

The 2015 New York City Legionnaires' Disease Outbreak: A Case Study on a History-Making Outbreak

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On July 17, 2015, the Bureau of Communicable Disease of the New York City (NYC) Department of Health and Mental Hygiene (DOHMH) detected an abnormal number and distribution of Legionnaires' disease (LD) cases in the South Bronx.¹⁻³ This cluster of cases would eventually grow into the largest outbreak of LD in NYC history. The NYC DOHMH led the outbreak response, part of which included sampling numerous cooling towers within NYC for *Legionella pneumophila* bacteria. In the aftermath of the outbreak, NYC became the first large jurisdiction in the United States to take a regulatory approach to the management of cooling towers to prevent *Legionella* contamination.⁴ Public health departments of all sizes can learn from how the DOHMH responded to this historic outbreak.

Background on Legionnaires' Disease

Legionnaires' disease is a type of pneumonia that is caused by inhalation of aerosolized water containing *L. pneumophila* bacteria, and approximately 5% to 15% of reported cases are fatal.^{5,6} These bacteria are frequently present at low levels in many potable water systems but can proliferate under certain circumstances (eg, warm, stagnant water with low levels of chlorine, such as in certain areas of buildings' plumbing systems). The bacteria pose great risk to human health when water containing the bacteria becomes aerosolized.

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Travel support to conduct these interviews was provided by a grant to Emory University from the Alfred P. Sloan Foundation. The authors thank staff from the NYC Department of Health and Mental Hygiene for allowing them to conduct interviews for this case study.

The authors declare no conflicts of interest.

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DOI: 10.1097/PHH.0000000000000558

Reported cases of legionellosis, which includes LD and the milder respiratory illness, Pontiac fever, have increased dramatically in the United States and other developed countries.^{5,7} More than 5000 cases of legionellosis were reported to the Centers for Disease Control and Prevention (CDC) in 2015, a 4-fold increase from 2001.⁸ Unfortunately, the number of reported cases is suspected to be just a fraction of actual cases.⁹ Underdiagnosis of LD could be due in large part to the fact that LD usually can be treated empirically with antibiotics commonly recommended for community-acquired pneumonia, thus reducing the need for clinicians to order diagnostic tests for LD. A urine antigen test (UAT) for *L. pneumophila* serogroup 1 is the primary method of LD diagnosis in hospitalized patients.¹⁰ The test, while rapid, is not often utilized except on the most severe cases (Exhibit 1).

Legionnaires' Disease in New York City

Legionellosis has been a reportable condition in New York State since 1985. Reported cases in NYC have risen from 47 in year 2000 to 438 in year 2015 (Figure).¹¹ When cases are identified, positive diagnostic test results are reported from clinical laboratories to the DOHMH via the New York State Department of Health's Electronic Clinical Laboratory Reporting System. Clinicians as well as other individuals within health care facilities, including infection control staff, are also required to report cases. The DOHMH investigates every reported case by examining medical records to determine whether there is a clinically compatible illness, interviewing patients or their close relations to identify potential exposures, and, when possible, obtaining clinical isolates for molecular typing.^{1,12} An environmental investigation will be opened when there is more than 1 case in a building in a given year, or 1 case in a high-risk setting (such as a nursing home or jail), or if routine case investigations identify a common exposure among sporadic cases.

In addition to the traditional case investigation process, the DOHMH utilizes automated systems to help detect clusters of disease in space and time.

EXHIBIT 1**Clinical Diagnosis of Legionnaires' Disease**

- There are a number of ways to diagnosis a patient with LD, including UAT, culture, direct fluorescent antibody staining, and polymerase chain reaction.
- UAT is the fastest test (takes less than 1 h to conduct on a urine specimen), requires the least invasive specimen, and can remain positive after antibiotic treatment has been initiated. As a result, it is the most widely used diagnostic test.
- UAT is both sensitive and highly specific for *L pneumophila* serogroup 1.
- Because the UAT is only capable of detecting *L pneumophila* serogroup 1, the gold standard for detection of LD is bacterial culture.
- Obtaining sputum specimens for culture is difficult and sputum must be collected before antibiotics have been started.
- Lack of reimbursement for specimen collection and diagnostic tests is often cited as reasons for not collecting patient specimens for culture.

Abbreviations: LD, Legionnaires' disease; UAT, urine antigen test.

One such tool utilized by the DOHMH is SaTScan.¹³ The DOHMH applies the SaTScan software daily to identify spatial-temporal clusters in reportable disease data.^{2,3} The DOHMH began using SaTScan in February 2014 to prospectively monitor occurrences of 35 diseases, including legionellosis. As one of the first health departments to adopt SaTScan for this purpose, all signals are carefully considered for validity to prevent premature concern over false-positive signals. In the summer of 2015, a signal for legionellosis was generated by the prospective space-time permutation scan statistic in SaTScan.^{3,14} DOHMH staff examined the cases that generated the signal and began prioritizing epidemiologic investigations to determine whether the cases were related and whether an outbreak could be verified.

Importance of the Problem

Known risk factors for LD include older age (>50 years), immunosuppression, and underlying lung

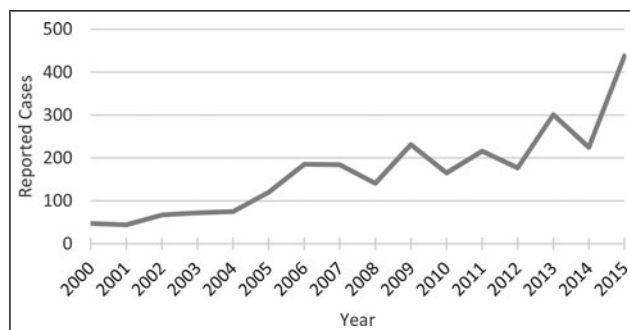


FIGURE Reported Cases of Legionellosis in New York City, 2000-2015

disease, all of which are increasing in the general population and are likely contributing to higher rates of disease.⁵ Engineering factors, such as deteriorating water distribution system infrastructure, poorly maintained premise plumbing systems, and increased installation of low-flow water fixtures conducive to *Legionella* growth, are also thought to be key factors contributing to the rise in cases.¹⁵

There is a strong association between LD and poverty in NYC; from 2002 to 2011, the rate of LD was 2.5 times higher in high-poverty areas than in low-poverty areas (3.0 cases per 100 000 people per year vs 1.2 cases per 100 000 people per year, respectively).¹² This association is sustained within each racial and ethnic group.

Compared with other parts of NYC, the Bronx has a disproportionately high incidence of LD.¹² The area where the outbreak occurred has a large population of homeless and elderly people. It is also an area with a large population of persons infected with HIV. Finally, the area is made up of residents with a low average income: an estimated 42% of residents live under the poverty level.¹⁶

South Bronx Outbreak: July 2015

The response to the July 2015 cluster began as a standard epidemiologic investigation: DOHMH staff interviewed case patients and close contacts in an attempt to determine the source of disease. For the purposes of the investigation, the Bureau of Communicable Disease defined an outbreak case as “Legionnaires’ disease—based on clinically compatible illness with a positive laboratory test—in a person who had spent time in any of the 7 affected zip codes with symptom onset after July 2, 2015.”³ Knowing that physicians do not typically test patients with pneumonia for LD and even less frequently obtain sputum samples for culture, DOHMH investigators proactively contacted clinicians at Bronx hospitals during the first week of the outbreak investigation to specifically ask them to consider LD in patients with appropriate respiratory symptoms and to encourage the collection of respiratory specimens for culture. The DOHMH also reached out to the NYC Office of the Chief Medical Examiner, a long-standing partnership that has been particularly effective during prior public health investigations, to request that autopsies be performed on fatalities due to unexplained respiratory illness to assist with case identification and further specimen collection. The increased scrutiny and performance of additional autopsies allowed the DOHMH to identify additional fatal cases related to the South Bronx outbreak.¹⁷

As described by one epidemiologist, “The initial epidemiological findings did not suggest any common exposures. There were no common buildings visited by case patients, and case residences were spread across a 6.5 mi² area.” Officials then began operating under the working theory that those who had gotten sick were being exposed outdoors. Cooling towers have been implicated in prior LD outbreaks, both in NYC and elsewhere.¹⁵ The hypothesis that a cooling tower was the source of the outbreak allowed officials to focus the scope of the environmental investigation. It also implied a large potential outbreak zone. On July 29, the DOHMH issued a citywide health alert aimed at all clinical staff members in internal medicine, pediatrics, geriatrics, primary care, infectious diseases, emergency medicine, family medicine, laboratory medicine, and infection control, requesting that they consider LD in patients presenting with community-acquired pneumonia and to request both culture and UAT.¹⁷

DOHMH leadership closely monitored the situation, and frequent meetings were held within the agency to review data and assign tasks. Environmental health and communicable disease response teams worked together to conduct case interviews and to identify a common exposure source. While the environmental and epidemiologic investigations were proceeding rapidly, rising case counts increased concern about the potential magnitude of the outbreak. On July 28, the DOHMH activated its incident command system (ICS) when it was apparent that the growing outbreak was going to require additional resources and greater logistical support to accelerate environmental testing and conduct more extensive community outreach. The decision to activate an ICS is a complex one that each agency must weigh within the context of the situation (Exhibit 2).

At the time of ICS activation, DOHMH officials had reports of more than 30 cases dispersed throughout the South Bronx.³ Environmental health staff at the DOHMH began sampling cooling towers for *Legionella*. Sampling began in the outbreak zone on the night of July 28 and continued throughout the following week. Towers that tested positive for *Legionella* were subsequently decontaminated. Officials utilized existing lists of buildings with cooling towers from the NYC Department of Buildings (DOB) and Department of Environmental Protection to identify sites to sample. Knowing that the lists were incomplete, the DOHMH also used epidemiologic information from case interviews and satellite imagery from Google Earth to identify buildings with cooling towers near where cases were clustering. One such cooling tower—that located atop the Opera House Hotel and

EXHIBIT 2

Overview of an Incident Command System

- An ICS is a modular agency structure and chain of command that is customized to maximize efficiency during an emergency response. The ICS is led by the IC who is in charge of the overall response. Each module, commonly referred to as a section, is led by a Section Chief who reports to the IC. Each section has a specific role within the response. Common sections include Operations, Planning, Logistics, and Finance and Administration.
- When an agency makes the decision to activate the ICS during an emergency, staff members who are activated immediately assume predetermined roles within the response. ICS activation is a signal to everyone in the agency that there is a new chain of command in place and that their job responsibilities may be changed.

Abbreviations: IC, Incident Commander; ICS, incident command system.

sampled on July 29—would eventually be identified as the source of the outbreak. The DOHMH then dispatched teams of inspectors to each cooling tower to collect samples. However, not enough DOHMH staff members were appropriately trained in environmental sampling protocols at the start of the sampling efforts. While all DOHMH employees have predetermined secondary emergency response roles, few had previous training in safely entering and sampling cooling towers. This dearth of trained individuals meant that the environmental health staff charged with coordinating the sampling of cooling towers struggled at first to enlist enough staff to go into the field and sample cooling towers as they were identified. Multiple requests for volunteers were sent out within the DOHMH and to sister agencies within the NYC government. The DOHMH employed a “train-the-trainer” methodology to address this issue. Environmental health staff paired individuals who possessed the necessary experience or training with those who did not, and the number of teams that were able to be mobilized to sample cooling towers grew.

In total, 55 cooling towers in the South Bronx were located, sampled, and tested for *Legionella*.³ Other NYC agencies, including NYC Emergency Management, NYC Police Department, and NYC Fire Department, as well as the CDC and neighboring local health departments, assisted DOHMH environmental health staff with locating and sampling the towers. Investigators took water and biofilm samples from each cooling tower. DOHMH police personnel transported half of each water sample to the New York State Department of Health laboratory at Wadsworth Center in Albany, New York, on the same day the sample was collected. The state laboratory screened each sample for *L pneumophila* DNA using polymerase chain reaction (PCR). PCR is only capable of detecting the presence of bacterial DNA, and while a major limitation is

that it cannot distinguish between live and nonviable bacteria, it served as a rapid alternative to standard culture methods for screening samples for the presence of *Legionella* DNA (Exhibit 3). Upon notification that *L pneumophila* DNA was detected by PCR in specific sample(s), the NYC Public Health Laboratory (PHL) confirmed the positivity by culturing the sample for *L pneumophila*. Because this confirmatory culture process requires 5 or more days, cooling tower owners were ordered to remediate on the basis of the results of the PCR screening test alone. While the vast majority of owners were compliant, some owners and property managers had limited understanding of their cooling tower systems and difficulty finding service companies with staffing resources to perform emergency disinfection.

In addition to PCR testing, NYC’s PHL, the New York State Department of Health, the and CDC utilized bacterial “fingerprinting” methods, including pulsed-field gel electrophoresis, whole-genome sequencing, and sequence-based typing, to further characterize the *L pneumophila* strains cultured from cooling tower samples and case patients (Exhibit 4). These “fingerprinting” methods allowed DOHMH investigators to begin comparing environmental isolates with the more than 2 dozen patient isolates that were collected from hospitals around NYC.

During the cooling tower investigation, disagreement between elected officials fueled negative media attention about the outbreak.¹⁸⁻²⁰ On August 7, Governor Cuomo described the outbreak as “a bad science-fiction movie.”²¹ Public concern grew over whether the city was capable of responding to an outbreak of this magnitude.²²⁻²⁴ Michael Benjamin, a former assembly member, political columnist, and resident of the South Bronx during the outbreak, wrote that “in nearly 40 years since the original deadly Legionnaires’ outbreak ... it’s mind-boggling that no rules or regulations were put into place to prevent deadly new eruptions of the disease.”²⁵ To address the growing fear and anxiety of Bronx residents, the governor announced that the state would expand free

EXHIBIT 4

Environmental Testing by Laboratory

New York State Department of Health	PCR, whole-genome sequencing
New York City Public Health Laboratory	Culture, pulsed-field gel electrophoresis
Centers for Disease Control and Prevention	Sequence-based typing
Private contract laboratory	Culture

Abbreviation: PCR, polymerase chain reaction.

cooling tower testing to all private building owners in the Bronx and across the state.²⁶ The additional capacity required to handle the increased number of samples ratcheted up the pressure on the state public health laboratory, which was already operating at capacity.

Despite the public contention between the mayor and the governor, the state and city health departments continued to work closely with each other during the outbreak. This collaboration ensured that essential work such as the testing of environmental samples continued at a rapid pace. DOHMH laboratory personnel also cited the on-site assistance from the CDC laboratory team as useful during the response. Laboratory expertise and data management worksheets provided by the CDC improved the data management capabilities of PHL and helped manage the large amount of testing necessary for the response.

DOHMH managers in the environmental health department and at PHL expressed concern about maintaining employee morale amid longer work days, changing shift requirements (some laboratory staff were asked to work overtime into the evening/night to allow work to continue), and short deadlines during the response. ICS roles are often filled by a predetermined rotation of people over the course of a response to limit employee burnout during a response. In the case of certain roles, such as the Communications Section chief and PHL leadership, little to no rotation occurred. The potential benefits of rotating staff

EXHIBIT 3

Overview of Environmental Testing for *Legionella* During the 2015 Legionnaires’ Disease Outbreak

PCR	Culture
Use: Screening	Use: Confirmation
Advantage: Rapid (test itself takes hours)	Advantage: Only captures viable bacteria
Disadvantage: Only detects the presence of bacterial DNA and therefore unable to distinguish viable from nonviable bacteria	Advantage: Samples could be cultured at the city laboratory
Disadvantage: Samples had to be sent to the state laboratory	Disadvantage: Lengthy (requires days to grow)

Abbreviation: PCR, polymerase chain reaction.

members had to be weighed against the desire to not disrupt the day-to-day response operations.

In an effort to address a growing sense of panic among the residents of the outbreak zone, the DOHMH conducted a number of communication and community engagement activities.^{22,23,25} Members of the DOHMH communications and public health preparedness groups attended several community town hall events, frequently accompanied by volunteer physicians from the local Medical Reserve Corp (MRC) chapters. The physicians were indispensable, offering medical consultations to those concerned that they may have been exposed, as well as providing an overall sense of comfort to the community. The DOHMH also mobilized Community Outreach Teams (COTs) to engage vulnerable populations in the outbreak area and the organizations that serve those populations. COTs are a relatively recent addition to the DOHMH emergency response toolkit, the concept becoming formalized after the 2014 Ebola virus disease crisis. Preidentified or preselected DOHMH staff members are assigned to COTs as a potential emergency response role during ICS activations. If the decision is made to create and deploy COTs for a particular response, COTs receive “just-in-time” training immediately before they go into the field to begin outreach activities. For this particular LD outbreak response, COTs targeted vulnerable populations including the elderly, the homeless, those with compromised immune systems, and those with limited access to health care. COTs also visited more than 100 vulnerable population service providers during the outbreak investigation. The partnership with the MRC again proved invaluable, as DOHMH officials were able to elicit the help of several Spanish-speaking doctors and nurses to provide medical assessments in high-risk areas such as senior centers, a supportive housing building for HIV-infected patients, and at public events. These outreach efforts, combined with a high level of media coverage, are credited with reducing the median time from illness onset to LD diagnosis from 5 days to 1 day.³

Aftermath

Of 55 cooling towers tested, 2 were found to have a *Legionella* strain indistinguishable by pulsed-field gel electrophoresis from 26 patient isolates. Whole-genome sequencing and epidemiologic evidence implicated a single cooling tower located at the Opera House Hotel as the source of the outbreak.³ The hotel had begun disinfection of that particular cooling tower on July 30. On August 3, Mayor Bill de Blasio released a statement saying that the city was looking into methods to proactively prevent future

outbreaks. The DOHMH seized on this moment of strong political capital to gain support for a citywide registry of cooling towers, an initiative that environmental health and communicable disease officials within the DOHMH recognized was necessary to expedite LD investigations. Now that there was a large community outbreak with evidence pointing toward a cooling tower as the culprit, the concept of having immediate and up-to-date knowledge on all cooling towers in the city was particularly appealing and creation of the registry became a priority. On August 6, DOHMH Commissioner Dr Mary Bassett ordered all cooling towers in NYC that had not been disinfected within the past 30 days to be evaluated for contamination and undergo disinfection within the next 2 weeks. Documentation of the cooling tower evaluation and subsequent disinfection was to be submitted to the DOB via an online portal. On August 10, the NYC Council introduced legislation that required all cooling towers to be registered with the DOB and inspected at least every 90 days during times of operation. The cooling tower legislation, officially known as Local Law 77, was enacted 8 days later on August 18. The outbreak was officially declared to have ended on August 20. A total of 138 cases and 16 deaths were attributed to this outbreak, making it the largest LD outbreak in NYC history.

Epilogue

A major agency-wide challenge during the response was the efficient management of incoming data. For example, while systems were already in place for obtaining and managing clinical data on LD diagnoses, there was no analogous system for managing data obtained from environmental sampling activities. Frequent requests for data from a host of external partners, including very important stakeholders such as elected officials, compounded the issue. DOHMH staff developed many new systems on the fly to reduce the time and effort required to sort, clean, and export environmental data in a useable fashion. In the year after the outbreak, the DOHMH has been working on developing a crosscutting data management workflow to ensure that epidemiologic, laboratory, and environmental data are compatible.

While improvements to data management and the response structure will be useful during future infectious disease outbreaks, the lasting impact of the July 2015 LD outbreak included the proposal and adoption of NYC Local Law 77 among other activities.²⁷ Local Law 77 sets stipulations for cooling tower registration and certification and imposes maintenance, inspection, and *Legionella* testing requirements for all buildings with cooling towers across the city.

Both new and existing cooling towers are required to register with the DOB. Furthermore, building owners are required to develop a maintenance plan for cooling towers that is in accordance with ASHRAE (American Society of Heating, Refrigerating, and Air Conditioning Engineers) Standard 188, an industry standard released in 2015.²⁸ In addition, Local Law 77 requires that cooling towers be tested for *Legionella* every 90 days when the cooling tower is in use and within 15 days prior to the initial use during any year. The Rules of the City of New York specify explicit maintenance activities that must be performed routinely and the remediation steps to be taken if routine *Legionella* testing procedures reveal certain thresholds of *Legionella* concentrations. The rules also establish acceptable methods for laboratory testing of environmental samples, as well as cleaning and disinfection of cooling towers. Finally, the rules carry with them an enforcement mechanism in the form of fines for buildings that fail to register a cooling tower, submit an annual certification, or fail an unannounced inspection by DOHMH inspectors.

Short- and long-term evaluations of the cooling tower regulations are ongoing. Evaluating the data in the registry will allow DOHMH officials to understand key characteristics of the city's cooling towers, such as the manufacturer, frequency of disinfection, location, owner or contractor, and the average number of bacterial colony-forming units in a tower, among others. Officials anticipate that this database will allow them to identify certain tower characteristics that are associated with an increased risk of *Legionella* amplification so that they can suggest modifications to cooling towers or building maintenance plans to prevent disease more effectively. Ultimately, officials hope that the cooling tower regulations contribute to a decrease in LD cases.

Discussion Questions

1. Consider the time span between when the initial signal was generated by SaTScan and when ICS was activated. What do you think the pros and cons may have been to immediately activating ICS upon observation of that signal?
2. Why was proactively reaching out to the city medical examiner a good idea during this outbreak response? How close is your jurisdiction's relationship with your medical examiner?
3. What steps could health department employees take to improve management of environmental sampling data?
4. What could the DOHMH have done, prior to or during the outbreak, that could have better managed public dissatisfaction with the response?
5. Should infectious disease data be released to the public on a routine basis? How rapidly? How should preliminary data be handled during an outbreak?
6. What role does public health play in mitigating adverse health conditions that result from neglected engineering or infrastructure components such as cooling towers? What is the role of the building owner or manager? Should public health play a role in ensuring that disease risk from neglected infrastructure is minimized? If so, how?
7. What expectations should the public health workforce have regarding job duties during public health emergencies such as infectious disease outbreaks?

In 2015, the New York City Department of Health and Mental Hygiene responded to an unprecedentedly large outbreak of Legionnaires' disease. Cases of Legionnaires' disease have increased dramatically in the United States since 2001. As epidemiologic and environmental risk factors for Legionnaires' disease increase, more people will be susceptible to the disease. Other health departments can learn from the actions DOHMH took during this outbreak and the subsequent cooling tower legislation New York City enacted to hopefully prevent future outbreaks. By learning from this experience, other jurisdictions can increase the efficiency and effectiveness of their own responses to future outbreak scenarios.

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