A Norovirus Outbreak Associated with Recreational Water Exposure at a Kent County Park
July, 2010

Recreational Waters and Public Health

What is a RWI?
• Waterborne disease from recreational water venues:
  – Swimming pools
  – Water parks and play areas
  – Hot tubs
  – Water fountains
  – Oceans, lakes, and rivers
What is a RWI?

- Transmitted by swallowing contaminated water
- Breathing contaminated aerosols or mists
- Bodily contact with contaminated water
- Usually diarrheal in nature
- Most vulnerable are children, pregnant women, and those with compromised immune systems

What is a RWI?

- Can cause a variety of illnesses:
  - Gastrointestinal
  - Swimmer’s ear
  - Legionaire’s disease
  - Folliculitis
  - Assorted eye irritations
  - Wound infections
  - Respiratory illnesses

RWI “bugs”

- Bacteria:
  - E. coli O157:H7
  - Shigella
  - Legionella
  - Pseudomonas
- Protozoa:
  - Giardia
  - Cryptosporidium
- Viruses:
  - Norovirus
  - Hepatitis A
How are RWIs Spread?

- Bathers themselves

How are RWIs Spread?

- Frequent exposures, high bather densities, and heavy use by diaper-aged children increase the likelihood of fecal contamination (Caster & Beach, 2004)
- Even in the absence of a fecal accident, the average bather sheds 0.14 grams of fecal material and children may shed up to 10 grams (Caster & Beach, 2004)

How are RWIs Spread?

- In addition, natural areas can be contaminated with microbes from combined/storm sewer overflows, illicit discharges, animal waste, and water runoff following rainfall (Centers for Disease Control).
- Fertilizer runoff from lawns can also contribute to algal blooms
How are RWIs Spread?/Beach litter

- Discarding of food related items
  - Attracts wildlife to beach
  - Increases fecal material on beach by birds/animals
  - Leads to beach closures due to high coliform counts

- Study in Lake County, Illinois of DNA of *E. coli* on their beaches
  - Found that 63% was from fecal material from gulls
  - One gram of gull feces contains 325,000,000 *E. coli* bacteria
Sandcastles and Children

Great Lakes Beach Closings and Advisories (Days) 1993 - 2009
(Source: Alliance for the Great Lakes)

Recreational Water Illness Outbreaks, United States*

*2007-2008 data are preliminary
(CDC, unpublished data)

Beach Closings/Advisories 1993-2009
(Source: Alliance for the Great Lakes)
Why the Increase after 1996?

- Increase awareness/recognition of public
- Which leads to an increase of reporting to local health authorities
- Which leads to increased surveillance by local health authorities AND
- There may just be a true increase of incidents and outbreaks

RWI Stats (source Centers for Disease Control)

- From 1995-2004, 255 documented RWI outbreaks
- 53% were of gastrointestinal variety
- Of which 56% from treated venues
- 62% caused by Cryptosporidium, 2.6% Giardia

Microbe Durability

- How long it takes to kill each microbe at 1 ppm free chlorine at a pH of 7.2-7.6:
  - E. coli ..................................<1 minute
  - Hepatitis A virus ........................16 minutes
  - Giardia, noroviruses\ldots\ldots.. 45 minutes
  - Cryptosporidium ......................15,300 minutes
Recreational Water Monitoring

Escherichia coli (E. coli) bacteria
- Used as an indicator organism
- Found in the gastrointestinal tract of all warm-blooded animals
- Do not necessarily present a direct public health risk, HOWEVER
- Suggest the likely presence of harmful pathogenic organisms
  - E. coli O157:H7
  - Salmonella
  - Shigella
  - Noroviruses
  - Enteroviruses
  - Cryptosporidium
  - Giardia

Recreational Water Monitoring
- Operators of public “treated” venues must collect at least one water sample for bacteriological analysis each quarter…
- The standard must be such that each sample be absent for the presence of total coliforms and E. coli.
- Venues that are “contaminated” must close temporarily and follow contamination protocols to prior to reopening
Recreational Water Monitoring

- Natural Bathing Beaches
  - Lakeshore beaches are sampled for E. coli at least weekly by lakeshore local or district health departments.
  - Some inland lake beaches are also monitored by local jurisdictions (local budgets may vary).
- Michigan Water Quality Standard is 300 cfu of E. coli per 100 ml sample for total body contact.
  - Based on geometric mean of at least 3 samples per beach.

Recreational Water Monitoring

- The issue with beach water sampling is that beaches are closed based on yesterday's samples.
- Beaches are also re-opened based on yesterday's samples.
- Rapid testing methods are presently experimental.
- Some beaches formulate predictive models to forecast beach health without sampling and having to wait 24 hours for results.

Recreational Water Monitoring

- With public treated venues, closures for public health and safety:
  - Can be done without waiting for water sample results.
  - A treated venue must maintain a measurable residual of 1 ppm free chlorine or 2 ppm bromine.
  - Water clarity must be such that the bottom drains are visible at all times.
Case History

- Water park in Marietta, GA -- 1998
- Documented low chlorine readings
- 26 children became infected with *E. coli*
- several were hospitalized for months, some with dialysis, one had a stroke
- law suits were filed
- reputation, business, and image were seriously affected

Another Case History

- New York state park spray park outbreak (summer 2005)
- Cryptosporidium linked to over 3000 illnesses spread to 36 New York counties, 26 states, and two countries.
- Several individuals pursuing class action law suits
- New rules for N.Y. require disinfection, filtration and UV light supplement for all spray parks
Our park in Kent County…

• Six acre beach
• 100 acre lake (former gravel pit, not very deep)
• One of four county beaches sampled by parks personnel
• Treated spray pad
• Maintained by parks personnel
• Food concessions service
• Bathhouse with bathrooms/lavatories

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• “Ambitious project to reclaim 1,500 acres of heavily-used land for public recreation.”
• The park encompasses “rolling terrain and extensive wetlands with woods, wildlife, fish and waterfowl.”

http://www.accesskent.com/CultureLeisureAndTransit/MillenniumPark/
Aerial View of Millennium Park

Twice the size of NY’s Central Park when complete

Millennium Commission

- 1998 – KC Parks developed plan to expand Johnson Park
- Secchia Commission developed goal to raise $2,000,000 by Earth Day 2000

Peter Secchia, CEO and Chairman, Universal Forest Products, former U.S. Ambassador to Italy
Fred Meijer of Meijer Thrifty Acres

Millennium Park borders the cities of Walker, Wyoming and Grandville
Park History

• 1700s - Land was wilderness. Home to four different Indian tribes. Site of burial mound.

• Trappers and fur traders visited on their trade routes

• 1850 - Grand Rapids became a city, forest was full of sugar maples (2-3 ft diameter) that were later cut

• 1870s – became a giant quarry for gypsum and gravel

• 1950s- oil was being pumped from wells

(Kent County Parks, Green Places Newsletter, Fall/Winter 2006)

• During construction of the park, abandoned oil wells were capped and secured.

• Wells from the 1930s-1940s were secured by drilling down 1,100 feet (wells are 1,600 feet below ground) and filling the area with grout.

• There were 4 leaking wells in the lake so the MDEQ brought in a barge to cap the wells.

(Kent County Parks, Green Places Newsletter, Fall/Winter 2006)
Site of Investigation

Lake Leota

Entrance to Millennium Park Beach

Park opened July 2004

Van Andel Beach House
Beach

Six acre beach on 100 acre lake

Beach

Shelter
Splash Pad

Outbreak Timeline

Monday, July 19

• EH received phone calls from 5 groups of individuals who had visited Millennium Park on July 16, 2010.

• EH has access to the most recent surface water samples collected by Parks. Coli form levels were “below the threshold for restrictions on total body contact.”

• EH followed up with Parks to test additional water samples.

• Lake periodically receives treatment for algae (copper sulfate)

Monday, July 19 (Continued)

• HAN sent to surrounding counties

The Kent County Health Department is investigating multiple reports of gastrointestinal illness potentially associated with exposure at Millennium Park in Kent County. Should you receive any reports of gastrointestinal illness listing Millennium Park in the patient’s exposure history, please contact the Kent County Health Department at...

• Communicable Disease/Epidemiology (CD/EPI)

Unit began speaking with individuals and collecting information

• Symptoms, incubation, duration point to norovirus

• Stool specimen collection kits distributed to willing participants.
**Norovirus Refresher**

- Non-enveloped, single-stranded RNA, round structured virus.  
  5 genogroups (GI, GII, & GIV infect humans)

**Symptoms of infection may include :**
- Watery or loose diarrhea
- Vomiting
- Abdominal pain/cramps
- Nausea
- Malaise
- Low-grade fever

**Incubation Period**
- 12-48 hours

**Duration**
- 1-3 days in healthy persons, 4-6 days can occur  
  (CDC, 2011)

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**How is the virus transmitted?**

1) **Person to person**
   - Directly through fecal-oral route
   - Ingestion of aerosolized vomitus
   - Indirect exposure via fomites or contaminated environmental surfaces

2) **Food** - eating contaminated food or eating food prepared by an infected food handler

3) **Water** – Recreational and drinking water  
  (CDC, 2011)

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**Characteristics that facilitate Spread**

- **Low infectious dose as low as < 18 virus particles**

- **Asymptomatic shedding** (up to 30%). CDC revised guidelines for detection in stool from ≤ 2 weeks to average of 4 weeks. Peak is 2-5 days. Point at which no longer contagious is not known.

- **Environmentally stable** - survives ≤10 ppm chlorine, freezing, and heating to 140° F

- **Strain diversity** - multiple types = lack of cross protection

- **Short term immunity** - immunity may last only 8 weeks to 6 months so reoccurrence possible.
  
  (Updated Norovirus Guidelines, CDC, 2011)
Tuesday, July 20 – Day 2

• Results from water samples collected on Monday still below level for concern

• CD/Epi received additional calls – total of 35 individuals were reporting they were ill

• Stool specimens were received

Tuesday, July 20 - Day 2

Media receives “tip” about illnesses at park

KCHD contacted by media at 5:00 PM

Official: 'Something occurred Friday' causing 30 people at Millennium Park to get sick

Kent County officials: illnesses not linked to Millennium Park beach and splash pad

Wednesday, July 21 - Day 3

• Hundreds of phone calls received

• One individual reports mysterious blue substance being poured into lake as cause of illnesses

• A questionnaire was developed to facilitate data collection

• Zoomerang survey created for data entry
Questionnaire

- Demographic information
- Name, address, phone, age, and sex
- Date at Park and Time at Park
- Ill or Not ill
- Symptoms- Vomiting, diarrhea, or other
- Onset Date
- Recovery Date

Questions

- Visit splash pad?
- Visit Lake?
- Put head under water or swallow water?
- Visit Concession stand?
- Visit Restroom?
- Visit drinking fountain?
- Visit fishing area?
- Obtain medical attention?

Zoomerang useful for data collection, for analysis, Epi Info used

Wednesday, July 21 - Day 3

- Meeting held with County administration, EH, Parks, Health Officer, CD/Epi, to prepare media response.
- Park to remain open
- Thorough cleaning of all hard surfaces
- Splash pad would be hyperchlorinated (recirculating system)
- Stool specimens tested at KCHD Regional Lab
Wednesday, July 21 - Day 3

• All 5 specimens positive for Norovirus G1
• Media release late on July 21 with results
• Discussed testing water for norovirus with MDCH

Water Testing for Norovirus

• Validated methods are available for water only at CDC. CDC or FDA should be contacted for guidance.

• “Water can be tested for noroviruses after large volumes of water are collected (e.g., up to 100 L of water) through specially designed filters.”

• “If a water source is strongly suspected as the source of an outbreak, a sample should be obtained as early as possible and stored frozen at -4°F (-20°C)”

(Updated CDC Norovirus Guidelines, 2011)

Data Analysis

• 378 interviewed in total
• 14 questionnaires “thrown out” for insufficient data
• 362 people that were interviewed had sufficient data
**Case definition**

- Individuals were identified as a case if they developed vomiting or diarrhea within 48 hours after visiting Millennium Park.

**Secondary Cases**

- Secondary cases were defined as individuals who developed vomiting or diarrhea greater than 48 hours after their visit to the park and were epi-linked to a primary case.

- Secondary cases were also defined as those who developed vomiting or diarrhea, were epi-linked to a primary case, but did not visit the park themselves.

- 9 individuals never went to park and were secondary cases.

**Results**

- [Diagram of results]

- [Additional results text]
Total Ill Cases By Date At Park

Total ill = 267

267 + 9 epi-linked cases with no park exposure = 276 ill

Date
Number of Cases
07/08/2010 1
07/09/2010 2
07/10/2010 3
07/11/2010 4
07/12/2010 14
07/13/2010 31
07/14/2010 2
07/15/2010 2
07/16/2010 4
07/17/2010 31
07/18/2010 2
07/19/2010 2
07/20/2010 1
07/21/2010 1

Total Ill = 255 of 267

Millennium Park Visitors Ill By Date from 7/14/2010-7/17/2010

N = 332

Attack Rate = 77% (255/332)

Additional 9 ill epi-linked no park exposure =264 total ill

77% not ill

23% ill

255 ill
Millenium Park 7/14/2010-7/17/2010
Ill By Gender

- Male: 137 (54%)
- Female: 117 (46%)

N = 254 (of 255)

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Millenium Park 7/14/2010-7/17/2010 Ill By Age Group

Age Group
- <1: 4
- 1-4 years: 72
- 5-9 years: 73
- 10-19 years: 37
- 20-49 years: 62
- 50-74 years: 3

N=251 (of 255)

Age range
5mo - 67 yrs.

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Millennium Park 7/14/2010 -7/17/2010

<table>
<thead>
<tr>
<th>Incubation period</th>
<th>Cases</th>
<th>Percentage</th>
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</thead>
<tbody>
<tr>
<td>between 12 and 48 hours</td>
<td>185</td>
<td>(73%)</td>
</tr>
<tr>
<td>over 48 hours</td>
<td>70</td>
<td>(27%)</td>
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</table>

Total | 255

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### Millennium Park 7/14/2010 – 7/17/2010 By Symptoms

<table>
<thead>
<tr>
<th>Symptom</th>
<th>Number</th>
<th>Percentage</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vomiting</td>
<td>222</td>
<td>87%</td>
</tr>
<tr>
<td>Diarrhea</td>
<td>166</td>
<td>65%</td>
</tr>
<tr>
<td>Abdominal Cramps</td>
<td>26</td>
<td>10%</td>
</tr>
<tr>
<td>Fever</td>
<td>16</td>
<td>6%</td>
</tr>
<tr>
<td>Nausea</td>
<td>13</td>
<td>5%</td>
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</tbody>
</table>

Total number ill = 255

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### Incubation

**7/14/2010-7/17/2010**

- Mean: 33.4 hours
- Median: 33.0 hours
- Range: 13-48 hours

N = 185

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### Duration

**7/14/2010-7/16/2010**

- Mean Duration: 27 hours
- Median: 24 hours
- Range: 2-89 hours

N = 153

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### Date at Park

**7/14/2010 - 7/17/2010**

- Physician Visit: 7
- Hospitalized: 2

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### Millennium Park Epi Curve

**Incubation Period for those visiting 7/14/2010-7/17/2010**

N = 255

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### Decision Making Prior to Receipt of Test Results

- Based upon the knowledge-based decision that microbes would dissipate in the water, and a decreased number of illnesses after 7/16/10

**Environmental factors influencing microbe dissipation:**
- Water Temperature
- Wind
- Wave action
- Precipitation
- Ultraviolet Light

### Summary Analysis

<table>
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<th></th>
<th>OR</th>
<th>CI</th>
<th>p-val</th>
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</thead>
<tbody>
<tr>
<td><em>Splash Pad</em></td>
<td>3.7</td>
<td>(2.2-6.2)</td>
<td>0.000002</td>
</tr>
<tr>
<td><em>Head Under Water or Swallowed</em></td>
<td>8</td>
<td>(4.5-14.3)</td>
<td>0.000001</td>
</tr>
<tr>
<td><em>Lake</em></td>
<td>9.5</td>
<td>(3.3-27.6)</td>
<td>0.000002</td>
</tr>
<tr>
<td>Concession Stand</td>
<td>1.2</td>
<td>(.57-2.7)</td>
<td></td>
</tr>
<tr>
<td>Restrooms</td>
<td>1.5</td>
<td>(.89-2.5)</td>
<td></td>
</tr>
<tr>
<td>Fishing Area</td>
<td>0.5</td>
<td>(.08-3.07)</td>
<td></td>
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<tr>
<td>Drinking Fountain</td>
<td>2.42</td>
<td>(.81-7.2)</td>
<td></td>
</tr>
</tbody>
</table>

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**Note:**

- Do not know temperature of surface water - not 140°F - not hot enough to kill norovirus

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**Links:**

- [www.weather.gov/climate](http://www.weather.gov/climate)
Wind Direction

<table>
<thead>
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<th>Date</th>
<th>Direction</th>
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</thead>
<tbody>
<tr>
<td>7/14/2010</td>
<td>170</td>
</tr>
<tr>
<td>7/15/2010</td>
<td>250</td>
</tr>
<tr>
<td>7/16/2010</td>
<td>240</td>
</tr>
<tr>
<td>7/17/2010</td>
<td>300</td>
</tr>
</tbody>
</table>

Wind Direction Changed from SE to SW Direction. Water currents moved towards beach.

Precipitation

- Water quality may be influenced by rainfall (WHO, 2009).
- As rainwater washes over land it picks up pollutants and carries them to water e.g. trash, motor oil, pet waste, pesticides, fertilizer, animal droppings etc. (NRDC)
- A number of individuals reported goose droppings on the beach during their interviews.
- Gull feces contain a greater average concentration of fecal coliform bacteria, but… average fecal sample weights of geese were more than 15X higher than those of the gulls. (Aldersiso, K.A. and DeLuca, N. 1999)
- KC data showed that coliform levels were safe.
Zoonotic Transmission?

- Interspecies transmission of noroviruses has not been documented. There are strains that infect pigs (GII, GIV), cows, and mice (GIII and GV). (CDC, 2011)

- “Norovirus was discovered recently as a cause of diarrhea in dogs (GIV.2), suggesting the potential for zoonotic transmission.” (Human is GIV.1) (CDC, 2011)

Millennium Park by Date Ill and Precipitation

- UV light can prevent viruses from reproducing. (Inactivation Credit of UV radiation for Viruses, Bacteria, and protozoan (oo)cysts in Water: a review, Hijnen, W, Beerendonk, EF, Medema,GJ, 2006)

- Turbidity—the amount of suspended and colloidal solids in water must be low (clear), for UV purification to work

- At Millennium Park, the buoys were set at 5 ft, water was likely turbid

- According to CDC “Shallow, poorly circulated swimming areas, although desirable to swimmers, might pose a higher risk than well-circulated areas” (MMWR Surveillance for Water-borne Disease Outbreaks, 2005-2006)
Despite EH factors- the fact remains…. pathogenic organism was likely in water for more than a day or more, but could not prove it.

Fecal Incident

• Likely that a fecal incident occurred prior to 7/16/10 or on 7/16/10

• Norovirus has a viral load of approximately 100 billion viral copies per gram of feces (CDC, 2011)

• All though it is unknown how many people were in the lake, approximately 1900 people visited the park on 7/16/10

Conclusion

• Our finding similar to Sinclaire et al study:

  “Fecal coliforms do not always adequately reflect viral pollution of recreational water”
Is the water safe for swimming?

- Are there any guidelines on this topic?

- Literature review yielded one document:
  “it may be necessary to close implicated swimming areas for
  72 hours to prevent additional transmission”
  (Foodborne and Waterborne Gastroenteritis, Hedberg and Osterholm, 1993)

- 12-48 hour incubation period prohibits early reporting

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Natural Resources Defense Council Sued EPA

- 2006 – EPA “failed to protect beachgoers from
  waterborne diseases.” They had not updated their
  beach water quality standards in 20 years.

- 2008 – As the result of legal pressure, the EPA has
  agreed to update its water quality standards by 2012

  [Link: http://www.nrdc.org/water/oceans/ttw/titinx.asp]

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Settlement

- EPA must “conduct new health studies and swimmer
  studies”

- “Approve a water-testing method that will produce same
  day results (current tests take 24 hours or more) so beaches
  are not closed or placed under advisory until after
  beachgoers have spent a day swimming in water”

- “Fund studies to identify beach water pollution.” (In 2009,
  the source of contaminated beach water was reported
  unknown more than half the time.)

  [Link: http://www.nrdc.org/water/oceans/ttw/titinx.asp]
• “Protect beachgoers from a broader range of waterborne illnesses”

• Agreement doesn’t require local beach officials to be using rapid-water tests

• NRDC urged congress to pass the Clean Coastal Environment and Public Health Act which will “push states to begin using rapid-water tests within one year of EPA validation.”