

*Webinar*

# Human and environmental risk assessment of pharmaceuticals in the Vecht river

Daniel Duarte <sup>1</sup>, Rik Oldenkamp <sup>2</sup>, Ad Ragas <sup>1</sup>

*<sup>1</sup> Department Environmental Science, Faculty of Science,  
Radboud University, <sup>2</sup> Amsterdam Institute for Global  
Health & Development*

*daniel.duarte@ru.nl  
r.oldenkamp@aighd.org  
a.ragas@fnwi.ru.nl*

*24 November 2020*

# Risk assessment

*any* Meeting



# Risk assessment

*Where  $\times$  When = Meeting*

$$1 \times 0 = 0$$

$$0 \times 1 = 0$$

$$1 \times 1 = 1$$



# Risk assessment

*Meeting*~Risk



# Risk assessment

$$Exposure \times Safe = Risk$$

$$\begin{array}{rcccccl} 1 & \times & 0 & = & 0 \\ 0 & \times & 1 & = & 0 \\ 1 & \times & 1 & = & 1 \end{array}$$



# Risk assessment

$$Risk = \frac{Exposure}{Safe\ limit}$$

High *exposure*  
does *not* imply  
high *risk*

# Risk assessment



$$Risk = \frac{Exposure}{Safe\ limit}$$

# Risk assessment



Ecological risk



Human health risk



Antimicrobial resistance risk





# Which pharmaceuticals?

























Diverse *classes*

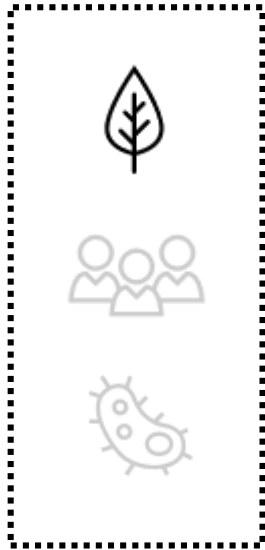
Diverse *properties*

Diverse *data* availability

Diverse *effects*

Diverse *consumption*

Substance	Therapeutic class	Today!
Amantadine	Antiparkinson	
Carbamazepine	Antiepileptics	 
Ciprofloxacin	Antibacterials	  
Cyclophosphamide	Antineoplastics	 
Diclofenac	NSAID	 
Doxycycline	Antibacterials	 
Erythromycin	Antibacterials	  
17 $\alpha$ -Ethinylestradiol	Sex hormones	 
Iopamidol	Contrast media	
Metformin	Antidiabetics	 
Metoprolol	Beta blocker	 
Oxazepam	Anxiolytics	
Phenazone	Analgesics	
Sulfamethazine	Antibacterials	
Valsartan	Angiotensin II receptor blockers	
(many more)	Antibacterials	



# Ecological risk assessment

## Ecological risk

Do these pharmaceuticals pose a **concerning risk** for aquatic organisms?

What is the **spatial distribution** of the risks?



# Ecological risk (single substance)

$$Risk = \frac{Exposure}{Safe\ limit}$$

Databases  
Reports  
Literature (> 450 new entries)

Toxicological  
data entries

~11 000

Usable  
data

● ~ 80

Safe  
limits

■ 8





# Ecological risk (single substance)

$$Risk = \frac{Exposure}{Safe\ limit}$$

Databases  
Reports  
Literature (> 450 new entries)

Toxicological  
data entries  
~11 000

Usable  
data

Safe  
limits



Literature  
safe limits  
107

56





# Ecological risk (single substance)

$$Risk = \frac{Exposure}{Safe\ limit}$$

Databases  
Reports  
Literature (> 450 new entries)

Toxicological  
data entries  
~11 000

Usable  
data

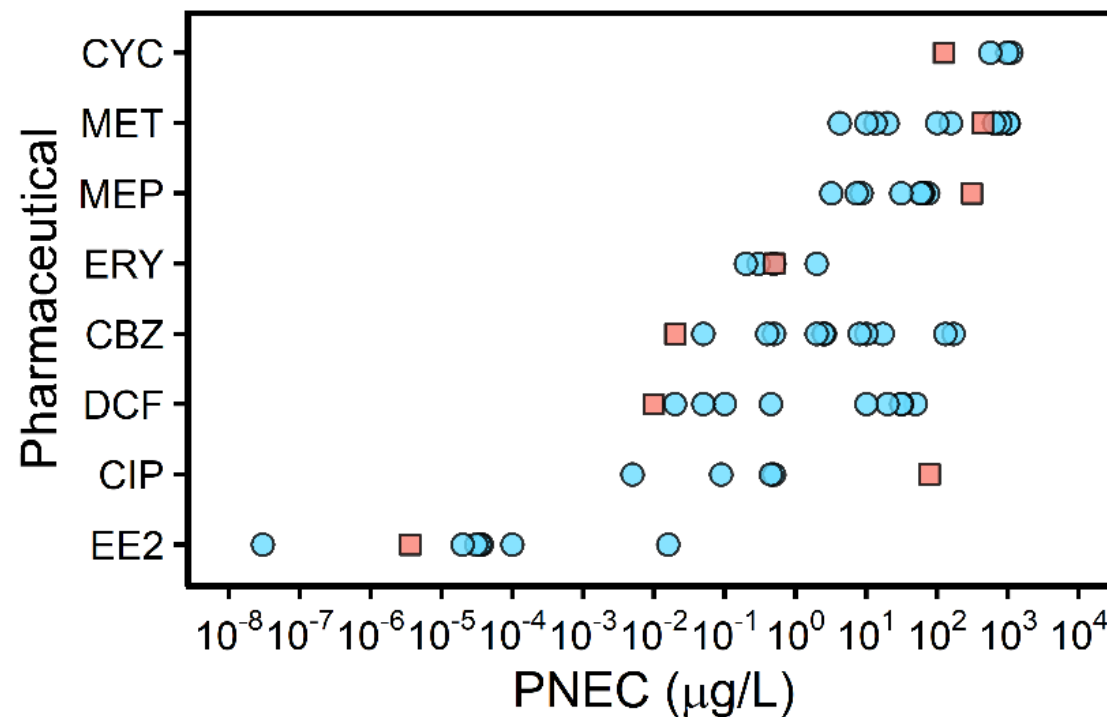
~ 80

Safe  
limits

8

Literature  
safe limits  
107

56

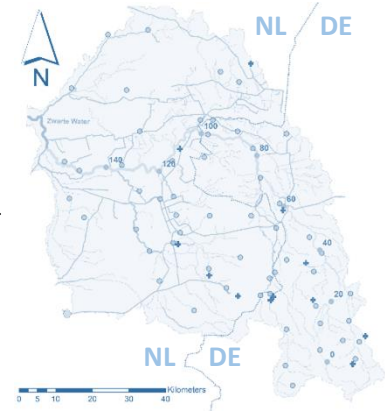


(Predicted No Effect Concentration)



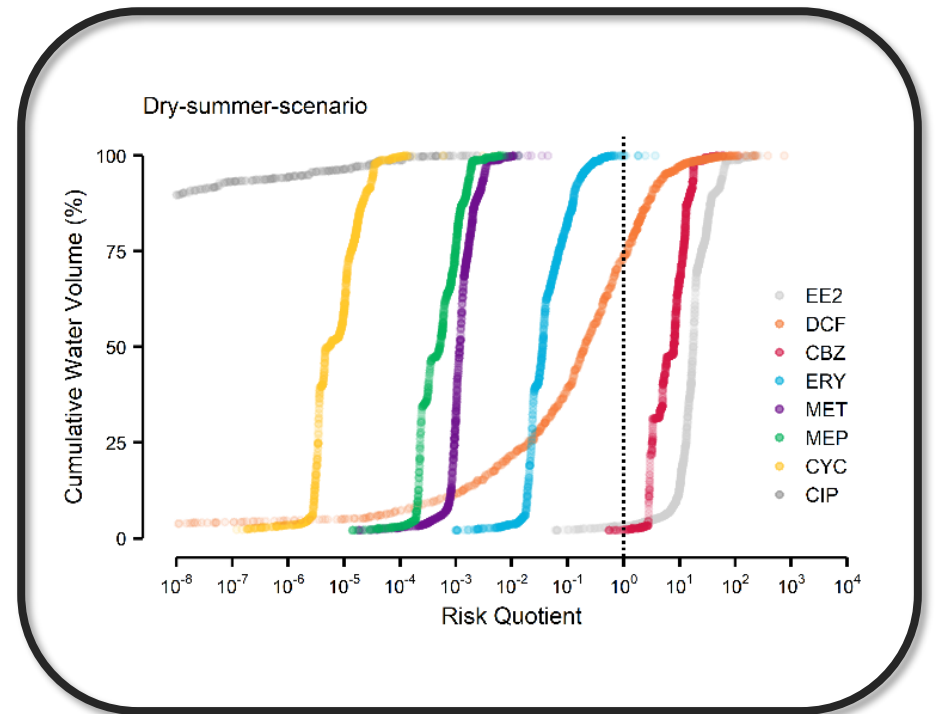
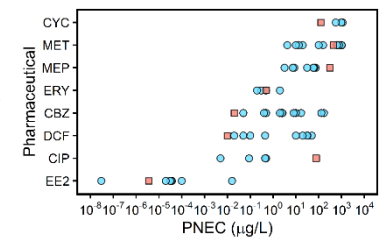
# Individual risk

$$Risk = \frac{Exposure}{Safe\ limit}$$



Exposure  
(predictions)

Safe limits





# Human health risk assessment



## Human risk

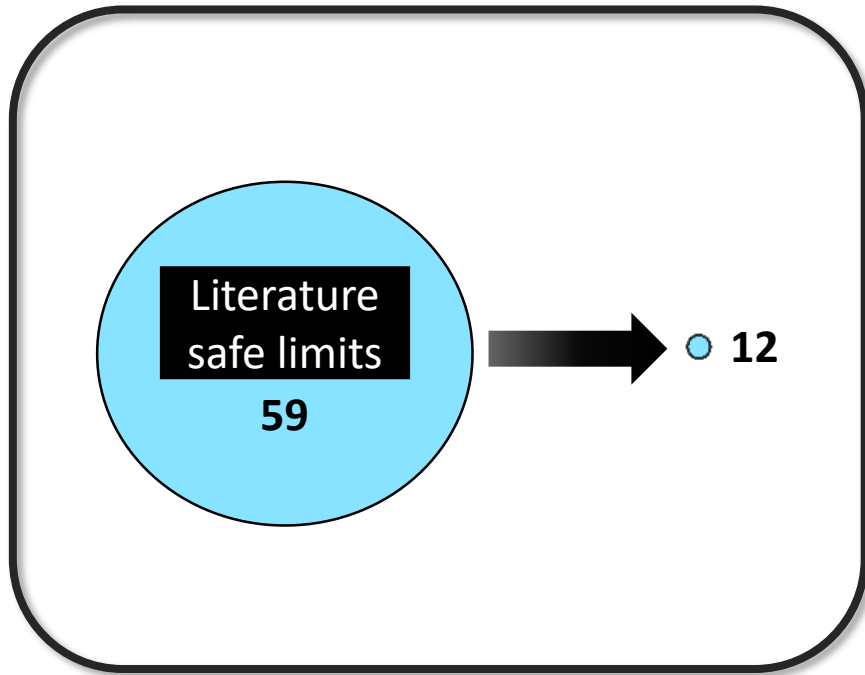
Do these pharmaceuticals pose a **concerning risk** for human health?

Which parameters **influence** the risks?

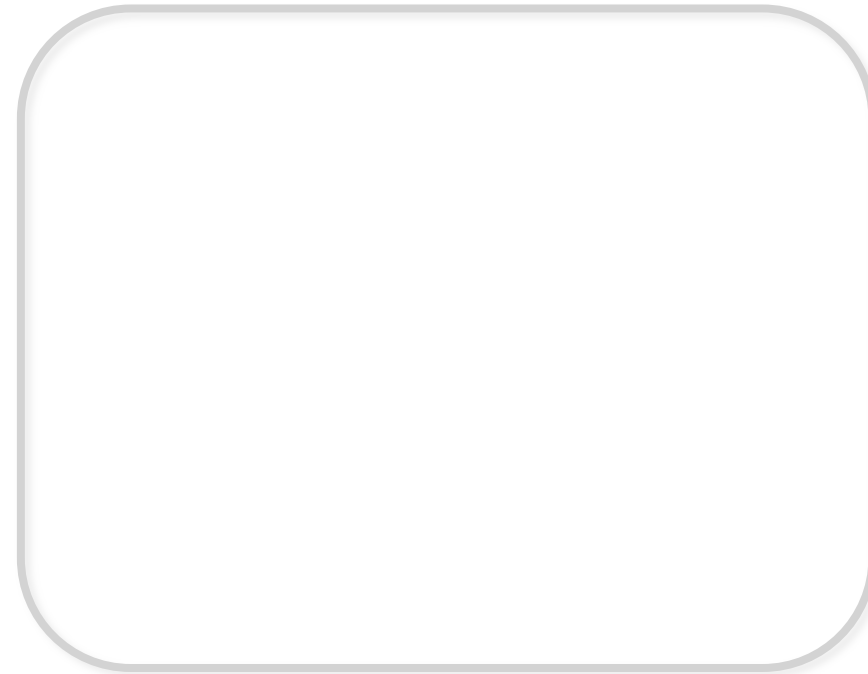
# Human risk

$$Risk = \frac{Exposure}{Safe\ limit}$$

Safe limits



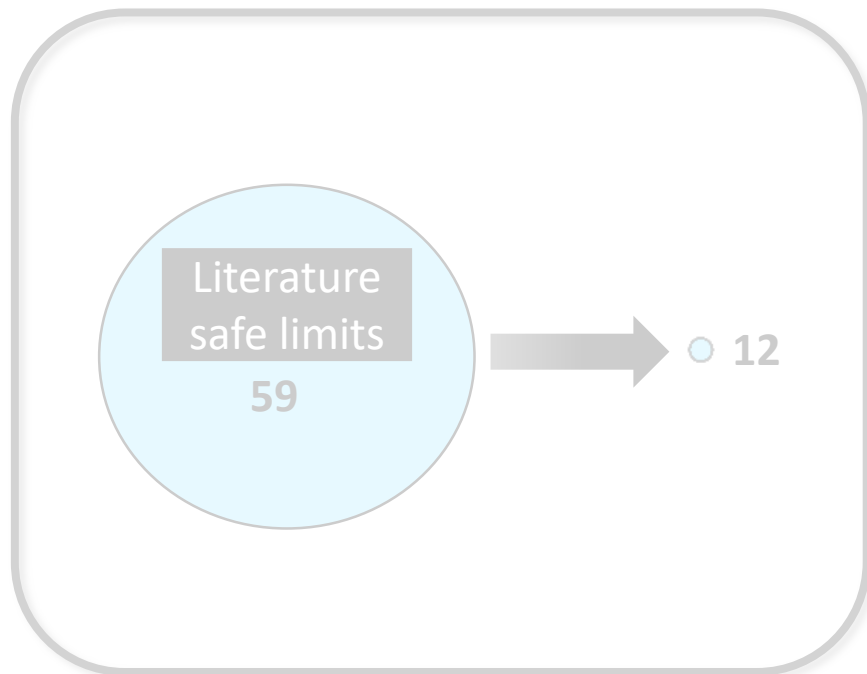
Exposure (predictions)



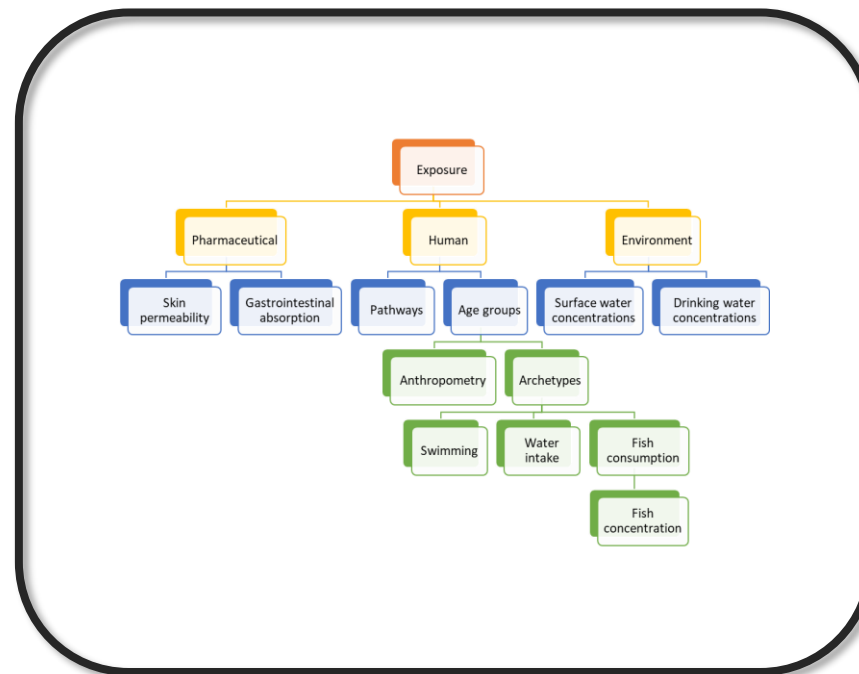
# Human risk

$$Risk = \frac{Exposure}{Safe\ limit}$$

## Safe limits

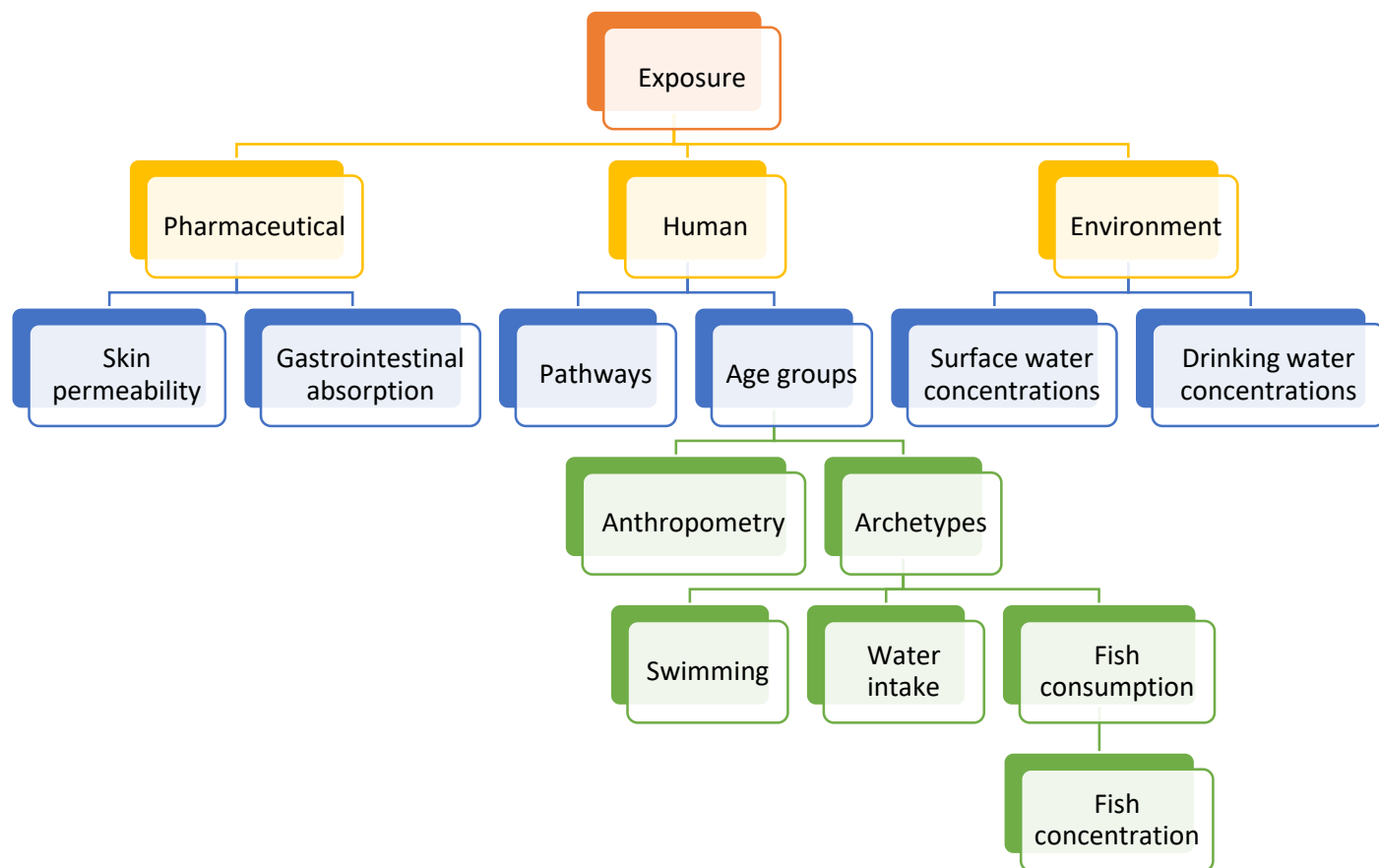


## Exposure model



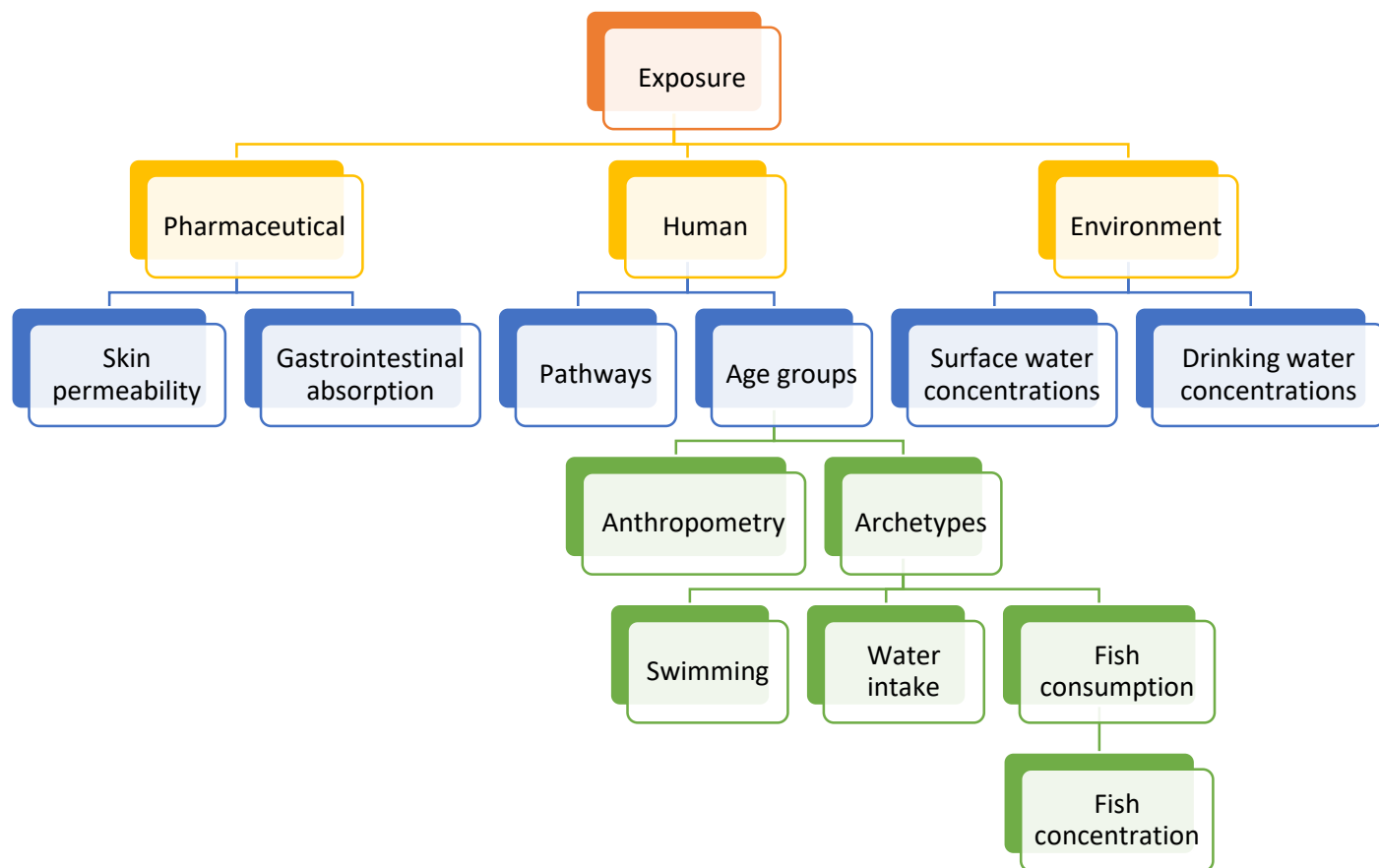
# Human risk

$$Risk = \frac{Exposure}{Safe\ limit}$$



# Human risk

$$Risk = \frac{Exposure}{Safe\ limit}$$



Inhalation

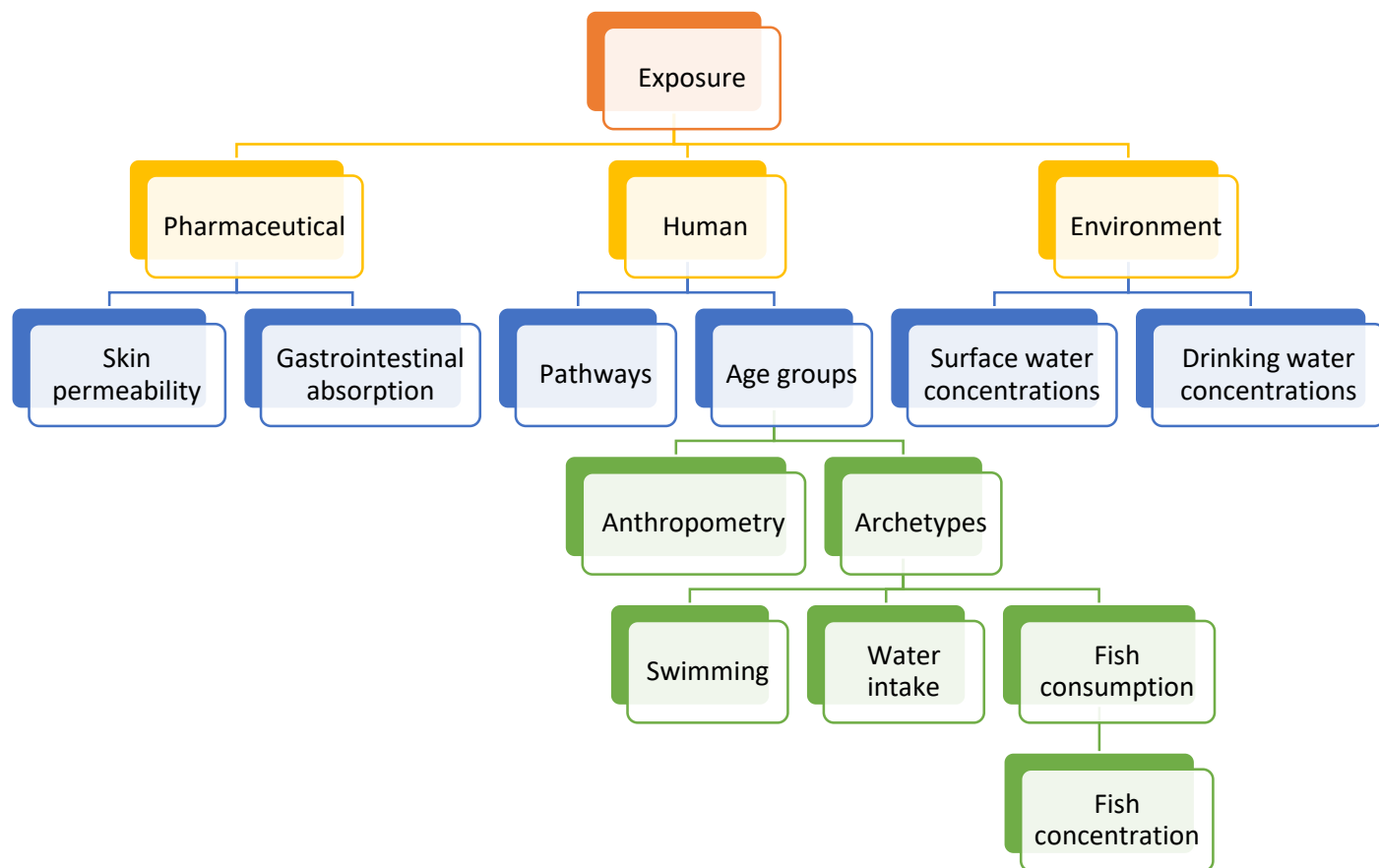
Oral

Dermal



# Human risk

$$Risk = \frac{Exposure}{Safe\ limit}$$



Infant (0-1 yrs)



Toddler (1-5 yrs)



Child (5-10 yrs)



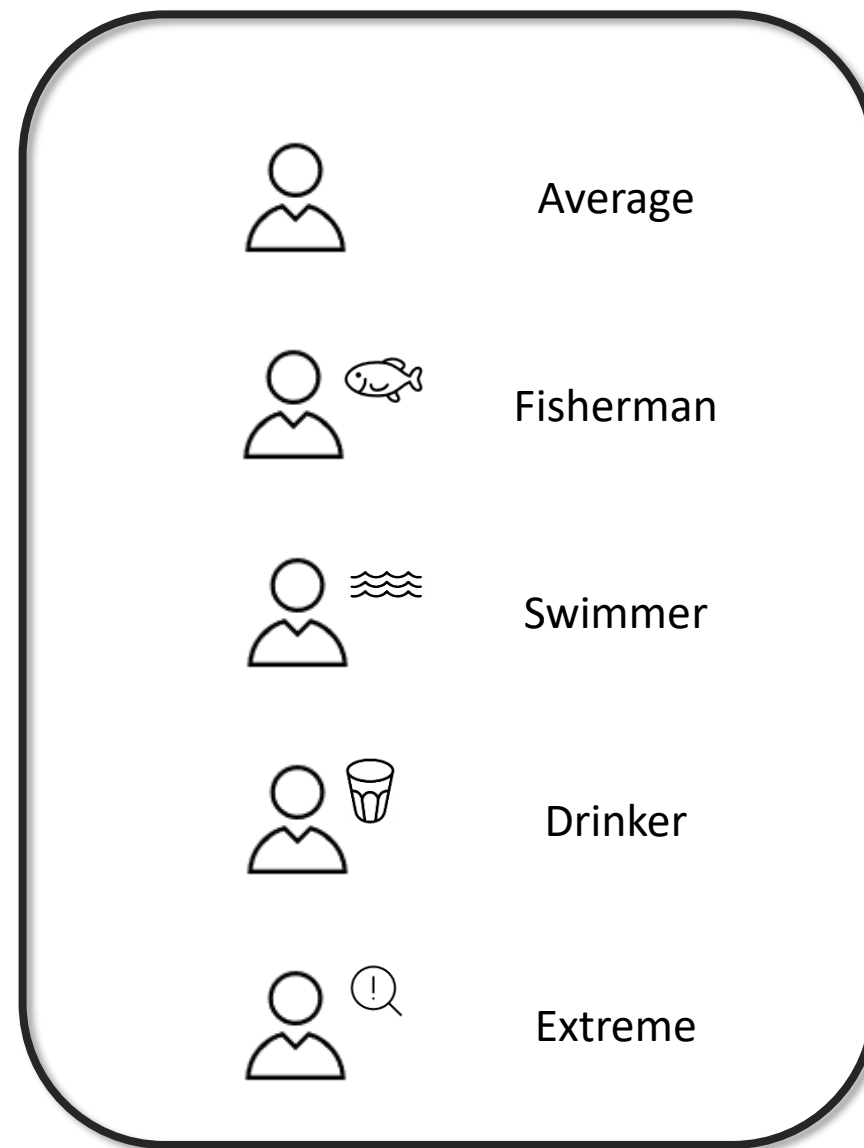
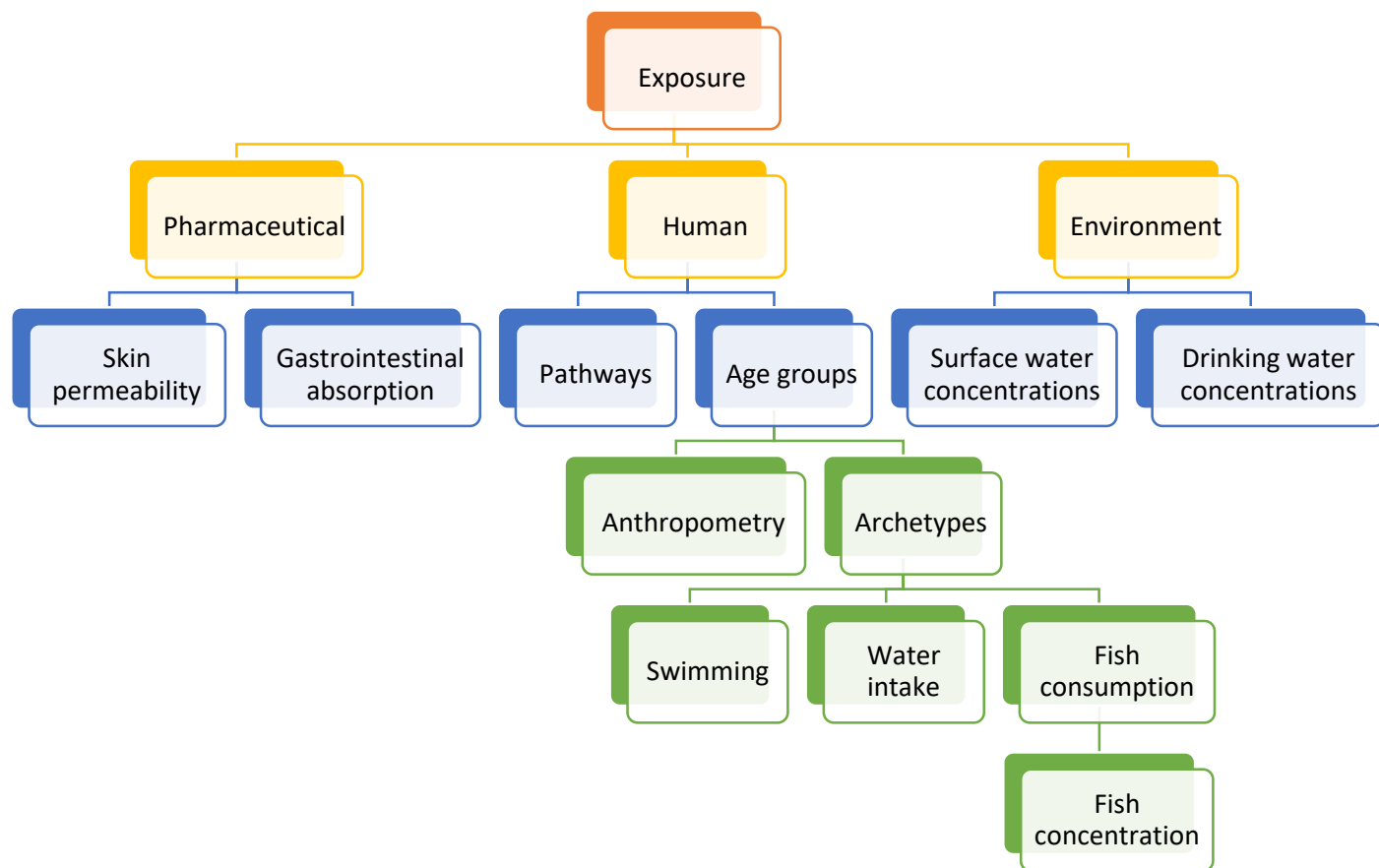
Adolescent (10-18 yrs)



Adult (18-80 yrs)

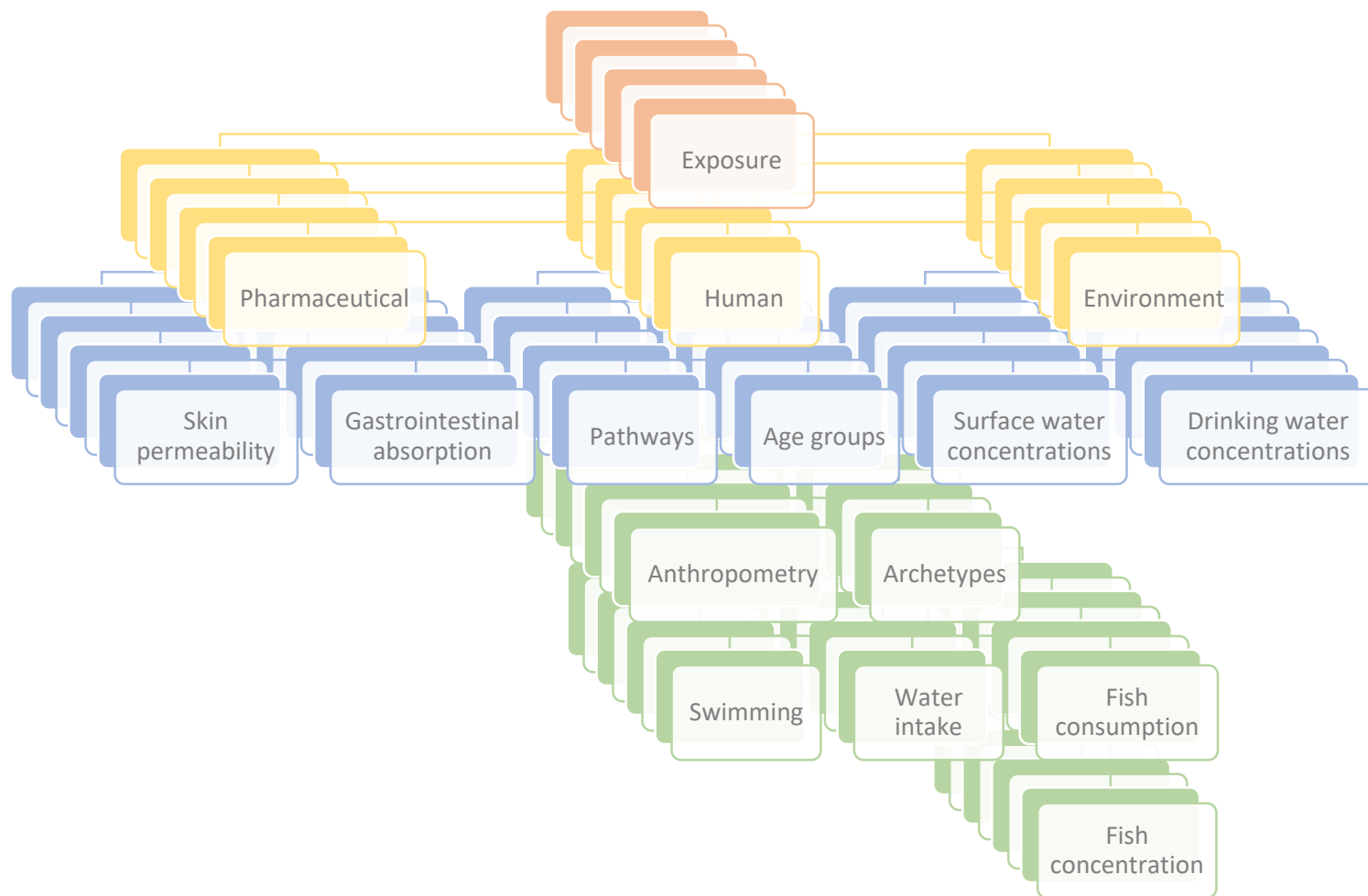
# Human risk

$$Risk = \frac{Exposure}{Safe\ limit}$$



# Human risk

$$Risk = \frac{Exposure}{Safe\ limit}$$



Scenario	Environmental conditions	
	Surface water concentration	Drinking water concentration
1	Mean	Negligible
2	Mean	Mean
3	Maximum	Mean
4a	Maximum	Maximum

Adulthood

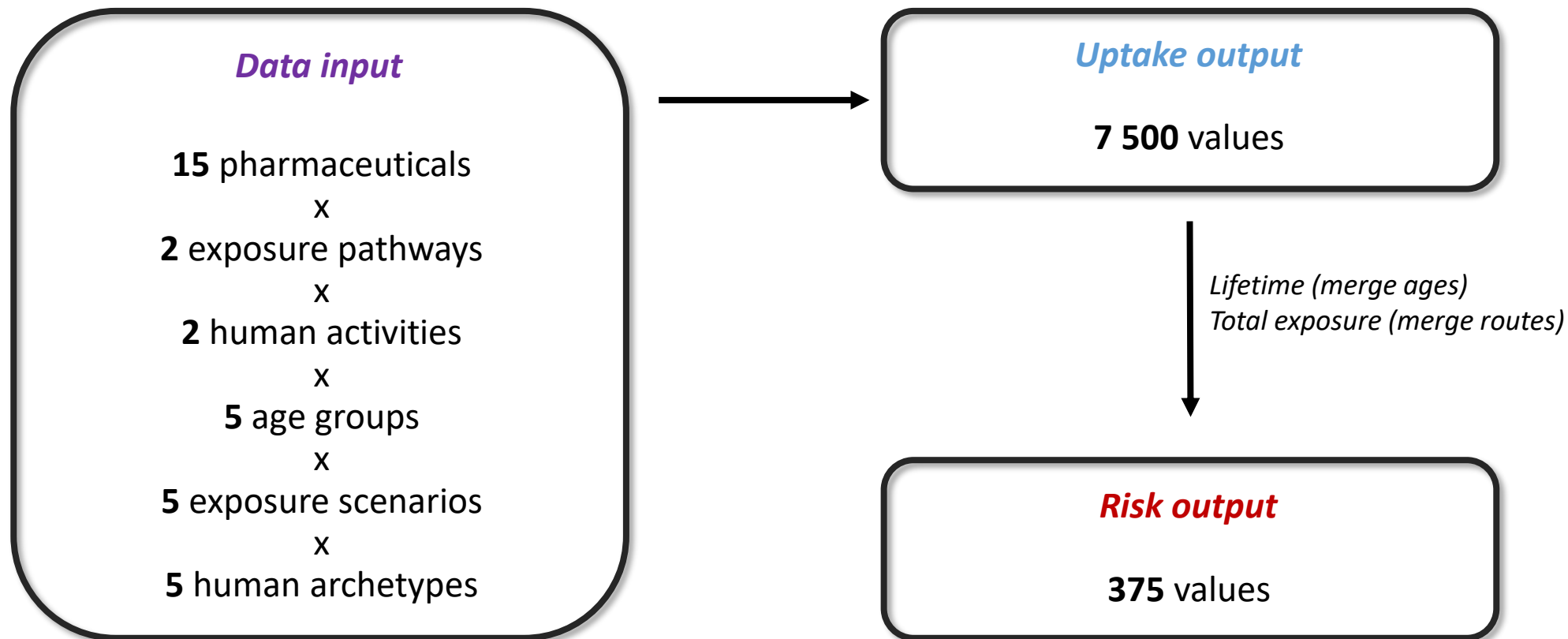
Childhood + Adulthood

4b	Maximum	Maximum
----	---------	---------



# Human risk

$$Risk = \frac{Exposure}{Safe\ limit}$$



No time to show all! So...



# Risk quotients

$$Risk = \frac{Exposure}{Safe\ limit}$$

## Main takeaway

No expected overall risk  
Keep an eye on doxycycline

### Highest

Doxycycline (antibiotic)  
(risk up to 2,5x higher than safe limit)

### Lowest

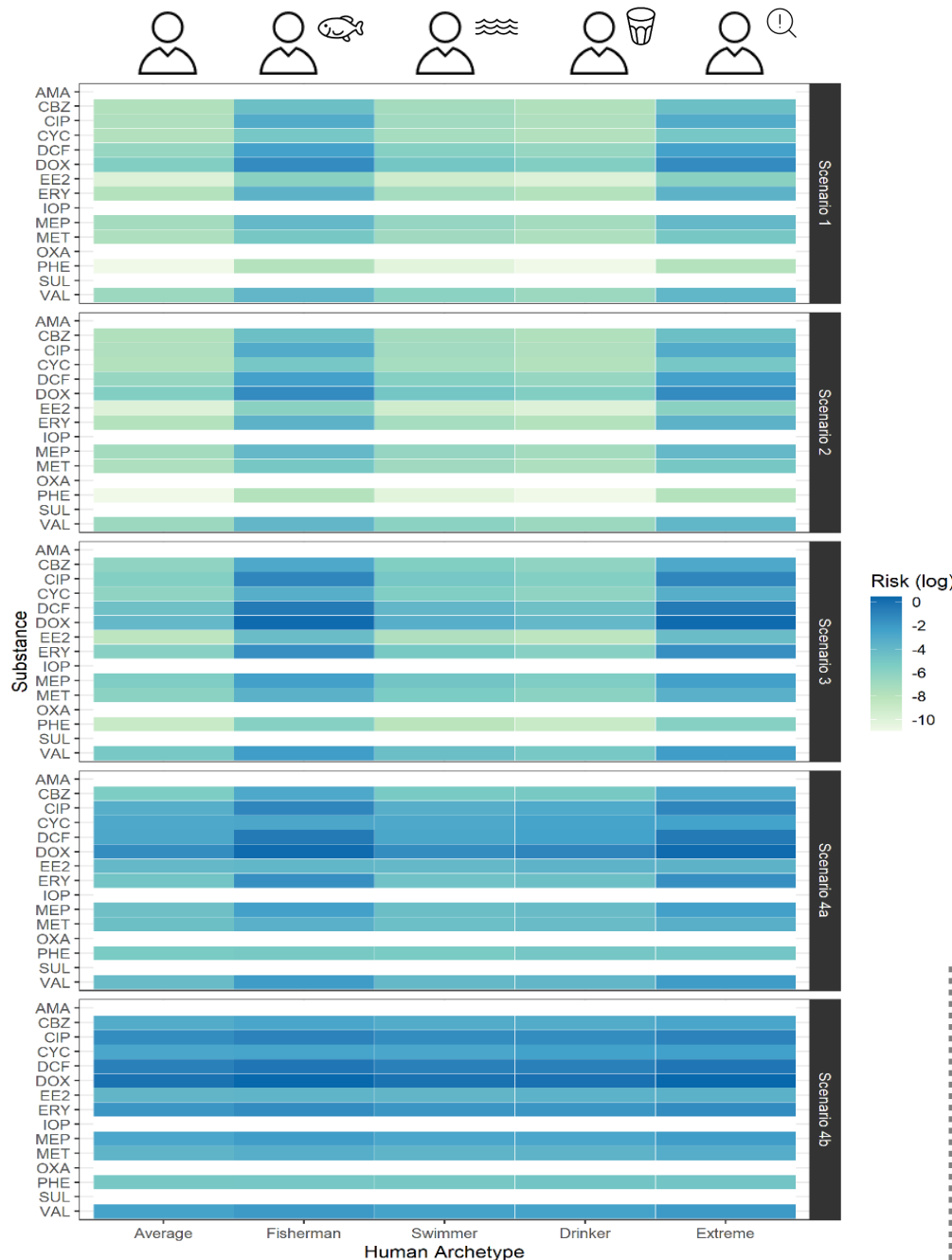
Phenazone (analgesic)

### Most at risk

Fisherman and Extreme

### “Game-changer”

Drinking water (Scn3 vs Scn4)



Scenario	Environmental conditions	
	Surface water concentration	Drinking water concentration
1	Mean	Negligible
2	Mean	Mean
3	Maximum	Mean
4a	Maximum	Maximum
4b	Maximum	Maximum



# Pharmaceutical uptake

$$Risk = \frac{Exposure}{Safe\ limit}$$

## Main takeaway

Pharm/Arch-dependent  
Keep an eye on diclofenac

### Highest

Diclofenac via fish  
consumption

### Route

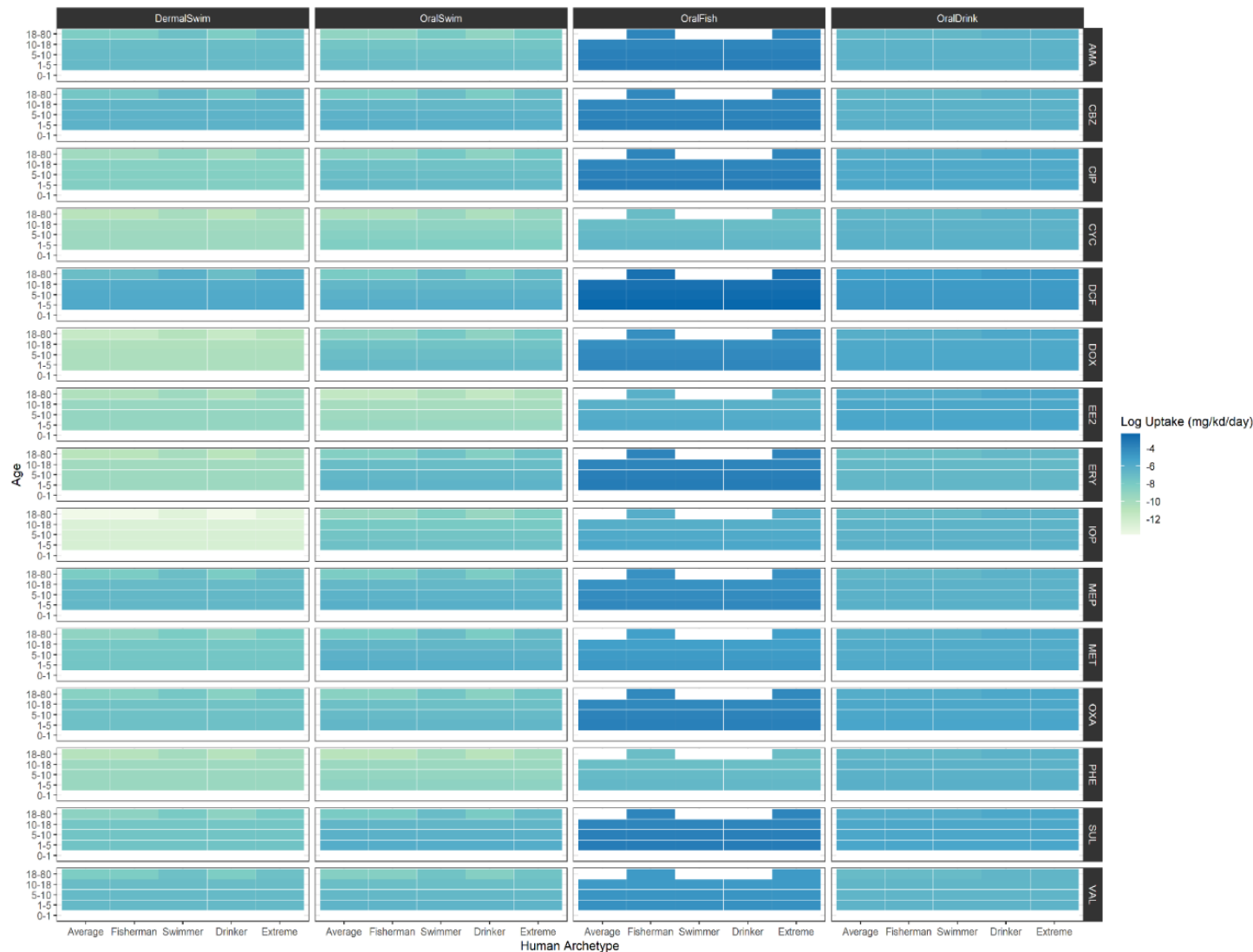
Oral swim and dermal  
swim BUT oral drink

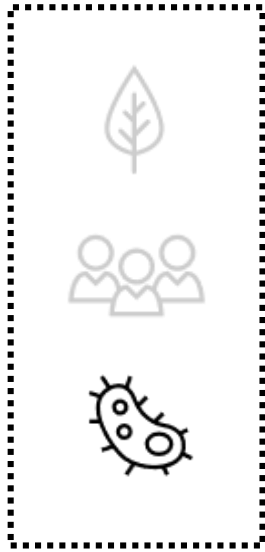
### Age

The older, the lower  
uptake (except swimmer)

## Scenario 4a

Max surface water & Max drinking water





# Antimicrobial resistance risk



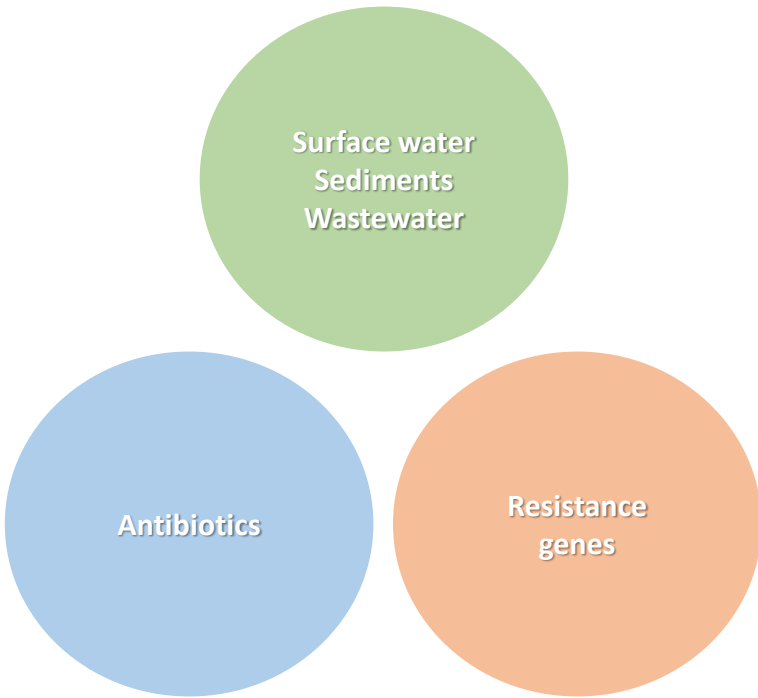
## Antimicrobial resistance

Does antibiotic selective pressure  
**correlate** with ARG abundance?

Does the type of environmental sample  
**influence** ARG abundance?



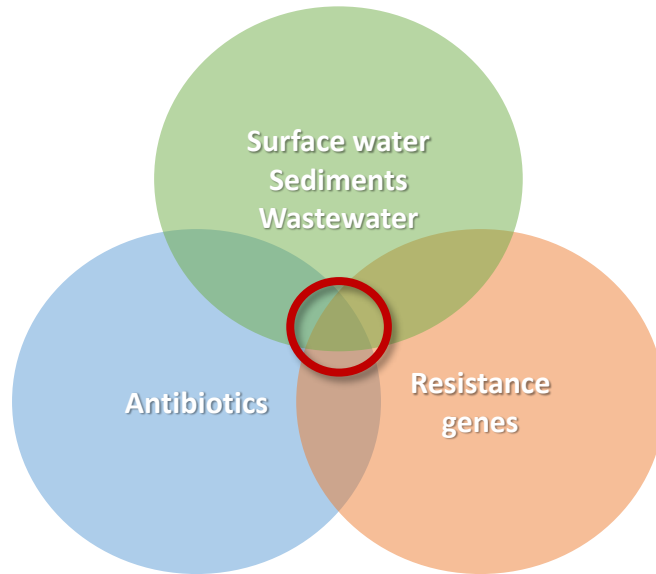
# Antimicrobial resistance





# Antimicrobial resistance

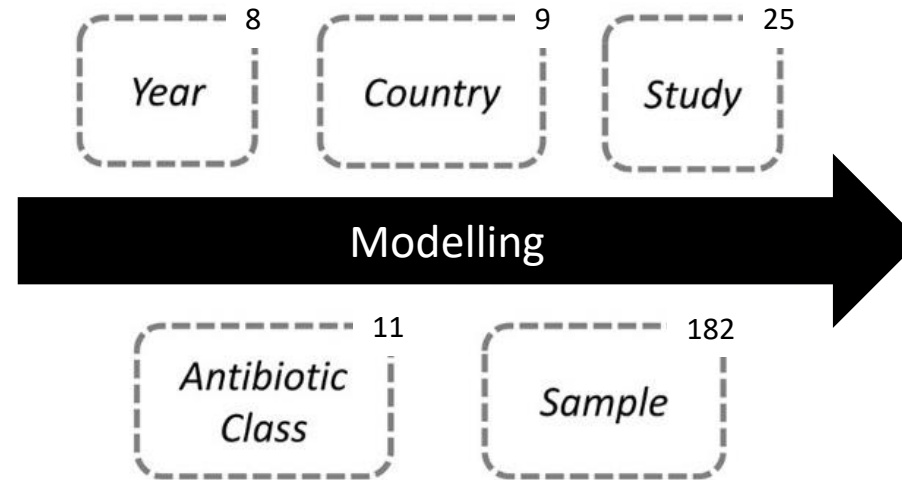
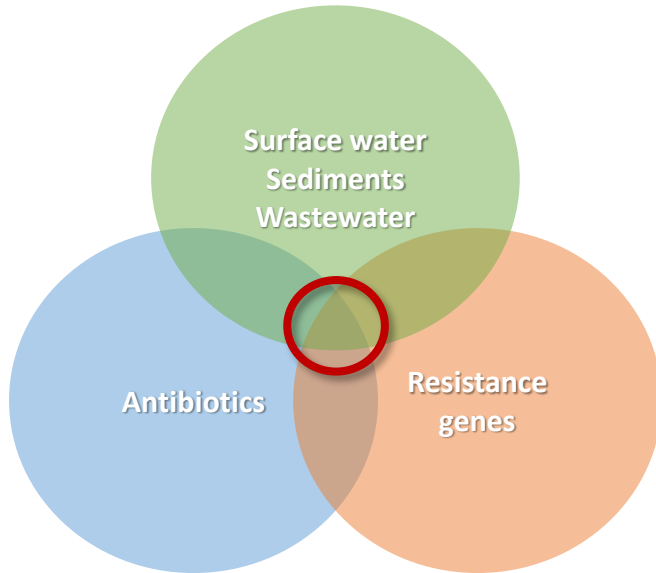
$$Risk = \frac{Exposure}{Safe\ limit}$$





# Antimicrobial resistance

$$Risk = \frac{Exposure}{Safe\ limit}$$

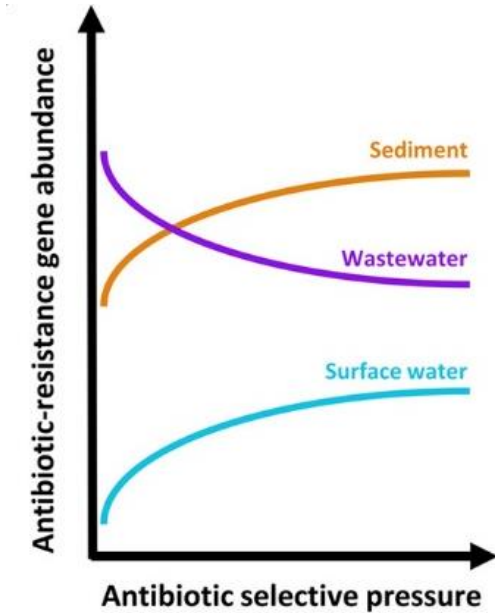
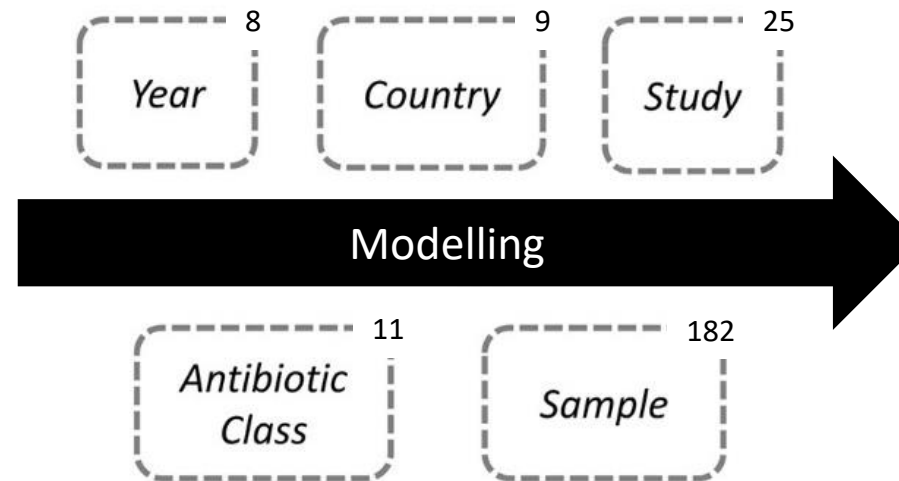
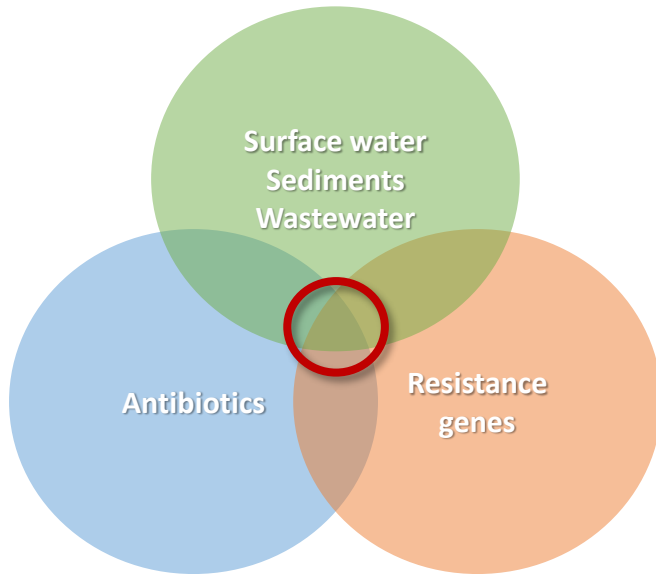






# Antimicrobial resistance

$$Risk = \frac{Exposure}{Safe\ limit}$$





*Thank you*

