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PATHOGEN AND HEALTH RISKS FROM FLOODING

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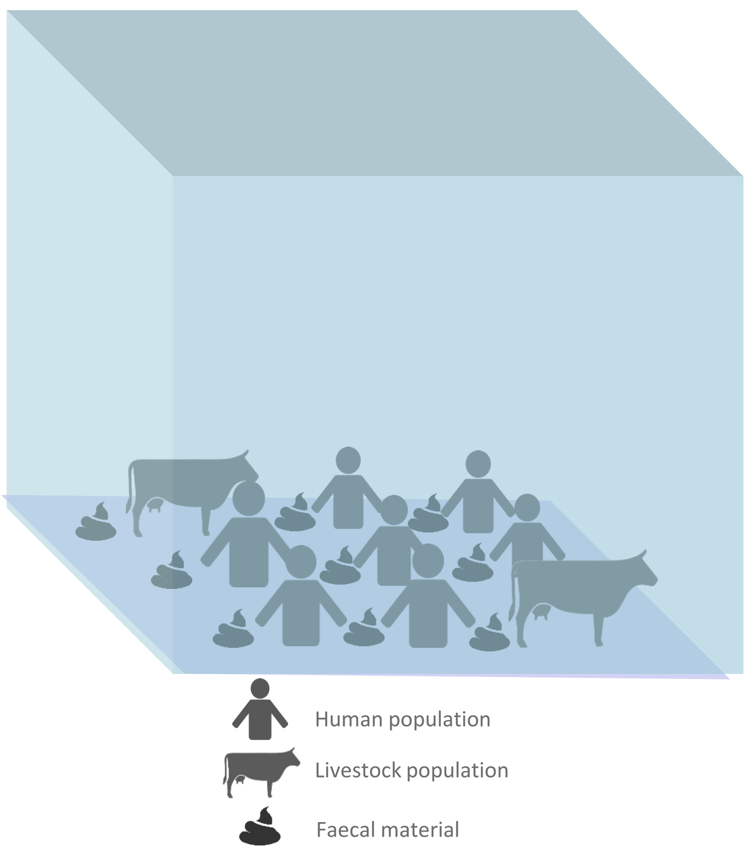
1. INTRODUCTION

High severity floods are often associated with an increased incidence of enteric disease compared to low severity floods. The purpose of this study was to investigate the infectivity of pathogenic microorganism in floodwater associated with flood severity as represented by flood depth. The organisms investigated in this study were *Escherichia Coli, Campylobacter, Cryptosporidium, Giardia*, and enteroviruses which are major waterborne pathogens originating from faecal material which cause intestinal disease potentially dispersed in floodwater.

2. METHODOLOGY

Framework for concentration of pathogen in floodwater



When flooding occurs, it is assumed that:

- The region is instantaneously and evenly flooded at the same flood depth throughout the region, and the floodwater contained in the region remains stagnant at its maximum level for the specified duration.
- Pathogens from the accumulation of faeces in latrines and livestock centres disperse homogeneously into the whole volume of floodwater.
- Livestock are washed off by the flood

STEP 1: Contribution from existing faecal material before flooding event

Amount of pathogen from latrines/ livestock centres = Human/ livestock population x Faecal production per day x Period of survival in faeces x Concentration of pathogen per gram of faeces

Pathogen content in floodwater = [Amount of pathogen from latrines x Amount of pathogen from livestock centres] ÷ Floodwater volume (Area x Flood depth)

STEP 2: Contribution from faecal load input during flooding event

Pathogen load input into floodwater per day, C = [Human faecal production per person per day x Population size x % of population affected x Concentration of pathogen per gram of faeces ÷ Floodwater volume]

Pathogen content in floodwater from the daily faecal load input, C_day = C x exp [-first-order decay rate x Time in days]

Pathogen content in floodwater =

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C2(1)=C_day(1);
for i = 2:1:length(time)
    C2(i) = C2(i-1)+C_day(i);
end
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STEP 3: Total amount of pathogen in floodwater = STEP 1 + STEP 2

Framework for infection risk from floodwater ingestion

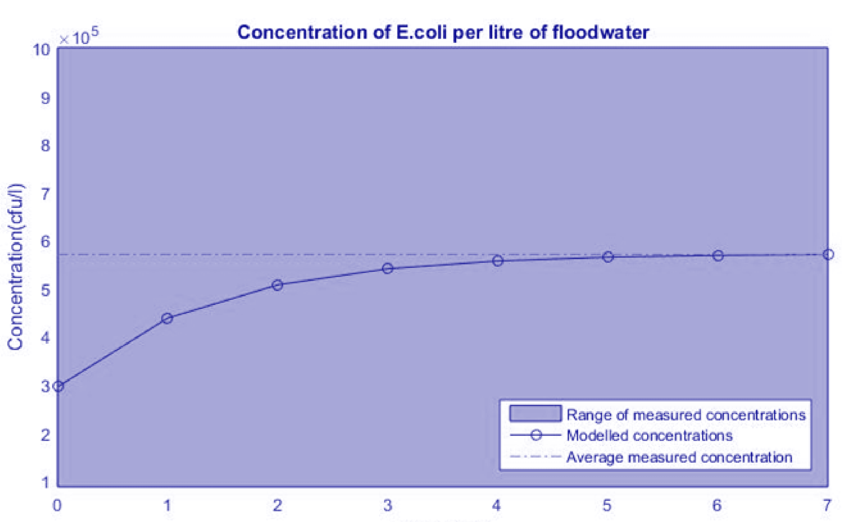
Infection risks were calculated using quantitative microbial risk assessment (QMRA) techniques which incorporated the framework predictions for concentrations of pathogens in floodwater.

3. VALIDATION OF FRAMEWORK

The reliability of the framework was tested using reported pathogen concentrations measured during a flood event in The Hague, and an epidemiological study of enteric disease occurrence during flooding events in Hanoi, Vietnam.

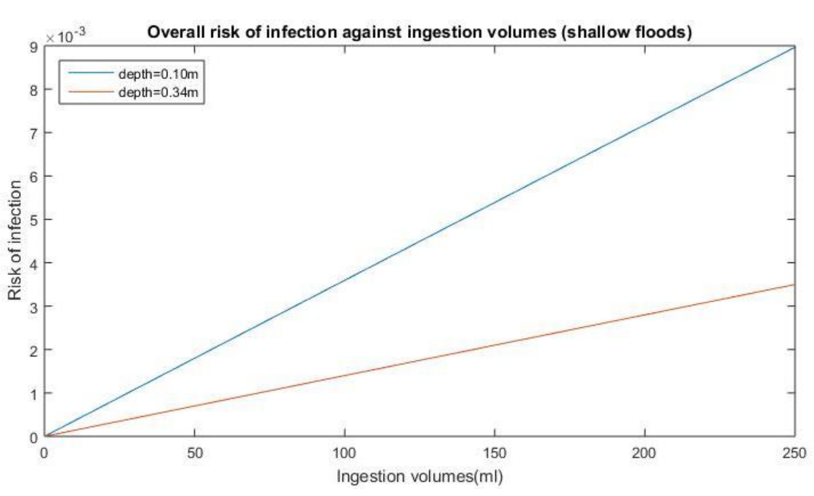
Validity Check 1: The Hague

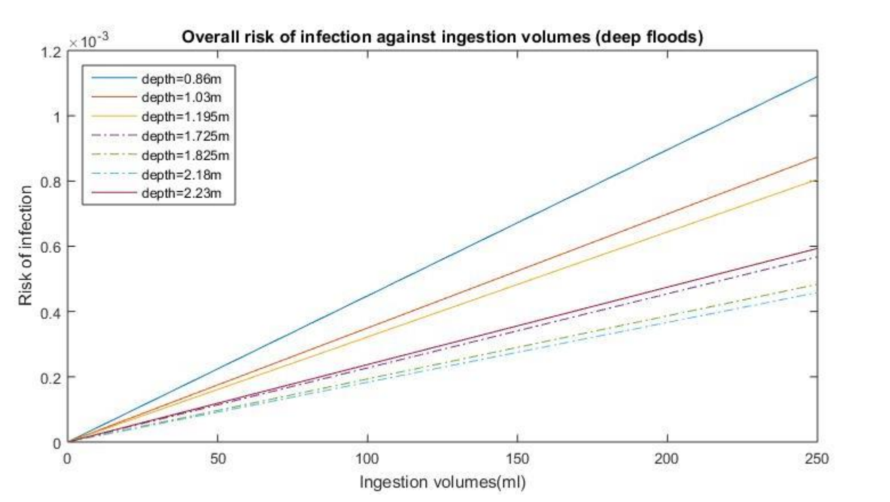
The predicted *E. coli* concentrations were within the range of measured values. (Veldhuis et al, 2010)



Validity Check 2: Hanoi, Vietnam

The computed infection ratios were generally within the range of reported values obtained from the health statistical date (Hong, 2004) except for the deep floods: 1.725m, 1.825m, and 2.18m

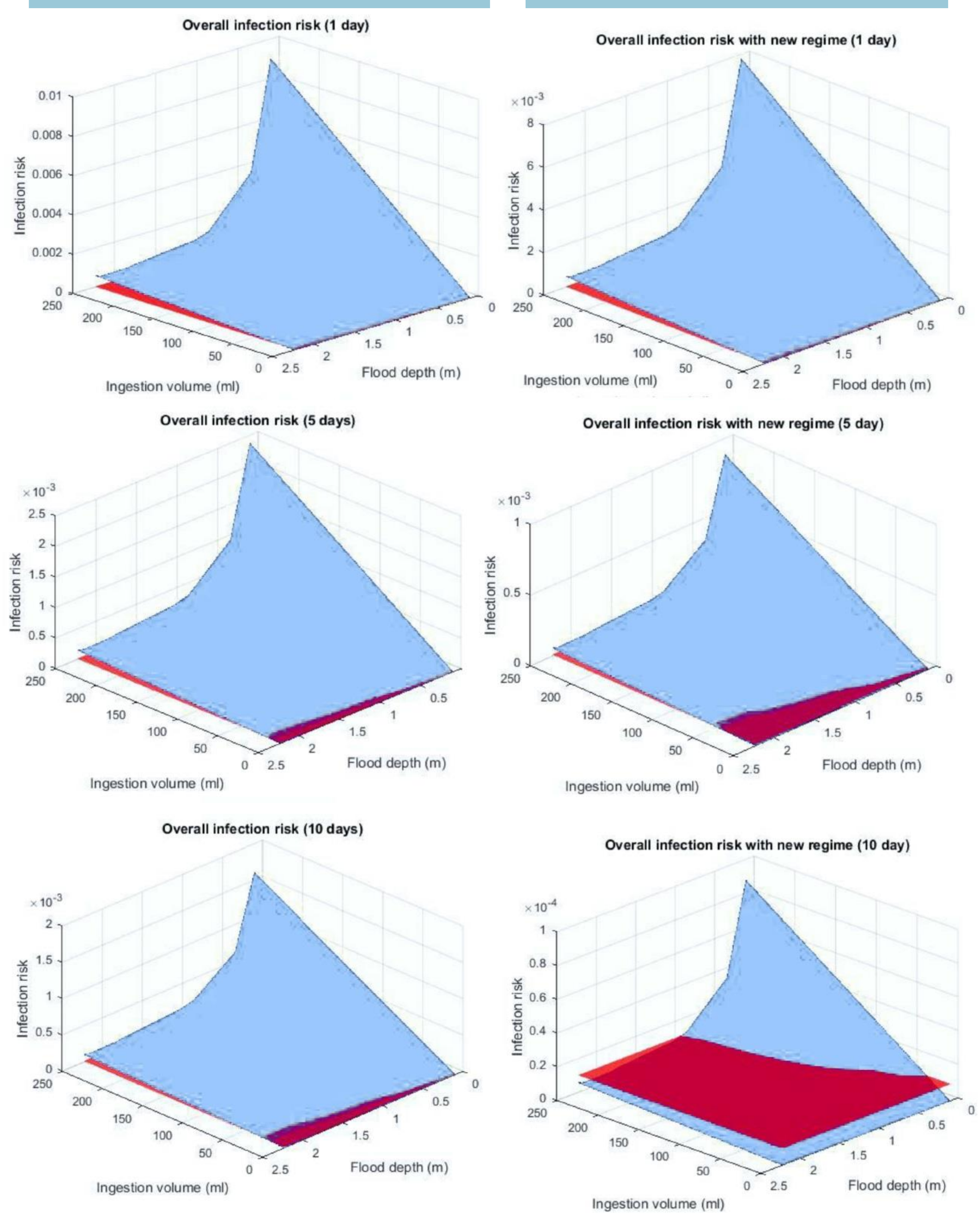




4. INFECTION RISKS

From the infection risks obtained for nine independent flood events of different depths in Hanoi, the risks were further analysed to investigate their severity based on acceptable risk threshold for drinking water by WHO which is 10^{-5} (WHO, 2001). The threshold was represented by a red intersecting slice.

	Without faeces capturing regime during flooding	With faeces capturing regime during flooding (Step 2 disregarded)



5. CONCLUSION AND RECOMMENDATIONS

- The apparent increase in pathogen infection rates recorded in high severity floods may be influenced by secondary factors linked to sanitary management and drinking water provision associated with population displacement rather than due to exposure to contaminated floodwater.
- The infectivity of floodwater could be reduced to an acceptable level after a few days of flooding by adopting a faeces capturing regime during flooding which would help eliminate the residual risks from the faecal load input during flooding.
- The methodology can be applied in future works to improve understanding of the mechanisms and primary transmission routes of infection from enteric pathogens during flooding events to better target resources, education, and remedial strategies to protect human health.

ACKNOWLEDGEMENT

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