Epidemiology of Legionnaires' Disease in Genesee County, Michigan, 2014-2017

Chart Book

May 2018

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Purpose:

- This chart book provides a summary of information that addresses the occurrence of Legionnaires' Disease in Genesee County, Michigan, with a focus on 2014-2015. It describes patient information that has been obtained after the 2014-2015 outbreaks of Legionnaires' Disease and information on cases in 2016-2017
- Data that support this document are the product of the enhanced surveillance associated with an outbreak investigation. Beyond traditional passive disease surveillance, outbreak investigations involve the collection of additional information from patients that are related to the outbreak. This process can include information from numerous sources, including supplemental patient interviews, intensive review of medical records, and data available from death certificate review. The information is compiled and analyzed to better describe the outbreak and potential sources of infection
- Visualizations were created to assist in understanding the epidemiology of the cases and summarize what is now known regarding exposures in Genesee County

Information for this report includes data that were made available to the Michigan Department of Health and Human Services (MDHHS) subsequent to the 2014-2015 outbreak. This report includes information gleaned from review of completed medical records, inherently delayed vital record (death certificate) information, laboratory testing summaries, and environmental testing information that were either not compiled or not provided to the MDHHS in 2014-2015.

Legionellosis – Background

- *Legionella* is a type of bacteria that normally lives in wet and warm environments
- *Legionella* can be routinely found in man-made water systems, as well as in most natural fresh-water sources and soil[1]
- Infection most commonly occurs from inhaling *Legionella*-containing water particles
  - Most individuals infected with *Legionella* bacteria never develop symptoms of disease
  - Pontiac Fever is rarely diagnosed since the mild symptoms lead few seek to medical attention
  - Legionnaires' Disease is pneumonia from *Legionella* bacteria
    - Most people who develop Legionnaires' Disease have one or more health risk factors[2], such as age ≥50 years, smoking (current and prior use), chronic lung disease (COPD, emphysema), a weakened immune system, systemic malignancy, diabetes, kidney disease, or liver disease[2,3]
  - *Legionella pneumophila,* serogroup 1 is the *Legionella* bacteria that most frequently causes Legionnaires' Disease
    - Most individuals who develop Legionnaires' Disease from *Legionella* bacteria other than *Legionella pneumophila* serogroup 1 (non-Lp1) have a weakened immune system from underlying disease or medication use[3]

[1]van Heijnsbergen E, et al. Confirmed and potential sources of Legionella reviewed. *Environ Sci Technol*. 2015, 49: 4797-4815.
[2]CDC. What clinicians need to know about Legionnaires' disease. Retrieved 7/14/2017 from https://www.cdc.gov/legionella/downloads/fs-legionella-clinicians.pdf (last updated 5/15/2017).
[3]Burillo A, et al. Microbiology and epidemiology of Legionnaires' disease. *Infect Dis Clin* N Am. 2017;31:7-27.
[4]Donohue M, et al. Widespread molecular detection of Legionella pneumophila serogroup 1 in cold water taps across the United States. *Envron Sci Technol*. 2014;48:3145-3152.
[5]Kruse E, et al. Prevalence and distribution of Legionella spp in potable water systems in Germany, risk factors associated with contamination, and effectiveness of thermal disinfection. *Am J Infect Control*. 2016;44:470-474.
[6]Travis TC, et al. Survey of Legionella species found in Thai soil. *Intl J Micro*. 2012, Article ID 218791.

Legionella is a type of bacteria that normally lives in wet and warm environments. *Legionella* can be routinely found in man-made water systems, as well as in most natural fresh-water sources and soil[1].

Infection with *Legionella* bacteria most commonly occurs from inhalation of *Legionella*-containing water particles, but can also occur due to aspiration (breathing in water as you drinking).

Most individuals infected with *Legionella* bacteria never develop symptoms of disease. Others may develop Pontiac Fever, which is rarely diagnosed since the mild symptoms lead few seek to medical attention.

Legionella infection can lead to a diagnosis of pneumonia called Legionnaires' Disease. Most people diagnosed with Legionnaires' Disease have one or more health risk factors[2]. Established risk factors include age ≥50 years, smoking (current and former smoking), chronic lung disease (COPD, emphysema), disorders or medication use leading to a weakened immune system, systemic malignancy (cancer), diabetes, kidney disease, or liver disease[2,3].

Legionella pneumophila serogroup 1 (Lp1) is the *Legionella* bacteria that most frequently causes Legionnaires' Disease. Most individuals who develop Legionnaires' Disease from other types of *Legionella* bacteria (i.e., non-Lp1) have a weakened immune system from underlying disease or medication use[3].

Sources:
(1) van Heijnsbergen E, et al. Confirmed and potential sources of *Legionella* reviewed. Environ Sci Technol. 2015, 49: 4797-4815.
(2) Centers of Disease Control and Prevention. What clinicians need to know about Legionnaires' Disease. Retrieved 7/14/2017 from https://www.cdc.gov/legionella/downloads/fs-legionella-clinicians.pdf (last updated 5/15/2017).
(3) Burillo A, et al. Microbiology and epidemiology of Legionnaires' Disease. Infect Dis Clin N Am. 2017;31:7-27.

Legionellosis – Background 2

- Identification of *Legionella* bacteria from a source does not necessarily indicate a risk for human disease[1]
  - Common sources of transmission to humans include showers/faucets, cooling towers, hot tubs, fountains, hot water tanks, and large plumbing systems[1-5]
  - Sources never or rarely associated with human disease include surface water (lakes, rivers), groundwater, rain, or natural soil[1,3,6]
- Diagnostic tests used to identify *Legionella* bacteria in clinical specimens include urinary antigen testing for Lp1, culture, paired serology, direct fluorescent antibody (DFA) testing, and polymerase chain reaction (PCR) testing[3]

[1]van Heijnsbergen E, et al. Confirmed and potential sources of Legionella reviewed. *Environ Sci Technol*. 2015, 49: 4797-4815.
[2]CDC. What clinicians need to know about Legionnaires' disease. Retrieved 7/14/2017 from https://www.cdc.gov/legionella/downloads/fs-legionella-clinicians.pdf (last updated 5/15/2017).
[3]Burillo A, et al. Microbiology and epidemiology of Legionnaires' disease. *Infect Dis Clin* N Am. 2017;31:7-27.
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[5]Kruse E, et al. Prevalence and distribution of Legionella spp in potable water systems in Germany, risk factors associated with contamination, and effectiveness of thermal disinfection. *Am J Infect Control*. 2016;44:470-474.
[6]Travis TC, et al. Survey of Legionella species found in Thai soil. *Intl J Micro*. 2012, Article ID 218791.

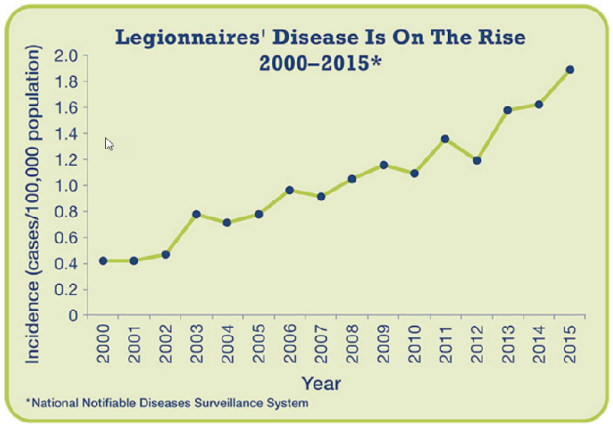
Identification of *Legionella* bacteria from a source does not necessarily indicate a risk for human disease[1]. Common sources of transmission to humans include showers/faucets, cooling towers, hot tubs, fountains, hot water tanks, and large plumbing systems[1-5]. Sources never or rarely associated with human disease include surface water (lakes, rivers), groundwater, rain, or natural soil[1,3,6].

Diagnostic tests used to identify *Legionella* bacteria in clinical specimens include urinary antigen testing (UAT) for *Legionella pneumophila* serogroup one (Lp1), as well as culture, paired serology, direct fluorescent antibody (DFA) testing, and polymerase chain reaction (PCR) testing[3] which can pick up many types of *Legionella*.

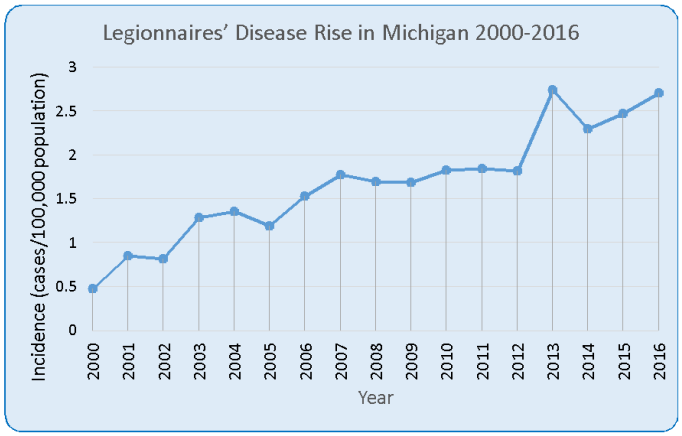
Sources:
(1) van Heijnsbergen E, et al. Confirmed and potential sources of *Legionella* reviewed. Environ Sci Technol. 2015, 49: 4797-4815.
(2) Centers of Disease Control and Prevention. What clinicians need to know about Legionnaires' Disease. Retrieved 7/14/2017 from https://www.cdc.gov/legionella/downloads/fs-legionella-clinicians.pdf (last updated 5/15/2017).
(3) Burillo A, et al. Microbiology and epidemiology of Legionnaires' Disease. Infect Dis Clin N Am. 2017;31:7-27.
(4) Donohue M, et al. Widespread molecular detection of *Legionella pneumophila* serogroup 1 in cold water taps across the United States. Envron Sci Technol. 2014;48:3145-3152.
(5) Kruse E, et al. Prevalence and distribution of *Legionella spp* in potable water systems in Germany, risk factors associated with contamination, and effectiveness of thermal disinfection. Am J Infect Control. 2016;44:470-474.
(6) Travis TC, et al. Survey of *Legionella* species found in Thai soil. Intl J Micro. 2012, Article ID 218791.

National and Statewide Legionnaires' Disease Incidence Trends

National Trends



Michigan Trends



Nationwide, the rate of Legionnaires' Disease cases has risen substantially in recent years, increasing by 286 percent between 2000 and 2014. Michigan experienced a 375 percent increase in the rate between 2000 and 2016, or about a 13 percent annual increase. Michigan's highest incidence rate occurred in 2013 (2.75 Legionnaires' Disease cases per 100,000 population), with second highest rate in 2016 (2.71 per 100,000 population).

The reasons for increasing rates of Legionnaires' Disease are likely multifactorial including:

- Increased use of diagnostic testing due to an increase in clinician awareness and testing availability*
- Improved reporting of the disease to public health
- True increase in frequency of Legionnaires' Disease due to:
    - Increase in number of persons with medical conditions or immunocompromising medications that put them at high risk for Legionnaires' Disease
    - Increase in number of persons at high risk due to an overall aging population
    - Aging plumbing infrastructure
    - Changes in climate

*No reliable method has been identified for determining the relative contribution of increases in *Legionella* diagnostic testing to overall trends of Legionnaires' Disease rates.

Investigation Methods and Definitions

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Legionellosis Case Definition

- Clinical Description
  - Legionellosis is associated with two clinically and epidemiologically distinct illnesses: Legionnaires' Disease, which is characterized by fever, myalgia, cough, and clinical or radiographic pneumonia, and Pontiac Fever, a milder illness without pneumonia
- Laboratory Criteria for Diagnosis
  - Confirmed
    - By culture: isolation of any *Legionella* organism from respiratory secretions, lung tissue, pleural fluid, or other normally sterile fluid
    - By detection of *Legionella pneumophila* serogroup 1 antigen in urine using validated reagents
    - By seroconversion: fourfold or greater rise in specific serum antibody titer to *Legionella pneumophila* serogroup 1 using validated reagents

From a public health perspective, a case of Legionellosis is defined based on clinical information provided by health care providers and laboratories.

The surveillance case definition is a set of uniform criteria used to define a disease for public health surveillance. Surveillance case definitions enable public health officials to classify and count cases consistently across reporting jurisdictions. Every year, case definitions are updated with the U.S. Centers for Disease Control and Prevention (CDC) using Position Statements developed by the Council of State and Territorial Epidemiologists (CSTE). They provide uniform criteria of national notifiable infectious and non-infectious conditions for reporting purposes (https://wwwn.cdc.gov/nndss/conditions/notifiable/2018/infectious-diseases/).

Confirmation of Legionellosis is defined as a case of illness who demonstrates the symptoms of the disease AND has laboratory determination of the presence of the causative organism (*Legionella*).

Culture Testing

- A sputum culture is a test to detect and identify bacteria or fungi that infect the lungs or breathing passages. Sputum is a thick fluid produced in the lungs and in adjacent airways. A sample of sputum is placed in a sterile container and sent to the laboratory for testing
- The experience of laboratory staff is also important, and laboratories experienced at *Legionella* culture are more likely to recover the organism

Reller, L. Barth, Weinstein, Melvin P., and Murdoch, David R. "Diagnosis of Legionella Infection" *Clinical Infectious Diseases* Volume 36, Issue 1, 1 January 2003, Pages 64–69

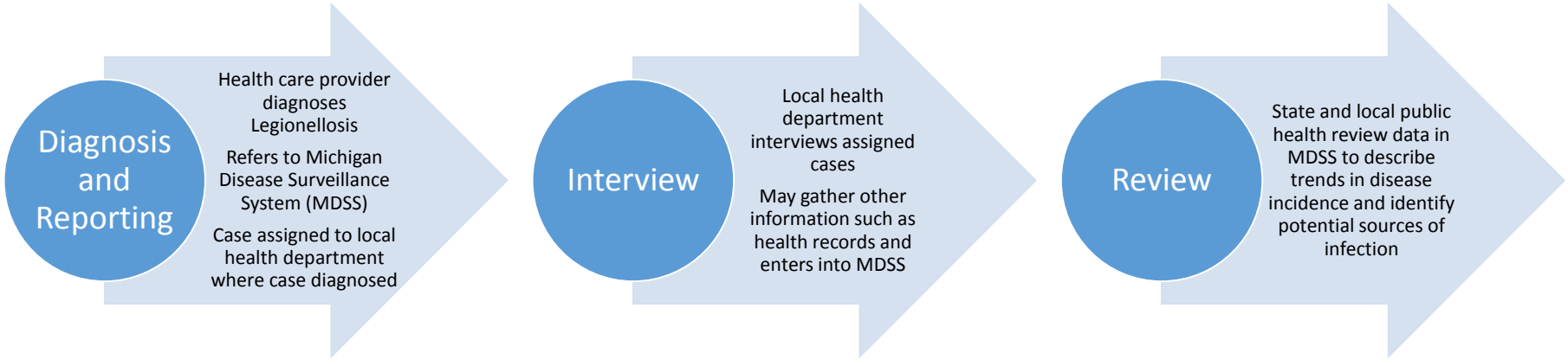
Obtaining material (i.e. sputum) from patients that can be cultured for *Legionella* growth in the laboratory is important for two reasons. First, cultures can identify any additional serogroups of *Legionella* that may not have been detected by urine antigen testing.

Secondly, clinical isolates that are cultured from patients can be compared to environmental isolates obtained from water in fountains, cooling towers and hospital water systems, to enhance epidemiologic findings with laboratory matches at the genetic level for the organism.

During the outbreaks of 2014 and 2015, the public health community strongly encouraged that ALL Genesee County hospitals obtain a sputum specimen at the time of urine collection for UAT for ALL patients in the recognized risk categories for Legionnaires' Disease.

Source: Reller LB, Weinstein MP, and Murdoch DR. "Diagnosis of *Legionella* Infection" Clinical Infectious Diseases Volume 36, Issue 1, 1 January 2003, Pages 64–69

Standard Public Health Case Investigation



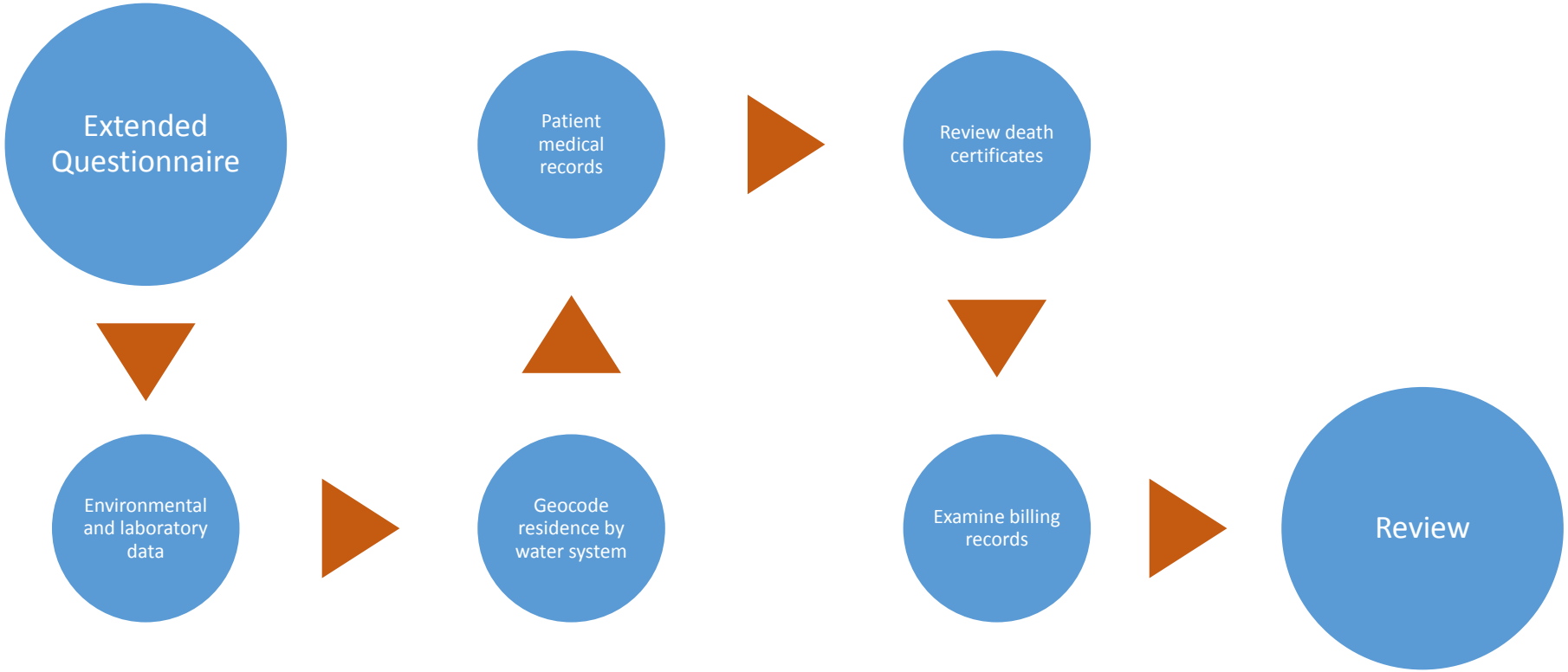
Potential cases of Legionnaires' Disease are identified through laboratory testing by health care providers. Cases are referred for public health assessment by the healthcare and laboratory communities via the Michigan Disease Surveillance System (MDSS). When referrals are made (either manually via a web portal or via automated electronic transmission), they are immediately geocoded and assigned to the appropriate local health jurisdiction for follow-up. The MDSS automatically refers potential cases of Legionnaires' Disease detected in Genesee County residents to the County Health Department.

Interviews are conducted of case patients (or their proxies if the patient is too ill to be interviewed) to gather information about disease onset and any exposure to potential sources of *Legionella* (such as water towers). Information on symptom onset, patient residence, recent health care received, recent travel, and other variables are collected to understand the case patient's history. The data collected about each case is entered into the MDSS and reviewed at state and local level to identify changes in trends of disease and potential outbreaks, as well as identify potential sources of infections.

The sooner patient interviews are completed by local public health staff and entered into the system, the sooner exposures can be evaluated to better understand trends and commonalities of exposure. Significant delays in the conduct of interviews slow down the identification of exposures that could be remediated to prevent other people from becoming infected. Further, delays can contribute to recall bias, as patients will recall less about their exposures prior to illness onset if the patient interview is conducted months vs. days after the patient's diagnosis. Delay also increases the risk that a patient will be lost to follow-up, as the challenge of tracking down patients to conduct interviews increases with time.

For 2014, during the first wave of illness, an average of 201 days passed between the MDSS referral of the patient to Genesee County Health Department and completion of patient interviews. Genesee County Health Department failed to accept the MDHHS offer of assistance and failed to complete patient interviews in a timely manner. In 2015, when MDHHS staff were assisting, patient interviews were completed an average of 4.6 days after referral, with a median of one day.

Suspected Outbreak: Enhanced Case Investigation



An outbreak may be suspected when there is a significant increase in cases reported or a common exposure(s) is identified. An enhanced public health investigation is undertaken to identify a potential source(s) of *Legionella* exposures that can cause infection. The information from initial interviews informs the development of outbreak specific questionnaires, further examination of data, and analysis. This process evolves as information is found out about cases and potential exposures.

The enhanced investigation in response to the 2014 and 2015 Genesee County outbreak included the collection of a substantial amount of additional data, much of which was not readily-available during the initial investigation. Data were collected to identify any *Legionella* exposures patients may have had during their incubation period - the time window when the exposure to the *Legionella* bacteria that infected the patient would have occurred. Of particular concern are buildings that are at higher risk of harboring and transmitting *Legionella* to people, due to the building's structure, size, age, or location, surrounding conditions, or susceptibilities of people found within. For example, buildings with more than ten stories and health care facilities are at particular risk of transmitting *Legionella* to patients. The key to preventing Legionnaires' Disease is for building owners and managers to maintain building water systems to reduce the risk of *Legionella* growth and spread.

The enhanced investigation in 2014-2015 Genesee County outbreak focused on key objectives that required multiple data collection and review steps:

Objective One: Identify status of exposure to high risk settings and buildings for all cases.

- Interview patients with extended questionnaire, re-interview patients with incomplete data.
- Gather additional medical records, including death certificates, whenever available.
- Review additional data from hospital infection control.
- Review health insurance billing claims data for some patients unable to be interviewed.

Objective Two: Assess place of residence during incubation period for all cases.

- Geocode all incubation period residential locations onto a map of the Flint water system. We did not include acute care healthcare facilities as places of residence.
- Compare addresses with residences receiving Flint water (including outside Municipal boundary).
- Compare case addresses with utility billing records for the incubation period.
- Review historical water use data by residential address, obtained from the City of Flint.

State and local public health reviewed supplemental data to describe trends in disease incidence and identify potential sources of *Legionella* infection.

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Other Outbreak Investigation Case Definitions

- Confirmed case[1]: laboratory confirmation of *Legionella* in a person with clinical illness compatible with Legionellosis
- Sporadic case: Legionellosis case with no common exposures to other Legionellosis cases
- Healthcare-associated case[1-3]: A person who visited, worked, or stayed in a hospital in Genesee County as an inpatient, outpatient, visitor, or employee during 2 weeks prior to Legionellosis symptom onset date
  - Possible healthcare-associated: Any health care facility exposure for a portion of 14 days[3] preceding symptom onset
  - Definite healthcare-associated: Continuous exposure to a hospital or long-term care facility for the entire 14 days[3] preceding symptom onset

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[1]https://wwwn.cdc.gov/nndss/conditions/legionellosis/case-definition/2005/. Accessed June 16, 2017.
[2]Soda EA, Barskey AE, Shah PP, et al. Vital Signs: Health Care–Associated Legionnaires' Disease Surveillance Data from 20 States and a Large Metropolitan Area — United States, 2015. MMWR Morb Mortal Wkly Rep 2017;66:584–589. DOI: http://dx.doi.org/10.15585/mmwr.mm6622e1.
[3]http://www.michigan.gov/documents/mdhhs/Legionellosis_investigation_guidance_070516_530365_7.pdf. Accessed June 16, 2017.

The definitions above were used to determine different types of cases, including confirmed cases, sporadic cases and health care associated-cases. National definitions were used, including from the Council of State and Territorial Epidemiologists.

Sources:
(1) https://wwwn.cdc.gov/nndss/conditions/legionellosis/case-definition/2005/. Accessed June 16, 2017.
(2) Soda EA, Barskey AE, Shah PP, et al. Vital Signs: Health Care–Associated Legionnaires' Disease Surveillance Data from 20 States and a Large Metropolitan Area — United States, 2015. MMWR Morb Mortal Wkly Rep 2017;66:584–589. DOI: http://dx.doi.org/10.15585/mmwr.mm6622e1.
(3) http://www.michigan.gov/documents/mdhhs/Legionellosis_investigation_guidance_070516_530365_7.pdf. Accessed June 16, 2017.

Timing Investigation Definitions

- Incubation Period: the 14 days prior to Legionnaires' Disease symptom onset
- Onset Date: Date of onset of the first symptom(s) consistent with a diagnosis of Legionnaires' Disease
- Referral Date: Date that the case was reported to public health by the diagnosing healthcare facility, laboratory or provider
- Outbreak Associated Death: confirmed case of Legionellosis who passed away during their treatment, within thirty days of discharge, and/or had Legionnaire’s Disease listed as a contributing factor on death certificate

Outbreak specific definitions were also determined for incubation period, onset date of first symptoms, MDSS referral date, and outbreak associated death.

Incubation Period for Legionnaires' Disease is usually the 10 days prior to symptom onset. During outbreak investigations, it is routine to consider an incubation period of up to 14 days prior to symptom onset as defined by the Centers for Disease Control and Prevention.

Onset date is the date that the first symptoms of Legionnaires' Disease are recognized, such as malaise, fever, or cough. Onset date is identified from the case interview or from notes in the case's medical records.

Referral Date is the date that the case was reported to public health by the diagnosing healthcare facility, laboratory or provider. Referral Date will be the most complete dates for any reportable disease, given that any reported case must have a referral date as a prerequisite to entry into the Michigan Disease Surveillance System.

Outbreak Associated Death are deaths that occurred to a case of Legionnaires' Disease. Patients who passed away during their treatment, within thirty days of being discharged from the health care facility, or who had Legionnaires' Disease listed as a contributing factor on their death certificate are considered to have had an outbreak associated death.

Geographic Definitions for Exposures

- Residential exposure variables
  - Flint water: Primary non-hospital during the incubation period (10-14 days preceding symptom onset, for non-outbreak and outbreak settings, respectively) at a location actively receiving Flint municipal water
  - Non-Flint water: Primary non-hospital residential address during the incubation period (10-14 days preceding symptom onset, for non-outbreak and outbreak settings, respectively) at a location serviced by a source of water other than Flint municipal water

The geographic definitions for residential exposure variables above are specific to this outbreak in Genesee County.

Information about where a Legionnaires' Disease patient was living during their incubation period was mapped to determine if the residence was served by the Flint water system or not. A residence not on Flint water could receive water from another municipal system or community water supply or from a private drinking water well.

Other definitions

- Environmental Isolate: Bacteria grown from a sample collected from a suspected source of infection (e.g., building water system sample)
- Clinical Isolate: Bacteria grown from a specimen (e.g., sputum) collected from a patient
- UAT: *Legionella* urinary antigen test detects the presence of antigen specific to *Legionella pneumophila* serogroup 1, the most common bacterial causing human illness, accounting for ~80% of Legionellosis cases

Results

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Culture Testing Submissions From Hospitals

2014 – 2015 Legionnaires' Disease Cases in Genesee County, Michigan

Collection and Submission of Sputum Samples from Genesee County Patients with Confirmed Legionnaires' Disease (LD), 2014–2016

Hospital of Diagnosis* (by year of onset)	Confirmed LD patients reported	LD patients with any sputum culture collected†	LD patients' sputum culture for *Legionella*†	Samples submitted to MDHHS BOL or CDC	Samples with viable isolates (*Legionella* grew)
2014					
McLaren Flint	17	1 (6%)	-	-	-
Hurley	13	1 (8%)	-	-	-
Genesys	5	-	-	-	-
Hospitals outside Genesee County	5	-	-	-	-
2015					
McLaren Flint	31	16 (52%)	6 (19%)	2 (6%)	1 (3%)
Hurley	3	3 (100%)	3 (100%)	3 (100%)	3 (100%)
Genesys	12	9 (75%)	4 (25%)	7 (58%)	4 (25%)
Hospitals outside Genesee County	4	-	-	-	-
2016					
McLaren Flint	5		1 (20%)	1 (20%)	1 (20%)
Hurley	5		3 (60%)	3 (60%)	3 (60%)
Genesys	6		3 (50%)	3 (50%)	1 (17%)
Hospitals outside Genesee County	1		-	-	-

*Guidance on respiratory sample culturing was targeted to the 3 Genesee County hospitals. †Based on review of available medical records, which may be incomplete. - = Zero samples collected/submitted

During an outbreak, hospitals should obtain a sputum sample from every suspected Legionnaires' Disease patient. The table above provides the number of patients each hospital treated, the number of sputum samples each hospital obtained (either respiratory or specifically for *Legionella* testing), the number of samples that were shared with the state health department laboratory to determine what type of bacteria were in the sample, and the number of submitted samples which were found to be testable in the State laboratory. Knowing the detailed analysis of the bacteria in the samples can help understand where people were infected and what needs to be done to prevent further infections.

NO specimens were provided to the MDHHS Bureau of Laboratories (BOL) from any of the 2014 cases of Legionnaires' Disease in Genesee County.

Twelve sputum specimens/isolates were delivered to the BOL from cases in 2015. Of the 12, eight were viable (testable). Four were found to be non-viable (i.e., no growth in laboratory or the sample contained contaminated, untestable isolates).

- Hurley Hospital submitted samples to BOL from 100 percent of the Legionnaires' Disease patients treated at their facility; Genesys Regional Medical Center provided samples for 58 percent of patients.
- While McLaren Flint treated 31 patients for Legionnaires' Disease in 2015 and collected 16 sputum samples, only two samples were submitted by McLaren Flint Hospital to MDHHS BOL (six percent).
    - These two specimens were from two of the earliest patients treated at the hospital in 2015 and were submitted before the general increase in cases was recognized (June 2015). After that point, no subsequent samples were received by BOL, even as patient counts increased dramatically through early August 2015. It would have been clear to the hospital that many of these patients had been recently treated in McLaren Flint Hospital.
    - Throughout 2014-2015, no environmental isolates from any positive environmental tests of the McLaren Flint's potable water system were submitted to BOL or retained by McLaren Hospital for

comparison to clinical specimens. Four samples were provided from two external cooling towers in August 2015.

- Genesee County Health Department reported to MDHHS that GCHD staff had directed that McLaren Hospital retain any isolates for further testing at a later date.

Case Demographics and Residential Geography

2014 – 2017 Epidemiology of Legionnaires' Disease in Genesee County, Michigan

2014-2015 / 2016-2017 Legionnaires' Disease in Genesee County Demographic Data

2014-2015

Total Confirmed Cases: 90

2014 - 40
2015- 50

Age

Range: 26-94 years (Median: 65.5 years; Mean: 65.4 years)

Sex

Male: 47 (52.2%)

Female: 43 (47.8%)

Health Risk Factors

Underlying medical conditions: 62/74 (83.8%)
(16 individuals have an unknown underlying medical condition status)

Current/former smoker: 57/73 (78.1%)
(17 individuals have an unknown smoking status)

Not a current/former smoker and no known underlying medical conditions: 3/73 (4.1%)

2016-2017

Total Confirmed Cases: 30

2016 - 17
2017 - 13

Age

Range: 39-90 years (Median: 60 years; Mean: 62.1 years)

Sex

Male: 15 (50%)
Female: 15 (50%)

Health Risk Factors

- Underlying medical conditions: 22 (73.3%)
- Current/former smoker: 23 (76.7%)
- Not a current/former smoker and no known underlying medical conditions: 2 (6.7%)

In 2014-2015, there were 90 confirmed cases of Legionnaires' Disease in Genesee County. In 2016-2017, there were 30 confirmed cases. The age range for cases in 2014 and 2015 outbreaks (26-94 years) falls within the expected range based on historic data for Michigan and the nation. In 2016 and 2017, the average age of the cases was approximately three years younger with a two percent lower percentage of male cases than in 2014-2015.

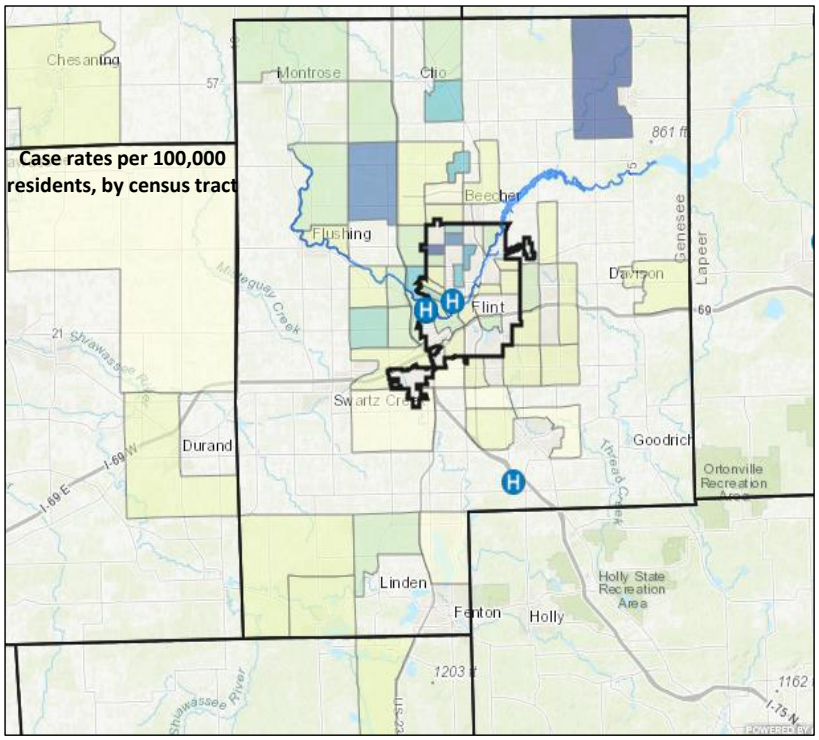
Enhanced information for comparison between outbreak and non-outbreak years is only available for cases from 2014-2017, when a supplemental data collection tool developed in 2015 was employed in response to the outbreak. Eighty-four percent of the 2014 and 2015 cases presented with existing underlying medical conditions, compared to 73 percent of the 2016-2017 cases. Not only does the presence of existing risk factors increase the likelihood of infection following exposure to *Legionella*, but the higher percentage of co-morbidities can be associated with a higher risk of hospitalization for treatment at the hospital where the exposure to *Legionella* bacteria took place.

The distribution of cases from 2014-2015 was consistent with other healthcare associated outbreak described in literature that included cases with increased median age and a higher case fatality rate[1,2,3]. Prior to the 2014-2015 outbreak years, Genesee County cases presented with a younger median age (53 years) and greater proportion of male patients which is consistent with community acquired Legionnaires' Disease patterns nationally [1,2,3].

Sources:
[1] Garrison LE, Kunz JM, Cooley LA, et al. Vital signs: deficiencies in environmental control identified in outbreaks of Legionnaires' disease—North America, 2000–2014. *MMWR Morb Mortal Wkly Rep* 2016;65:576–84.
[2] Jespersen S, Søgaard OS, Schønheyder HC, et al. Clinical features and predictors of mortality in admitted patients with community- and hospital-acquired legionellosis: A Danish historical cohort study. *BMC Infectious Diseases* 2010;10:124.
[3] Phin N, Parry-Ford F, Harrison T, et al. Epidemiology and clinical management of Legionnaires' disease. *Lancet Infect Dis* 2014;14:1011-21.

Rates of Legionnaires' Disease by Census Tract per 100,000 Population — Genesee County, Michigan, 2014–2015

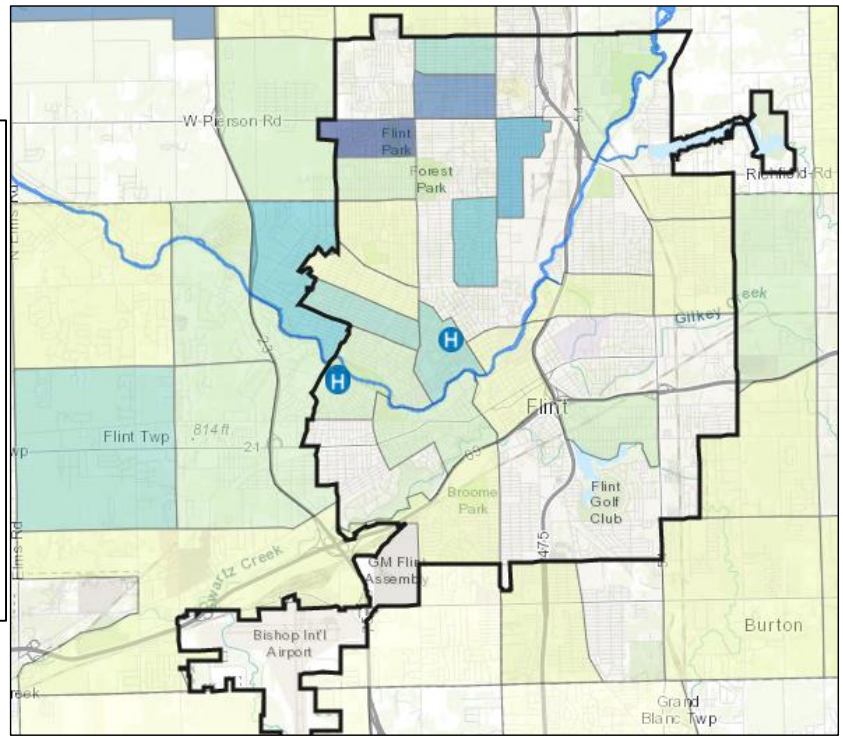
Cases rates of all confirmed cases associated with Genesee County



Average yearly rate of Legionnaires' disease
(per 100,000 persons)

- 71-80 cases/yr
- 61-70 cases/yr
- 51-60 cases/yr
- 41-50 cases/yr
- 31-40 cases/yr
- 21-30 cases/yr
- 11-20 cases/yr
- 1-10 cases/yr
- Genesee County Hospital

Cases rates of all confirmed cases associated with Flint



The water source at the patient's address during the case's incubation period was assessed. This relevant address identifies where the patient spent their incubation period, regardless of permanent residential address. This assessment did not specify the amount of time the patient may have spent at that address in the two weeks prior to illness onset.

The number of cases in a geographic area divided by the number of people who live there is called an incidence rate. The rate makes it possible to compare the number of cases of a disease in geographic areas of different population sizes.

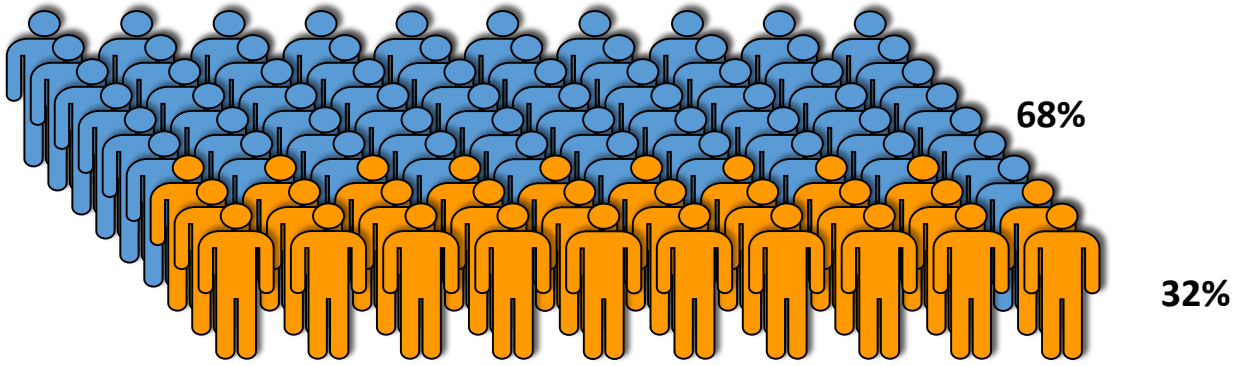
These maps show the rates of Legionnaires' Disease in Genesee County and the City of Flint by census tract of the patients' incubation period residence for 2014 and 2015.

- Rates are per 100,000 residents per year
- The dark black outline depicts the boundary of the City of Flint (enhanced in the second map)
    - Note: Not all census tracts within Flint municipal boundaries are on the Flint water system; the water also system extends beyond the municipal boundaries in several locations; some residents outside the Flint municipal boundaries are on Flint water.
- The colors in the map correspond to the rate of cases (see legend). For example, dark purple indicates census tracts where there were more than 70 to 80 cases of Legionnaires' Disease per 100,000 people.

The cases of Legionnaires' Disease were distributed throughout Genesee County in both years. While there was considerable variability in rates by census tract, there is no evidence of strong clustering, either within Flint or the rest of Genesee County.

These rates do not allow for assessment of any possible small-scale clustering (one to five cases) geographically.

2014–2015 Legionnaires' Case Patients by Incubation Period Residence On/Off Flint Municipal Water



Case patients not residing on City of Flint water

Case patients residing on City of Flint water

The water source at the patient's address during the case's incubation period was assessed. This relevant address identifies where the patient spent their incubation period, regardless of permanent residential address. This assessment did not specify the amount of time the patient may have spent at that address in the two weeks prior to illness onset.

This graphic presents counts of Legionnaires' Disease patients who lived on and off the City of Flint water system during their incubation period.

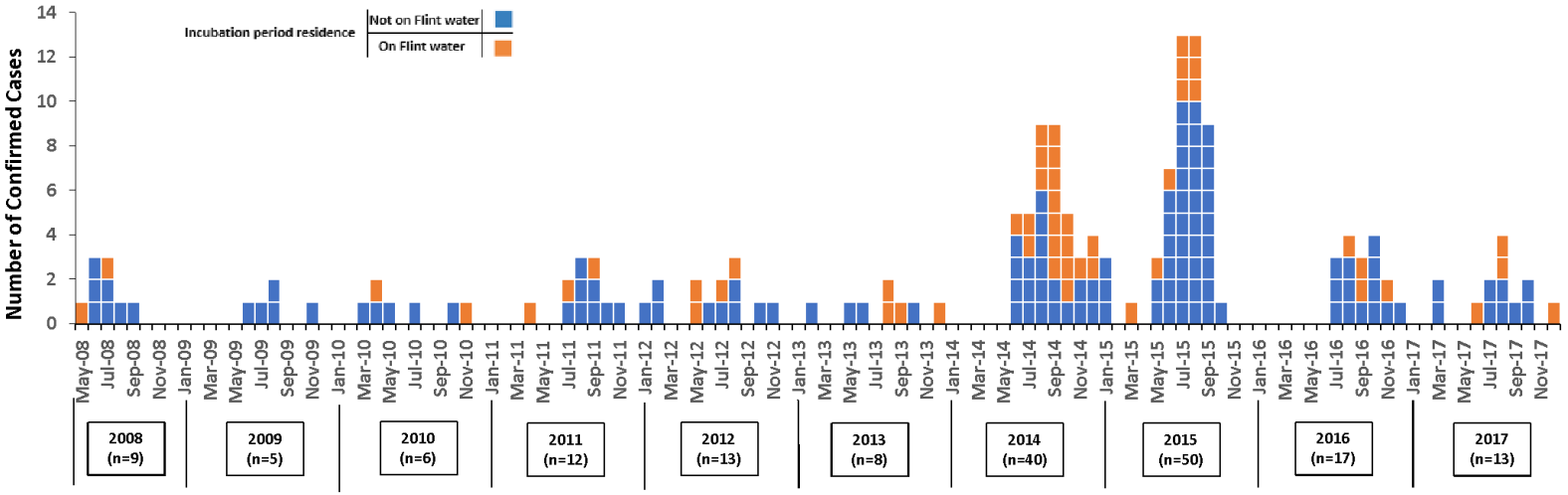
During 2014-2015, 61 cases of Legionnaires' Disease (68 percent) lived in a residence that was not serviced by City of Flint water system during their incubation period. (Blue figures)

Twenty-nine cases of Legionnaires' Disease (32 percent) lived at a residence that was serviced by City of Flint water system during their incubation period. (Orange figures)

By comparison, in the baseline period (2011-2013), 64 percent of cases lived in a residence that was not serviced by City of Flint water system during their incubation period. Thirty-six percent lived at a residence in the City of Flint.

Trends for Legionnaires' Disease in Genesee County by Water Source

Legionnaires' Disease Cases by Month of Onset or Referral Date by Water Source --
Genesee County, January 2008 -- December 2017
[This includes 4 non-Genesee residents (1 in November 2014, 3 in August 2015)]



This chart presents the incidence of Legionnaires' Disease in Genesee County between January 2008 and November 2017. Each block on the chart represents one confirmed Legionnaires' Disease patient whose symptoms started during that month. If symptom onset was not available in the record for 2008-2013 cases, the referral date was used in its place.

- Orange blocks: case patients with incubation period residence on the Flint water system.
- Blue blocks: case patients with incubation period residence not on the Flint water system.
- Text boxes below the graphic provide the total number of cases each year.

Legionnaires' Disease typically presents with a seasonal pattern of increased incidence from late spring to early fall. There were two waves of illness evident in 2014 and 2015 outbreak. These waves were clearly delineated with a return to expected levels during the spring months of 2015.

These data demonstrate a return to near expected baseline number of cases in 2016 and 2017. The average number of cases in the baseline period before the outbreak (between 2011 and 2013) was 11 annually (range: 8-13). When the average annual statewide increase of 13 percent is applied to this county, the expected incidence for Legionnaire's Disease would be between 12 and 13 cases in 2014, 14 in 2015, 15 to 16 in 2016, and 17 to 18 cases in 2017. Seventeen cases were reported in 2016 and 13 in 2017. The observed number of cases in 2016 and 2017 represent a return to the expected number of cases, adjusting the baseline number for the increase in cases statewide.

The distribution of case patients by water system varied by year. Fifty percent of Legionnaires' Disease patients were on Flint water system in 2013 and in 2014. In all other years, more than 50 percent of the cases were from non-Flint water residences.

Note that these data include four non-Genesee residents (one case in November 2014, and three in August 2015).

High Risk Facility Exposures

2014 – 2015 Legionnaires' Disease Cases in Genesee County, Michigan

In nature, *Legionella* live in fresh water and rarely cause illness. In man-made settings, *Legionella* can grow if water is not properly maintained. These man-made water sources become a health problem when small droplets of water that contain the bacteria get into the air and people breathe them in. Outbreaks of Legionnaires' Disease are often associated with large or complex water systems, like those found in hospitals, hotels, and cruise ships. ASHRAE and CDC recommend that buildings have a Water Management Plan for hot and cold water systems if the facility:

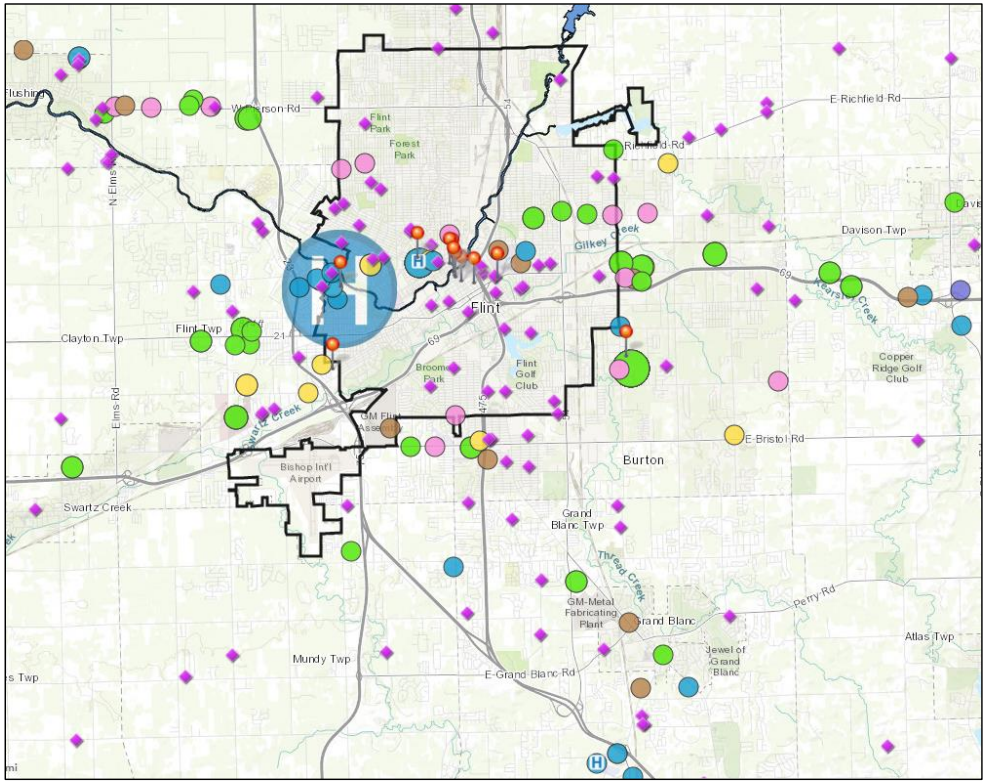
- is a health care facility where patients stay overnight or where people who have chronic and acute medical problems or weakened immune systems are housed,
- is a building that primarily houses people older than 65 years (ex. retirement home or assisted-living facility),
- has multiple housing units and a centralized hot water system (ex. hotel or apartments), or
- has more than 10 stories (including basement levels).

Some devices can also spread contaminated water droplets, such as cooling towers, hot tubs that are not drained between each use, decorative fountains, or centrally-installed misters, atomizers, air washers or humidifiers. These devices need a water management plan to maintain their safe use.

Water management programs identify hazardous conditions and initiate steps to minimize the growth and transmission of *Legionella* and other waterborne pathogens in building water systems. Water management industry standards are laid out in the (ASHRAE 188: Legionellosis: Risk Management for Building Water Systems June 26, 2015. ASHRAE: Atlanta). The CDC has developed a practical guide for implementing these standards "Developing a Water Management Program to Reduce *Legionella* Growth and Spread in Buildings." (https://www.cdc.gov/legionella/WMPtoolkit).

MDHHS asked about patients about locations they visited or traveled to during their incubation period (14 days before they became ill), to identify commonalities between patients' exposures to buildings or devices that could potentially harbor *Legionella* bacteria.

Facilities at High Risk for *Legionella* Transmission In and Near the City of Flint in Proximity to All Non-Residential Exposures Reported by Case Patients Genesee County, 2014-2015



LEGEND

Potential Incubation Period Exposure Sites Reported by Case Patients

- >50 cases
- 31-50 cases
- 16-30 cases
- 5-15 cases
- 1-5 cases

- Health care facilities[1]
- Shopping centers[2]
- General public buildings[3]
- Sites involving outdoor exposures[4]
- Buildings providing services/facilities involving water[5]
- Other public buildings with potentially complex water systems[6]

Buildings at Increased Risk for Legionnaires' Disease

(due to either facility characteristics or vulnerability of population)

- Building ≥ 8 stories in height
- Long-term care facility
- Hospital

[1]Health care facilities: hospitals, long-term care facilities, outpatient clinics
[2]Shopping centers: grocery stores, retail shopping centers
[3]General public buildings: churches, smaller office buildings, restaurants, auditoriums, schools, theaters
[4]Sites involving outdoor exposures: landscaping sites, construction sites, other outdoor work sites, campgrounds
[5]Buildings providing services/facilities involving water: car washes, salons, gymnasiums
[6]Other public buildings with potentially complex water systems: hotels, casinos

Public Health asked Legionnaires' Disease patients about locations they had visited or traveled to during their incubation period (14 days before they became ill), in order to identify commonalities between patients' exposures to buildings or devices that could potentially harbor *Legionella* bacteria.

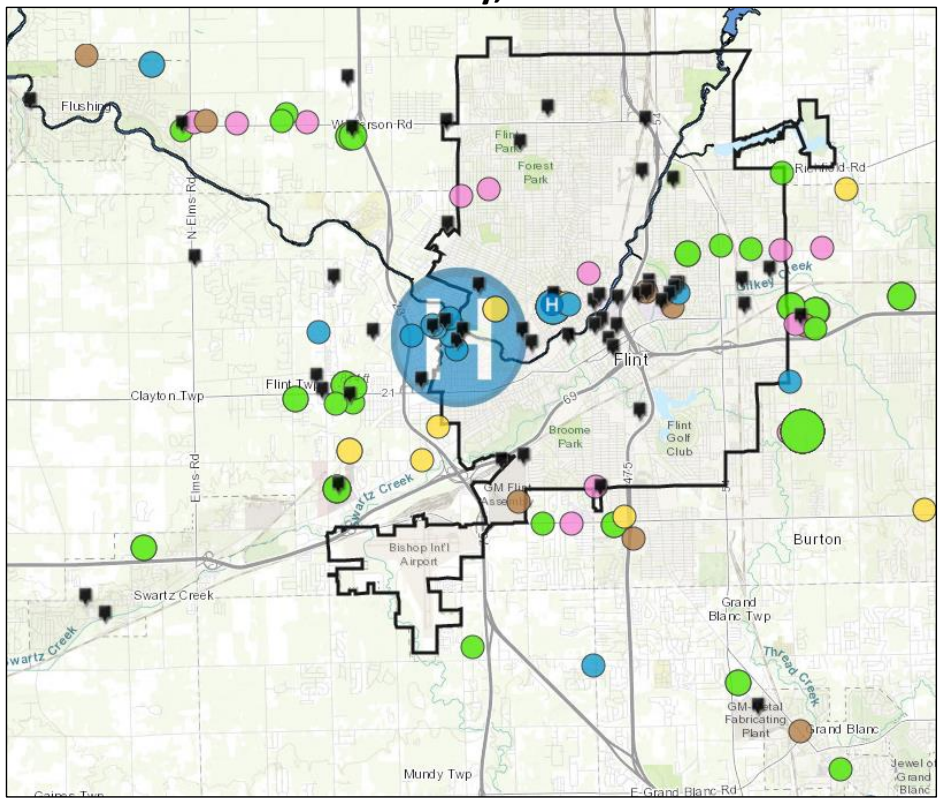
Legionella bacteria are most likely to grow within the plumbing systems of buildings where ideal conditions for growth such as warmer temperatures and stagnation are common. Buildings may be considered "high risk" for *Legionella* based either on certain building characteristics that are more likely to promote *Legionella* growth or based on increased susceptibility of the building occupants to developing Legionnaires' Disease (individuals of older age or with certain medical conditions).

Similar to other cities around the state of Michigan, the City of Flint has many buildings considered to be at high risk, such as homes for the elderly (pink diamonds), tall buildings (orange pins), and hospitals (blue circle with H). This map shows the proximity of these high risk buildings in relation to all reported non-residential sites of exposure during case patients' incubation periods. Residential sites of potential exposure were also assessed but are not shown here in order to protect patient privacy. There were no residential sites of potential exposure shared by multiple patients.

The map above provides color coded circles which demonstrate the number of Legionnaires' Disease patients who reported visiting different locations (i.e., hospitals, grocery stores, office buildings, car washes, etc.) during their incubation period. The color of the circle describes the type of facility. The size of the circle represents how many Legionnaires' Disease patients reported visiting or staying at that site during their incubation period.

The most frequently visited place among these patients was McLaren Flint Hospital (51 patients). The next most frequently visited locations were two grocery stores who receive their water from municipal systems other than the Flint water system (10 and six patients, respectively). Six case patients indicated they visited Hurley Hospital, which is on the Flint water system. Three of those six also reported visiting McLaren Flint Hospital during their incubation period.

Potential Cooling Towers in and Near the City of Flint in Proximity to All Non-Residential Exposures Reported by Case Patients
Genesee County, 2014-2015



LEGEND

Potential Incubation Period Exposure Sites Reported by Case Patients

- >50 cases
- 31-50 cases
- 16-30 cases
- 5-15 cases
- 1-5 cases

- Health care facilities[1]
- Shopping centers[2]
- General public buildings[3]
- Sites involving outdoor exposures[4]
- Buildings providing services/facilities involving water[5]
- Other public buildings with potentially complex water systems[6]

Potential Cooling Tower Sites

Hospital

[1]Health care facilities: hospitals, long-term care facilities, outpatient clinics
[2]Shopping centers: grocery stores, retail shopping centers
[3]General public buildings: churches, smaller office buildings, restaurants, auditoriums, schools, theaters
[4]Sites involving outdoor exposures: landscaping sites, construction sites, other outdoor work sites, campgrounds
[5]Buildings providing services/facilities involving water: car washes, salons, gymnasiums
[6]Other public buildings with potentially complex water systems: hotels, casinos

Public Health asked Legionnaires' Disease patients about locations they had visited or traveled to during their incubation period (14 days before they became ill), in order to identify commonalities between patients' exposures to buildings or devices, such as cooling towers, that could potentially harbor *Legionella* bacteria.

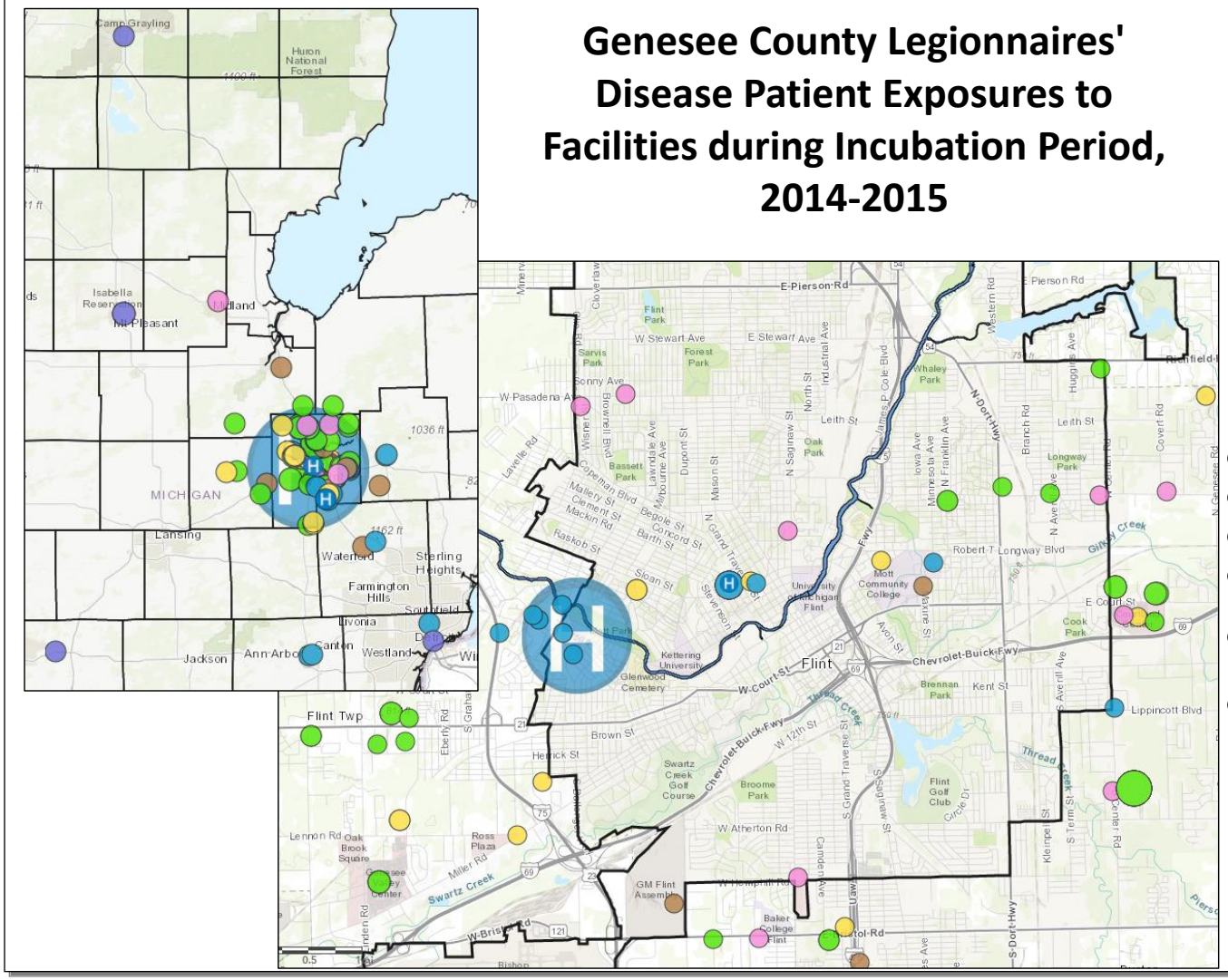
In addition to certain buildings being high risk for *Legionella* growth, cooling towers are also known to be sites where *Legionella* bacteria can grow and then spread to the surrounding areas through tiny water droplets. Because cooling towers have been associated with a number of Legionnaires' Disease outbreaks worldwide, a standard part of Legionellosis outbreak investigations involves mapping cooling towers in relation to locations where Legionnaires' Disease patients may have traveled during their incubation period.

This map shows those cooling towers in the City of Flint and surrounding areas (black markers) that were able to be identified through satellite images such as Google Maps. This map shows the proximity of these cooling towers in relation to all non-residential sites of exposure during case patients' incubation periods. Residential sites of potential exposure were also assessed but are not shown here to protect patient privacy. There were no residential sites of potential exposure shared by multiple patients.

The map above also provides color coded circles which demonstrate the number of Legionnaires' Disease patients reporting visiting different locations (i.e., hospitals, grocery stores, office buildings, car washes, etc.) during their incubation period. The color of the circle describes the type of facility. The size of the circle represents how many Legionnaires' Disease patients reported visiting or staying at that site during their incubation period.

The most frequently visited place among these patients was McLaren Flint Hospital (51 patients). The next most frequently visited locations were two grocery stores outside of the Flint water system (10 and six patients, respectively). Six case patients indicated they visited Hurley Hospital, which is on the Flint water system. Three of those six also reported visiting McLaren Flint Hospital during their incubation period.

Genesee County Legionnaires' Disease Patient Exposures to Facilities during Incubation Period, 2014-2015



LEGEND

Potential Incubation Period Exposure Sites Reported by Case Patients

- **>50 cases**
- **31-50 cases**
- **16-30 cases**
- **5-15 cases**
- **1-5 cases**

- **Hospitals**
- **Health care facilities[1]**
- **Shopping centers[2]**
- **General public buildings[3]**
- **Sites involving outdoor exposures[4]**
- **Buildings providing services/facilities involving water[5]**
- **Other public buildings with potentially complex water systems[6]**

[1]Health care facilities: hospitals, long-term care facilities, outpatient clinics
[2]Shopping centers: grocery stores, retail shopping centers
[3]General public buildings: churches, smaller office buildings, restaurants, auditoriums, schools, theaters
[4]Sites involving outdoor exposures: landscaping sites, construction sites, other outdoor work sites, campgrounds
[5]Buildings providing services/facilities involving water: car washes, salons, gymnasiums
[6]Other public buildings with potentially complex water systems: hotels, casinos

Public Health asked Legionnaires' Disease patients about locations they had visited or traveled to during their incubation period (14 days before they became ill), in order to identify commonalities between patients' exposures to buildings or devices that could potentially harbor *Legionella* bacteria. Legionnaires' Disease patients from Genesee County traveled to facilities across Michigan.

This map provides color coded circles which demonstrate the number of Legionnaires' Disease patients reporting visiting different locations (i.e., hospitals, grocery stores, office buildings, car washes, etc.) during their incubation period. Residential sites of potential exposure were also assessed but are not shown here in order to protect patient privacy. There were no residential sites of potential exposure shared by multiple patients. The color of the map circles describes the type of facility. The size of the circles represents how many Legionnaires' Disease patients reported visiting or staying at that site during their incubation period.

The most frequently visited place among these patients was McLaren Flint hospital (51 patients). The next most frequently visited locations were two grocery stores outside of the Flint water system (10 and six patients, respectively). Six case patients indicated they visited Hurley Hospital, which is on the Flint water system. Three of those six also reported visiting McLaren Flint hospital during their incubation period.

No other large building with high risk plumbing in or outside Flint was identified as a common location that patients visited during the two week incubation period before their symptoms began. If deficiencies within the Flint water system were a major contributor to the increase in cases in Genesee County during 2014-2015, it would be expected that there would be clustering of places of common exposure in the multiple high risk buildings and residential settings in the City of Flint. This was not observed.

MDHHS assessed many types of facilities and other structures of potential *Legionella* exposures. McLaren Flint Hospital remains the strongest epidemiologic signal of potential source to *Legionella* bacteria among the 2014-2015 cases. When considering the length of exposure (i.e., time during incubation period spent at the facility), the

association with McLaren Flint Hospital is even more clearly evident, accounting for over 50 percent of all patient exposure time among all locations where two or more Legionnaires' Disease patients visited (data not displayed).

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Sites Visited during Patient's Incubation Period, On or Off the Flint Water System, 2014-2015

		Residence (Count (Percent)) On Flint Water	Not Flint Water	Total
Total sites	Sites on Flint Water	65 (71%)	54 (24%)	119 (37%)
	Sites Not on Flint Water	26 (29%)	174 (76%)	200 (63%)
	Total Visits	91	228	
Sites excluding all residential addresses	Visits to Sites on Flint Water	33 (56%)	54 (33%)	87 (39%)
	Visits to Sites Not on Flint Water	26 (44%)	111 (67%)	137 (61%)
	Total Visits	59	165	
Sites excluding all McLaren Flint exposures	Visits to Sites on Flint Water	13 (33%)	16 (13%)	29 (17%)
	Visits to Sites Not on Flint Water	26 (67%)	111 (87%)	137 (83%)
	Total Visits	39	127	
Sites excluding all healthcare exposures	Visits to Sites on Flint Water	9 (28%)	8 (8%)	17 (12%)
	Visits to Sites Not on Flint Water	23 (72%)	97 (92%)	120 (88%)
	Total Visits	32	105	

Based on data about typical commuting patterns between Flint and surrounding areas, some people have hypothesized that the 2014-2015 cases of Legionnaires' Disease among non-Flint residents could have been due to their exposure to the Flint water system due to repeated commutes into Flint. MDHHS used the data collected from Legionnaires' Disease patients on the extended questionnaire to determine how many patients living in Flint traveled outside of Flint and vice versa.

The 2014-2015 Legionnaires' Disease patients visited 319 sites of potential exposure during their incubation period, including 119 sites on the Flint water system (37 percent) and 200 sites not on the Flint water system (63 percent). Patients who lived on the Flint water system visited 91 places. Patients who lived outside of Flint visited 228 places. The majority of places visited by patients who lived on the Flint water system were on the Flint water system (71 percent). The majority of places visited by patients who did not live on the Flint water system were also not on the Flint water system (76 percent). After excluding visits to residential addresses, patients who lived on the Flint water system visited 59 sites. Fifty-six percent of these 59 non-residential sites were also on the Flint water system.

Among patients who did not live on the water system, the majority (67 percent) of 165 non-residential places visited were not on the Flint water system. Patients who did not live on the Flint water system had 54 site visits on the Flint water system. Of these 54, a total of 16 were not at McLaren Flint Hospital and only eight were for reasons other than seeking health care. Aside from McLaren Flint Hospital, no other high risk facility was identified in these 54 visits.

After excluding all McLaren Flint and residential exposures, Legionnaires' Disease patients visited 29 places on the Flint water system (17 percent of places) and 137 places outside of the Flint water system (83 percent of places). The majority of sites visited by patients who lived outside of Flint were also outside of Flint (87 percent), but 67 percent of the places visited by patients who lived on the Flint water system were also off of Flint water.

The majority of non-residential and non-health care sites visited by Legionnaires' Disease patients were to sites not on the Flint water system, regardless of patient's residence. These data are consistent with demographic patterns seen among Legionnaire's patients (during any year), which demonstrate that they are on average significantly different in terms of age, number of medical conditions, and commuting behavior compared to the general populations of Flint and Genesee County.

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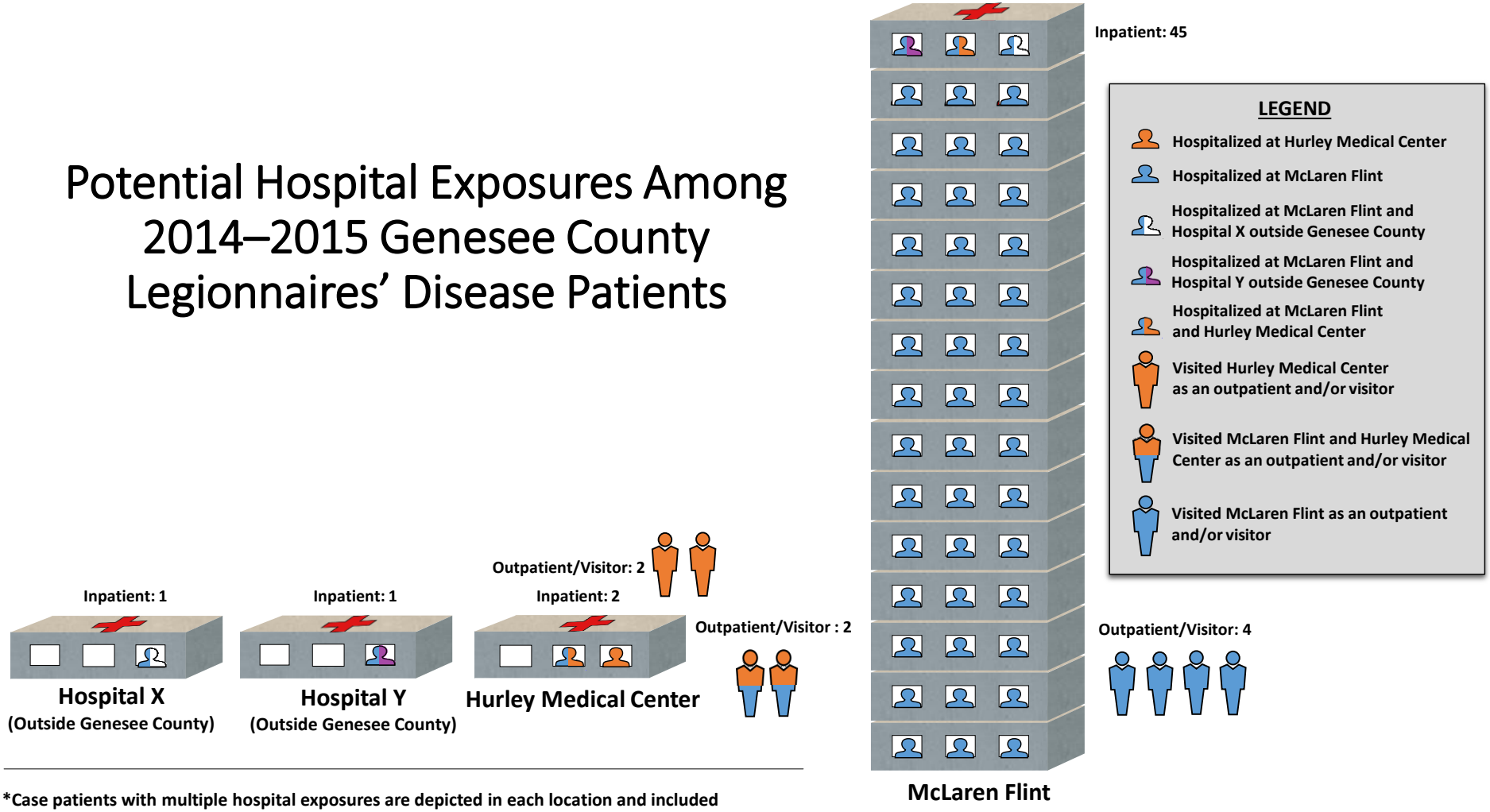
Potential Hospital Exposures Among 2014–2015 Genesee County Legionnaires' Disease Patients



*Case patients with multiple hospital exposures are depicted in each location and included in the count for each location. In cases with both inpatient and outpatient exposures, only the inpatient exposure is shown here

The majority of cases of Legionnaires' Disease reported in Genesee County for 2014-2015 had exposure to a hospital during their fourteen day incubation period. This graphic representation summarizes those exposures, specifying the hospital where the exposure occurred and the type of exposure (inpatient stays, outpatient visits or as a visitor). This information was available for the 83 patients who had a completed exposure history that was ascertained through interview and/or record review (83 of 90 patients or 92 percent).

Of the 83 patients for whom complete exposure history was available, 54 (65 percent) case patients had hospital building exposure during their 14 day incubation period.

- Forty-six of these 54 case patients experienced healthcare exposures in an inpatient setting, with the remaining eight reporting exposure as outpatients or visitors.
- Of the 46 case patients with inpatient exposures, 45 (98 percent) were hospitalized at McLaren Flint Hospital at some point during their 14 day incubation period.

A significant majority (51 of 54, or 94 percent) of the case patients with any hospital healthcare exposures were at McLaren Flint Hospital during their 14 day incubation period. Forty-six of 54 (85 percent) of the case patients were exposed only to McLaren Flint during their 14 day incubation period, including 42 inpatient exposures and four with outpatient or visitor exposures.

Three case patients of 54 (six percent) were exposed only to Hurley Medical Center during their 14 day incubation period, including one as an inpatient and two as outpatients or visitors.

Two case patients of 54 (four percent) were hospitalized at hospitals outside Genesee County during their incubation period, in addition to being hospitalized at McLaren Flint Hospital.

The awareness of the need for proper water management in facilities where vulnerable populations gather has been recognized by federal and state government. For example, the U.S. Centers for Medicaid and Medicare Services (CMS) expects Medicare certified healthcare facilities to have water management policies and

procedures to reduce the risk of growth and spread of *Legionella* and other opportunistic pathogens in building water systems (https://www.cms.gov/Medicare/Provider-Enrollment-and-Certification/SurveyCertificationGenInfo/Downloads/Survey-and-Cert-Letter-17-30.pdf).

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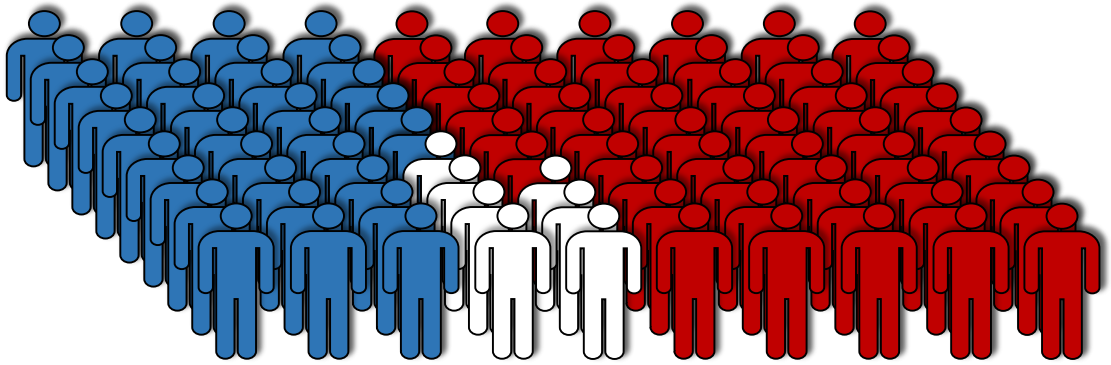
2014–2015 Legionnaires' Disease Cases by McLaren Flint Hospital Exposure during Incubation Period



Cases with no McLaren Flint exposure

Cases with unknown/incomplete history of exposure to McLaren Flint

Cases with McLaren Flint exposure

An evaluation of potential healthcare exposure is always included in patient assessments by public health. It is a part of standard review because, historically, healthcare facilities have been associated with outbreaks of Legionnaires' Disease. This association is in part due to the number of patients with pre-existing conditions that increase risk of infection. The complex nature of hospital water systems can also facilitate *Legionella* growth and dispersion, increasing risk of infection. CDC defines large healthcare and hospital facilities as high risk buildings for Legionnaires' Disease transmission. For this investigation, healthcare exposure has been defined as any inpatient, outpatient, or visitor contact with a hospital during the patient's incubation period.

- **During 2014-2015, 51 cases of Legionnaires' Disease (56.7 percent) occurred in individuals with an identified healthcare exposure at McLaren Flint hospital. (Red figures)**
- 32 cases of Legionnaires' Disease (35.6 percent) occurred in patients with no identified healthcare exposure. (Blue figures)
- Seven cases of Legionnaires' Disease (7.8 percent) occurred in patients with unknown/incomplete healthcare exposure history. (White figures)

MDHHS continues to evaluate additional information as it is obtained to update the characterization of patient's healthcare-associated exposures. As information becomes available, some of these unknown cases may be reclassified to having healthcare-associated exposure.

Of the 83 cases in 2014-2015 for whom a response was known (Red and Blue figures), 65 percent (n=54) had an identified healthcare exposure. Fifty-one (94 percent) of those 54 individuals who had a healthcare exposure indicated an exposure at McLaren Flint Hospital (Red Figures).

Based on comparison with available summaries of Legionellosis outbreaks[1], Genesee County experienced the largest potable water healthcare-associated outbreak of Legionnaires' Disease in the nation's history.

Source: Vital Signs: Deficiencies in Environmental Control Identified in Outbreaks of Legionnaires' Disease — North America, 2000–2014 MMWR/ June 10, 2016 / 65(22);576 - 584 and www.specialpathogenslab.com/legionella-outbreaks.php

Number of Medicare Discharges by Hospital per Zip Codes of Residence, Genesee County Area

LEGEND

>2000 discharges

1401-2000 discharges

801-1400 discharges

51-800 discharges

<50 discharges

Gensys Patients

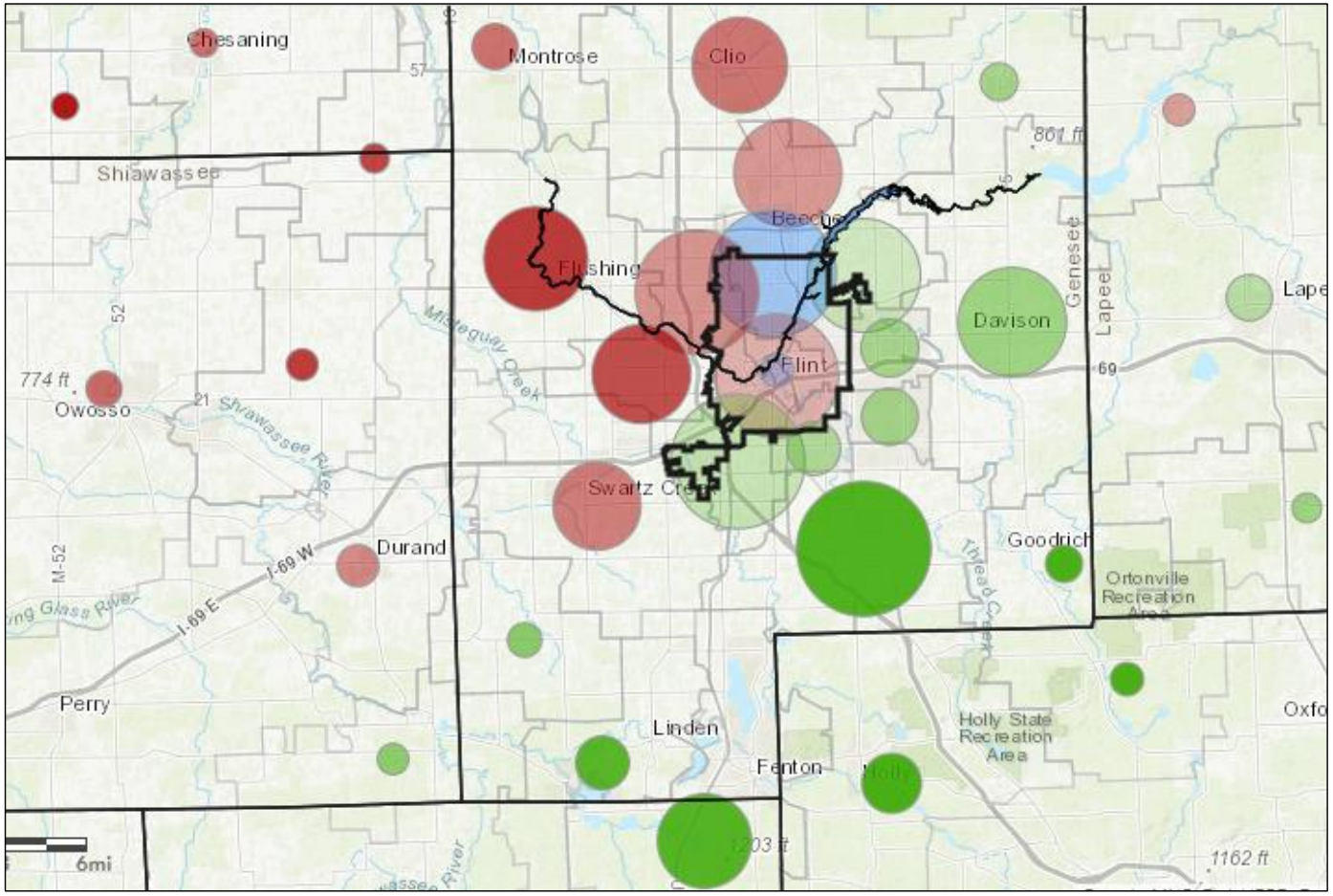
Hurley Patients

McLaren Flint Patients

Relative Frequency of Most Common Exposure

>75%

<35%



This map describes where each hospital in Genesee County most frequently draws its Medicare patients (catchment area).

- Each zip code has a circle whose size represents the number of hospital discharges for Medicare patients who live in the zip code.
- The color of the circles indicate the hospital where most of the discharges originated (red is McLaren Hospital, blue is Hurley Hospital, and green is Genesys).
- The depth of the color of the circle represents the relative proportion of total discharges that occurred from a particular hospital. For example, if the percent of all discharges that occurred from McLaren Hospital in a zip code was over 75 percent, the circle would be dark red. If a circle is light pink, the discharges from McLaren would be less than 35 percent of all discharges from that zip code.

McLaren Flint Hospital tends to draw its Medicare patients from the area north and west of the hospital and from Flint itself. Hurley Hospital tends to draw its Medicare patients from Flint and the area north of Flint. Genesys Regional Medical Center tends to draw its Medicare patients from areas to the east and south of Flint.

LEGEND

14 cases

10-13 cases

7-9 cases

4-6 cases

≤3 cases

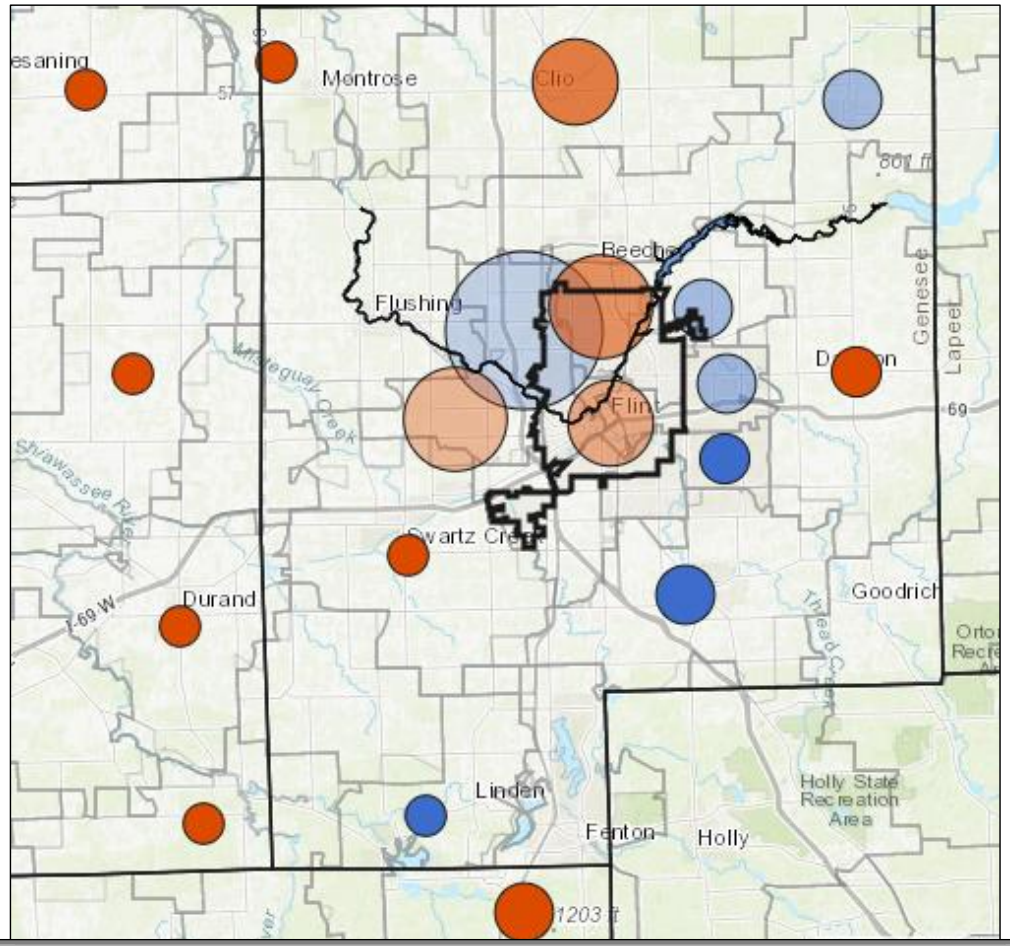
Red = McLaren Flint Hospital Exposure
Blue = No McLaren Flint Hospital Exposure

Relative Frequency of Most Common Exposure

>75%

<35%

Cases by Incubation Period Zip Code, with Relative Contribution of McLaren Flint Hospital Exposure, 2014-2015



This map describes the locations where the Legionnaires' Disease patients lived during their incubation periods.

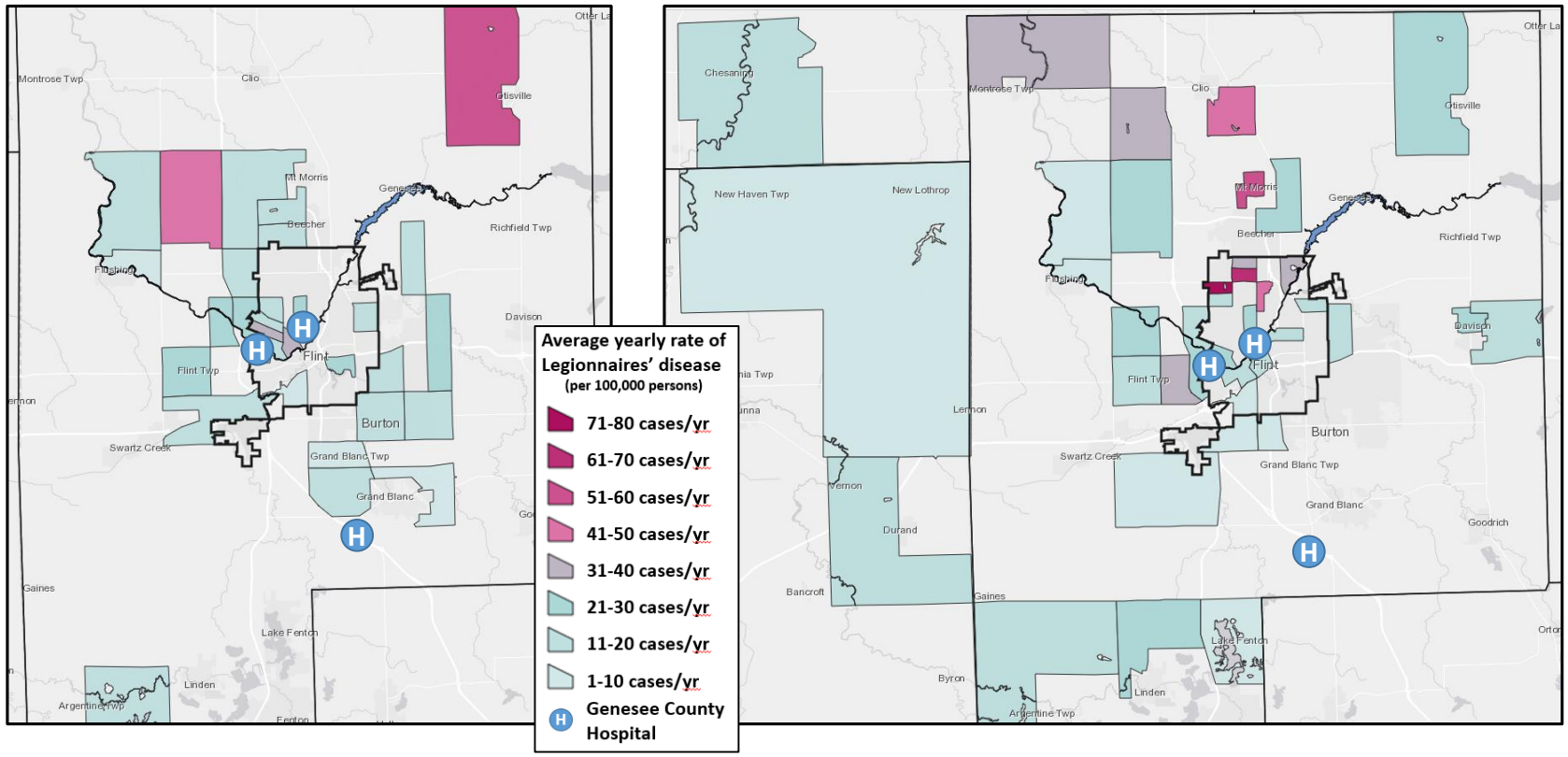
- Each zip code with a patient residence is indicated with a circle.
- The size of the circle represents the number of Legionnaires' Disease patients who lived in the zip code during their incubation period. The largest circle has 14 cases of Legionnaires' Disease.
- The color of the circles indicate what percentage of those patients had exposure to McLaren Flint Hospital. Circles colored in red represent zip codes where patients were more frequently associated with an exposure to McLaren Flint Hospital during their incubation period. The darker the color indicates the higher percentage of McLaren Flint exposed patients. The Blue circles represent zip codes where a higher percentage of patients had no exposure to McLaren Flint hospital during their incubation period.

The zip codes where Legionnaires' Disease patients were most likely to have McLaren Flint Hospital exposure tend to be in the area from which McLaren Flint draws its Medicare patients at highest levels.

Rates of Legionnaires' Disease by McLaren Flint Exposure, by Census Tract per 100,000 Population — Genesee County, Michigan, 2014–2015

Rates of Non-McLaren Flint-Associated Cases and Unknown McLaren-Flint-Associated Cases (N=39)

Rates of Possible or Definite McLaren Flint-Associated Cases (N=51)



These maps show the rates of Legionnaires‘ Disease in Genesee County by census tract of incubation period residence for those cases with exposure to McLaren Flint Hospital and those without known exposure to McLaren Flint Hospital.

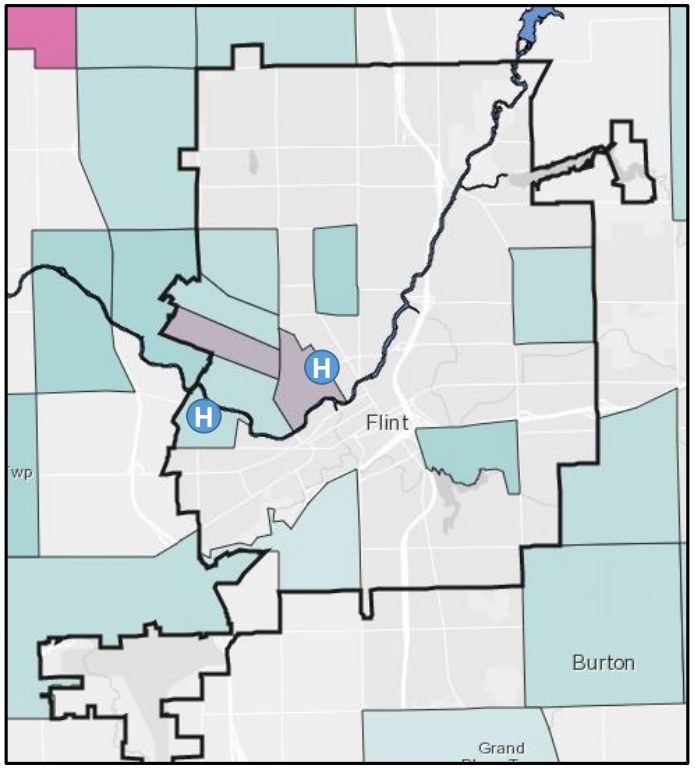
- Rates are per 100,000 residents
- The dark black outline depicts the boundary of the City of Flint.
    - Note: Not all census tracts within Flint municipal boundaries are on the Flint water system; the water system extends beyond the municipal boundaries in several locations so that some residents outside the Flint municipal boundaries are on Flint water.

Cases with known exposure to McLaren Flint are predominantly located on the Western side of Genesee County and surrounding counties. This distribution reflects the overall distribution of patients seeking medical care at McLaren Flint Hospital. McLaren Flint Hospital’s patient referral network is widespread, but the highest percentage of patients originate from the West side of the City of Flint, and the Western and Northwestern areas of Genesee County.

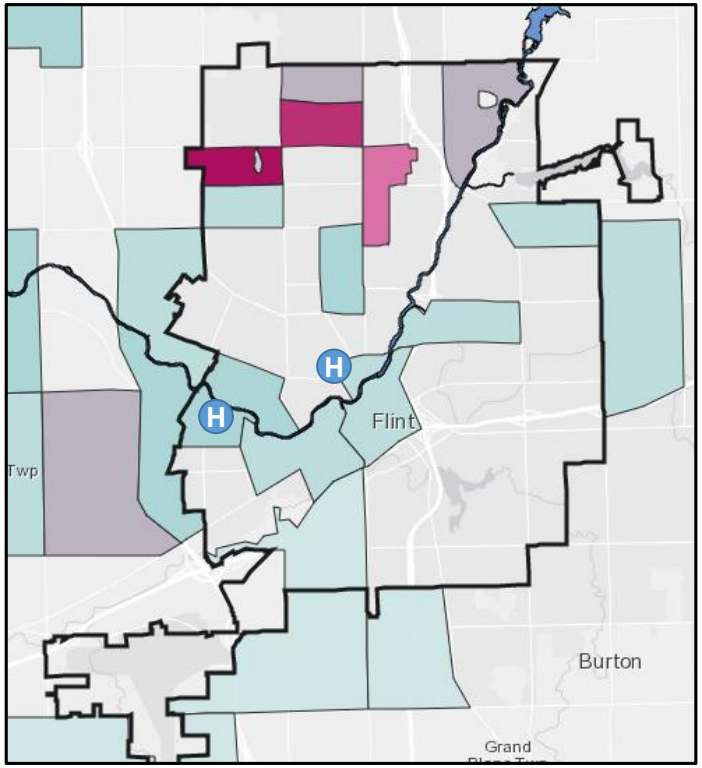
The census tract rates for non-McLaren Flint associated cases tend to be lower than the rates for McLaren Flint cases.

Rates of Legionnaires' Disease by McLaren Flint Exposure, by Census Tract per 100,000 Population — Genesee County, Michigan, 2014–2015

Rates of Non-McLaren Flint-Associated Cases and Unknown McLaren-Flint-Associated Cases



Rates of Possible or Definite McLaren Flint-Associated Cases



Average yearly rate of Legionnaires' disease
(per 100,000 persons)

- 71-80 cases/yr
- 61-70 cases/yr
- 51-60 cases/yr
- 41-50 cases/yr
- 31-40 cases/yr
- 21-30 cases/yr
- 11-20 cases/yr
- 1-10 cases/yr
- Genesee County Hospital

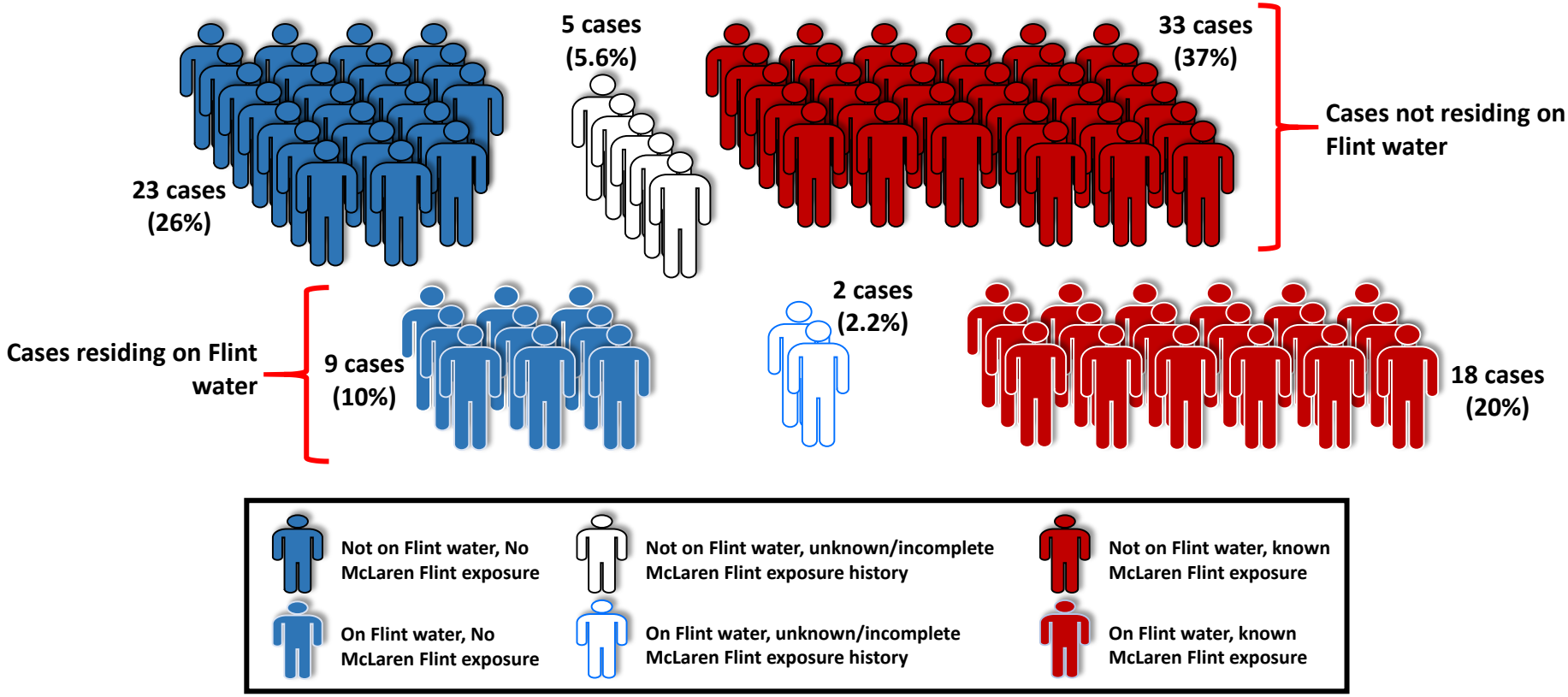
These maps are blown up to show the rates of Legionnaires‘ Disease in the City of Flint more clearly. The rates of Legionnaires’ Disease by census tract of incubation period residence for 2014 and 2015 are shown for those cases with possible or definite exposure to McLaren Flint Hospital and those without known exposure to McLaren Flint Hospital.

- Rates are per 100,000 residents
- The dark black outline depicts the boundary of the City of Flint.
    - Note: Not all census tracts within Flint municipal boundaries are on the Flint water system; the water system extends beyond the municipal boundaries in several locations so that some residents outside the Flint municipal boundaries are on Flint water.

Cases with known exposure to McLaren Flint are predominantly located on the Western side of Genesee County and surrounding counties. This distribution reflects the overall distribution of patients seeking medical care at McLaren Flint Hospital. McLaren Flint Hospital’s patient referral network is widespread, but the highest percentage of patients originate from the West side of the City of Flint, and the Western and Northwestern areas of Genesee County.

The census tract rates for non-McLaren Flint-Associated cases tend to be lower than the rates for McLaren Flint-Associated cases.

2014–2015 Legionnaires' Disease Cases by McLaren Flint Exposure and Residence On/Off Flint Municipal Water During Incubation Period



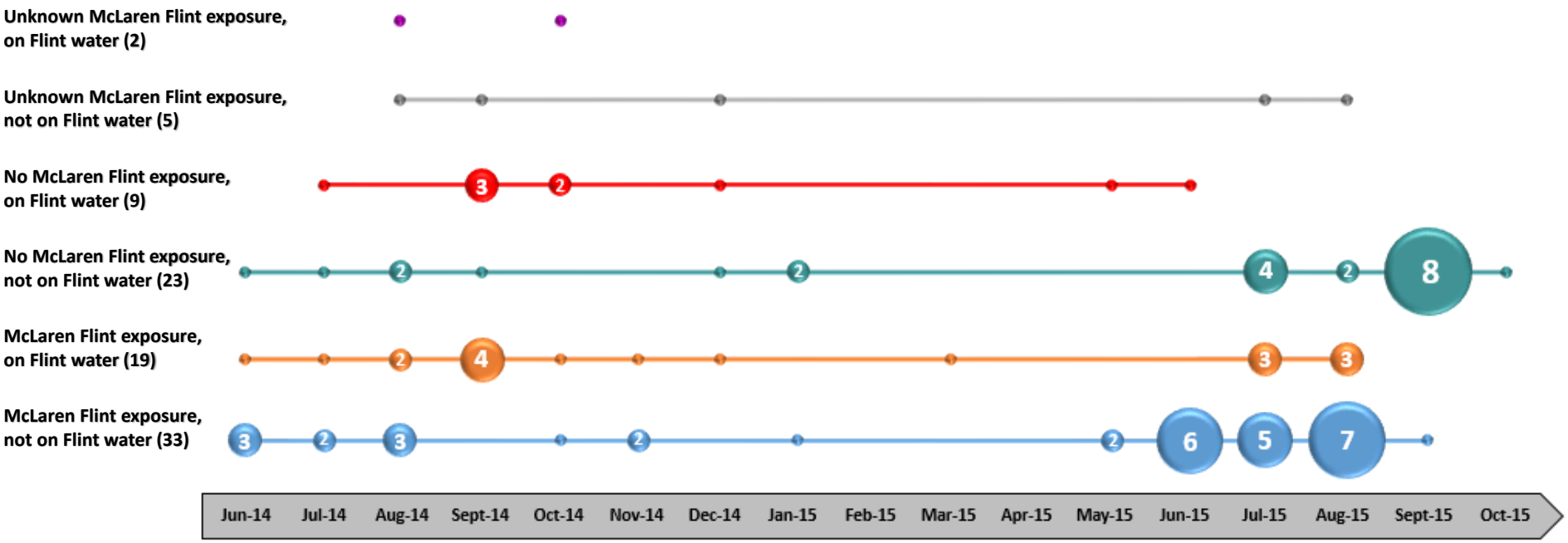
This slide depicts the interaction between the exposures of residence on/off Flint water (bottom row and top row of figures) and McLaren Flint Hospital healthcare exposure during the incubation period (Red figures). Flint water status was determined for all cases. The health care exposure status was unknown or incomplete for seven cases (White figures), including five patients not residing on Flint water and two residing on Flint water during their incubation period.

MDHHS continues to evaluate additional information as it is obtained to update the characterization of patient's health care associated exposures. As information becomes available, some of these unknown cases may be reclassified to having healthcare-associated exposure.

During 2014-2015, 54 cases had a healthcare exposure. Fifty-one of the 54 (94 percent) had a healthcare exposure (inpatient, outpatient or visitor) confirmed at McLaren Flint (Red figures).

Of the 32 cases who did not have a McLaren Flint health-care associated exposure, nine resided on Flint water. Ten percent of the 90 cases were on Flint water and had no healthcare-associated exposure (Blue figures with white outline).

2014–2015 Genesee County Legionnaires' Disease Cases by Exposure to McLaren Flint and Flint Water Residence



This is a visualization of the interaction of McLaren Flint Hospital healthcare exposure (inpatient, outpatient, visitor at McLaren Flint Hospital during incubation period) and residential water service exposure for the 90 cases of Legionnaires' Disease in 2014 and 2015.

- The number of cases per month is displayed. Multiple cases in a month are represented by a larger circle.
- Cases are displayed by both their healthcare-association (McLaren Flint Hospital Exposure/No McLaren Flint Exposure/Unknown McLaren Flint Exposure) and Flint water supply at residence (Flint water/Not on Flint water) during their incubation period.

There are four important findings illustrated in this chart:

1. **There is no demonstrated clustering of non-healthcare-associated cases in patients living on the Flint water system (Red circles). There were no new cases in this group after June of 2015, while the outbreak continued to promulgate.**

2. **The majority of infections occurred among individuals with an identified McLaren Flint Exposure, depicted by Orange and Light Blue circles.**

3. **Eight cases are observed in the non-healthcare/non-Flint water group in September of 2015 (Teal circles). No common exposures were identified for this group.**

4. **Healthcare-associated cases with residence not on Flint water (Light Blue circles) declined dramatically in August of 2015.**

MDHHS continues to evaluate additional information as it is obtained to update the characterization of patient's health care associated exposures. As information becomes available, some of these unknown cases may be reclassified to having health care associated exposure.

Changes to Flint Water System and Treatment of McLaren Flint Water

2014 – 2015 Legionnaires' Disease Cases in Genesee County, Michigan

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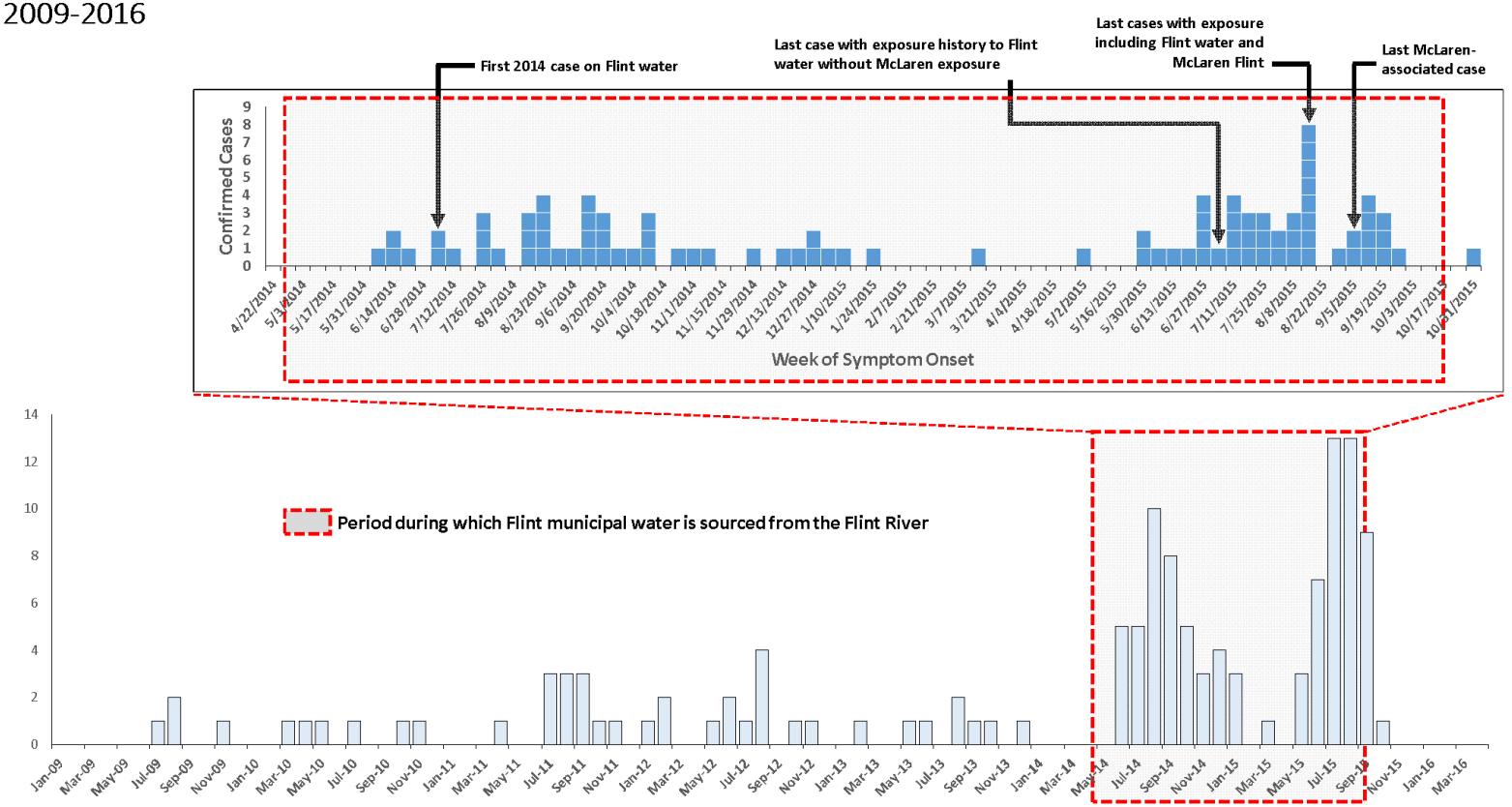
Epi Curve of Genesee County Legionnaires' Disease by Month of Onset and by Week of Onset, 2009-2016

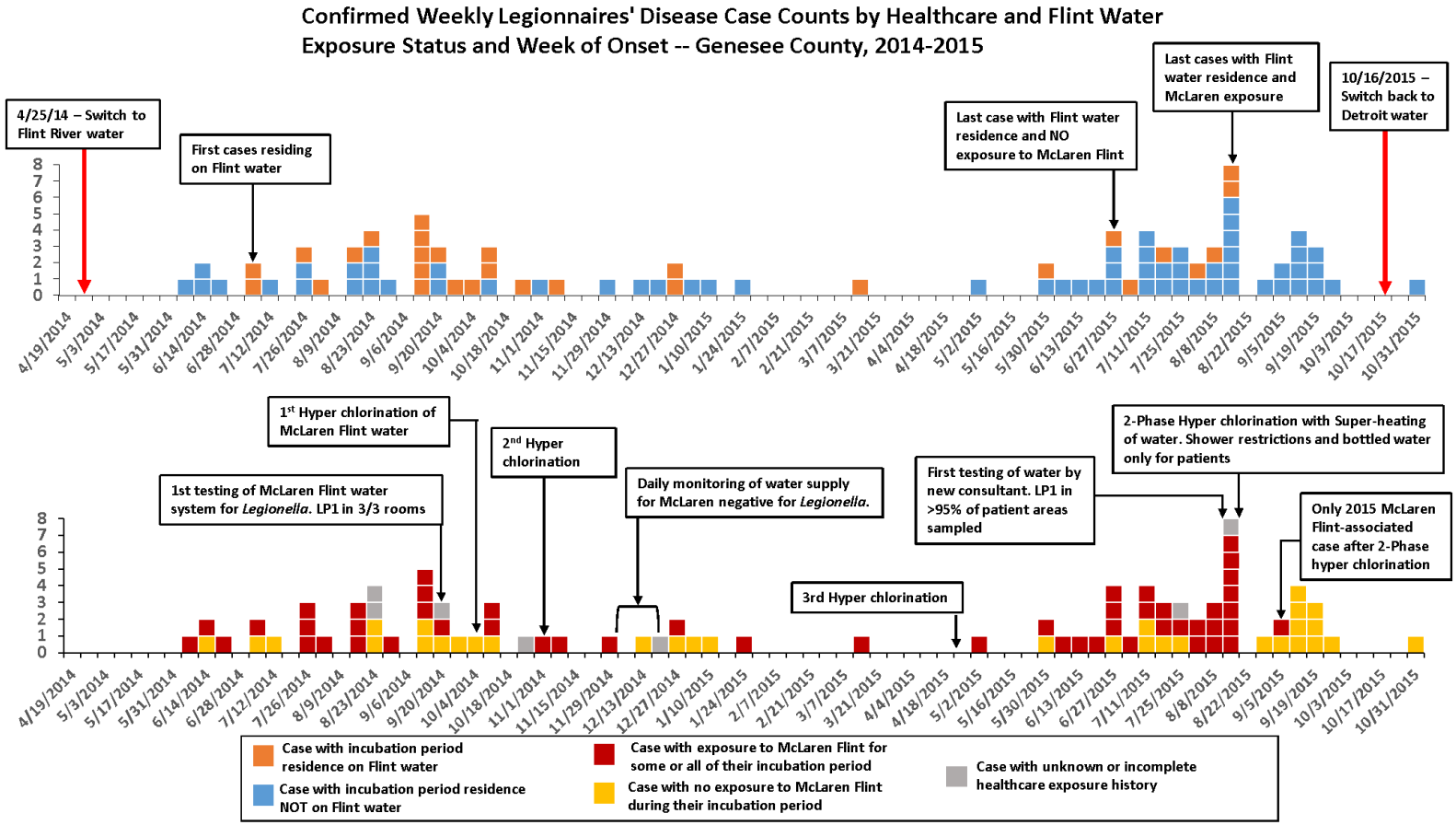


Epidemiologic curves (epi curves) present the number of cases of disease occurring over time. Curves can be presented by different time periods (e.g., day, week, month), depending on the communicable disease that is being tracked and the source of infection (e.g., foodborne, waterborne or interpersonal transmission).

Infectious diseases occur after a person has had exposure to the virus, bacteria, or other infectious vector, then the infection multiples in the person's body. Eventually the person can exhibit symptoms of the disease and the infection will be recognized clinically. The time between exposure to infectious material and when clinical symptoms occur varies by disease. The date that symptoms are first recognized is called the onset date.

To understand temporal relationships between disease incidence and potential exposure, it is important to understand the date of onset of symptoms, not just the date when the disease was diagnosed or when it was referred to the local health department. Other versions of this epi curve have presented cases classified by referral date rather than onset date, which is an important distinction. Referral date lacks the specificity that an onset date provides to establish an incubation period to examine for potential exposures. For all of the 2014-2015 cases, these chart presents the "Onset Date" for cases, not the referral date that the case was forwarded to the public health system.

This chart presents two versions of the epi curve at a monthly scale and a weekly scale. Using a scale in weeks versus months allows for clearer representation of cases in relation to environmental factors. The monthly epi curve collapses much of the variation which is available in the pull out.


Confirmed Weekly Legionnaires' Disease Case Counts by Healthcare and Flint Water Exposure Status and Week of Onset -- Genesee County, 2014-2015
4/25/14 – Switch to Flint River water
First cases residing on Flint water
Last case with Flint water residence and NO exposure to McLaren Flint
Last cases with Flint water residence and McLaren exposure
10/16/2015 – Switch back to Detroit water
1st Hyper chlorination of McLaren Flint water
2nd Hyper chlorination
1st testing of McLaren Flint water system for Legionella. LP1 in 3/3 rooms
Daily monitoring of water supply for McLaren negative for Legionella.
3rd Hyper chlorination
First testing of water by new consultant. LP1 in >95% of patient areas sampled
2-Phase Hyper chlorination with Super-heating of water. Shower restrictions and bottled water only for patients
Only 2015 McLaren Flint-associated case after 2-Phase hyper chlorination
Case with incubation period residence on Flint water
Case with incubation period residence NOT on Flint water
Case with exposure to McLaren Flint for some or all of their incubation period
Case with no exposure to McLaren Flint during their incubation period
Case with unknown or incomplete healthcare exposure history

This epidemiologic curve represents the weekly counts of cases between April 2014 and November 2015. Column height is the number of cases with illness onset that week. Exposure history is illustrated as follows: Orange boxes - case' incubation period residence on Flint water system; Blue boxes - case's residence not on Flint water; Red boxes - cases who had incubation period exposure to McLaren Flint; Yellow boxes - cases who had no incubation period exposure to McLaren; Gray boxes - cases whose exposure information for McLaren was unknown/incomplete. Boxes and arrows identify changes in water source and use of disinfectant. City of Flint changes are indicated by red arrows; changes in McLaren's water management practices by black arrows.

The key findings from these two charts:

- **There is no clear correlation between onset date and Flint water residence (Orange boxes).**

- **June 2015 was the last onset for a patient living on Flint water with no McLaren Flint exposure.**

- **McLaren Flint began *Legionella* testing of water system on September 15, 2014. Those results show *Legionella pneumophila* serogroup 1 in both hot and cold water from 75 percent of patient rooms tested.**

- **McLaren Flint hyper-chlorinated its water system on October 4, 2014, November 1, 2014 and April 19, 2015.**

- **Daily testing of water supply lines entering McLaren Flint hospital between December 4-19, 2014 was negative for *Legionella*. McLaren was advised by their consultant that persistent *Legionella* growth was due to internal hospital factors, rather than the Flint water.**

- **On August 11 and 12, 2015, Special Pathogens Laboratory tested McLaren Flint systems for *Legionella. L. pneumophila* serogroup 1 was found in more than 95 percent of patient areas sampled.**

- **On August 14 and 19, 2015, McLaren Flint conducted two-phase hyper chlorination and superheated its water systems. During this time, they also implemented shower restrictions and use of only bottled water for patients, based on consultant's recommendations.**

- **Hospital-associated cases decreased after this two-phase hyper chlorination and superheating process. Only one McLaren-associated case occurred in the month after this treatment, down from a peak of seven cases in one week.**

- **No cases with incubation period residence on Flint water system occurred after week of August 15, 2015.**

- **A subset of 12 cases in late 2015 have no clear source of infection identified (September/October weeks in yellow), including no Flint water nor McLaren Flint exposures.**

While the installation of the two-phase hyper chlorination and superheating at McLaren Flint preceded a significant reduction of cases, the same cannot be said for the switch back to the Detroit water system. The reduction in cases related to McLaren Flint's intervention would not be evident in outbreak curves representing cases by month.

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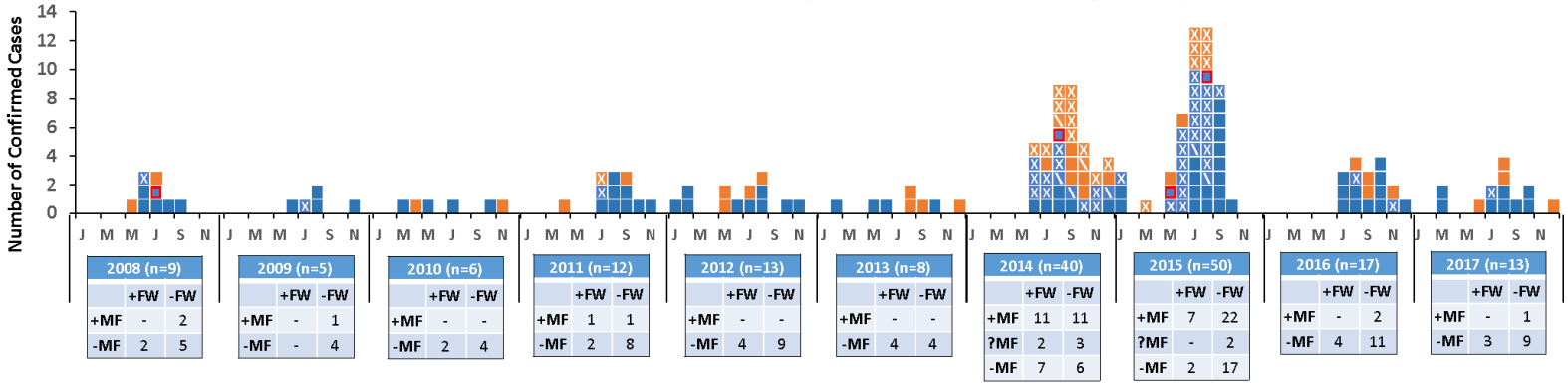
Historical Trends for Legionnaires' Disease in Genesee County

Legionnaires' Disease Cases by Month of Onset or Referral Date -- Genesee County, 2008–2017

[This includes 4 non-Genesee residents (1 in November 2014, 3 in August 2015)]



2008 (n=9)	+FW	-FW
+MF	-	2
-MF	2	5

2009 (n=5)	+FW	-FW
+MF	-	1
-MF	-	4

2010 (n=6)	+FW	-FW
+MF	-	-
-MF	2	4

2011 (n=12)	+FW	-FW
+MF	1	1
-MF	2	8

2012 (n=13)	+FW	-FW
+MF	-	-
-MF	4	9

2013 (n=8)	+FW	-FW
+MF	-	-
-MF	4	4

2014 (n=40)	+FW	-FW
+MF	11	11
?MF	2	3
-MF	7	6

2015 (n=50)	+FW	-FW
+MF	7	22
?MF	-	2
-MF	2	17

2016 (n=17)	+FW	-FW
+MF	-	2
-MF	4	11

2017 (n=13)	+FW	-FW
+MF	-	1
-MF	3	9

- Case patient with residence on Flint water with no exposure to McLaren Flint
- Case patient with residence on Flint water with confirmed exposure to McLaren Flint for part of their incubation period
- Case patient with residence on Flint water with unknown or incomplete healthcare exposure history (i.e. exposure to McLaren Flint cannot be ruled out)
- Case patient with residence NOT on Flint water with no exposure to McLaren Flint
- Case patient with residence NOT on Flint water with confirmed exposure to McLaren Flint for all 14 days of their incubation period
- Case patient with residence NOT on Flint water with confirmed exposure to McLaren Flint for part of their incubation period
- Case patient with residence NOT on Flint water with unknown or incomplete healthcare exposure history

This chart presents the incidence of Legionnaires' Disease in Genesee County between January 2008 and November 2017. Each block on the chart represents one confirmed Legionnaires' Disease patient whose symptoms started during that month. Some cases in 2008-2013 were missing an onset date. If symptom onset was not available in the record, the referral date was used in its place. Orange blocks represent patients with incubation period residence on the Flint water system and Blue blocks are patients whose incubation period residence was not on the Flint water system. Blocks with a white and red dot are patients who had their entire incubation period in McLaren Flint Hospital. Blocks with a white X are patients with exposure to McLaren Flint for part of their incubation period. Blocks with a white line are patients whose exposure to McLaren Flint cannot be ruled out.

The total number of cases for each year is summed below the chart, including the number of cases by water source and McLaren Flint hospital exposures. +FW indicates cases who resided on the Flint water system. -FW indicates cases who did not live on the Flint water system. +MF indicates cases who had incubation period exposure to McLaren Flint Hospital. -MF indicates cases who did not have exposure to McLaren Flint Hospital. ?MF indicates cases whose information about McLaren Flint Hospital was incomplete.

Key findings from this chart include:

- **In 2016 and 2017, the number of cases returned to the expected numbers of cases, adjusting the baseline number for the increase in cases statewide.**

- **The distribution of case patients by water system varied by year. Fifty percent of patients were on Flint water system in 2013 and in 2014. In all other years, more than 50 percent of patients were from non-Flint water residences.**

- **Prior to 2013, the number of cases without McLaren Flint exposure was small, relative to the overall number of cases. The number of cases with exposure to McLaren Flint hospital increased in 2014 and 2015 and then decreased in 2015 and 2016.**

- **There were four Legionnaires' Disease patients who had exposure to McLaren Flint for all 14 days of their incubation period (one in 2008, one in 2014, and two in 2015). None of these cases had a residence on the Flint water system.**

- **Based on records available to the MDHHS, no other hospital in Genesee County had a confirmed case during 2008-2017.**

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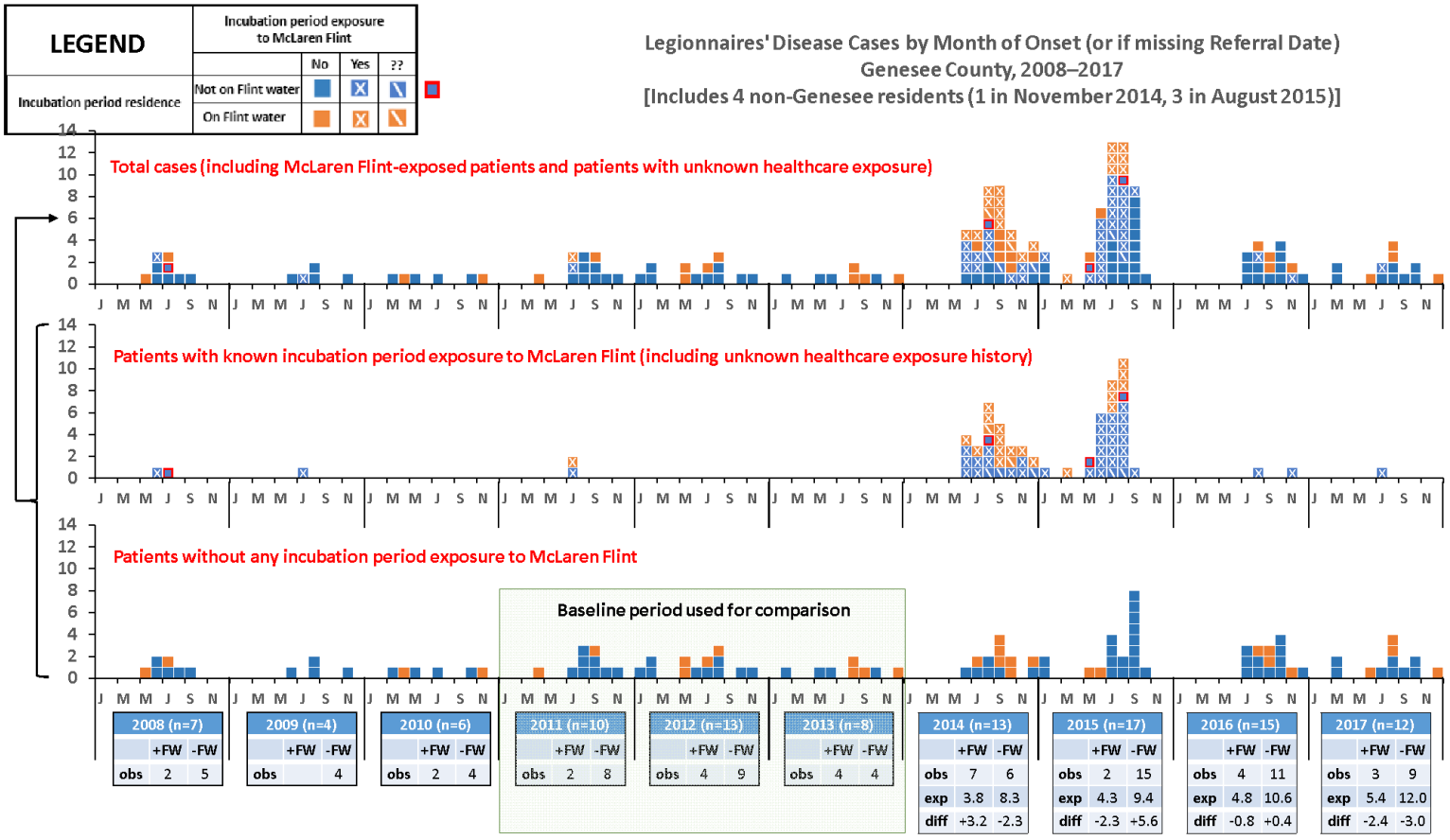
LEGEND
Incubation period exposure to McLaren Flint
No
Yes
??
Incubation period residence
Not on Flint water
On Flint water
Legionnaires' Disease Cases by Month of Onset (or if missing Referral Date)
Genesee County, 2008–2017
[Includes 4 non-Genesee residents (1 in November 2014, 3 in August 2015)]
Total cases (including McLaren Flint-exposed patients and patients with unknown healthcare exposure)
Patients with known incubation period exposure to McLaren Flint (including unknown healthcare exposure history)
Patients without any incubation period exposure to McLaren Flint
Baseline period used for comparison
2008 (n=7) +FW -FW obs 2 5
2009 (n=4) +FW -FW obs 4
2010 (n=6) +FW -FW obs 2 4
2011 (n=10) +FW -FW obs 2 8
2012 (n=13) +FW -FW obs 4 9
2013 (n=8) +FW -FW obs 4 4
2014 (n=13) +FW -FW obs 7 6 exp 3.8 8.3 diff +3.2 -2.3
2015 (n=17) +FW -FW obs 2 15 exp 4.3 9.4 diff -2.3 +5.6
2016 (n=15) +FW -FW obs 4 11 exp 4.8 10.6 diff -0.8 +0.4
2017 (n=12) +FW -FW obs 3 9 exp 5.4 12.0 diff -2.4 -3.0

These three charts separate the cases with McLaren Flint exposure from those without that exposure. The top chart shows all case patients; the blocks are color coded and labeled as to incubation period residence on and off the Flint water system and exposure to McLaren Flint Hospital. The second chart shows only cases with a known incubation period to McLaren Flint (including those with an unknown exposure history). The bottom chart includes only patients known to have no exposure to McLaren Flint.

During investigations of communicable disease outbreaks, the three years prior to the beginning of an outbreak is usually selected as a "baseline period" that describes what level of disease incidence normally occurs in a geographic area. For Genesee County, the years 2011-2013 are considered the baseline period (Box on bottom chart). The average annual number of cases in this period on and off Flint water (3.3 and seven, respectively) were calculated to compare to the number of cases observed in later years. This expected number was multiplied by 13 percent each year, to adjust for the expected increase in Legionnaires' Disease case from the statewide increase. For example, the annual expected number of cases for residents living on Flint water was 3.3 for the 2011-2013 period. For 2014, the number was 3.8 (3.3*1.13). For 2015, the number was 4.3 (3.8*1.13).

The boxes under the bottom chart provide the total number of cases each year who had no incubation period exposure to McLaren Flint and the distribution of those cases by residential water source (+FW indicates cases who resided on the Flint water system. -FW indicates cases who did not live on the Flint water system). The difference (diff) in the number of cases observed (obs) compared to the expected (exp) number of cases in each year is also calculated.

Key findings from the third chart (including only patients known to have no exposure to McLaren Flint Hospital) include:

- **2014 is the only year where there are more patients with Flint water exposure than non-Flint water exposure (seven and six cases, respectively).**

- **In 2014, the observed number of cases for patients residing on Flint water (seven) was higher than expected (3.8) by 3.2 cases. In 2015, 2016 and 2017, the number of observed cases were lower than expected (-2.3 cases, -0.8 cases, and -2.4 cases, respectively).**

- **In 2015 and 2016, the observed cases for patients not residing on Flint water (15 and 11) was higher than expected (9.4 and 10.6) by 5.6 and 0.4 cases, respectively. The number of cases was lower than expected for people not living on Flint water in 2014 and 2017 (-2.3 cases and -3.0 cases).**

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2014–2015 non-McLaren-Associated Legionnaires' Disease Cases in Genesee County

- 32 total case patients had no incubation period exposure to McLaren Flint in 2014-2015
  - 9 with residence on Flint water
  - 23 with residence on non-Flint water
- Compared rates of non-McLaren cases in 2014-2015 with expected rates
- The difference from expected cases was similar for people living on and off Flint water

Number of Cases per 100,000 People Per Year, Genesee County cases in 2011-2013, non-McLaren cases in 2014-2015

Geographic residence	Expected based on 2011-2013	Observed in 2014-2015	Rate Diff.
Flint Water System	3.3	4.5	1.2
Not on Flint Water	2.1	3.5	1.4

In 2014-2015, 32 case patients were confirmed to have had no incubation period exposure to McLaren Flint Hospital. Of these individuals, nine resided on the Flint water system and 23 patients did not. Having removed cases confirmed to have a McLaren-Flint exposure during their incubation period, there were 4.5 cases per 100,000 people annually among people living on the Flint water system in 2014-2015. Further, there were 3.5 cases per 100,000 people annual among people who lived in Genesee County but not on the Flint water system.

The rates of Legionnaires' Disease in Genesee County before the 2014-2015 outbreak are called baseline rates. Baseline rates for Flint water versus non-Flint water for 2011-2013 were based on population size denominators for water system areas (Flint water, non-Flint water, other municipal water, and private well water) provided by the Michigan Department of Environmental Quality and U.S. Environmental Protection Agency data for 2015 and methods taken from CDC (Active Bacterial Core Surveillance for Legionellosis — United States, 2011–2013. MMWR. October 30, 2015 / 64(42);1190-3.) The number of cases per 100,000 per year in 2011-2013 is the number of cases we would have expected to see in Genesee County if there was no outbreak in 2014-2015. We excluded any cases with exposure to McLaren Flint hospital.

Among people living on Flint water system in 2011-2013, there were 3.3 cases of Legionnaires' Disease per 100,000 people per year (11 cases). Among people living in Genesee County but not on the Flint water system, there were 2.1 cases of Legionnaires' Disease per 100,000 people per year in 2011-2013 (21 cases).

The difference between the expected and observed rates was similar for people living on the Flint water system (1.2 more cases than expected per 100,000 people) and those not living on the Flint water system (1.4 more cases than expected per 100,000 people). (This analysis did not adjust for increase in Legionnaires' Disease across the state.)

Risk of Mortality Among Legionnaires' Disease Patients

2014 – 2015 Legionnaires' Disease Cases in Genesee County, Michigan

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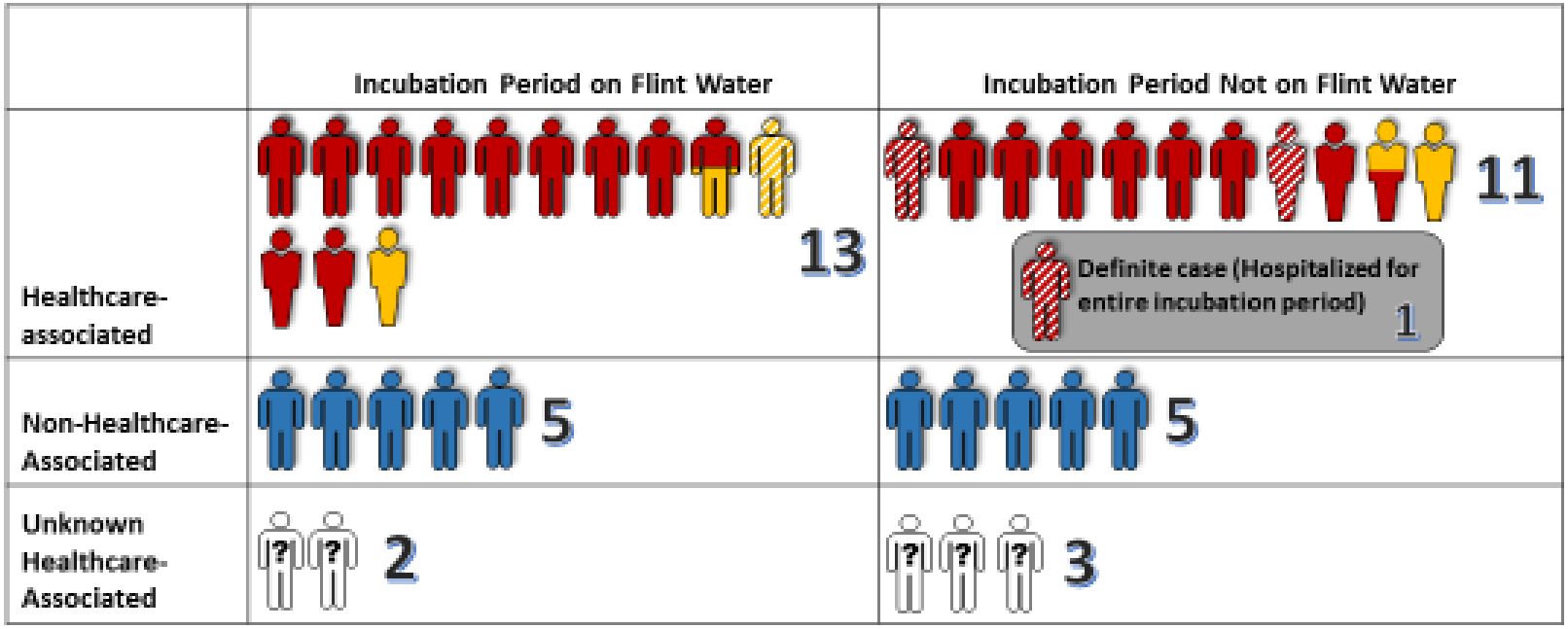
2014 Cases Classified by Flint Water and Healthcare Exposures*



*In cases with both inpatient and outpatient exposures, only the inpatient exposure is depicted here.

This chart represents water and health care exposures for 2014 cases. The Left column displays patients with incubation period residence on Flint water. Color and shape of figures indicate place and type of health care exposure. In cases where the patient had both inpatient and outpatient exposure, only the inpatient exposure is depicted here.

- **In calendar year 2014, there was one definite healthcare-associated case of Legionnaire's Disease. This patient spent their entire 14 day incubation period at McLaren Flint Hospital.**
- **Only five of the 40 cases were individuals with no known healthcare exposure who also resided in a residence that was serviced with Flint water.**

This chart also provides information on the number of deaths that occurred during this outbreak. *Outbreak Associated Deaths are deaths in confirmed cases of Legionellosis who passed away during their treatment, who passed away within thirty days of discharge, and/or who had Legionnaires' Disease listed as a contributing factor to death on registered death certificate.* These individuals are indicated by cross hatching on the figures above.

- **Four Legionnaires' Disease-associated deaths were identified in 2014.**
- **All of those patients had healthcare exposures, with three of the four patients having exposure at McLaren Hospital, including one case who spent their entire incubation period at McLaren Hospital (definite health care associated case).**
- **Only one of the 2014 cases who died had lived in a residence serviced by the Flint water system during their incubation period.**

MDHHS continues to evaluate additional information as it is obtained to update the characterization of patient's health care associated exposures. As information becomes available, unknown cases may be reclassified to having health care associated exposure.

2015 Cases Classified by Flint Water and Healthcare Exposures*

	Incubation Period Residence on Flint Water	Incubation Period Residence Not on Flint Water
Healthcare-associated	7	20 Definite cases (Hospitalized for entire incubation period) 2
Non-Healthcare-Associated	2	17
Unknown Healthcare-Associated		2

*In cases with both inpatient and outpatient exposures, only the inpatient exposure is depicted here.

This slide represents another way to look at the health care and water system exposure data for 2015 cases. The Left column displays patients with incubation period residence on Flint water. Color and shape of figures indicate place and type of health care exposure. In cases where the patient had both inpatient and outpatient exposure, only the inpatient exposure is depicted here.

- **In calendar year 2015, there were two definite healthcare-associated cases; both individuals spent their entire 14 day incubation period at McLaren Flint Hospital.**
- **Only two of 50 cases in 2015 had no known healthcare exposure and also resided in a residence that was serviced with on Flint water.**

Outbreak Associated Deaths: For this investigation, *outbreak-associated deaths were defined as deaths in confirmed cases of Legionellosis who passed away during their treatment, who passed away within thirty days of discharge, and/or who had Legionnaires' Disease listed as a contributing factor to death on registered death certificate.* These individuals are indicated by cross hatching on the figures above.

- **Eight Legionnaires' Disease associated deaths were identified from the 50 cases.**
- **All seven of the deaths for whom an exposure history was completed had exposure at McLaren Hospital during the 14 day incubation period.**
- **None of the eight decedents lived in a residence serviced by Flint water during their 14 day incubation period.**

MDHHS continues to evaluate additional information as it is obtained to update the characterization of patient's health care associated exposures. As information becomes available, unknown cases may be reclassified to having health care associated exposure.

Conclusions (1):

- Missing or delayed interviews and lack of clinical isolates hampered this investigation
- This report includes assessment of information that was not available to the MDHHS during 2014-2015
- There were two distinct waves of illness (June 2014 – March 2015, May 2015-October 2015)
- The data demonstrates a return to near baseline in 2016 and 2017
- Geographically, the 2014 and 2015 cases were distributed throughout Genesee County

Conclusions (2):

- One common source has been identified that explains the majority of case transmissions – a common healthcare facility exposure at McLaren Flint Hospital
- No other large building with high risk plumbing was identified as a frequent location that case patients visited
- The geographic distribution of Legionnaires' Disease patients who had incubation period exposure to McLaren Flint Hospital was similar to the geographic distribution of Medicare patient hospitalizations for the hospital
- After removing patients exposed to McLaren, 2014 is the only year where more patients had Flint water exposure than non-Flint water exposure (7 and 6 cases, respectively)
- Of the 12 outbreak associated deaths, 10 cases had exposure to McLaren Flint Hospital during their incubation period

Conclusions (3):

- The 2015 outbreak ended before the switch back to Detroit water:
  - Cases sharply declined in August 2015 after McLaren Flint Hospital superheated their water and installed secondary disinfection systems
  - Even in an environment of increased testing, reports of incident cases of Legionnaires' Disease nearly stopped weeks before the return to the Detroit water system
- If the water source and corrosion to the pipes were the primary contributors to the outbreak, cases would have been expected to continue up until and even after the water was switched back to Detroit
- If the water source and corrosion to the pipes were the primary contributors to the outbreak, more cases with exposure to other high risk facilities (hospitals, nursing homes) would be expected

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