



The SIRI Model in Epidemiology: Pertussis and Malaria

Gabriela Gomes





Models establish bridges between levels of organisation

EPIDEMIOLOGY

**mathematical models
computer models**

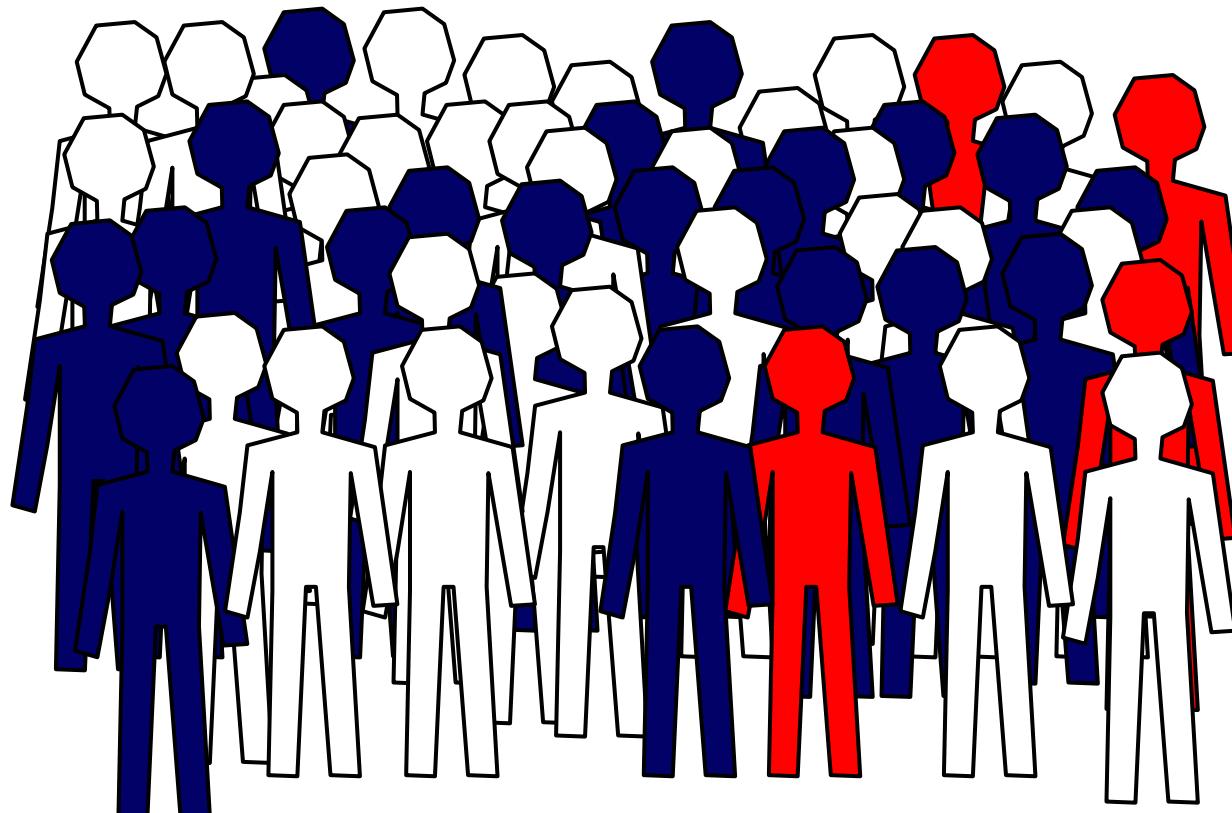
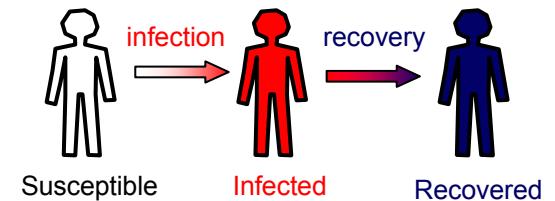
ORGANISM-centered biology

mathematical models
computer models
animal models

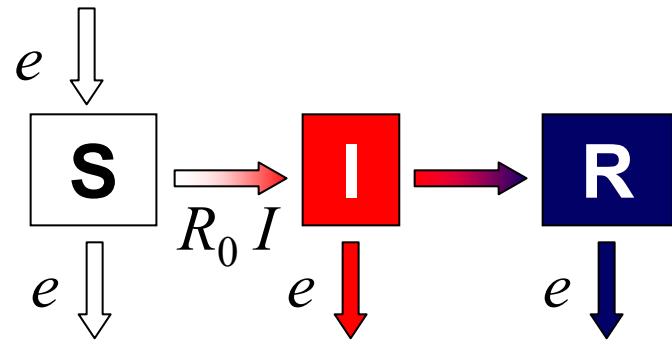
MOLECULAR and CELL biology



SIR model – totally protective immunity

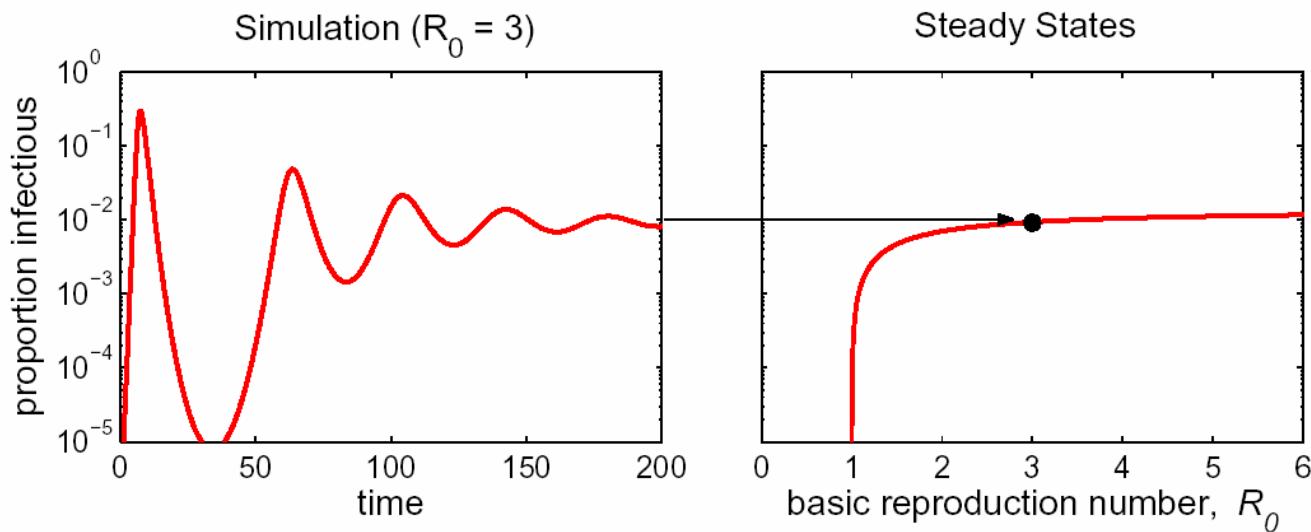


Endemic threshold – $R_0 = 1$



$$\frac{dS}{dt} = e - R_0 IS - eS$$

$$\frac{dI}{dt} = R_0 IS - I$$





The basic reproduction number, R_0

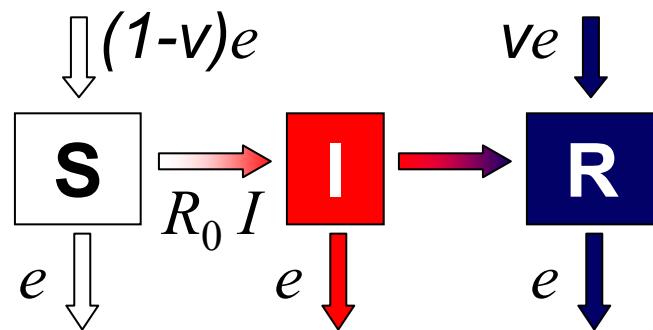
The expected number of secondary cases arising from a single infectious individual in a totally susceptible population.

Disease	R_0
Smallpox	4
Measles	17
Rubella (England and Wales)	6
Rubella (Gambia)	15

R_0 depends on the disease and the population.

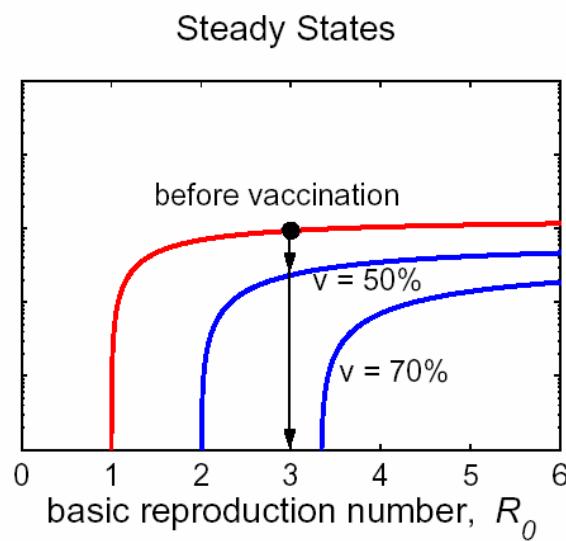
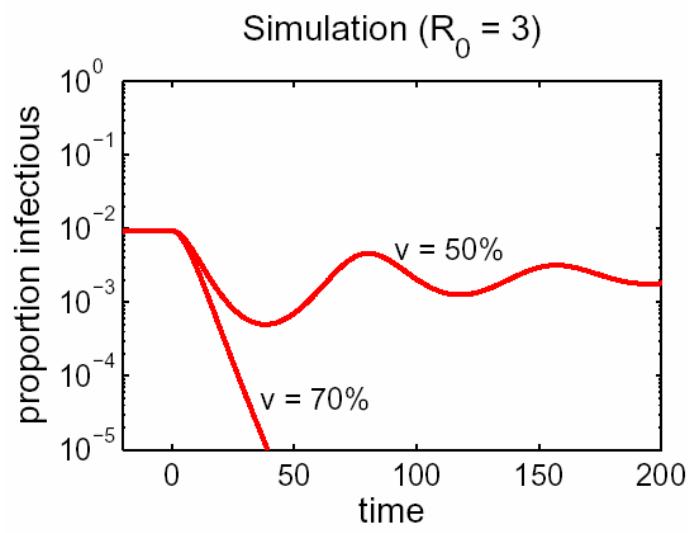


Vaccination reduces the susceptibility pool



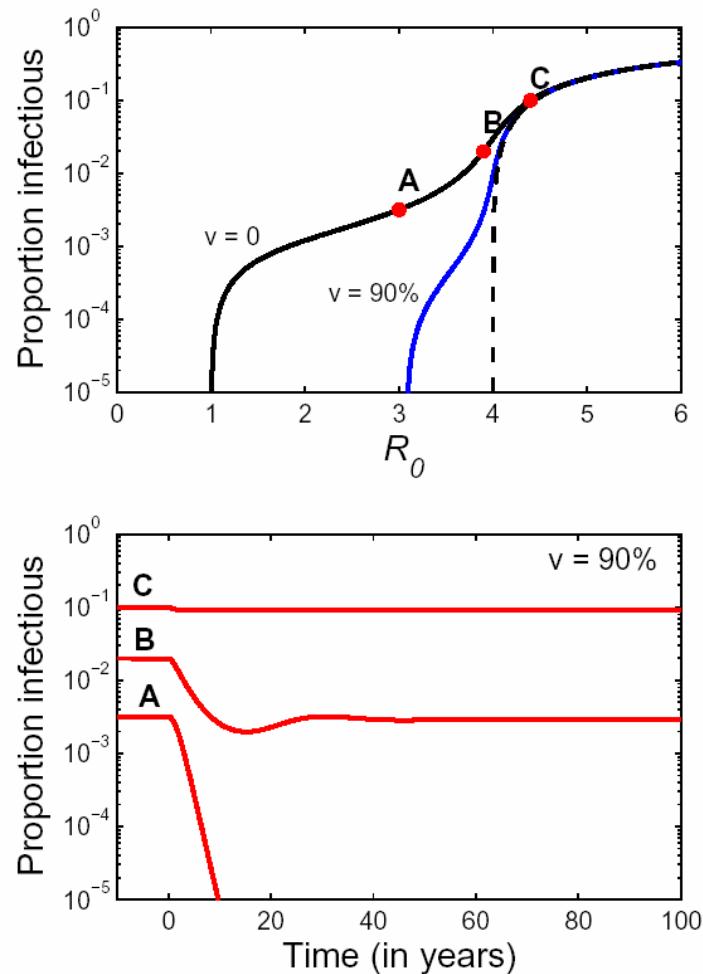
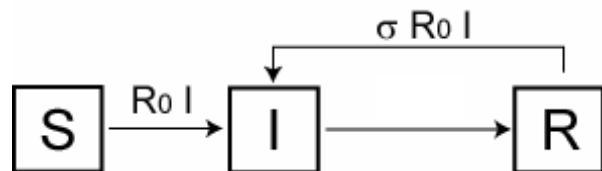
$$\frac{dS}{dt} = (1 - v)e - R_0 IS - eS$$

$$\frac{dI}{dt} = R_0 IS - I$$



Partial immunity induces a **reinfection threshold**, $R_0 = 1 / \sigma$, above which the prevalence of infection is very high and insensitive to vaccination.

σ : reduction in the risk of infection due to partial immunity.



Tuberculosis – geographical variability

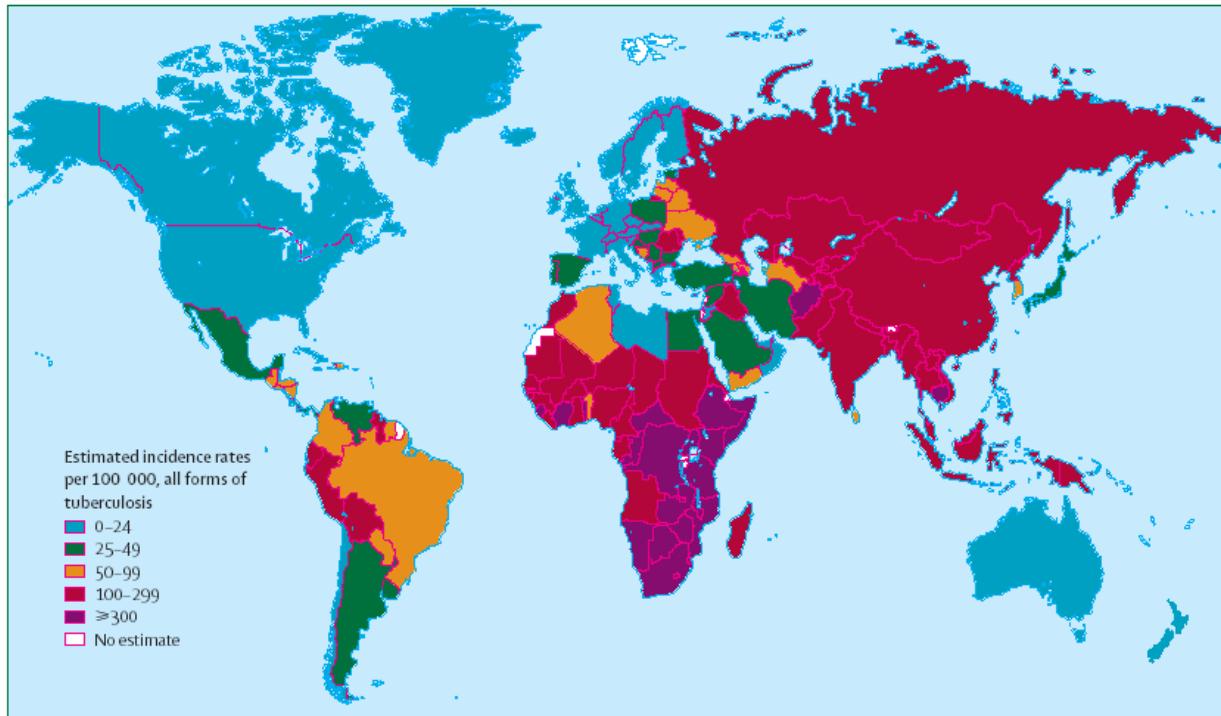


Figure 1: Distribution of tuberculosis in the world in 2003⁴

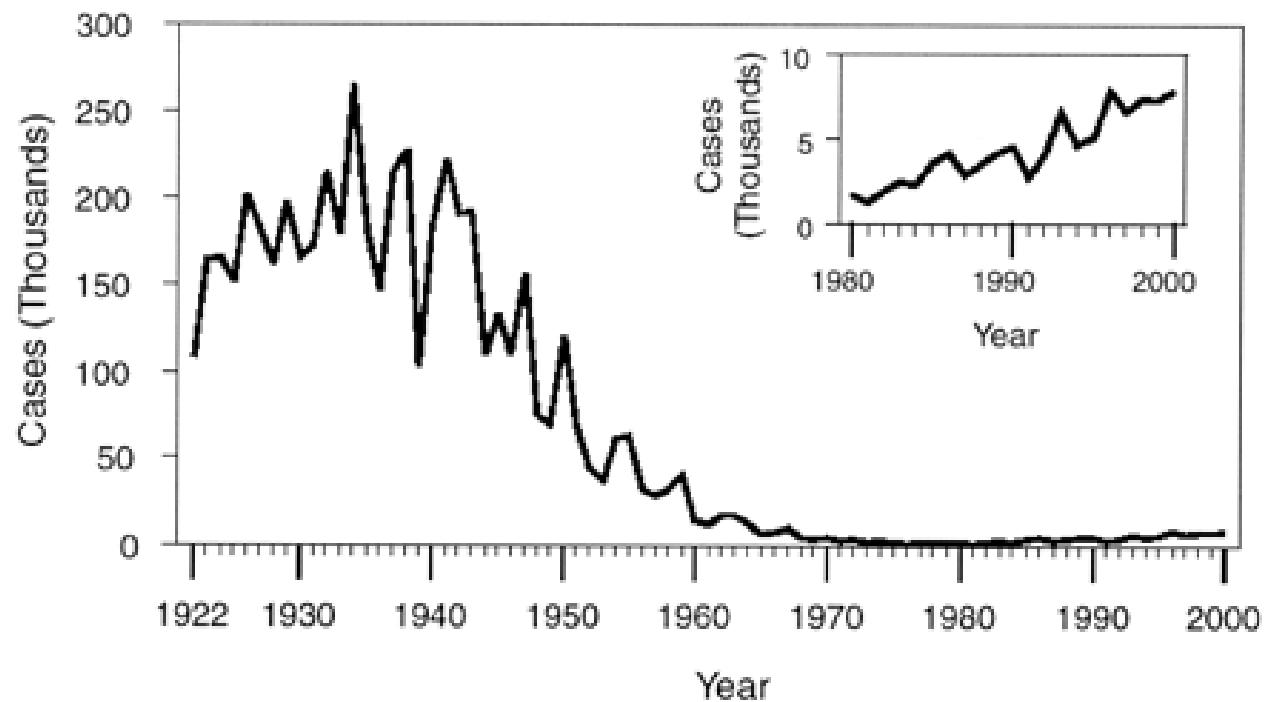
Gomes MGM, Franco AO, Gomes MC, Medley GF 2004 The reinfection threshold promotes variability in tuberculosis epidemiology and vaccine efficacy. *Proc. R. Soc. Lond. B* 271, 617-623.

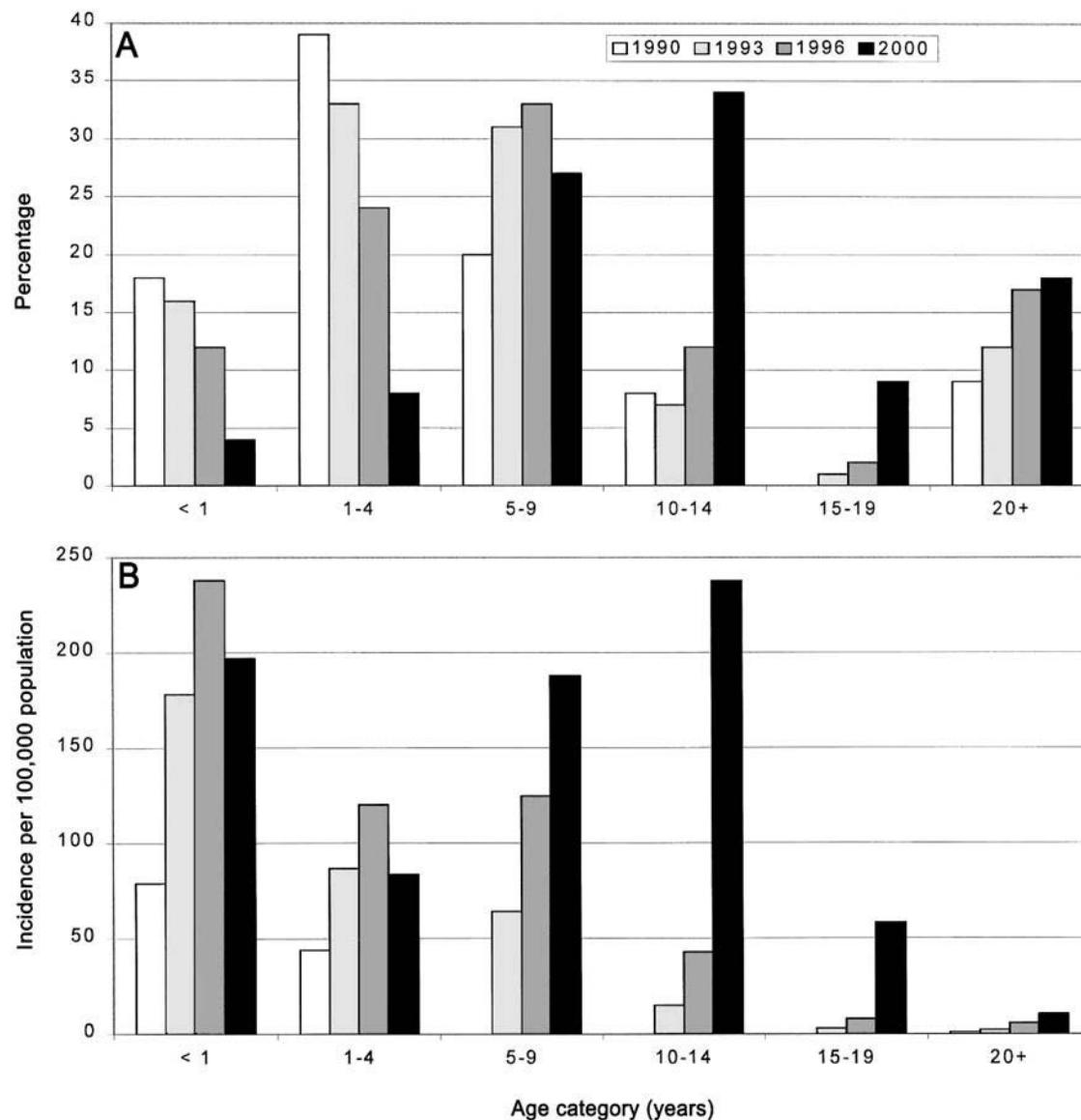
Gomes MGM, Rodrigues P, Hilker FM, Mantilla-Beniers NB, Muehlen M, Paulo ACAS, Medley GF 2006 The potential of post-exposure interventions in global tuberculosis control (*submitted*).

Rodrigues P, Rebelo C, Gomes MGM 2007 Resistant tuberculosis: A reinfection model. *Theoretical Population Biology* 71, 196-212.

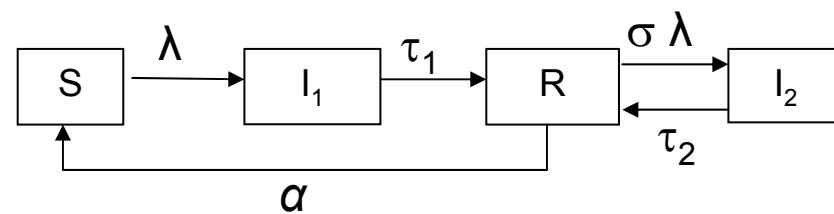


Pertussis - resurgence





Ricardo Águas - IGC



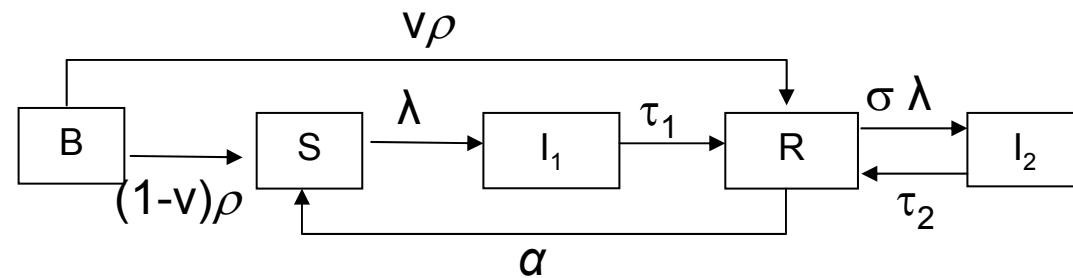
Águas R, Gonçalves G, Gomes MGM (2006) Pertussis: Increasing disease as a consequence of reducing transmission. *Lancet Infectious Diseases* 6, 112-117.



Theoretical Epidemiology

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Ricardo Águas - IGC



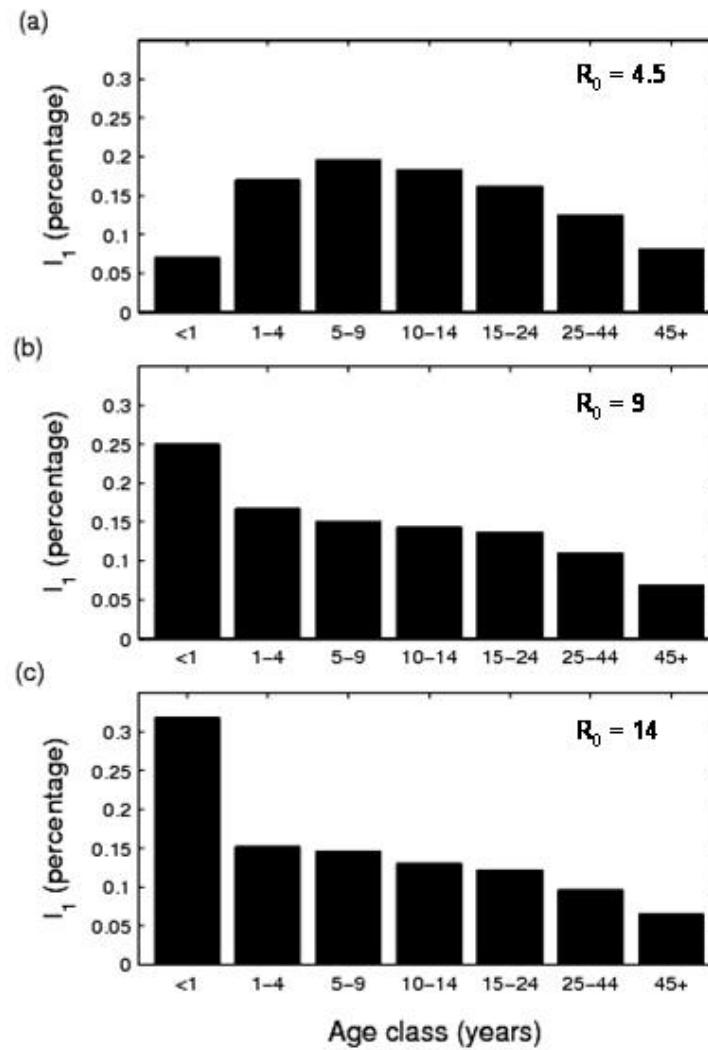
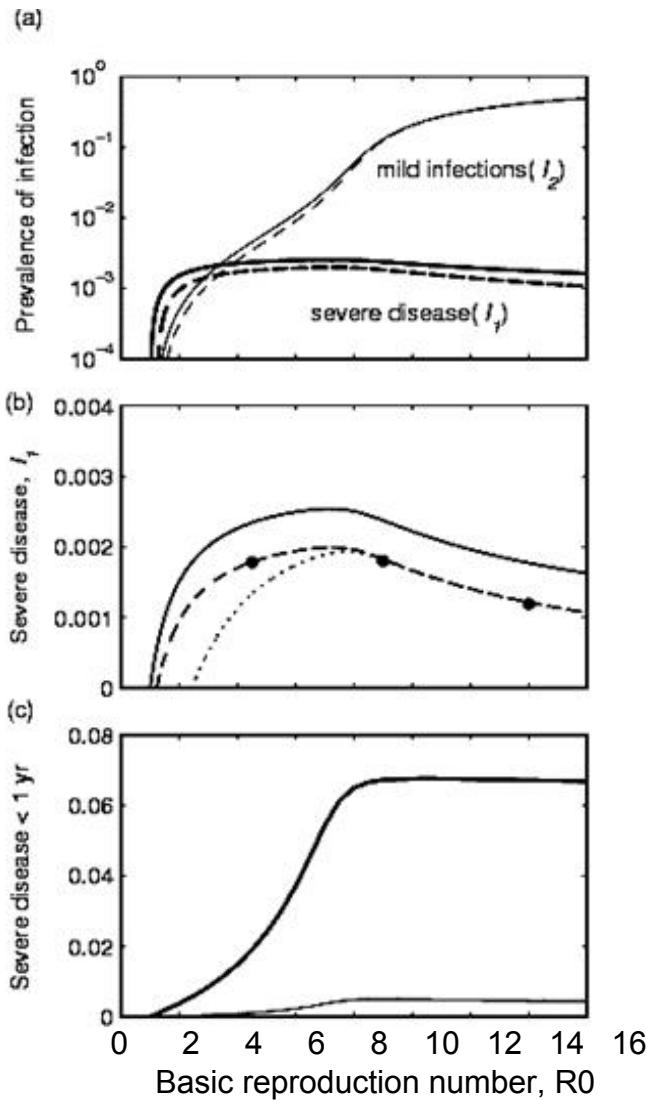
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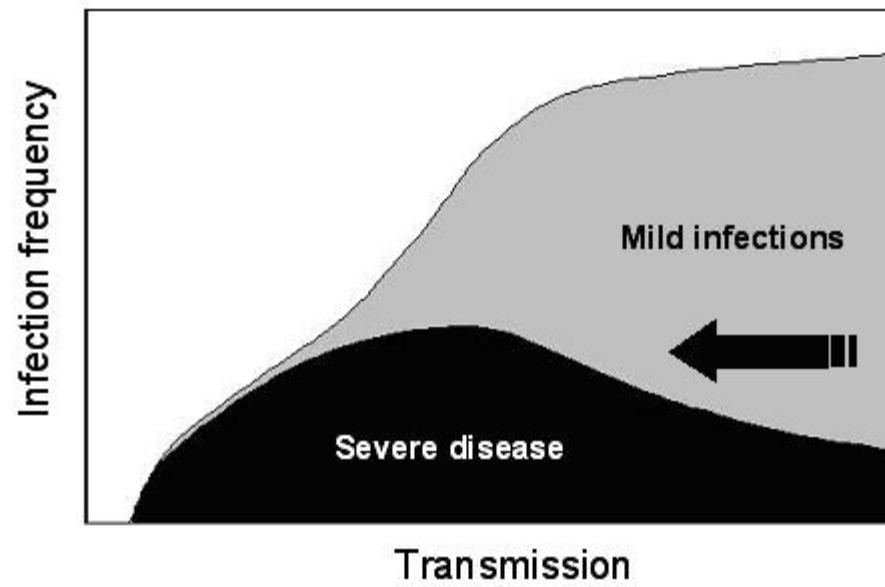
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Pertussis - resurgence



Increasing disease with decreasing transmission



Model equations

$$\frac{dS_0}{dt} = (1 - \nu_0)\mu + \alpha R - S_0(\lambda + \mu)$$

$$\frac{dR}{dt} = \nu_0\mu + \tau_1 I_1 + \tau_2 I_2 - R(\sigma\lambda + \alpha + \mu)$$

$$\frac{dI_1}{dt} = \lambda S_0 - I_1(\tau_1 + \mu)$$

$$\frac{dI_2}{dt} = \sigma\lambda R - I_2(\tau_2 + \mu)$$



Age-dependent model equations

$$\frac{\partial S_0}{\partial t} + \frac{\partial S_0}{\partial a} = \alpha R - S_0(\lambda + v_0\mu + \mu)$$

$$\frac{\partial R}{\partial t} + \frac{\partial R}{\partial a} = v_0\mu + \tau_1 I_1 + \tau_2 I_2 - R(\sigma\lambda + \alpha + \mu)$$

$$\frac{\partial I_1}{\partial t} + \frac{\partial I_1}{\partial a} = \lambda S_0 - I_1(\tau_1 + \mu)$$

$$\frac{\partial I_2}{\partial t} + \frac{\partial I_2}{\partial a} = \sigma\lambda R - I_2(\tau_2 + \mu)$$

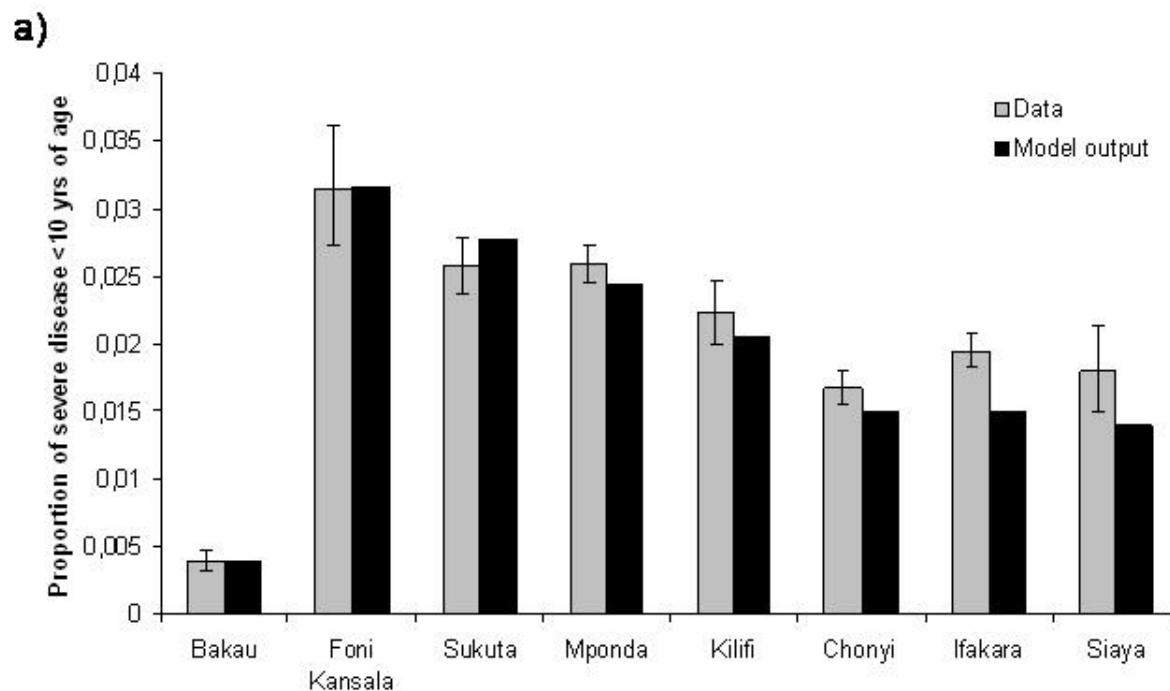
Boundary conditions:

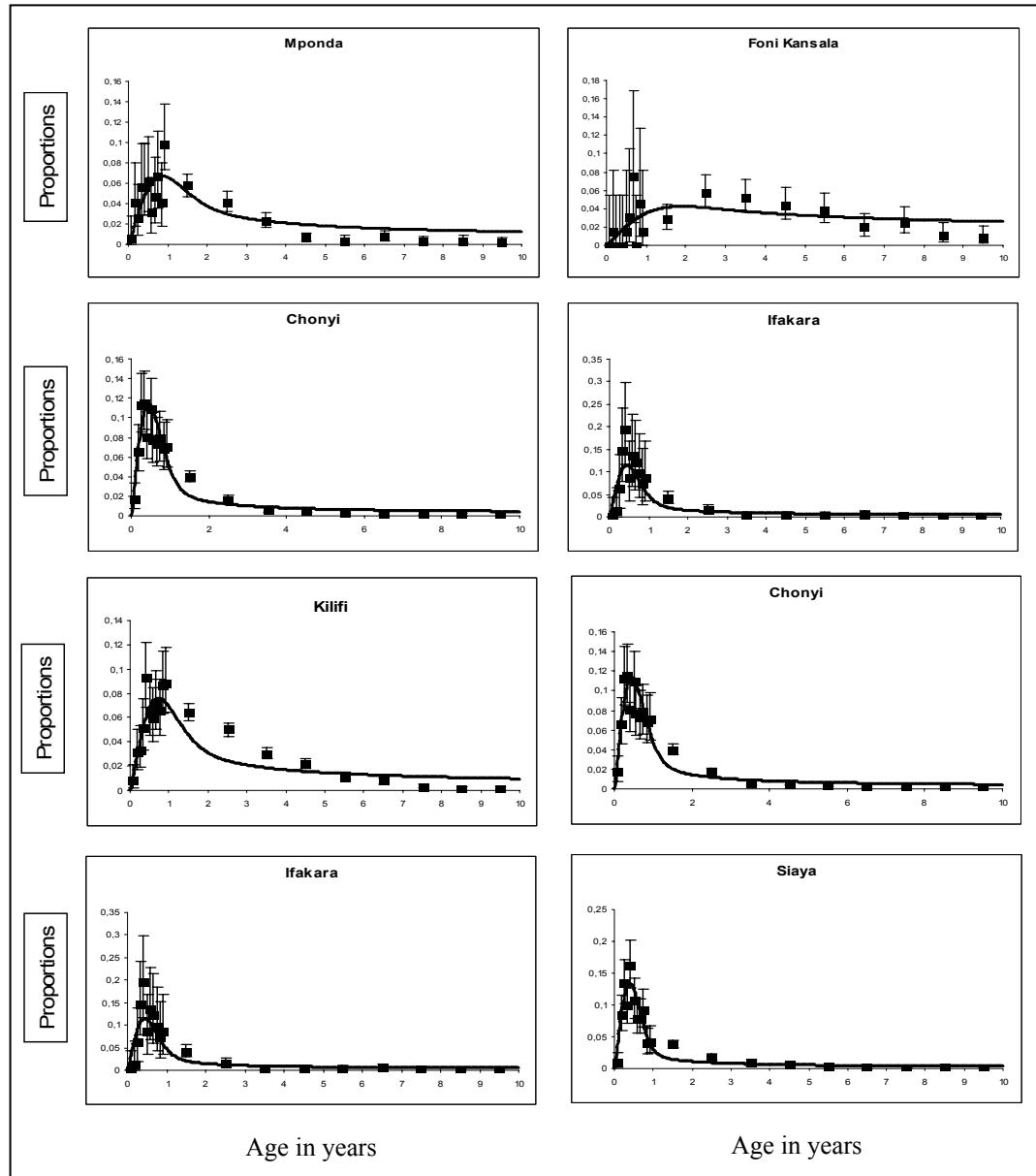
$$S_0(t,0) = \mu$$

$$R(t,0) = I_1(t,0) = I_2(t,0) = 0$$

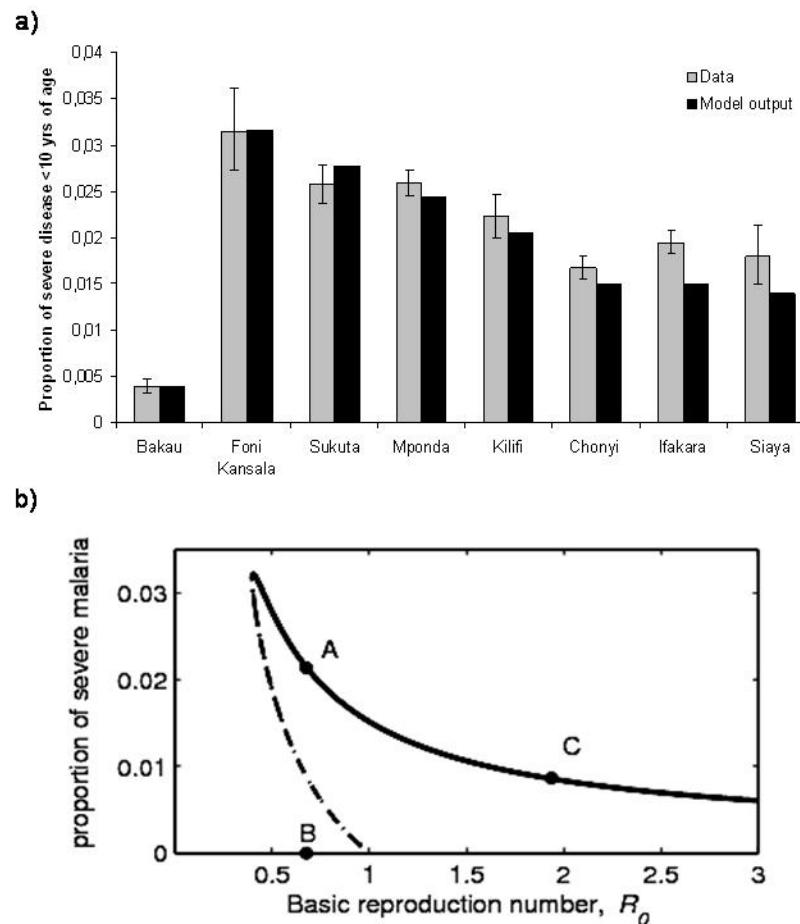


Malaria – data from sub-Saharan Africa



Malaria – data from
Sub-Saharan Africa

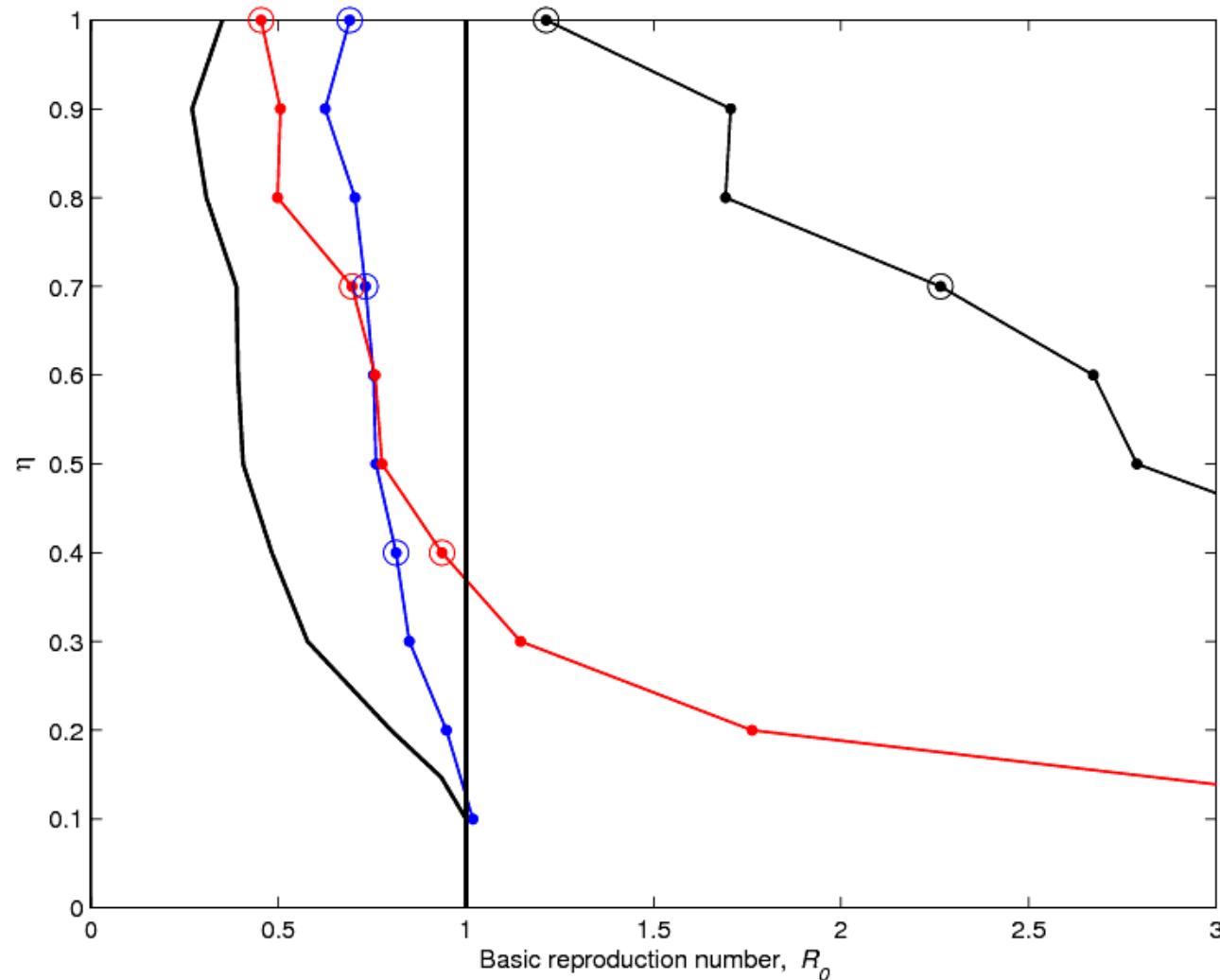
Malaria – sustainability of interventions



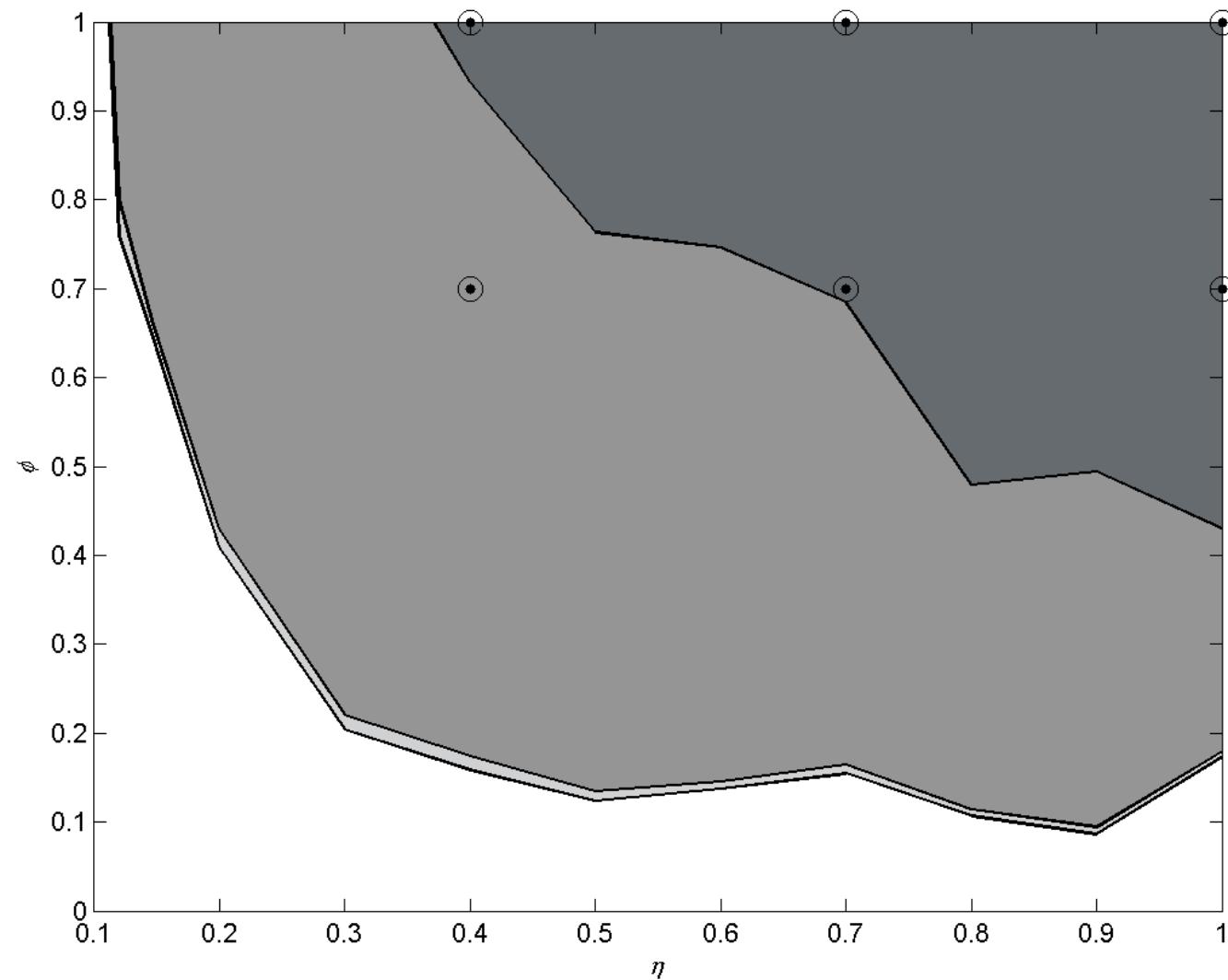
Águas R, White LJ, Snow RW, Gomes MGM 2007 Prospects for sustainable malaria control in sub-Saharan areas of mesoendemic transmission (*submitted*).



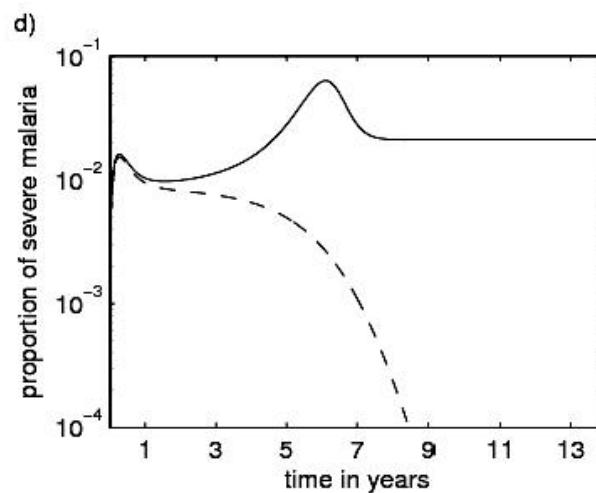
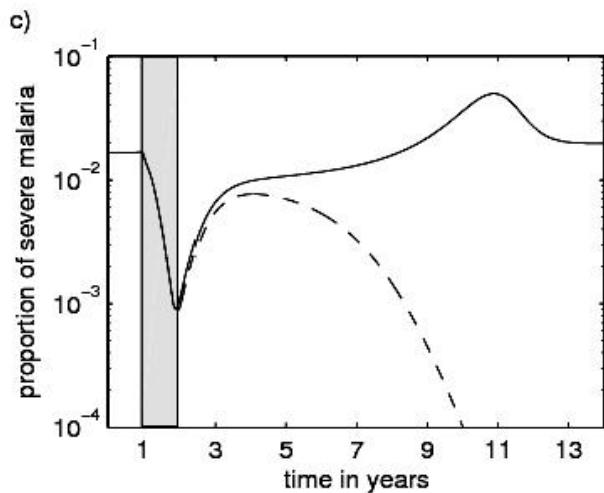
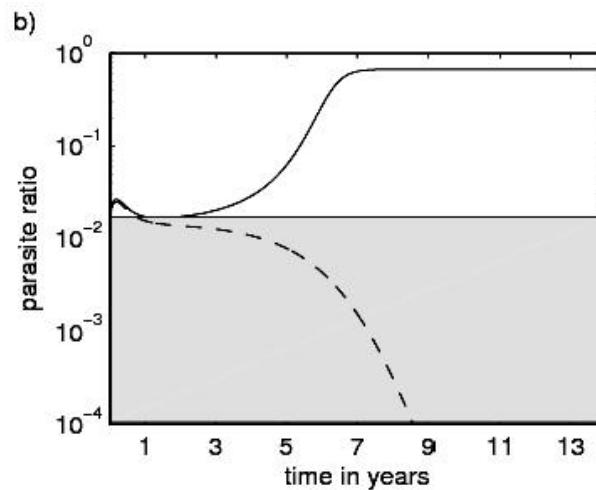
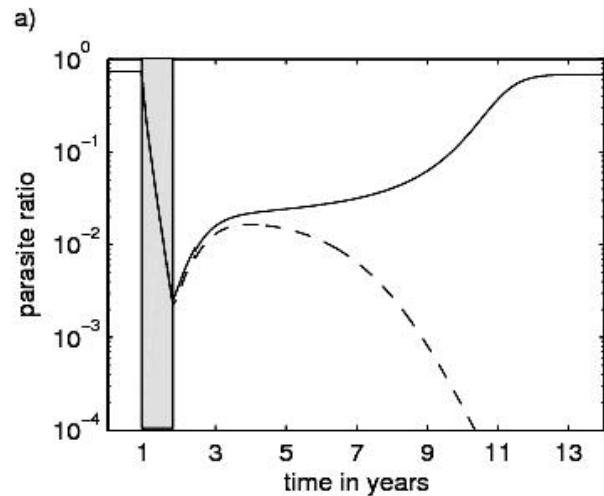
Malaria – sensitivity to reporting rate



Malaria – sensitivity to infectively reduction



Malaria – intervention design





Advanced Courses and Workshops:

<http://sites.igc.gulbenkian.pt/ggomes/meetings.php>

First Summer School on “Mathematics in Biology and Medicine”

Advanced Course on “Tuberculosis: Scientific Basis for Control”

First Workshop on “Pathogen Diversity and Disease Epidemiology”

Science in Society Workshops - “Gripenet”

Advanced Course on “Infectious Disease Epidemiology”

Second Summer School on “Mathematics in Biology and Medicine”

Second Workshop on “Pathogen Diversity and Disease Epidemiology”





Epidemic monitoring and forecast

- Fast
- Transparent
- Uniform

Marquet RL, Bartelds AIM, van Noort SP, Koppeschaar CE, Paget J, Schellevis FG, van der Zee J 2006 An internet-based monitoring of influenza-like illness (ILI) in the general population of the Netherlands during the 2003-2004 influenza season. BMC Public Health 6, 242.

van Noort SP, Lourenço J, Rebelo de Andrade H, Muehlen M, Gomes MGM 2007 Internet-based surveillance of ILI performs uniformly in the Netherlands, Belgium and Portugal (submitted).



Número de participantes:
 Portugal: 4221
 Holanda: 19963
 Bélgica: 7017

Recomende a um amigo!
 E-mail: enviar

Login: preencha o questionário semanal ou altere os seus dados

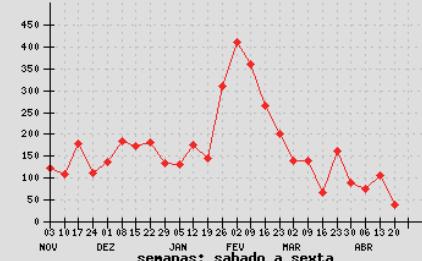
Participe! obtenha um login e preencha o questionário de adesão

Mapas
 Consulte os mapas:
[Edição 2005/2006](#)
[Edição 2006/2007](#)

[A Gripe vai à Escola](#)
[Edição 2005-2006](#)
[Newsletters 2006/2007](#)
[Kit multimédia](#)

Gripe no mínimo
 Portugal encontra-se sem actividade gripe significativa. Tal como no resto da Europa, segundo os últimos dados do European Influenza Surveillance Scheme, a epidemia regrediu para os níveis anteriores ao do Inverno. O indicador de intensidade era baixo para os 25 países que reportaram dados sobre síndrome gripe. O Influenza A (H3N2) continua a ser o vírus dominante. A campanha de monitorização Gripenet desta época termina a 30 de Abril.

Incidência por 10.000 habitantes



semanas: sábado a sexta

[seguir para o topo](#)

Novidades Gripenet

Lista de Equipas Inscritas
 Está disponível a **lista definitiva** das equipas registadas no Gripenet. Navegue as listas [nesta página](#)

Lista de Trabalhos Recebidos
 Está disponível a lista **definitiva** dos trabalhos recebidos pela equipa Gripenet. Navegue as listas [nesta página](#)

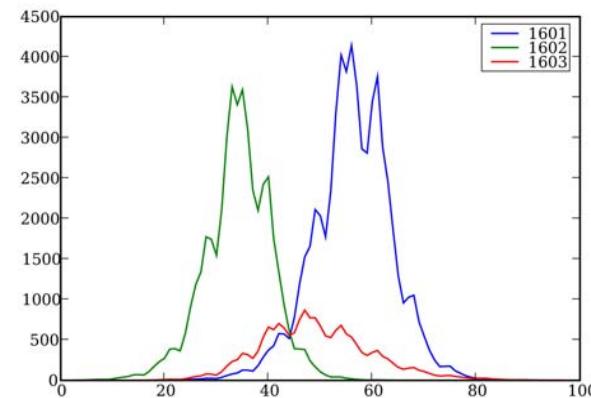
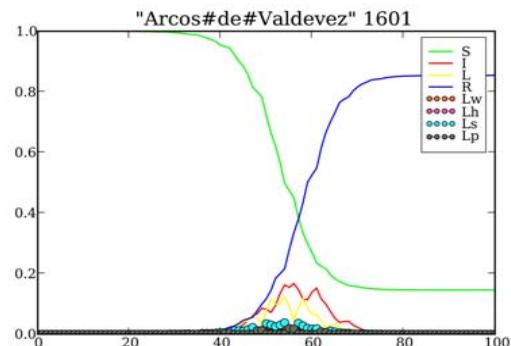
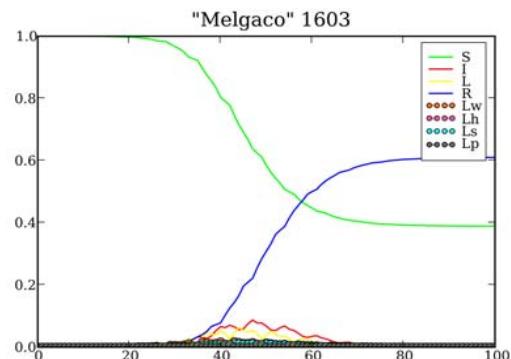
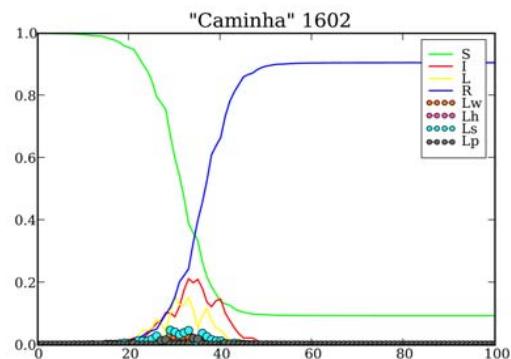
O Gripenet leva-te ao Science Museum, em Londres !!

Já sabias que o "Gripe vai à Escola" te pode levar a Londres para visitares o fantástico "Science Museum"? É verdade! O Gripenet e o British Council oferecem-te a possibilidade de passar um magnífico fim-de-semana em Londres para descobrires mais acerca do mundo da ciéncia e, claro, também para te divertires! Este prémio destina-se aos vencedores das categorias "página web" e "newsletter electrónica"!

Plataforma Escolas Gripenet
 A Plataforma Escolas Gripenet é um espaço de trabalho à distância e visa um melhor acompanhamento dos trabalhos em execução no concurso A Gripe vai à Escola.



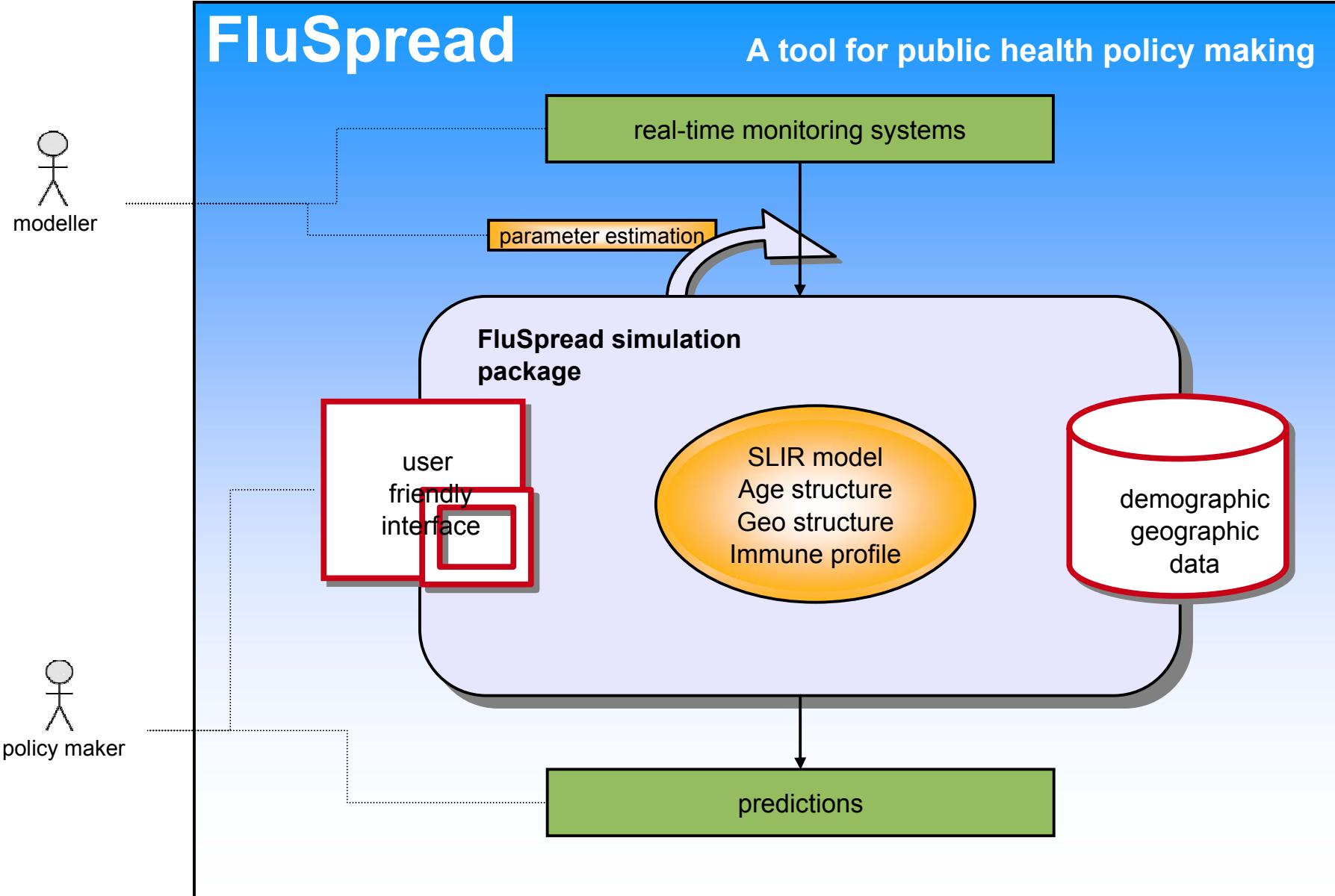




José Lourenço - IGC

Demographic and
Geographical
Information







Marie Curie Actions
Human resources and mobility

Reinfection Threshold
April 2005 – March 2009



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