

EPIDEMIOLOGY STUDIES OF SWIMMING-ASSOCIATED ILLNESS AT BEACHES WITH NON-POINT SOURCES OF FECAL POLLUTION

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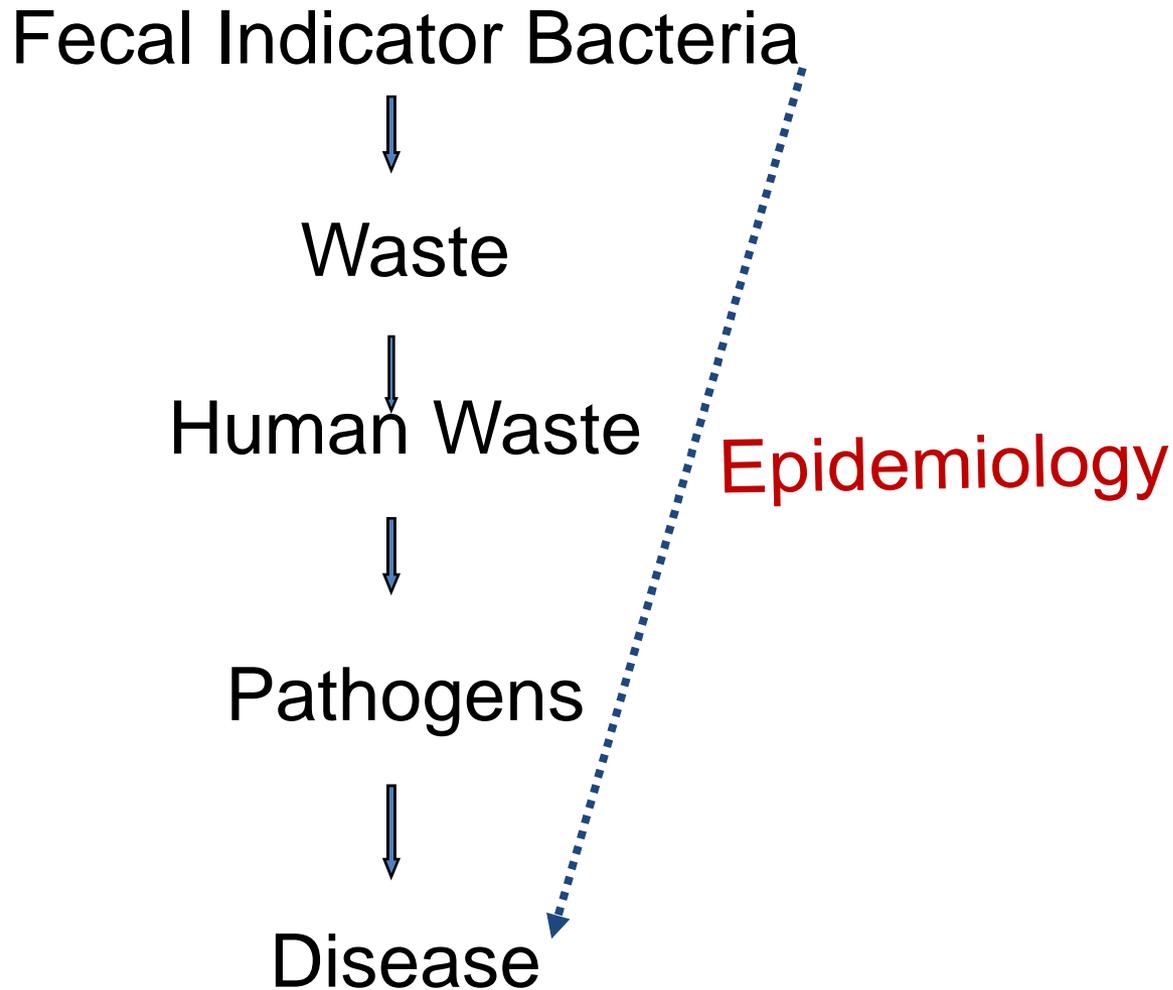
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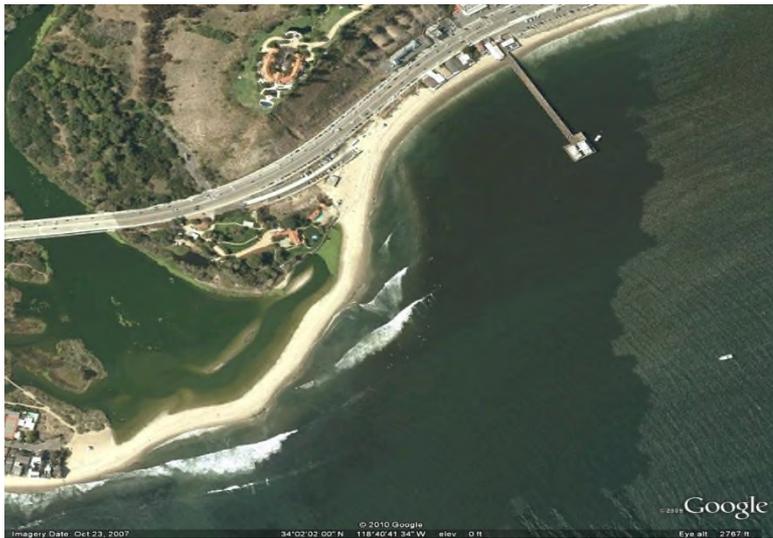
Basis for monitoring: *a chain of inference*



Non-point source beaches

- Most past epidemiology studies focused on beaches impacted by point sources
 - High risk wastewater effluent
 - Verified relationship between FIB and illness
- Non-point source is a big issue nationwide
 - Huge investment has been made to resolve sewage impacts
- We conducted epidemiology studies at non-point source beaches
 - Elevated illness in swimmers compared to non-swimmers?
 - FIB correlated with illness?

Beaches



General approach

- Enroll swimmer and non-swimmers at the beach
 - Follow up in 2 weeks for illness
- Collect water quality data same day/location as enrollment
 - Analyze for FIB
- Compare illness between swimmers and non-swimmers
 - Correlate illness with FIB levels

NUMBER OF PARTICIPANTS

	Swimmers	Non-swimmers	Total
Doheny	5940	3585	9525
Avalon	4256	1672	6165
Malibu	3689	1857	5540
Mission Bay	4971	3742	8797

SYMPTOMS MEASURED

GASTROINTESTINAL

Nausea

Vomiting

Diarrhea

Cramps

Highly Credible Gastrointestinal
Illness 1 (HCGI-1)

HCGI-2

HCGI-3

DERMATOLOGICAL

Skin rash

Infected scrapes or wounds

RESPIRATORY

Cough

Cough with phlegm

Nasal congestion

Sore throat

Significant respiratory
disease (SRD)

NON-SPECIFIC

Fever

Chills

Earache

Ear discharge

Eye irritation

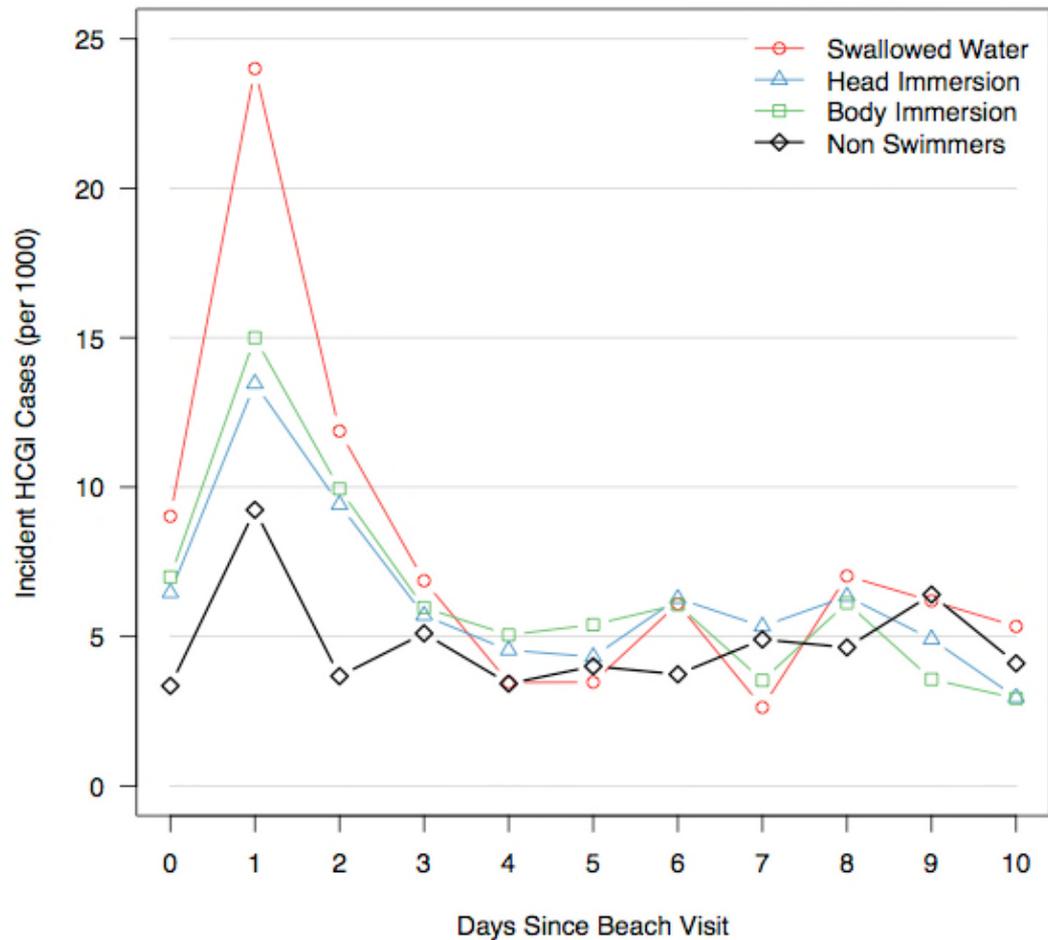
Doheny State Beach

- Source:
 - Lagoon (berm closes or opens)



- Illness:

- increase in HCGI incidents in swimmers vs. non-swimmers
- Increases with more water exposure



- Relationship

- Odds ratio: Probability of illness increases with FIB levels for swimmer who swallowed water

- berm status as effect modifier

Berm Status	OR [95% CI]
Berm Open	1.94 [1.23,3.05]
Berm Closed	1.29 [0.88,1.88]
Combined	1.52 [1.12,2.06]

Avalon Beach



- Source: leaking sewage via groundwater discharge
- Illness: Increased HCGI incidents in swimmer vs. non-swimmer
 - if groundwater discharge is high
- Relationship: FIB levels correlated with HCGI risk
 - if groundwater discharge is high

Groundwater discharge	OR [95% CI]
High	1.85 [1.06, 3.23]
Low	0.77 [0.42, 1.42]
Combined	1.26 [0.81,1.97]

Mission Bay



- Source: Extensive remediation effort prior to epidemiology study
- Illness: Observed very little HCGI illness
- Relationship: FIB did not predict health risk

Culture-based FIB monitoring

- In epidemiology study, FIB data from the same day of water exposure is used to predict illness
- In reality: FIB data from the day before water exposure is used to predict illness



Reality check

(Doheny HCGI-3 odds ratio lagged comparison)

- No association between the lagged FIB (i.e. reality) and illness
 - Even with swallow water and berm open

	OR [95% CI]
EPA 1600	1.94 [1.23,3.05]
qPCR	1.95 [1.05,3.59]
EPA 1600 (Lagged 1 day)	1.86 [0.67,5.20]

Take home

- If you don't know your source, FIB may give you faulty information
 - Investing in source identification is important
- Site-specific criteria are an option at some non-point source beaches
 - Making sure no human source
- Rapid methods may be appropriate for variable beaches
 - Unnecessary for always good or always bad beaches
 - Inappropriate if monitored infrequently



Thank you!

	<u>Method</u>	<u>Investigator</u>
Traditional Indicator Bacteria		
Enterococcus	Idexx	SCCWRP
Enterococcus	MF	SCCWRP
Fecal Coliform	Idexx	SCCWRP
Fecal Coliform	MF	SCCWRP
Total Coliform	Idexx	SCCWRP
Total Coliform	MF	SCCWRP
Rapid Methods		
Enterococcus	QPCR	EPA
Enterococcus	QPCR	Noble
Enterococcus	TMA	Moore
Enterococcus	IMS	Jay
E. coli	QPCR	Shanks
E. coli	QPCR	Noble
E. coli	IMS	Bushon
E. coli	IMS	Jay
Enterococcus	IMS	Bushon
Enterococcus	Raptor	Harwood
Enterococcus	QPCR	Noble
	Narrow	
Virus		
Adenovirus	QPCR	Sobsey
Enterovirus	QPCR	Stewart
Norovirus	QPCR	Stewart
Norovirus	QPCR	Sobsey
Polyomavirus	QPCR	Harwood
Polyomavirus	PCR	Harwood
HAV	QPCR	Fuhrman

	<u>Method</u>	<u>Investigator</u>
Phage		
Phage +/-	Culture	Stewart
Phage +/-	Culture	Sobsey
Rapid phage	Antibody	Sobsey
Marker Genes		
Bacteroides	QPCR	EPA
Bacteroides theta	QPCR	Noble
Bacteroides theta	QPCR	EPA
Human Bacteroides (HF183)	QPCR	Field
Human Bacteroides (HF183)	QPCR	Wuertz
Human Bacteroides (HF183, HF134, HumM19)	QPCR	Shanks
B. dorei	PCR/QPCR	Shanks
B. stericoris	PCR	Shanks
B. uniformis	QPCR	Shanks
C. perfringens	QPCR	Shanks
Enterococcus ESP gene	QPCR	Scott
E. coli virulence gene	QPCR	Sadowsky
Phylochip		Anderson
Other Bacteria		
Methanogens	QPCR	Ufnar
Legionella	QPCR	Gast
Staphylococcus aureus	Culture	Goodwin
Staphylococcus aureus	QPCR	Goodwin

OTHER INDICATOR SUMMARY

- No other indicators, or combination of indicators consistently worked better than *Enterococcus* across three beaches
 - F+ phage slightly outperformed *Enterococcus* at the two beaches it was measured
 - There were three human *Bacteroides* derivatives that outperformed *Enterococcus* at Avalon
 - None of the combination indicators consistently had a higher odds ratio than EPA1600, but the detection score indicator was significant at both Avalon and Doheny and had the lowest odds ratio variance among any of the indicators