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REF: Illinois Veterans Home *Legionella* Investigation — Quincy, Illinois, 2017

INTRODUCTION

The setting

The Illinois Veterans Home in Quincy, Illinois (IVHQ) was the site of a large legionellosis outbreak in 2015 with 46 confirmed cases of Legionnaires' disease (35 among IVHQ residents, six among IVHQ staff, and five among community members) and 12 confirmed cases of Pontiac fever (all among IVHQ residents). At the request of IDPH, CDC conducted an Epi-Aid in September 2015. CDC recommendations are described in the 2015 Epi-Aid Trip Report.[1] In response to the outbreak and CDC recommendations, IVHQ hired a consultant with expertise in *Legionella* testing and remediation to develop a water management program (WMP) to further reduce risk of disease transmission. As part of the WMP, IVHQ and IDPH implemented multiple engineering changes to help control *Legionella* growth, intended to result in higher hot water temperatures and detectable disinfectant levels in water throughout the campus. They also installed 0.2 micron point-of-use filters for the removal of *Legionella* on all showerheads and on the hand-held sprayers associated with therapy tubs. Although point-of-use filters are typically implemented as a temporizing measure to reduce risk of disease while remediation activities are underway, IVHQ and IDPH opted to maintain these filters permanently as part of their WMP. Following the Epi-Aid in 2015, there was a substantial reduction in both cases of Legionnaires' disease associated with IVHQ and in detectable *Legionella* in the water systems.

Five Legionnaires' disease cases were identified in association with IVHQ in 2016, leading to a second CDC Epi-Aid in August of that year. Additional CDC recommendations to further refine

[1] Westercamp M, et al. Undetermined source of an healthcare-associated outbreak of Legionnaires' disease — Illinois, 2015. Available at: http://www.dph.illinois.gov/sites/default/files/publications/cdc-trip-reportquincyil12.31.15.pdf

the WMP are described in the 2016 Epi-Aid Trip Report.[2] Following the second investigation, specific interventions included replacement of the dishwashing sprayer at Smith Hall, which was used by two case-patients during their exposure periods, and addition of Smith Hall to the Sunday flushing schedule. In addition, the IVHQ WMP team continued to closely monitor water parameters and *Legionella* testing results; when positive test results or unexpected values were encountered, the team reviewed the WMP and adapted their contingency responses to address identified risks for *Legionella* growth and transmission. IDPH and IVHQ staff have committed substantial time, effort, and resources to achieving control of *Legionella* growth at IVHQ through effective water management including the installation of a supplemental disinfection system. While WMPs aim to reduce risk for Legionnaires' disease, complete eradication of *Legionella* in any large, complex building water system may not be possible; therefore, some risk for Legionnaires' disease may remain in spite of a fully-operational WMP, especially for susceptible individuals exposed to building water that contains *Legionella*.[3]

Purpose of the investigation

Between January and November 2017, six confirmed cases of Legionnaires' disease were reported among residents of IVHQ. Illinois Department of Public Health (IDPH) promptly notified CDC as they learned of each new case. CDC consulted remotely with IDPH and IVHQ regarding each case to help identify potential sources of exposure in order to protect other IVHQ residents, staff, and visitors. After two cases occurred in October 2017, IVHQ staff identified inconsistent levels of disinfectant in the water main supplying IVHQ and some buildings on campus. In their root cause investigation, IVHQ staff hypothesized that the inconsistent disinfectant levels may have been the result of inadvertent mixing directly with municipal water due to a redundant water main valve that was found in a partially open position. Disinfectant levels stabilized after the valve was closed and locked. After the report of the sixth case with onset in November, IDPH requested on-site technical assistance from CDC. A team including an epidemiologist, a microbiologist, and two environmental health specialists deployed to Quincy, IL on December 3, 2017. The objectives of the investigation were to:

- Review detailed clinical and exposure histories of all Legionnaires' disease cases associated with IVHQ in 2017;
- Review current procedures for pneumonia and Legionnaires' disease surveillance and clinical testing at IVHQ and Blessing Hospital (the local hospital where IVHQ residents are hospitalized) to ensure that cases of Legionnaires' disease are diagnosed, treated, and reported in a timely manner;

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[2] Ahmed SS, et al. Healthcare-associated outbreak of Legionnaires' disease among veterans — Quincy, Illinois, 2016. Available at: http://www.dph.illinois.gov/sites/default/files/publications/cdc-trip-report quincyil06.26.17.pdf

[3] ASHRAE. Legionellosis: risk management for building water systems. ANSI/ASHRAE Standard 188–2015. Atlanta, GA: ASHRAE; 2015.

- Review IVHQ WMP documents and records to evaluate whether the program could be adjusted to further reduce risk for *Legionella* growth and transmission;
- Conduct an environmental assessment and sampling for *Legionella* in all buildings at IVHQ where 2017 case-patients spent any portion of their exposure periods.

METHODS

This report addresses the observations and findings from the on-site investigation conducted December 4–6, 2017.

Descriptive epidemiology and disease surveillance

With epidemiology staff from IDPH and Adams County Health Department and clinical staff from IVHQ, the CDC team reviewed the medical history, clinical course, and potential exposures to water both on and off the IVHQ campus for each reported case of Legionnaires' disease associated with the facility in 2017. Clinical staff at IVHQ were interviewed to understand current practices related to pneumonia surveillance and clinical testing for Legionnaires' disease. Blessing Hospital clinical, infection prevention, laboratory, and hospital administration staff were interviewed regarding procedures for evaluating and testing for Legionnaires' disease, particularly among residents of IVHQ hospitalized for pneumonia or who received a diagnosis of pneumonia following admission.

Water management program review

With IDPH environmental health staff, the CDC team interviewed IVHQ staff and reviewed documents and records to assess the performance of the WMP in 2017. The CDC team's review included:

- IVHQ campus water main schematics and plumbing blueprints of Elmore, Markword, Somerville, and Therapy buildings;
- Characteristics of the Elmore building plumbing system (e.g., sink and shower locations, fixture design, hot and cold water piping system design) in comparison to other buildings' plumbing systems, particularly other buildings in which skilled nursing care is provided;
- Location of buildings associated with case-patients relative to the location of water main automatic flushing stations (strategically installed in 2016 to increase water flow throughout the campus) and the water treatment plant;
- Selected routine flushing logs and discussed routine flushing procedures at IVHQ;
- Contingency responses performed following identification of cases and/or positive environmental cultures for *Legionella*;
- Available daily water quality record keeping; we discussed any potential changes impacting water quality with the water treatment operator;

- Water parameter data and *Legionella* sampling results from the beginning of 2017 to date to evaluate the recent performance of the WMP, further investigate possible case exposures, and inform the environmental assessment and sampling plan.

Environmental assessment and sampling

Along with IVHQ, IDPH, and Adams County Health Department staff, the CDC team conducted a walkthrough of buildings associated with case-patient exposures in 2017. Sampling sites were selected based upon prior sampling results, epidemiologic information, and observations made during the walkthrough.

Sampling for *Legionella* was undertaken per previously published protocols.[4] At each sample location, water parameters (i.e., temperature, free chlorine, total chlorine, and chlorine dioxide) were measured to characterize the potential risk for *Legionella* amplification. One-liter bulk water samples were collected from various points with appreciable risk for aerosolization in the potable water system of selected buildings, including showers, sink faucets, and tub filler faucets. Showerhead point-of-use filters were removed before sampling to allow access to the piping interior. Bulk water samples were also collected from a water main automatic flushing station and an ice machine. The team considered collecting bulk water samples from toilets but observed that the flush mechanism was of low velocity and determined that the risk of aerosolization from toilets was likely minimal. Swabs of biofilm from sink faucets, showerheads, and drains were collected with Dacron-tipped sterile swabs. Sodium thiosulfate was added to each bulk water and swab sample to neutralize the disinfectant. Bulk water samples and swabs were maintained in insulated coolers and sent to CDC's *Legionella* laboratory within 48 hours of sample collection.

The CDC team used a SAS handheld air sampler to collect 200L air samples. The samples were taken during flushing procedures and tub filling activities.

Note that the cooling towers that serve the IVHQ campus were shut down for the season on October 17, 2017 according to IVHQ staff. Neither environmental assessment nor sampling were performed on the cooling towers during the site visit.

Laboratory methods

Environmental samples were cultured for *Legionella* at CDC according to previously described methods.[5] Samples were processed within 48 hours of collection and inoculated on buffered charcoal yeast extract (BCYE) plates either without antibiotic selection or containing PVC and

[4] CDC. Sampling Procedure and Potential Sampling Sites. Available at: https://www.cdc.gov/legionella/downloads/cdc-sampling-procedure.pdf

[5] Kozak NA, Lucas CE, Winchell JM. Identification of *Legionella* in the environment. *Methods Mol Bio*. 2013;954:3–25.

GPVC ([P] = polymyxin B (1000 U/L), [V] = vancomycin (5mg/mL), [C] = cyclohexamide (80 mg/mL), [G] = glycine (2 g/L)). Isolates displaying growth only when supplemented with cysteine were tested using a multiplex *Legionella* PCR assay which detects *Legionella* species, *L. pneumophila*, and *L. pneumophila* serogroup 1. Isolates were tested using a 7-gene sequence-based typing scheme to determine sequence type (ST).[6,7] Isolates were further examined using whole genome MLST (wgMLST).[8] Genome sequences were generated using the Illumina MiSeq sequencer.

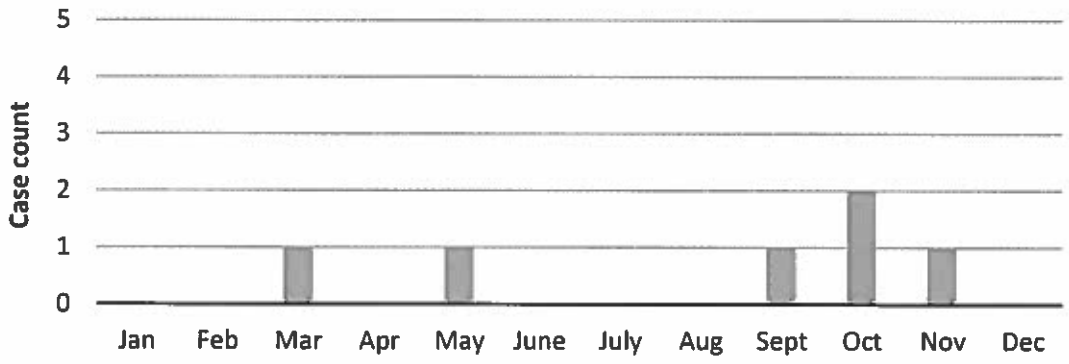
RESULTS

Descriptive epidemiology and disease surveillance

Descriptive epidemiology

A total of six confirmed cases of Legionnaires' disease with possible exposures to IVHQ were identified in 2017, including the four cases diagnosed between September and November 2017 mentioned above (**Figure 1**). Five of these six cases occurred in IVHQ residents and one in an employee.

Figure 1. Epi curve of confirmed Legionnaires' disease cases associated with IVHQ — January 1 to December 4, 2017



Ages ranged from [redacted]; five were male, and one death was reported (**Table 1**). All six case-patients were diagnosed via UAT; no clinical specimens for *Legionella* culture were obtained.

[6] Gaia V, et al. Consensus sequence-based scheme for epidemiological typing of clinical and environmental isolates of *Legionella pneumophila*. *J Clin Microbiol*, 2005;43(5):2047–52.
[7] The European Working Group for *Legionella* Infections. *Legionella* SBT Quality Assessment. Available at: http://www.hpa-bioinformatics.org.uk/cgi-bin/legionella/sbt/seq_assemble_legionella1.cgi
[8] Raphael BH, et al. Genomic resolution of outbreak-associated *Legionella pneumophila* serogroup 1 isolates from New York State. *Appl Environ Microbiol*. 2016 May 31;82(12):3582–90.

Table 1. Select characteristics of confirmed Legionnaires' disease cases associated with IVHQ — January 1 to December 4, 2017

Characteristic	N (%)
Total cases	6 (100)
Age in years, range	[redacted]
Male	4 (66.7)
Current/former smoker	5 (83.3)
Chronic lung disease*	2 (33.3)
Immunocompromised†	1 (16.7)
Difficulty swallowing	1 (16.7)
Hospitalization	4 (66.7)
Death	1 (16.7)

*Includes chronic obstructive pulmonary disease (COPD) and emphysema
†Includes cancer, diabetes, kidney failure, and medications that suppress the immune system

According to case investigations conducted by the Adams County Health Department in collaboration with IVHQ clinical staff, symptom onsets among resident cases ranged from May 22, 2017 to November 19, 2017 (**Table 2**). No exposures were common to all resident cases. Three case-patients resided in the [redacted] building during their exposure periods; the other two cases resided in [redacted] and [redacted]. The case-patient who resided in [redacted] reported during his interview that he occasionally performed flushing on the sink located in his room. He noted that he stood in close proximity to the sink throughout the process. The resident of [redacted] did not leave the building during his exposure period. One case-patient reported visiting the Therapy building during his exposure period to water plants in the attached greenhouse. Three case-patients reported leaving the IVHQ campus during their respective exposure periods for activities including off-site outpatient appointments, shopping, and/or visiting family.

Table 2. Selected potential exposure locations per case of Legionnaires' disease among residents of IVHQ — January 1 to December 4, 2017

Case	Date of symptom onset	Building of residence	Bedroom with in-room sink	Tub	Shower*	Therapy building	Off-campus
Resident 1	05/22/2017	[redacted]	Yes	Yes	No	No	Yes
Resident 2	09/02/2017	[redacted]	Yes	No	Yes	Yes	Yes
Resident 3	10/03/2017	[redacted]	No	Yes	No	No	No
Resident 4	10/08/2017	[redacted]	Yes	No	Yes	No	Yes
Resident 5	11/19/2017	[redacted]	Yes	No	Yes	No	No

*Shower with point-of-use filter installed

The employee case-patient had a reported onset date of March 5, 2017. According to the patient interview, she primarily worked in the Fifer building, but may have visited other IVHQ buildings in the 10 days prior to symptom onset. Notably, this case-patient also reported spending several hours during her exposure period in the vicinity of an operating hot tub located in the atrium of an out-of-state hotel.

Disease surveillance

IVHQ maintains a log of residents diagnosed with pneumonia that includes those diagnosed at either at IVHQ or at Blessing Hospital, where all residents who need hospitalization are admitted. IVHQ and public health staff review this log routinely to look for increases in pneumonia diagnoses above baseline. IVHQ leadership encourages performance of *Legionella* testing on residents with pneumonia. From January through November, 92 patients were diagnosed with clinical or radiographic pneumonia and 88 of those were tested for *Legionella*. IVHQ and public health staff evaluate each new case of Legionnaires' disease independently for possible exposures to water at IVHQ and in the community and compare these exposures to other recent cases to look for common sources of exposure. New cases of Legionnaires' disease also trigger contingency responses, as dictated by the WMP, as well as a review of the WMP. While IVHQ takes a vigorous approach to disease surveillance, a few limitations were observed.

- A written protocol for evaluating healthcare-associated pneumonia and criteria for performance of *Legionella* testing has not been created. Without such a protocol in place, it is difficult to ensure consistency of practice among the group of clinicians providing patient care at IVHQ.
- IVHQ does not have internal capacity to perform UAT. IVHQ currently sends samples for UAT to Blessing Hospital. Blessing Hospital in turn sends UATs to a reference laboratory

instead of performing them in-house, potentially leading a delay in diagnosis (**Table 3**). This delay can impact patient care if *Legionella*-specific therapy is delayed. Delayed case reporting can also hinder the timeliness of public health action at IVHQ. Recently IVHQ has started also sending samples for UAT to another facility, Hannibal Regional Hospital, which has the capacity to perform UAT in-house and thus can offer a quicker turnaround time for results.

- When a lower respiratory specimen is obtained at IVHQ, it can be frozen and sent to Blessing Hospital, which then sends the specimen to a reference laboratory. Even so, lower respiratory specimens are rarely obtained from patients with pneumonia at either IVHQ or Blessing Hospital, and neither facility has written protocols to ensure systematic collection of specimens.
- There are opportunities to strengthen coordination between care providers at IVHQ and Blessing Hospital to ensure that appropriate *Legionella* testing is performed on patients with pneumonia and that results are communicated between facilities.

Table 3. *Legionella* testing results and timing of results from Blessing Hospital for confirmed Legionnaires' disease cases among residents* of IVHQ — January 1 to December 4, 2017

Case	Symptom onset date	Urine collection date	UAT result date
Resident 1	05/22/2017	05/26/2017	05/30/2017
Resident 2	09/02/2017	09/11/2017	09/15/2017
Resident 3	10/03/2017	10/10/2017†	10/14/2017
Resident 4	10/08/2017	10/08/2017	10/12/2017
Resident 5	11/19/2017	11/20/2017	11/24/2017

*Employee case-patient was not diagnosed or treated for Legionnaires' disease at IVHQ or Blessing Hospital

†Per IVHQ infection prevention staff, urine was initially collected on 10/05/2017 but had to be recollected on 10/10.

Water management program review

Building water system design

The Elmore building hot and cold water plumbing design is similar to the other skilled nursing buildings. There are a variety of room designs across campus, with some rooms having a sink in the room, while others have sinks in a separate bathroom. In the Elmore building, all resident rooms contain a sink in close proximity to the bedside (**Table 2**). Campus-wide, showers and soaking tubs are located in shared facilities rather than individual residents' rooms.

Disinfectant data collected by the CDC team on site and water parameter records following closure of the open water main valve revealed adequate disinfectant levels in all buildings

regardless of distance from the water main automatic flushing stations or from the water treatment plant.

Water parameter data and Legionella *testing*

In the buildings surveyed, available records and conversations with IVHQ staff indicated that the WMP was being followed as written, except for flushing as mentioned below. Appropriate water parameter and sampling results are maintained on hard copy and in an online system. Corrective actions and contingency responses are documented per the WMP. The WMP team continues to convene monthly to discuss program activities. Verification and validation steps are occurring as outlined in the WMP.

Flushing

Per the WMP, all showers, sinks, and tubs are flushed at least daily in all buildings. According to interviews with IVHQ staff, patient care and janitorial staff typically carry out flushing activities. CDC staff observed significant splashing during sink flushing in the Elmore building and others related to high water volume and velocity.

Per observations and discussions with IVHQ staff, in the skilled nursing buildings and Elmore in particular, flushing starts at a room at one end of the hallway where each fixture is turned on (both hot and cold). The staff member moves from room to room until every fixture on the corridor or floor is flushed. The total flushing time may be up to 20 minutes in each room. In skilled care buildings, including Elmore, flushing reportedly took place at night; residents were typically in the rooms while flushing was ongoing.

The CDC team's review of available flushing logs did not reveal any missed flushing events. However, the written logs lacked additional details such as what time of day flushing was conducted. Based upon their observations, IVHQ staff reported during interviews that despite documentation in written logs, daily flushing may not have been conducted consistently in all locations (e.g., water discoloration, a possible indicator of stagnant water, was occasionally observed from fixtures that should have been flushed daily). Furthermore, written verification by supervisors that flushing activities were conducted appropriately is recommended per industry standards but was not documented at IVHQ.

Per conversations with IVHQ staff, the CDC team learned that hot water flushing causes hot water tanks to empty in various buildings, resulting in cold water complaints at points of use multiple times a day. This could result in water in the permissive range for *Legionella* growth throughout the hot water distribution system.

Environmental assessment

The CDC team conducted targeted environmental assessments of the Elmore, Markword, Somerville, and Therapy buildings. The locations of *Legionella* environmental sampling and

corresponding water parameter measurements are listed in **Appendix B**. Hot water temperatures ranged from 86.9–106.0°F with a median value of 100.8°F. Current industry guidelines recommend circulated minimum tempertures of 124.0°F,[9] however, measured temperatures at the tap will be lower than this wherever thermostatic mixing valves are installed to prevent scalding, as has been done at IVHQ. As indicated in IVHQ's WMP, water temperatures at fixtures are measured after blending of hot and cold water at thermostatic mixing valves. IVHQ's WMP stipulates that fixtures are monitored daily to ensure that water at the tap does not exceed the scalding limit of 110.0°F. Isolated hot water temperatures (prior to mixing) are not routinely measured at points of use at IVHQ, however, isolated hot water temperatures are measured as part of the contingency response to positive water samples for *Legionella* or cases of Legionnaires' disease, as indicated in IVHQ's WMP. The water heater in the Elmore basement was not sampled by the CDC team because it was inaccessible; however, the thermostat set point was observed to be >140°F.

IVHQ adds supplemental chlorine to their water system on site. Free chlorine ranged from 0.4–2.7 mg/L (median: 1.4 mg/L). Total chlorine was assessed at four locations in the cold water, all of which had a detectable residual (range: 0.8–2.2 mg/L). Disinfectant targets, as specified by IVHQ's WMP for both hot and cold water distribution and measured daily at sinks and showers, are 0.2–4.0 mg/L for free chlorine and 0.5–2.0 mg/L for total chlorine.

Chlorine dioxide is also generated on site and is added to the system in addition to the supplemental chlorine. Chlorine dioxide ranged from 0.0–1.6 mg/L, with a median value of 0.2 mg/L. Chlorine dioxide and chlorite (a byproduct of chlorine dioxide generation) are measured by the Illinois certified water operator. Control limits for chlorine dioxide do not appear to be listed in the WMP.

***Legionella* culture results**

The results of CDC's testing for *Legionella* in environmental samples are listed in **Appendix B**. Of 48 samples collected, one bulk water sample from a shower was positive for *L. pneumophila* serogroup 1. This positive sample was obtained from a showerhead that normally contains a 0.2 micron point-of-use filter (i.e., the filter was removed and a bulk water sample was obtained). The filter was put back in place and a post-filter bulk water sample was obtained, which was negative (demonstrating the effectiveness of the filter to remove *Legionella* from the potable water).

Sequence-based typing of isolates from this sample revealed that they were ST36, the same type associated with the 2015 outbreak and recovered again from the facility in 2016.

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[9] ASHRAE. Minimizing the risk of legionellosis associated with building water systems. ASHRAE Guideline 12-2000. Atlanta, GA: ASHRAE; 2000.

Furthermore, wgMLST analysis (**Appendix C**) of the isolates recovered in 2017 revealed they share >99.5% identical alleles with sequences of isolates recovered in 2015 and 2016.

CONCLUSIONS AND RECOMMENDATIONS

Efforts by IDPH and IVHQ to control *Legionella* resulted in substantially fewer Legionnaires' disease cases in 2016 (N=5) and 2017 (N=6) compared to 2015 (N=46). In 2015, the ST36 outbreak strain was found throughout the water system at IVHQ. The same strain, albeit in only single locations, was found during CDC's sampling in 2016 and again in 2017, indicating the persistence of this strain in the IVHQ water system. Because IVHQ has addressed issues identified previously with low levels of disinfectant and temperatures conducive to growth, it is probable that this strain persists in protective biofilm, scale, and sediment that are present in the plumbing infrastructure at IVHQ. Long-term persistence of particular strains has been documented in other facilities.[10–14] Complete eradication of *Legionella* in any large, complex building water system may not be possible.

Overall, based on interviews with staff, documentation review, and results of our environmental assessment and sampling, the IVHQ water management team continues to follow a comprehensive WMP. The team appears to be implementing appropriate contingency responses when associated cases are identified, and modifying the program as necessary to optimize performance. There is no known safe level of *Legionella* in building water systems, and cases have been associated with very low levels of bacteria.[15] Therefore, the intent of a WMP is to manage building water systems to reduce the hazardous conditions that allow the *Legionella* to grow and spread to susceptible individuals.

Recognizing the persistence of this strain within IVHQ and the probability that some level of *Legionella* colonization may continue, our recommendations are focused on minimizing the risk of exposure among residents, staff, and visitors. IVHQ and similar skilled nursing and long-term care facilities nationwide house populations that are highly susceptible to Legionnaires' disease because of advanced age and underlying health conditions. While adoption of these

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[10] Kozak-Muiznieks NA, et al. Three genome sequences of *Legionella pneumophila* subsp. *pascullei* associated with colonization of a health care facility. *Genome Announc*. 2016;4(3). pii: e00335-16

[11] Silk BJ, et al. Eight years of Legionnaires' disease transmission in travelers to a condominium complex in Las Vegas, Nevada. *Epidemiol Infect*. 2012;140:1993–2002.

[12] Cowgill KD, et al. Recurrence of legionnaires disease at a hotel in the United States Virgin Islands over a 20-year period. *Clin Infect Dis*. 2005;40(8):1205–7.

[13] Lepine LA, et al. A recurrent outbreak of nosocomial legionnaires' disease detected by urinary antigen testing: evidence for long-term colonization of a hospital plumbing system. *Infect Control Hosp Epidemiol*. 1998;19(12):905–10.

[14] Kool JL, et al. More than 10 years of unrecognized nosocomial transmission of legionnaires' disease among transplant patients. *Infect Control Hosp Epidemiol*. 1998;19(12):898–904.

[15] Demirjian A, et al. The importance of clinical surveillance in detecting Legionnaires' disease outbreaks: A large outbreak in a hospital with a Legionella disinfection system — Pennsylvania, 2011–2012. *Clin Infect Dis*. 2015;60(11):1596–1602.

recommendations should further reduce risk, the possibility of future cases of disease associated with IVHQ cannot be eliminated.

IVHQ and public health staff continue efforts to rapidly identify cases of Legionnaires' disease though disease surveillance. Nevertheless, there are still challenges with timely diagnosis and opportunities exist to strengthen coordination between care providers at IVHQ and Blessing Hospital. Recommendations intended to address these gaps are provided.

Recommendations

CDC recommendations provided as part of the 2015 and 2016 Epi-Aid investigations should be reviewed and considered active. The additional recommendations below are based on the observations and findings made during the CDC team's 2017 site visit.

Disease surveillance

- IDPH should identify mechanisms for local capacity to conduct UAT to improve turnaround time to 48 hours or less. If Blessing Hospital is unable to develop the capacity to conduct same-day, in-house UAT, then other options for rapid diagnosis for IVHQ residents should be pursued.
- Residents and patients of IVHQ who develop pneumonia should be tested for Legionnaires' disease with both culture of lower respiratory specimens and UAT, regardless of whether they are treated at IVHQ or at Blessing Hospital.
- IVHQ should develop a written protocol for healthcare-associated pneumonia surveillance and *Legionella* testing specific for IVHQ and provide it to IVHQ clinical staff.
- When IVHQ residents requiring hospitalization are treated at Blessing Hospital, IDPH should facilitate coordination between IVHQ and Blessing Hospital to ensure that hospitalized residents who develop pneumonia are tested for Legionnaires' disease, and that test results are communicated between the facilities promptly, especially if testing is coordinated through a separate facility or laboratory.

Water management program

- Continue to maintain disinfectant levels and temperatures within ranges as indicated in the WMP.
    - Chlorine dioxide control limits should be specified in the WMP.
    - IVHQ should establish control limits for the hot water temperature range at fixtures (prior to mixing) in accordance with current industry standards and choose a representative set of control points. This is important to verify over time that the heating system is working as intended to control *Legionella* growth up to the mixing valve. Unexpected values should prompt review of the WMP and a search for the root cause of low temperatures.

- IVHQ should incorporate measurement of hot water temperatures at these control points into the WMP. At IVHQ, thermostatic mixing valves are accessible below every sink. Cold water can be temporarily disconnected from the mixing valve to allow access to isolated hot water for measurement of maximum temperatures.

- IVHQ should modify current flushing protocols as recommended below and as needed based upon continuous review of the WMP's performance data to further reduce the risk of *Legionella* transmission.
  - Residents should not be in their rooms while daily flushing activities take place.
  - IVHQ may need to adjust frequency, location, and/or duration of hot water flushing to ensure that thermal control limits are maintained within the hot water system.
  - Staff members who perform flushing should limit their own exposure to *Legionella*-containing aerosols.
    - It is important to educate staff members about Legionnaires' disease (e.g., risk factors, signs and symptoms, importance of early diagnosis and treatment). Legionnaires' disease more commonly occurs in people with underlying risk factors.[16]
    - CDC does not have *Legionella*-specific prevention guidance for employees. For employees engaged in flushing activities, wearing a half-face air-purifying respirator equipped with an N95 filter[17] may be appropriate; however, the effectiveness of this practice has not been evaluated. After turning on the water, staff members may choose to step out of the room while flushing is ongoing.
  - IVHQ should add time of day flushing was conducted and written verification to flushing logs and should ensure that someone who is not directly responsible for flushing verifies that the activity occurred and is documented.

- IVHQ should ensure that drains are not occluded and that flushing is conducted in a manner that minimizes splashing.
- To further reduce the risk of *Legionella* transmission, IVHQ could consider expanding the installation of point-of-use filters validated for the removal of *Legionella* from only showerheads to all potable water fixtures (including sink faucets) campus-wide. In general, the use of point-of-use filters is viewed as a temporizing measure, but they can be used on a long-term basis as a risk reduction strategy if properly maintained.
  - Note: the impact of facility-wide, long-term point-of-use filters is not understood and may have unintended consequences (i.e., degradation of building water quality

[16] CDC. Legionnaires' Disease Fact Sheet. Available at: https://www.cdc.gov/legionella/downloads/fs-legionnaires.pdf

[17] Respirators must be used in accordance with a comprehensive respiratory protection program, which includes fit testing, training, and medical clearance ahead of their use.

due to reduced water flow, increased water age, reduced residual disinfectant, and the development of biofilms, all of which may support growth of *Legionella* and potentially other opportunistic premise plumbing pathogens). Ongoing performance evaluation of the WMP will be necessary to monitor for such unintended consequences.

  - Installation of point-of-use filters on all fixtures could change current recommendations for flushing activities. Flushing may shorten the lifespan of the filter substantially, and thus it may help to remove the point-of-use filters from each fixture during the flushing process. However, once the filters have been removed, the risk of exposure to *Legionella*-containing aerosols would continue to be a risk, and thus modifications to the flushing protocols as recommended above still apply.

- IVHQ can consider working with the soaking tub manufacturer to identify *Legionella* filtration options for water that is delivered to or through the tub filler.

Since 2015, IDPH and IVHQ staff have committed considerable time, effort, and resources to implementing a water management program that has reduced both the number of Legionnaires' disease cases associated with IVHQ and the amount of detectable *Legionella* in the water systems. How much further our recommended changes will reduce risk is unclear. Every approach to risk reduction has benefits but also has challenges and can lead to unintended consequences. Even with a fully optimized WMP, cases of Legionnaires' disease are possible in any facility that contains a large, complicated water system and that houses a highly susceptible population. However, modifications to the existing IVHQ WMP as recommended in this report may further reduce the risk for *Legionella* growth and transmission.

APPENDIX A. *LEGIONELLA* ECOLOGY AND EPIDEMIOLOGY

Legionnaires' disease is a type of bacterial pneumonia caused by inhalation of aerosolized droplets of water containing *Legionella*. Although *Legionella* are ubiquitous freshwater and soil inhabitants, in building water systems, the bacteria can amplify and expose a susceptible population through showers, faucets, cooling tower drift, hot tubs, and decorative water fountains. Risk factors for Legionnaires' disease include older age (≥50 years), smoking, and underlying medical conditions such as chronic lung disease or immunosuppression. The following conditions in building water systems can promote the amplification and potential transmission of *Legionella*:[18]

- Warm temperatures (77–107°F)
- Inadequate disinfectant
- pH outside range of approximately 6.5–8.5
- Water stagnation and water pressure changes
- Presence of free-living protozoa
- Presence of biofilm, scale, and sediment in piping
- Changes in water pressure due to construction, water main breaks, or municipal water quality

To meet public health criteria as a confirmed case of Legionnaires' disease, a patient must have clinically compatible illness (i.e., evidence of clinical or radiographic pneumonia) and a confirmatory diagnostic test:

- 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; or
- By seroconversion: fourfold or greater rise in specific serum antibody titer to *L. pneumophila* serogroup 1 using validated reagents.[19]

The most commonly used diagnostic test for Legionnaires' disease is the urinary antigen test (UAT). While UAT has the advantage of rapid turnaround time, the test can only detect *L. pneumophila* serogroup 1 (which accounts for the majority of cases in the US). Culture of lower respiratory tract specimens allows for detection of all species and serogroups, and enables comparison of clinical and environmental isolates to confirm potential sources of exposure.

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[18] Garrison LE, et al. Vital Signs: Deficiencies in environmental control identified in outbreaks of Legionnaires' disease – North America, 2000–2014. *MMWR*. 2016;65:576–84.

[19] CDC. CSTE Position Statement: Strengthening Surveillance for Travel-Associated Legionellosis and Case Definitions for Legionellosis. Available at: http://www.cdc.gov/legionella/health-depts/inv-tools-single/cste-position-statement.html

Because healthcare facilities host susceptible populations and often have cooling towers and complex premise plumbing systems, *Legionella* growth and transmission are particular concerns for their water systems.[20] CDC typically recommends that a full investigation for the source of *Legionella* be performed when:[21]

- ≥1 case of definite healthcare-associated Legionnaires' disease (a case in a patient who spent the entire 10 days prior to onset of illness in a healthcare facility) is identified, or
- ≥2 cases of possible healthcare-associated Legionnaires' disease (cases in patients who spent a portion of the 10 days before symptoms began in a healthcare facility) are identified within 12 months of each other.

However, where there is a history of Legionnaires' disease cases possibly associated with a facility and there is concern that a potential risk for *Legionella* transmission still exists, investigating even a single case of possible healthcare-associated Legionnaires' disease is prudent.

[20] Garrison LE, et al. Vital Signs: Deficiencies in environmental control identified in outbreaks of Legionnaires' disease – North America, 2000–2014. *MMWR*. 2016;65:576–84.
[21] CDC. Developing a water management program to reduce *Legionella* growth and spread in buildings. Available at: http://www.cdc.gov/legionella/downloads/toolkit.pdf

APPENDIX B. ENVIRONMENTAL SAMPLE LOCATIONS, WATER PARAMETERS, AND *LEGIONELLA* CULTURE RESULTS — IVHQ, 2017

CDC sample ID	Collection date	Sample type	Sample description	Temp (°F)	Free Cl_2 (mg/L)	Total Cl_2 (mg/L)	ClO_2 (mg/L)	*Legionella* culture results
IL17-1-001	12/5/2017	swab	Therapy Building, cardiac room sink	NA	NA	NA	NA	ND[22]
IL17-1-002	12/5/2017	bulk water	Therapy Building, cardiac room sink, hot	103.6	2.5	NC[23]	0.00	ND
IL17-1-003	12/5/2017	bulk water	Therapy Building, cardiac room sink, cold	60.6	1.0	0.8	0.02	ND
IL17-1-004	12/5/2017	swab	Therapy Building, wheelchair washer hose	NA	NA	NA	NA	ND
IL17-1-005	12/5/2017	swab	Therapy Building, wheelchair washer sink drain	NA	NA	NA	NA	ND
IL17-1-006	12/5/2017	bulk water	Therapy Building, cardiac room sink, hot	102.6	1.2	NC	0.00	ND
IL17-1-007	12/5/2017	bulk water	Therapy Building, cardiac room sink, cold	70.0	1.8	NC	0.18	ND
IL17-1-008	12/5/2017	swab	Somerville 215 sink faucet	NA	NA	NA	NA	ND
IL17-1-009	12/5/2017	swab	Somerville 215 sink drain	NA	NA	NA	NA	ND
IL17-1-010	12/5/2017	bulk water	Somerville 215 sink, hot	106.0	0.6	NA	0.00	ND
IL17-1-011	12/5/2017	bulk water	Somerville 215 sink, cold	68.5	0.5	1.3	0.00	ND
IL17-1-012	12/5/2017	swab	Somerville 213 sink faucet	NA	NA	NA	NA	ND
IL17-1-013	12/5/2017	bulk water	Somerville 213 sink, hot	104.2	0.9	NC	0.18	ND
IL17-1-014	12/5/2017	bulk water	Somerville 213 sink, cold	67.1	1.9	NC	0.21	ND
IL17-1-015	12/5/2017	bulk water	Somerville locker room (across from room 100), cold	55.9	2.5	2.2	0.09	ND
IL17-1-016	12/5/2017	bulk water	Elmore 110A sink, cold	63.1	1.8	1.7	0.35	ND
IL17-1-017	12/5/2017	swab	Elmore 110A sink faucet	NA	NA	NA	NA	ND
IL17-1-018	12/5/2017	swab	Elmore 110A sink drain	NA	NA	NA	NA	ND

[22] ND = not detected
[23] NC = not collected

CDC sample ID	Collection date	Sample type	Sample description	Temp (°F)	Free Cl_2 (mg/L)	Total Cl_2 (mg/L)	ClO_2 (mg/L)	*Legionella* culture results
IL17-1-019	12/5/2017	bulk water	Elmore 110A sink, hot	97.3	1.1	NC	0.00	ND
IL17-1-020	12/5/2017	bulk water	Elmore, 1st floor tub	90.1	0.6	NC	0.00	ND
IL17-1-021	12/5/2017	swab	Elmore, 1st floor tub, filler	NA	NA	NA	NA	ND
IL17-1-022	12/5/2017	swab	Elmore, 1st floor tub, drain	NA	NA	NA	NA	ND
IL17-1-023	12/5/2017	swab	Elmore 226 sink faucet	NA	NA	NA	NA	ND
IL17-1-024	12/5/2017	swab	Elmore 226 sink drain	NA	NA	NA	NA	ND
IL17-1-025	12/5/2017	bulk water	Elmore 226 sink, hot	NC	1.4	NC	0.25	ND
IL17-1-051	12/5/2017	bulk water	Elmore 226 sink, cold	NC	2.7	NC	0.18	ND
IL17-1-052	12/5/2017	swab	Elmore 206 sink faucet	NA	NA	NA	NA	ND
IL17-1-053	12/5/2017	bulk water	Elmore 206 sink, hot	101.5	0.7	NC	0.07	ND
IL17-1-054	12/5/2017	swab	Elmore 206 sink drain	NA	NA	NA	NA	ND
IL17-1-055	12/5/2017	bulk water	Elmore 206 sink, cold	61.2	1.7	NC	0.21	ND
IL17-1-056	12/5/2017	swab	Elmore 2nd floor shower, hose, pre-filter	NA	NA	NA	NA	ND
IL17-1-057	12/5/2017	bulk water	Elmore 2nd floor shower, pre-filter	91.6	0.7	NC	0.17	positive
IL17-1-058	12/5/2017	bulk water	Elmore 2nd floor shower, post-filter	NC	NC	NC	NC	ND
IL17-1-059	12/5/2017	bulk water	Elmore laundry room sink, cold	57.6	2.2	NC	0.28	ND
IL17-1-060	12/5/2017	bulk water	Elmore laundry room ice machine, left (A)	NA	NA	NA	NA	ND
IL17-1-061	12/5/2017	swab	Markword 2nd floor tub filler	NA	NA	NA	NA	ND
IL17-1-062	12/6/2017	bulk water	Markword 2nd floor tub	86.9	1.7	NC	0.13	ND
IL17-1-063	12/6/2017	swab	Markword 215/218 sink faucet	NA	NA	NA	NA	ND
IL17-1-064	12/6/2017	swab	Markword 215/218 sink drain	NA	NA	NA	NA	ND
IL17-1-065	12/6/2017	bulk water	Markword 215/218 sink, cold	56.7	2.6	NC	1.58	ND

CDC sample ID	Collection date	Sample type	Sample description	Temp (°F)	Free Cl_2 (mg/L)	Total Cl_2 (mg/L)	ClO_2 (mg/L)	*Legionella* culture results
IL17-1-066	12/6/2017	bulk water	Markword 215/218 sink, hot	100.0	0.4	NC	0.16	ND
IL17-1-067	12/6/2017	bulk water	Automatic flushing station near carpenter shop	NC	1.3	NC	0.26	ND
IL17-1-068	12/6/2017	bulk water	Elmore laundry room ice machine, left (B)	NA	NA	NA	NA	ND
IL17-1-069	12/6/2017	air	Markword 215 restroom	NA	NA	NA	NA	ND
IL17-1-070	12/6/2017	air	Therapy Building, cardiac exam room	NA	NA	NA	NA	ND
IL17-1-071	12/6/2017	air	Elmore 226	NA	NA	NA	NA	ND
IL17-1-072	12/6/2017	air	Elmore 1st floor tub room	NA	NA	NA	NA	ND
IL17-1-073	12/6/2017	air	Markword 2nd floor tub room	NA	NA	NA	NA	ND

APPENDIX C. *LEGIONELLA PNEUMOPHILA* WHOLE GENOME MLST (WGMLST) FROM ISOLATES ASSOCIATED WITH IVHQ, 2015–2017

Year	Isolate	Serogroup	Source	ST	State	Sample Description
2015	D7594	1	Clinical	36	IL	Lung tissue (patient A)
2015	D7599	1	Clinical	36	IL	Lung tissue (patient B)
2016	F4612	1	Environmental	36	IL	Smith sink (Phigenics)
2016	F4605	1	Environmental	36	IL	Sommerville 203 sink (Phigenics)
2016	F4607	1	Environmental	36	Il	Fletcher 1-7 (Phigenics)
2016	F4613	1	Environmental	36	IL	Schapers tub (Phigenics)
2015	F4529	1	Environmental	36	IL	Schapers 104 sink
2017	F4819	1	Environmental	36	IL	Elmore 2nd floor shower, pre-filter (CDC)
2017	F4820	1	Environmental	36	IL	Elmore 2nd floor shower, pre-filter (CDC)
2015	F4516	1	Environmental	36	IL	Cooling tower
2016	F4615	1	Environmental	36	IL	Sommerville 203 sink (CDC)
2017	F4821	1	Environmental	36	IL	Elmore 2nd floor shower, pre-filter (CDC)
2015	F4508	1	Environmental	1	IL	Cooling tower