Wet Weather Epidemiology Study

Photo: Paul Fisher / Surfline.com
Problem Statement

- Most beach water quality problems in dry weather have been addressed in So Cal

- Wet weather is more problematic
  - Bacteria exceedences are regional, not local
  - Cost of compliance is estimated in the $billions

- Not clear whether there is a health risk
  - Epidemiology studies all conducted in the summer
Our Study Questions

- Is surfing associated with an increased risk of illness?

- Is illness risk greater when surfing following wet weather compared to dry weather?

- What is the association between *Enterococcus* and illness following wet weather events?

- What level of *Enterococcus* corresponds to the same risk of illness as current water quality objectives?
Our Study Answers

- There is an increased risk of illness associated with surfing.
- Illness risk is greater when surfing following wet weather compared to dry weather.
- There is an association between *Enterococcus* and illness following wet weather.
- The illness risk is lower than *Enterococcus* quality objectives would predict.
Study Approach

- Recruited 650 surfers across any San Diego County beach
  - Daily surfing activity and 12 health symptoms

- More than 33,000 days of follow-up and 10,000 surf sessions
  - Compare illness rates when surfing vs. not surfing
  - Compare illness rates surfing in dry vs. wet weather

- Enterococcus relationships at 2 beaches
  - Ocean Beach and Tourmaline Surfing Park
  - Collect beach water quality daily
  - Collect discharge during storm events
Cumulative Incidence of Gastrointestinal Illness

- Not Surfing: 18.0 episodes per 1000 people
- Surfing, Winter Dry: 25.0 episodes per 1000 people
- Surfing, Winter Wet: 30.2 episodes per 1000 people

Excess Risk: 12.2 per 1000
USEPA Risk: 32 per 1000
Gastrointestinal Illness, Wet Weather

Excess Risk GI per 1,000 people (± 95% CI)

Enterococcus (CFU per 100 mL)
Next Steps

- Enhanced source identification
- Ability to extrapolate
  - Quantitative Microbial Risk Assessment (QMRA)
- Economics analysis
  - Cost benefit scenarios
- Time-specific thresholds
  - Wet weather criteria/TMDL targets based on allowable risk
Pathogen and Human Marker Detection Frequency in Storm Runoff Discharges

<table>
<thead>
<tr>
<th></th>
<th>Norovirus</th>
<th>Adenovirus</th>
<th>Enterovirus</th>
<th>Campylobacter</th>
<th>Salmonella</th>
<th>Human Marker (HF183)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>San Diego River</strong></td>
<td>96%</td>
<td>22%</td>
<td>0%</td>
<td>100%</td>
<td>25%</td>
<td>86%</td>
</tr>
<tr>
<td><strong>Tourmaline Creek</strong></td>
<td>72%</td>
<td>9%</td>
<td>0%</td>
<td>45%</td>
<td>9.5%</td>
<td>95%</td>
</tr>
</tbody>
</table>
Excess Risk in Wet Weather vs. Unexposed

Varying Wet Weather Window Definition
Days Since Rain >0.1in / 24hr

Excess cases per 1,000 people

Primary Analysis

0 Days
0–1 Days
0–2 Days
0–3 Days
0–4 Days
0–5 Days
GI illness rates By Storm Size

Unadjusted IRR

<table>
<thead>
<tr>
<th>Storm Size</th>
<th>Incidence per 1000 days</th>
</tr>
</thead>
<tbody>
<tr>
<td>Unexposed</td>
<td>ref</td>
</tr>
<tr>
<td>Dry Weather</td>
<td>6.0</td>
</tr>
<tr>
<td>Small Storm</td>
<td>8.4</td>
</tr>
<tr>
<td>Medium Storm</td>
<td>5.5</td>
</tr>
<tr>
<td>Large Storm</td>
<td>19.5</td>
</tr>
</tbody>
</table>

Incident Episodes: 90, 116, 7, 14, 10

Days At Risk: 14,884, 13,769, 1,264, 1,261, 512