Water Study Update and Open House

5:30-7:30pm
Wednesday, December 14th, 2016
at the Flint Public Library in the first floor General Reading Room.

Agenda

1. Introductions

Flint Area Community Health and Environment Partnership (FACHEP)

NSF Point-of-Use filter study

2. FACHEP Panel

3. FACHEP Update and preliminary results

Questions & Answer

4. NSF Filter Study

Questions & Answer

5. Closing Remarks

Project Funding

RAPID: Chemical treatment efficiency of point-of-use filters deployed in Flint, Michigan. National Science Foundation, Award Number:1633013; Shawn McElmurry (PI), Susan Masten (co-I); Wayne State University

RAPID: Assessing microbiological quality across point-of-use filters deployed in Flint, Michigan. National Science Foundation, Award Number:1632974; Nancy Love (PI), Terese Olson (co-PI); University of Michigan

RAPID: Microbiome Analysis of Household Biofilm Specimens in Flint, Michigan. National Science Foundation, Award Number:1639066; Paul Kilgore (PI), Mark Zervos (co-PI), Geehan Sulyeman (co-I); Wayne State University

Flint Area Community Health and Environment Partnership (FACHEP) – PHASE II McElmurry, S.P. (PI); Kilgore, P. (co-PI); Sobeck, J. ; Seeger, M.; Zervos, M.; Sullivan, L.; Pauli, B. L.; Love, N.G.; Masten, S. (+17 other investigators). Michigan Department of Health and Human Services (MDHHS) Award #20163753-00

McElmurry, S.P.; Miller, C.J.; Pitts, D.K.; Sackey, D.J.; Seeger, M.; Masten, S.J.; Hanna-Attisha, M. Rapid Response to Contaminants in Flint Drinking Water. National Institute of Health; National Institute of Environmental Health Sciences. Award # 1R21ES027199-01

Flint Area Community Health and Environment Partnership (FACHEP)

Objectives:

- Reduce the occurrence of Legionellosis-associated cases, hospitalizations and deaths to levels at or below those seen in years prior to 2014.
- Define potential sources of *Legionella* exposure in residential households and high-risk facilities.
- Develop evidence-based approaches for reducing exposure to *Legionella* among Flint residents.
- Build on the strengths of residents and strengthen capacity in existing institutions to address common threats to the health and wellbeing of the community.

FACHEP Team

Shawn McElmurry, PhD, PE; **Yongli Zhang**, PhD., Civil & Environmental Engineering, Wayne State University (WSU)
Paul Kilgore, MD, MPH, Pharmacy Practice, WSU.
Matt Seeger, PhD, Communications, WSU.
Mark Zervos, MD, Mary Perri, Division Infectious Diseases, Henry Ford Health System.
Laura Sullivan, PhD, Mechanical Engineering, Kettering
Ben Pauli, PhD., Liberal Studies, Kettering.
Joanne Sobeck, PhD; **Joanne Smith-Darden**, PhD; **Poco Kernsmith**, PhD; **Susan Lebold**, JD, LMSW; **Tam E. Perry**, PhD; School of Social Work, WSU

Jessica Robbins-Ruszkowski, PhD, Institute of Gerontology, Department of Anthropology, WSU
Michele Swanson, PhD, Microbiology and Immunology, University of Michigan (UM)
Nancy Love, PhD, PE, Civil & Environmental Engineering, UM
Rick Sadler, PhD, Family Medicine, Michigan State University (MSU)
David Mushinski, PhD, Economics, Colorado State University (CSU)
Sammy Zahran, PhD, Center for Disaster and Risk Analysis, CSU
Susan Masten, PhD, PE, Civil & Environmental Engineering, MSU

Kettering University · Colorado State University · University of Michigan · Michigan State University · Henry Ford Health System · Wayne State

FACHEP Sampling

Locations Sampled:

1. Hot water heater
2. Hot shower water
3. Shower arm swab
4. Cold water from primary sink (5 min flush)
5. Point-of-use filters

Enhanced water quality assessment

Anions (chloride, sulfate, etc.)
Cations (calcium, iron, etc.)
Nutrients (phosphorus, nitrogen)
Organic Carbon (total, assimilable, etc.)
Free chlorine
Others (pH, temperature, etc.)
Bacterial cell counts
Legionella (culturable and PCR)
DNA sequence-based typing and whole-genome sequencing

Rigorous sampling design

- Statistically robust (284 homes in Flint)
- Comparison/control groups
- Internal and external quality control

Water Filter Study: Assessing microbiological and chemical quality across point-of-use filters deployed in Flint, Michigan

Coordinated project goals: Evaluate the microbiological and chemical quality of water applied to and produced by filters deployed in Flint, Michigan. The work completed will generate results that inform development of a Best Practices document for managing filter use in Flint and beyond.

University of Michigan · Michigan State University · Wayne State · Henry Ford Health System · UT Health The University of Toledo · National Science Foundation

Panel Discussion

Miranda Murray - Behavioral Health Specialist

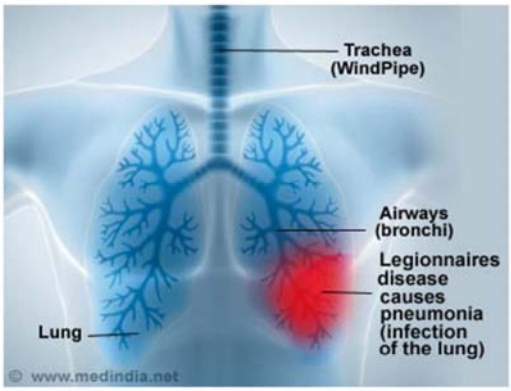
Quincy Murphy - Community Navigator

Shawn Jones - Environmental Sampling

Shayne Hodges - Environmental Sampling

Legionellosis = Legionnaires' Disease

- Legionnaires' disease in America is not new---This disease has affected Americans for at least 50 years.
- Legionnaires' disease is a form of severe pneumonia. A mild form of Legionellosis is called Pontiac Fever.
- Legionnaires' disease is a lung disease that interferes with people's ability to breath.



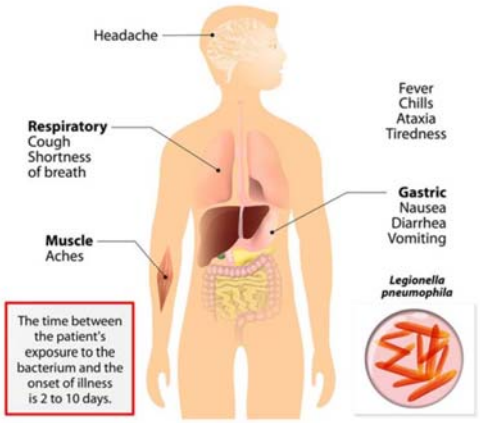
Potential Sources of Legionella Germs

- Freshwater lakes, rivers, ponds and streams.
- Improperly maintained water systems.
- Institutional air conditioners, hot tubs, spas, steam rooms, misters, and decorative fountains.

Who may be most at risk for Legionnaires' disease?

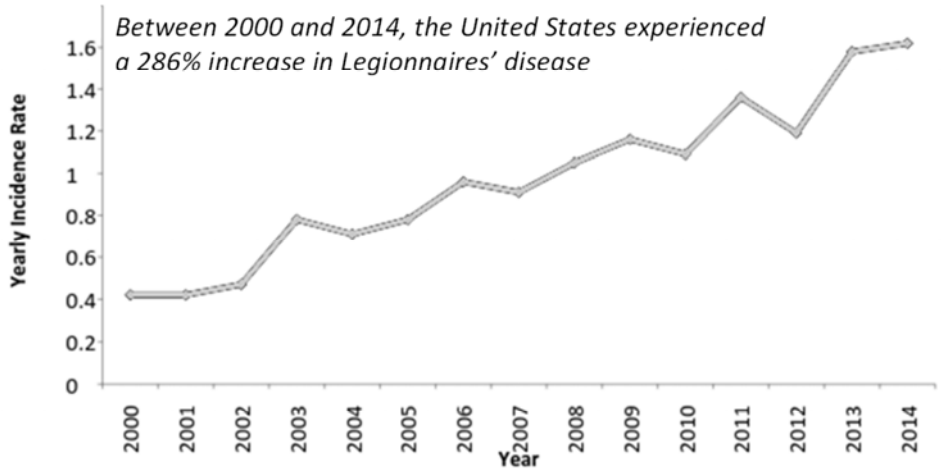
- Anyone of age 50 years and older.
- Current or former smokers.
- Heavy drinkers.
- Anyone suffering from a chronic illness such as diabetes, lung disease, cancer, kidney or liver disease.
- Anyone with reduced immunity (e.g., organ transplant patients or those on special medications like steroids)

Early Warning Signs of Legionnaires' Disease



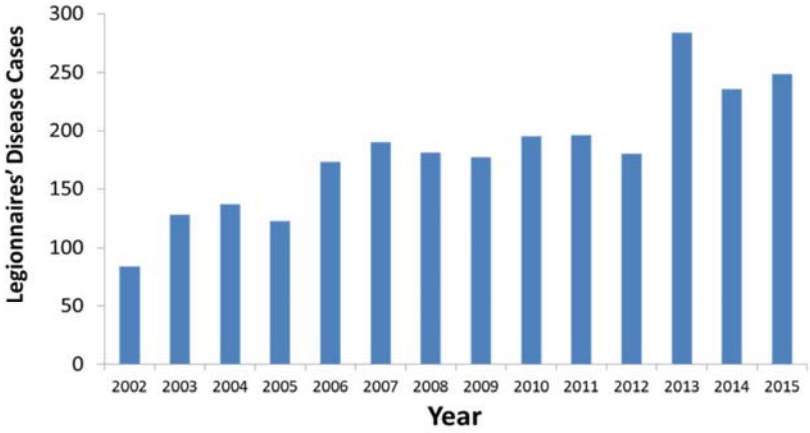
- Feeling generally unwell (malaise)
- Reduced appetite (anorexia)
- Headache, muscle aches and pains
- Body chills or shivering
- High fever (up to 102—105° F)
- Cough (dry cough or with phlegm or blood)
- Shortness of breath
- Chest pain
- Abdominal pain, nausea/vomiting, diarrhea
- Confusion, other mental status changes

National Trends in Legionnaires' Disease



Data Source * US Centers for Disease Control and Prevention, National Notifiable Diseases Surveillance System (incidence rates per 100,000 persons)

Legionnaires' Disease in Michigan



Source: Michigan Disease Surveillance System, Michigan Department of Health & Human Services

Have Legionnaires' Disease Cases Been Reported in Michigan?

All Cases in Michigan by Year

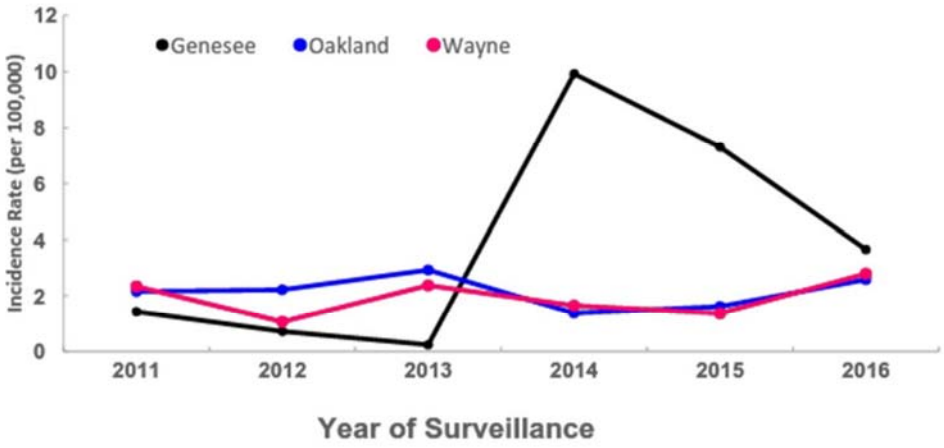
Total Cases Reported In Each Of The Last 5 Years***				
2012	2013	2014	2015	2016
186	284	236	264	**292** (Jan 1 to Dec 10)

Cases Reported In The Last 4 Weeks**			
5	0	3	5

Cases reported last four weeks in Michigan	Year to date total, Genesee County (GC)
13	15*

Data current as of weekly surveillance reported (through December 10, 2016)

Legionellosis Incidence in Genesee, Oakland and Wayne County, 2011--2016



How your doctor can help

See your doctor at a clinic or hospital right away—do not wait until your symptoms get worse

Talk with your doctor about your current health conditions, travel history and medications.

Talk with your doctor about possible tests for Legionnaires' disease.

See your doctor for regular check-ups

Increase your healthy behaviors

Stop smoking, get your pneumococcal and/or influenza vaccinations

How do Doctors Diagnose Legionnaires' Disease?

- To clearly identify Legionnaires' disease, doctors collect urine and sputum to run specific laboratory tests.
- A simple urine test will identify Legionnaires' disease in 60% to 80% of suspected cases; this test will be negative 99% of the time when *Legionella pneumophila* "serogroup 1" bacteria are absent.
- Testing phlegm (sputum) by growing *Legionella* in culture can also help identify patients who may have Legionellosis.

Preliminary Survey Results: Addressing Immediate Needs of Flint Residents

- Of the 187 household members that were interviewed, 29% requested specific assistance with accessing resources.
- 29% reported needing assistance with basic needs, utility bills and transportation; almost one-quarter of requests related to home conditions and needed home repair; 13% requested assistance with addressing stress, anxiety, depression, anger and grief, and 12% identified financial challenges.
- Over half of those who requested assistance were either able to access additional resources or are in the process of getting assistance.

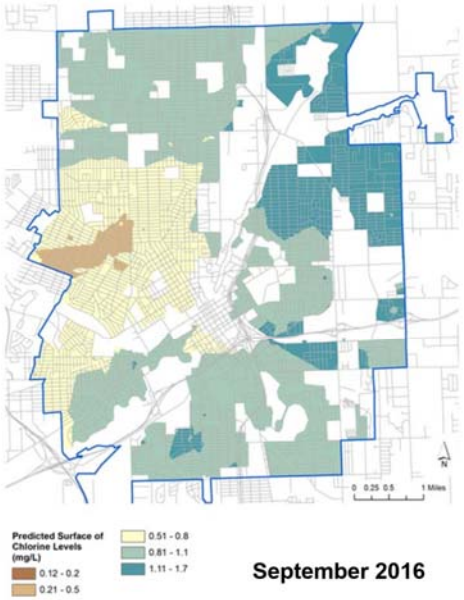
Chemical and Biological Analysis

Over 187 homes sampled September 6 - October 29.

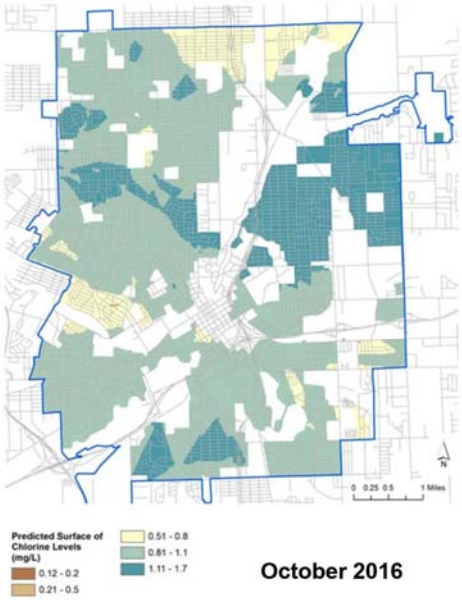
~25% of homes were not on Flint water (in Genesee County)

Chlorine levels were found to be less than 0.2 mg/L in ~10% of homes on Flint water

Our sample period was after the typical or expected peak of Legionellosis.



September 2016

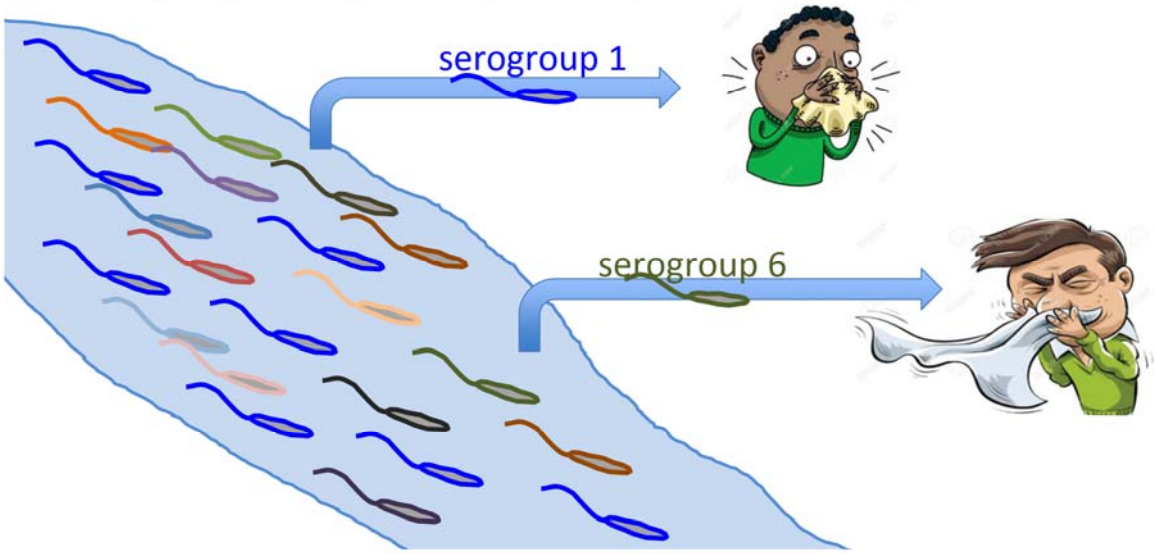


October 2016

Preliminary *Legionella* Results

- Sampling started after seasonal peak
- *Legionella* was detected in slightly more than ~12% of randomly selected homes in the period from September 6 to October 29.
- No significant difference in the number of homes having *Legionella* inside (133) and outside (46) of Flint.
- *Suspected Legionella* species (culture) detected in 23% of hot water heaters, 30% of shower water, and 47% of kitchen faucets tested.
- *Confirmed Legionella* species (culture) in 22% of hot water heaters, 28% of shower water, and 50% of kitchen faucets tested.
- *Legionella pneumophila* serogroup 6 predominate (63%) strain confirmed

Although it's not the most common type, "serogroup 6" *Legionella pneumophila* can cause pneumonia



Because it is most common Legionnaires' Disease type, the medical urine test is designed to detect serogroup 1

Scientists and physicians also know less about serogroup 6 *Legionella pneumophila.*

What's next:
Laboratory studies of *Legionella* collected in Flint

Fingerprint these *Legionella* strains!
I want to know where they've been!

Does a heavy metal bath weaken
OR strengthen them?

Do white blood cells kill them?
OR
Do they grow in white blood cells?

Can we take what we know from studies with Ann Arbor water and apply it to the water in Flint, MI?

Infrastructure risk factors in Flint, MI

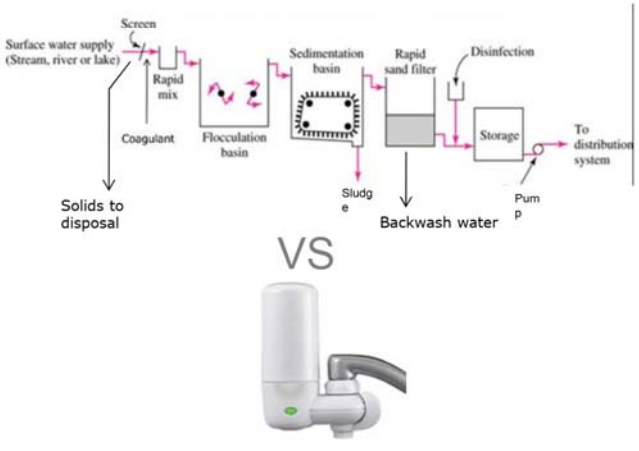
- Chlorinated
- Distribution system damaged by corrosion event, creating very high rate of main breaks
- Aging underground infrastructure, shrinking city, poor pipe placement sightings
- High rate of abandonment, shutoffs, and low % of backflow preventers
- High level of health disparity

The comparable situation in Ann Arbor, MI

- Chloraminated
- No comparable incident in Ann Arbor. Lower rate of main breaks
- Aging underground infrastructure supported by strong tax base, stable population
- High rate of residency, expect higher rate of backflow preventers
- Lower level of health disparity

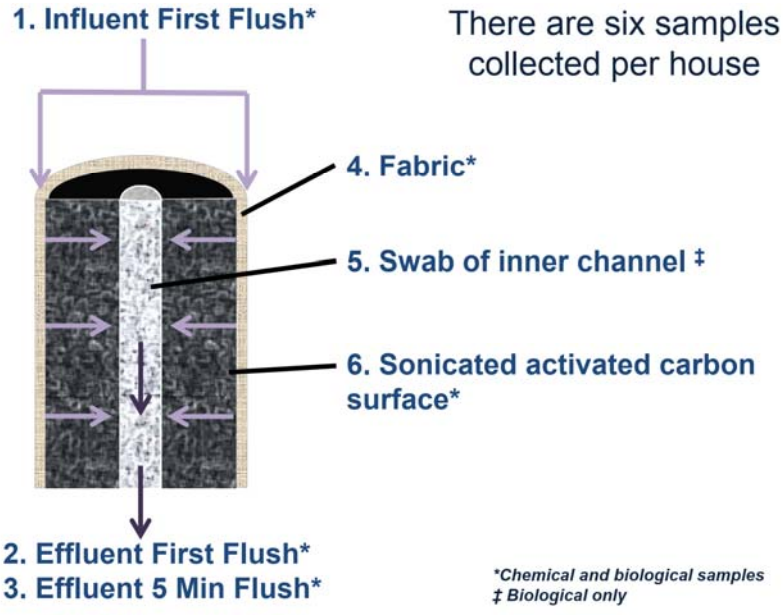
Differences justify evaluating filter performance in Flint.

The practice in drinking water treatment is to use multiple barriers to protect public health against multiple contaminant types. Used alone, activated carbon point-of-use filters reflect a single point of treatment.

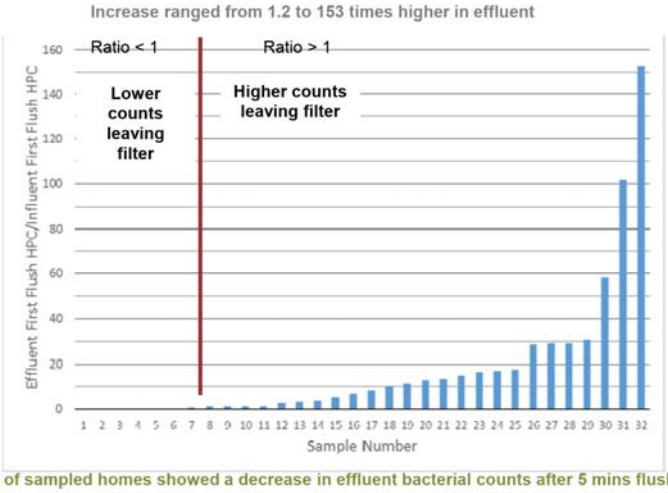


Filter Study: Chemical Analysis

- Disinfection by-product formed from the reaction of chlorine and naturally occurring organic matter
- Seasonal variation
- Cold water samples (Dec. 2015 - Oct. 2016)
    - Before filtration
        - TTHM: Mean 30.6 ppb (15-61 ppb), highest values in August 2016
        - Pb: Mean 1.9 ppb (ND-5.4 ppb)
        - Cu: Mean 53.1 ppb (8.1-235.7ppb)
    - After filtration
        - TTHM: Below detection limit (~1 ppb)
        - Pb: Below detection limit (~0.25 ppb)
        - Cu: All less than 3.0 ppb, most below detection limit (~1ppb)



In 79% of homes, bacterial counts leaving filter with first flush are higher than the first flush entering the filter



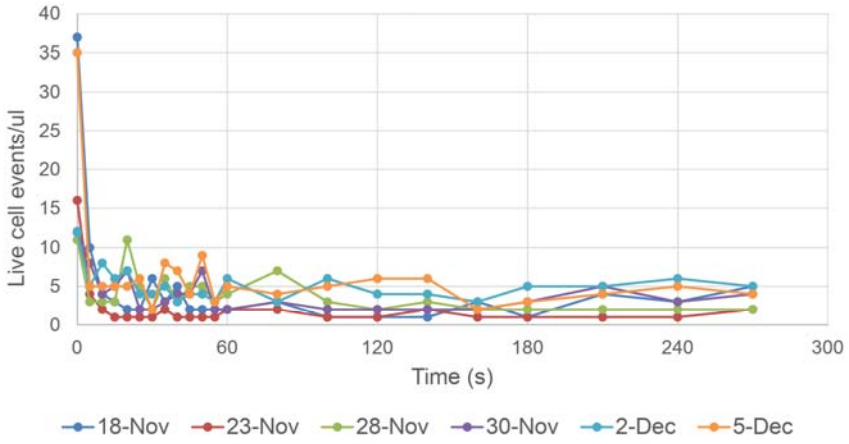
94% of sampled homes showed a decrease in effluent bacterial counts after 5 mins flushing

Bacterial counts by heterotrophic plate count (HPC), captures <10% of bacteria, does not distinguish pathogens and non-pathogens

How long should one flush to reduce microbial concentrations to baseline levels?

Triplicate PoU Rig to evaluate how cell counts change with flush time and filter life

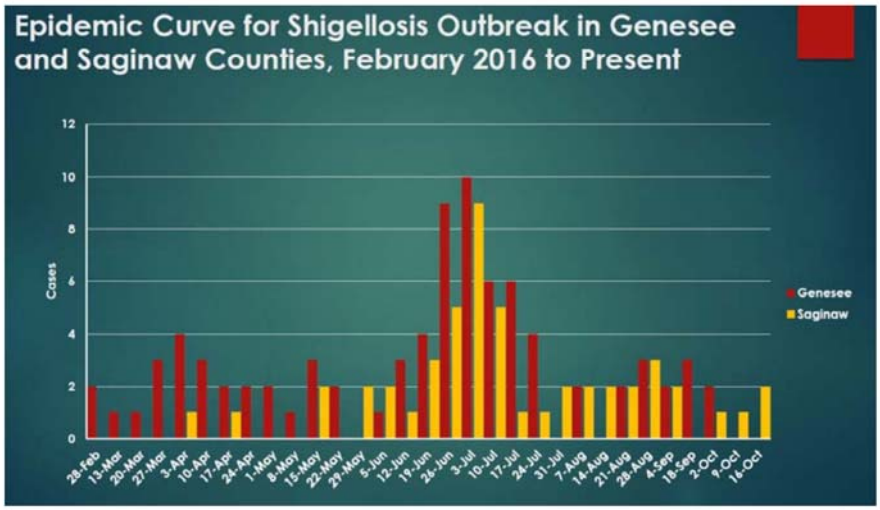
After three weeks of operation, flush study results suggest that flushing < 1 minute is sufficient to reduce bacterial counts substantially



Filters do a great job of reducing lead, copper and TTHMs in finished, filtered water

Filters increase the abundance of bacteria in the filtered water of most homes in Flint

Which bacteria are present, and did their relative abundance in water change as a result of the filter?



We used a DNA-based method to look for *Shigella* or enteroinvasive *Escherichia coli* (*E. coli*) genes associated with proteins that confer illness – a functional gene.

- Method is demonstrated by others
- Method is highly sensitive and can detect to one cell per sample
- 13 of 16 home samples, including all filter fabric samples from July, have been analyzed and are negative

From July samples, we saw high abundance of Enterobacteriaceae family of bacteria coming out of some filters and decided to take a closer look

- Enterobacteriaceae include pathogens (enteroinvasive *E. coli*, *Shigella*, others) and non-pathogens. They are found in animal and human guts.
- Enterobacteriaceae counts coming out of filters during Ann Arbor study were much lower
- We find Enterobacteriaceae family bacteria abundance to increase across point-of-use filters in 1 of 4 homes.
  - ✓ We have not looked for other pathogens from this family of bacteria yet
  - ✓ We do not know which strains are responsible for this increase.
- Enterobacteriaceae family bacteria are found in other city drinking waters
  - ✓ Are levels in Flint water unusual?

In Summary with regard to point-of-use filters, based on samples analyzed so far:

- Filters in Flint are behaving as expected and previously experienced:
  - ✓ Removing lead and copper effectively
  - ✓ Removing TTHMs
  - ✓ Removing disinfectant residual
  - ✓ Supporting growth of bacteria in most cases
- Point-of-Use filters cause an increase in bacterial counts in 79% of home sampling events (32 total)
- We have not detected any pathogenic species in filters so far.
  - ✓ Shigella is absent from all samples we have processed so far using a validated DNA-based analysis approach
  - ✓ We have detected bacterial families that contain pathogens and are prioritizing which to analyze.
- We are still evaluating whether there are bacterial agents of concern and hope to sample and analyze into next summer to monitor changes over all four seasons

Summary

- Chlorine levels are not what they should be in some of the homes that have been sampled so far.
- Indicators of certain types of bacteria are present in relatively higher amounts in one out of every four homes sampled as part of the filter study compared to levels found in water of other cities.
- Many residents of Flint are still reporting skin and lung illnesses.
- The predominant strain of *Legionella* bacteria confirmed in Flint homes is a type that will not be detected by the standard rapid urine antigen detection diagnostic tests run by your doctor, yet is known to cause disease in susceptible humans
- Since the chemical and bacterial load each change with temperature, additional seasons of data are required to determine if the systems is improving (water monitoring needs to continue)

ATTACHED IS Handout from FACHEP presentation Dec. 14, 2018:

Water Study Update and Open House

5:30-7:30pm
Wednesday, December 14th, 2016
Flint Public Library

Reported Legionellosis Disease Trends

Every day, the Michigan Department of Health and Human Services received Legionellosis case reports. These reports are compiled in the electronic surveillance system known as the Michigan Disease Surveillance System (MDSS). As part of the FACHEP project, we have been tracking and analyzing Legionellosis case reports in 2016 as well as conducting analysis of Legionellosis cases from previous years. Our period of analysis currently covers 2011 through 2016.

The number and incidence rate for Legionellosis in Genesee County has declined from peaks seen in 2014 and 2015. Numbers and rates of Legionellosis remain above the yearly number and incidence rates seen in the pre-2014 time period (2011 through 2013).

Resident Survey

Of the 187 household members that were interviewed, 29% requested specific assistance with accessing resources.

Requests for assistance included basic needs, utility bills and transportation; almost one-quarter of requests related to home conditions and needed home repair; 13% requested assistance with addressing stress, anxiety, depression, anger and grief, and 12% identified financial challenges.

Over half of those who requested assistance were either able to access additional resources or are in the process of getting assistance.

Household Environmental Water Testing

More than 180 homes sampled September 6 - October 29 with ~25% of the homes sampled outside of Flint's water system (in Genesee County).

Samples were collected from the following locations in each home:

1. Hot water heater
2. Hot shower water
3. Shower arm swab
4. Cold water from primary sink (5min flush)
5. Point-of-use filters

Chlorine levels were found to be less than 0.2 mg/L in ~10% of homes on Flint water.

Our sample period was after the typical or expected peak of Legionellosis.

In the period, Legionella detected slightly more than ~12% of randomly selected homes from September 6 to October 29,

No significant difference in the number of homes having legionella inside (133) and outside (46) of Flint.

Suspected Legionella species detected (cultured, not confirmed): 23% hot water heaters, 30% shower water, 47% kitchen faucets

Legionella species confirmed (cultured, confirmed): 22% hot water heaters, 28% shower water, 50% kitchen faucet.

In household water samples tested during the 2016 household survey, *Legionella pneumophila serogroup 6* was the predominant strain detected (63% of strains confirmed).

In clinical illness, the most common strain causing disease in people is Legionella serogroup 1.

Using standard clinical diagnostic tests now available, detection of non-serogroup 1 *Legionella* may be limited as rapid diagnostic tests for Legionella are designed to detect only serogroup 1.

Point-of-Use Filters

Point-of-Use filters are effective in removing metals (lead and copper) and trihalomethanes (TTHMs) to non-detectable levels

The filters are designed to breakdown chlorine. Not surprisingly, our studies have shown that 90% of the filtered water samples had a residual free chlorine level less than 0.1 mg/L.

Because high concentrations of lead in water is sporadic, unpredictable. We encourage people to continue to use their filters and change the filter cartridges according to the manufacturer's recommendations.

Filters are necessary to provide barrier to lead and other metals at point of use, along with disinfection byproducts. The filters are also designed to capture (adsorb) organic matter, the source of which are the natural products of degradation found in the surface water. Filters are known to be ineffective at removing bacteria and actually increase bacterial counts because (i) the organic matter serves as food for the bacteria in the filter and (ii) the disinfectant is low or gone so does not prevent their growth. This is well established over decades. If a resident wants to keep bacterial counts low, a second treatment barrier is needed. That barrier can be a form of disinfection (boiling, UV disinfection lamp) or physical barrier (membrane).

We sampled 16 homes across 32 sampling events. The number of bacteria present in water increases across filter in 79% of sampled events. Flushing for five minutes reduces bacterial count; we are doing additional studies with Detroit water to determine how long one should flush for. However, flushing decreases the life of the filter.

We initiated multiple DNA-based experiments to determine which bacteria are present. We always run at least two independent methods to confirm our microbiological results. This is a slow and multi-step process that is still underway, plus we have to be strategic about which bacteria we try to characterize because we have a limited amount of DNA to work with. To date, we have focused this work on quantifying bacteria that are associated with illness patterns in Flint.

Water from 13 of 16 sampled homes and filter fabrics from the 7 homes monitored in July were tested for evidence of Shigella (total of 87 samples) using an established DNA-based method; all samples were negative.

We also saw that Enterobacteriaceae, a family of bacteria that contain both known enterics (in human or mammalian gut), pathogens, as well as non-gut microbes and non-pathogens, were present in Flint

water. Shigella is a member of the Enterobacteriaceae. Because of the number of interruptions in the Flint distribution system (line breaks, LSL replacements), we felt this was important to pursue. We saw that the levels in several samples were higher than levels we saw in Ann Arbor's water, but decided we needed to compare to other cities that use chlorine disinfection in the same way as Flint. We have tracked down some data sets and are currently re-evaluating our Flint data to make this comparison to address the question: is the level of Enterobacteriaceae in Flint's water unusually high?

Separately, we compared how numbers of Enterobacteriaceae change across point-of-use filters. We found that Enterobacteriaceae concentrations increased substantially after filtration in 1 of 4 homes; however, we have not looked for pathogens in those samples yet. We are in the process of screening a subset of samples, including those with increasing Enterobacteriaceae across the filter, for a range of common waterborne pathogens.

So, to date, we have not detected specific pathogens in the drinking water or coming out of the filters, but we have only analyzed specifically for one pathogen (Shigella) and are in the process of looking for a range of other common waterborne pathogens with the samples we have.

Because high concentrations of lead in water is sporadic and still unpredictable, we encourage residents to continue to use their filters and change the filter cartridges according to the manufacturer's recommendations. If you are concerned about bacterial levels coming from the filter, you can flush water for at least a minute before using it, and bypass the first flush of water around the filter after long (overnight) stagnation periods. If you want to add a second treatment barrier, a reasonable option is to disinfect the water by boiling, or to just use bottled water.

Regular water use or flushing the premise plumbing each day helps with multiple problems. It helps to reduce bacterial counts by raising residual chlorine levels and will likely assist in further passivating pipes. This will not however, increase the chlorine residual in the water from the faucet filters. Flushing water through the faucet filters decreases bacterial counts but will also reduce the life of the filter.

Summary:

- Chlorine level are not what they should be in some of the homes that have been sampled so far.
- Point of use filters increase bacterial counts in most homes, and change which bacteria are most abundant. We see increases in some bacteria across filters in homes and we are evaluating whether the types and levels of these bacteria are cause for concern.
- During home visits, many Flint residents report skin and lung illnesses. While we do not have data validate these reports, this is consistent with what others have reported.
- The predominant strain of Legionella bacteria found in Flint homes is a strain that may not be detected by the standard rapid urine antigen detection diagnostic tests run by your doctor yet are known to cause disease in susceptible humans
- Since the chemical and bacterial loads change with temperature, additional seasons of data are required to determine if the systems is improving (water monitoring needs to continue)

December 14, 2016, Flint Library Presentation

Major Points

Reported Legionellosis Disease Trends

Introduction:

Every day, the Michigan Department of Health and Human Services received Legionellosis case reports. These reports are compiled in the electronic surveillance system known as the Michigan Disease Surveillance System (MDSS). As part of the FACHEP project, we have been tracking and analyzing Legionellosis case reports in 2016 as well as conducting analysis of Legionellosis cases from previous years. Our period of analysis currently covers 2011 through 2016.

Results:

The number and incidence rate for Legionellosis in Genesee County has declined from peaks seen in 2014 and 2015. Numbers and rates of Legionellosis remain above the yearly number and incidence rates seen in the pre-2014 time period (2011 through 2013).

Compared with crude Legionellosis incidence rates in Oakland and Wayne counties, the Legionellosis incidence rate for Genesee County in 2016 was not significantly different. (Genesee county: 3.65 [range: 2.2, 6.0]; Oakland County: 2.74 [range: 1.82, 3.64] and Wayne County: 2.78 [range: 2.10, 3.68]. These crude incidence rate comparisons provided limited information and do not reveal differences in age group incidence rates.{approval needed}

In Genesee County and nationwide, the majority of Legionnaires' disease cases have been found in middle aged and older adults. {approval needed}

In Genesee County during 2016, the Legionellosis incidence rate for the age groups of 40-79 years and greater than or equal to 80 years is 6.3 and 11.7/100,000, respectively. For the age group of 40-79 years in Genesee County, the 2016 incidence point estimate is higher than baseline years of 2011, 2012, and 2013 (the years prior to the epidemic seen in 2014 and 2015). {approval needed}

Of these years 2011--2013, due to limitations in statistical power, we can only state that the incidence rate in 2013 was statistically significantly lower compared with 2016. {approval needed}

Household Environmental Water Testing

Introduction: Approximately 180 homes sampled September 6 - October 29 with ~25% of the homes sampled outside of Flint's water system (in Genesee County). Samples were collected from the following locations in each home:

1. Hot water heater
2. Hot shower water

3. Shower arm swab
4. Cold water from primary sink (5min flush)
5. Point-of-use filters

Results:
Chlorine levels were found to be less than 0.2 mg/L in ~10% of homes on Flint water.

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In household water samples tested during the 2016 household survey, *Legionella pneumophila* serogroup 6 was the predominate strain detected (63% of strains confirmed)..

In clinical illness, the most common strain causing disease in people is Legionella serogroup 1.

Using standard clinical diagnostic tests now available, detection of non-serogroup 1 *Legionella* may be limited as rapid diagnostic tests for Legionella are designed to detect only serogroup 1.

Point-of-Use Filters

Introduction:

Point-of-Use filters are effective in removing metals (Lead and Copper) and Trihalomethanes (TTHMs) to non-detectable levels

The filters are designed to breakdown chlorine. Not surprisingly, our studies have shown that 90% of the filtered water samples had a residual free chlorine level less than 0.1 mg/L.

Filters are necessary to provide barrier to lead and other metals at point of use, along with disinfection byproducts. The filters are also designed to capture (adsorb) organic matter, the source of which are the natural products of degradation found in the surface water. Filters are known to be ineffective at removing bacteria and actually increase bacterial counts because (i) the organic matter serves as food for the bacteria in the filter and (ii) the disinfectant is low or gone so does not prevent their growth. This is well established over decades. If a resident wants to keep bacterial counts low, a second treatment barrier is needed. That barrier can be a form of disinfection (boiling, UV disinfection lamp) or physical barrier (membrane).

Results:

We sampled 16 homes across 32 sampling events. The number of bacteria present in water increases across filter in 79% of sampled events. Flushing for five minutes reduces bacterial count; we are doing additional studies with Detroit water to determine how long one should flush for. However, flushing decreases the life of the filter.

We initiated multiple DNA-based experiments to determine which bacteria are present. We always run at least two independent methods to confirm our microbiological results. This is a slow and multi-step process that is still underway, plus we have to be strategic about which bacteria we try to characterize because we have a limited amount of DNA to work with. To date, we have focused this work on quantifying bacteria that are associated with illness patterns in Flint.

Water from 13 of 16 sampled homes and filter fabrics from the 7 homes monitored in July were tested for evidence of gung (total of 87 samples) using an established DNA-based method; all samples were negative.

We also saw that Enterobacteriaceae, a family of bacteria that contain both known enterics (in human or mammalian gut), pathogens, as well as non-gut microbes and non-pathogens, were present in Flint water. Shigella is a member of the Enterobacteriaceae. Because of the number of interruptions in the Flint distribution system (line breaks, LSL replacements), we felt this was important to pursue. We saw that the levels in several samples were higher than levels we saw in Ann Arbor's water, but decided we needed to compare to other cities that use chlorine disinfection in the same way as Flint. We have tracked down some data sets and are currently re-evaluating our Flint data to make this comparison to address the question: is the level of Enterobacteriaceae in Flint's water unusually high?

Separately, we compared how numbers of Enterobacteriaceae change across point-of-use filters. We found that Enterobacteriaceae concentrations increased substantially after filtration in 1 of 4 homes; however, we have not looked for pathogens in those samples yet. We are in the process of screening a subset of samples, including those with increasing Enterobacteriaceae across the filter, for a range of common waterborne pathogens.

So, to date, we have not detected specific pathogens in the drinking water or coming out of the filters, but we have only analyzed specifically for one pathogen (Shigella) and are in the process of looking for a range of other common waterborne pathogens with the samples we have.

Because high concentrations of lead in water is sporadic and still unpredictable, we encourage residents to continue to use their filters and change the filter cartridges according to the manufacturer's recommendations. If you are concerned about bacterial levels coming from the filter, you can flush water for at least a minute before using it, and bypass the first flush of water around the filter after long (overnight) stagnation periods. If you want to add a second treatment barrier, a reasonable option is to disinfect the water by boiling, or to just use bottled water.

The only way to eliminate risk from lead in drinking water is to remove the source of lead. Sources can include lead service lines as well as internal premise plumbing and fixtures.

Flushing the premise plumbing for 5 minutes each day helps with multiple problems. It helps to reduce bacterial counts by raising residual chlorine levels and will likely assist in further passivating pipes. This will not however, increase the chlorine residual in the water from the faucet filters. Flushing water through the faucet filters decreases bacterial counts but will also reduce the life of the filter.

Summary Points/Take Home Messages:

There are several things that remain concerning to our group

a. Chlorine level are not what they should be in some of the homes that have been sampled so far.
b. Point of use filters increase bacterial counts in most homes, and change which bacteria are most abundant. We see increases in some bacteria across filters in homes and we are evaluating whether the types and levels of these bacteria are cause for concern.
c. During home visits, many Flint residents report skin and lung illnesses. While we do not have data validate these reports, this is consistent with what others have reported.
d. The type of Legionella bacteria found in Flint homes is a strain that may not be detected by the standard rapid urine antigen detection diagnostic tests run by your doctor yet are known to cause disease in susceptible humans

Since the chemical and bacterial loads change with temperature, additional seasons of data are required to determine if the systems is improving (water monitoring needs to continue)

Additional Supporting Information for Talking Points Noted Above:

Sampling protocol

- 187 homes sampled (as of Nov. 1 {Shawn update}). Of those homes: ~25% were not on Flint water, but in Genesee County.
- Our sample period was after the peak. In the period, Legionella detected slightly more than 15% of homes

Limitations (laying out data we would like to have):

i. Lost part of year -
data must be taken in context - key why second year of data Funding for project from DHHS did not come through until after seasonal peak in Legionellosis cases

ii. Lack of data sharing:
   1. City has yet to share detailed water distribution model that would allow us to see if there are relationships between measurements we have made and how the system works
   2. Despite numerous requests, Genesee County Health Department has not shared a information on buildings that would be considered high risk
   3. GCHD has yet to allow us to accompany them on investigations of patients with Legionellosis.

iii. Many unknowns - massive corrosion event, and people are not using water as is typical.

Analysis of Epidemiologic Data: Trends in Legionellosis Surveillance

iv. This activity of FACHEP focuses on understanding past and present patterns of Legionellosis in Genesee county.

v. Information from Genesee county can be compared with other county-level information.

vi. In our analysis, we have identified Oakland and Wayne county as comparison counties. These counties were chosen for their larger populations, presence of public health departments that conduct disease surveillance and population demographics that are similar to Genesee county.

vii. Crude incidence rates are based on the occurrence of Legionnaires' disease among all ages in a given population. Because the highest risk of Legionnaires' disease occurs among

older age groups, comparison of crude rates from one year to another or one county to another provide limited information on persons who may be at risk for Legionnaires' disease.

viii. For this reason, it is common to compare age-group specific incidence rates for Legionnaires' disease across years and different populations such as those in other counties or states. Comparing rates for specific age groups gives us more information on disease patterns in older persons who are at increased risk of Legionnaires' disease.

ix. When considering incidence rates of disease, public health scientists examine the calculated figure for incidence rate (sometimes called the "point estimate") as well as the range of incidence rates (typically examined as the lower and upper limit of the 95% confidence interval). The point estimate is determined by dividing the number of cases that occur over a given time period (such as one year) by the total persons in the population from which the cases are reported.

x. The 95% confidence interval reflects our degree of uncertainty in the point estimate of the incidence rate. This uncertainty varies depending on the number of cases and the population size where we measure the incidence.

xi. In Genesee county, the majority of Legionnaires' disease cases have been found in middle aged and older adults. In particular, persons who are 40 years of age and older. Compared with previous years of 2011, 2012, 2013 and 2015, the crude incidence and age group specific incidence rates of Legionellosis in 2016 was not statistically significantly different.

xii. In Genesee county, the crude (9.92/100,000) and age group specific incidence rates (17.39/100,000 in ages 40-79 yrs and 29.5/100,000 in ages ≥ 80 yrs) of Legionellosis was significantly higher in 2014 compared with 2016. This difference was statistically significant.

xiii. Compared with crude Legionellosis incidence rates in Oakland and Wayne counties, the Legionellosis incidence rate for Genesee County in 2016 was not significantly different. (Genesee county: 3.65 [range: 2.2, 6.0]; Oakland County: 2.74 [range: 1.82, 3.64] and Wayne County: 2.78 [range: 2.10, 3.68]. These crude incidence rate comparisons provided limited information and do not reveal differences in age group incidence rates.

xiv. In Genesee county during 2016, the Legionellosis incidence rate point estimate for the age groups of 40-79 years and greater than or equal to 80 years is 6.3 and 11.7/100,000, respectively. For the age group of 40-79 years in Genesee county, the 2016 incidence point estimate is higher than baseline years of 2011, 2012, and 2013 (the years prior to the epidemic seen in 2014 and 2015). However, of these years 2011--2013, due to limitations in statistical power, we can only state that the incidence rate in 2013 was statistically significantly lower compared with 2016.

xv. For the calculation of 2016 incidence rates, we have assumed the population to be the same as in 2015. For some counties, the population may have increased or decreased. Thus, these figures for 2016 should be considered as estimates until census population projections for 2016 are made available.

Household Water Testing for Legionella

xvi. Legionella detected slightly more than 10% of homes (note that Our sample period was after the peak.)

xvii. Legionella pneumophila serogroup 6 predominate strain detected. Serogroup 1 is type detected by standard test.

Filter study

xviii. Filters for TTHMs and metals

1. Filters effective in removing metals and TTHMs - non-detect levels of TTHMs and lead from filters
2. Because high concentrations of lead in water is sporadic, unpredictable. We encourage people to continue to use their filters and change the filter cartridges according to the manufacturer's recommendations.

xix. Filters ineffective with bacteria

1. Filters are known to be ineffective with bacteria and to increase bacterial counts - because the organic matter serves as food for the bacteria in the filter. This is well established over decades.
    a. The filters are designed to degrade chlorine. Our studies have shown that 90% of the filtered water

samples have residual chlorine < 0.1 ppm, which is not surprising.

b. The filters are also designed to capture (sorb) organic matter, the source of which are the natural products of degradation found in the surface water.

2. Based what we currently know, based on the amount and type of bacteria, observed in Flint water appears to be unusual.
    a. Bacteria increases across filter in 79% of sampled events.
    b. Some bacterial families known to contain pathogens detected. Other than Shigella, pathogenic forms have not been monitored for yet.
    c. The levels of the Enterobacteriaceae family increase across filters in about 25% of the homes monitored as part of the PoU study. We are still trying to determine if this warrants concern.
    d. Water from all sample events were tested for evidence of Shigella using a DNA-based method; all samples were negative.

xx. Second barrier needed

1. Filters are insufficient to address bacterial anomalies. To do that, a second barrier is needed. That barrier can be a form of disinfection (boiling, UV disinfection lamp) or physical barrier (membrane).

xxi. Effect of flushing filters directly

1. Flushing for five minutes reduces bacterial count; we are doing additional studies with Detroit water to determine how long one should flush for.
2. However, flushing decreases the life of the filter.

We encourage people to continue to use their filters and change the filter cartridges according to the manufacturer's recommendations.

Concerns that remain

xxii. Chlorine level are not what they should be in some of the homes that have been sampled so far.

xxiii. We found relatively higher (1 out of 4 homes) levels of certain types of bacteria that are present in relatively higher amounts in 1 out of 4 homes compared to levels found in other city waters.

xxiv. Many residents are still reporting skin and lung illnesses

xxv. Less common types of Legionella bacteria may be found in water. These include strains that may not be detected by the standard tests run by your doctor but may rarely cause disease in humans

xxvi. Multiple seasons of data required to determine if the systems is improving (water monitoring needs to continue)

Question & Answer:

1. **Did you test for Stenotrophomonas maltophilia?** Response: We have analyzed samples for a number of bacteria at various levels. The only bacteria we have so far specifically targeted through a variety of techniques have been legionella, shigella and *E.coli*. We have performed high level analyses that identify hundreds of different types of bacteria based on the amount of DNA present in our samples but this analysis is done at a very high level - the family level (kingdom>phylum>class>order>family>genus>species). Stenotrophomonas genera is fairly common in water systems.

2. **When you say chlorine levels are not safe, how do you determine what chlorine levels should be?** Response: The Surface Water Treatment Rule that is part of the Ten State Standards, a set of guidance established by Great Lakes states and is commonly accepted by practicing engineers, recommends chlorine levels should be above 0.2 mg/L. In slightly more than 5% of the homes we have sampled the chlorine residuals were zero.

3. **Is the water safe to drink?** Response: Coupled with our concerns about microbiological quality, we are not ready at this time to say all water in Flint is safe to drink. We do not think the water is safe in all locations in the city. The quality of water in Flint is definitely getting better but sporadic, unpredictable high concentrations are found for lead, and lead service lines remain in place.

4. **Would you drink the water?** Response: Not straight out of the faucet. Water from the Flint system still should be filtered before it is consumed. In our opinion, for healthy adults, there is limited risk to using filtered tap water in Flint - but this risk is unknown. Its best if there is a second level of protection, such as boiling the water after filtration. This creates another layer of protection by killing any bacteria in the water. Anyone who is sick, immune compromised, undergoing chemo or radiation therapy for cancer, or an infant – they should continue to use bottled water.

5. **Should I use bottled water?** Response: If you have concerns, using bottled water is always an option. Bottled water that comes from a tap (i.e., not mineral water) and with additional treatment continues to be a safe option. If you rely on bottled water for your primary source of drinking water, you should discuss this with your dentist as you may not be receiving appropriate amounts of fluoride.

6. **When will the water be safe?** Response: We are not saying the water is unsafe. It very well may be safe now in some parts of the city. We just are not comfortable at this stage of our independent analysis making a claim about water safety in the face of the data we have, and not until we have evaluated the water quality over all four seasons. The Flint water system is big and it has undergone a major corrosive event. The chemical water quality is improving but the extent and pace of improvement is unclear. We will continue to monitor the water at least for another year.

7. **Did the water cause the Legionnaires outbreak?** Response: Research in the literature indicates that conditions associated with the corrosion event in the Flint water distribution system are consistent with other Legionnaires' disease outbreaks. There is some evidence that suggests a connection. Determining a direct cause and effect linkage between water exposure and disease requires analysis of data in real-time; that is, at the time the event, like an outbreak, is occurring.

   Public health research using epidemiologic methods can help us understand if there is an association between water changes or Legionella bacteria in water and the occurrence of Legionnaires' disease in people.

   To more fully understand the causes of Legionnaires' disease in Flint, we must have detailed information on cases including laboratory tests done for Legionella and exposure history information and cases and a comparison group of healthy residents.

   Also, comparing Legionella strains that infect humans to those strains we find in water samples will help identify potential linkages to exposure of residents to Legionella in water sources in and outside Flint.

Additional detail for Q and A if needed:

b. Is the water safe to drink?

i. RESPONSE TO QUESTION

1. We are not ready to make a broad statement that all water in Flint is safe, to drink.
2. We do not think the water is safe in all locations in the city.
3. It is definitely getting better but I believe I have been told that Sporadic, unpredictable high concentrations are found for lead
4. fixtures and plumbing inside residents homes installed before 2014 may contain more than ¼% lead that needs to be removed.
5. We do not know the source of some of the bacteria, which complicates determining risk for residents.
6. Chlorine level are not what they should be in some of the homes that have been sampled so far. (How do we answer the question: how do we determine "what they should be" - not sure how much detail we want to go into - SWTR, Ten State Standards - more than 5% of the chlorine residuals are zero and the chlorine residuals in all the samples taken were below that recommended in the Ten State Standards (0.2 mg/L).
7. Relatively higher (1 out of 4 homes) levels of certain types of bacteria
8. Many residents are still reporting skin and lungh illnesses
9. Less common types of Legionella bacteria may be found in water. These include strains that may not be detected by the standard tests run by your doctor but may rarely cause disease in humans

c. RELATED RECOMMENDATION - THE USE OF FILTERS

1. We encourage people to continue to use their Filters and that they change the filter cartridges according to the manufacture's recommendations.
2. point-of-use filters should be used in homes where LSLs exist or where uncomfortably high (>15 ppb) lead has been detected (and residents have a right to those data to make a decision).

3. POU filters should be used In schools or child-care facilities or hospitals, the limit that demands action is lower.
4. PoU filters are a single barrier and not adequate to protect public health as a sole treatment because of their role in enhancing microbial exposure, and our experience with some bacterial groups that make us worry about the microbial quality of the distributed water. If you have concerns, coupling the PoU filter with another disinfecting barrier is appropriate.
5. PoU Filters in some cases may enhance the growth of microbes in drinking water. And some of our tests have shown bacteria which we don't want to see – but again, all water contains bacteria. We have no found any cases where that bacteria is associated with disease.
6. Pb levels are high enough in some homes throughout the city that ALL residents should use filters to remove Pb from tap water.

ii. RELATED RECOMMENDATION - BOILING WATER

1. Boiling water after it is filtered creates a second level protection. Once this is done, I would recommend that it is safe to drink for healthy adults to drink. Those who are immune compromised may wish to continue to use bottled water.
2. You may also chose to boil the war after it has been filtered. This creates another layer of protection by killing any bacteria in the water.
3. Because a predictor of bacteria in tap water has not yet been identified, we recommend that residents who have not determined that bacteria is absent should boil their filtered water.

iii. RELATED RECOMMENDATION - FLUSHING

1. We suggest that you continue to use water because doing so flushes the system and helps improve the water quality.
2. Flushing the premise plumbing for x minutes each day will likely may help to reduce bacterial counts by raising residual Chlorine levels, and will likely assist in further passivating lead and galvanized steel pipes.

3. This will not however, increase the chlorine residual in the water from the faucet filters. Flushing water through the faucet filters will reduce the life of the filter.

d. Would you drink the water?

i. RESPONSE TO QUESTION

1. Not straight out of the faucet. Water from the Flint system still should be filtered before it is consumed. In our opinion, for healthy adults, there is limited risk to using filtered tap water in Flint - but this risk is unknown. Its best if there is a second level of protection, such as boiling the water after filtration. This creates another layer of protection by killing any bacteria in the water. Anyone who is sick, immune compromised, undergoing chemo or radiation for cancer, or an infant – they should continue to use bottled water
2. Not straight out of the faucet. And I can't expect others to do it if I wouldn't.
3. Have to figure out how to answer this one but the simple answer is no.
4. In our opinion, for healthy adults, there is limited risk to using filtered tap water in Flint but this risk is unknown.
5. Its best if there is a second level of protection, such as boiling the water after filtration. This creates another layer of protection by killing any bacteria in the water.
6. Anyone who is sick, immune compromised, undergoing chemo or radiation for cancer, or an infant – they should continue to use bottled water

ii. RELATED RECOMMENDATIONS - ADDITIONAL BARRIERS

1. If appropriate multiple barriers are added in the home (NF or RO membrane, UV lamp, or boiling), I would allow my children to drink the water. Of course, this means $$$$. This is the conundrum.
2. Water from the Flint system still should be filtered before it is consumed. Its best if there is a second level barrier such as boiling. This creates another layer of protection by killing any bacteria in the water.

iii. RELATED RECOMMENDATIONS - using bottled water

1. For someone who is sick, immune compromised, someone undergoing chemo or radiation for cancer, or an infant – it might make sense to use bottled water

e. Should I use bottled water?

i. RESPONSE TO QUESTION

1. Bottled water that comes from a tap (i.e., not mineral water) and with additional treatment continues to be a safe option (note: Not all bottled waters are created equal, but we probably can't get into that).
2. If you have concerns, using bottled water is always an option.
3. If you rely on bottled water for your primary source of drinking water, you should discuss this with your dentist as you may not be receiving appropriate amounts of fluoride.

f. When will the water be safe?

i. RESPONSE TO QUESTION

1. We don't know.
2. It very well may be safe now in some parts of the city.
3. We just are not 100% comfortable at this stage making blanket claims and we simply don't know when we can say with 100% confidence that all water in Flint is safe to drink for all people.
4. The Flint water system is big and it has undergone a major corrosive event. The chemical water quality It is improving but it is unclear on the extent and pace of improvement is unclear and how long it will take. We will continue to monitor the water at least for another year.

ii. RELATED RECOMMENDATION - more data is needed to answer this question

1. (NOTE THAT WHEN WE SAY THAT FLINT WATER IS PROBABLY THE MOST CLOSELY TESTED WATER IN THE COUNTRY, IT MAY BE DIFFICULT FOR RESIDENTS TO UNDERSTAND WHY WE NEED MORE DATA)

2. It very well may be safe now in some parts of the city, but without pooling all the data (chemical, microbiological, distribution system data) from multiple agencies and researchers and letting an unbiased team evaluate it, it is difficult to see the "big picture" over time.
3. I think they tried to do this within FWICC but not all water quality indicators were considered, especially the impact of the filters beyond lead and THMs.
4. Barriers to getting comprehensive, shared data, protocols etc would have to come down, as well as egos, to allow this much needed analysis to happen. We have tried to get access to current distribution system breaks and other data but don't have it yet to fully contextualize our data set. If that is so, then the Flint residents will be the one's left hanging and it will be hard to get consensus around this question for a long time.
5. Multiple seasons of data required to determine if the systems is improving (water monitoring needs to continue)

g. Did the water cause the Legionnaires outbreak?

i. RESPONSE TO QUESTION

1. Research in the literature indicates that conditions associated with the corrosion event in the Flint water distribution system are consistent with other Legionnaires' disease outbreaks.
2. Insufficient data
    a. Determining a direct cause and effect linkage between water exposure and disease requires analysis of data in real-time; that is, at the time the event, like an outbreak, is occurring.
    b. We have not been able to connect the water specifically to the cases of Legionnaires disease we have seen in Flint or to other diseases, such as Shigella.
3. Its very hard to make those specific connections. When a water system is not managed correctly, it can allow harmful bacteria to grow. This may very well have been the case in Flint.

ii. RELATED RECOMMENDATION - more data needed

1. Multiple seasons of data required to determine if the systems is improving (water monitoring needs to continue)
2. the definitive confirmation (comparing a clinical isolate with a water isolate) has not occurred. Until that occurs, we cannot answer this question
3. Public health research using epidemiologic methods can help us understand if there is an association between water changes or Legionella bacteria in water and the occurrence of Legionnaires' disease in people.
4. To more fully understand the causes of Legionnaires' disease in Flint, we must have detailed information that includes: a) information on cases of reported Legionnaires' disease; b) laboratory diagnosis infoon; d) collection and laboratory testing of water samples from locations where cases may have been exposed to Legionella bacteria (e.g., homes).
5. If Legionella bacteria are grown in samples from patients and if Legionella bacteria are grown from environmental water samples, the bacteria in these samples can be compared to see if they are the same or similar strain. This comparison will help determine if the strain in environmental samples may be the cause of Legionnaires' disease.
6. To obtain appropriate environmental samples and test them rapidly, we need notification of newly reported Legionnaires' disease cases and the ability to visit case residence locations (with health department staff). When there, our teams will interview Legionnaires' disease cases to confirm exposure information and our team will collect appropriate water and environmental samples.
7. If Legionella bacteria are grown in samples from patients and if Legionella bacteria are grown from environmental water samples, the "fingerprints" of the bacteria in these samples can be compared to see if they are the same or similar strain. This comparison will help determine if the strain in environmental samples may be the cause of Legionnaires' disease. To obtain appropriate environmental samples and test them rapidly, we need notification of newly reported Legionnaires' disease cases and the ability to visit case residence locations (with health department staff). When there, our teams will interview

Legionnaires' disease cases to confirm exposure information and our team will collect appropriate water and environmental samples.