

# UBIQUITOUSNESS OF *LEGIONELLA PNEUMOPHILA* IN THE WATER SUPPLY OF A HOSPITAL WITH ENDEMIC LEGIONNAIRES' DISEASE

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SINCE 1977 there have been numerous outbreaks of nosocomial Legionnaires' disease; however, in only one was a reservoir established for *Legionella pneumophila*. Dondero and his colleagues have suggested that the organisms were spread from a contaminated cooling tower adjacent to a hospital with 39 cases of Legionnaires' disease.<sup>1</sup> *L. pneumophila* has also been isolated from showerheads and mixing valves of hospitals in the United States and England.<sup>2,3</sup> The two largest sustained outbreaks of nosocomial Legionnaires' disease have been at the Wadsworth Veterans Administration Hospital in Los Angeles and here at the Pittsburgh Veterans Administration Medical Center.<sup>4,5</sup> Although a definitive epidemiologic link has not been established, the potable water supply of both these medical centers has been shown to be contaminated with *L. pneumophila*.<sup>2,6</sup>

The isolation of *L. pneumophila* from the potable water to which five of six patients with nosocomial Legionnaires' disease were directly exposed prompted an extensive, ongoing environmental survey for *L. pneumophila* within our hospital. Fortunately, the initial survey was performed just before an outbreak of 14 culture-confirmed cases of nosocomial Legionnaires' disease over a three-week period. In this report we demonstrate that *L. pneumophila* is more widely distributed within the hospital than previously realized and that the water-distribution system is the reservoir for the organism.

## METHODS

### Sites Associated with Legionnaires' Disease

Between November 1980 and March 1981, six nosocomial cases of Legionnaires' disease were diagnosed; all were due to *L. pneumophila*, serogroup 1. Environmental sampling of faucet and shower sites in the rooms and ward of these patients was performed immediately after diagnosis to determine whether the patients had been exposed to water contaminated with *L. pneumophila*.

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### Survey of Entire Hospital

Specimens for culture were taken from showers and faucets at each of 13 nursing units and five nonpatient areas (offices or laboratories). A total of 15 showers and 35 faucets were included in this survey (Fig. 1).

### Monthly Surveillance Sites

Five showers and five faucets were selected as surveillance sites for monthly culture. These sites were selected to provide a representative mix of patient and nonpatient areas as well as east and west hospital wings. The purpose of this periodic surveillance was to monitor the extent, duration, and degree of *L. pneumophila* contamination in our hospital. We anticipated that we might also be able to correlate environmental surveillance data with the occurrence of nosocomial outbreaks of Legionnaires' disease.

### Specimen Collection and Preparation

Samples were obtained by swabbing the water outlet with a Dacron swab (dislodging the sediment within the fixture) and then collecting 100 to 200-ml aliquots of water. A 0.1-ml aliquot of each sample was inoculated onto selective differential medium, which is a modification of previously described mediums used for isolation of *L. pneumophila*.<sup>7-12</sup>

### Screening Suspected Isolates

Colonies morphologically similar to those of *L. pneumophila* were subcultured to buffered charcoal-yeast extract and five per cent sheep-blood agar plates. If growth did not occur on blood agar after two days of incubation, the isolate was tested by slide agglutination against antiserum for serogroups 1 and 5, as previously described<sup>13</sup>; positive results were considered presumptive identification of *L. pneumophila*. All suspected isolates were also confirmed by direct immunofluorescence testing with antisera against six serogroups of *L. pneumophila*.<sup>14,15</sup>

## RESULTS

### Sites Associated with Legionnaires' Disease

*L. pneumophila* (serogroup 1) was isolated from the showers or faucets used by five of six patients with Legionnaires' disease (serogroup 1) within one week of the onset of their nosocomial pneumonia.

### Survey of Entire Hospital

Nine of 15 showers and 24 of 35 faucets yielded the organism. Figure 1 shows that the organism was virtually ubiquitous throughout the hospital's water system.

Of the 51 *L. pneumophila* organisms isolated from environmental specimens, 46 were in serogroup 1 and five were in serogroup 5. Organisms from serogroups 2, 3, 4, and 6 were not isolated. All suspected isolates that were positive according to slide agglutination testing against either serogroup 1 or 5 were also positive against either serogroup 1 or 5 when tested by direct immunofluorescence.

### Monthly Surveillance Sites

Of the 10 sites from which specimens were obtained for culture, all were positive for *L. pneumophila* in the April sampling, which fortuitously preceded an outbreak of 14 cases of culture-confirmed Legionnaires' disease over a three-week period. The concentration of *L. pneumophila* at these sites ranged from 5 to

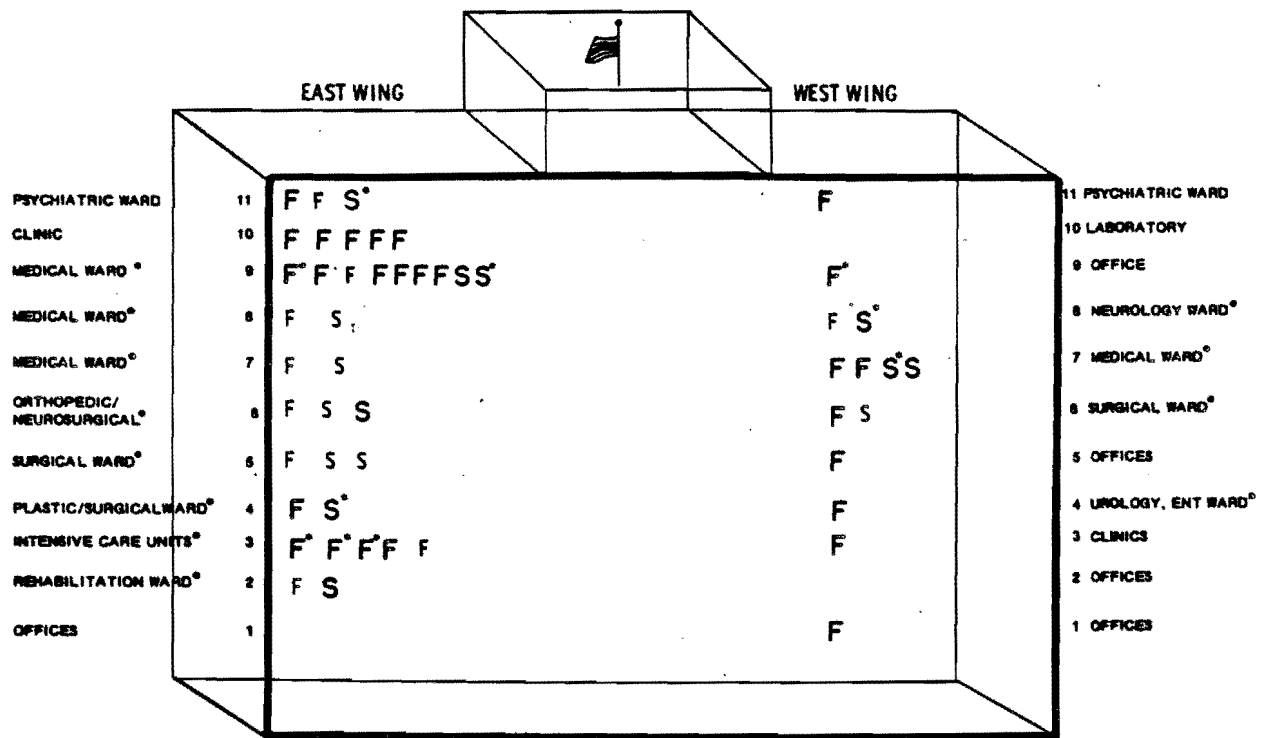


Figure 1. Locations of Water Sites Sampled for *L. pneumophila*.

F denotes faucet and S shower. Boldface type indicates that the site was positive for *L. pneumophila*. Asterisks refer to sites surveyed monthly, and dots indicate sites where Legionnaires' disease occurred.

200 colony-forming units per plate. In the monthly cultures of April, May, and June, six of the 10 sites yielded *L. pneumophila* (Table 1). The concentration of *L. pneumophila* in these months ranged from 20 to 300 colony-forming units per plate.

#### DISCUSSION

Since March 1979, we have encountered more than 50 cases of nosocomial Legionnaires' disease at our hospital. Our environmental survey for *L. pneumophila* was prompted by the ready isolation of the organism from the water fixtures in the rooms of five of six patients with nosocomial Legionnaires' disease. The environmental survey of the entire hospital produced the startling finding that the organism was ubiquitous in the water-distribution system of our hospital. We detected no clustering or localization of the organism in particular wards, in either the east or west wing, or in different water-riser systems. We found the organism in showers, faucets, a bedpan flusher,<sup>4</sup> and hot-water storage tanks.<sup>12</sup> As Figure 1 shows, if matched controls had been selected for the six cases of nosocomial Legionnaires' disease, the water sites of the controls would, in all likelihood, also have been positive for *L. pneumophila*. Since the organism is so widespread, it is clear that mere exposure to contaminated water is an insufficient condition for the occurrence of Legionnaires' disease. In every patient ward

except the psychiatric ward, where underlying organic disease would be expected to be less likely or less severe than in medical or surgical wards, a case of nosocomial Legionnaires' disease was observed. Host susceptibility is undoubtedly a critical factor for the development of infection. *L. pneumophila* was not isolated on three patient wards where Legionnaires' disease had occurred; however, the organism had been isolated from two of these wards during previous spot surveys.

Table 1. Presence or Absence of *L. pneumophila* in a Monthly Survey of 10 Water Sites in the Hospital.

| SITE *       | TEST RESULT |     |      |      |
|--------------|-------------|-----|------|------|
|              | APRIL †     | MAY | JUNE | JULY |
| SICU, faucet | +           | +   | -    | +    |
| SICU, faucet | +           | +   | -    | +    |
| MICU, faucet | +           | +   | -    | +    |
| 4E, shower   | +           | +   | -    | +    |
| 7W, shower   | +           | -   | -    | -    |
| 8W, shower   | +           | -   | -    | -    |
| 9E, shower   | +           | -   | -    | -    |
| 9E, faucet   | +           | +   | -    | +    |
| 9W, faucet   | +           | +   | +    | +    |
| 11E, shower  | +           | -   | -    | -    |

\*SICU denotes surgical intensive-care unit, and MICU medical intensive-care unit. E and W refer to the east and west wings of the hospital.

†Nosocomial outbreak of Legionnaires' disease occurred in April.

We and others have shown that hospital patients who acquire Legionnaires' disease have previously been exposed to potable water containing *L. pneumophila*.<sup>2-4</sup> In April 1981, we initiated a monthly survey of 10 selected water sites; surprisingly, all 10 sites yielded *L. pneumophila* (Table 1). During the next three weeks, a nosocomial outbreak of 14 cases of culture-proved Legionnaires' disease occurred. During the months after the outbreak passed, the number of sites yielding *L. pneumophila* also decreased (Table 1). Although the finding that all sampling sites were positive for *L. pneumophila* just before a nosocomial outbreak of Legionnaires' disease may simply have represented coincidence, this finding is still consistent with the hypothesis that the water supply is the reservoir for Legionnaires' disease in our hospital. Further studies are under way to determine the mode of transmission. The results of this monthly survey also show that *L. pneumophila* persists for long periods within the water system (Table 1); the organism has been intermittently present in some sites in our hospital for over two years.<sup>2</sup> Indeed, it may even be regarded as part of the bacterial flora within the water system of the hospital. Efforts are being made to eradicate the organism from the water system of the hospital.

In summary, *L. pneumophila* can be readily isolated from the environment of patients with Legionnaires' disease. The serogroup of the environmental isolates is the same as that of the pathogenic isolates (serogroup 1). *L. pneumophila* is ubiquitous within the water system of a hospital with endemic Legionnaires' disease, and the frequency of hospital-acquired Legionnaires' pneumonias can be correlated with the extent of contamination of the water system by the organism. We have also determined that *L. pneumophila* is present in highest concentrations in the sediment of various water sites, including faucets, showers, and hot-water tanks, and that *L. pneumophila* has a predisposition for the thermal environment of the hot-water distribution system.<sup>12</sup>

On the basis of our study, we formulate the following scenario: *L. pneumophila* is introduced into the potable water supply (perhaps by seeding with low numbers of organisms from the supplying reservoir). The storage tanks and water system serve as a concentration mechanism whereby the organism proliferates in the hot-water system. It is disseminated to patient areas through showers, faucets, and other water outlets, and it then resides in the sediment. Events that mechanically dislodge the sediment (including pressure changes) may create a massive increase of *L. pneumophila* within the potable water, thereby setting the stage for a nosocomial outbreak of

Legionnaires' disease. The mode of transmission remains to be defined. In institutional outbreaks of Legionnaires' disease, epidemiologic investigation has usually focused on nearby cooling towers and evaporative condensers.<sup>16-18</sup> This study now indicates that attention should be directed to the water-distribution system within the institution.

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## REFERENCES

1. Dondero TJ Jr, Rendtorff RC, Mallison GF, et al. An outbreak of Legionnaires' disease associated with a contaminated air-conditioning cooling tower. *N Engl J Med.* 1980; 302:365-70.
2. Cordes LG, Wiesenthal AM, Gorman GW, et al. Isolation of *Legionella pneumophila* from hospital shower heads. *Ann Intern Med.* 1981; 94:195-7.
3. Tobin JO'H, Beare J, Dunnill M, et al. Legionnaires' disease in a transplant unit: isolation of the causative agent from shower baths. *Lancet.* 1980; 2:118-21.
4. Brown A, Yu VL, Elder EM, Magnussen MH, Kroboth F. Nosocomial outbreak of Legionnaires' disease at the Pittsburgh Veterans Administration Medical Center. *Trans Am Assoc Physicians.* 1980; 93:52-9.
5. Haley CE, Cohen ML, Halter J, Meyer RD. Nosocomial Legionnaires' disease: a continuing common-source epidemic at Wadsworth Medical Center. *Ann Intern Med.* 1979; 90:583-6.
6. Shands KN, Ho JL, Meyer RD, Fraser DW. Potable water: possible role in epidemic Legionnaires' disease. Presented at the 20th Interscience Conference on Antimicrobial Agents and Chemotherapy. Abstract 501, September 22-24, 1980.
7. Edelstein PH, Finegold SM. Use of a semiselective medium to culture *Legionella pneumophila* from contaminated lung specimens. *J Clin Microbiol.* 1979; 10:141-6.
8. Feeley JC, Gibson RJ, Gorman GW, et al. Charcoal-yeast extract agar: primary isolation medium for *Legionella pneumophila*. *J Clin Microbiol.* 1979; 10:437-41.
9. Pasculle AW, Feeley JC, Gibson RJ, et al. Pittsburgh pneumonia agent: direct isolation from human lung tissue. *J Infect Dis.* 1980; 141:727-32.
10. Wadowsky RM, Yee RB. A glycine-containing selective medium for isolation of *Legionellaceae* from environmental specimens. *Appl Environ Microbiol.* 1981; 42:768-72.
11. Vickers RM, Brown A, Garrity GM. Dye-containing buffered charcoal-yeast extract medium for differentiation of members of the family *Legionellaceae*. *J Clin Microbiol.* 1981; 13:380-2.
12. Stout J, Yu VL, Vickers RM, Zuravleff J, Brown A, Best M. Environmental surveillance for *Legionella pneumophila* just prior to a nosocomial outbreak of Legionnaires' disease. Presented at the 21st Interscience Conference on Antimicrobial Agents and Chemotherapy. Chicago, Abstract 293, November 4-6, 1981.
13. Wilkinson HW, Fikes BJ. Slide agglutination test for serogrouping *Legionella pneumophila* and atypical *Legionella*-like organisms. *J Clin Microbiol.* 1980; 11:99-101.
14. Cherry WB, Pittman B, Harris PP, et al. Detection of Legionnaires' disease bacteria by direct immunofluorescent staining. *J Clin Microbiol.* 1978; 8:329-38.
15. Fliermans CB, Cherry WB, Orrison LH, Thacker L. Isolation of *Legionella pneumophila* from nonepidemic-related aquatic habitats. *Appl Environ Microbiol.* 1979; 37:1239-42.
16. Miller RP. Cooling towers and evaporative condensers. *Ann Intern Med.* 1979; 90:667-70.
17. Tobin JO'H, Swann RA, Bartlett CLR. Isolation of *Legionella pneumophila* from water systems: methods and preliminary results. *Br Med J.* 1981; 282:515-7.
18. Cordes LG, Fraser DW, Skaliy P, et al. Legionnaires' disease outbreak at an Atlanta, Georgia country club: evidence for spread from an evaporative condenser. *Am J Epidemiol.* 1980; 111:425-31.