



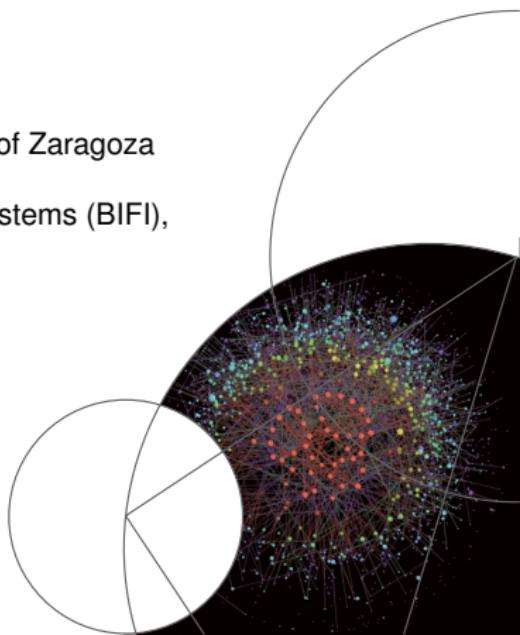
The Evolutionary Vaccination Dilemma in Complex Networks

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&

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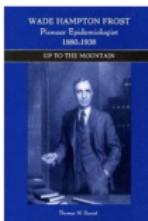
Section 1

Vaccination Dilemma

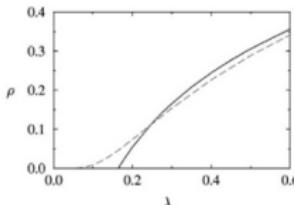
Once upon a time . . .



1760



1928 ca.

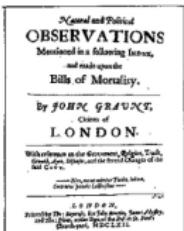


2001

•••

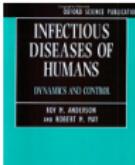


1662

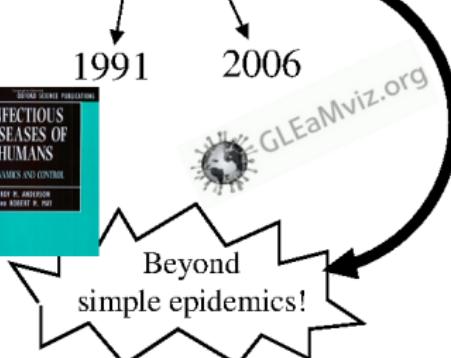


$$\begin{cases} \frac{d}{dt}S(t) = -\lambda(t)S(t), \\ \frac{d}{dt}I(t) = \lambda(t)S(t) - \gamma I(t), \\ \frac{d}{dt}R(t) = \gamma I(t), \end{cases}$$

1927



1991



2006

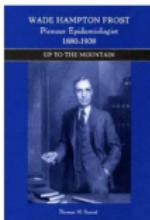
GLEaMviz.org



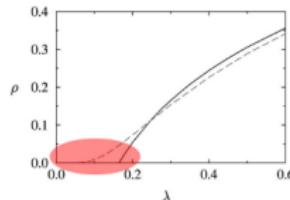
Once upon a time . . .



1760



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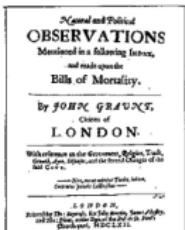


2001

...



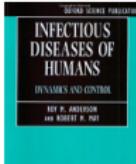
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1927

$$\begin{cases} \frac{d}{dt}S(t) = -\lambda(t)S(t), \\ \frac{d}{dt}I(t) = \lambda(t)S(t) - \gamma I(t), \\ \frac{d}{dt}R(t) = \gamma I(t), \end{cases}$$

1991



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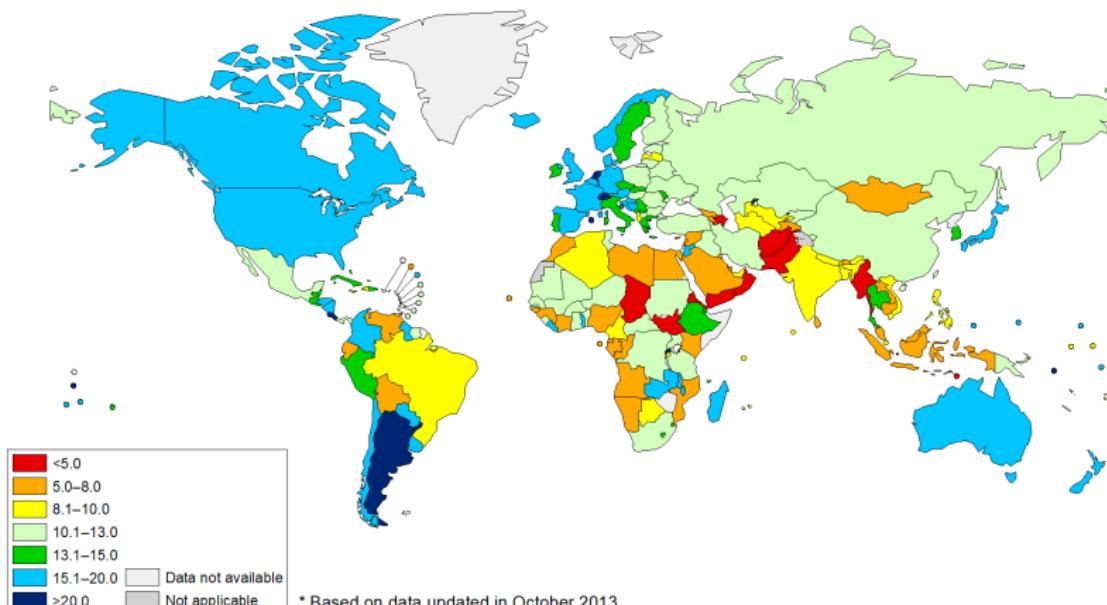


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A serious problem

**General government expenditure on health as a percentage
of total government expenditure (in US\$), 2011 ***

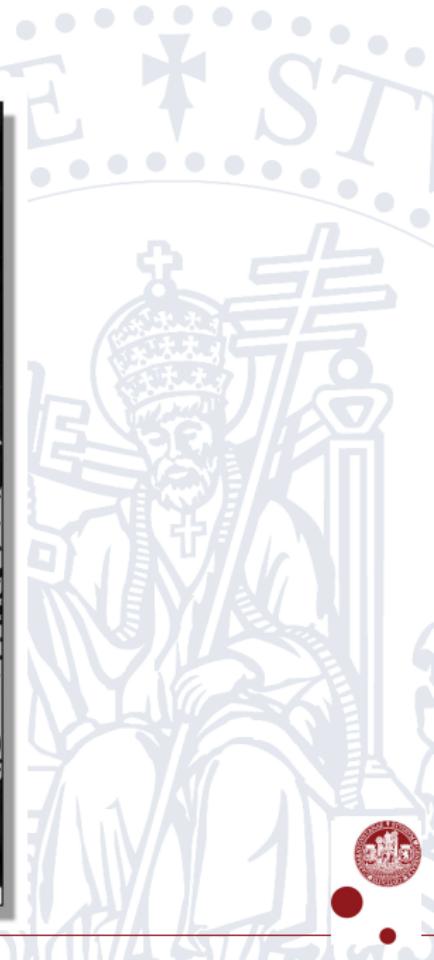


The boundaries and names shown and the designations used on this map do not imply the expression of any opinion whatsoever on the part of the World Health Organization concerning the legal status of any country, territory, city or area or of its authorities, or concerning the delimitation of its frontiers or boundaries. Dotted lines on maps represent approximate border lines for which there may not yet be full agreement.

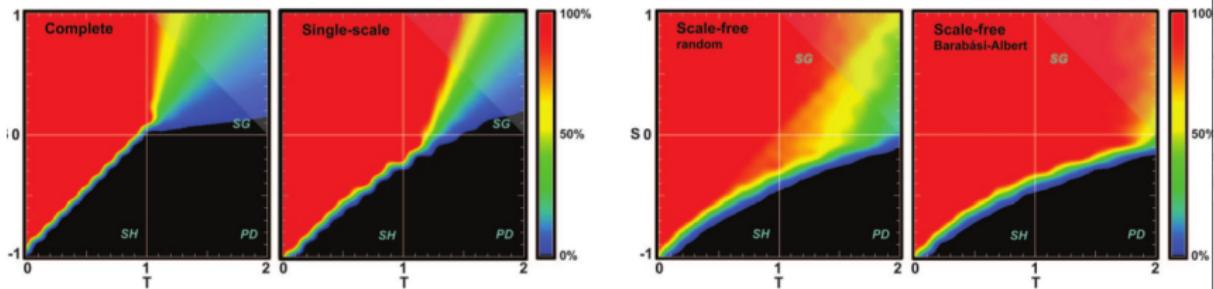
Data Source: Global Health Observatory, WHO
Map Production: Public Health Information
and Geographic Information Systems (GIS)
World Health Organization

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A serious problem



A serious problem



- Nowak M A, & May R M. *Evolutionary games and spatial chaos*. Nature, **359**, 826 (1992).
- Nowak M A. *Five rules for the evolution of cooperation*. Science, **314**, 1560 (2006).
- Santos F C, Pacheco J M, & Lenaerts T. *Evolutionary dynamics of social dilemmas in structured heterogeneous populations*. PNAS, **103**, 3490 (2006).



Clash of titans



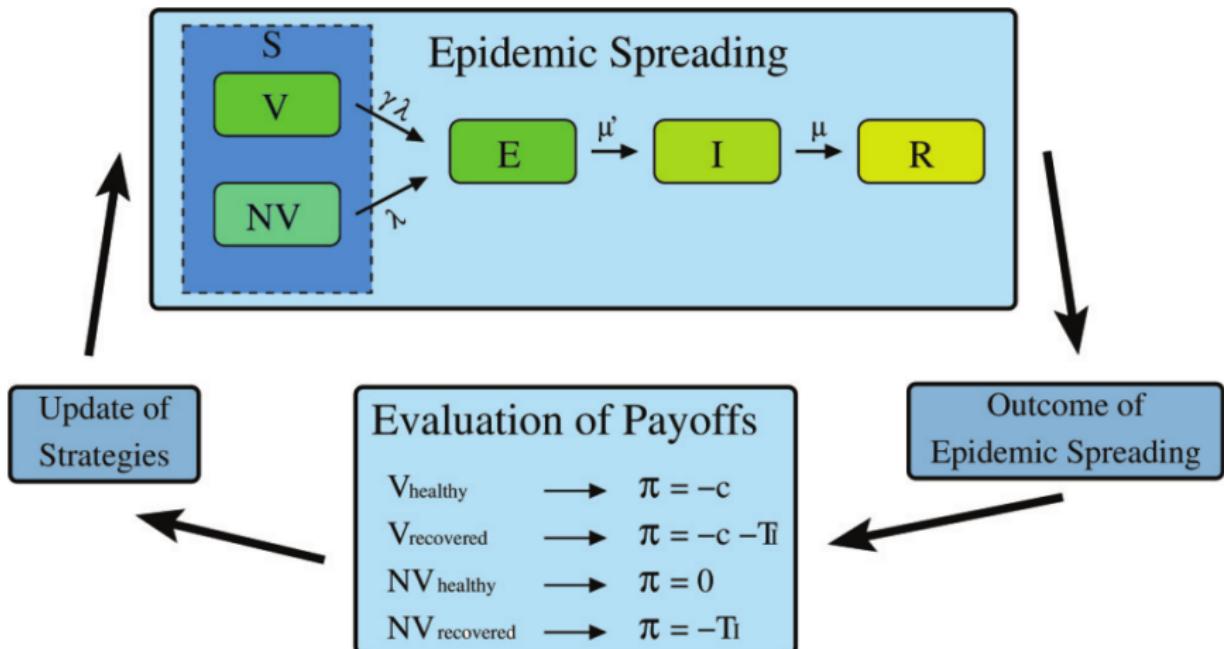
Clash of titans



**Cooperation VS Spreading
who will prevail?**



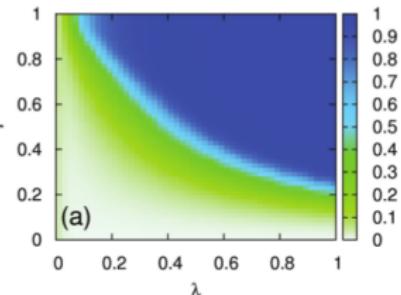
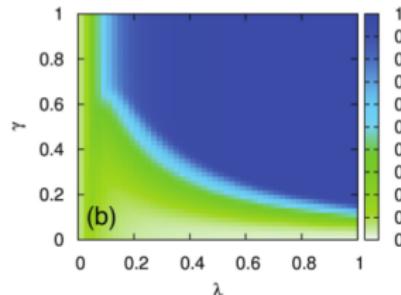
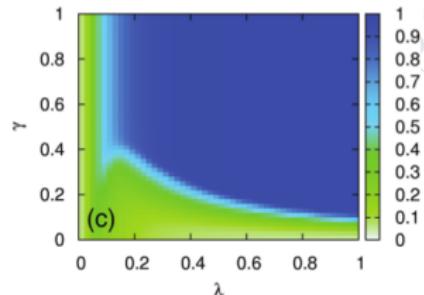
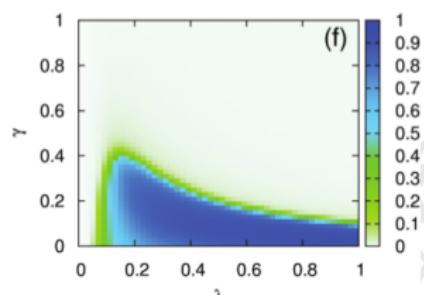
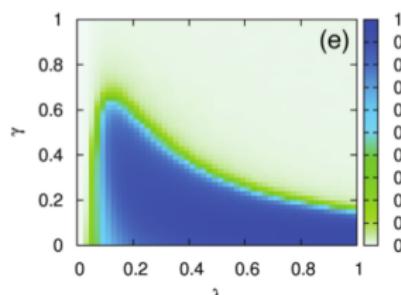
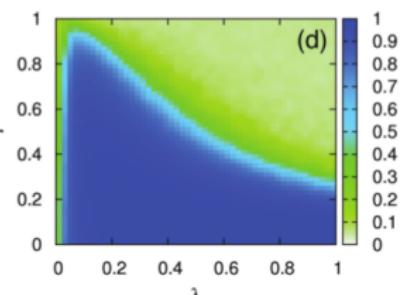
Clash of titans



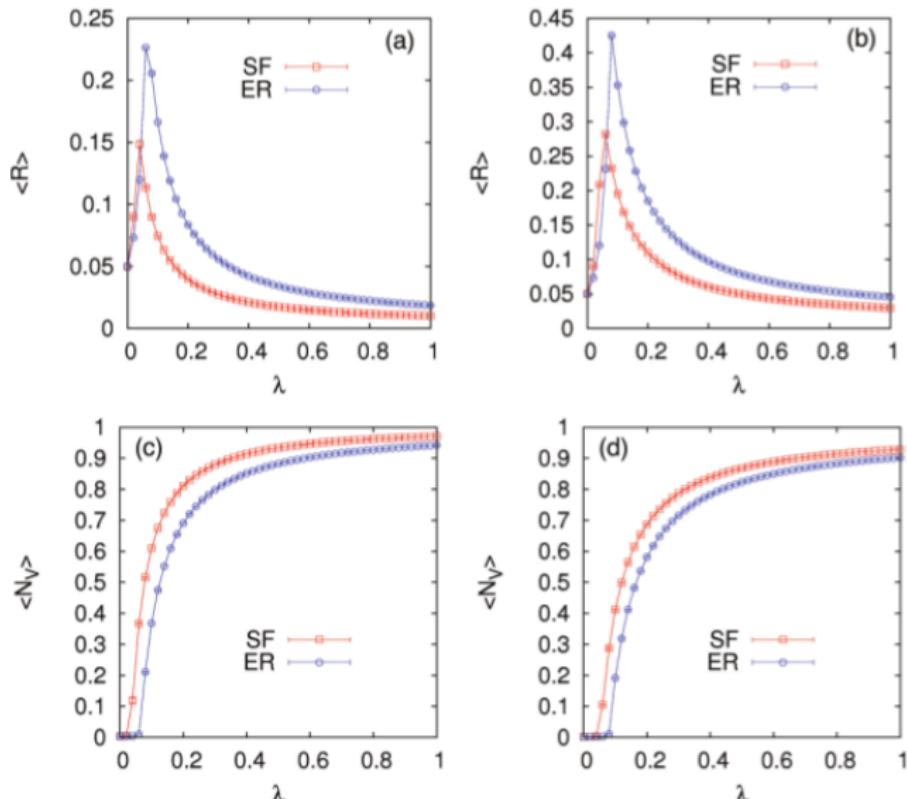
Section 2

Results

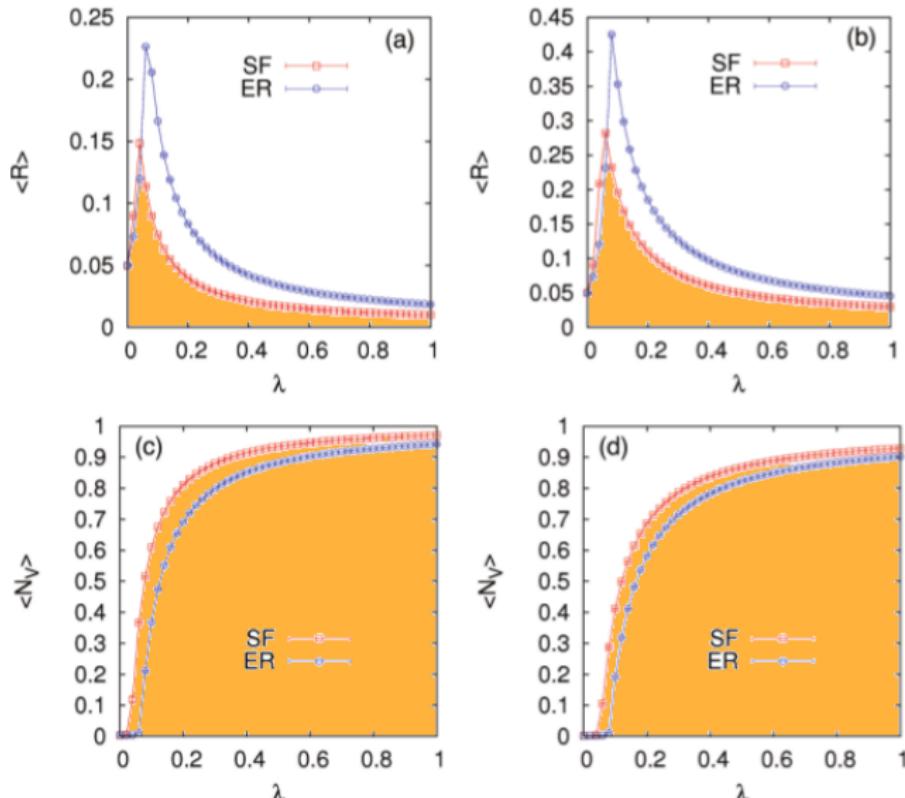
General picture

 $c = 0.1$ $\langle R \rangle$  $c = 0.5$  $c = 1.0$  $\langle Nv \rangle$ $\langle Nv \rangle$ 

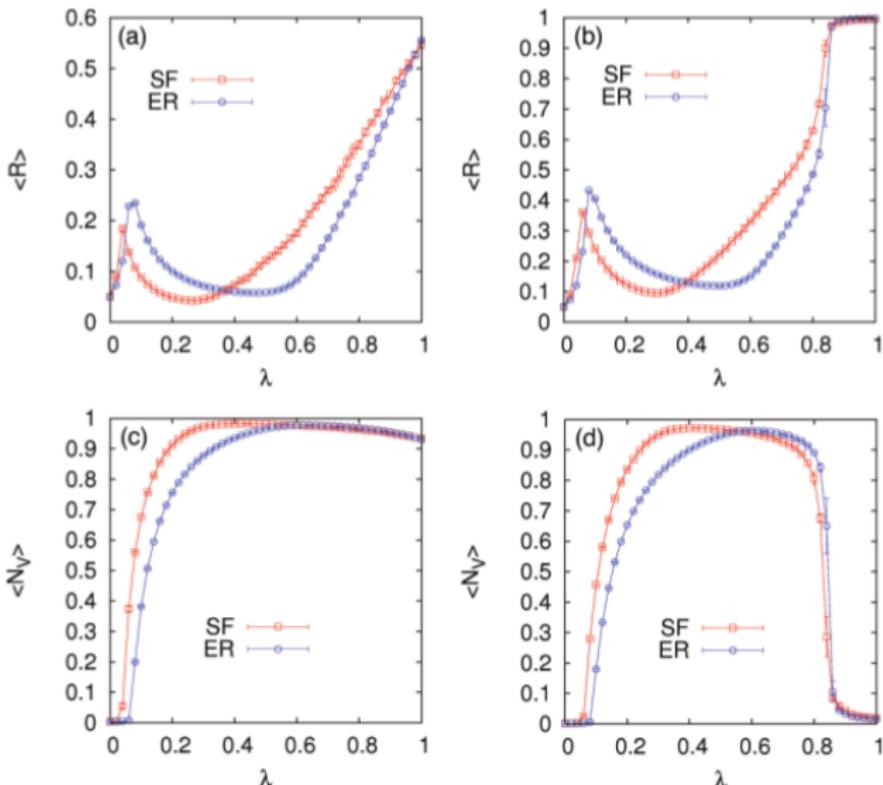
Role of topology – ideal case $(\gamma = 0)$



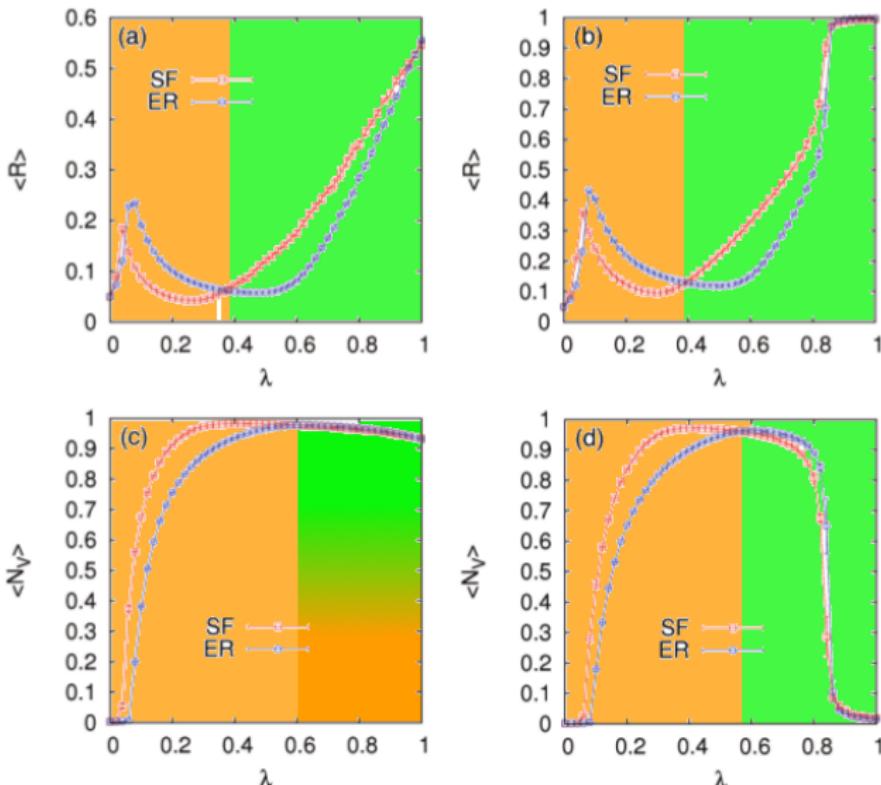
Role of topology – ideal case $(\gamma = 0)$



Role of topology – realistic case ($\gamma \neq 0$)



Role of topology – realistic case ($\gamma \neq 0$)



Section 3

Conclusions

Summing up . . .

Take home messages

- Cooperation is able to win over spreading (under certain circumstances).



Summing up . . .

Take home messages

- Cooperation is able to win over spreading (under certain circumstances).
- If the vaccine is not perfect, we observe different regions of prevalence.



Acknowledgements

PHYSICAL REVIEW E

statistical, nonlinear, and soft matter physics

Highlights Recent Accepted About fl

Evolutionary vaccination dilemma in complex networks

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