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BRIEF REPORT



Remediation of novel sources linked to an outbreak of Legionnaires' disease in a manufacturing facility

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ABSTRACT

In September 2022, public health officials identified a legionellosis outbreak among workers at a manufacturing facility. Upon recognition of the outbreak, public health officials and company management investigated to identify the source and prevent additional cases. Facility management assembled an inventory of potential water sources and worked with a consultant to conduct sampling. *Legionella* bacteria were cultured from bulk water samples collected from two water jet cutters and a floor scrubber. All other sampling locations had no *Legionella* identified by culture. Legionellosis cases were distributed throughout the facility. Floor scrubbers were used to clean up water that spilled from the water jet cutters and to clean the floors adjacent to employee work areas. After multiple cycles of cleaning and disinfection of the water jet cutters and floor scrubbers, repeat sampling revealed no *Legionella* detected. Company management returned the equipment to service in November 2022 with a maintenance, disinfection, and monitoring plan; no additional cases of legionellosis among employees have been reported. Evidence indicates that water jet cutters provided a conducive environment for *Legionella* growth, while floor scrubbers may have also contributed to employee exposure. This case study describes a remediation plan and illustrates the importance of identifying all potential *Legionella* sources and maintaining a comprehensive water management program to protect workers from *Legionella* and other waterborne pathogens.

KEYWORDS

Legionella; occupational health; outbreak investigation; manufacturing

Introduction

Legionella, a naturally occurring bacteria, can pose a health risk to humans when it proliferates in engineered water systems that create water droplets (aerosols) that are inhaled by humans (CDC 2021). Inhaling aerosols containing *Legionella* is associated with three clinically and epidemiologically distinct illnesses collectively referred to as legionellosis; a severe pneumonia that can be fatal called Legionnaires' disease, a milder non-pneumonic form of illness known as Pontiac fever, and extrapulmonary legionellosis. The genus *Legionella* contains >60 species; however, *Legionella pneumophila* is the causative agent for 90% of cases worldwide (Gomez-Valero et al. 2014). Most cases in the United States are caused by *Legionella*

pneumophila, particularly serogroup 1. Historically, most outbreaks of legionellosis are associated with buildings with large complex engineered water systems and aerosolizing devices. Factors that are optimal for the growth of *Legionella* include temperatures between 35–46 °C, stagnation of piped water, and insufficient disinfectant residuals (Buse et al. 2012).

Sources of *Legionella* recognized in workplaces include plumbing systems (e.g., showers, faucets), cooling towers, and other aerosol-generating systems (Principe et al. 2017). Workplaces that have been associated with outbreaks include hotels, hospitals, long-term care facilities, plastic injection molding manufacturers, and automobile manufacturers (NIOSH 2019). Reports of legionellosis outbreaks in

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workplaces are relatively rare; a systematic review in 2016 identified 47 articles reporting 805 confirmed cases of legionellosis associated with a workplace (221 Legionnaires' disease; 584 Pontiac fever) from 1949–2015 (Principe et al. 2017). The primary sources of infection from these reports were cooling towers (42.5%), coolant systems (14.9%), and water systems (17.0%), which occurred in multiple occupational environments, such as industrial facilities, office buildings, and health care facilities.

From May–November 2022, 34 cases of legionellosis were reported among workers at a large manufacturing facility (10 confirmed; 24 probable); among these, 15 workers were hospitalized, and two died. The outbreak and investigation have previously been described (Mohamed et al. 2025). This case study presents the process of identification and remediation of water jet cutters and floor scrubbers as likely sources of the outbreak. To the authors' knowledge, these have not been described as sources in previous outbreaks. Below, the isolation of *Legionella* in these reservoirs, potential transmission pathways, and implementation of a remediation program for the identified sources are described.

Methods

The manufacturing facility involved in this outbreak is a 1 million square foot building with approximately 1,450 employees. Following the identification of cases of legionellosis diagnosed in facility employees in late August 2022, the South Carolina Department of Health and Environmental Control (DHEC), assisted by subject matter experts from the Centers for Disease Control and Prevention (CDC), worked with company management to investigate the outbreak and take steps to prevent additional cases. During a visit to the workplace, the team toured the facility, viewed equipment, and spoke with company management and employees about work processes and practices. Following the visit, the team continued to work with company management to review ongoing sampling data and discuss control measures.

Working with a consultant, company management identified over 30 potential water sources in the building, including the plumbing system, two abrasive water jet cutters, other machinery used in the production process, floor scrubbers, a cooling tower, and a supplemental comfort cooling system.

Sampling methods have been previously described (Mohamed et al. 2025). Briefly, on September 18, 2022, initial bulk water samples were collected from

sources of concern listed in the inventory. All samples were sent to an Environmental Legionella Isolation Techniques Evaluation (ELITE) Program member laboratory (CDC 2022). Samples were tested using Qualitative Polymerase Chain Reaction Assays for *Legionella* and via culture. Following this period, all samples were sent for culture only. Standardized culture procedures included ISO 11731:2017 *Detection and Enumeration of Legionella* and CDC: *Procedures for the Recovery of Legionella from the Environment*. *Legionella* species recovered from the culture method included *Legionella pneumophila* and *Legionella* species not *pneumophila*. All samples were shipped overnight, on ice, and arrived in acceptable condition. Collection volumes ranged from 150–1,000 mL, and the minimum reporting level of tests ranged from 0.2–1 colony-forming units per milliliter (CFU/mL). Results indicated with 0 were reported as “No *Legionella* isolated” by the reporting laboratory.

All *L. pneumophila* isolates were run against serogroup 1 reagent and serogroup 2–15 reagent. Subsequently, during the remediation process, samples were tested following the same methods.

At the same time initial samples were collected, company management took steps to reduce exposure to water sources until results were available. Precautions included placing both water jet cutters into idle mode, temporarily halting floor scrubber use, and turning off the cooling tower. Company management worked with consultants, equipment manufacturers, and the DHEC and CDC investigation team to identify disinfection, remediation, and monitoring steps using an iterative approach. Company management evaluated disinfection and remediation steps by testing bulk water samples collected at least 48 hours after each treatment.

Results

L. pneumophila serogroup 1 was isolated from initial bulk water samples from both water jet cutters (>100 colony-forming units [CFU] per milliliter [mL]) (Figure 1) and one floor scrubber (6 CFU/mL). No *Legionella* were isolated from samples collected from other sources. Cases occurred in workers with workstations throughout the facility, including areas distant from the water jet cutters, indicating that exposure was likely not confined to a specific area of the facility.

According to facility management, water jet cutters were used daily to cut sheet metal components, and water was aerosolized during the process. The water

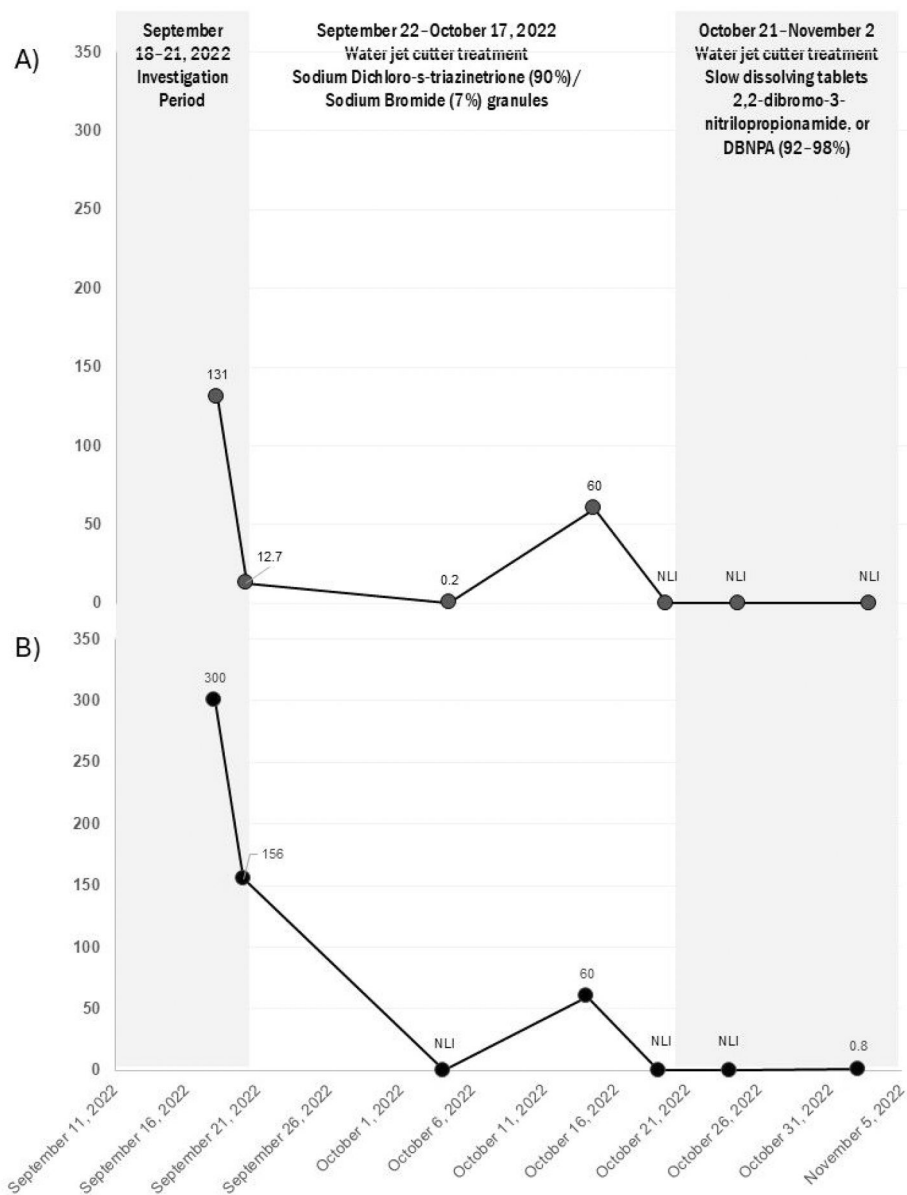


Figure 1. Culture results for *Legionella* from bulk water samples (range: 200–1,000 milliliters [mL]) collected from two water jet cutter basins (A and B) during September–November 2022, and how sampling results aligned with timing of remediation steps. All positive samples were *L. pneumophila* serogroup 1, except the sample from water jet cutter 2 collected on November 2, which was *L. pneumophila* serogroup 2–15. All samples collected after November 4, 2022, had no *Legionella* growth detected. Collection volumes ranged from 150–1,000 milliliter and the minimum reporting level of tests ranged from 0.2–1 CFU/mL. NLI = no *Legionella* isolated.

jet cutters were filled with water from the premises plumbing system; water was automatically added as needed to maintain an adequate level. Garnet was used as the abrasive (or grit). Heat generated by the water jet cutting process increased the temperature of the water basin to 35–40°C. The water basin was drained and refilled quarterly.

Legionella were isolated from one of the six wet floor scrubbers most recently in service. Scrubbers moved throughout the facility and sprayed clean water (and sometimes detergent) from a clean water tank onto the floor, used brushes to stir up the dirt, and

then used a water vacuum system to suck up the dirty water into a separate tank. The exhaust air from the vacuum system was discharged beneath and to the sides of the scrubbers. Aerosols could be created during this process.

Remediation and prevention

Upon receiving the initial sampling results, company management worked with contractors to drain, clean, and disinfect both water jet cutters and the floor scrubbers. Company management also added new

consumables (e.g., filters) and added biocide as per the biocide manufacturer's recommended disinfection dosage. Initially, management treated both water jet cutter basins with bromine microbicide sodium dichloro-s-triazinetriene (90%)/sodium bromide (7%) granules. However, testing of samples collected at least 48 hr after treatment revealed *Legionella* remained in the basins of both water jet cutters (Figure 1). Subsequently, management treated both water jet cutters with slow-dissolving tablets of 2,2-dibromo-3-nitropropionamide, or DBNPA (92–98%), a wide-spectrum biocide. After multiple cycles of cleaning and disinfection, two rounds of testing of bulk water samples from both water jet cutters collected at least 48 hr apart were found to have no *Legionella* detected, and the water jet cutters were returned to use in November 2022.

Similarly, initial remediation of floor scrubbers included draining and cleaning the equipment, replacing consumables (e.g., filters), and adding 2 gallons of chlorine bleach to tanks, which was allowed to sit for 8 hr before being drained. The tanks were then rinsed and filled with fresh water and biocide.

Company management developed and implemented a comprehensive water management program with input from consultants, equipment manufacturers, and the DHEC and CDC investigation team. The program included a written plan that details the preventative maintenance approaches being taken for the water jet cutters and floor scrubbers, which involves both mechanical and chemical preventative maintenance (Table 1).

As part of preventative maintenance, facility management also began using a continuous biocide feed of DBNPA (2,2-dibromo-3-nitropropionamide) (20%) in addition to the slow-dissolving tablets. The volume of biocide used in water jet cutters and floor scrubbers was determined by meeting a target concentration of 0.25–1.0 chlorine (Cl) parts per million (ppm). Monitoring was conducted daily to ensure this target was reached; biocide levels were adjusted as needed to meet the target.

Facility management continued to monitor the water jet cutters until they were decommissioned in December 2023, and as of August 2025, continued to monitor floor scrubbers in accordance with their water management plan.

Discussion

Investigation findings indicate that water jet cutters and floor scrubbers were the likely sources of exposure to *Legionella* in this workplace. Water jet cutters provided an environment conducive to *Legionella*

growth, and proliferation, and both types of equipment provided potential pathways for water aerosolization. Specifically, evidence suggests that the floor scrubbers may have spread the bacteria to locations distant from the water jet cutters. However, community outbreaks have shown that *Legionella* can be transported over long distances from the source (up to 10 km) (Nygård et al. 2008, Sala Ferré et al. 2009, Weiss et al. 2017). Therefore, it is possible that workers were exposed to *Legionella* from either the water jet cutters or the floor scrubbers.

A previous account described a case of Legionnaires' disease in a street cleaning worker who had used high-pressure hoses attached to trucks filled with ground or municipal drinking water; *Legionella* was isolated from the tanks of two street cleaning trucks the worker used (Valero et al. 2017). Previous investigations have noted a carpet-cleaning unit as a potential source of exposure during a hospital-based outbreak (Kioski 1997) and evaluated the generation and dispersion of droplets from cleaning equipment (Burfoot et al. 2003).

Consistent with the hierarchy of controls (NIOSH 2023), company management took action to eliminate *Legionella* from the equipment. Because water jet cutters have not previously been discussed as a reservoir for *Legionella*, company management worked with the water jet cutter manufacturer and consultants to identify cleaning, disinfection, and preventative maintenance protocols while maintaining the integrity of the equipment. Company management also introduced administrative controls, such as dedicating individual floor scrubbers to designated areas to prevent potential transport of *Legionella* throughout the facility.

The identification and sampling of potential reservoirs of *Legionella* in this facility helped validate the remediation plan and informed a comprehensive water management program (CDC 2021). The program included key elements necessary to reduce the likelihood of worker exposure to *Legionella* and other waterborne pathogens from building water systems. Program elements included a description of building water systems, the identification of areas where *Legionella* could grow and spread, the establishment of control measures and acceptable operating parameters, and a corrective action plan if *Legionella* were detected. No cases of legionellosis among workers have been reported to public health authorities as of August 2025.

Limitations

Limitations of the larger outbreak investigation have been discussed previously (Mohamed et al. 2025).

Table 1. Initial remediation and current preventive maintenance actions for cleaning and disinfecting water jet cutters and floor scrubbers.

Action	Frequency
Water Jet Cutters	
<i>Initial Precautions</i>	
Placed in idle mode	Upon identifying the hazard
Drained and cleaned	Upon positive sample results
<i>Current Mechanical Preventative Maintenance (PM)</i>	
Inspection	Weekly
Cleaning	Weekly
Overhaul maintenance	Quarterly
Deionization system filter change	As needed, based on monthly PM to check the system Andon light
Deionization system maintenance	As needed, based on monthly PM to check the system status light
<i>Current Chemical Preventative Maintenance</i>	
Biocide feed—DBNPA (2,2-dibromo-3-nitropropionamide) (20%)	Continuous
Water quality testing	Daily (free chlorine and pH)
Inspect feed pumps	Daily
Check chemical inventory	Daily
DBNPA (92–98%) tablets	Daily, as required to maintain free chlorine target level
DBNPA (92–98%) tablets disintegration check	Daily
Floor Scrubbers	
<i>Initial Precautions</i>	
Cleaned and drained	Upon positive sample results
Parts replaced if not able to be cleaned	Upon positive sample results
<i>Current Preventative Maintenance</i>	
Inspection	Daily
Cleaning	After each use
Overhaul maintenance	Quarterly
Disinfection	Monthly

Specific to the findings presented here, limitations common to sampling and laboratory testing for *Legionella* apply. In this evaluation, culture methods were relied on to inform decisions about remediation. *Legionella* can be challenging to culture (Whiley and Taylor 2016); therefore, it is possible that *Legionella* were present at levels below the limit of detection, leading to false negative results. Sampling from complicated devices such as water jet cutters and floor scrubbers can miss potential bacterial reservoirs. Chemicals or materials used in the normal operation of the equipment (e.g., grit, cleaning agents) can add to the complicated nature of the devices and affect sampling results. In addition, water quality testing parameters (e.g., temperature, free chlorine, and pH) were not collected at the time of each sampling event. Finally, sampling data from the water jet cutters and floor scrubbers were only available for a relatively short time following the investigation period. Although the company continued to conduct monitoring, additional sampling results are not available. In addition, here the team observed the effect of a small number of approaches for control of *Legionella*. Other options may exist that were not considered in this situation. Studies that track the success of various control measures in these sources over longer periods, while considering the occupational safety and health implications of interventions, may help address these limitations and further identify effective and safe control measures.

Conclusions

ASHRAE Standard 188 establishes minimum legionellosis risk management requirements for certain building water systems (ASHRAE 2021). Devices that release non-potable water aerosols in the building or on-site should have a water management program. While effective water management programs contain the same elements, decisions about where, how, and how frequently to monitor risk of *Legionella* growth and transmission should be made by the water management program team, who are most familiar with the equipment, facilities, and work processes. Such decisions should be based on the specific characteristics of the building water system or device(s) included, as well as the characteristics of the potentially exposed population.

The lessons learned from this outbreak and response highlight the importance of considering non-traditional sources of exposure to *Legionella* in the workplace and providing key steps to control and maintain these systems free of waterborne pathogens. These lessons will remain important to consider as new technologies emerge that could serve as atypical sources of *Legionella* exposure.

Recommendations

The development and implementation of a water management program with acceptable operating

parameters and control measures is key to reducing risks from exposures to *Legionella* in the workplace.

Disclosure statement

Authors include the company medical director and an environmental consultant hired by the company to perform *Legionella* sampling; authors declare no other competing interests.

Disclaimer

The findings and conclusions in this report are those of the authors and do not necessarily represent the official position of the National Institute for Occupational Safety and Health, Centers for Disease Control and Prevention. Mention of any company or product does not constitute endorsement by the National Institute for Occupational Safety and Health, Centers for Disease Control and Prevention.

Data availability statement

The data underlying this article are presented in the article.

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