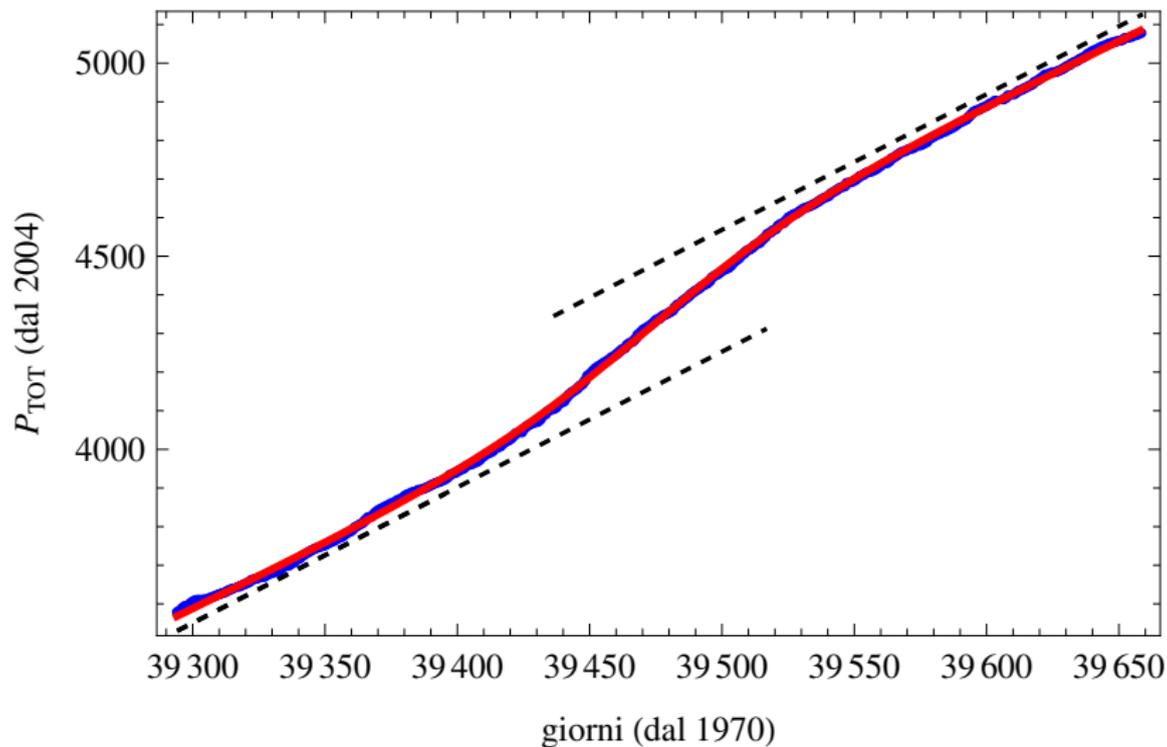


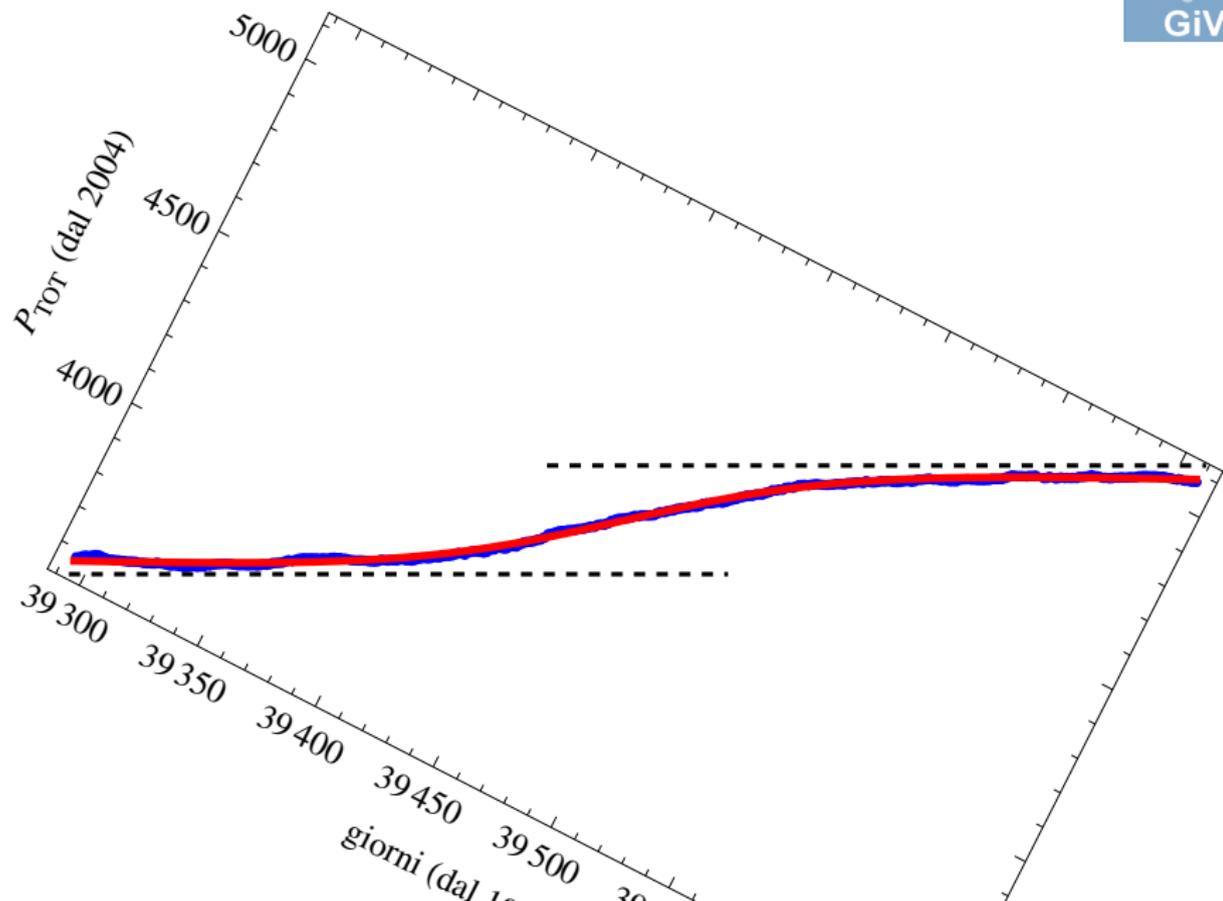




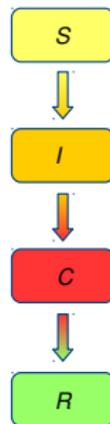








- Equazioni evoluzione temporale
- Determinazione dei parametri caratteristici
  - Contagiosità
  - Durata incubazione
  - Durata contagiosità

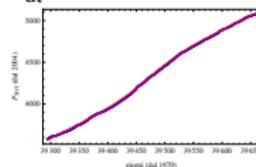


$$\frac{dS}{dt} = -\beta C S$$

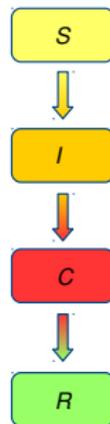
$$\frac{dI}{dt} = \beta C S - I/\tau_{\text{inc}}$$

$$\frac{dC}{dt} = I/\tau_{\text{inc}} - C/\tau_{\text{cont}}$$

$$\frac{dR}{dt} = C/\tau_{\text{cont}}$$



- Equazioni evoluzione temporale
- Determinazione dei parametri caratteristici
  - Contagiosità
  - Durata incubazione
  - Durata contagiosità

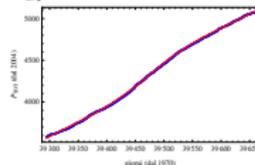


$$\frac{dS}{dt} = -\beta C S$$

$$\frac{dI}{dt} = \beta C S - I/\tau_{\text{inc}}$$

$$\frac{dC}{dt} = I/\tau_{\text{inc}} - C/\tau_{\text{cont}}$$

$$\frac{dR}{dt} = C/\tau_{\text{cont}}$$



- È possibile fare previsioni?
  - Controllo epidemia
  - Pianificazione interventi



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Messico	0.4%
Regno Unito	0.04%
Regno Unito	0.026%
New York	0.2%

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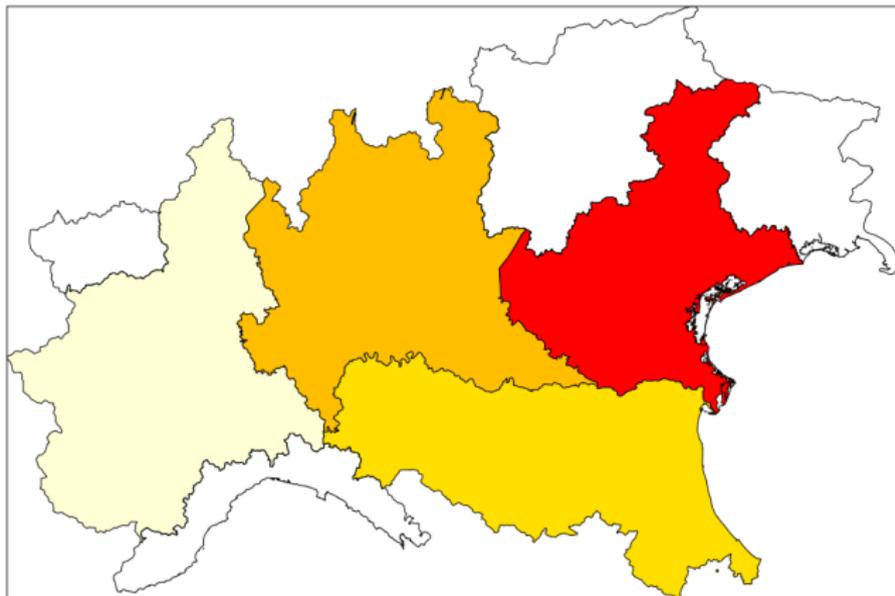
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Messico	0.4%
Regno Unito	0.04%
Regno Unito	0.026%
New York (casi confermati)	0.2%
New York (indagine telefonica)	0.0008%

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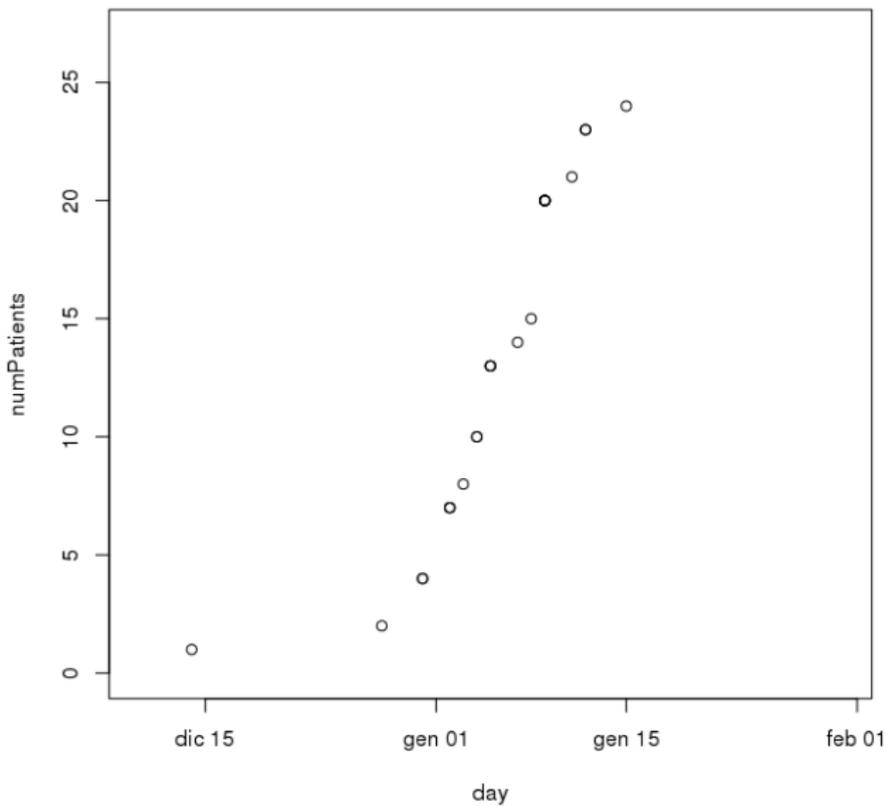


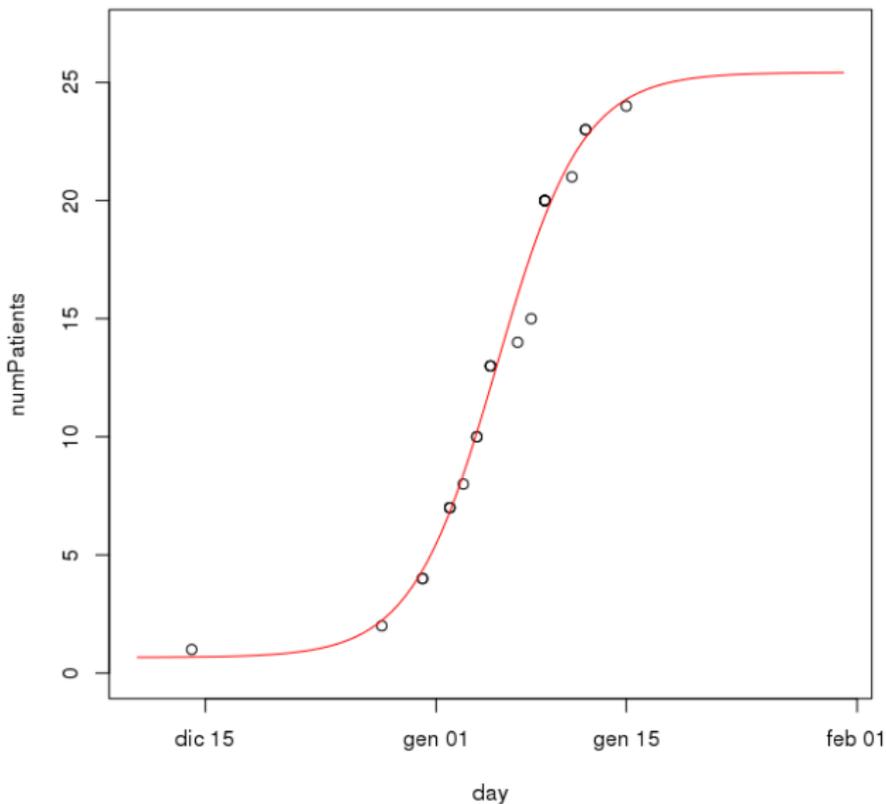
cinque anni dopo

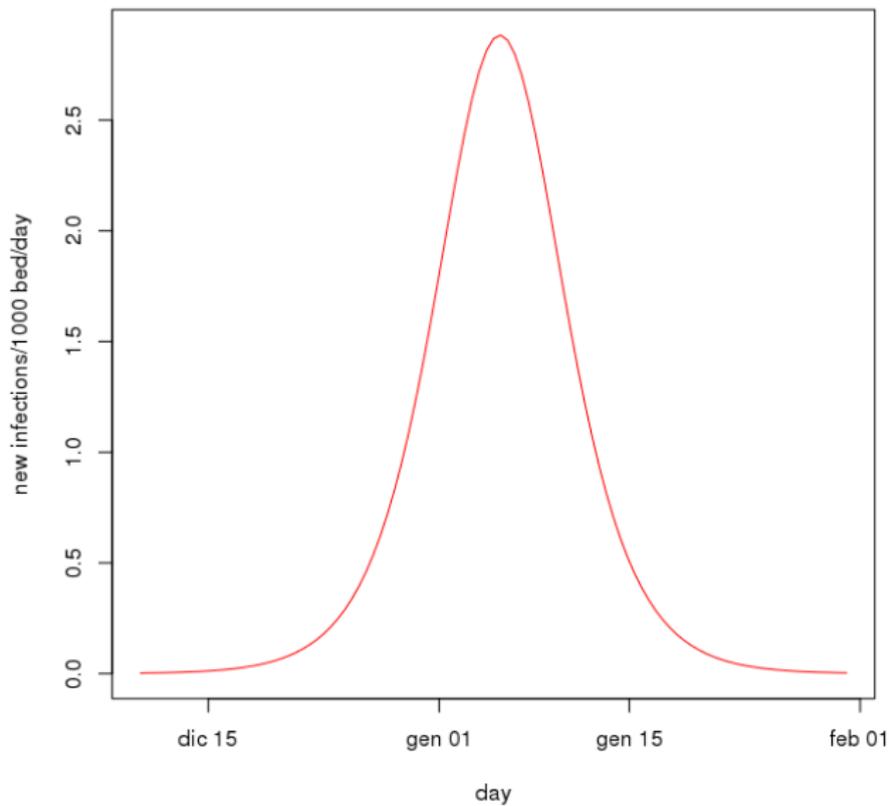


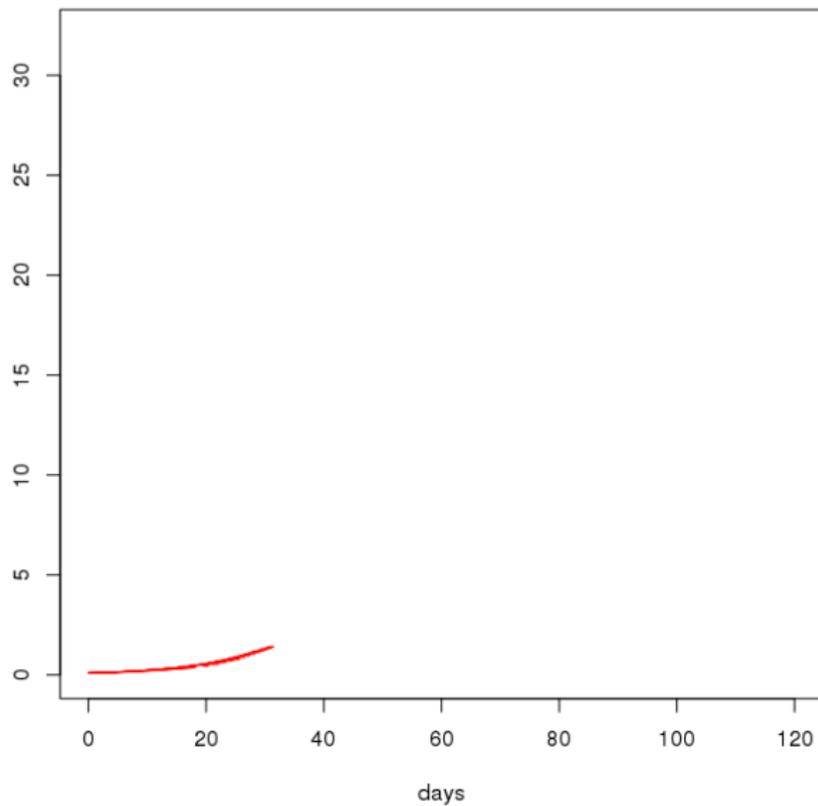
	Pazienti	TI con H1N1
Veneto	12	5
Lombardia	6	4
Emilia-Romagna	5	2
Piemonte	1	1

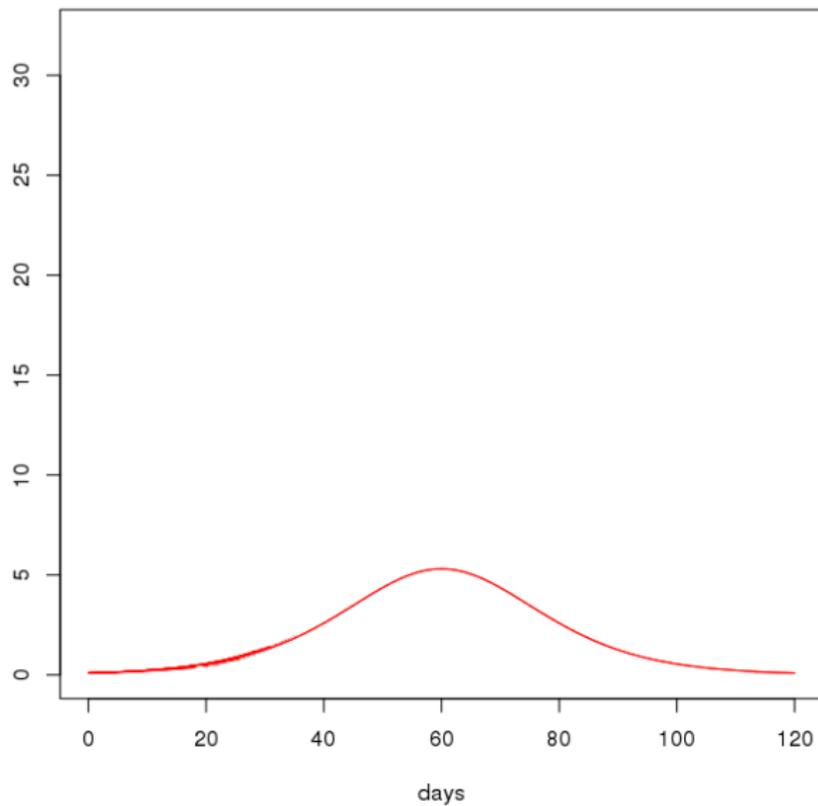
# Evoluzione temporale – H1N1 totali

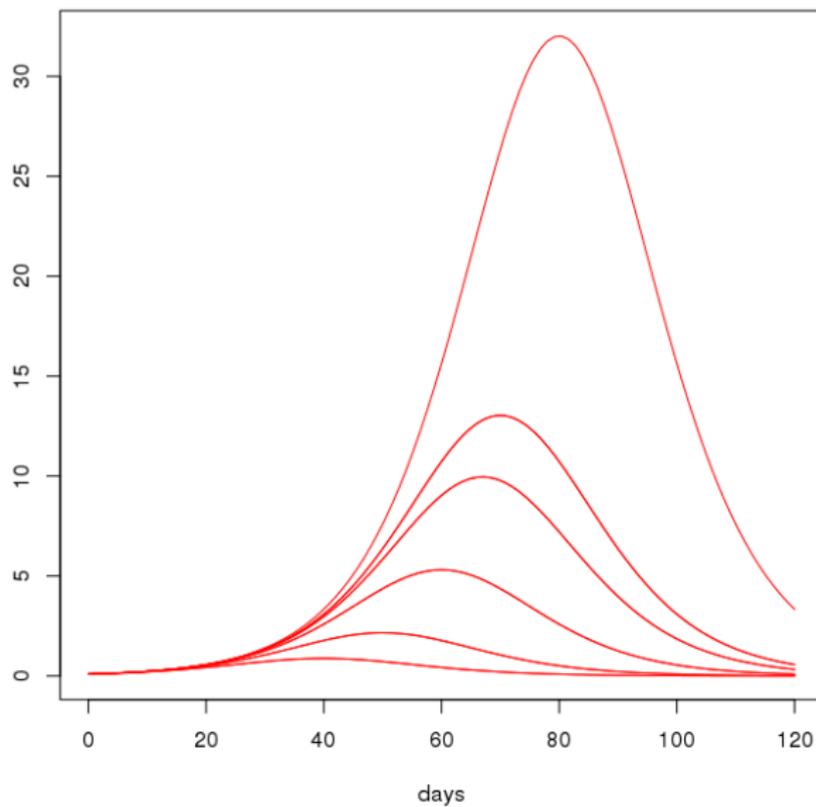


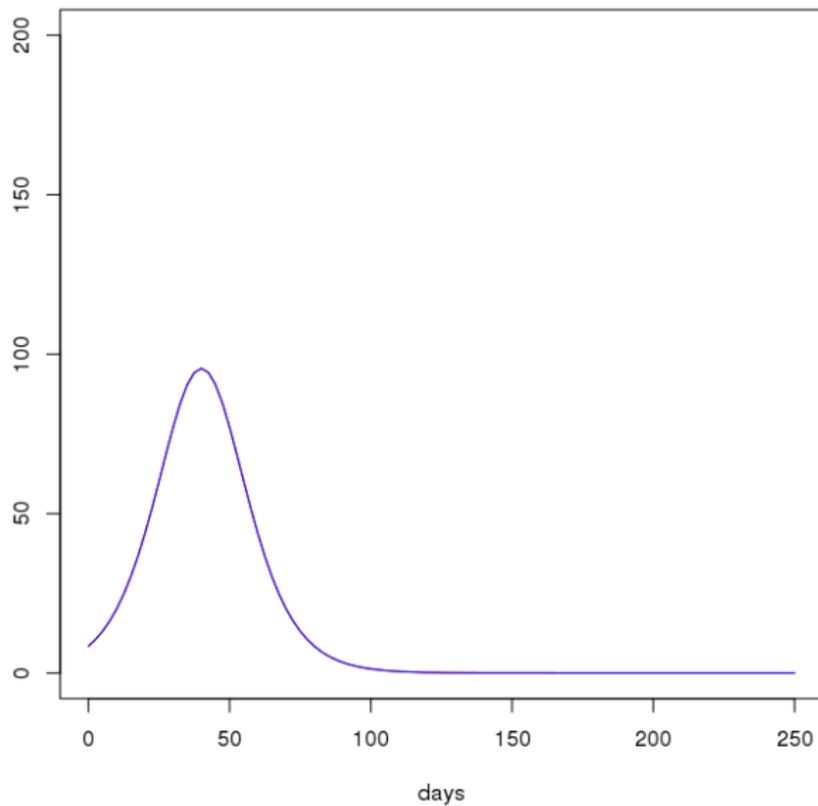


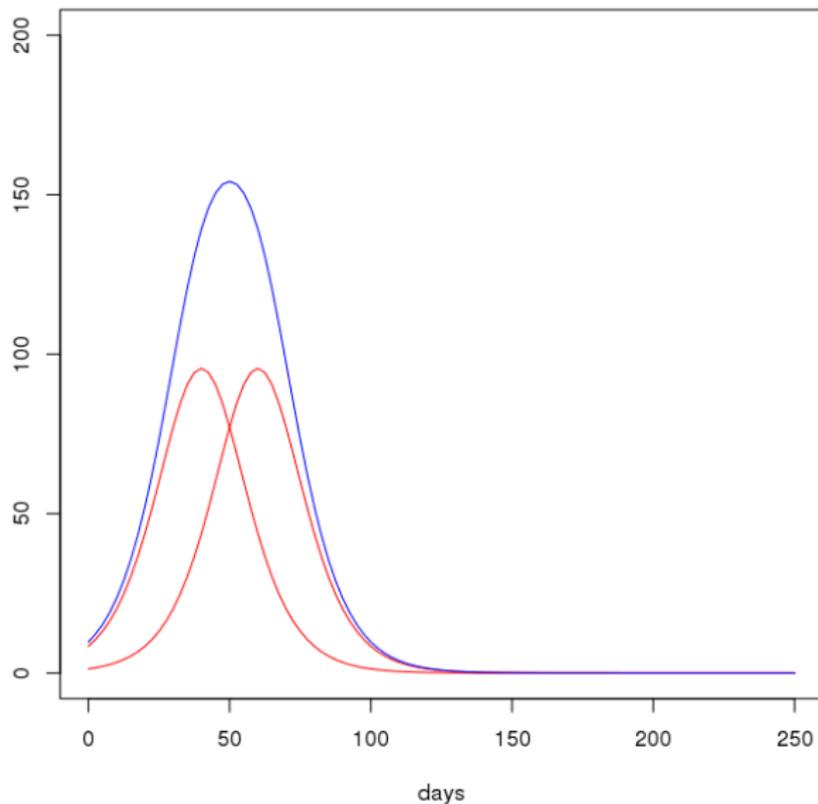


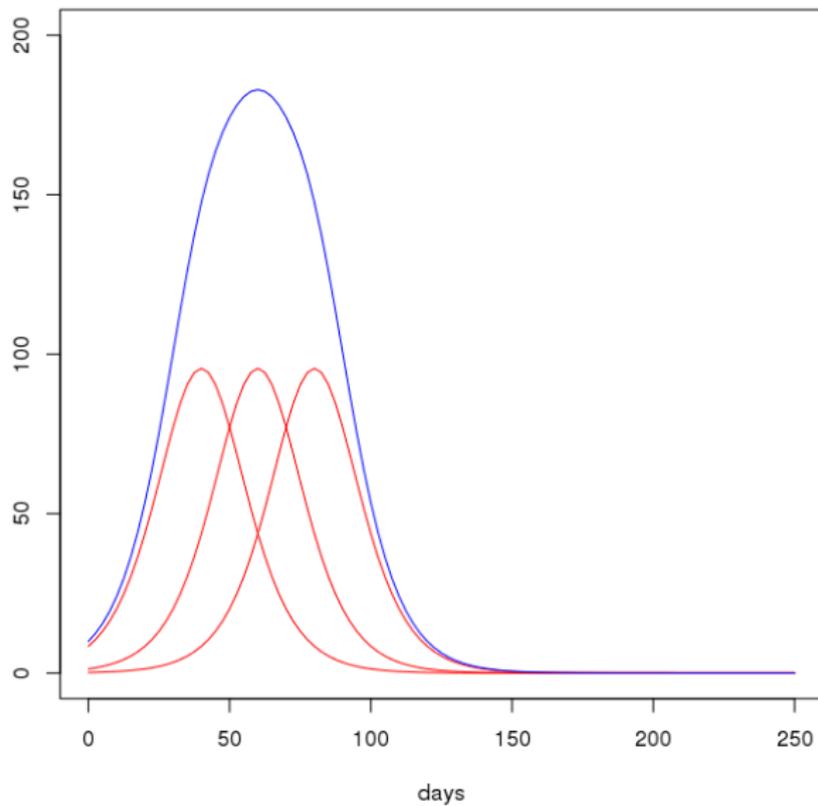






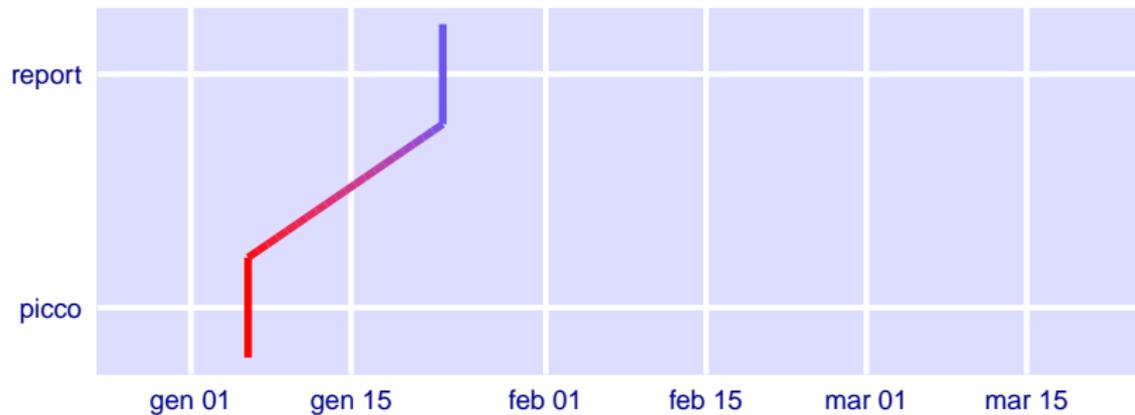




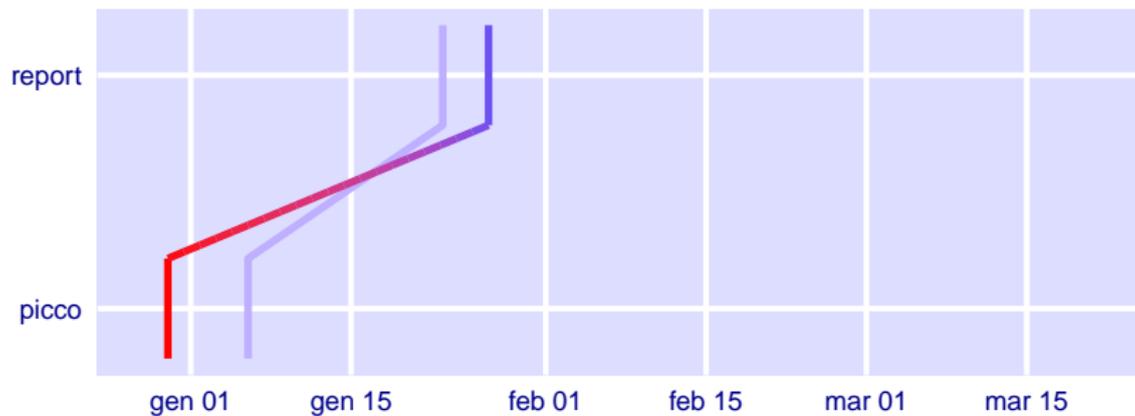


tre mesi dopo

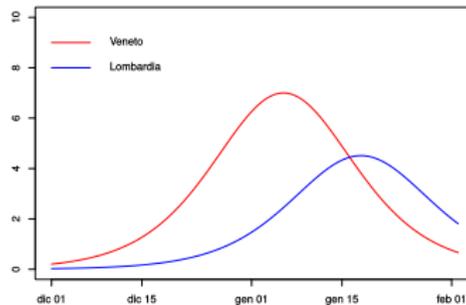
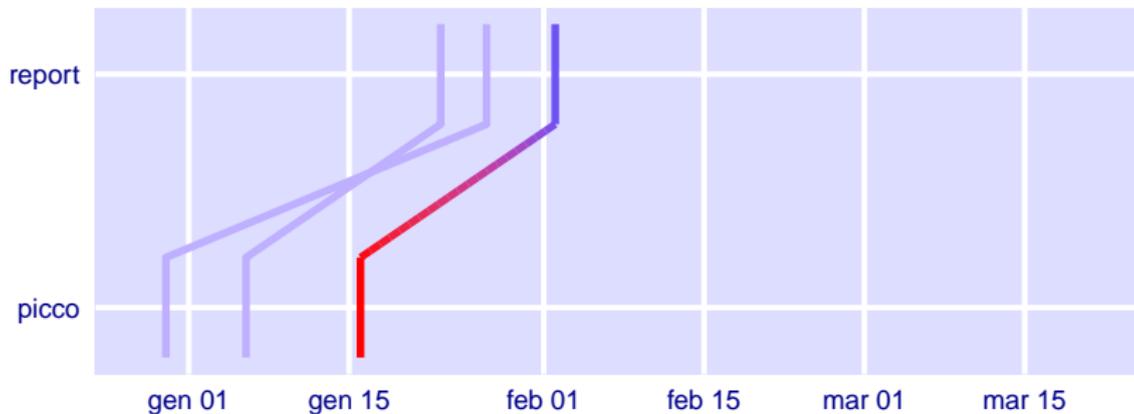
# Che cosa è successo



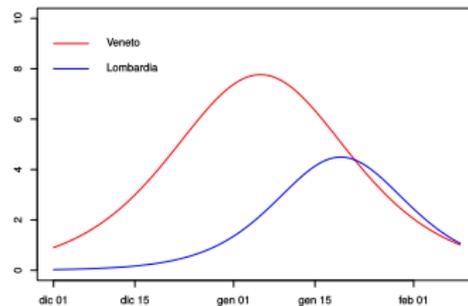
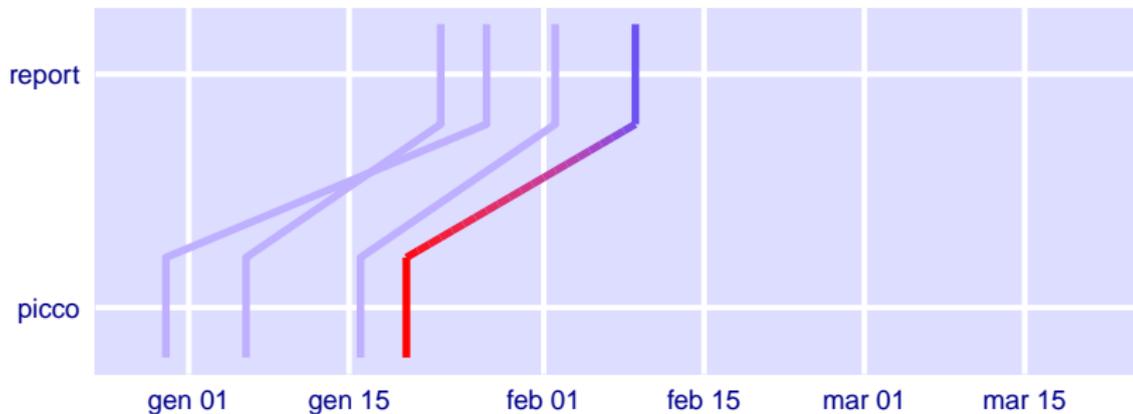
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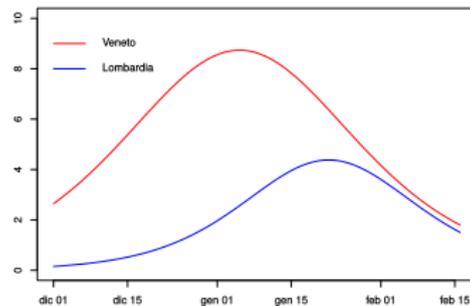
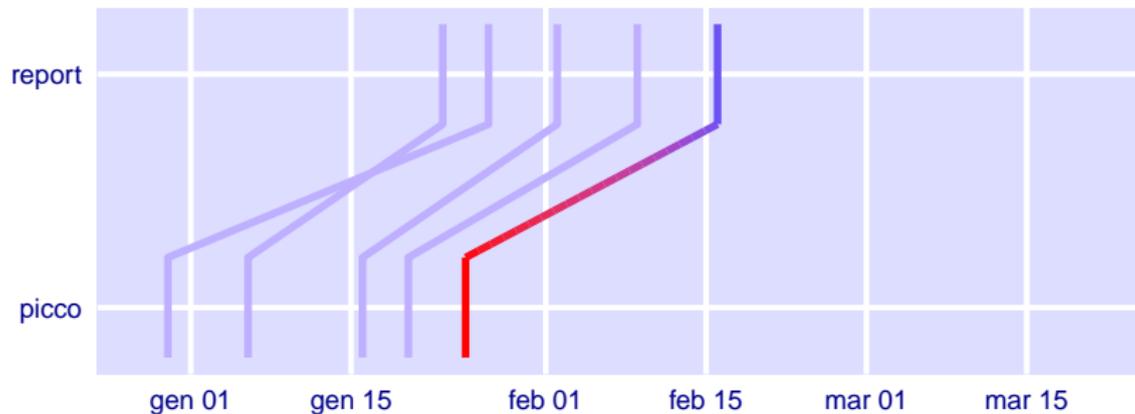
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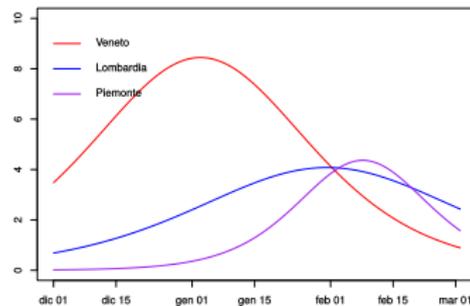
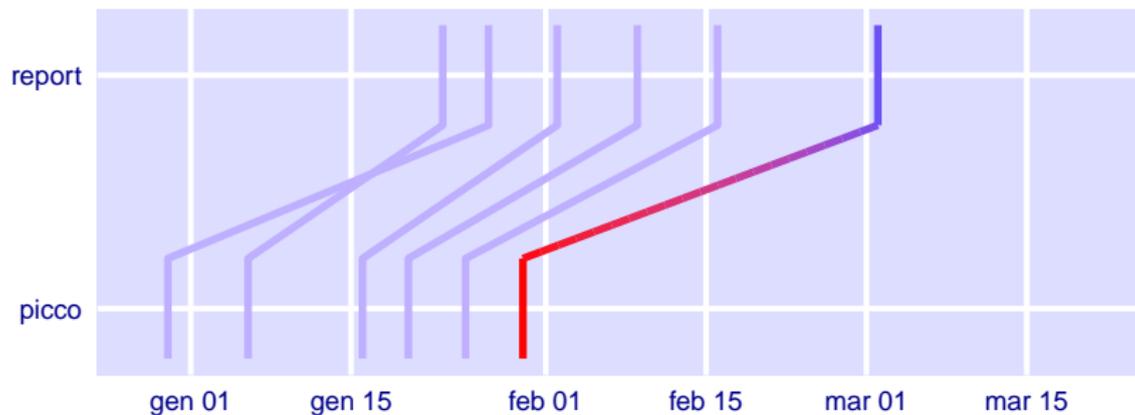
# Che cosa è successo



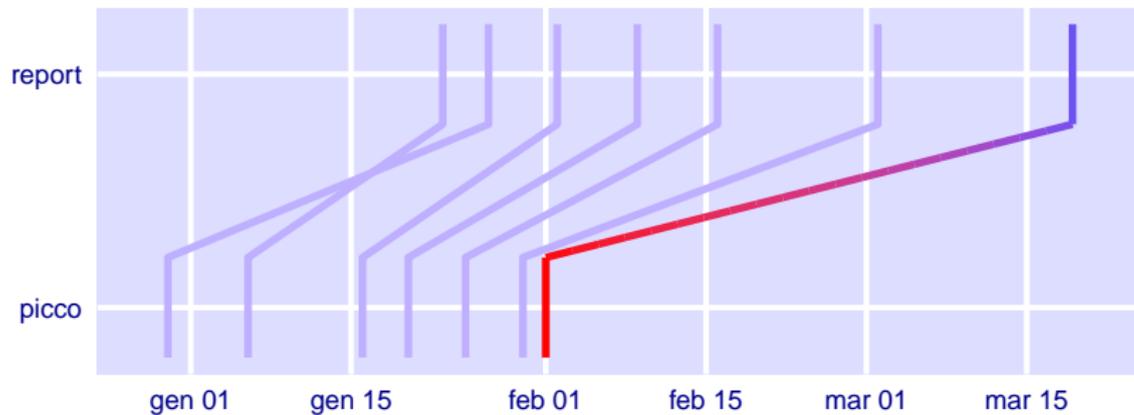
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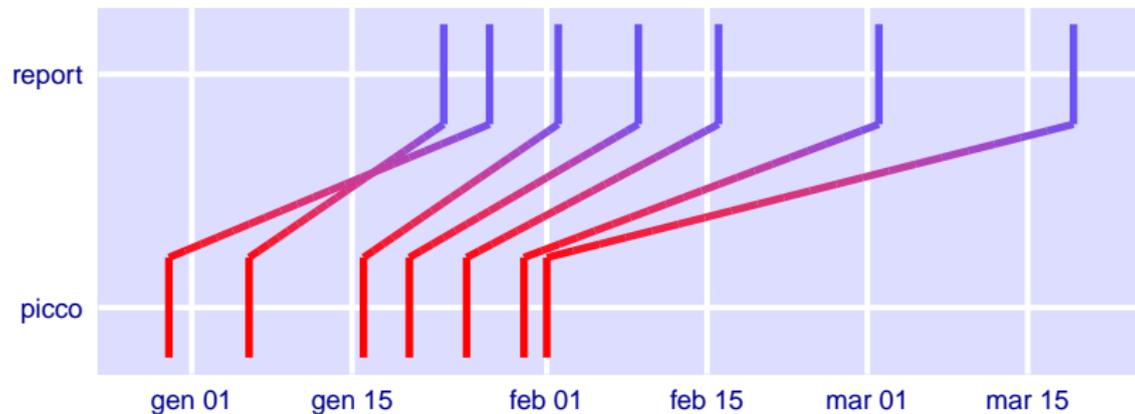
# Che cosa è successo



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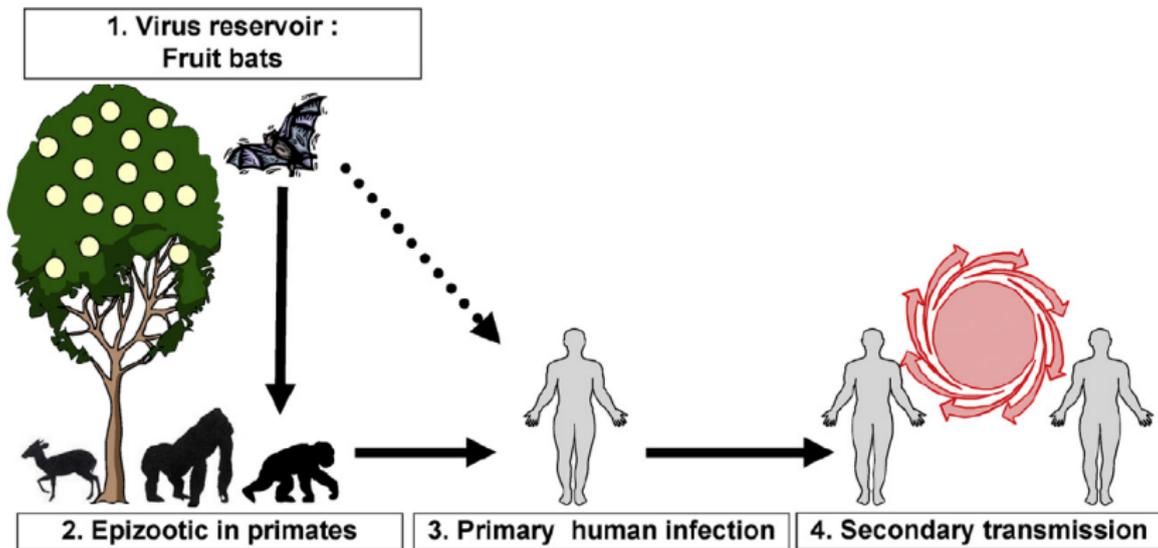


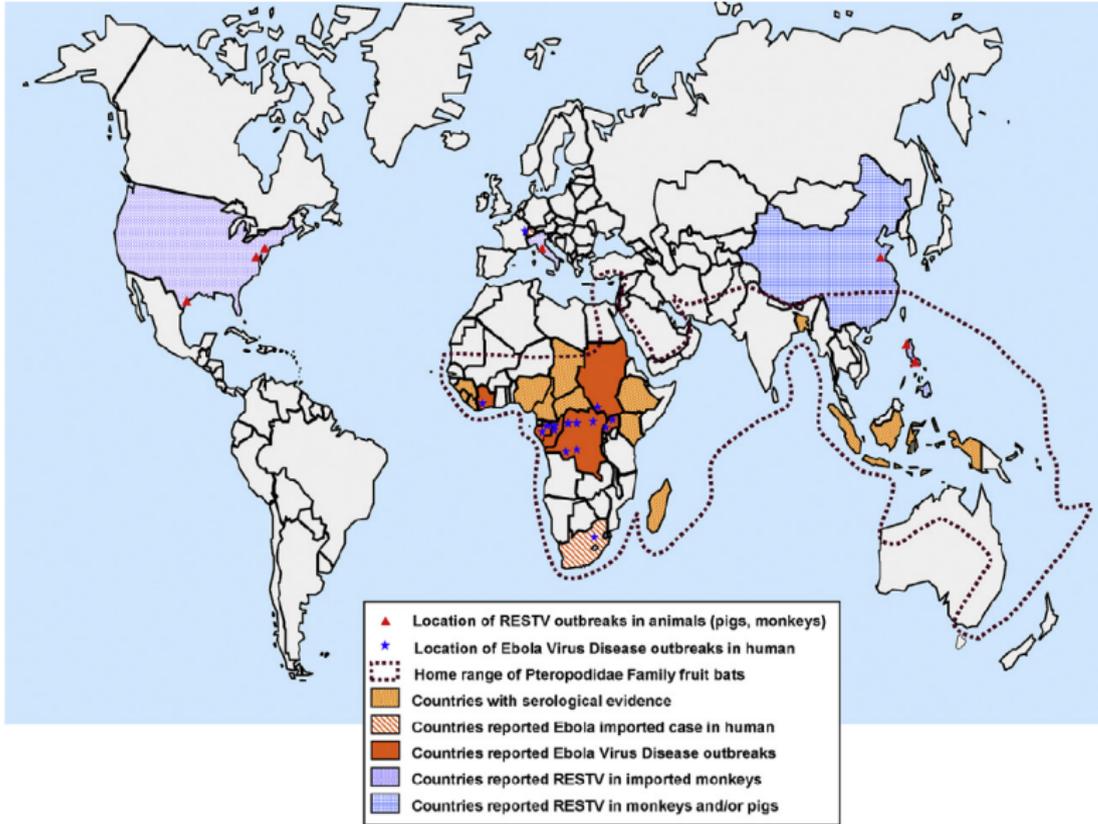
- Previsioni molto incerte
- Risultati cambiano nel tempo all'arrivo di nuovi dati
- Quali indicazioni seguire?

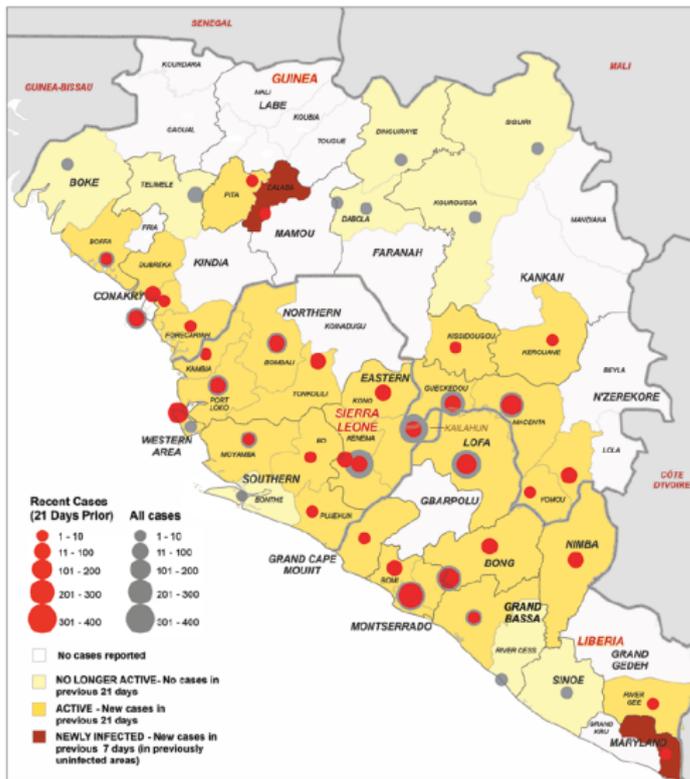


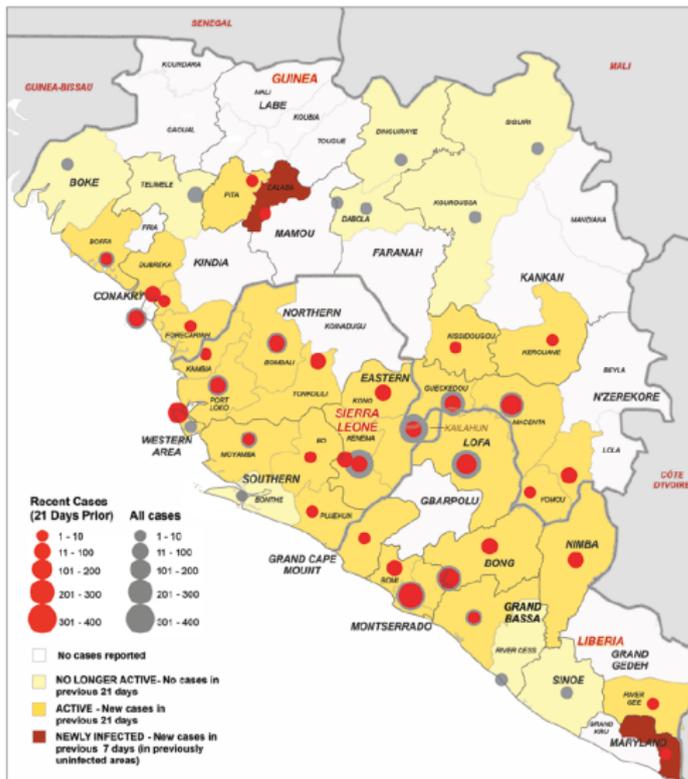
un anno prima

EBOLA

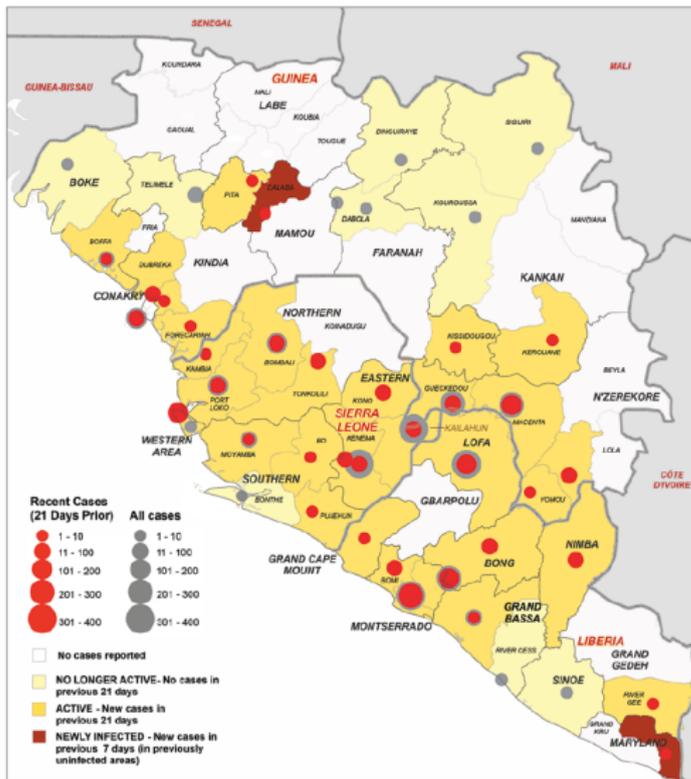




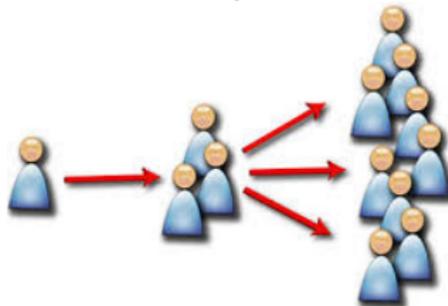




● Mortalità: ~ 70%



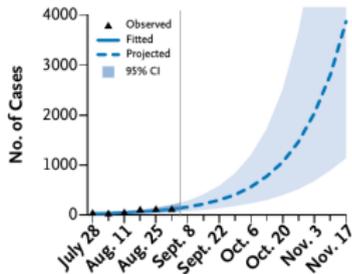
- Mortalità: ~ 70%
- Numero di riproduzione



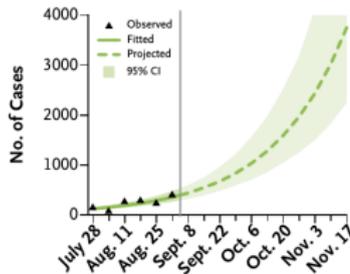
Guinea	1.44 – 2.01
Liberia	1.72 – 1.94
Sierra Leone	2.02 – 2.26
Nigeria	0.67 – 1.96

## ● WHO – 14 Settembre 2014

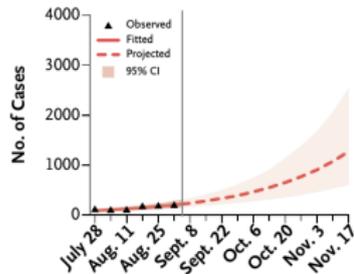
A Guinea



B Liberia

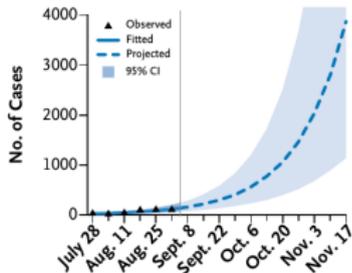


C Sierra Leone

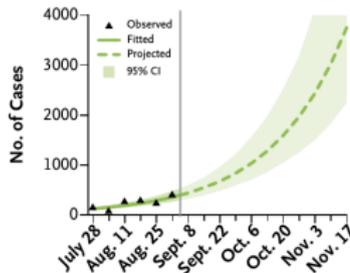


## ● WHO – 14 Settembre 2014

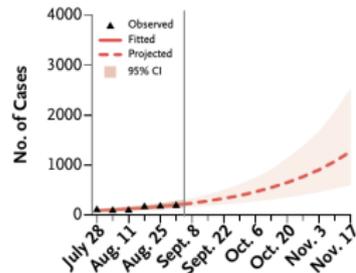
**A** Guinea



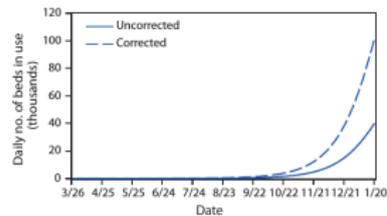
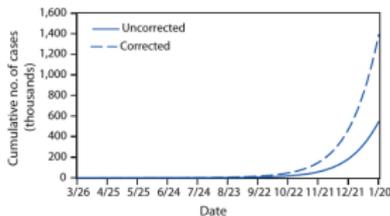
**B** Liberia



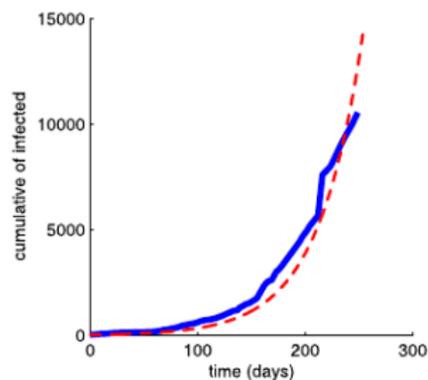
**C** Sierra Leone



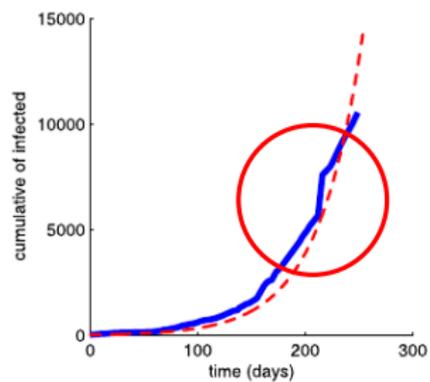
## ● CDC – 13 Settembre 2014



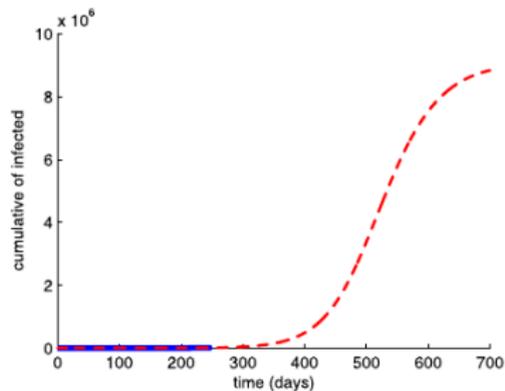
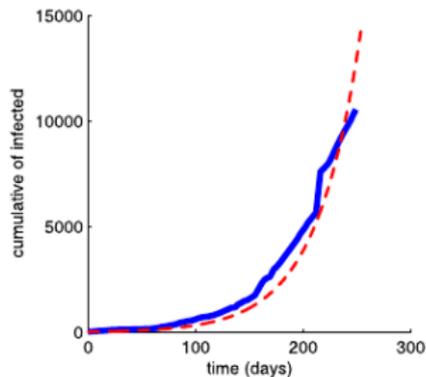
- 01 Dicembre 2014



- 01 Dicembre 2014

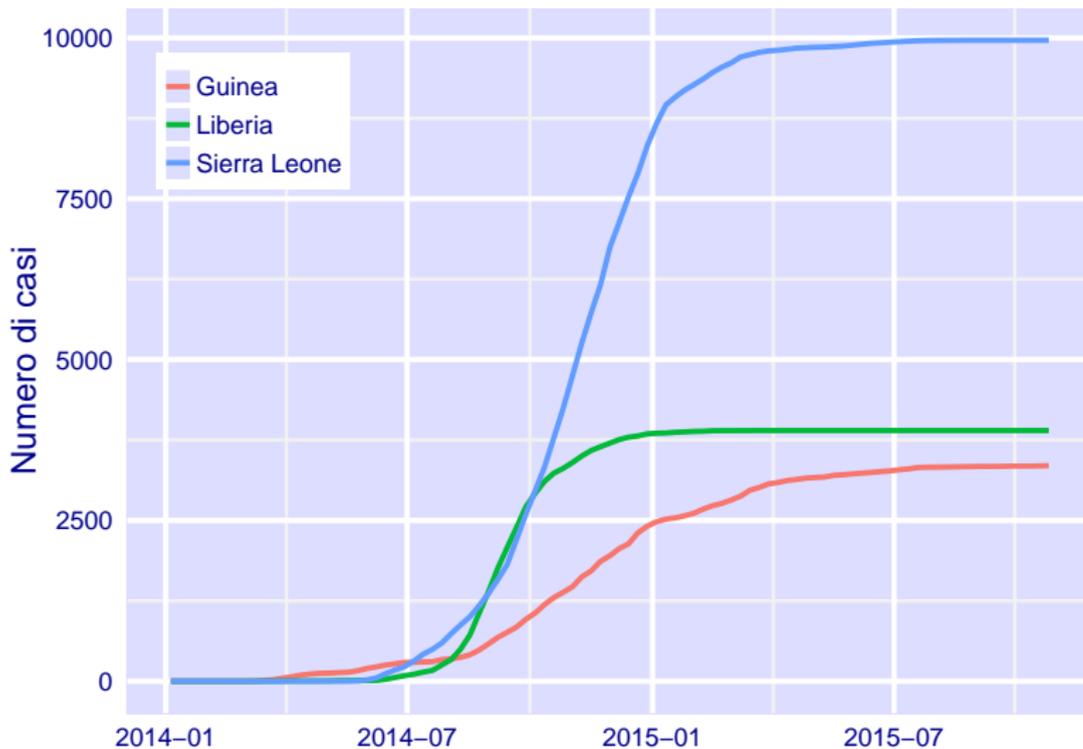


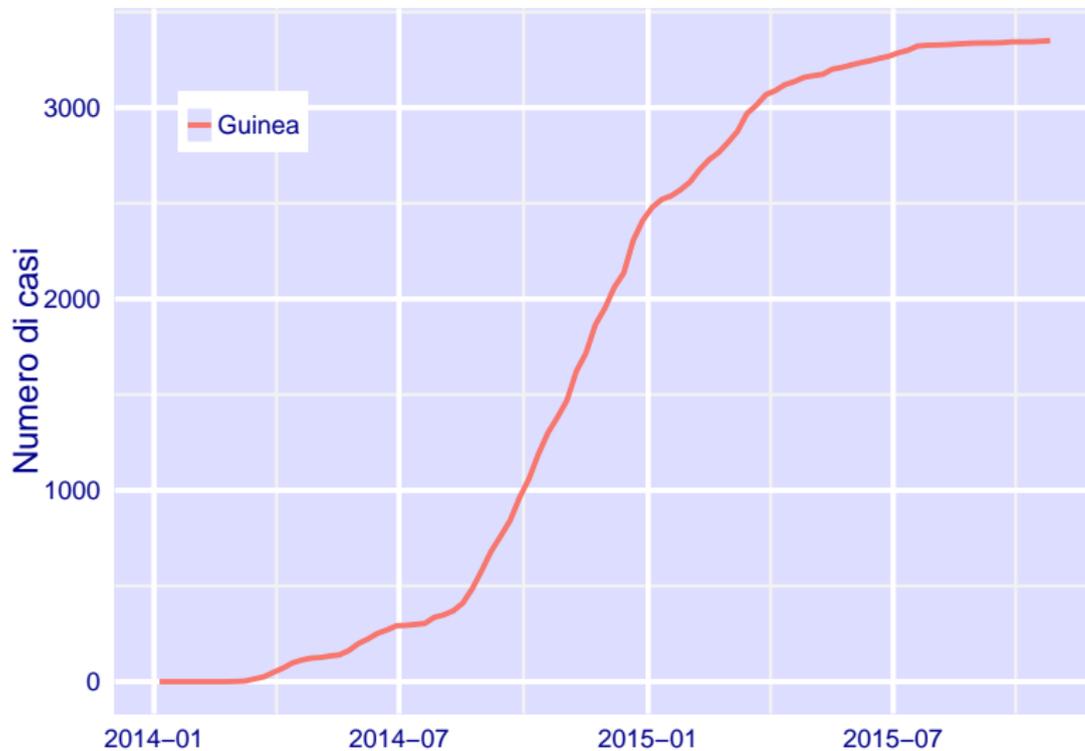
● 01 Dicembre 2014

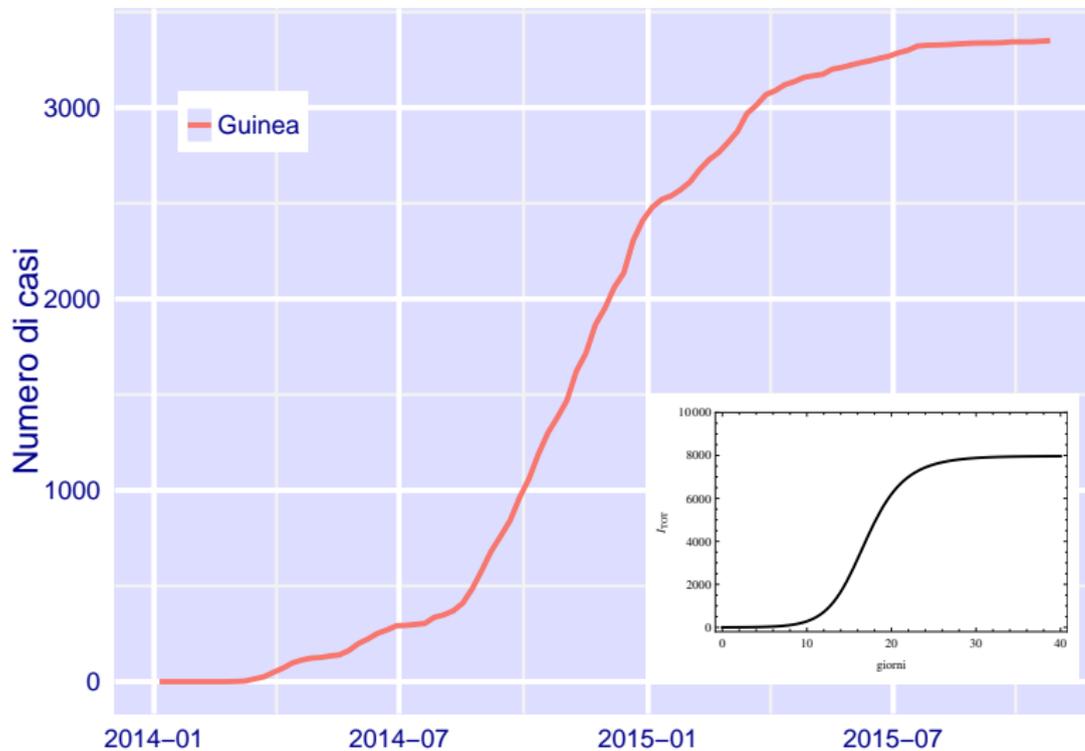


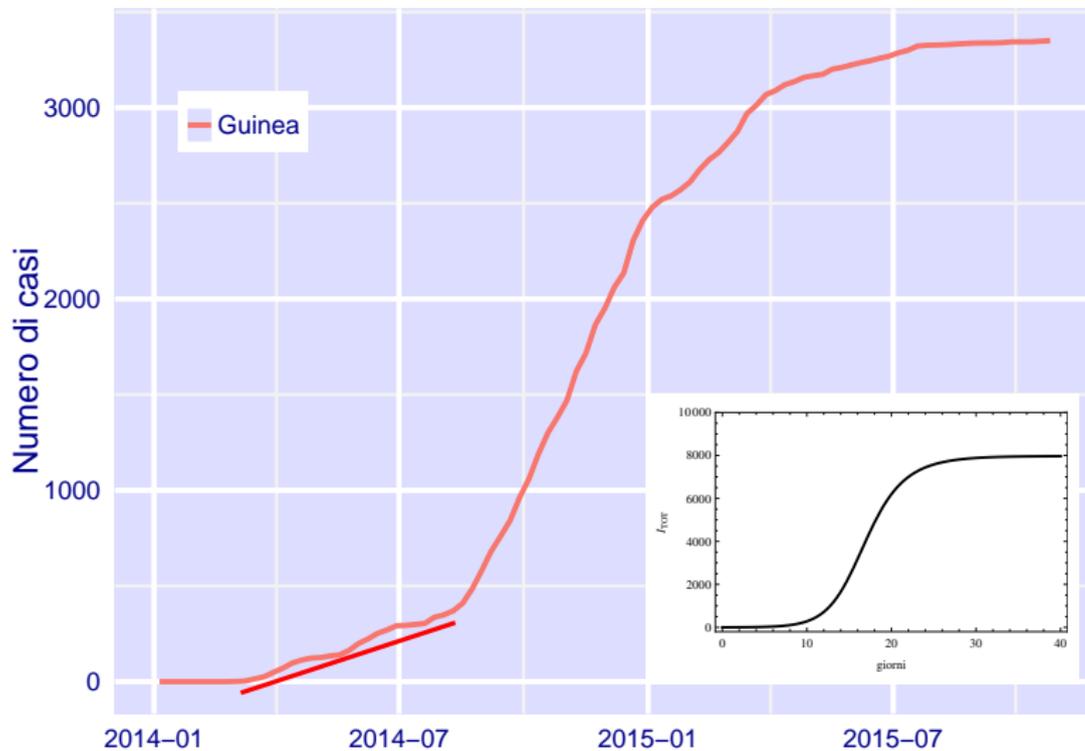
**casi previsti: 9 000 000**

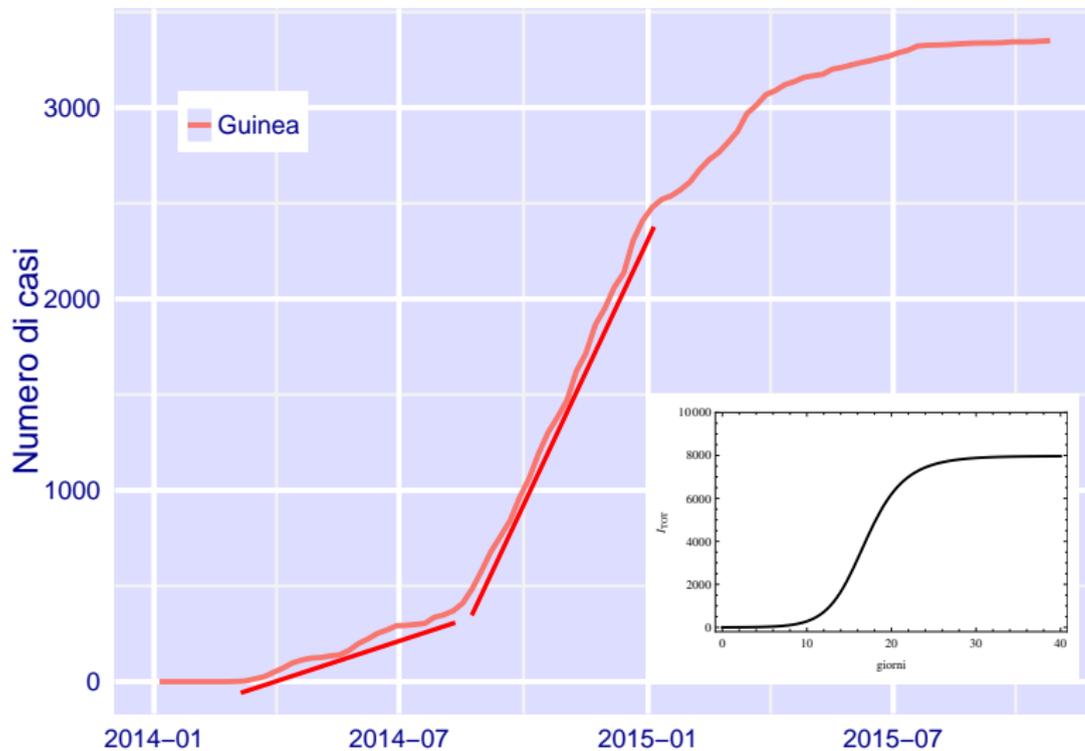
# Che cosa è successo?

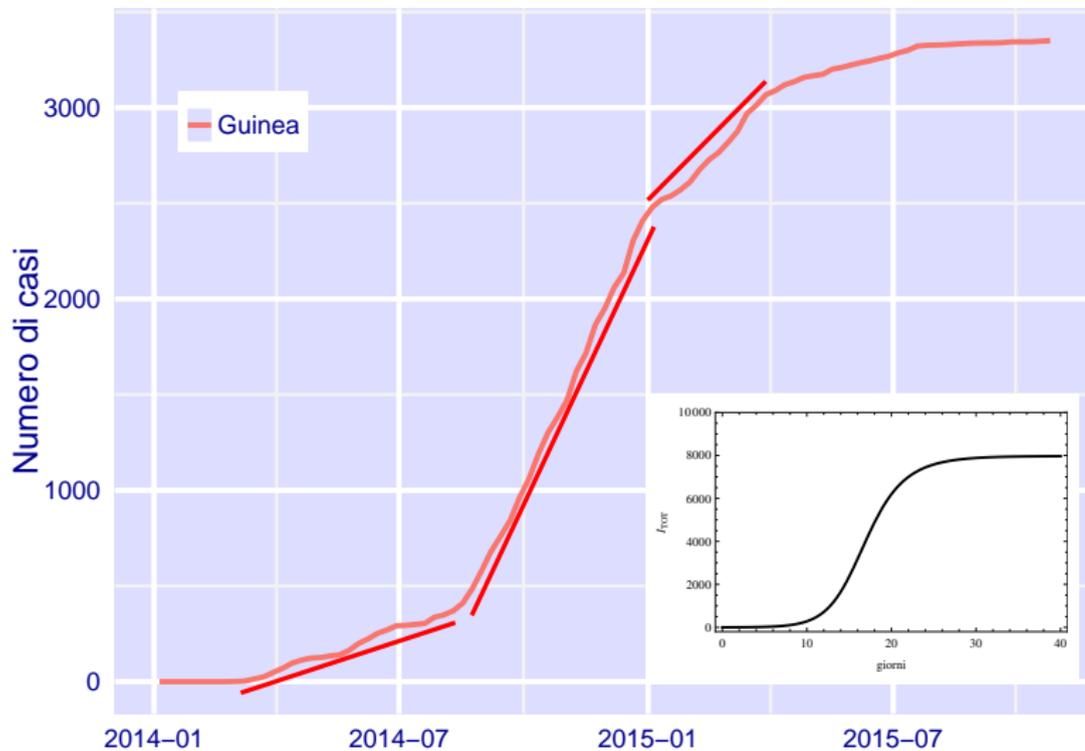






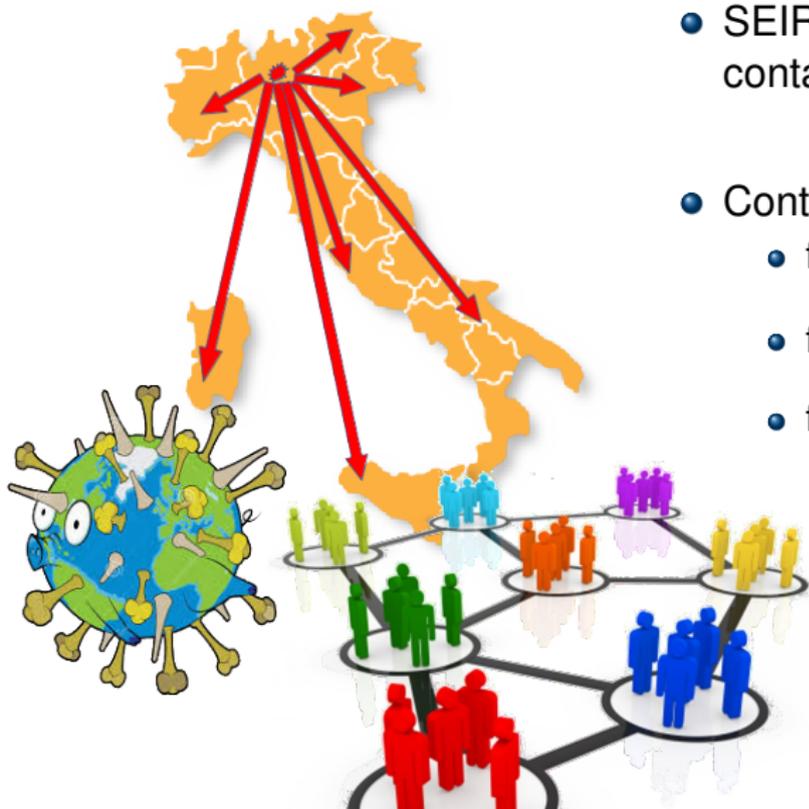








- SEIR: **tutti** i contagiosi possono contagiare tutti i suscettibili!



- SEIR: **tutti** i contagiosi possono contagiare **tutti** i suscettibili!
- Contagiosità
  - fattori biologici: infettività
  - fattori geografici
  - fattori sociali
    - pratiche funerarie
    - dimensione famiglie
    - dimensione comunità







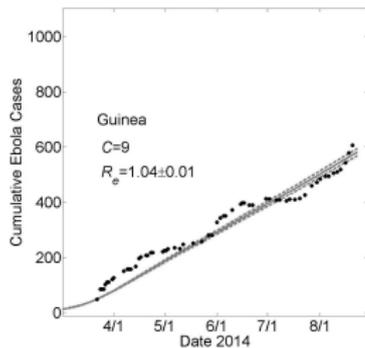






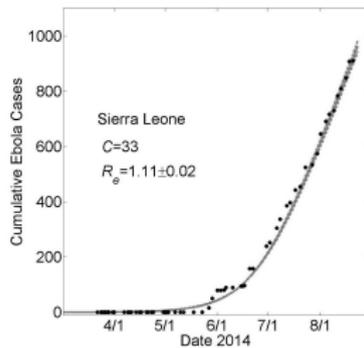
Guinea

$$C = 9$$



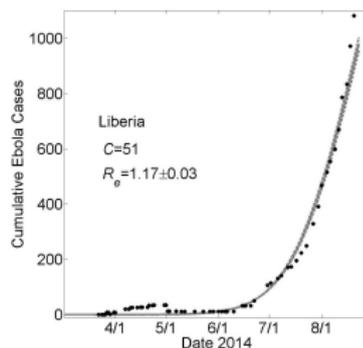
Sierra Leone

$$C = 33$$



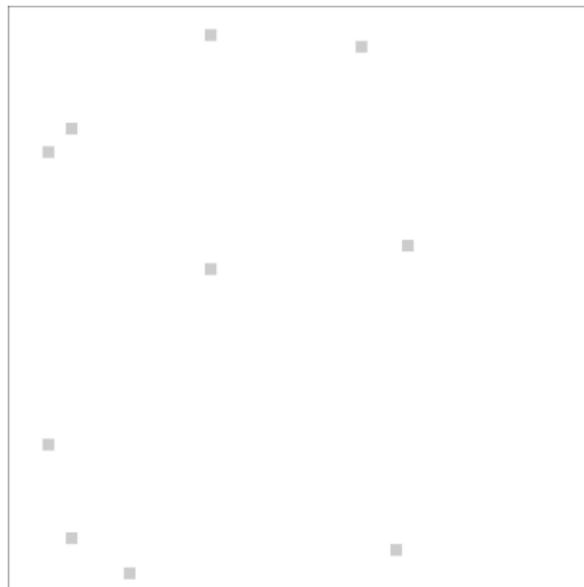
Liberia

$$C = 51$$



Infetti iniziali = 10

$$R_{\text{fam}} = 1.2 \quad R_{\text{com}} = 0.2$$

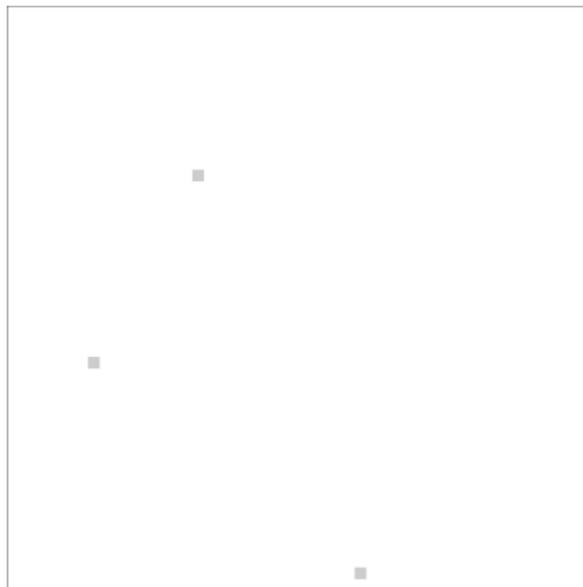


$$R_{\text{fam}} = 1 \quad R_{\text{com}} = 0.13$$

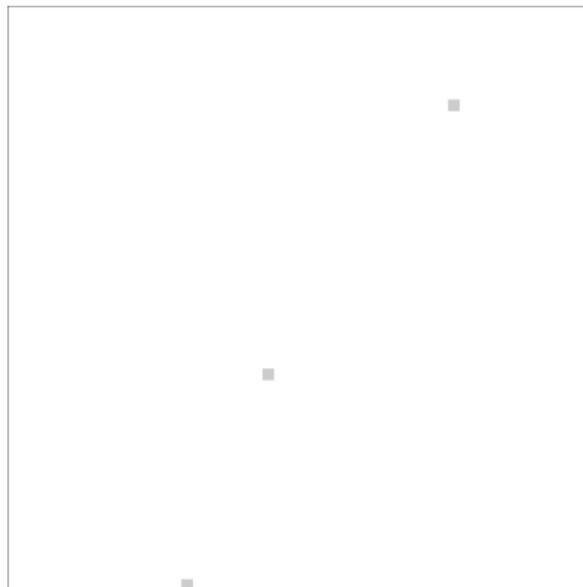


Infetti iniziali = 3

$$R_{\text{fam}} = 1 \quad R_{\text{com}} = 0.14$$



$$R_{\text{fam}} = 1 \quad R_{\text{com}} = 0.14$$



- **Imprevidibilità**

- **Imprevedibilità**
- Fattori socio-economici
- Interventi minimi  $\Rightarrow$  significativi miglioramenti



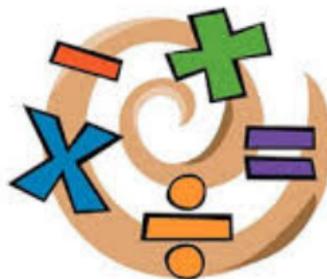
# Che cosa imparare da questi modelli...

- **Imprevedibilità**
- Fattori socio-economici
- Interventi minimi  $\Rightarrow$  significativi miglioramenti

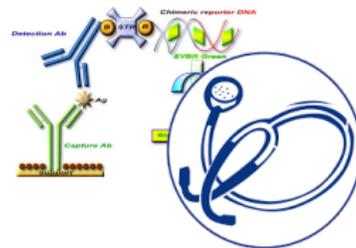


## Obiettivo

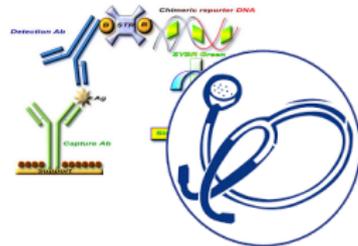
Modelli non previsionali ma suggerimenti interventi efficaci



- Sistemi sanitari
  - Sorveglianza
  - Capacità di test (es: PCR)

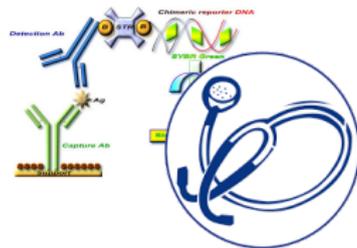


- Sistemi sanitari
  - Sorveglianza
  - Capacità di test (es: PCR)



- Risorse umane
  - Personale sanitario
  - Incident managers
  - Epidemiologi
  - Leader locali

- Sistemi sanitari
  - Sorveglianza
  - Capacità di test (es: PCR)



- Risorse umane
  - Personale sanitario
  - Incident managers
  - Epidemiologi
  - Leader locali

- Risorse non umane
  - Comunicazione e raccolta dati
  - Mezzi di trasporto
  - Materiali



