



Microbial Risk Assessment of the Water Reuse Scheme in Braunschweig based on WHO guidelines

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Outline

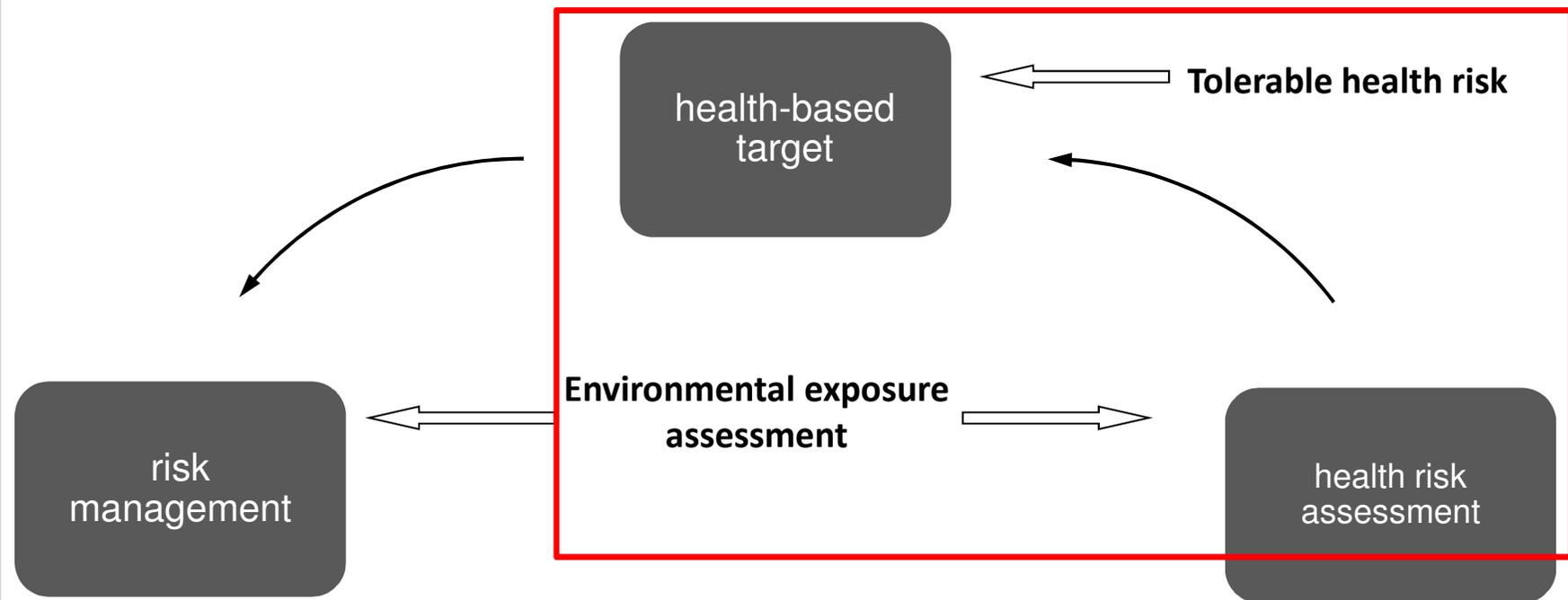
1. Background
 - WHO approach and scope
 - Risk and risk assessment

2. Case study in Braunschweig:
 - Initial situation
 - Selection of exposure routes
 - Selection of pathogens
 - Exposure modeling
 - Results

3. Conclusion + recommendations

Stockholm approach and HACCP (Hazard analysis and critical control points)

“the most effective means of consistently ensuring safety in wastewater use is through the use of a comprehensive risk assessment and risk management approach that encompasses all steps of the process [...]” (WHO 2006, p. 16, chap. 2.6, l. 4).



Introduction to risk assessment

Hazard

A biological, chemical or physical agent, which may cause a adverse effect on human health or the environment

Risk

A function of the probability of a harmful effect as a consequence of the realization of the hazard

Risk = probability x severity of the consequences

Different types of risk

- technical risk (e.g. failure)
- economic risk (e.g. investments)
- environmental risk (e.g. ecotoxicity)
- human health risks (e.g. causing disease)

General structure of health risk assessments:

1. Hazard identification
2. Hazard characterization
3. Exposure assessment
4. Risk characterization

Tolerable level of risk

Pathogens (*DALY= disability adjusted life years*)

$$DALY = YLL + YLD$$

YLL = years of life lost

YLD = years lived with disability

Tolerable level for wastewater reuse (WHO):

10^{-6} additional DALYs pppy = **1 additional μ DALY pppy**

1. Calculation of the annual **probability of infection**
2. Multiplying the probability with a **severity factor** (for watery diarrhea 0.09-0.12)

DALYs per 100000 in Germany: 10358

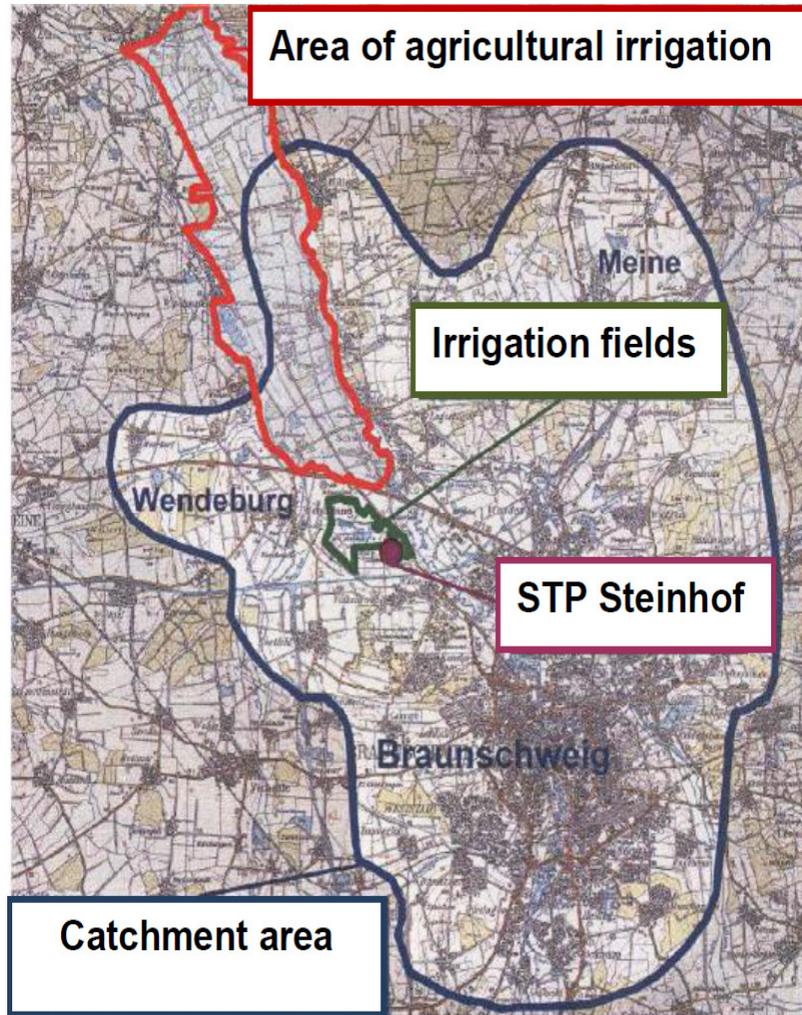
Alcohol abuse 392

Depression 766

traffic accidents 161

Diarrhea 22

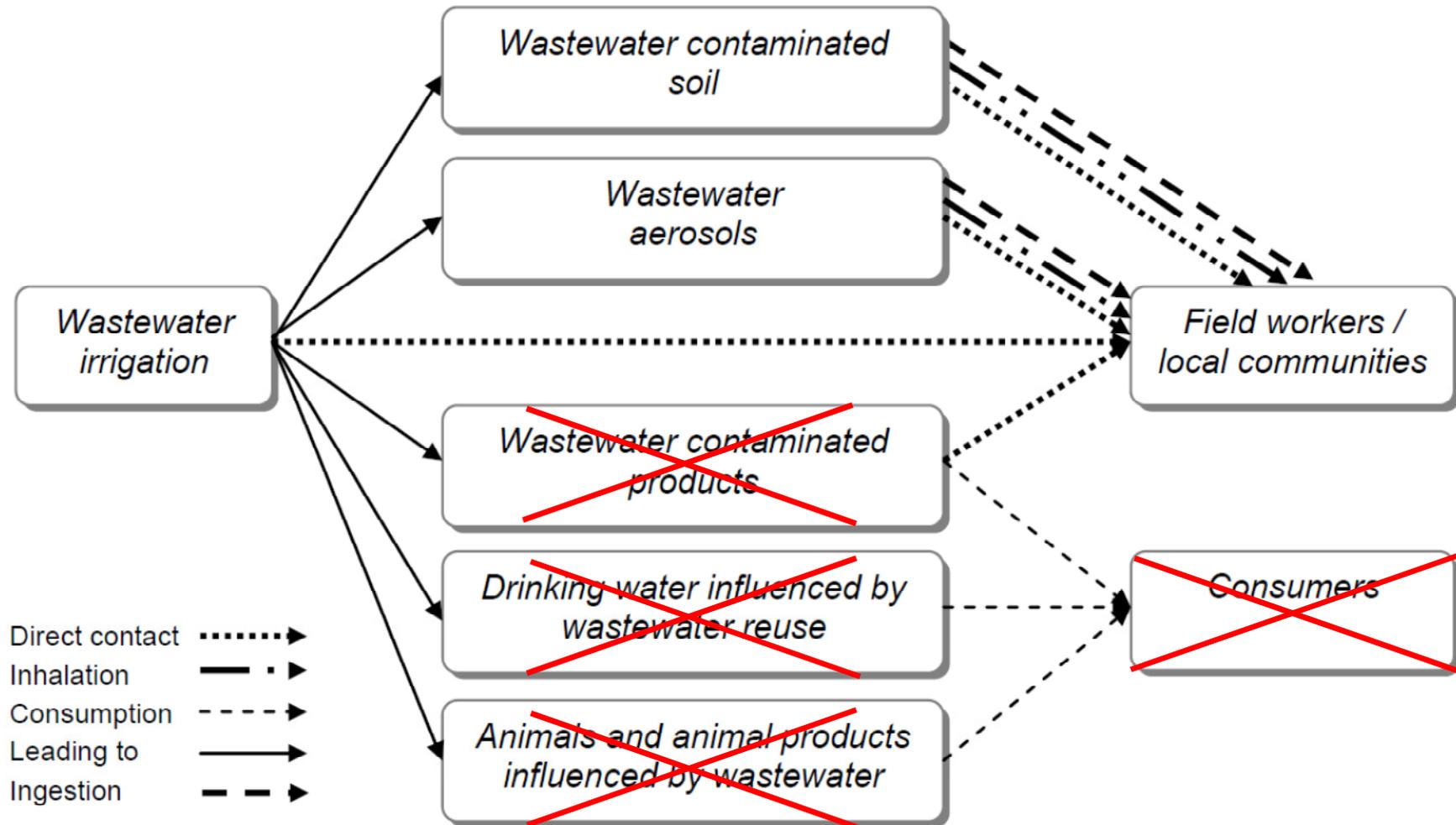
Braunschweig: Initial Situation (2011)



- Secondary effluent is used for irrigation via sprinkler irrigation
- During summer: digested sludge is added to the water
- Microbial parameters not regulated in legal permission
- Minimum distance to local communities regulated (60-150m)
- No microbial data available!

→ Risk assessment based on literature data

Braunschweig: Selection of relevant pathways



Braunschweig: Assumptions for exposure scenarios

Fieldworkers

- No pathogen die-off
- $N(\text{pathogens}) \text{ in } 100\text{ml}_{\text{water}} \triangleq N(\text{pathogens}) \text{ } 100\text{g}_{\text{soil}}$ (Mara et al. 2005)
- 1-10mg soil (Mara et al. 2005)
- Number of exposure events 100 per person per year (pppy)

Nearby residents

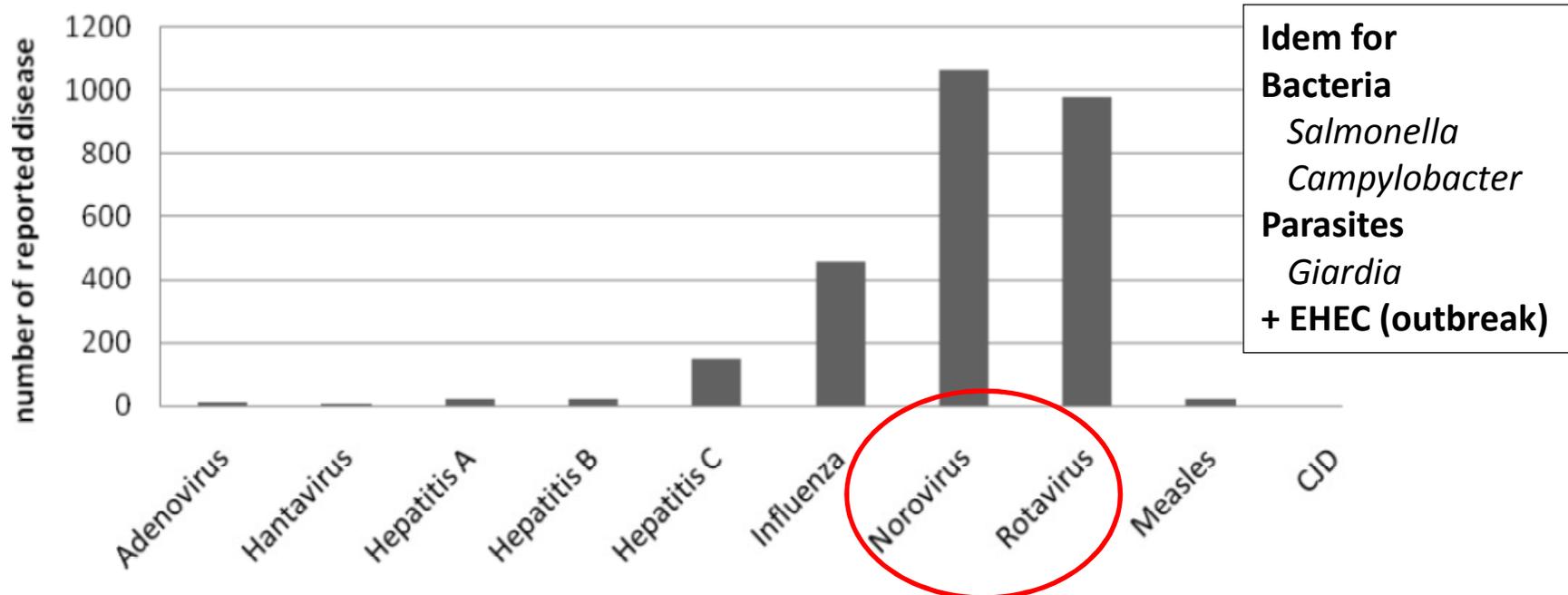
- No pathogen die-off
- $N(\text{pathogens}) \text{ in } 100\text{ml}_{\text{water}} \triangleq N(\text{pathogens}) \text{ } 100\text{g}_{\text{soil}}$ (Mara et al. 2005)
- Number of exposure events 365pppy
- Average wind speed 3m/s (Deutscher Wetterdienst)
- Minimum distance 60-150m (legal permission for irrigation)

→ 0.06-0.21mg soil per exposure event (Viau et al. 2011)

Selection of reference pathogens

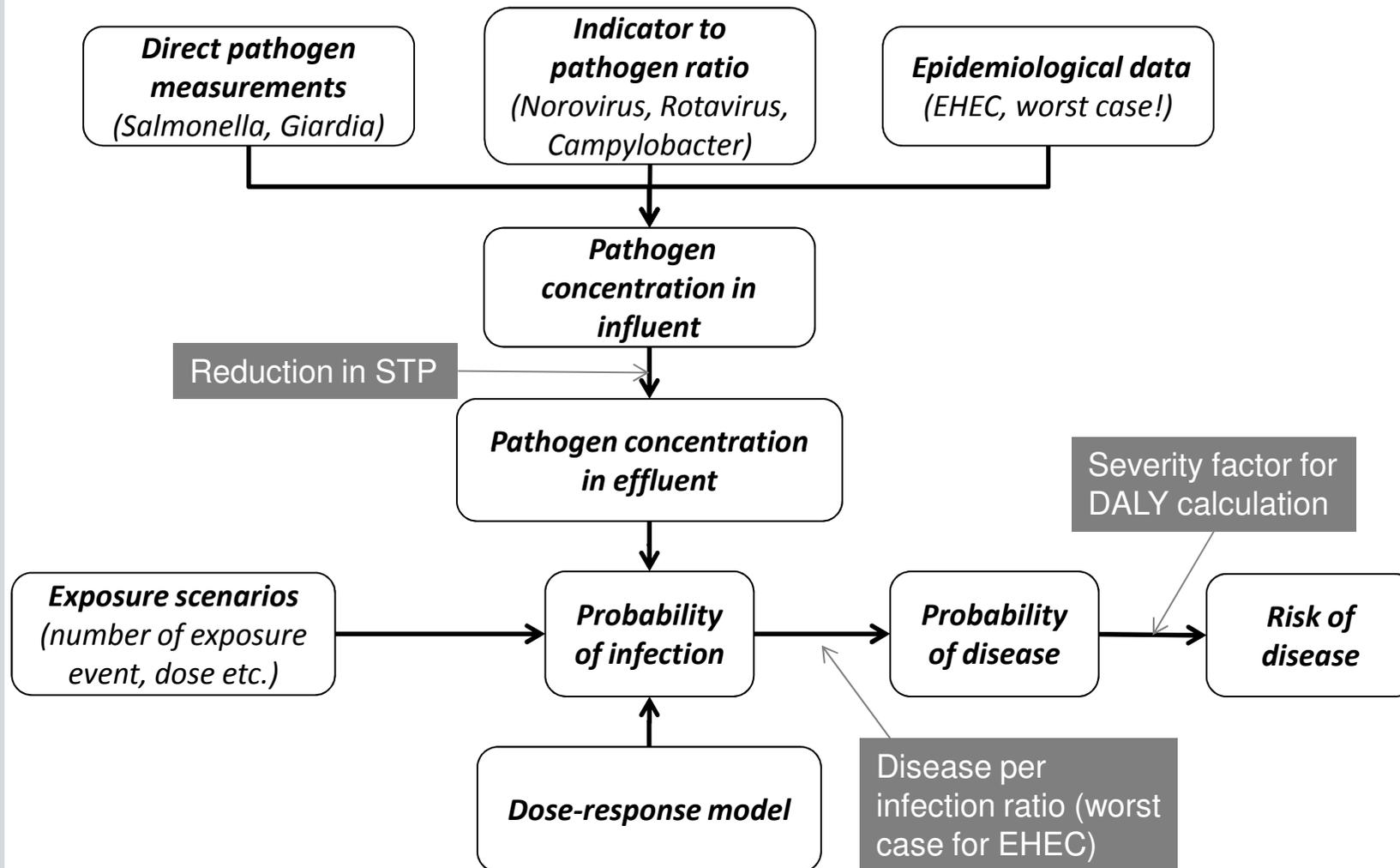
Logical approach: the pathogens causing the most cases of disease are the most prevalent ones in STP Braunschweig

disease caused by viruses and prions

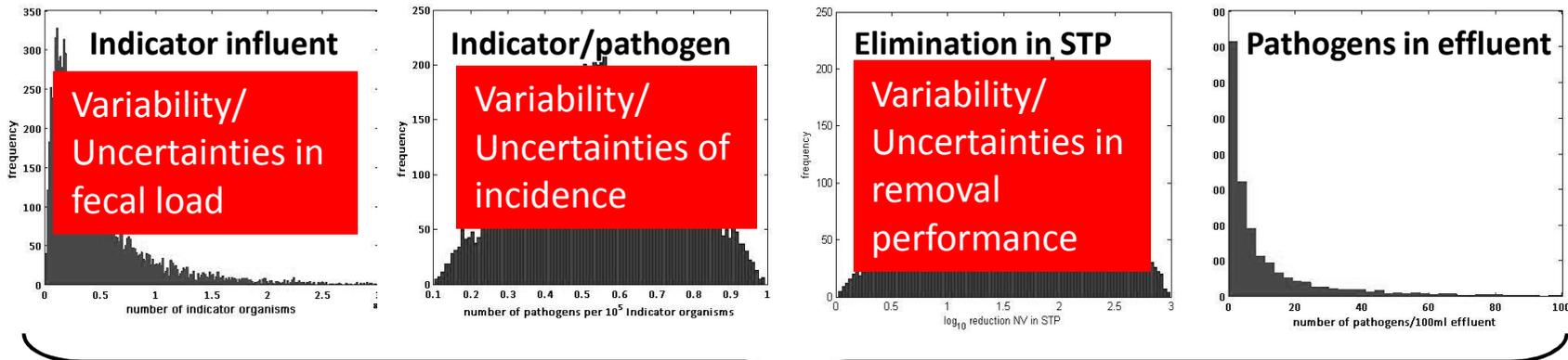


Number of disease incidents caused by viral infections or infections by prions (CJD). The diagram shows the mean reported number from 2001-2010 in the governmental district of Braunschweig [Robert-Koch-Institut].

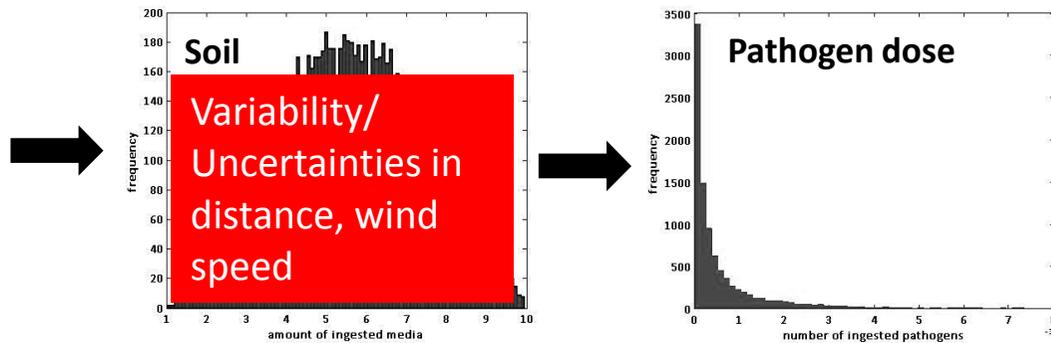
Model overview and exposure scenarios



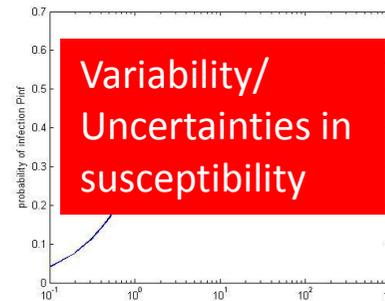
Statistical analysis via Monte-Carlo (1000x N(exposure))



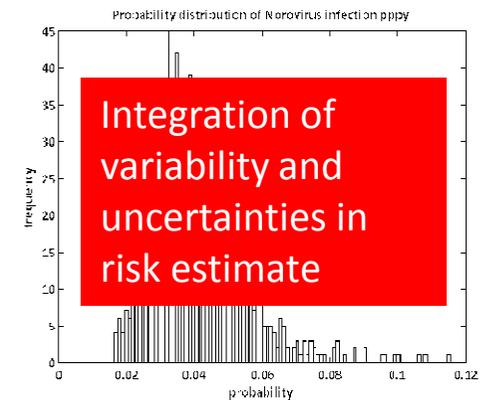
STP Braunschweig



Dose per person per exposure event



Dose-response model

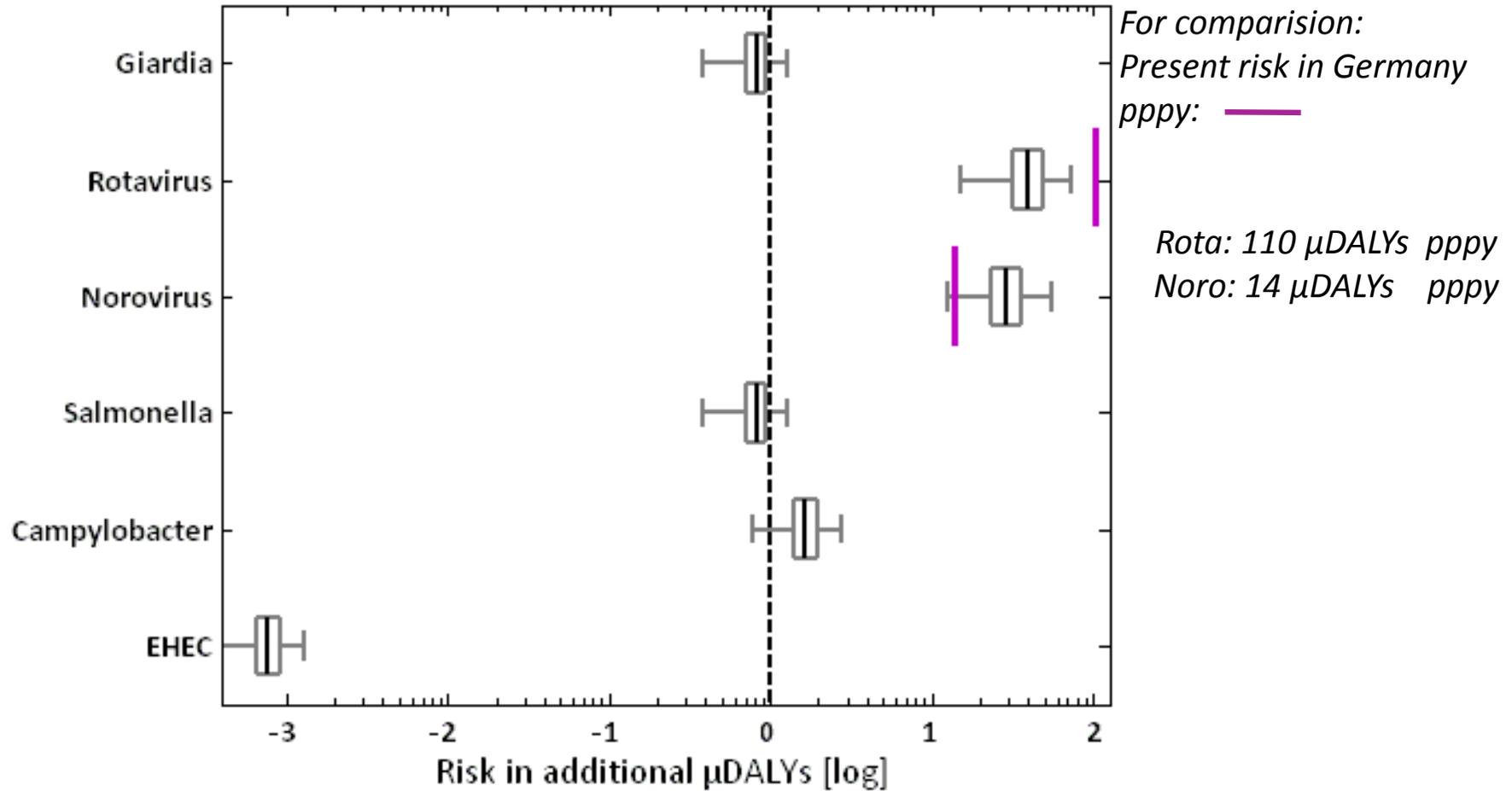


Risk estimate

Model: QMRA

Risk for fieldworkers

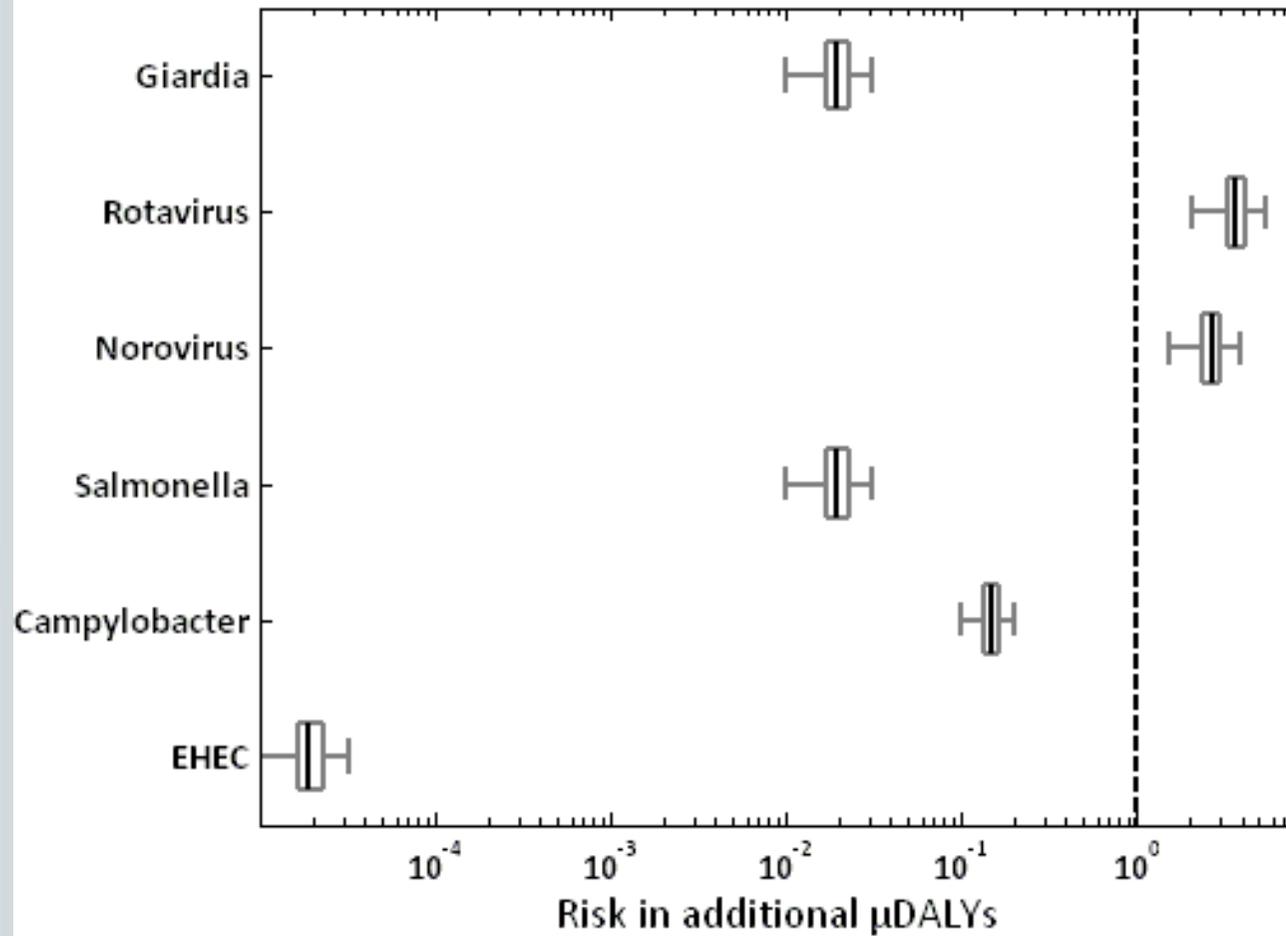
Annual risk of infection in μ DALYs
(fieldworker scenario)



WHO standard = 1 μ DALY

Risk for nearby residents

Annual risk of infection in μ DALYs
(Nearby residents)



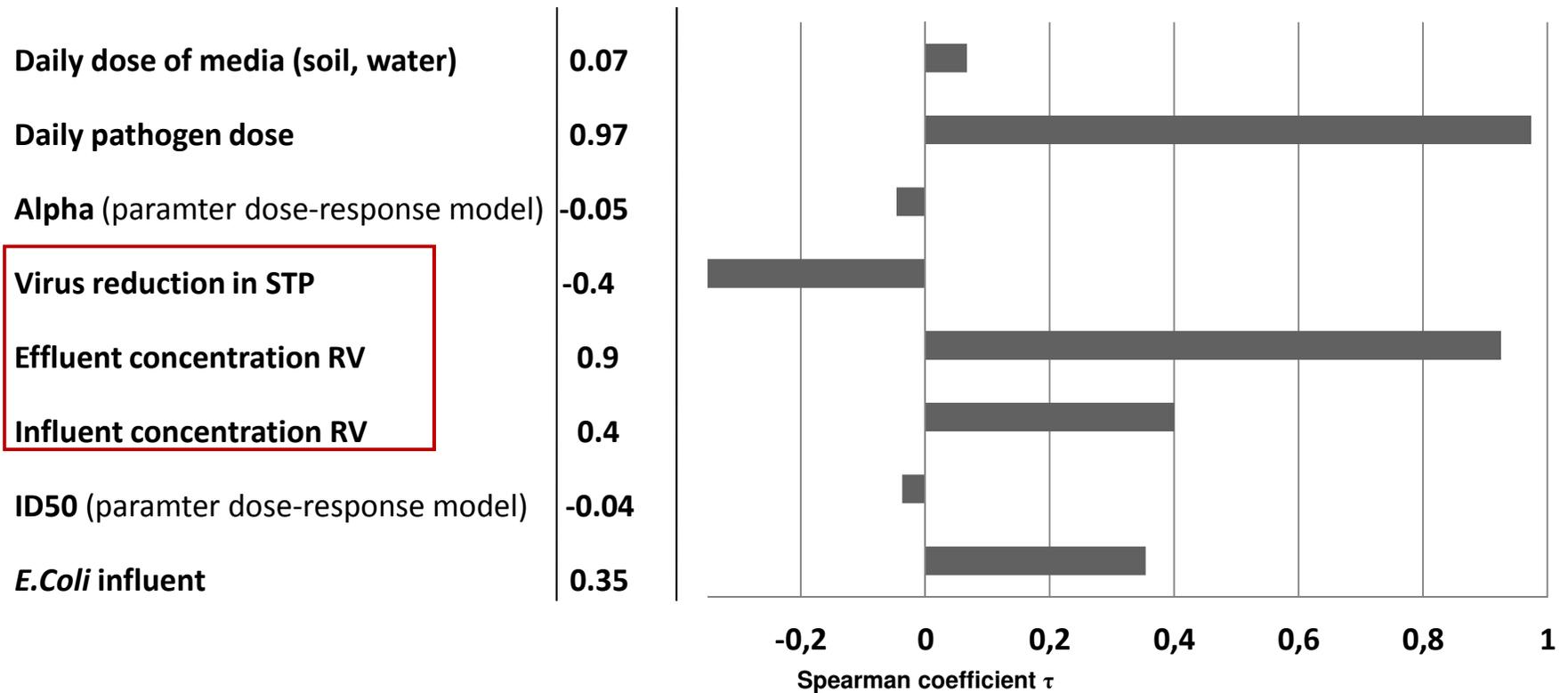
For comparison:
Present risk in Germany pppy:

Rota: 110 μ DALYs pppy

Noro: 14 μ DALYs pppy

WHO standard = 1 μ DALY

Sensitivity analysis for QMRA (Rotavirus)



Influence of pathogen concentrations > variability of susceptibility and amount of media exposure

Conclusion on hygienic risks

Evaluation

- EHEC is not of concern
- Bacterial and parasites infections are very close or below to tolerable levels
- Risk resulting from viruses exceed the tolerable level of 1 μ DALY (WHO)
- An additional log reduction of 1.5 log units necessary for WHO standards

Limitations

- Based on literature values
- effluent only, sludge not assessed

General conclusion

- Hazards of highest priority could be identified
- Study can be used as a first step towards an overall risk-based management
- Definition of tolerable level is crucial

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