

# How influenza pandemic control can lead to unpreparedness: modelling the ecotoxicity of pharmaceutical usage

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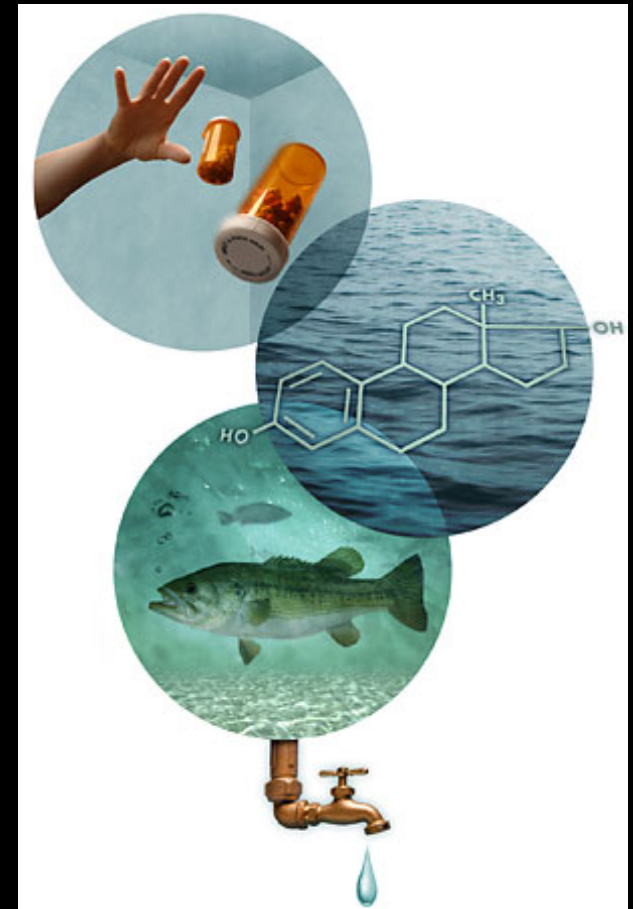


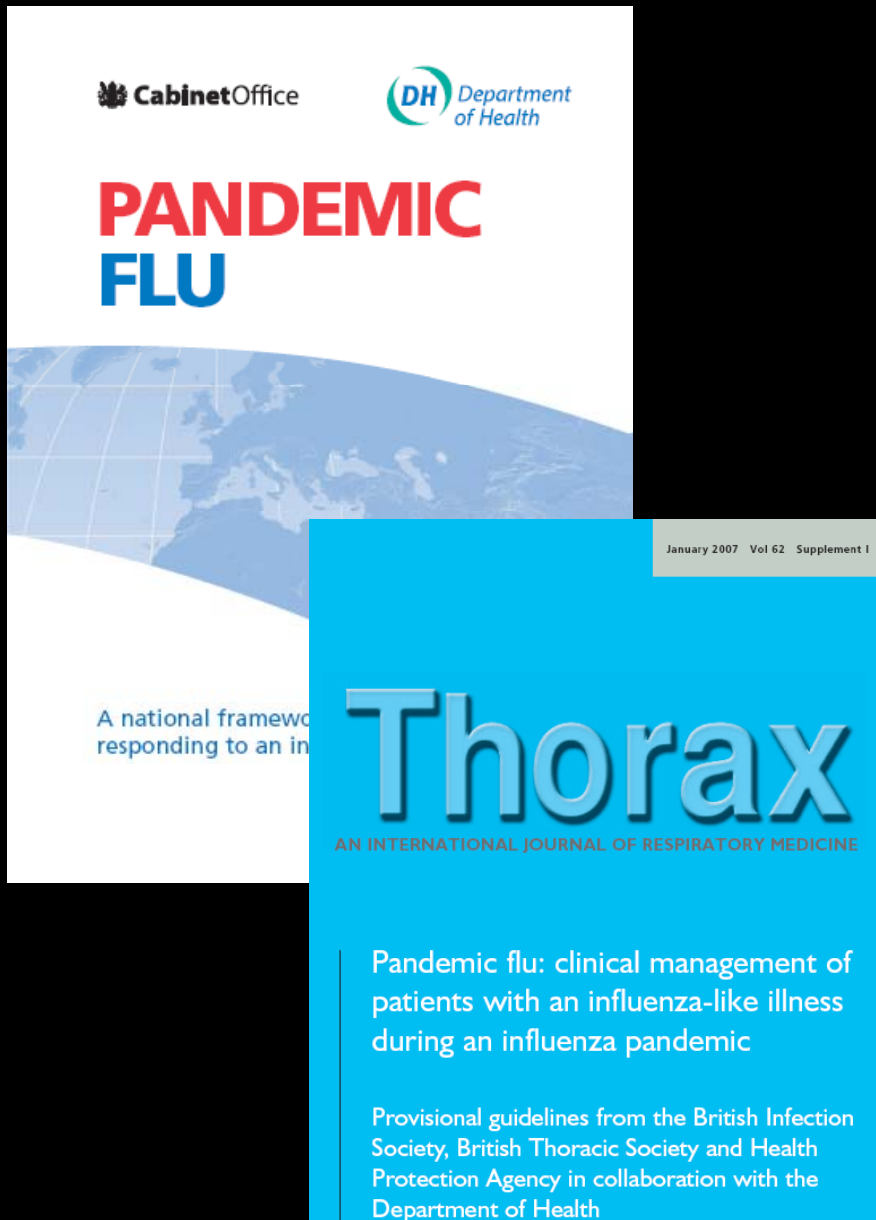
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Wallingford, UK

# “Dilution is the Solution to Pollution”

- Many drugs are minimally metabolised in the body.
- As a general rule, if a drug persists in the body it will likely persist in the environment.
- Is there enough water available to dilute projected drug use during an influenza pandemic?
- If not, what’s the potential impact?





# What is Pandemic Preparedness?

... to slow the spread of influenza, through:

1) vaccines,

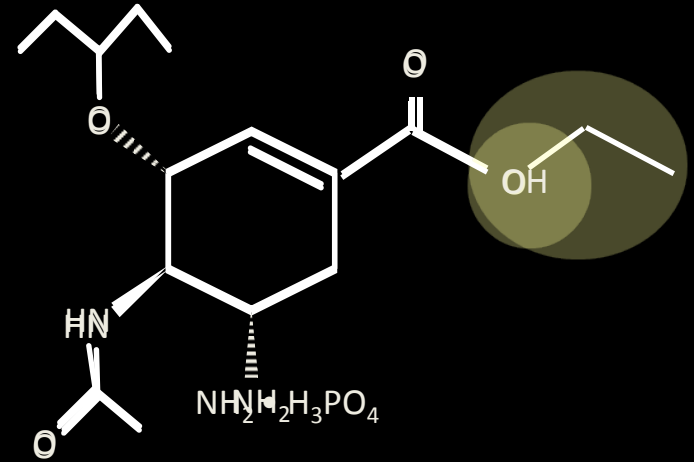
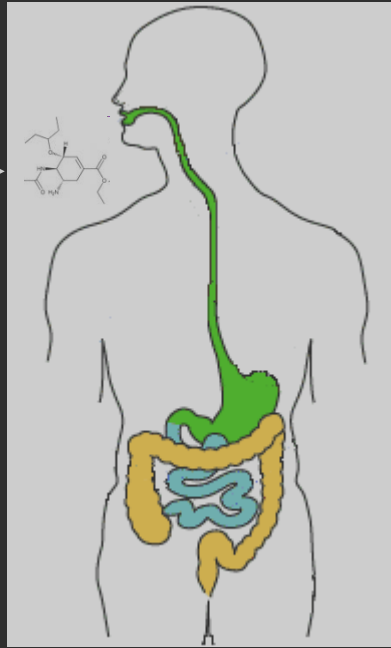
2) non-pharmaceutical measures

3) antivirals



2 x 75 mg/d for 5 days

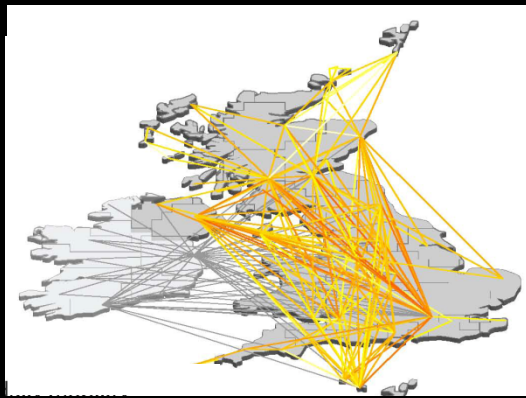
?



## Impact Assessment



# 1. epidemic model



*GLEaM* – Global Epidemic and Mobility model

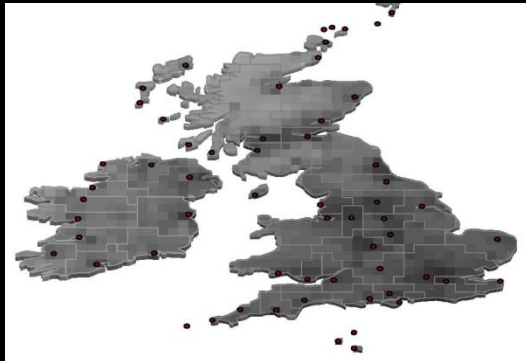
## air mobility layer

- 3400 airports in 220 countries
- 20,000 connections
- traffic data (IATA, OAG)
- >99% commercial traffic



## commuting mobility layer

- daily commuting data
- >30 countries in 5 continents
- universal law of mobility



## demographic layer

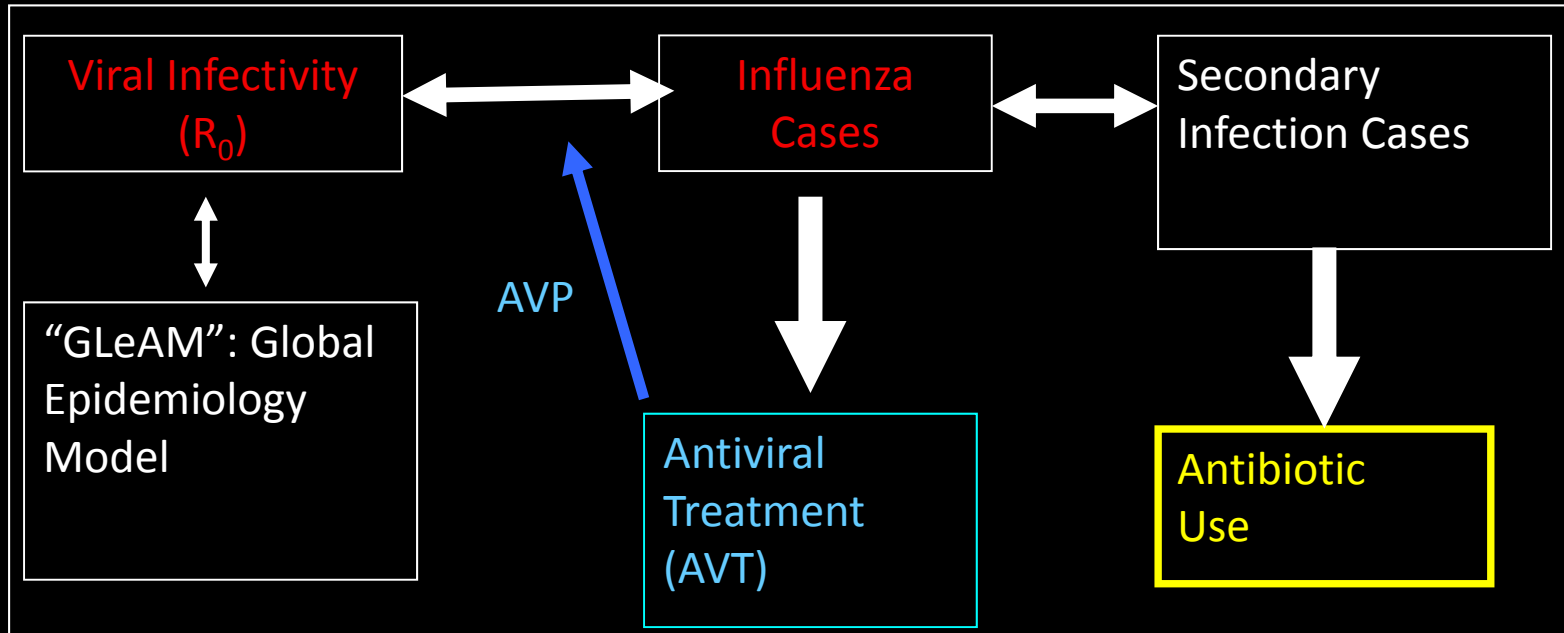
- cells  $\frac{1}{4}^\circ \times \frac{1}{4}^\circ$
- tessellation around transportation hubs



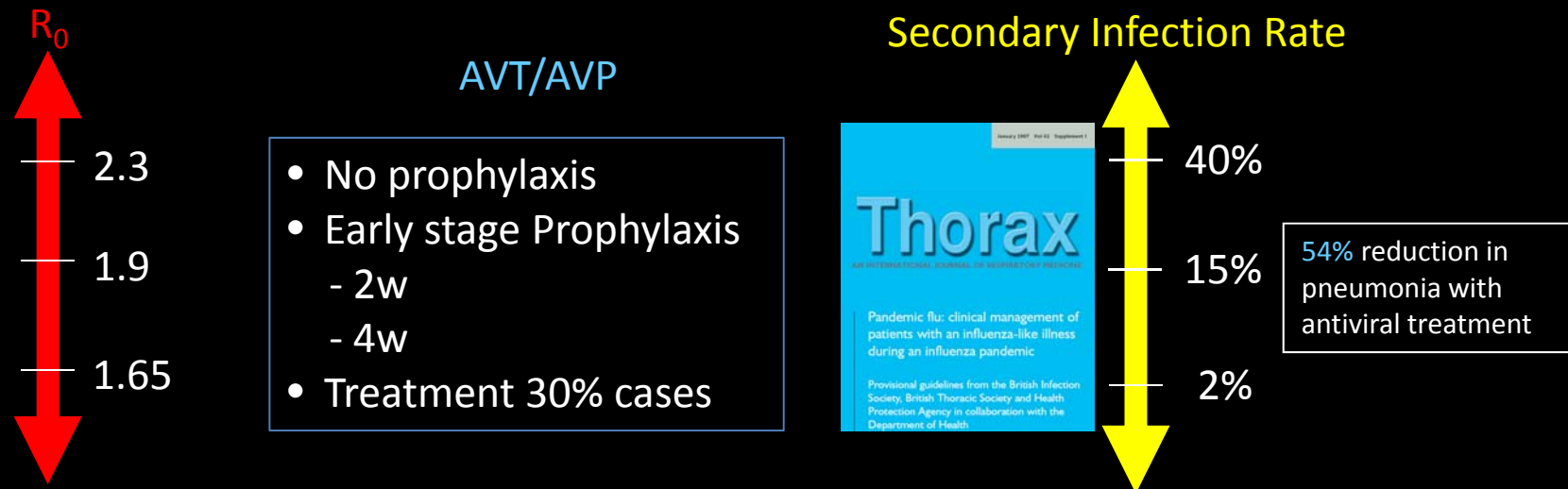
[www.epiwork.eu](http://www.epiwork.eu)

Balcan et al. PNAS (2009)

# Pharmaceutical Use Model During an Influenza Pandemic

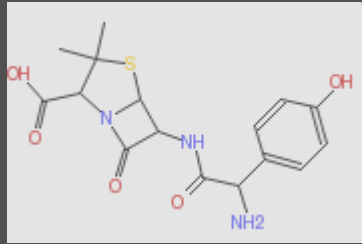


$R_0$  = number of secondary cases of influenza produced by 1 infected individual

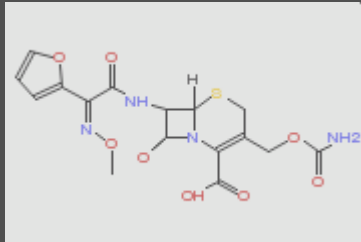


**β-lactam  
Cephalosporin**

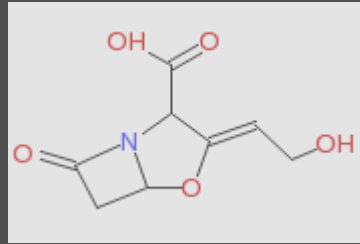
Amoxicillin



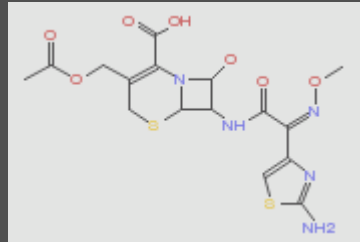
Cefuroxime



Clavulanic acid

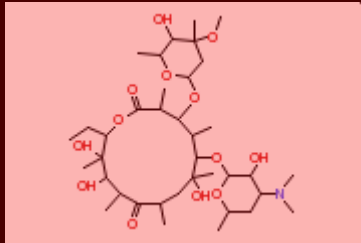


Cefotaxime

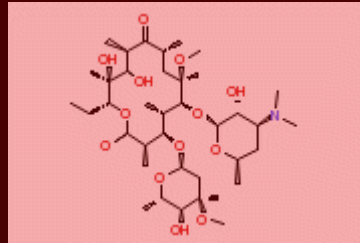


**Macrolide**

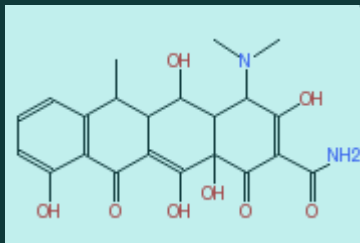
Erythromycin



Clarithromycin



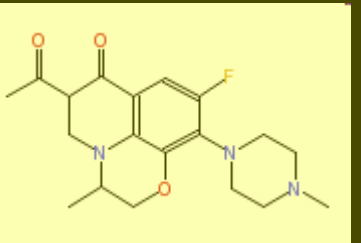
**Tetracycline**



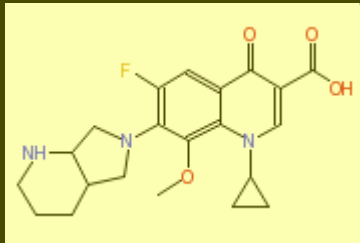
Doxycycline

**Quinolone**

Levofloxacin

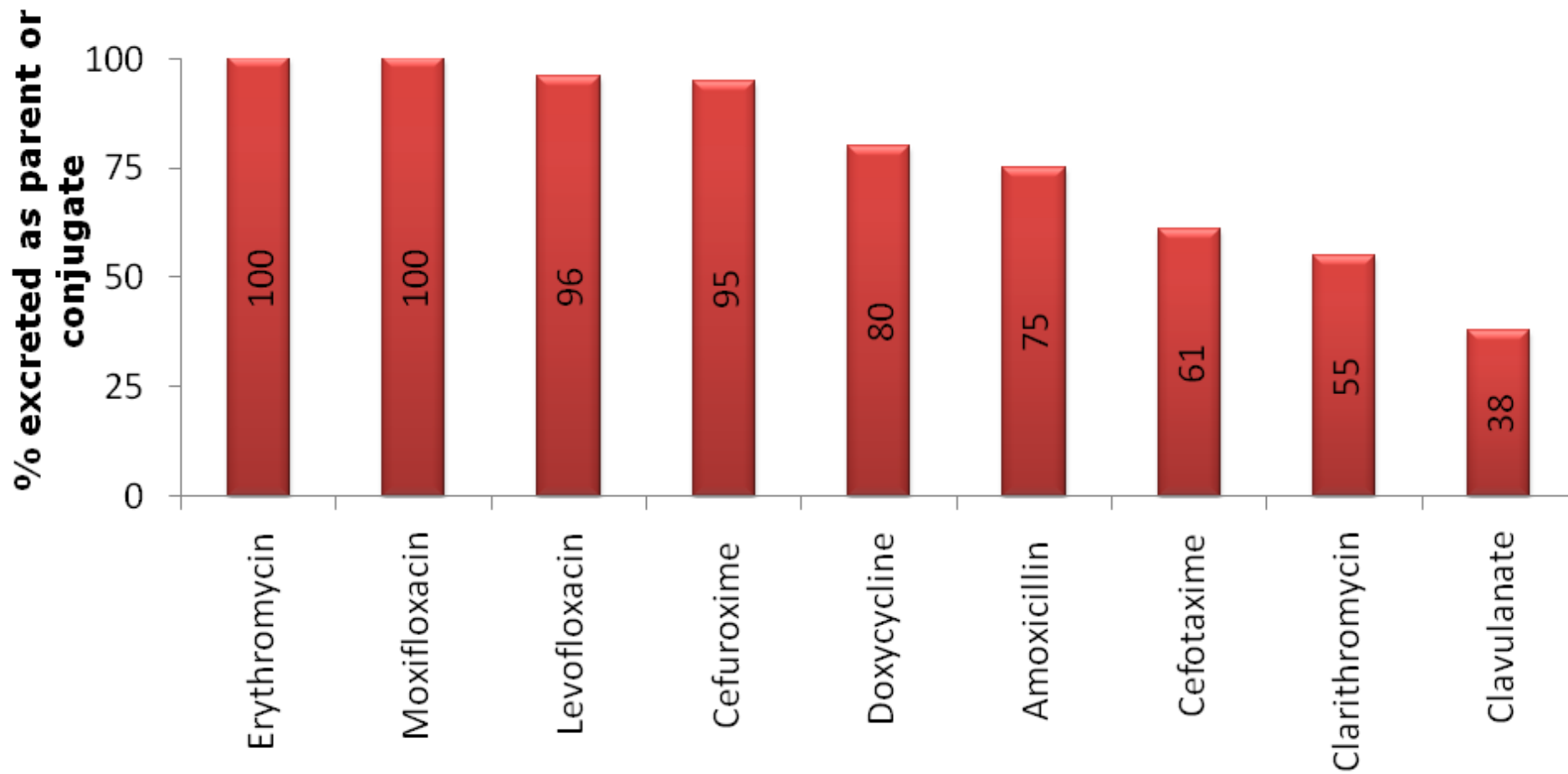


Moxifloxacin



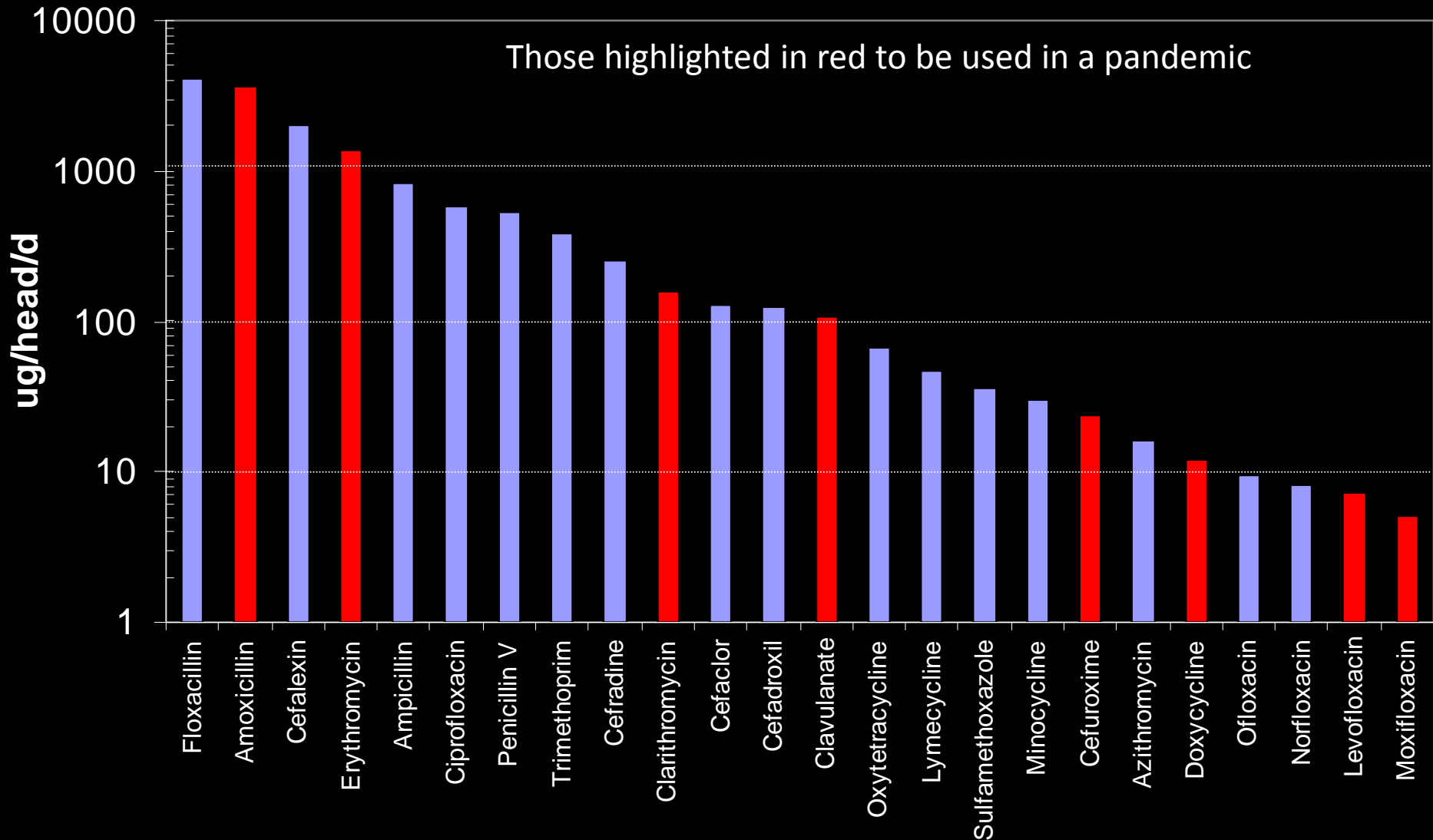


# from body to waste

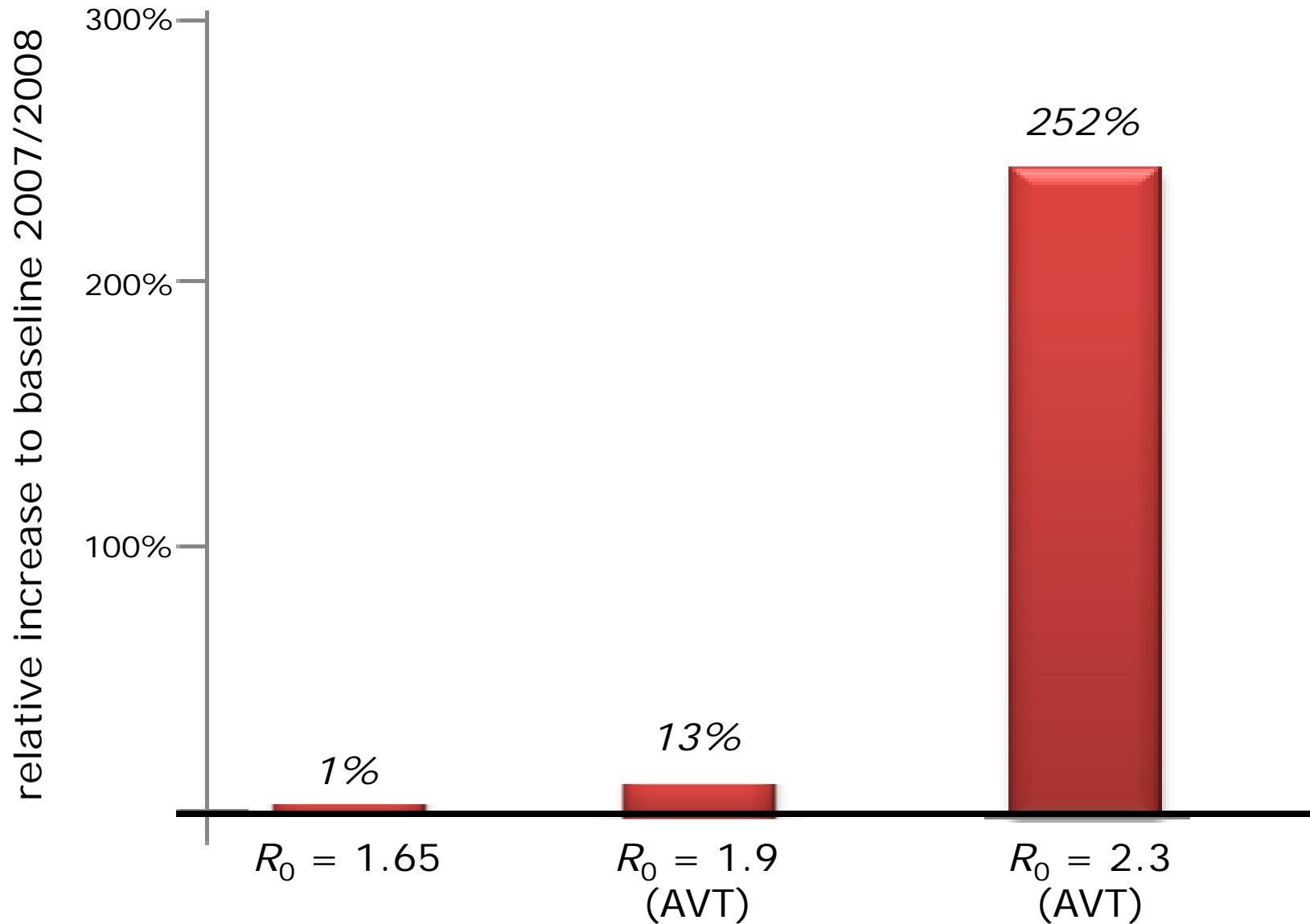




# Baseline Antibiotic Use (excreted in England)

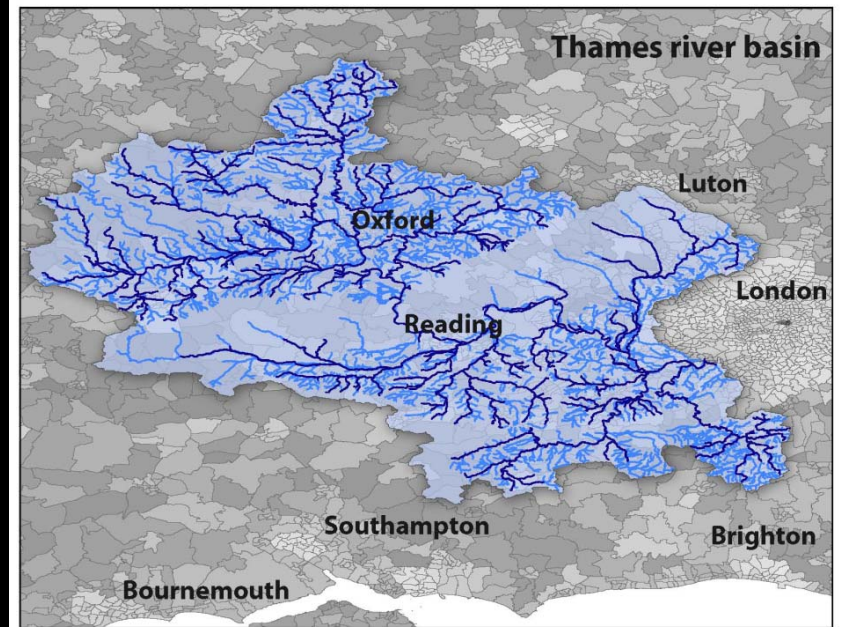
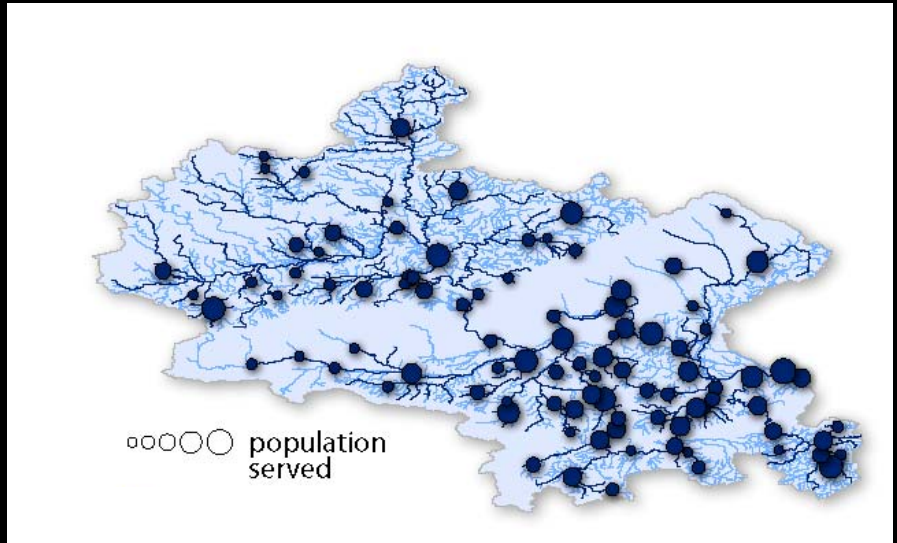


# results: antibiotics in WWTPs

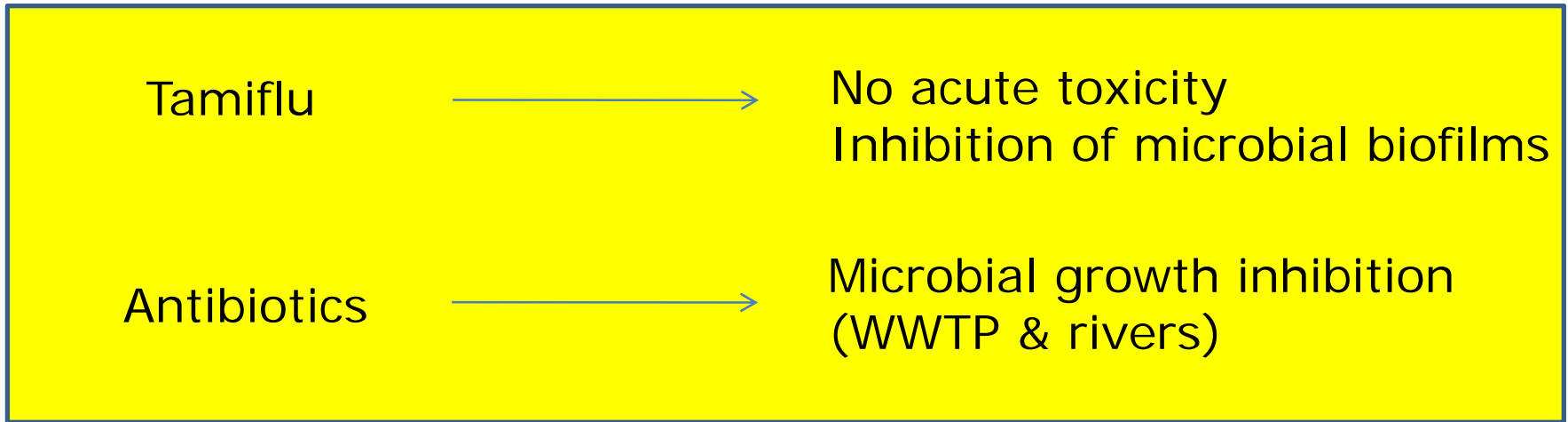


# LF2000-WQX works

- Estimates water quality on a reach by reach basis
  - starting at the top
- Makes a mass balance of the inputs to the reach
  - Sewage treatment plants, industrial discharges, tributaries
- New concentrations calculated at the end of the reach allowing for degradation of the compound of interest
- Output in GIS format

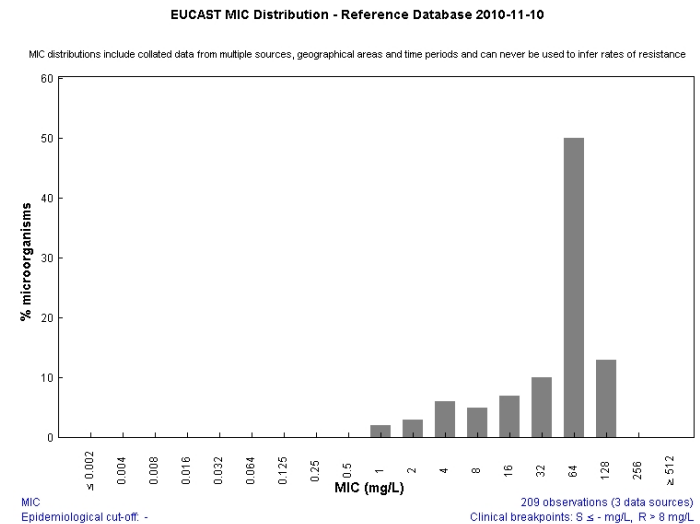


# Determining Impact

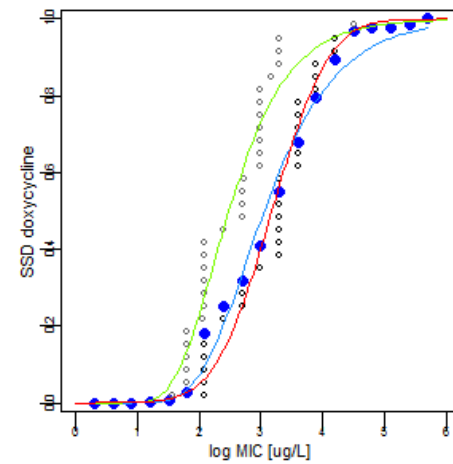
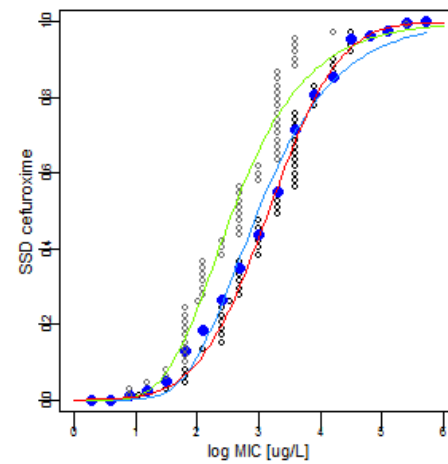
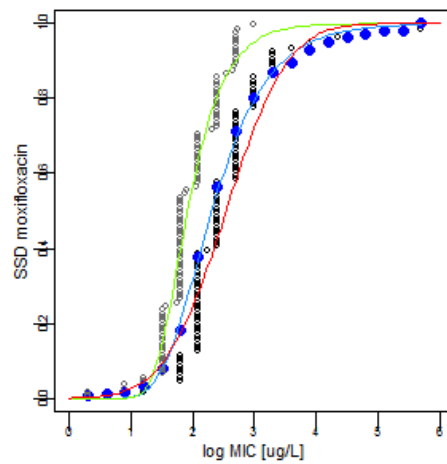
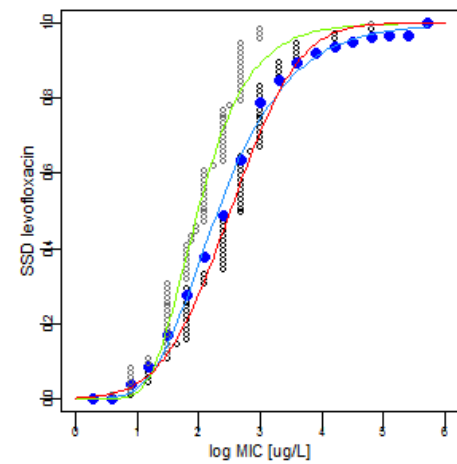
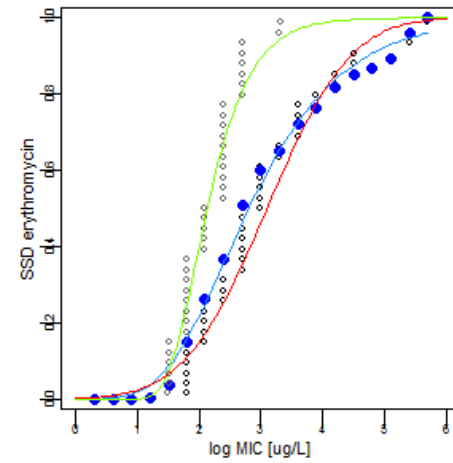
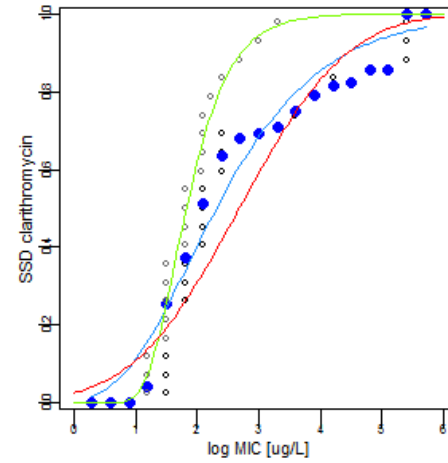
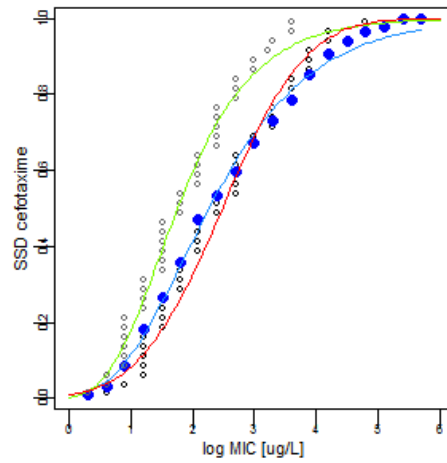
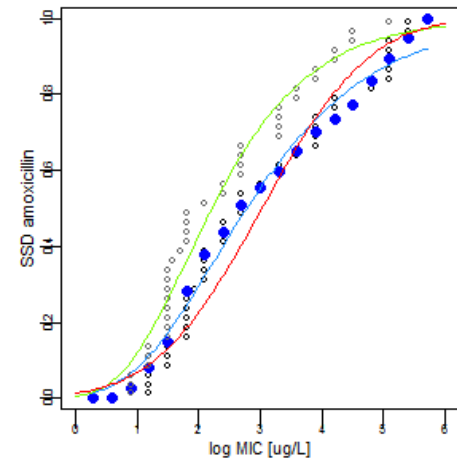


## toxicity (0-100%)

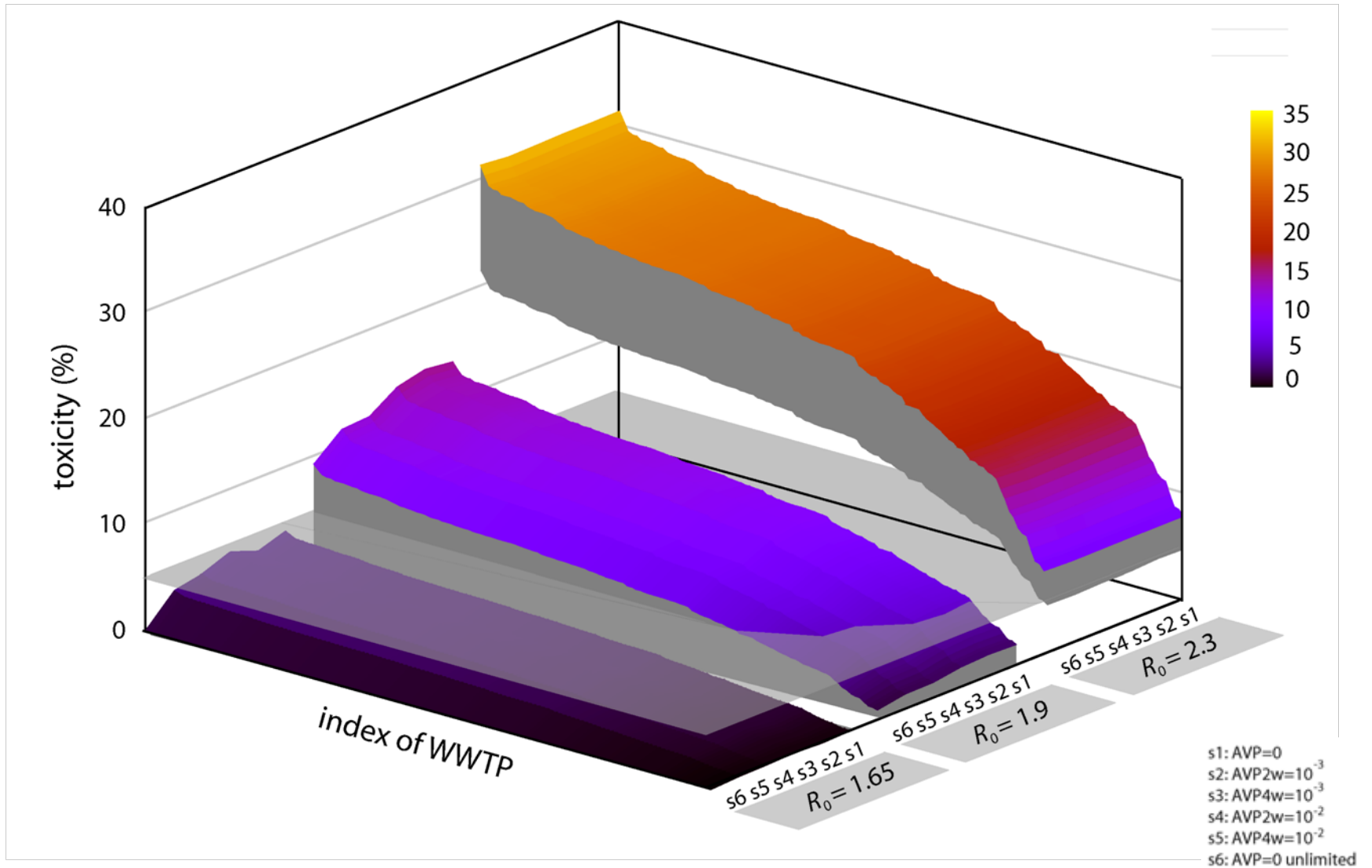
*'Potentially affected fraction'*  
of sewage or river microbial  
species



# Ecotoxicity: Species sensitivity distributions based on Minimum Inhibitory Concentrations



# results: toxicity in WWTPs



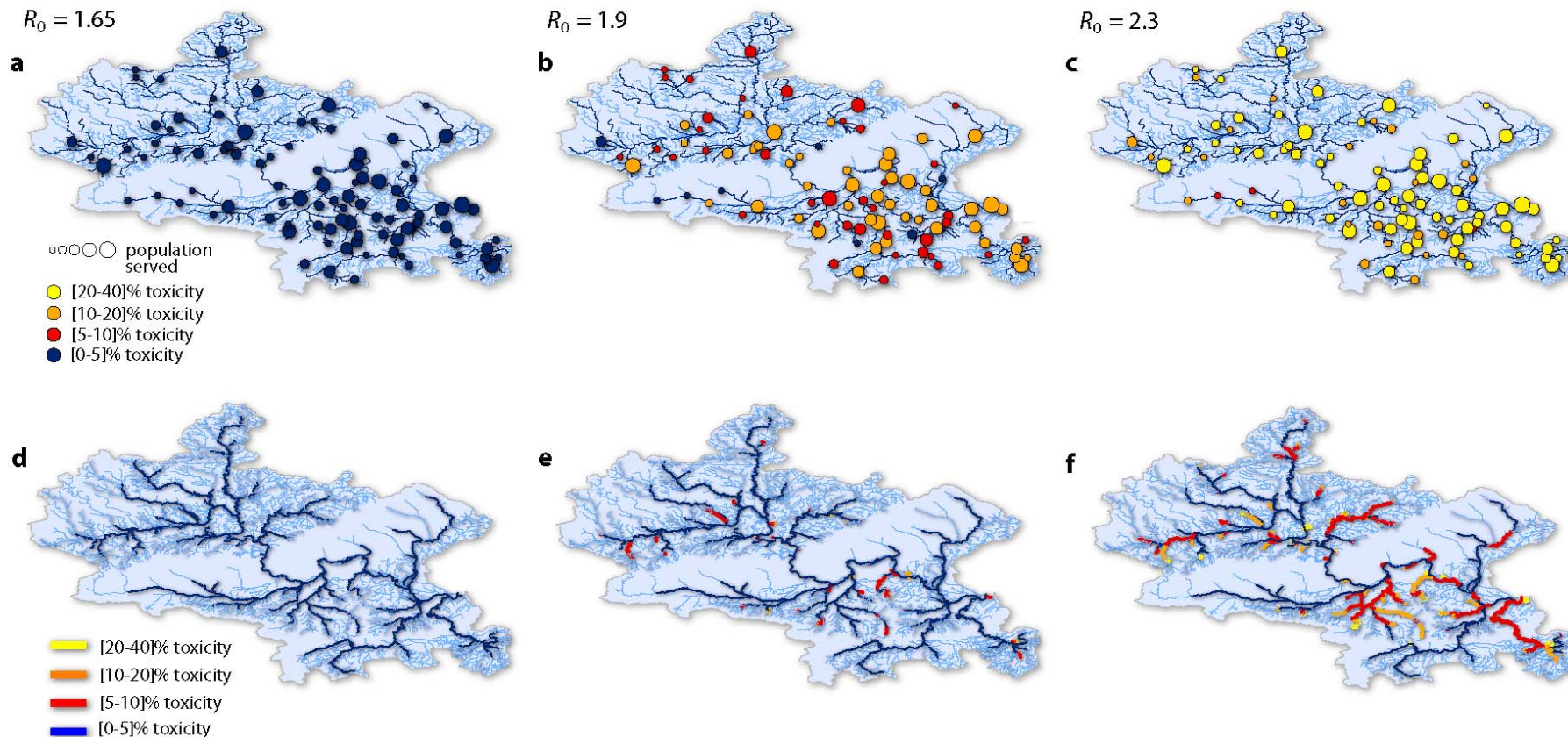


# Spatial distribution of toxicity in WWTPs & Rivers

% of sewage plants >5% PAF

≤ 85

≤ 100



% of Thames River length >5% PAF

≤ 10

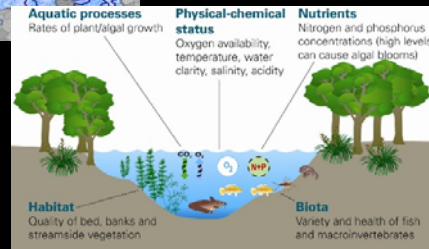
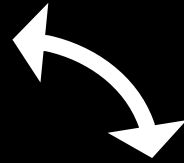
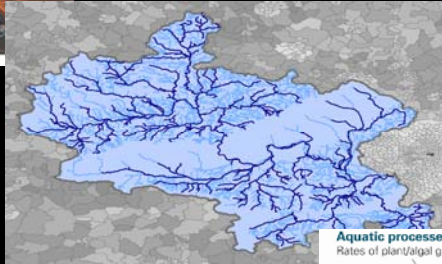
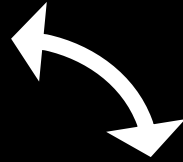
≤ 40

# General Conclusions

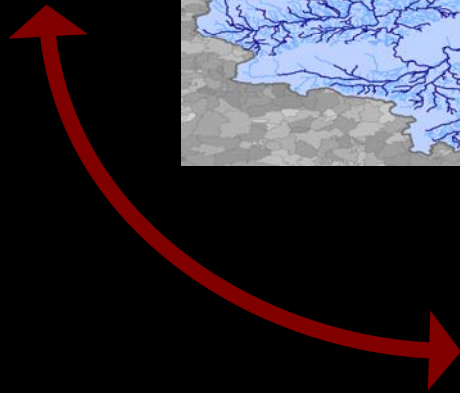
- A mild pandemic with a low rate of secondary infections is not projected to result in problems for sewage works or most UK rivers.
- A pandemic with an  $R_0 > \sim 2.0$  is likely to pose operational challenges to sewage works which could result in the release of untreated sewage into receiving rivers.



# Impact



disruption of WWTPs  
widespread river pollution



- contamination of rivers
- degradation of drinking water
- spread of **antiviral and antibiotics resistance**
- eutrophication :
  - loss of aquatic ecosystem (fish kill)
  - temporary loss of ecosystem function

Solutions ?

**VACCINATION!!**

# Priority Research

- Empirically determine vulnerability of sewage works.
- Assess the short and long term risks to widespread antiviral and antibiotic release into the environment.
- Empirically determine vulnerability of drinking water to contamination.

# Pandemic usage of Pharmaceuticals

www.prepare.org.uk

The image shows a screenshot of the PREPARE website homepage. At the top left is the PREPARE logo, and at the top right is a search bar. Below the logo is a navigation menu with links for HOME, ABOUT, LITERATURE, WORKSHOPS, LINKS, and CONTACT US. A breadcrumb trail indicates 'You are here: Home'. On the right side, there are social media icons for 'Subscribe' (RSS) and 'Follow' (Twitter). The main content area is divided into three sections: a 'WELCOME TO PREPARE' section with introductory text and a forest stream image; a 'FEATURED ARTICLE' section with a fish image and article details; and a 'FEATURED AUTHOR' section with a profile picture and bio for Andrew Singer. A 'TWITTER' section is also present on the right side.

**PREPARE** SEARCH

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## WELCOME TO PREPARE

PREPARE is a UK Natural Environment Research Council knowledge exchange initiative with the overall aim to integrate the information and expertise required to assess the implications of pharmaceutical usage during a major disease outbreak for the environment, and the risk posed to current wastewater infrastructure.

The PREPARE Initiative aims to inform policy, regulation and emergency planning to ensure that ecotoxicologic and human health risks associated with pharmaceutical usage under pandemic and epidemic conditions are thoroughly assessed utilising all and currently available knowledge.



## FEATURED ARTICLE




### Dissipation and removal of oseltamivir (Tamiflu) in different aquatic environments

Chemosphere 79(8):891-897

Cesare Accinella, Maria Ludovica Saccà, Jerker Fick, Mariangela Mencarelli, ...

## FEATURED AUTHOR



Andrew Singer has a broad research interest focused around soil, water and air pollution. Throughout his academic ...

Read Andrew's most recent article: [Dissipation and removal of oseltamivir \(T...](#) or, read [Andrew's full bio](#)

## TWITTER

Virus can remain infectious for up to two weeks at low temperatures [# 2010/09/10](http://ow.ly/2Cwn3)

Strategic Review of Health

# Thanks to Collaborators...and you!

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