Department of
Environmental Systems
Science

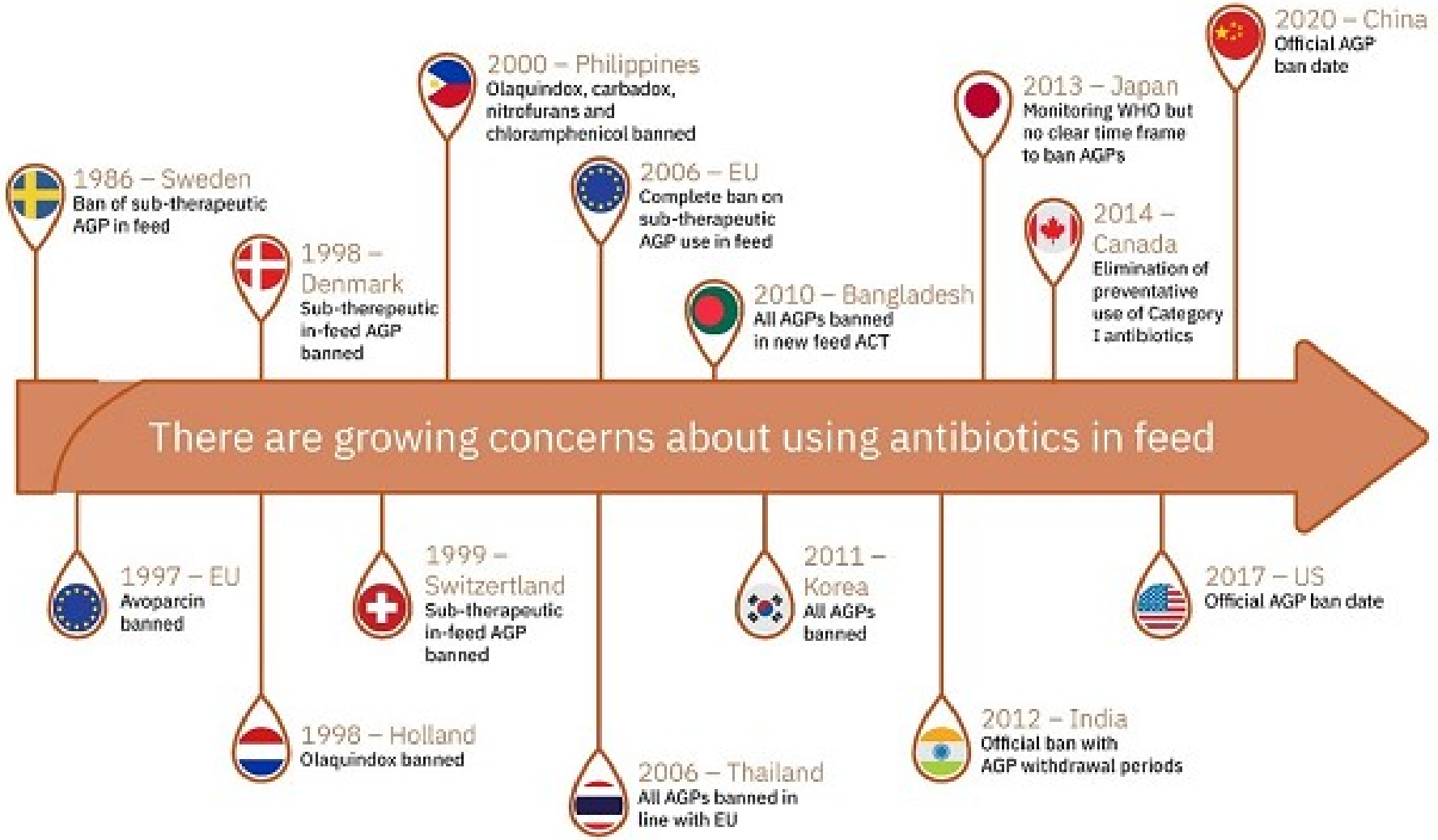
Can taxation of veterinary antibiotics reduce antimicrobial resistance?

Alex Morgan

Antimicrobial use and resistance in livestock production in a One Health context

22.05.2023

Controlling Antibiotic Usage

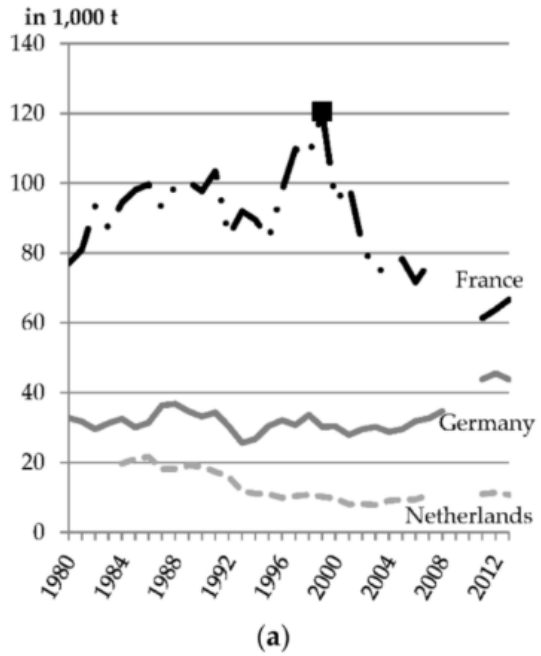


Taxation of Pollutants?

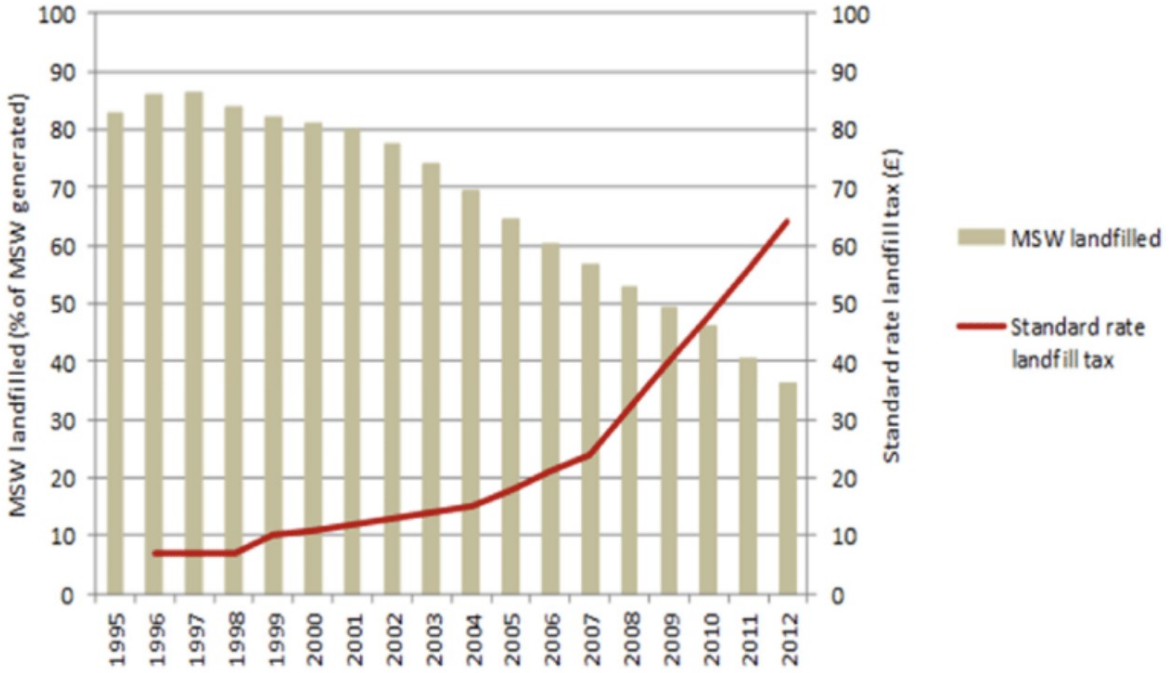
Bans are <u>all or nothing,</u> <u>do not allow for flexibility</u> and <u>can not generate revenue</u>

Carbon Tax

Under a carbon tax, the government sets a price that emitters must pay for each ton of greenhouse gas emissions they emit. Businesses and consumers will take steps, such as switching fuels or adopting new technologies, to reduce their emissions to avoid paying the tax.



<u>Pesticide tax</u>



<u>Landfill tax</u>

Can we apply taxation to control antibiotic resistance?

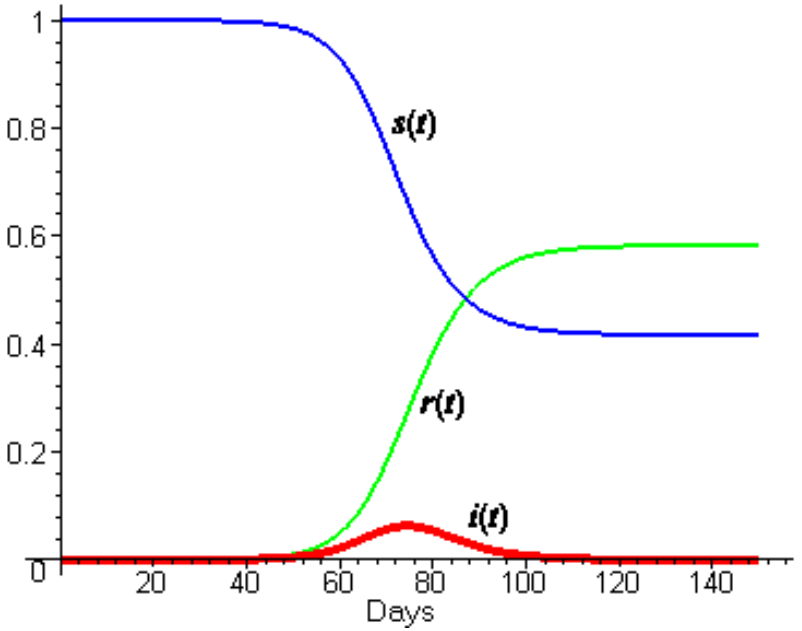
Reducing antimicrobial use in food animals

Consider user fees and regulatory caps on veterinary use

User fees. Imposing a user fee of 50% of the current price on veterinary antimicrobials could reduce global consumption by 31% (target 3C). More important, such a policy would also generate yearly revenues between US$ 1.7 billion and 4.6 billion (Protocol

Prof. Thomas Van Boeckel

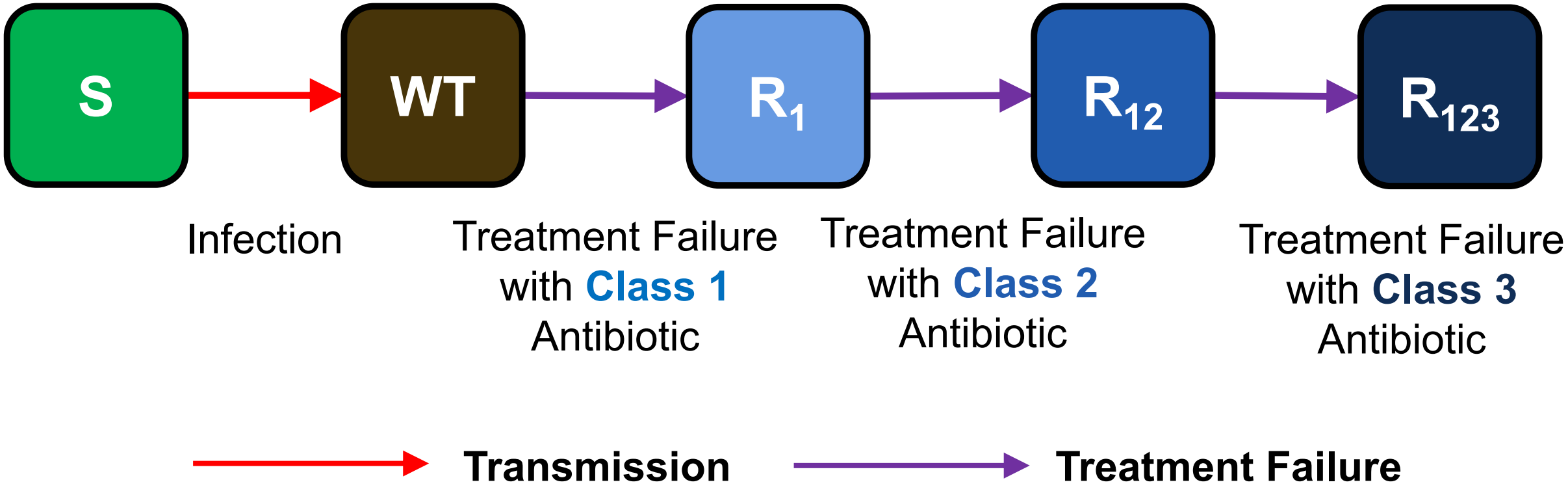
Expand on exploratory work to consider non-linear dynamics of AMR!



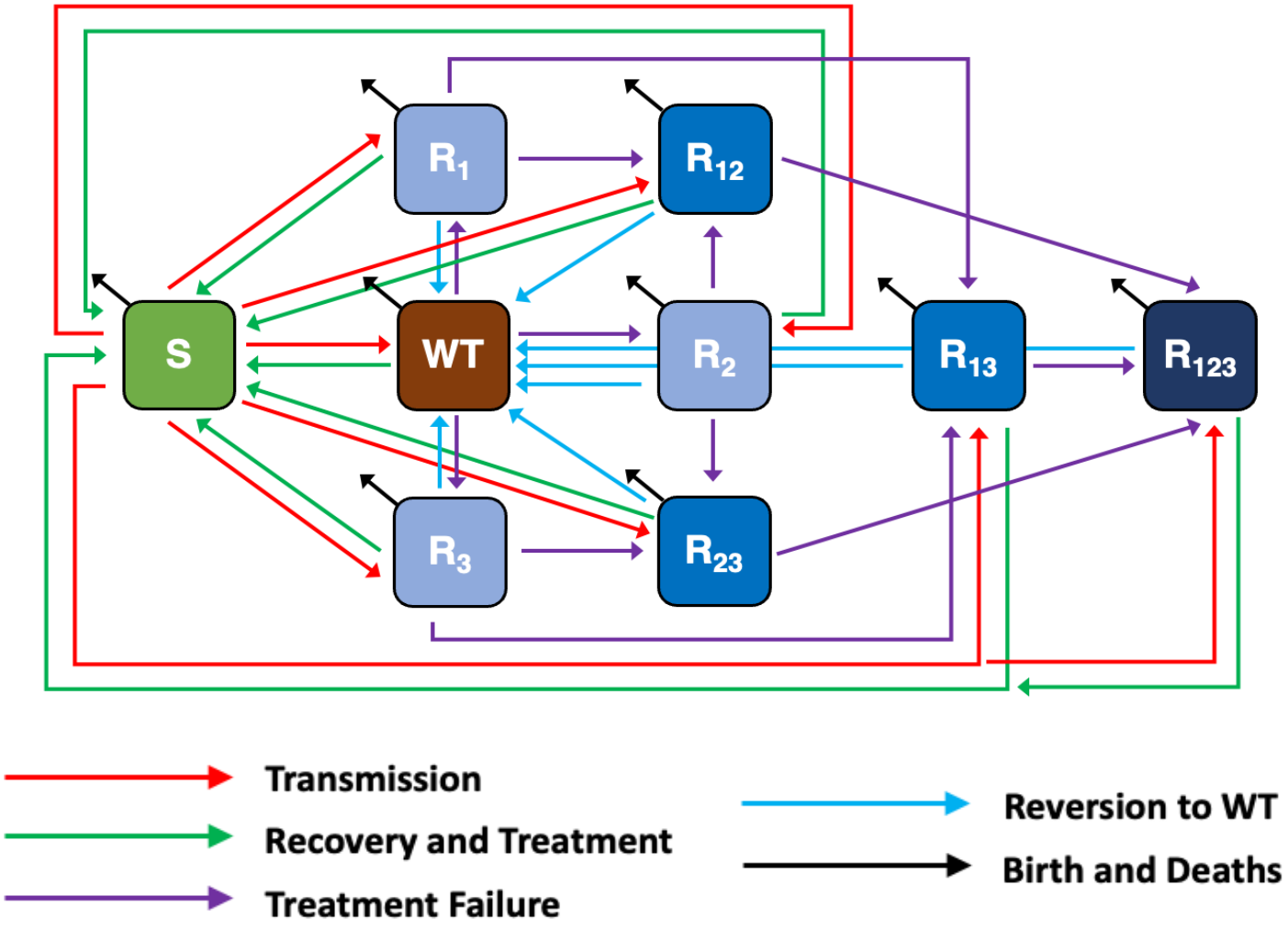
1. Transmission of Infectious Agents among livestock
2. Interactions Between Multiple Drugs
3. Birth/Death Dynamics of Livestock

Mathematical Model of Antimicrobial Resistance

Example pathway for the generation of a R_{123} infection



Mathematical Model of Antimicrobial Resistance



Key Assumptions of Antibiotic Usage

Antibiotic Usage has two effects…

1) Success! - Increased rate of recovery back to susceptibility
2) Failure! - A probability of treatment failure, resulting in gain of resistance

Three antibiotics modelled:

Proportion of the population using the antibiotic 1, 2 or 3 (σ_1, σ_2, σ_3)

Price Elasticities: How to model taxation?

Price elasticity of demand

How sensitive is the quantity demanded to the change in price?

Elastic (-2) ⟷ Inelastic (-1)

PED

Cross price elasticity of demand

How sensitive is the quantity demanded to the change in price of another good?

Subsitute (-1) ⟷ Complementary (1)

CPED

Price Elasticities: How to model taxation?

Taxing antibiotic classes will drive down usage of taxed class and drive up usage of non taxed classes

VCIA: Veterinary Critically Important Antimicrobial Agents
VHIA: Veterinary Highly Important Antimicrobial Agents
VIA: Veterinary Important Antimicrobial Agents

1. What is the most effective taxation strategy? How does this compare to bans?

Effect on…

1. Resistance

2. Average Number of Effective Antibiotics?

How to evaluate the effectiveness of taxation?

Step 1

$\beta = [0.01, 1]$

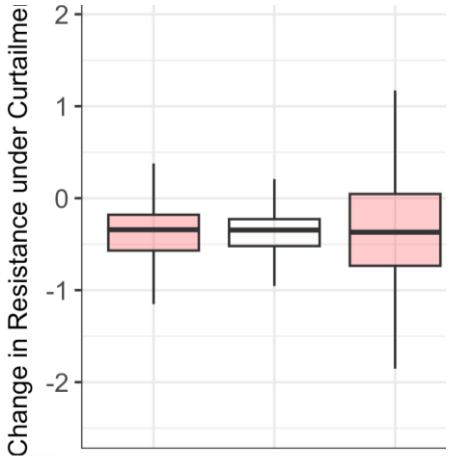
$\ldots = [\ldots, \ldots]$

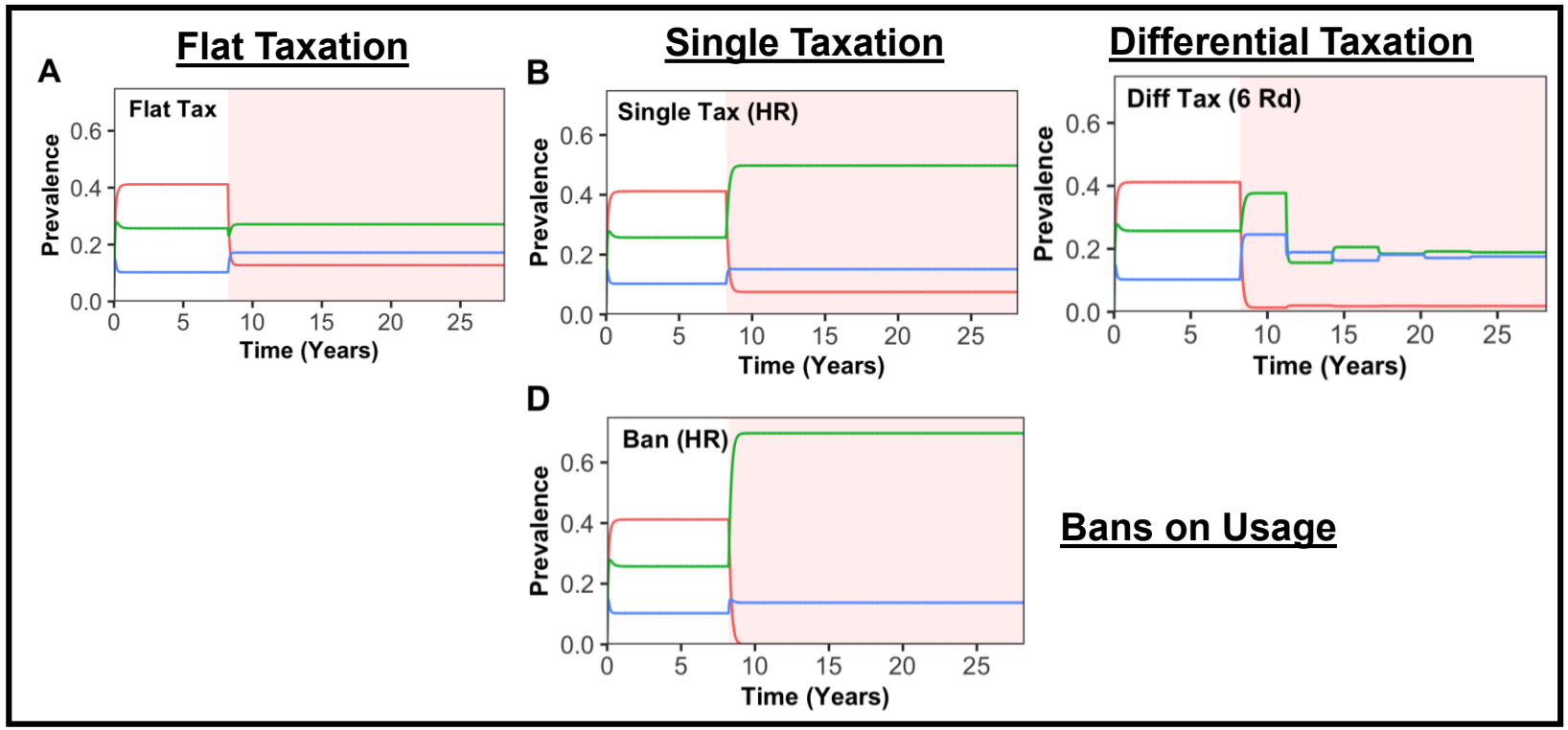
$\lambda = [0.005\ 0.05]$

Step 2

	Parameters			Interventions		
Run	β	...	λ	Flat Tax	Int…	Diff Tax
1	0.02	…	0.01	0.1	…	0.2
…	…	…	…	…	…	
1000	0.05	…	0.8	0.2	…	0.3

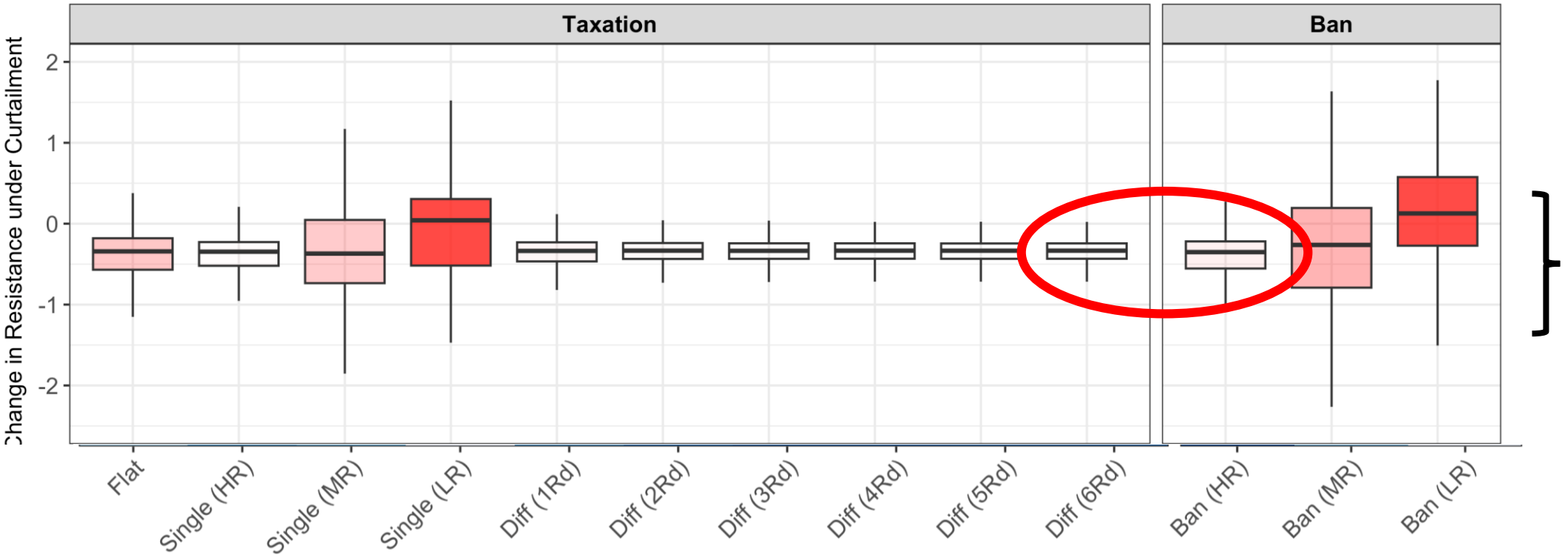
Step 3





Taxation may be as effective as bans to reduce resistance

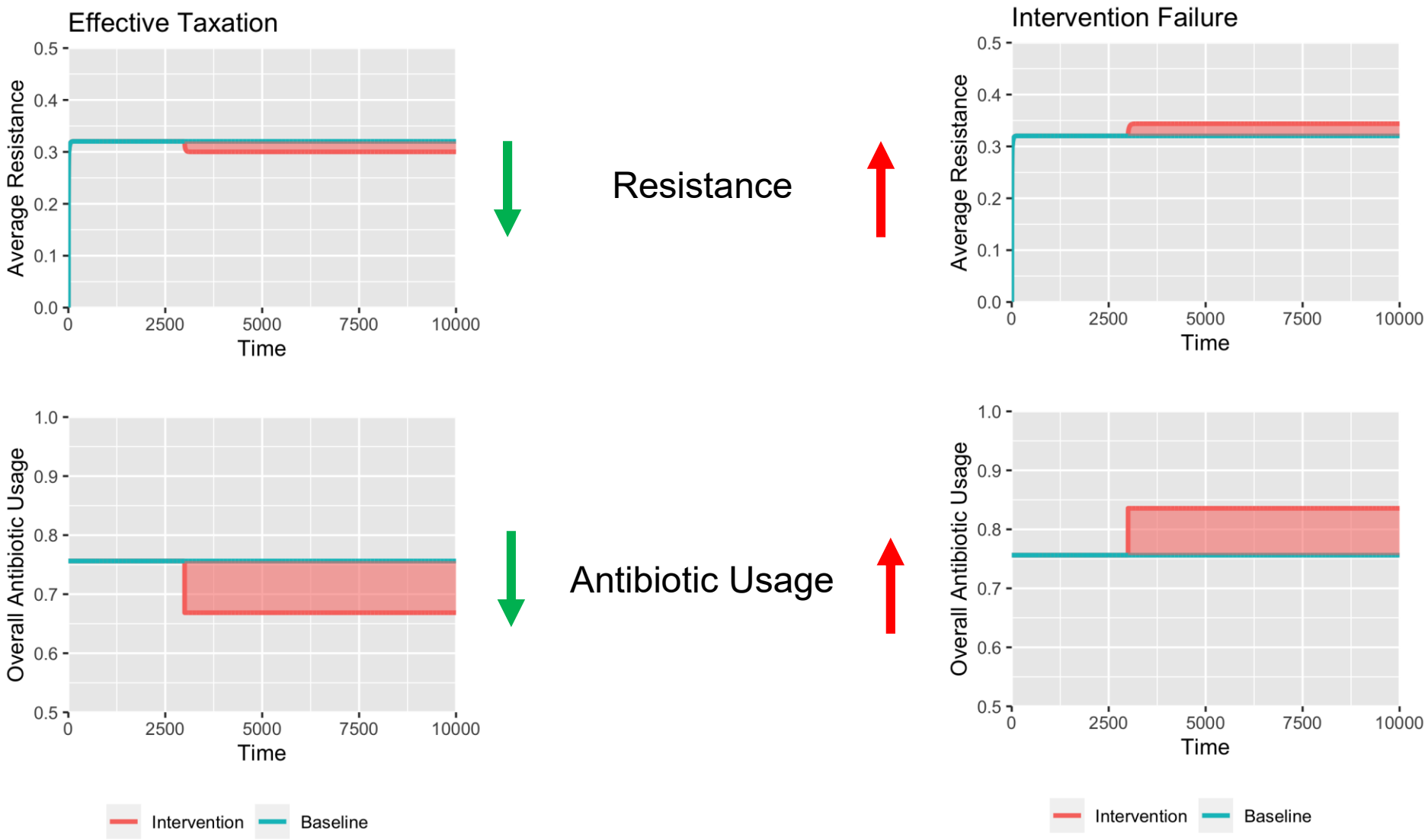
A



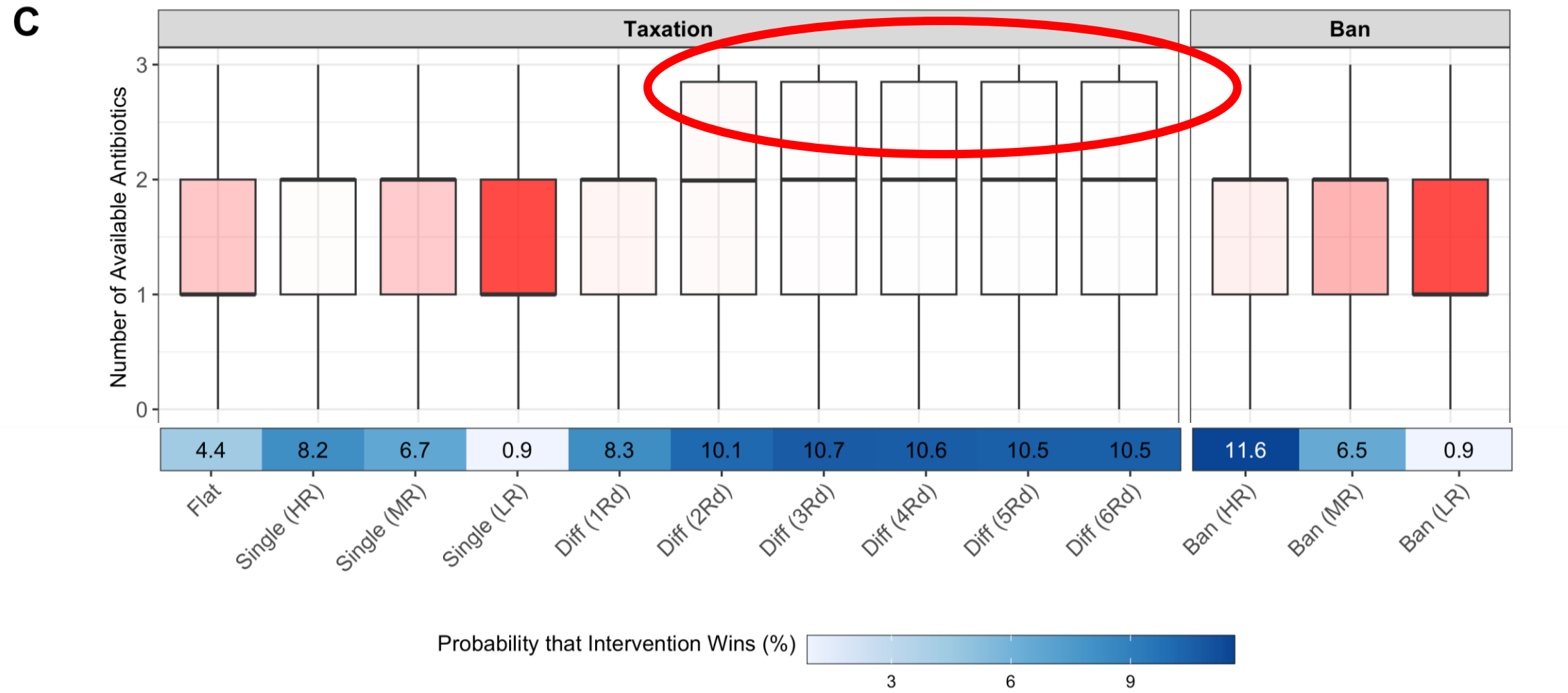
More Intervention Failure

Less Intervention Failure

What is intervention failure?



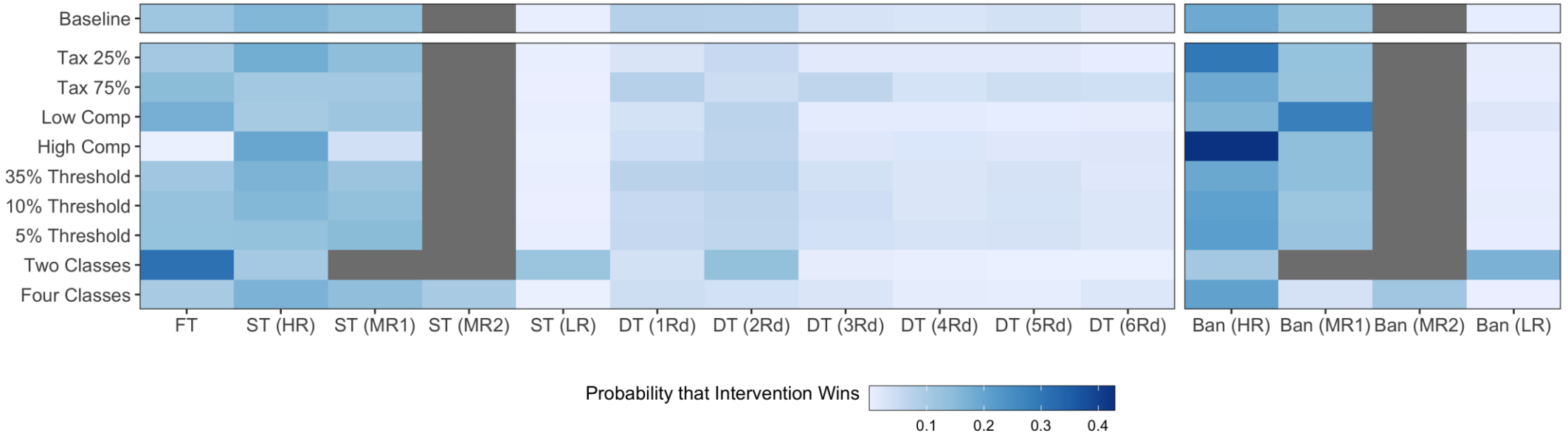
Taxation may be better than bans to ensure the average availability of antibiotics…



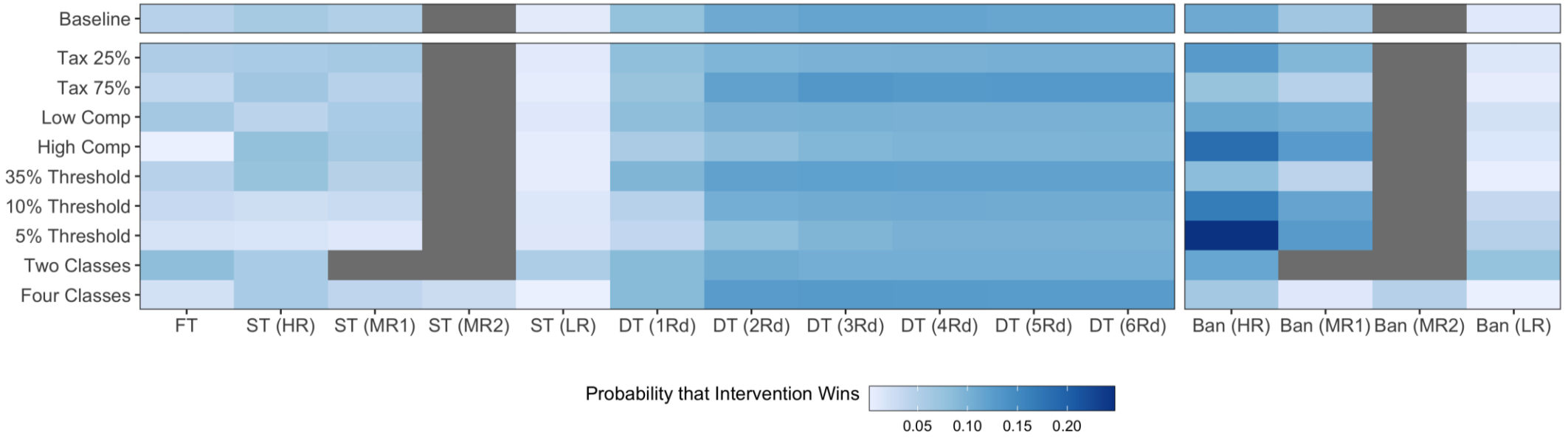
2. Are these trends robust?

1. To alterations in PED?
2. To the threshold for what is an effective antibotics?
3. To intensity of taxation?
4. To the number of antibiotics modelled?

Average Resistance



Average Antibiotics Available



3. How much revenue could we make from taxation?

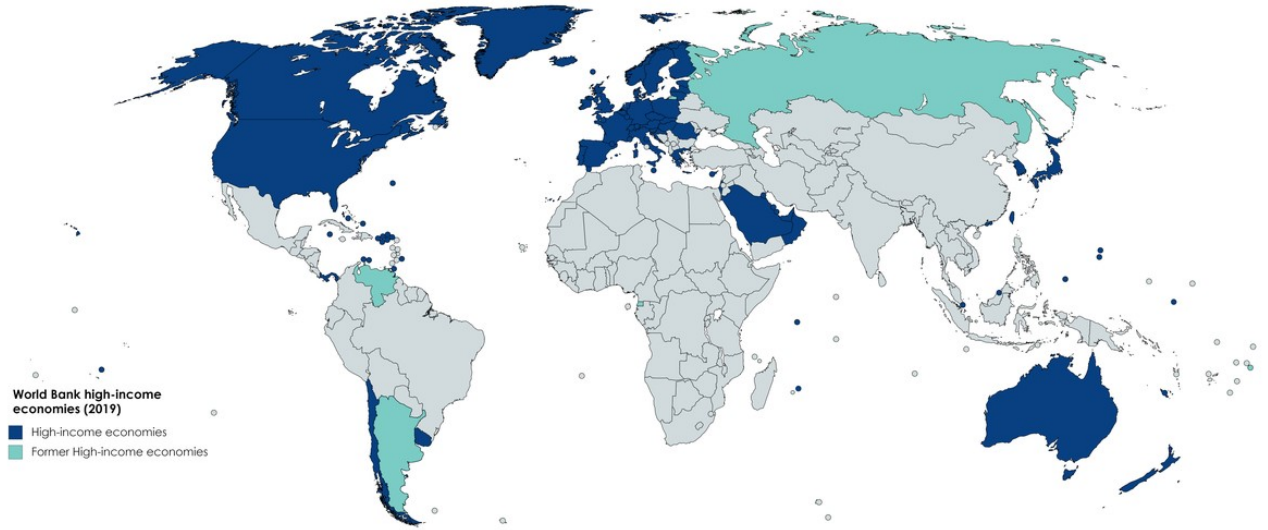
Need information on total revenue from livestock antibiotics

1. Price of antibiotics

2. Total Sales of Antibiotics

Step 1

Separate World into HIC vs LMIC



Step 2

Identify Resistance and Price for **US (HIC)** and **China (LMIC)**

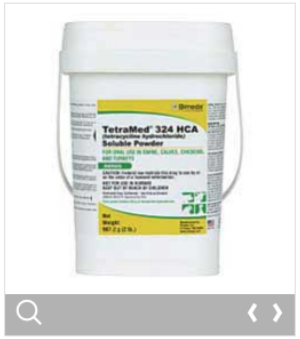
Antibiotic Class	Chickens		Swine		Cattle	
	Salmonella	*Campylobacter*	*Salmonella*	*Campylobacter*	*Salmonella*	*Campyl*
China - 2015 onwards						
Tetracyclines	52	82.6	59.3	NA	59.5	N/
Amphenicols	32	15.5	36.5	NA	85	N/
Penicillin	52.2	20.5	27.7	NA	25.33	N/
Cephalosporins	14.6	53.85	6.76	NA	14.33	N/
Sulphonamides	39.76	NA	40.54	NA	78	N/
Macrolides	NA	7.5	NA	NA	NA	N/

$$PED = \begin{bmatrix} -1.5 & 1 & 0.5 \\ 0.5 & -1.25 & 0.75 \\ 0.25 & 0.5 & -1 \end{bmatrix}$$

Tetracycline Hydrochloride 324 for Livestock

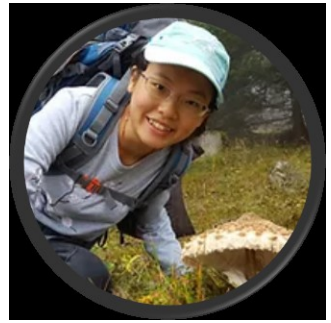
by Bimeda

★★★★★ 7 Read Reviews | Write a review



ITEM	SIZE	PRICE	QTY EACH	SHIPPING
1338RX **	2 lb	$61.38	4 @ $63.99	FREE
1339RX **	5 lb	$113.58		6 lbs

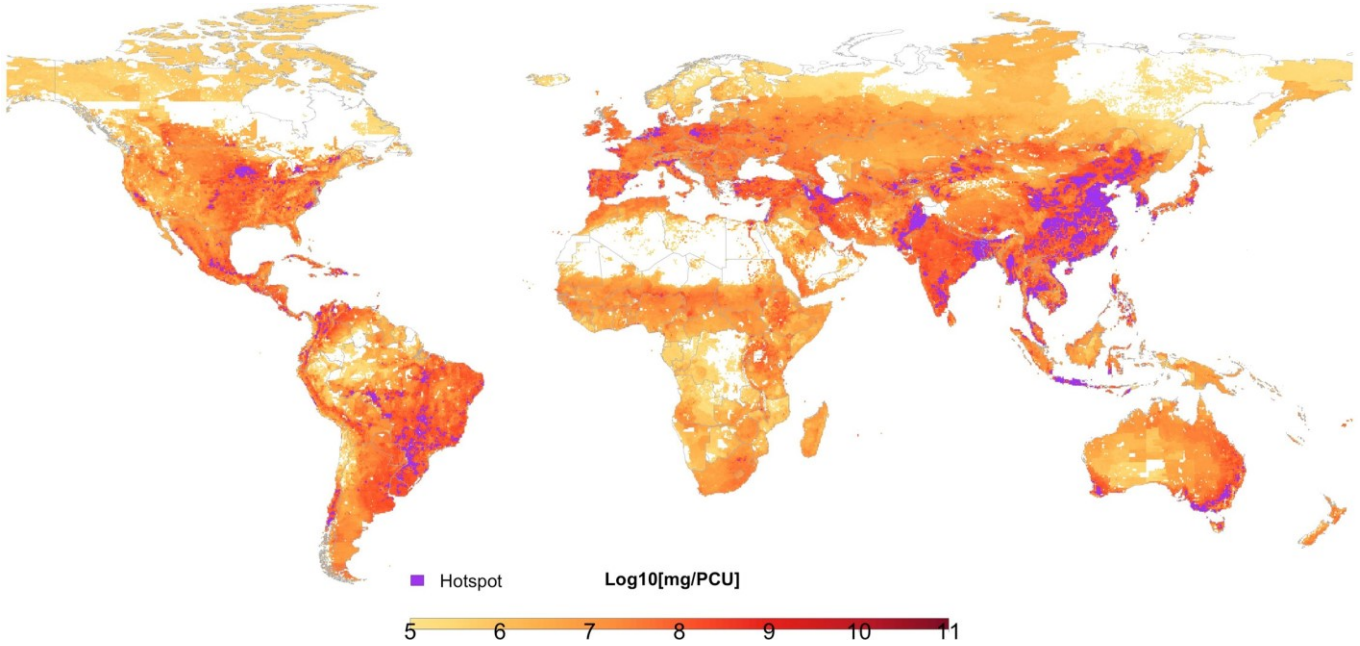
** marked items are currently not available.



Cheng Zhao

Step 3

Identify Antibiotic Sales Data for all HICs and LMICs



Ranya Mulchandani

Step 4

Find the Total Revenue for 3 antibiotic identities for LMICs and HICs

e.g. HIC Revenue for Antibiotic Group 1 =
Total Antibiotic Sales Group 1(HIC) x Average Price of Group 1 Antibiotics (US)

e.g. LMIC Revenue for Antibiotic Group 1 =
Total Antibiotic Sales Group 1 (LMIC) x Average Price of Group 1 Antibiotics (China)

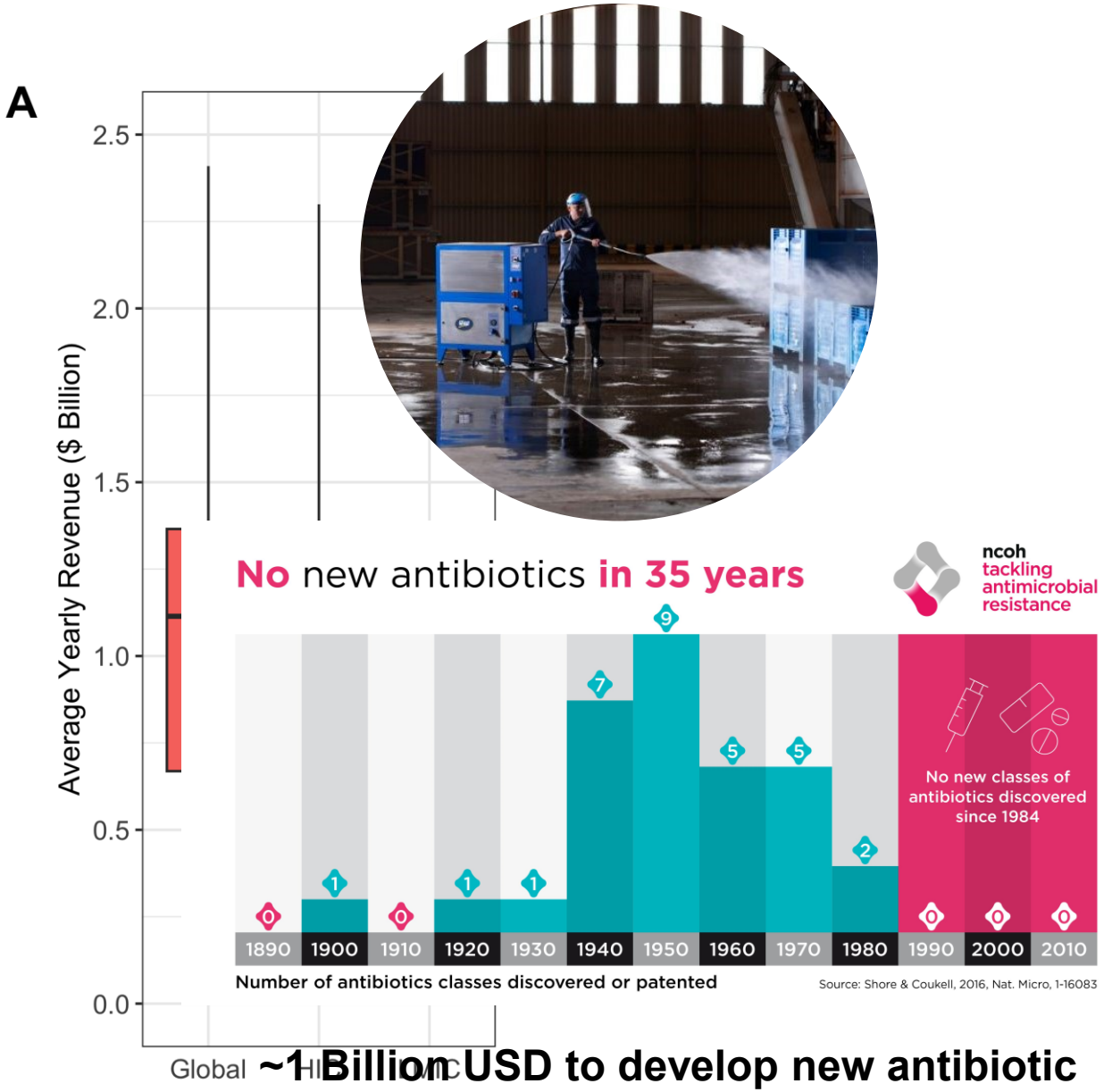
What is the revenue generated from taxation?

For 50% Taxation…

<u>Global Revenue from Taxation = $1.1 Billion</u>
($0.61 and $1.52)

Revenue from **LMICs** = $50 Million (79.6% Sales)

Revenue from **HICs** = $1.06 Billion (20.4% Sales)



~1 Billion USD to develop new antibiotic

Wrapping Up…

1. *What is the most effective taxation strategy? How does this compare to bans?*

Bans, but taxation is very similar in efficacy (in particular differential taxes)
(*additional benefits to intervention failure and average number of effective antibiotics*)

2. *Are these trends robust?*

More or less robust to changes in model assumptions
(*apart from alterations to PEDs and thresholds for effective antibiotics*)

3. *How much revenue could we make from taxation?*

Approximately $1 Billion USD ($0.61 and $1.52)

Questions…

1. What other benefits does taxation have?

2. What about permit trading?

3. Is is equitable that we tax LMICs at the same level as HICs?

4. Is it equitable that HIC contribute more to global pool of $, despite using less?

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Questions?