Flint Hospital 2015 vs. 2016
What a difference a year makes.....

2015: Flint River without Corrosion Control
2016: Detroit Water with Enhanced Corrosion Control

Photographs: Zhu “Joyce” Ni, Min Tang, Pan Ji, Mariah Gnegy
1) Fourth round of lead in water testing
(led by Ms. LeeAnne Walters, Flint residents and funded by EPA)

2) A special study of Legionella and Shigella testing
(led by William Rhoads and funded by the State of Michigan)

3) Fourth round of disinfection by-product testing (led by Dr. Susan D. Richardson, a team at the University of South Carolina and funded by the EPA)

4) Flint Filter Fears
   (Sloan Foundation Research from 2011-2013)
Flint resident sampling: August 2015 - November 2016

Min Tang, Kelsey Pieper and Marc Edwards
Sampling in November 2016

Sampling organized by LeeAnne Walters and the Flint citizen science team
First draw lead in November 2016

Reduction in lead levels

Percent of home above 15 ppb

Aug.15: 17%
Mar.16: 15%
Jul.16: 9.7%
Nov.16: 6%

EPA standard: n=154
Non-detectable first draw lead

% non-detect lead (<1 ppb)

- Aug.15: 8%
- Mar.16: 36%
- Jul.16: 44%
- Nov.16: 57%

Reduction in lead levels

n=154
First draw iron concentrations

<table>
<thead>
<tr>
<th>Month</th>
<th>% above EPA iron (0.3 ppm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aug.15</td>
<td>14%</td>
</tr>
<tr>
<td>Mar.16</td>
<td>14%</td>
</tr>
<tr>
<td>Jul.16</td>
<td>9%</td>
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<td>Nov.16</td>
<td>5%</td>
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n=154
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Conclusions

1. It is likely that Flint is meeting the lead action level
   • However, this is not an approved LCR sampling pool

2. Lead and iron levels have continued to decrease since July 2016

3. Residents should use lead filters or bottled water until further notice from the State or EPA
Water Quality Testing in Homes

June 2016 – 30 Homes

- Tested water
  - Metals (Pb, Fe, Al, Cu)
  - Chemistry (Cl₂, pH, temperature)
  - *Legionella*
- Extensive tank cleaning
  - Flush, drain, scour out sediment
- Re-tested water
Key Conclusions Regarding Legionella

- **Legionella** colonization rates were very low relative to levels of concern
  - 2 of 30 homes had culturable *L. pneumophila* serogroup 1, that was MAb 2 positive
- Chlorine levels reaching homes were relatively high
Follow-Up Sampling in One of the Homes

<table>
<thead>
<tr>
<th>Culture <em>L. pneumophila</em> serogroup 1, MAb2 positive?</th>
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<tbody>
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<td>Kitchen Tap:</td>
</tr>
<tr>
<td>Cold Water</td>
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<tr>
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BQL = “Below quantification limit” (i.e., present, but in very low concentration)
BD = “Below detection” (i.e., none detected)
Follow-Up Sampling in One of the Homes

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Possible Explanations for Improved Water Quality with Respect to *Legionella*

- Amount of time back on Detroit water
  - Generally improved water quality stability
  - Chlorine residuals throughout system
  - Reduced iron
- Seasonality
  - Cooler weather = cooler water in mains
- Increased water heater temperature
  - Hot water temperature = 53.7 °C in August 2016

Reflects high quality distribution system operations overseen by EPA and MDEQ
The Saginaw & Genesee County *Shigella* Outbreak

Owen Strom, William Rhoads, Emily Garner, Amy Pruden and Marc Edwards
2016 Outbreak of *Shigella*

- Saginaw & Genesee counties
- Starting March 1, 2016
- 180 cases as of November 14th
- Public concern that drinking water could be the source of the outbreak.
- MDHHS and CDC investigating
Shigella

- Bacteria
- Symptoms
  - Severe Diarrhea
  - Abdominal pain
  - Fever

http://www.cdc.gov/shigella/index.html
Detection in Water

• 30 Homes sampled June 2016
2016 Outbreak of *Shigella*

- Saginaw & Genesee counties
- Starting March 1, 2016
- 180 cases as of November 14th
- Public concern that drinking water could be the source of the outbreak.
- MDHHS and CDC investigating
Detection in Water

• Samples from June 2016

• 5 types of samples
  • 1 Liter
  • Hot, cold, stagnant, flushed, main

• Kitchen faucet, shower head, and hose bib

• Total of 150 samples tested
Results

• Tested Presence/Absence of DNA from common pathogenic *Shigella*

• Endpoint polymerase chain reaction (PCR)
  • Identifies DNA from once living or dead *Shigella*
  • Sensitive to the four pathogenic *Shigella* species

• All 150 samples **negative**

*Matrix spike to confirm inhibition was not present.*
CDC and MDHHS Investigation

• Initial Conclusion 1
  • “Shigella does NOT appear to be spreading through a drinking water system”

• Initial Conclusion 2
  • “Shigella bacteria appear to be spreading in the community from person to person”

• Initial Conclusion 3
  • “The Outbreak is slowing down”
The 2\textsuperscript{nd} “fourth party” study funded by EPA

Is There a Disinfection By-Product Problem in Flint?

Joshua M. Allen
Amy A. Cuthbertson, Susana Y. Kimura, Hannah K. Liberatore,
Meghan E. Franco, Susan D. Richardson
Key Question: Are there chemicals/DBPs present at unusual levels?
Strategy

• Compare Flint hot and cold water to water of other cities → Anything unusual?
• **Other cities:**
  - Detroit (uses chlorine and same source water [Lake Huron] as Flint)
  - Grovetown, GA (surface water system using chlorine)
  - Lyons, GA (groundwater system using chlorine)
Quantitative Methods

- **VOCs (including THM4)**
  - Purge and Trap
  - GC-MS

- **Iodo-Trihalomethanes**
  - Haloacetonitriles
  - Haloketones
  - Tri-Haloaldehydes
  - Mono, di-Halonitromethanes
  - Liquid-liquid extraction (LLE) with 2 mL MTBE
  - Selected Ion Monitoring (SIM) GC-MS

- **Iodoacetic acids (IAAs)**
  - Haloacetamides (HAms)
  - Tribromoacetonitrile (TBAN)
  - Trihalonitromethanes (THNMs)
  - LLE with 5 mL MTBE times 3 and concentrated under N$_2$
  - HAmS
  - TBAN
  - THNMs
  - IAA
  - Diazomethane derivatization
  - SIM GC-MS
  - GC-MS/MS

- **Mono, di-Haloaldehydes**
  - PFBHA derivatization
  - LLE with 10 mL hexane times 3 and concentrated under N$_2$
  - GC/HRT-MS
Conclusions

Flint appears to have no DBP issues when compared to other cities

- Increased THM levels from cold to hot water seen in all cases, but below the 80 µg/L regulatory limit.
- Unregulated DBPs detected were found at low to trace levels.
- Comprehensive analyses results showed Detroit and Flint water is very similar in composition.
- Preliminary data shows all iodo-acids to be < 10 ng/L in Flint and Detroit.
Much of Flint No Longer Believes Filtered Water is Safe

Two dinners with Flint residents   12/15/2017
Water filters could increase bacteria in Flint water, researchers say

“…. it's important to let water run through the filter for at least one minute to let the bacteria that has built up in the activated carbon filter disperse. Other tactics for clearing the bacteria from the water include boiling water or using a UV disinfection lamp.”
I located my letter from the Wayne State research team. The name of the bacteria is the Enterobacteriaceae family DNA. The presence of this type of bacteria is what I am also concerned about.
Impact of Water Chemistry, Pipe Material and Stagnation on the Building Plumbing Microbiome

Pan Ji, Jeffrey Parks, Marc A. Edwards, Amy Pruden
Over 62% water samples in our survey (not Michigan) were *Enterobacteriaceae* positive.

Pan Ji. Field drinking water survey at 5 water utilities across U.S. 16S rRNA amplicon sequencing data and 16S qPCR data.
Estimated absolute abundance of *Enterobacteriaceae* family in the positive samples.

Pan Ji. Field drinking water survey at 5 water utilities across U.S. 16S rRNA amplicon sequencing data and 16S qPCR data
Numbers related to the positive detects box plot (gene copies/L)

<table>
<thead>
<tr>
<th></th>
<th>Min</th>
<th>25%</th>
<th>Median</th>
<th>Mean</th>
<th>75%</th>
<th>Max</th>
</tr>
</thead>
<tbody>
<tr>
<td>Influent</td>
<td>1670</td>
<td>5690</td>
<td>8830</td>
<td>27930</td>
<td>14150</td>
<td>316000</td>
</tr>
<tr>
<td>8-hr stagnation</td>
<td>192</td>
<td>3930</td>
<td>10700</td>
<td>28170</td>
<td>29700</td>
<td>1050000</td>
</tr>
</tbody>
</table>

“Normal” = 0 to 1,000,000 gene copies/L