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The birds did it!

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Protecting Human Health

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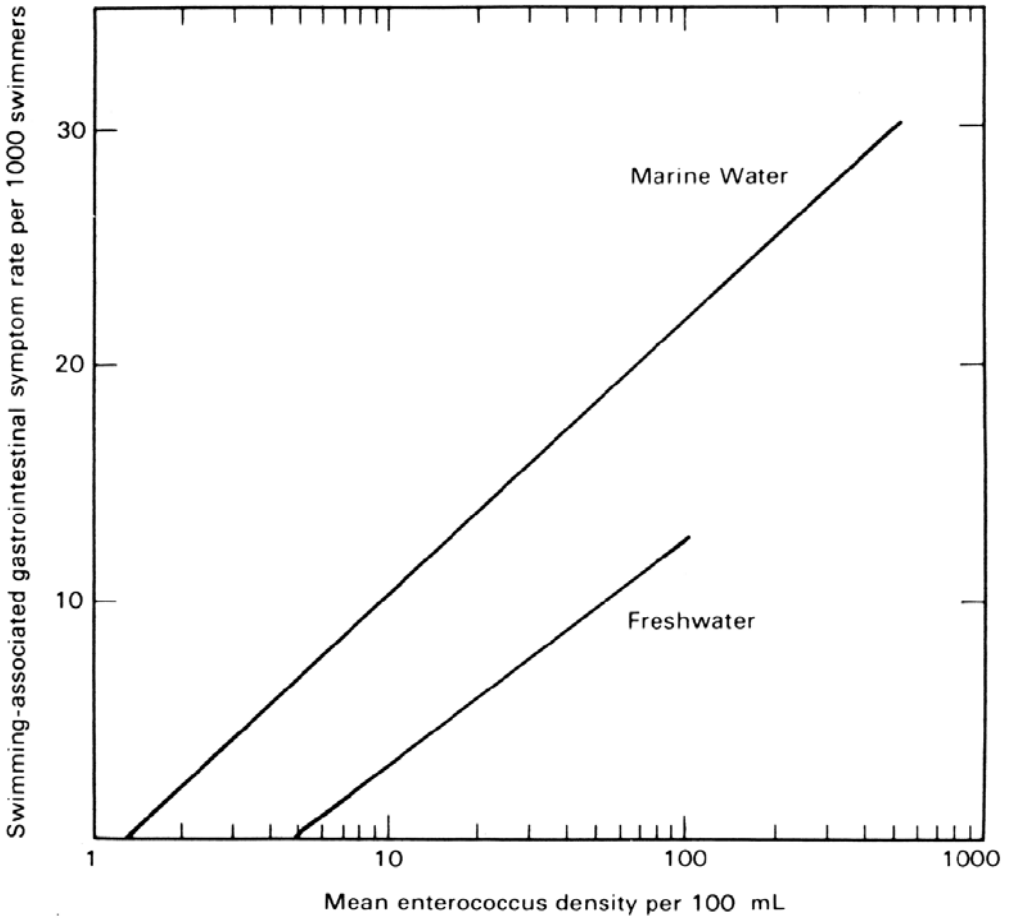

Figure 9. Marine and freshwater criteria for swimming-associated gastrointestinal illness and water quality using enterococci to measure the water quality. (Marine data obtained from Table 7, Reference 6.)

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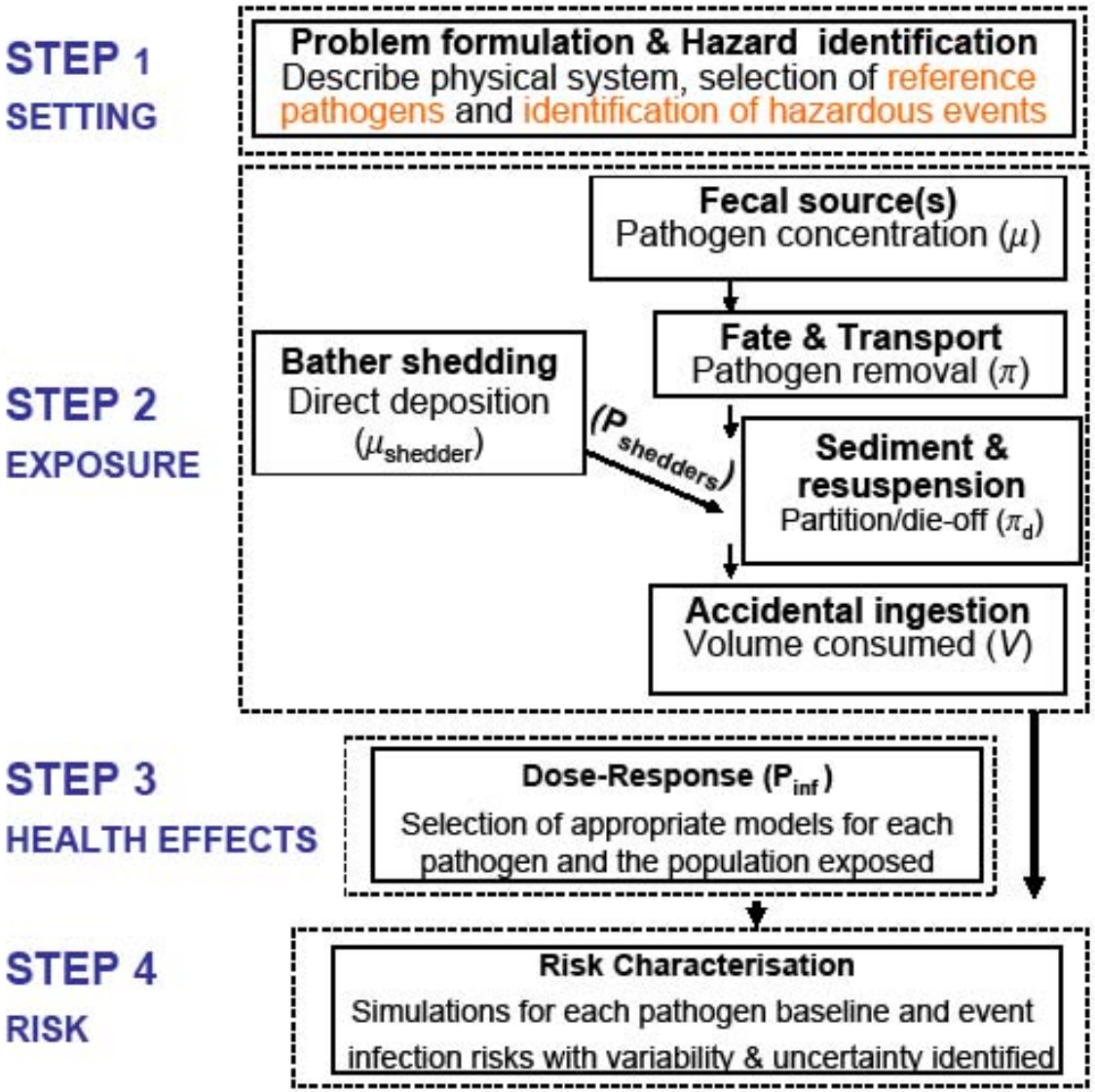
Question

Is the risk of swimming-associated gastrointestial illness from non-sewage impacted waters different than the risk from sewage impacted waters?

Approach: Quantitative Microbial Risk Assessment (QMRA)



1. Setting: Reference Pathogens

Sewage:

Norovirus
Giardia
Campylobacter
Cryptosporidium
Salmonella

Gulls:

Campylobacter
Salmonella

2. Exposure

For a bathing water enterococci concentration of 104 cfu/100mL, the pathogen dose from seagulls is calculated as:

$$\mu_{sp}^{s} = \frac{C_{ENT} * F^{s}}{R_{ENT}^{s} * 100} * R_{sp}^{s} * p^{s} * I^{s} * V$$

where

S is the source

C_{ENT} is the surfzone concentration of ENT using culture method (cfu/100mL)

F^s is the fraction of total ENT from source s

R_{ENT}^{s} is the ratio of the count of ENT to the mass of feces for gulls and human shedders (cfu/g) or to the volume of sewage (cfu/L)

V is the volume of water ingested (mL)

R_{sp}^{s} is the ratio of the count of pathogen species to the mass of feces for gulls and human shedders (cfu/g) or to the volume of sewage (cfu/L)

p^s is the fraction of human-infectious pathogen strains from source s

I_{sp}^{s} is the infection rate in population of source s

Parameter	S	Units	Distribution	Reference
Ratio of ENT to source R^s_{ENT}	Sw	cfu/L	Uniform $a = 1E7 \quad b = 1E8$	(Tschobanoglous et al., 2003)
	G	cfu/g	Uniform $a = 1E6 \quad b = 1E8$	(Fogarty et al., 2003; Haack et al., 2003)
Ratio of *C.jejuni* to source (R^s_{Cj})	Sw	cfu/L	NA	NA
	G*	cfu/g	Uniform $a = 2E3 \quad b = 1E6$	(Lévesque et al., 2000)
Ratio of *Salmonella spp* to source (R^s_S)	Sw	cfu/L	Uniform $a = 3E0 \quad b = 1E3$	(Karine Lemarchand, 2003)
	G	cfu/g	Uniform $a = 2E2 \quad b = 1E9$	(Lévesque et al., 2000)
Ratio of *Cryptosporidium spp* to source (R^s_c)	Sw	oocysts/L	Uniform $a = 5E-1 \quad b = 4E4$	(Rose et al., 2004)
	G	oocysts/g	NA	NA
Ratio of *Giardia spp* to source (R^s_G)	Sw	cysts/L	Uniform $a = 7E0 \quad b = 1E4$	(Rose et al., 2004)
	G	cysts/g	NA	NA
Ratio of *Norovirus* to source (R^s_N)	Sw	genome/L	Uniform $a = 9E2 \quad b = 3E7$	(Haramoto et al., 2006; Katayama et al., 2008)

*C. spp. **Assumed same as *C. jejuni* ***C. parvum*

3. Health Effects

Pathogen	Units	Dose-Response	Reference
Campylobacter jejuni	cfu	Adult Beta-Poisson $P_{inf} = 1 - {}_1F_1(\alpha, \alpha+\beta, -\mu) = 1 - \sum_{n=0}^{\infty} \frac{(\alpha)_n}{(\alpha+\beta)_n} \frac{(-\mu)^n}{n!}$ $\alpha = 0.145 \quad B = 7.59$ $P_{ill\|inf} = 0.2$	(Black et al., 1988) (Teunis et al., 2005)
Salmonella Bareilly	cfu	Gompertz $P_{ill} = 1 - \exp(-\exp(-\ln(a) + b\ln(u)))$ $\ln(a) = 11.68 \quad b = 0.82$	(Coleman and Marks, 1998; Coleman et al., 2004; Coleman and Marks, 2000: Soller JA et al., 2007)
Cryptosporidium spp	oocysts	exponential $P_{inf} = 1 - e^{-E(r)\mu}$ $E(r) = 0.09$ $P_{ill\|inf} = 0.7$	(EPA 2005)
Giardia spp	cysts	exponential $P_{inf} = 1 - e^{-E(r)\mu}$ $E(r) = 0.0199$ $P_{ill\|inf} = 0.9$	(Perz et al., 1998; Rose et al., 1991)
Norovirus	genomes	$P_{inf} = 1 - {}_2F_1(\alpha, \frac{u(1-a)}{a}, \alpha+\beta, -\frac{-a}{1-a})$ $\alpha = 0.04 \quad a = 0.0001 \quad \beta = 0.055$ $P_{ill\|inf} = 1 - (1+\eta\mu)^{-r}$ $\eta = 2.55E-3 \quad r = -0.086$	(Teunis and Havelaar, 2000)

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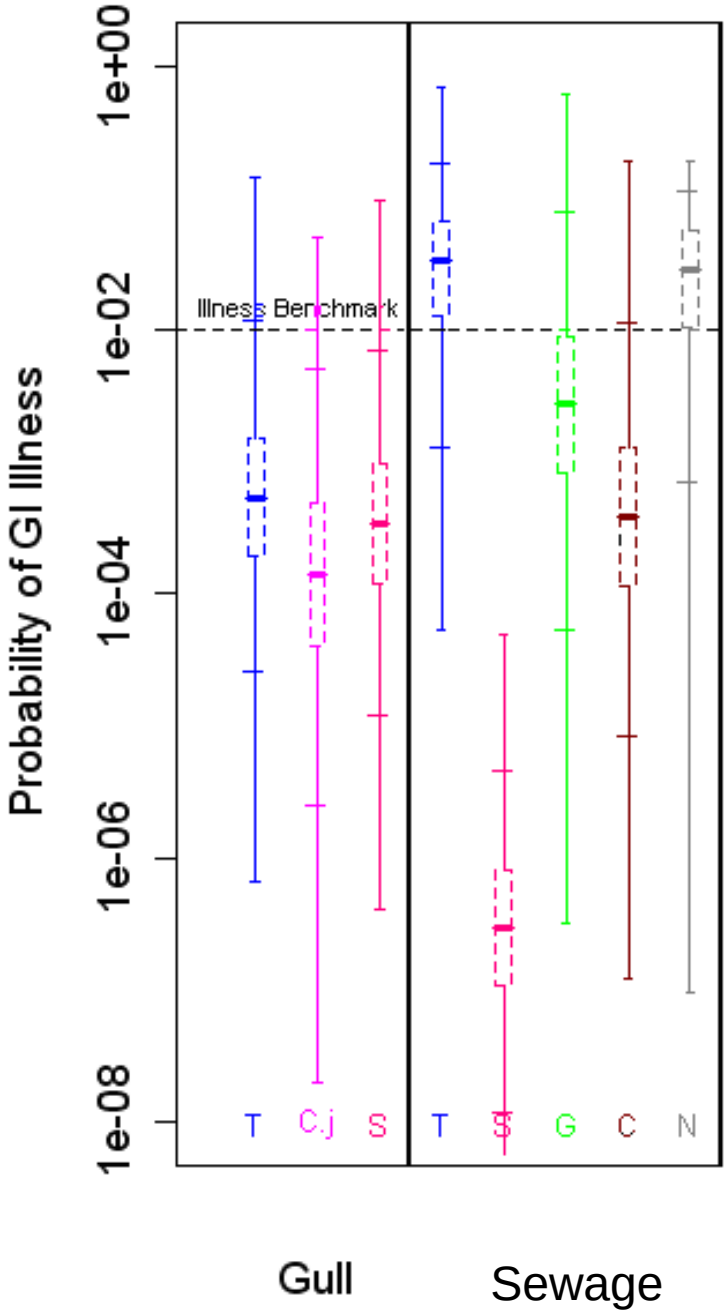
Results



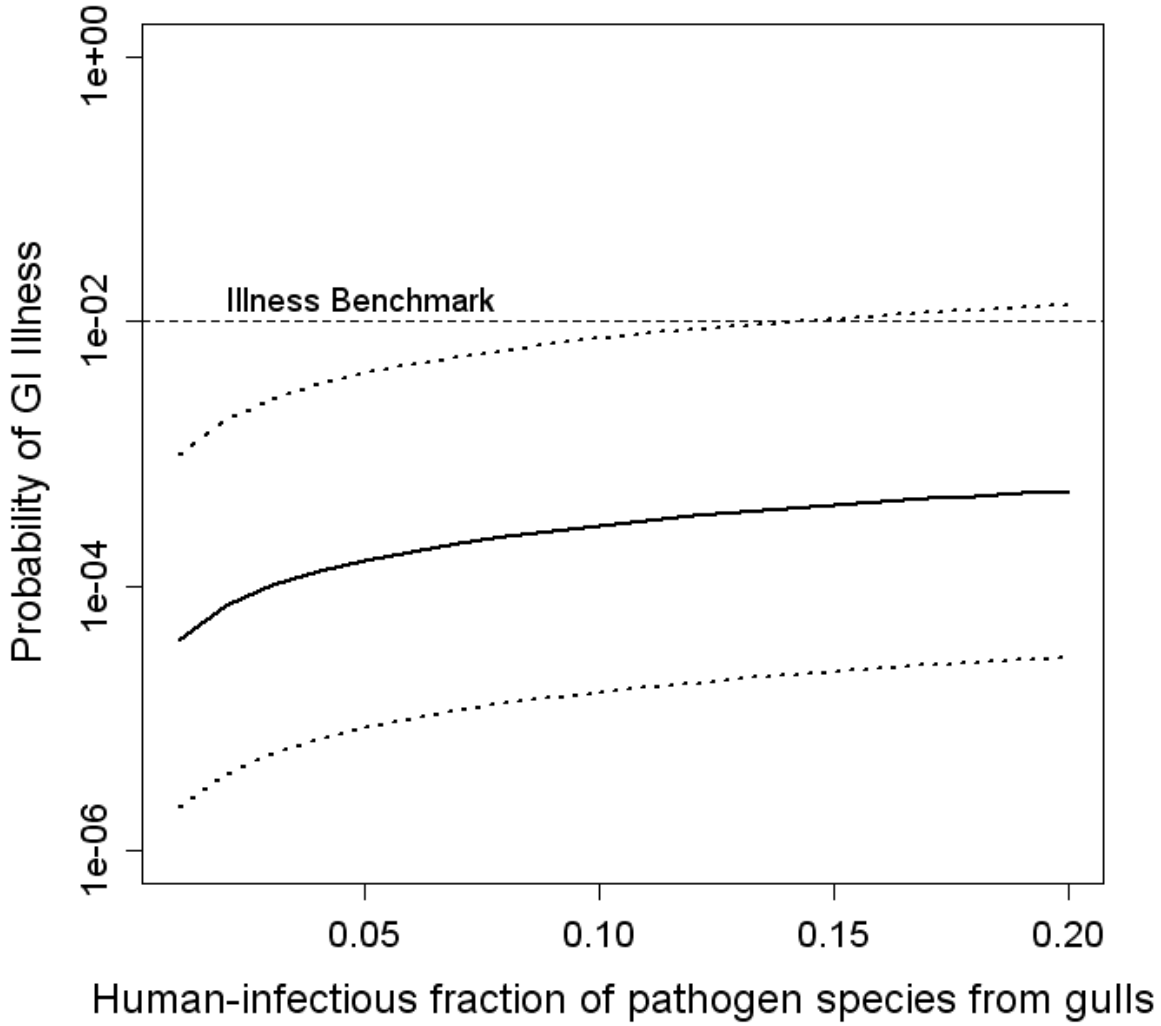
Total	T
Campylobacter jejuni	C.j
Salmonella bareilly	S
Giardia spp.	G
Cryptosporidium spp.	C
Norovirus	N

Assuming:

Fresh Contamination

104 CFU/100mL ENT

Sensitivity analysis:
Probability of GI illness vs changes in the assumed fraction of gull *Campylobacter* strains that are human infectious



Conclusions

- Using seagulls as an example non-sewage source, the upper 95% CI probability of illness from ingestion of water containing fresh gull feces at 104 cfu/100mL ENT is greater than the illness benchmark of 0.01
  - Assuming that 20% of total *Campylobacter* and *Salmonella* strains from gulls are human infectious
- Risk estimate is sensitive to the fraction of human infectious pathogens in animal feces
- Given the high level of uncertainty in predicting the probability of illness using QMRA, exclusively seagull impacted water may not be significantly lower in risk than sewage impacted water

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- The pathogen uncertainty is common with many animal sources of fecal contamination; hence, it is important that future research focus on specifying pathogen densities to allow comparison of risk estimates from epidemiologic studies with QMRA, which may ultimately allow risk characterization from unstudied sources of fecal contamination at recreational beaches.

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Thank you