

# A proactive approach to prevention of health care-acquired Legionnaires' disease: The Allegheny County (Pittsburgh) experience

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**Background:** The Allegheny County Health Department (ACHD) in Pennsylvania distributed the first guidelines for prevention and control of health care-acquired Legionnaires' disease (LD) by 1995. The proactive approach advocated in the guidelines differed notably from that of the Centers for Disease Control and Prevention (CDC) by recommending routine environmental testing of the hospital water distribution system even when cases of health care-acquired Legionnaires' disease had never been identified.

**Objectives:** Our purpose was to (1) evaluate the impact of the ACHD guidelines on the *Legionella* diagnostic and preventive practices of health care facilities in Allegheny and surrounding counties and (2) compare the incidence of health care-acquired LD before and after issuance of the ACHD guidelines.

**Methods:** CDC case reports of LD from 1991 to 2001 were tabulated and compiled by the ACHD Infectious Disease Unit and the Association for Professionals in Infection Control and Epidemiology, Inc, Three Rivers Chapter. A survey was distributed to 110 hospitals and long-term care facilities in the region. The results were analyzed as occurring either in the preguideline period (1991-1994) or postguideline period (1995-2001).

**Results:** A significant decrease in the number of health care-acquired cases was demonstrated between the preguideline (33%) and postguideline (9%) periods ( $P = .0001$ ). In contrast, community-acquired cases increased from 67% pre guideline to 91% post guideline. A total of 71% of the facilities were colonized with *Legionella*. Disinfection of the water distribution system was initiated by 44% of facilities. Use of urinary antigen testing significantly increased from 40% pre guideline to 79% post guideline ( $P = .0001$ ).

**Conclusions:** Health care-acquired LD declined significantly after the issuance of guidelines for prevention and control of health care-acquired LD. The decline was associated with health care facilities performing routine environmental monitoring of their water distribution systems followed by the initiation of disinfection methods if indicated. Two unanticipated benefits were (1) cases of LD in the community and long-term care facilities were uncovered as a result of increased availability of *Legionella* tests and (2) litigation and unfavorable publicity involving ACHD hospitals ceased. (*Am J Infect Control* 2005;33:360-7.)

*"If you don't look for it, you won't find it. If you don't find it, you don't think you have a problem. If you don't think you have a problem, you don't do anything about it."*

Bruce Dixon MD, Director  
Allegheny County Health Department  
CNN & Time television program, November 1999

Since the early 1980s, it has been known that health care-acquired Legionnaires' disease occurs from exposure to *Legionella* in hospital water distribution systems.<sup>1-3</sup> As early as 1983, Pittsburgh investigators began advocating a proactive approach to prevention of health care-acquired Legionnaires' disease through active case detection and disinfection of the hospital water system.<sup>4,5</sup> This approach differed notably from that of the Centers for Disease Control and Prevention (CDC) by recommending routine environmental testing of the hospital water distribution system even if cases of health care-acquired Legionnaires' disease had never been discovered. In time, others would adopt this approach. Seven prospective studies have been performed in 52 hospitals in which cases of health care-acquired Legionnaires' disease had never been diagnosed. Environmental cultures for *Legionella* were performed on the water distribution systems of each of

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these hospitals and *Legionella* laboratory testing was also performed for patients with health care-acquired pneumonia. In all 7 studies, health care-acquired Legionnaires' disease was ultimately discovered in hospitals colonized with *Legionella*; likewise, no cases were discovered in those hospitals in which *Legionella* was absent from the water distribution systems.<sup>6-8</sup> Hospitals found to have zero or a low proportion of distal water sites yielding *Legionella* could devote their laboratory resources elsewhere because health care-acquired Legionnaires' disease does not occur in hospitals in which the organism has not colonized the water distribution system. On the other hand, hospitals found to have *Legionella* in the water supply could intensify clinical surveillance for occult cases of Legionnaires' disease by recommending application of *Legionella* diagnostic tests (respiratory tract culture on selective media, urinary antigen). When this approach has been implemented in hospitals that had never identified health care-acquired cases of Legionnaires' disease, cases have invariably been detected.<sup>5,9-11</sup>

During 1991 and 1992, 93 cases of Legionnaires' disease were reported in Allegheny County. Thirty-three percent (29/93) of these cases were health care acquired. In response to reported outbreaks of health care-acquired cases, a task force was formed to develop a guideline document for hospitals in Allegheny County. The task force included representatives from the Allegheny County Health Department (ACHD) and local medical, public health, and drinking water regulatory agencies. The task force developed formal recommendations for health care institutions, which directed hospitals to determine whether *Legionella* was in the water supply and implement case detection and remediation, if necessary. In 1993, "Approaches to Prevention and Control of *Legionella* Infection in Allegheny County Health Care Facilities" was published and subsequently revised in 1997 (available on [www.legionella.org](http://www.legionella.org)). By 1995, the Allegheny County *Legionella* prevention guidelines were fully distributed throughout Allegheny and surrounding county health care facilities.

In a 1999 CNN and Time broadcast on Legionnaires' disease, Dr Bruce Dixon, director of ACHD, expressed his impression that health care-acquired Legionnaires' disease was on the decline in Allegheny County as a result of this proactive approach. The ACHD and the Association for Professionals in Infection Control and Epidemiology, Inc (APIC), Three Rivers Chapter, conducted a collaborative study to determine whether this subjective impression was factually accurate.

## METHODS

The guidelines were distributed to infection control practitioners throughout Allegheny and surrounding

counties by the APIC Three Rivers Chapter by 1994. For the purposes of this study, the preguideline period was defined as 1991 to 1994 and the postguideline period was defined as 1995 to 2001.

## Survey

In January 2000, the Allegheny County Health Department distributed a survey to the membership of the APIC, Three Rivers Chapter, which included 110 infection control practitioners at hospitals and long-term care facilities in Allegheny and surrounding counties. This survey contained questions pertaining to facility size, type, and university affiliation as well as questions pertaining to *Legionella* prevalence after 1993. *Legionella* information included incidence of health care-acquired Legionnaires' disease, diagnostic methods used, environmental monitoring, and water disinfection methods.

## Case report review

The CDC/ACHD case report forms for Legionnaires' disease from 1991 to 2001 were reviewed and tabulated. Case report data were entered into a database without a link to health care facility or individual patient. The CDC reporting forms included demographic and diagnostic data, causative agents, health care-acquired versus community-acquired, and patient outcome. A confirmed case of Legionnaires' disease was defined as pneumonia by chest radiography and at least one of the following: (1) culture isolation of *Legionella* from a respiratory specimen or lung tissue, (2) positive urinary antigen, (3) detection of *Legionella* in respiratory specimen by direct fluorescent antibody (DFA) test, or (4) demonstration of a 4-fold rise in antibody titer against *Legionella pneumophila* (acute versus convalescent phase serum to  $\geq 128$ ).<sup>12</sup> Legionnaires' disease that occurred in a patient who was continuously hospitalized >10 days before onset of symptoms met the case definition for health care-acquired Legionnaires' disease.

## Statistical analysis

Statistical comparisons were done with use of Prophet Statistics (BBN Systems/AB Tech Corp, version 6.0). Categorical data were compared with the chi-square or Fisher exact test. Continuous variables were compared with the *t* test or Mann-Whitney test.

## RESULTS

### Survey

Forty-four percent (48/110) of the health care facilities responded to the survey. Fifty-six percent (27/48)

**Table 1.** Survey results for 48 health care institutions within Allegheny and surrounding counties. Health care–acquired cases of Legionnaires' disease declined as a result of environment surveillance and disinfection predominantly in acute care facilities

Institution type	Participating health care facilities	Percentage (No./total)			Performed in-house diagnostic test		No. with cases of Health care–acquired Legionnaires' disease
		Performed environment surveillance (culturing of hot water tanks and distal sites)	Colonized with <i>Legionella</i>	Disinfected water system	Urinary antigen	Culture	
Total	48	65% (31/48)	71% (22/31)	44% (21/48)	42% (20/48)	44% (21/48)	23% (11/48)
Acute care	29	69% (20/29)	70% (14/20)	48% (14/29)	52% (15/29)	55% (16/29)	28% (8/29)
Transplant	6	83% (5/6)	80% (4/5)	83% (5/6)	83% (5/6)	83% (5/6)	50% (3/6)
No transplant	23	65% (15/23)	67% (10/15)	39% (9/23)	44% (10/23)	48% (11/23)	22% (5/23)
Long-term care	15	47% (7/15)	57% (4/7)	27% (4/15)	13% (2/15)	13% (2/15)	20% (3/15)
Other*	4	100% (4/4)	100% (4/4)	75% (3/4)	75% (3/4)	75% (3/4)	25% (1/4)

\*Three facilities were a combination of acute care/long-term care, and one was a mental health facility.

of responding facilities were within Allegheny County and 44% (21/48) were in surrounding counties. Of these, 35% (17/48) were university affiliated, 60% (29/48) were acute care, 31% (15/48) were long-term care, 6% (3/48) were combined acute and long-term care, and 2% (1/48) were mental health facilities (Table 1). The mean number of beds was 255. Sixty-nine percent (33/48) of these facilities had critical care beds and 13% (6/48) had transplant programs (solid organ and/or bone marrow transplant). Sixty percent (29/48) of these facilities had not identified a case of health care–acquired Legionnaires' disease between 1993 and 2000; 23% (11/48) had diagnosed at least 1 case. Fifty percent (3/6) of transplant facilities identified at least 1 case of health care–acquired Legionnaires' disease between 1993 and 2000.

**Diagnostic testing.** An assessment of diagnostic methods demonstrated that in-house diagnostic testing (Table 1) versus reference laboratory testing varied in relation to facility size. Overall, 44% (21/48) of health care facilities had in-house testing available, with 83% (5/6) of facilities with greater than 400 beds having in-house capability. Long-term care facilities were less likely to have in-house testing available, 13% (2/15) versus 65% (18/29) in acute care ( $P = .001$ ).

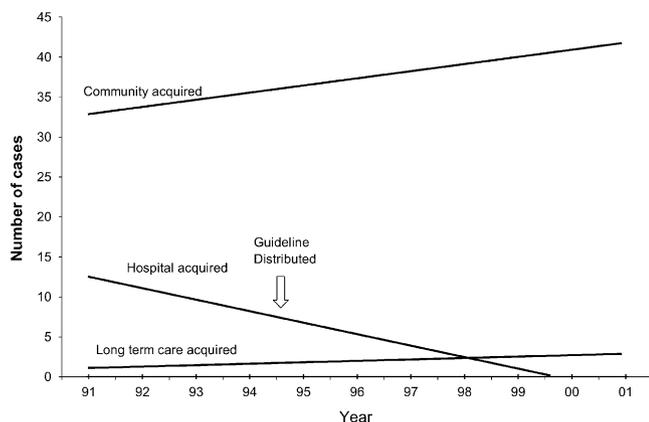
**Environmental surveillance.** Environmental sampling of the water distribution system was done by 65% (31/48) of the facilities. Fifty-eight percent (18/31) of these facilities initiated environmental sampling before identifying a case of health care–acquired Legionnaires' disease. Within Allegheny County, 89% (24/27) of health care facilities performed environmental surveillance compared with 33% (7/21) of health care facilities outside Allegheny County ( $P = .0001$ ). Seventy-one percent (22/31) of the sampled water systems were colonized with *Legionella*, and 75% (15/20) identified *L pneumophila* serogroup 1 in

their water systems. Two hospitals did not identify the serogroup of the colonizing strain. Facilities that performed environmental cultures were significantly more likely to have instituted in-house diagnostic testing for *Legionella*, 71% (22/31) versus 12% (2/17) ( $P = .0001$ ). The frequency of water sampling ranged from monthly to annually. The frequency was decided by each individual institution on the basis of the type of disinfection system used, the risk of the patient population, and the level of *Legionella* colonization.

**Disinfection method.** By 2000, 44% (21/48) of the surveyed health care facilities had disinfected their water distribution systems. Eighty-five percent (17/20) of those with *Legionella* isolated from the water distribution system initiated disinfections. Four methods of disinfection were used: 35% (17/48) used the super-heat and flush method (hot water temperature  $>150^{\circ}\text{F}$ ), 29% (14/48) used a copper-silver ionization system, and 4% (2/48) used continuous hyperchlorination. Twelve health care facilities used more than one disinfection method.

### Case report review

Four hundred eighty-seven case reports were reviewed at the ACHD. Of these, 88% (428/487) met the case definition for either health care–acquired (76) or community-acquired (352) Legionnaires' disease. The mean age was 65 years (range 15-95 years) with 59% (45/76) of patients being male. The underlying risk factors identified among health care–acquired cases were smoker 42% (32/76), steroids 36% (27/76), cancer 26% (20/76), diabetes 17% (13/76), transplant 11% (8/76), and dialysis 8% (6/76). In 22% (17/76) of health care–acquired cases, no underlying risk factors were identified on the case report forms. During the preguideline period (1991-1994), 33% (51/156) of cases were

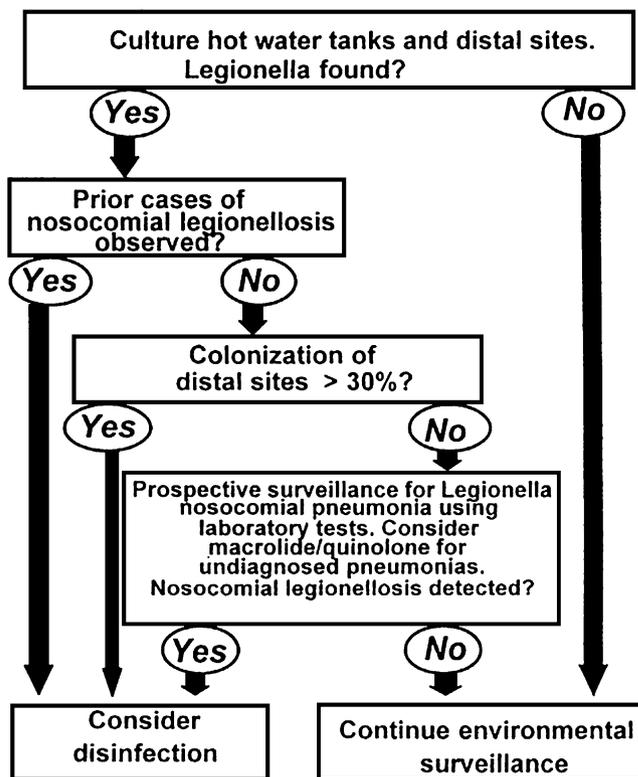


**Fig 1.** There was a significant reduction in the number of health care–acquired cases of Legionnaires’ disease in the postguideline period, whereas there was an increase in the number of cases diagnosed in long-term care facilities and in the community.

health care acquired compared with 9% (25/272) during the postguideline period (1995-2001) ( $P = .0001$ ) (Fig 1). However, the percentage of health care–acquired Legionnaires’ disease cases diagnosed in long-term care facilities increased from 4% (2/49) in the preguideline period to 60% (15/25) ( $P = .0001$ ) in the postguideline period. Also, the proportion of Legionnaires’ disease cases that were community-acquired increased from 67% (105/156) in the preguideline period to 91% (247/272) in the postguideline period.

The use of laboratory methods for *Legionella* diagnosis changed from the preguideline versus postguideline period. During the preguideline period, culture was the predominant diagnostic test in 56% (88/156) of the cases compared with 20% (54/272) of cases in the postguideline period. During the preguideline period, urinary antigen was the basis for diagnosing 40% (63/156) of cases compared with 79% (214/272) of cases during the postguideline period ( $P = .0001$ ). On the other hand, *Legionella* serology and DFA testing decreased in the postguideline period: 21% (33/156) to 8% (22/272) and 31% (48/156) to 9% (24/272), respectively.

Eighty-two percent (127/154) of culture-confirmed cases were due to *L pneumophila*, with serogroup 1 being the most prevalent (76/96 typed cases). Other *Legionella* species/serogroups identified were *L pneumophila* serogroup 5 (6), *Legionella micdadei* (4), *L pneumophila* serogroup 6 (3), *Legionella bozemanii* (3), *L pneumophila* serogroup 3 (2), *L pneumophila* serogroup 4 (1), and unidentified *Legionella* (1). On the basis of urinary antigen testing, 93% (397/428) of cases were caused by *L pneumophila* serogroup 1.



**Fig 2.** The ACHD approach to prevention of health care–acquired Legionnaires’ disease.

Mortality for health care–acquired cases was not significantly different in the preguideline period (38%, 15/39) compared with the postguideline period (53%, 10/19) ( $P = .31$ ).

Ninety-three percent (300/322) of the community-acquired cases were diagnosed in hospitals that had in-house testing for Legionnaires’ disease (Fig 2).

**DISCUSSION**

Despite years of diagnosing and treating health care–acquired cases of Legionnaires’ disease throughout the United States, a national consensus opinion for prevention of this disease still does not exist. Two approaches to prevention have been proposed, one by Pittsburgh investigators and the ACHD and one by the CDC (Table 2).

A fundamental difference between these two approaches is the recommendation to perform environmental surveillance for *Legionella* and whether knowledge of the presence of *Legionella* in the hospital water supply can enhance detection and prevention of the disease.

Where the CDC does not recommend routine environmental surveillance for *Legionella* (pneumonia prevention guidelines), the ACHD guidelines do.<sup>13,14</sup> Instead, the CDC advocates increased clinical

**Table 2.** Comparison of CDC pneumonia prevention guidelines with ACHD *Legionella* prevention guidelines<sup>13,14</sup>

	CDC	ACHD
Initial approach to prevention	Educate and maintain high index of suspicion for the diagnosis; perform diagnostic tests on suspected cases, especially high-risk patients	Initiate environmental surveillance for <i>Legionella</i> even if cases of health care–acquired Legionnaires' disease have not been discovered previously. If positive, institute diagnostic testing in house and consider disinfection (see below).
Environmental sampling of water distribution system	Perform after identification of 1 or 2 cases of health care–acquired LD Perform to evaluate the potential for transmission in facilities with patients at exceedingly high risk of developing LD (ie. HSCT recipients)	Frequency of environmental monitoring should be yearly and more often if transplants (HSCT or solid organ) are performed.
Recommended environmental sampling sites	Collection of water samples from environmental sources implicated by epidemiologic investigation and from other potential sources of aerosolized water.	All hot water tanks plus distal sites <500 bed health care facility → a minimum of 10 distal sites >500 bed health care facility → 2 distal sites per 100 beds
When to consider disinfection	Any detectable <i>Legionella</i> species	If >30% of distal sites positive or If <30% positive but prior cases of nosocomial LD observed
Goals of disinfection	Maintain undetectable levels of <i>Legionella</i> species	<30% of distal sites positive for <i>Legionella</i>
Recommended disinfection methods	Thermal eradication Chlorination	Copper-silver ionization Thermal eradication Chlorination Instantaneous steam heating systems Ultraviolet irradiation

LD, Legionnaire's disease.

surveillance by the routine use of *Legionella* diagnostic testing for all cases of health care–acquired pneumonia. Environmental surveillance is only recommended after 1 or 2 definitive cases of health care–acquired Legionnaires' disease have been identified. The CDC makes one exception for units housing hematopoietic stem cell transplant (HSCT) or solid organ transplant recipients. In the *2003 Guidelines for Environmental Infection Control in Health-care Facilities*, the CDC states that periodic culturing for Legionellae in potable water supplies from these units can be performed as part of a comprehensive strategy to prevent Legionnaires' disease.<sup>15</sup> However, the majority of health care–acquired Legionnaires' disease does not occur in this group of patients.<sup>16</sup> We have argued that this approach is not an adequate preventive approach and have preferred a more proactive approach to assess the risk for health care–acquired Legionnaires' disease.

The ACHD guidelines emphasize prevention by recommending routine environmental surveillance for *Legionella* in all acute care hospitals even in the absence of identified cases. All hospitals are to perform an environmental survey yearly, more often if transplants are performed. The environmental sampling should consist of all hot water tanks and a defined number of distal sites (faucets or showerheads).<sup>15</sup> This is recommended because the absence of cases may merely reflect underuse of diagnostic tests that are necessary to document cases. In fact, numerous studies have documented that the identification of a single

health care–acquired case has led to the retrospective diagnosis of prior cases that were missed.<sup>17-19</sup> Knowledge of the presence of *Legionella* in the potable water system can heighten the index of suspicion in health care providers treating patients with health care–acquired pneumonia and prompt greater use of *Legionella* diagnostic testing.

In this report, we provide the first evidence-based data that the ACHD approach to prevention has resulted in a decrease in health care–acquired Legionnaires' disease in the Western Pennsylvania region. The majority (58%) of health care facilities in the western Pennsylvania region performed environmental surveillance for *Legionella* (Table 1). Within Allegheny County, 89% (24/27) of health care facilities performed environmental surveillance compared with 33% (7/21) of health care facilities outside of Allegheny County ( $P = .0001$ ). Fifty percent of transplant centers and 28% of all acute care facilities identified cases of health care–acquired Legionnaires' disease. Most important, a significant reduction in health care–acquired Legionnaires' disease was observed in the period after the ACHD guidelines were distributed. In the preguideline period (1991-1994), the percentage of health care–acquired cases was 33% compared with 9% in the postguideline period (1995-2001) ( $P < .0001$ ).

The reduction in health care–acquired Legionnaires' disease was likely due to the fact that 48% of the acute care hospitals (83% of transplant centers) disinfected the hospital water distribution system

(Table 1). These institutions effectively eliminated the source of infection for their patients. Thermal disinfection (superheat and flush) and copper-silver ionization were the most commonly used disinfection methods. Although thermal disinfection has been shown to be effective, it is a short-term solution because *Legionella* will recolonize the system in weeks to months.<sup>20</sup> Copper-silver ionization has been shown to be an effective method for controlling *Legionella* in hospital water systems and for reducing health care-acquired Legionnaires' disease.<sup>21</sup> Newer disinfection approaches, such as chlorine dioxide and the use of monochloramine, are under evaluation.<sup>22,23</sup>

The ACHD guidelines recommend that environmental surveillance be performed at least annually and more often in a transplant center. The guideline suggests that for a 500-bed hospital the survey include 10 distal outlets plus the hot water tanks. A hospital should consider disinfection of the hospital water system if one of two conditions are met: (1) *Legionella* has been found in the water distribution system and prior cases of health care-acquired legionellosis have been observed or (2) *Legionella* has been found in the water distribution system and >30% of distal sites are positive for *Legionella*. The level of *Legionella* was set at 30% on the basis of previous studies, which have demonstrated a correlation between the extent of colonization (percent positivity) and the risk of legionellosis.<sup>4,24,25</sup> In setting this cut point, we acknowledge that it is unrealistic to expect that a complex water distribution system could be entirely free of a naturally occurring bacterium such as *Legionella*, even with continuous disinfection. We and other researchers have documented that reducing *Legionella* to a low level (<30% positivity) is sufficient to minimize the risk of endemic legionellosis.<sup>21</sup>

It should be noted that the results of environmental monitoring can be affected by several factors, such as the type of sample collected (swab and water), the methods used for sample processing (acid pretreatment and filtration), and the media used for culture isolation.<sup>26</sup> Therefore, it is recommended that samples be processed in a laboratory that is experienced in *Legionella* isolation methods. The majority of the health care facilities that performed *Legionella* environmental surveillance during the study period sent samples to the Special Pathogens Laboratory of the VA Medical Center, Pittsburgh, Pa.

One reason to emphasize prevention of health care-acquired Legionnaires' disease is that the mortality is about 40%, a high mortality for a disease that is preventable. A CDC study found a mortality rate of 40% for health care-acquired cases versus 20% in community-acquired cases.<sup>27</sup> The ACHD findings on mortality were similar. Overall, the mortality was 43% for health

care-acquired cases and 15% for community-acquired cases. We expected that with improved antimicrobial therapy for Legionnaires' disease and improved rapid diagnosis, the outcome would improve as well. Although overall mortality decreased from the preguideline to the postguideline period (25% vs 16%,  $P = .06$ ), mortality related to health care-acquired Legionnaires' disease did not (38% vs 53%,  $P = .31$ ).

As knowledge of this disease and the use of diagnostic testing have increased, cases of Legionnaires' disease are being diagnosed in patient populations and in health care settings not previously associated with an increased risk of Legionnaires' disease. These include immunocompromised children in pediatric hospitals colonized with *Legionella*, and elderly patients residing in long-term care facilities and rehabilitation centers colonized by *Legionella*.<sup>16</sup> Although our data show that the percentage of health care-acquired Legionnaires' disease decreased in this region, the number of Legionnaires' disease cases diagnosed in the community and long-term care facilities increased during the postguideline period (Fig 1). Specifically, community-acquired cases increased from 67% (105/156) cases in the preguideline period to 91% (247/272) in the postguideline period ( $P = .0001$ ). This increase in cases seen in the community and long-term care facilities was likely a result of the increased index of suspicion for Legionnaires' disease by clinicians and more frequent application of *Legionella* laboratory tests. This is supported by the finding that cases of community-acquired Legionnaires' disease that were detected tended to be in those hospitals complying with the guidelines by having in-house testing available for Legionnaires' disease.

As long-term care facilities identified their water distribution systems as a potential source of exposure, cases of Legionnaires' disease were diagnosed. During the preguideline period, only 4% (2/49) of health care-acquired cases were acquired in long-term care facilities compared with 65% (17/44) during the postguideline period ( $P = .0001$ ).

Changes in the patterns of *Legionella* infection also include changes in the methods used to make this diagnosis. A review of Legionnaires' disease cases reported to the CDC from 1980 to 1998 documented a significant decrease in diagnosis by culture, direct fluorescent antibody, and serologic testing, whereas diagnosis by urinary antigen testing increased from 0% to 69%.<sup>27</sup> We documented a similar trend in Allegheny County. Urinary antigen testing was used to diagnose LD in only 40% of cases during the preguideline period but became the predominant method of diagnosis in the postguideline period, accounting for 79% of the diagnoses ( $P = .001$ ).

The advantage of urinary antigen testing is that results can be obtained within 3 hours. The limitation of

this test is that it is specific only for the diagnosis of *L pneumophila* serogroup 1 infection. In this study, 93% of the cases were attributed to *L pneumophila* serogroup 1. Taking into account that 90% of community-acquired cases of Legionnaires' disease are due to this serogroup, this test has notable advantages for rapid diagnosis.<sup>27-29</sup>

We would not, however, recommend the urinary antigen test as the sole diagnostic test but would rather recommend that culture be performed in tandem. Diagnosis of *Legionella* infection resulting from other species and serogroups is more likely in hospitals. *Legionella* culture may provide the only means for making the diagnosis and for providing an isolate for epidemiologic investigation.

We recognize that there are inherent weaknesses with any retrospective study. One limitation is that 56 health care facilities did not respond to our survey. However, all major health care facilities within Allegheny County responded to the survey. Within Allegheny County, only 2 acute-care facilities opted to not participate in the survey.

A second limitation could be that patient management (ie, empiric therapy and infection control practices) during the 2 study periods may not have been comparable. However, we are not aware of any hospitals making overt changes in patient management. For example, no hospital instituted prophylactic antibiotic therapy for Legionnaires' disease. In recent years, some municipal water treatment plants have switched from chlorine to monochloramine as the primary disinfectant. Monochloramine has been linked to reductions in *Legionella*.<sup>30</sup> The Pittsburgh Water Treatment Plant has not switched to monochloramine, so this cannot account for the observed decline in health care-acquired Legionnaires' disease. Moreover, if some other factor led to the observed decline in health care-acquired Legionnaires' disease, then it is logical to extrapolate the same trend in community-acquired cases should have occurred in parallel. In fact, the percentage of cases that were community acquired actually increased in the postguideline period, from 67% (105/156) to 91% (247/272) of all reported cases ( $P = .0001$ ).

Finally, it might be argued that the index of suspicion for Legionnaires' disease decreased in the post-guideline period from an undetected bias or other unknown reason or that the reduced incidence was coincidental and not related to the implementation of the guidelines. This scenario is extremely unlikely given the emphasis placed on *Legionella* prevention for each hospital as outlined in the guidelines. And finally, both community-acquired cases and long-term care cases increased in the postguideline period (Fig 1).

An unanticipated benefit was the fact that litigation and unfavorable publicity for health care facilities with cases of health care-acquired Legionnaires' disease all

but ceased. The ACHD took an active role in educating the lay media that hospitals with cases of Legionnaires' disease were ones that provided superior care by their capability for making the laboratory diagnosis and their ability to disinfect their water supply.

The principal finding of this study is that a proactive strategy was successful in preventing cases of health care-acquired Legionnaires' disease. Although there are weaknesses in the study, the outcome is biologically plausible: identify the source, control the source, and eliminate the disease.

## Public health implications

The ACHD guidelines provided a proactive, effective, and uniform approach for the control of *Legionella* in hospital water systems within Allegheny County and surrounding counties. The implementation of the guidelines is an example of effective public health action to prevent infection within a specified population—hospitalized patients. It has been reported that as many as 18,000 cases of Legionnaires' disease occur each year in the United States.<sup>24,31,32</sup> Given that up to 25% of these cases are health care acquired, an estimated 99,000 cases of health care-acquired Legionnaires' disease have occurred in the 22 years since 1983. Assuming an average mortality rate of approximately 40%, then more than 39,000 lives have been lost as a result of this illness since 1983.

The excess costs associated with one case of health care-acquired pneumonia have been estimated to be a minimum of \$7000 per episode.<sup>33</sup> If health care-acquired Legionnaires' disease was prevented on the national scale, the cost savings would be more than \$34 million per year. The experience in Allegheny County demonstrates that this savings, in both lives and dollars, is achievable. In addition, the unfavorable publicity and litigation that are involved with the discovery of health care-acquired Legionnaires' disease would also be prevented.

These guidelines have already been used by other public health groups within the United States, such as the State of Maryland.<sup>34</sup> This study provides the first evidence-based data that documents the effectiveness of proactive guidelines and places additional importance on their usefulness as a reference for health care facilities elsewhere.

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