

Ebola e H1N1

Lo studio della dinamica delle malattie infettive

STEFANO FINAZZI



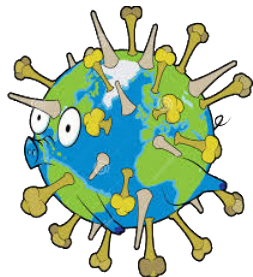
GiViTi

Gruppo Italiano per la Valutazione degli Interventi in Terapia Intensiva



PESARO, 5 NOVEMBRE 2015

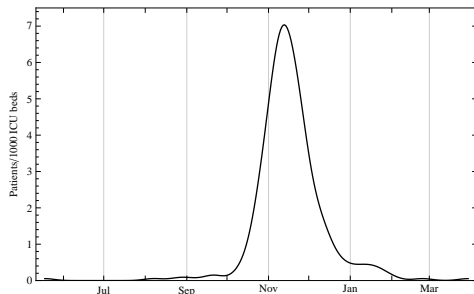
- Determinazione caratteristiche
 - contagiosità
 - mortalità
 - numero totale di contagiati
 - ...



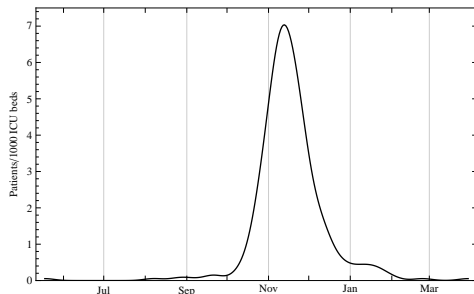
- Pianificazione interventi
 - controllo diffusione epidemia
 - allocazione ottimale risorse
 - contenimento costi sociali ed economici

sei anni fa

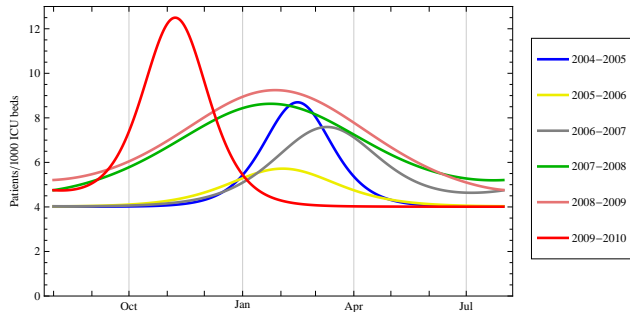
H1N1

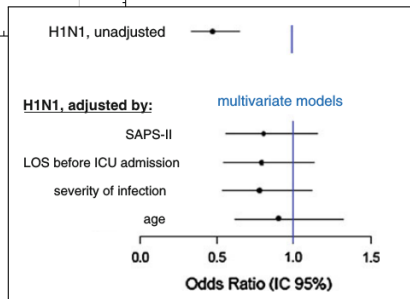
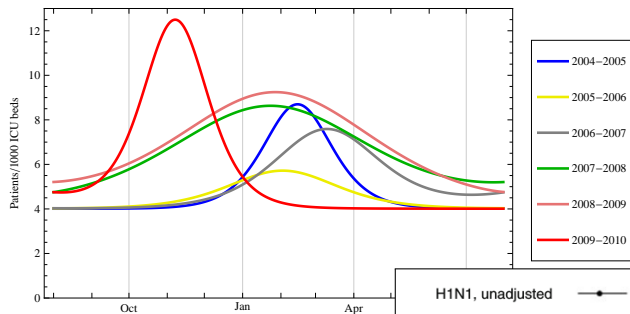


- Quale terapia? ECMO?
- Centralizzazione?
- Problemi logistici per TI?
- Mortalità maggiore?



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- Centralizzazione?
- Problemi logistici per TI?
- Mortalità maggiore?





Suscettibili



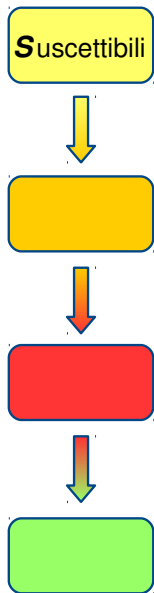
Infettati



Contagiosi



Guariti
Morti



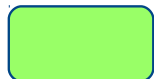
Modellizzazione di un fenomeno epidemico



Suscettibili



Infettati



Nuovi infettati al giorno

S

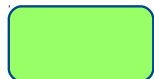
Modellizzazione di un fenomeno epidemico



Suscettibili



Infettati



Nuovi infettati al giorno

$$S \times C$$

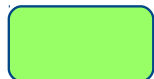
Modellizzazione di un fenomeno epidemico



Suscettibili



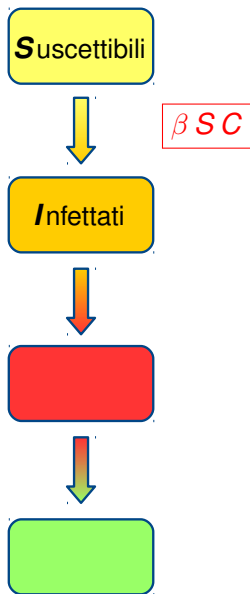
Infettati

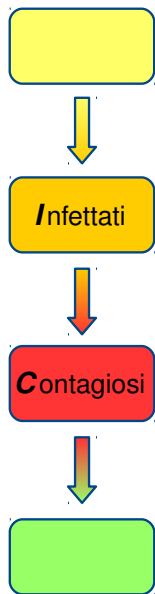


Nuovi infettati al giorno

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

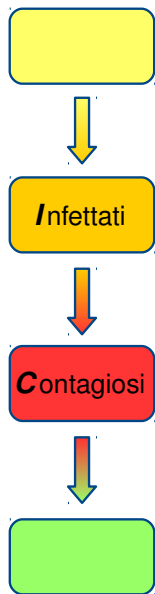
β = Contagiosità





Nuovi contagiosi al giorno

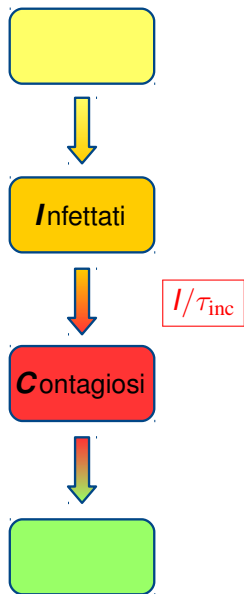
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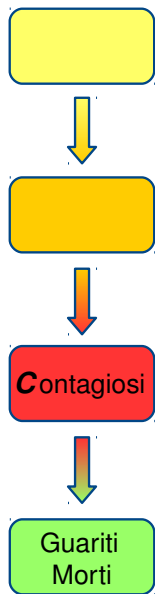


Nuovi contagiosi al giorno

$$I / \tau_{\text{inc}}$$

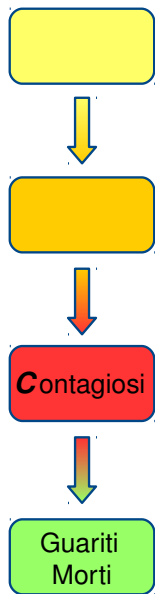
τ_{inc} = Tempo medio incubazione





Nuovi guariti/morti al giorno

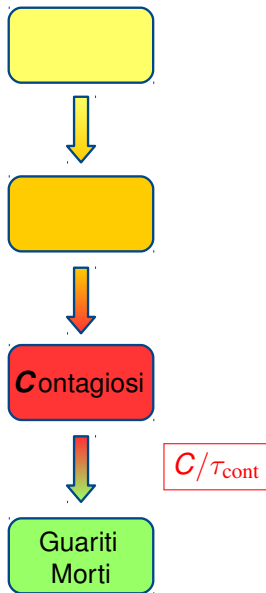
C

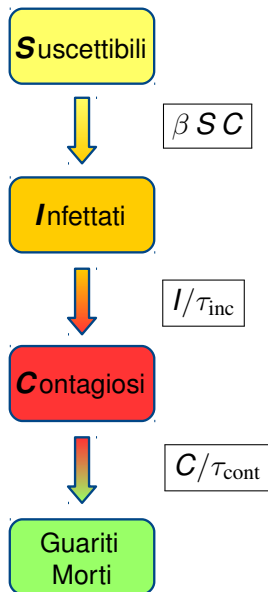


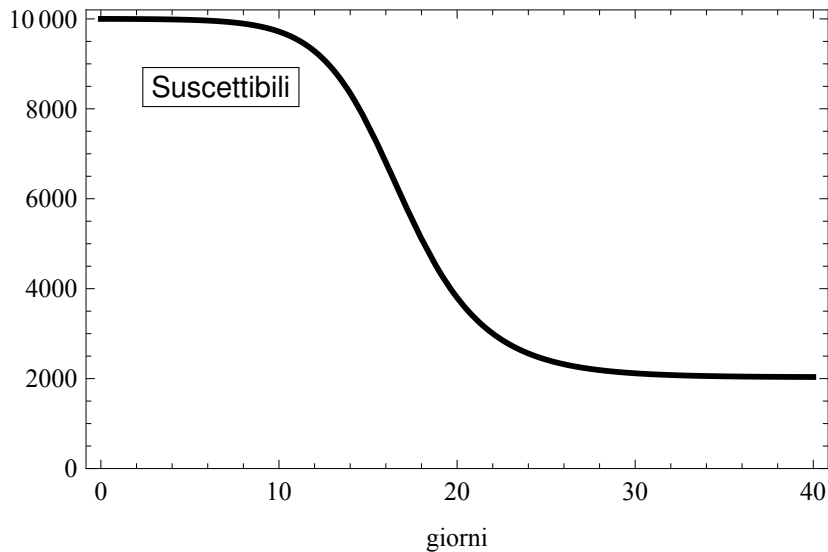
Nuovi guariti/morti al giorno

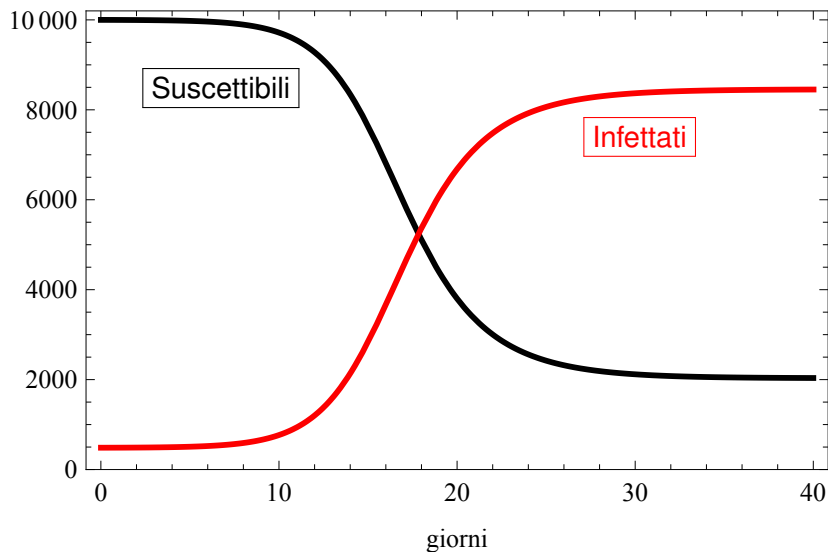
$$C/\tau_{\text{cont}}$$

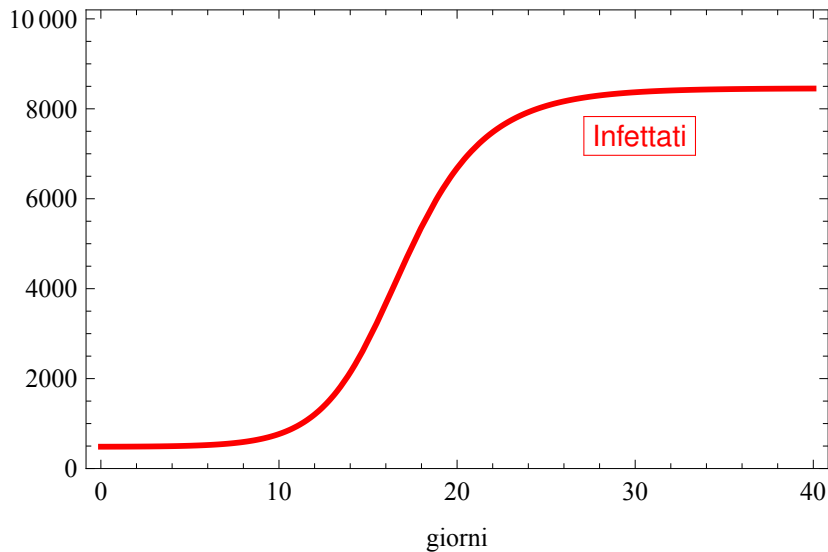
τ_{cont} = Tempo medio contagiosità

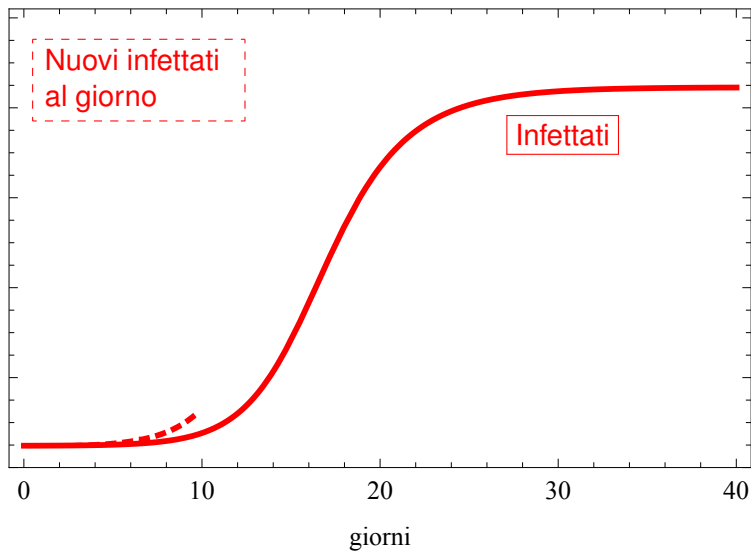


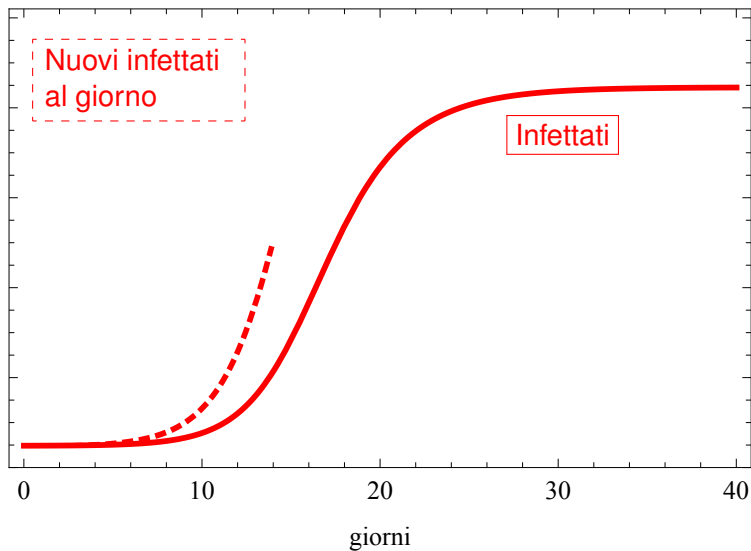


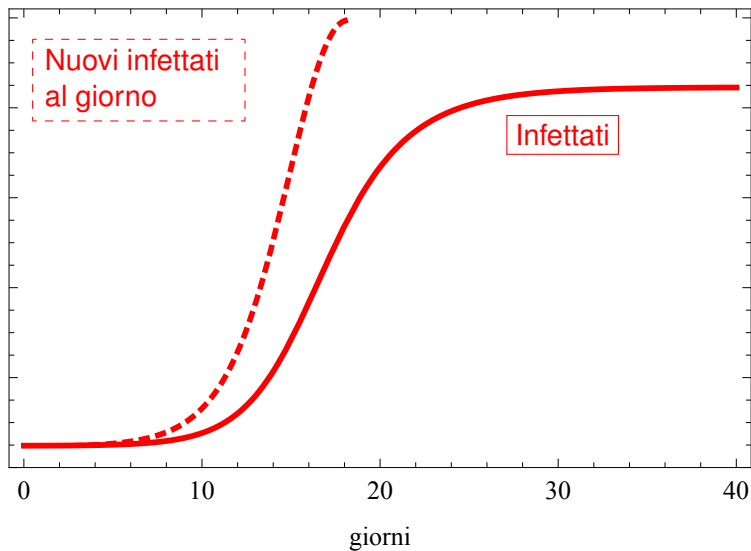


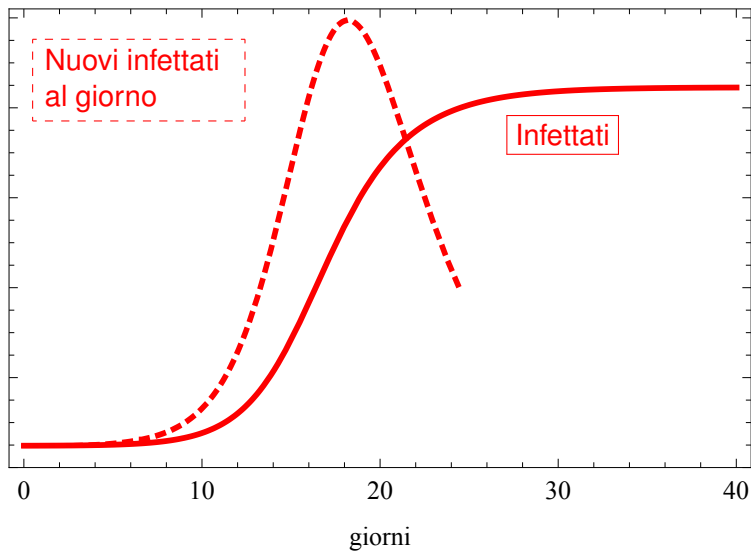


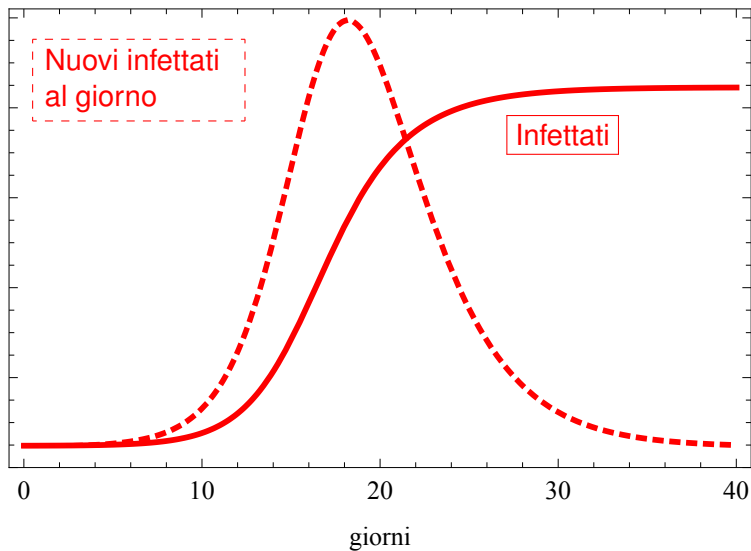


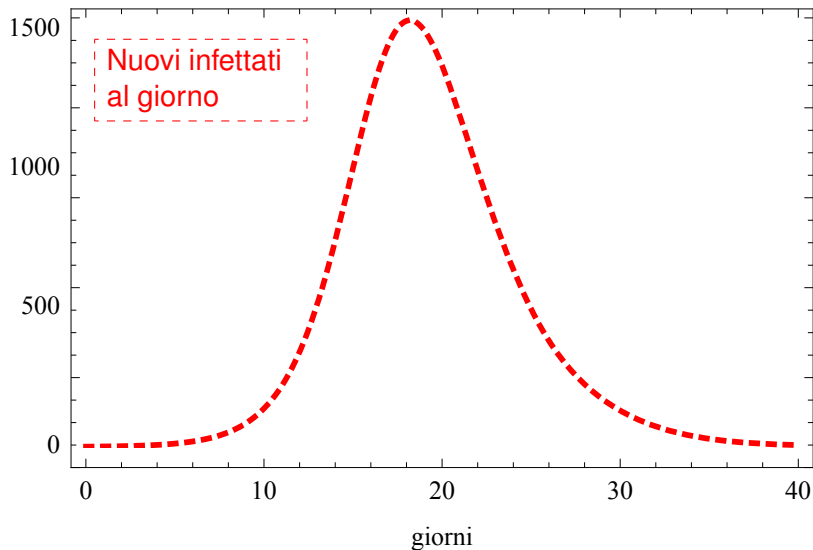


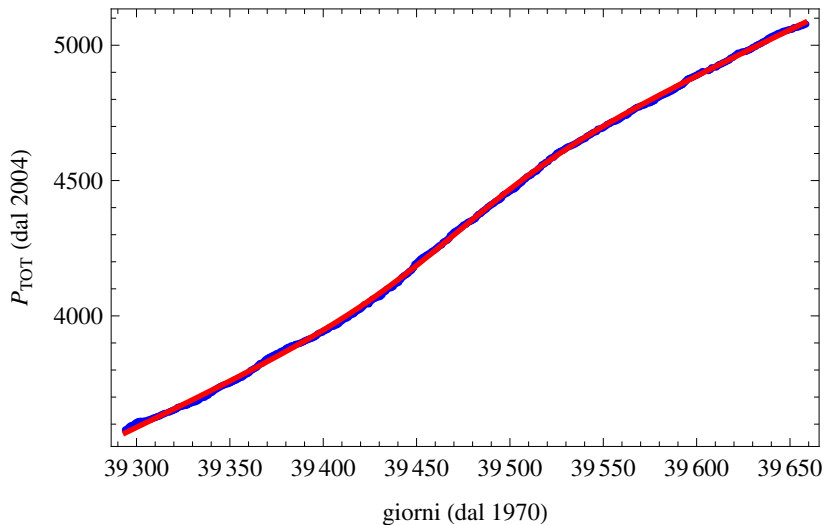


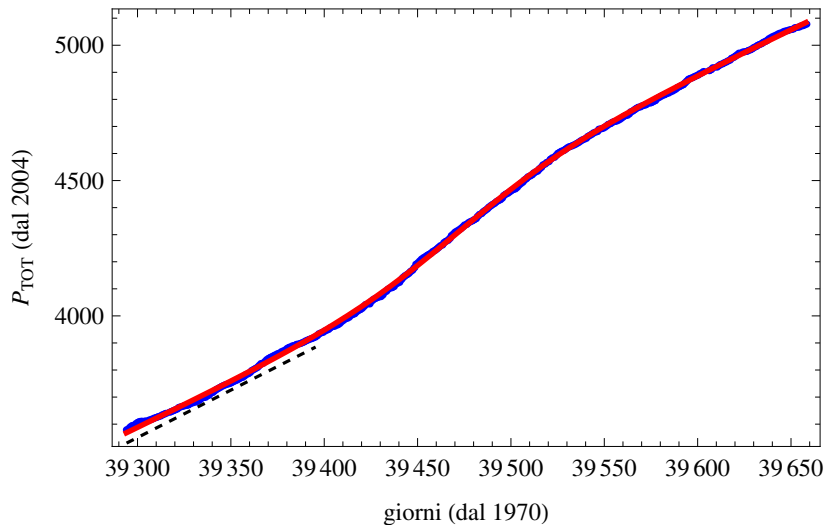


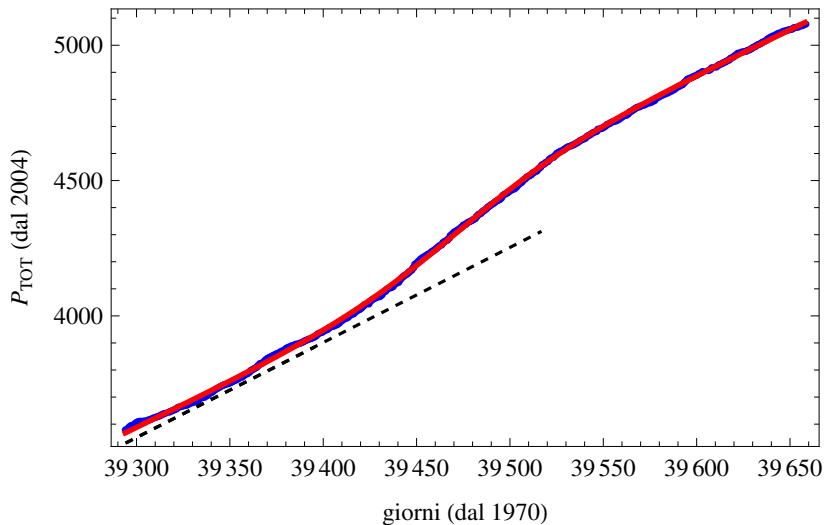


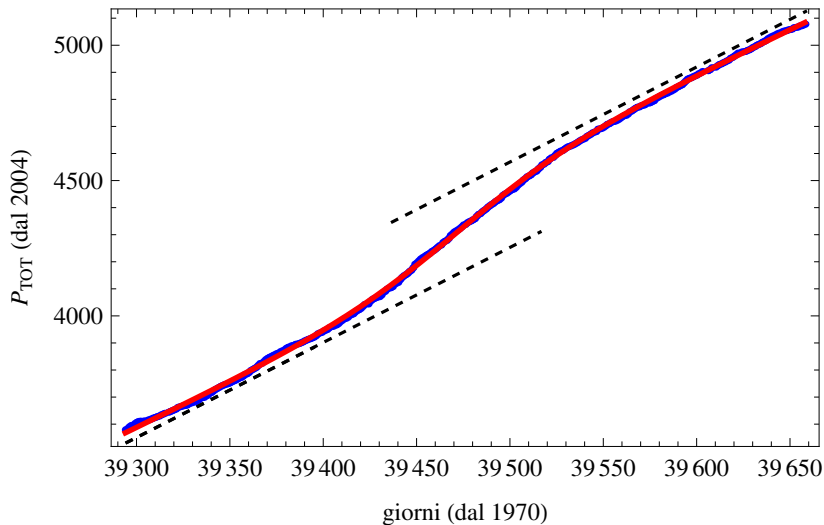


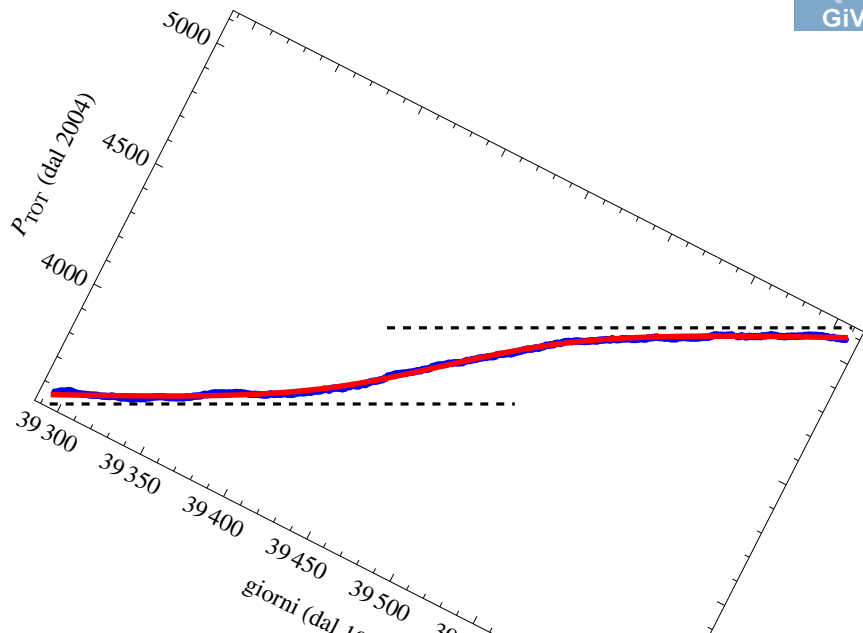












- Equazioni evoluzione temporale
- Determinazione dei parametri caratteristici
 - Contagiosità
 - Durata incubazione
 - Durata contagiosità

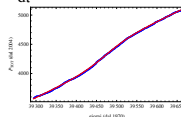


$$\frac{dS}{dt} = -\beta C S$$

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

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

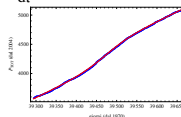
$$\frac{dR}{dt} = C/\tau_{\text{cont}}$$



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



$$\begin{aligned}\frac{dS}{dt} &= -\beta C S \\ \frac{dI}{dt} &= \beta C S - I/\tau_{\text{inc}} \\ \frac{dC}{dt} &= I/\tau_{\text{inc}} - C/\tau_{\text{cont}} \\ \frac{dR}{dt} &= C/\tau_{\text{cont}}\end{aligned}$$



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

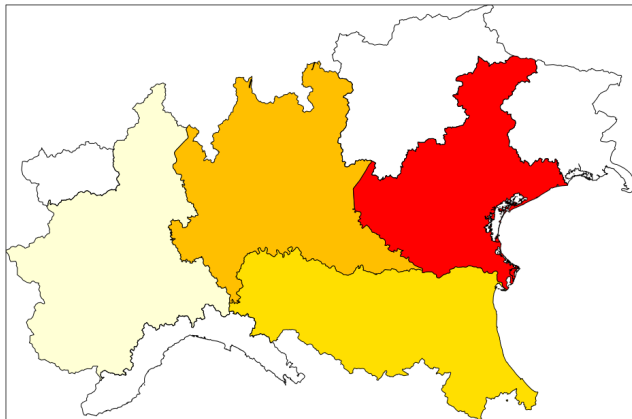


Messico	0.4%
Regno Unito	0.04%
Regno Unito	0.026%
New York	0.2%

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

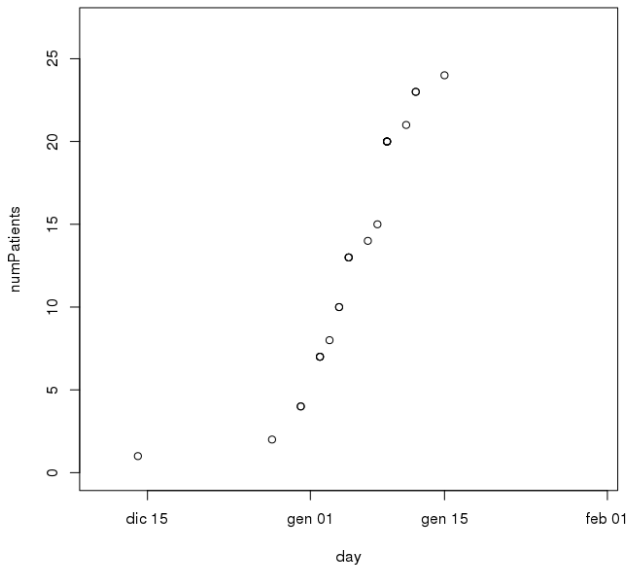


cinque anni dopo

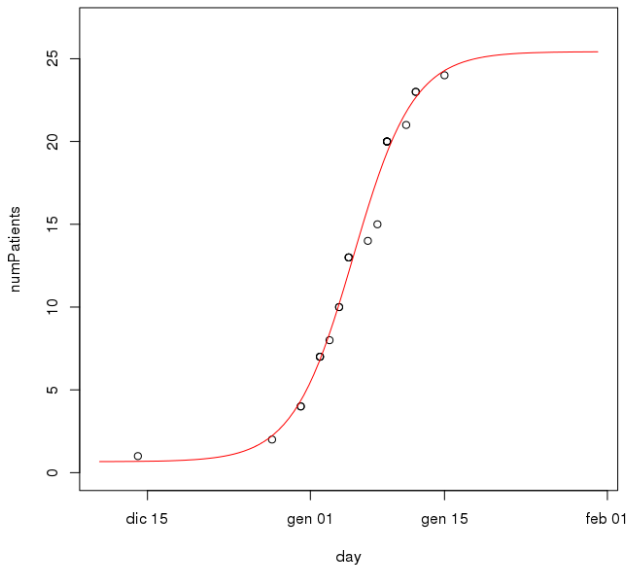


	Pazienti	TI con H1N1
Veneto	12	5
Lombardia	6	4
Emilia-Romagna	5	2
Piemonte	1	1

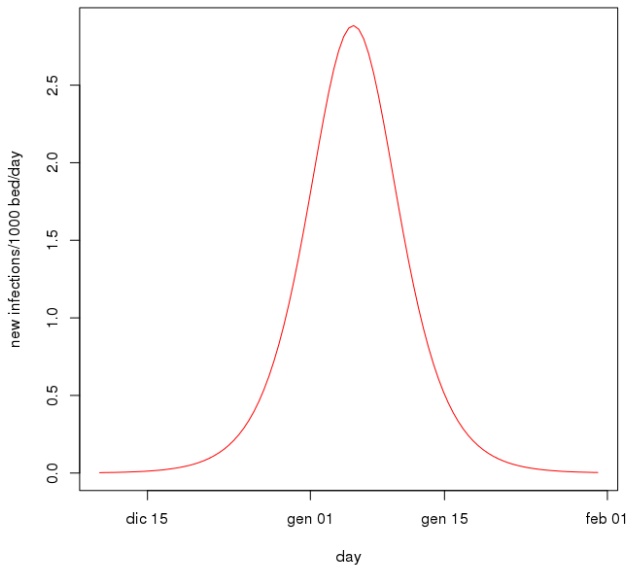
Evoluzione temporale – H1N1 totali

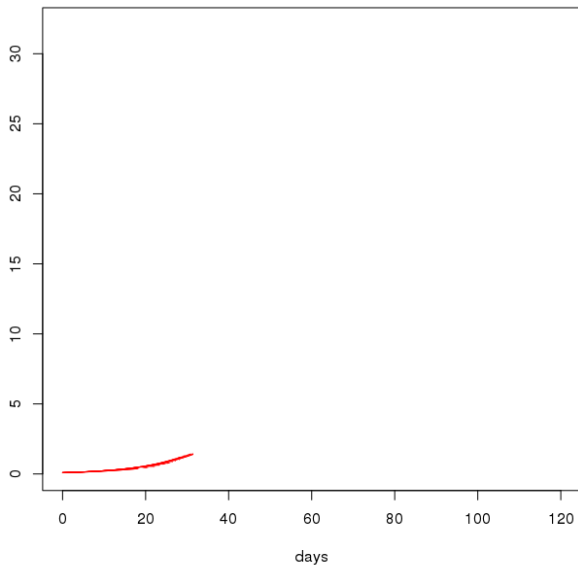


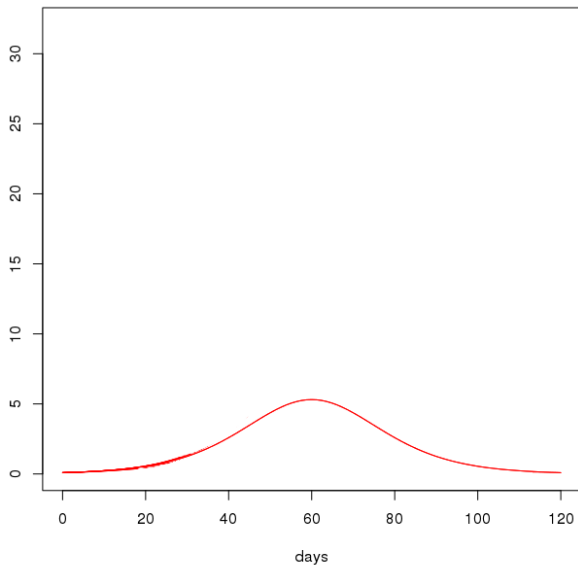
Evoluzione temporale – H1N1 totali – Modello

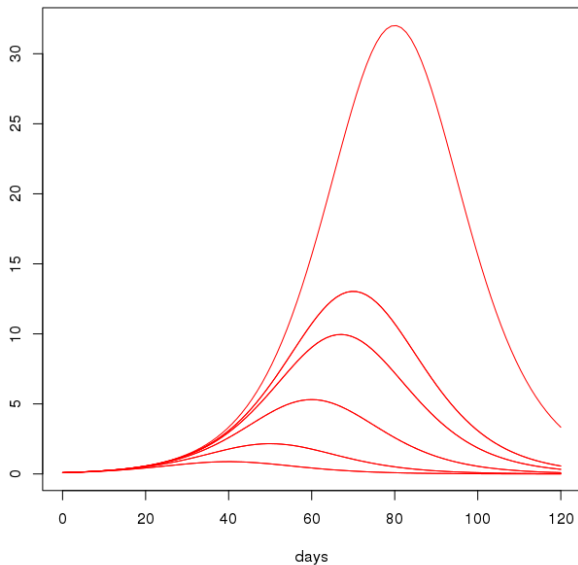


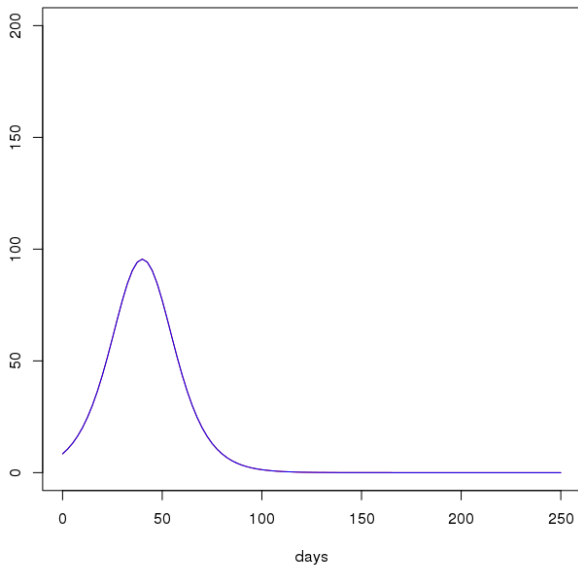
H1N1 – Nuovi casi al giorno – Modello

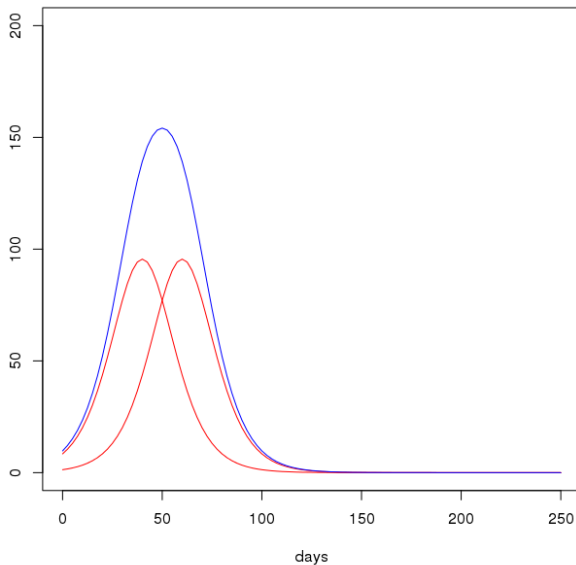


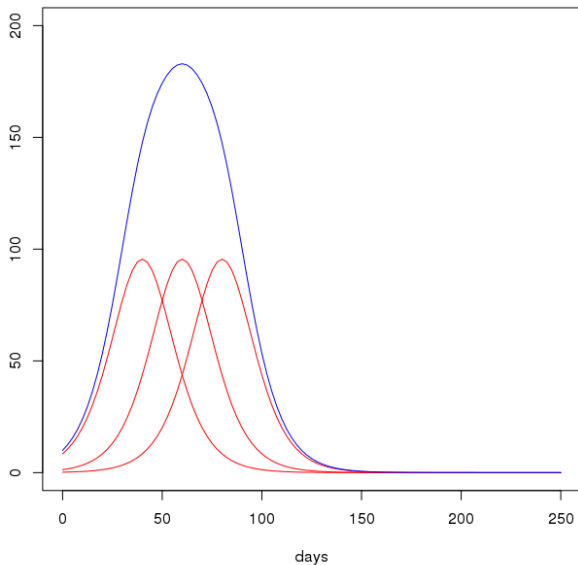






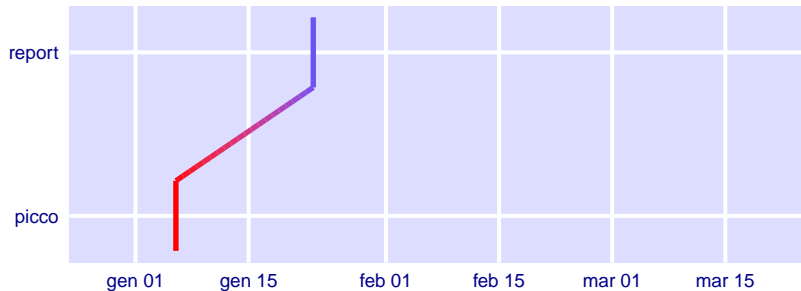




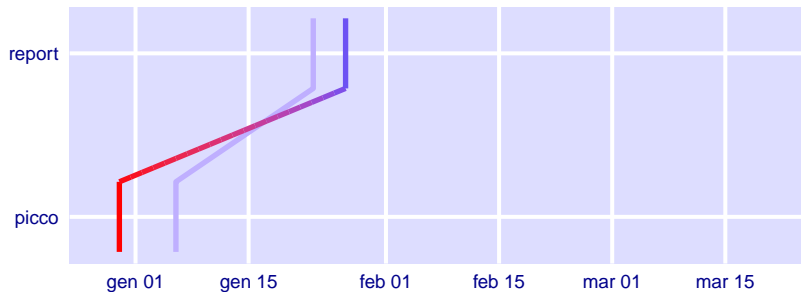


tre mesi dopo

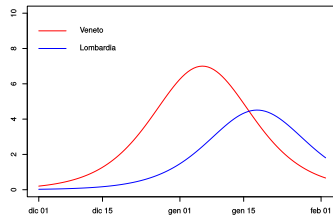
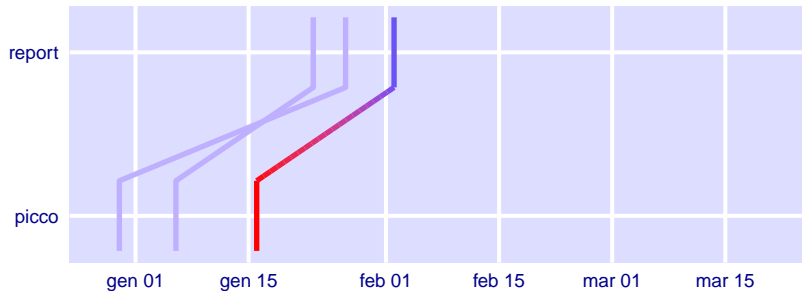
Che cosa è successo



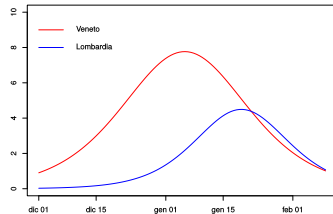
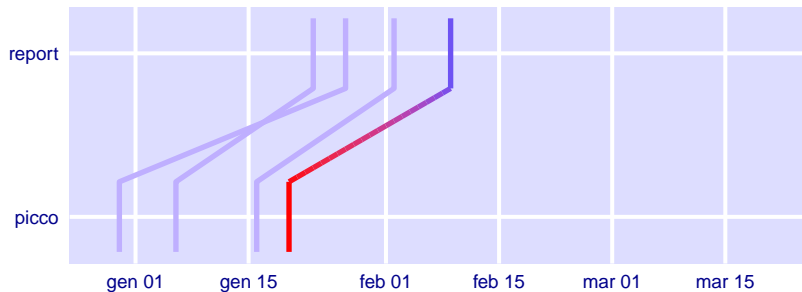
Che cosa è successo



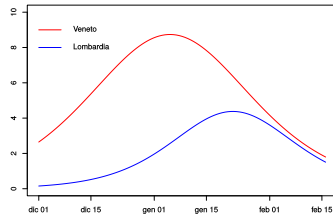
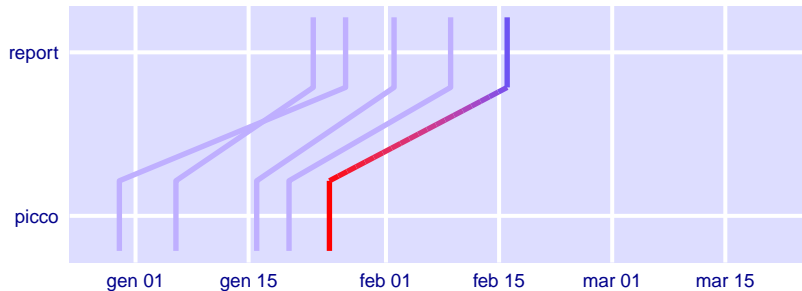
Che cosa è successo



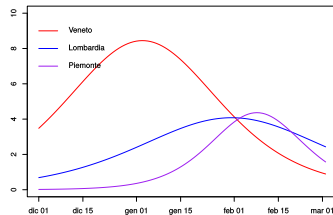
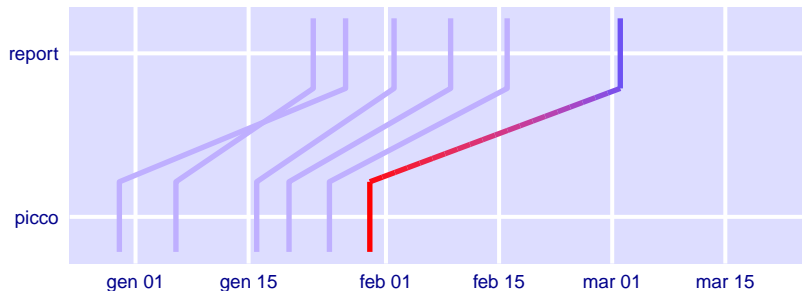
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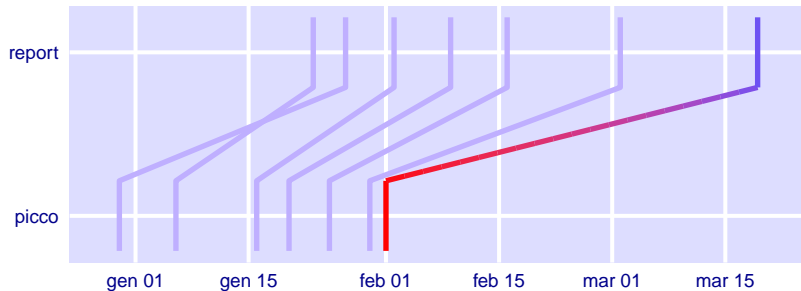
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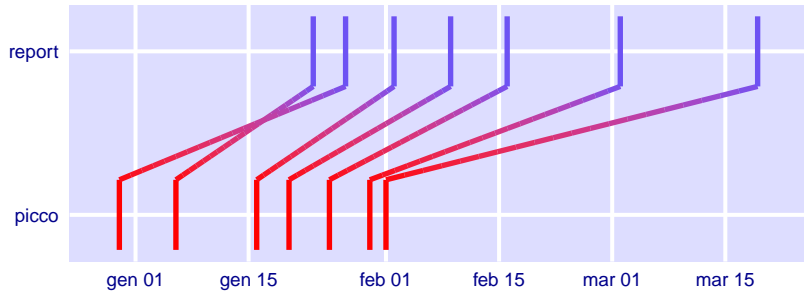
Che cosa è successo



Che cosa è successo



Che cosa è successo

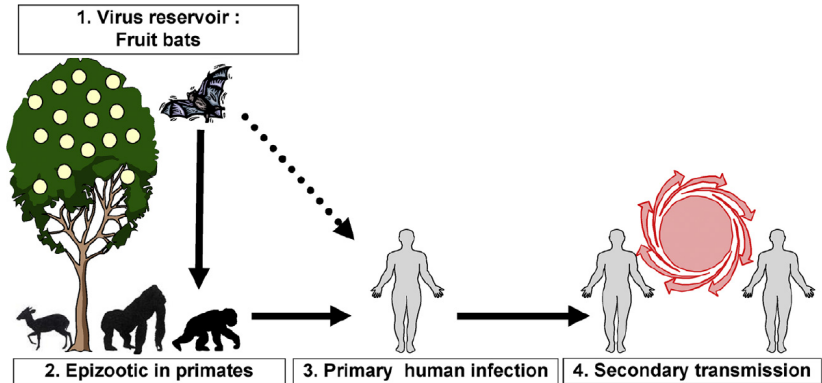


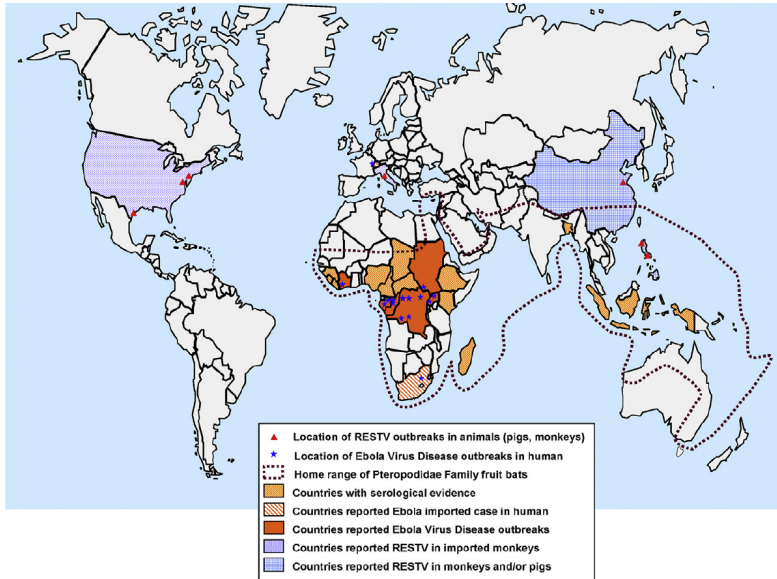
- Previsioni molto incerte
- Risultati cambiano nel tempo all'arrivo di nuovi dati
- Quali indicazioni seguire?

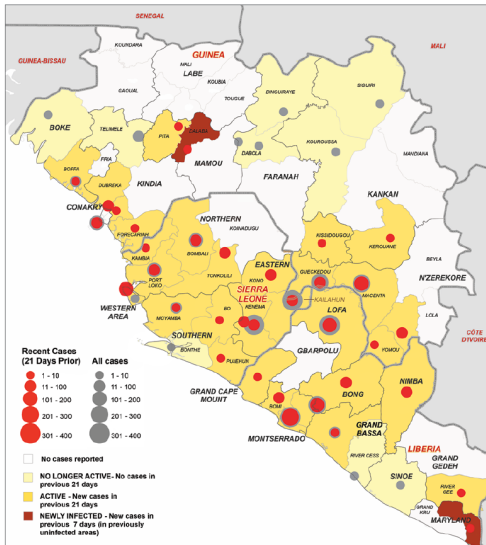


un anno prima

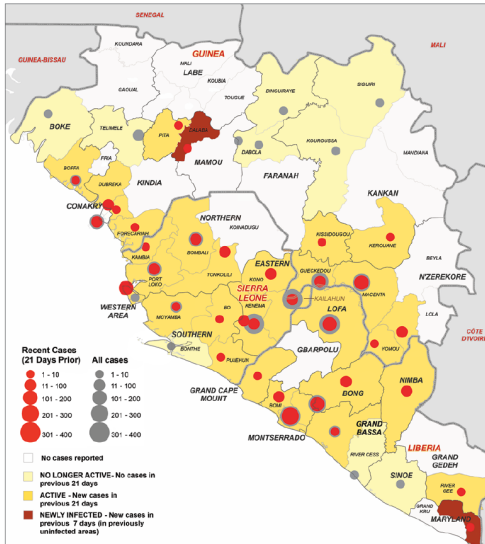
EBOLA

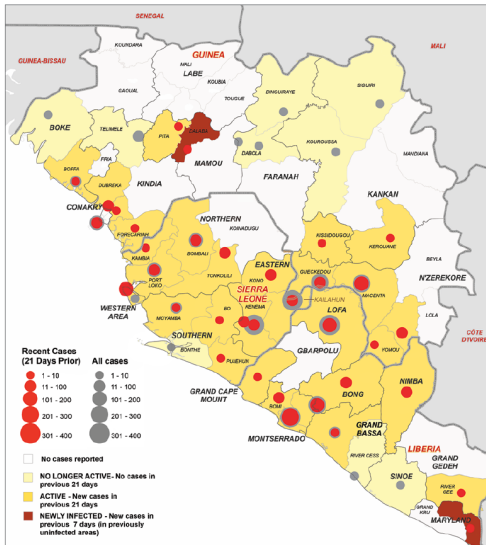




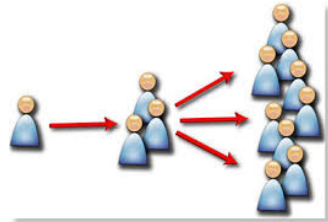


● Mortalità: ~ 70%





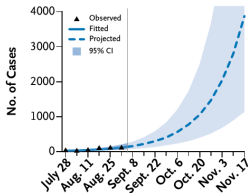
- Mortalità: ~ 70%
- Numero di riproduzione



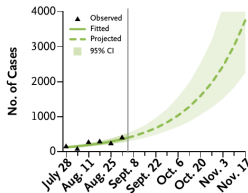
Guinea	1.44 – 2.01
Liberia	1.72 – 1.94
Sierra Leone	2.02 – 2.26
Nigeria	0.67 – 1.96

● WHO – 14 Settembre 2014

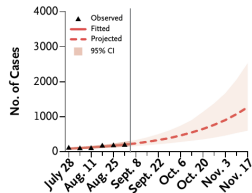
A Guinea



B Liberia

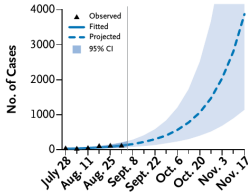


C Sierra Leone

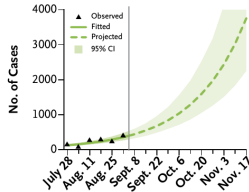


● WHO – 14 Settembre 2014

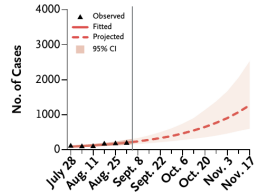
A Guinea



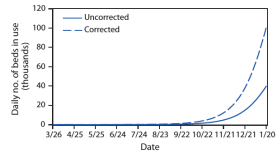
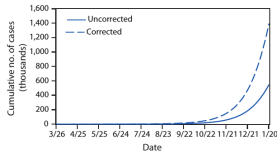
B Liberia



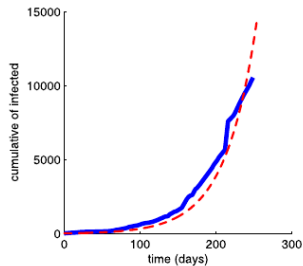
C Sierra Leone



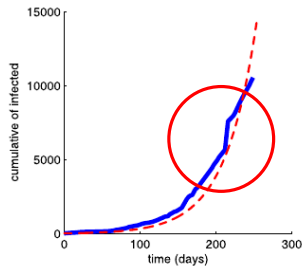
● CDC – 13 Settembre 2014



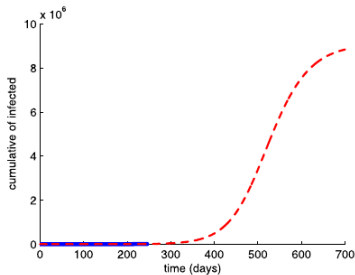
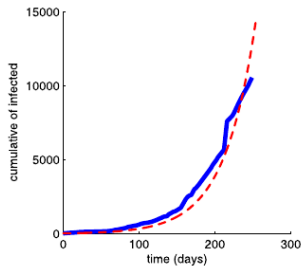
● 01 Dicembre 2014



● 01 Dicembre 2014

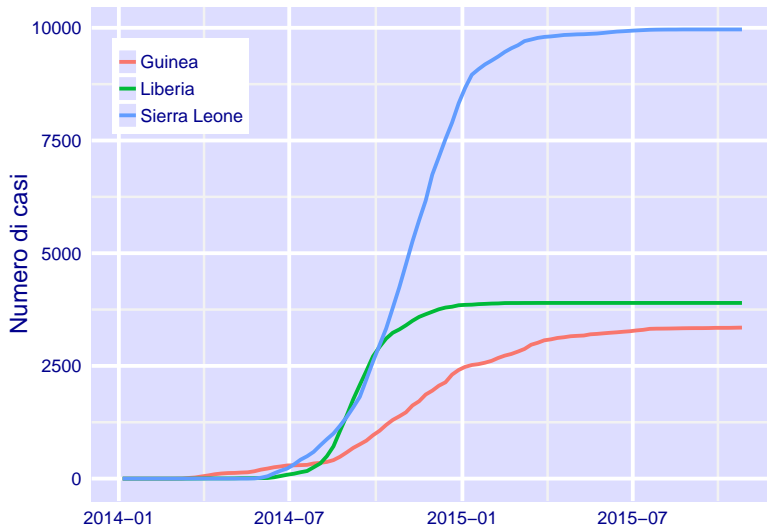


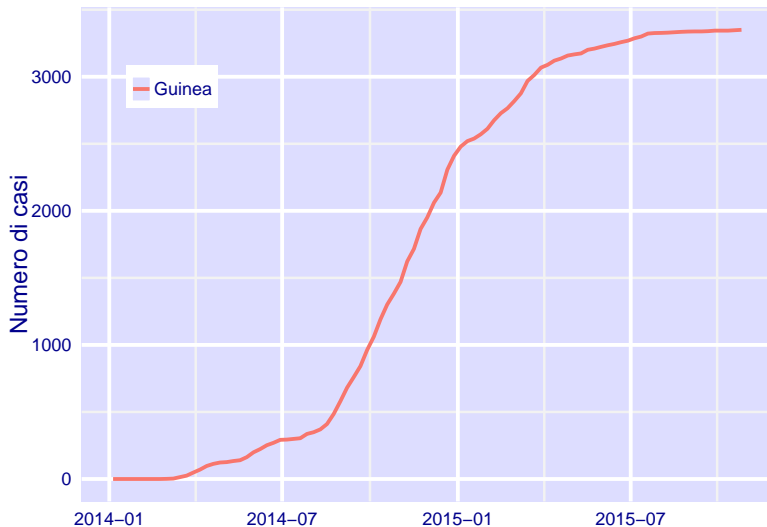
● 01 Dicembre 2014

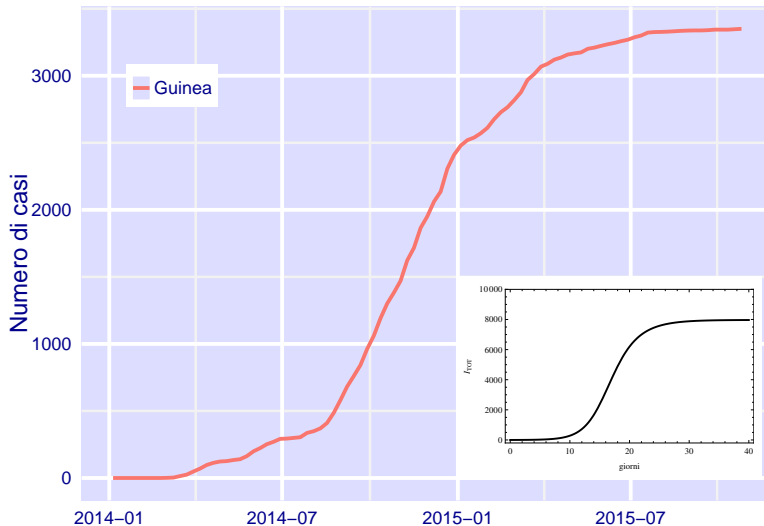


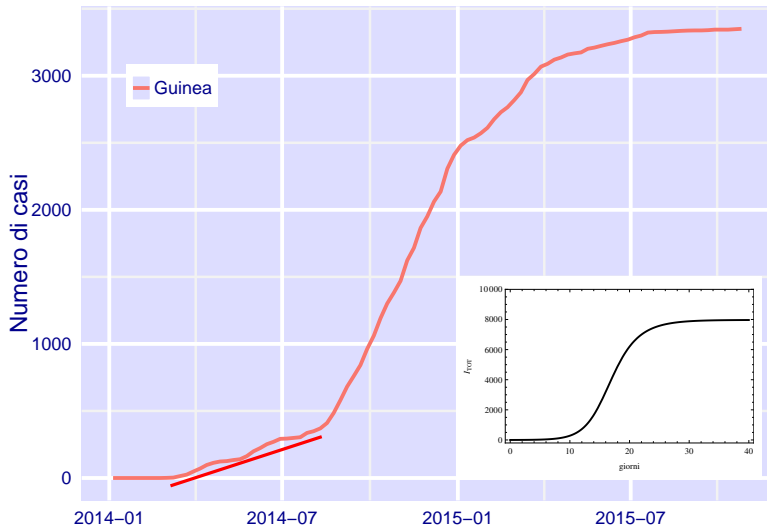
casi previsti: 9 000 000

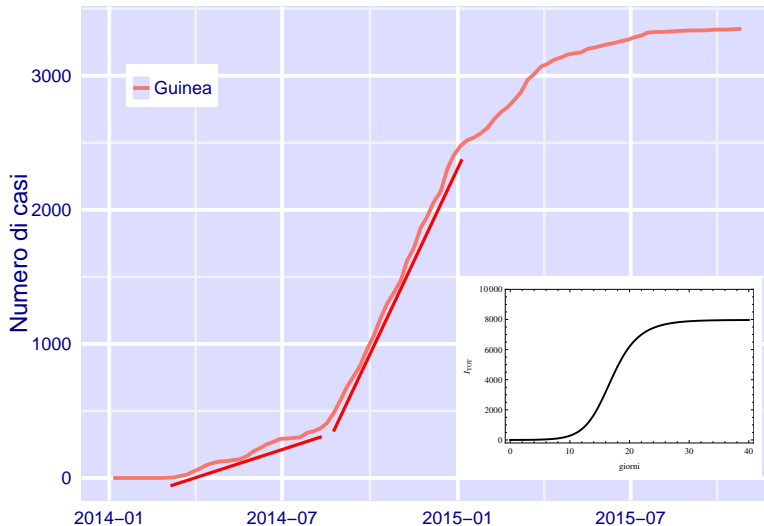
Che cosa è successo?

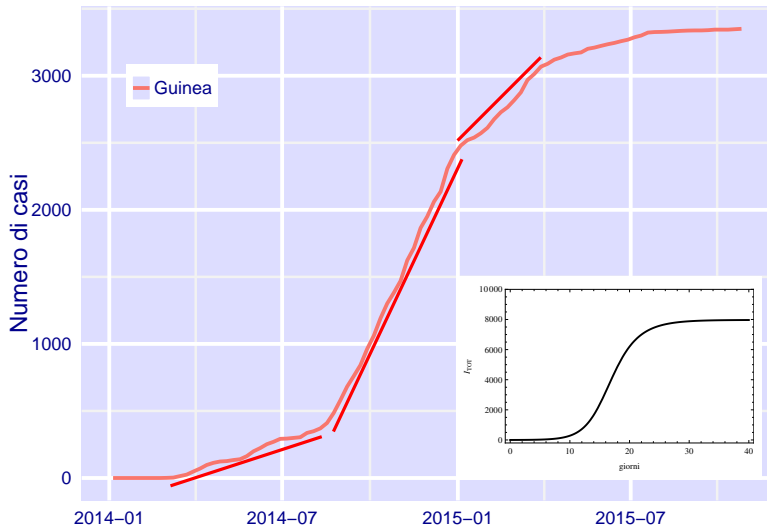






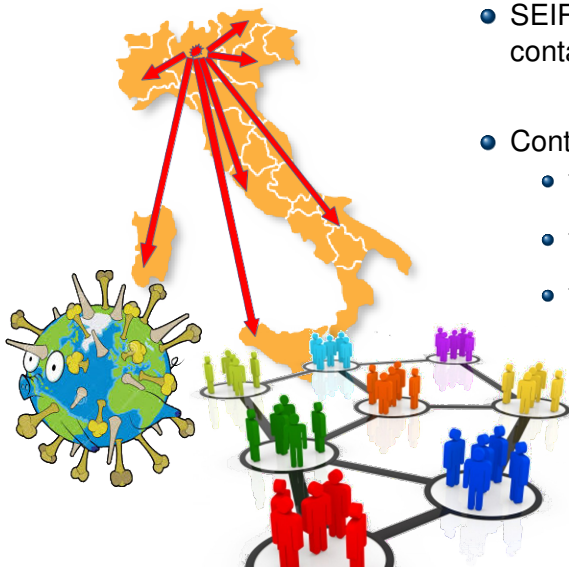








- SEIR: **tutti** i contagiosi possono contagiare tutti i suscettibili!



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







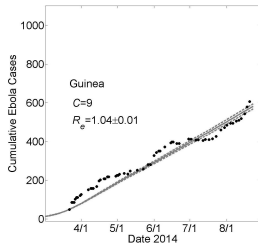






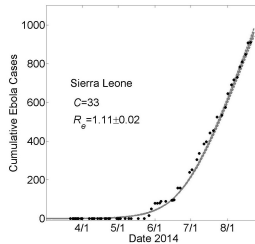
Guinea

$$C = 9$$



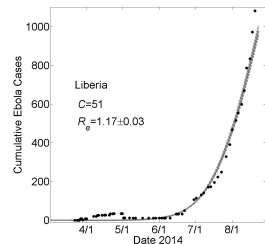
Sierra Leone

$$C = 33$$



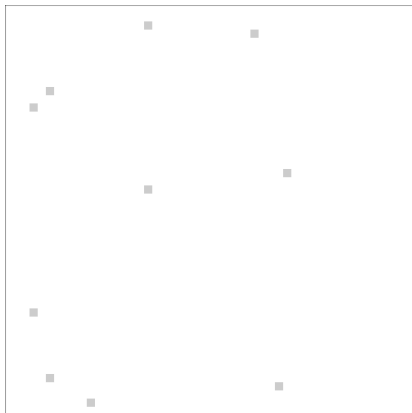
Liberia

$$C = 51$$



Infetti iniziali = 10

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



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

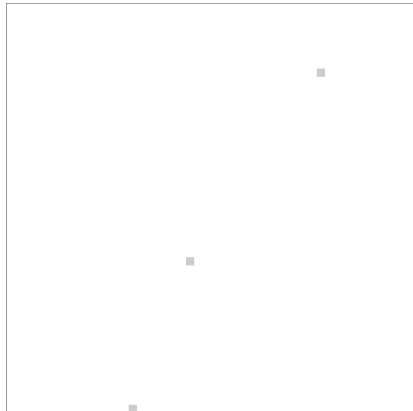


Infetti iniziali = 3

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



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



Che cosa imparare da questi modelli...



- Imprevedibilità

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- Fattori socio-economici
- Interventi minimi \Rightarrow significativi miglioramenti



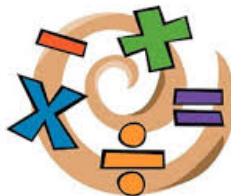
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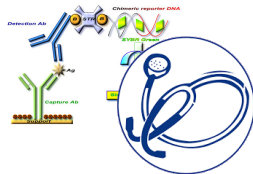


Obiettivo

Modelli non previsionali ma suggerimenti interventi efficaci

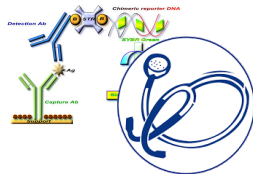


- Sistemi sanitari
 - Sorveglianza
 - Capacità di test (es: PCR)



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

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- Risorse umane
 - Personale sanitario
 - Incident managers
 - Epidemiologi
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- Risorse non umane
 - Comunicazione e raccolta dati
 - Mezzi di trasporto
 - Materiali



