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# Introduction of Monochloramine into a Municipal Water System: Impact on Colonization of Buildings by *Legionella* spp.

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**Legionnaires' disease (LD) outbreaks are often traced to colonized potable water systems. We collected water samples from potable water systems of 96 buildings in Pinellas County, Florida, between January and April 2002, during a time when chlorine was the primary residual disinfectant, and from the same buildings between June and September 2002, immediately after monochloramine was introduced into the municipal water system. Samples were cultured for legionellae and amoebae using standard methods. We determined predictors of *Legionella* colonization of individual buildings and of individual sampling sites. During the chlorine phase, 19 (19.8%) buildings were colonized with legionellae in at least one sampling site. During the monochloramine phase, six (6.2%) buildings were colonized. In the chlorine phase, predictors of *Legionella* colonization included water source (source B compared to all others, adjusted odds ratio [aOR], 6.7; 95% confidence interval [CI], 2.0 to 23) and the presence of a system with continuously circulating hot water (aOR, 9.8; 95% CI, 1.9 to 51). In the monochloramine phase, there were no predictors of individual building colonization, although we observed a trend toward greater effectiveness of monochloramine in hotels and single-family homes than in county government buildings. The presence of amoebae predicted *Legionella* colonization at individual sampling sites in both phases (OR ranged from 15 to 46, depending on the phase and sampling site). The routine introduction of monochloramine into a municipal drinking water system appears to have reduced colonization by *Legionella* spp. in buildings served by the system. Monochloramine may hold promise as community-wide intervention for the prevention of LD.**

Legionellae are ubiquitous bacteria in aquatic environments. Legionellae cause two clinical syndromes in humans, Legionnaires' disease (LD), a severe form of pneumonia, and Pontiac fever, a self-limited flu-like illness. Between 8,000 and 18,000 hospitalized cases of LD occur in the United States each year; approximately 20% are fatal (15). Although outbreak-associated cases of LD are investigated more intensively, most cases of LD are thought to be sporadic and community acquired (5). Yet, unlike other causes of bacterial respiratory infections where vaccines may be protective, there are no community-wide prevention measures for LD.

In 1998, the U.S. Environmental Protection Agency (EPA) established the Stage 1 Disinfectants and Disinfection Byproducts Rule that requires all U.S. public water systems that use a residual disinfectant to reduce human exposure to total trihalomethanes (18). Water utilities can achieve this goal in several ways, but one of the most common is to change the disinfectant from residual chlorine to monochloramine (MC). MC, essentially a combination of chlorine (CL) and ammonia, is thought to be more effective over longer distribution systems, and it penetrates amoeba-rich biofilms, the principal reservoir of *Legionella* amplification (6), better than free chlorine (8, 14). As of 1990, approximately 23% of municipal water systems in the United States used MC as the primary residual disinfectant (12).

LD is acquired from environmental sources, such as potable water systems, whirlpool spas, and cooling towers. Colonization of these water sources by *Legionella* spp. is necessary though not sufficient for transmission of the bacteria to humans. The risk of colonization of individual buildings has been associated with the age of the building, the complexity of the water system, and the type of hot water heater used (1). On the basis of the results of previous in vitro experiments (7, 8) and studies indicating that hospitals supplied with MC-treated water were less likely to have sporadic cases and outbreaks of LD (11, 13), we hypothesized that changing the residual disinfectant of a municipal water system from CL to MC might result in decreased *Legionella* colonization of building water systems across the community. To test this hypothesis, we obtained water samples for culture from buildings served by a municipal water system before and after the system switched from CL to MC.

## MATERIALS AND METHODS

**Water distribution system.** Municipal water for Pinellas County, Florida, is provided to a population of 600,000 by production wells, reaching depths of 500 to 900 feet, in five well fields located near the western coast of Florida. From a hydraulic and operational standpoint, the Pinellas County Utilities (PCU) system functions as two large distribution systems. In the northern system, groundwater is treated with forced draft aeration, disinfectant, sodium hydroxide (for pH adjustment) and an ortho-polyphosphate blend for corrosion control. In the central-southern system, water is minimally treated with sodium hydroxide and

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disinfectant at a treatment plant and, when it is received at PCU's Interim Treatment Facility, pH and disinfectant residual are adjusted as needed. While chlorine had been the primary residual disinfectant for many years, the levels of naturally occurring organic material prompted PCU to plan a switch from CL to MC in May 2002. Chloramination began with chlorine treatment of aerated water for 6 to 20 h (0.5 to 1.0 mg/liter free chlorine) followed by the addition of ammonia (4.5 parts of chlorine to 1 part of ammonia) and adjustment of pH to 7.8 with sodium hydroxide. Additional chlorine was added to the treated water, if needed, as it passed through an online chlorine analyzer.

**Environmental sampling.** A convenient sample of buildings served by PCU was identified by obtaining a listing of all hotels ($n = 355$) and county government buildings ($n = 149$) that receive water from the PCU system. Single-family homes belonging to utility workers ($n = 74$) were identified through employee records at PCU. Owners of each building were contacted by telephone, informed of the purpose of the study, and asked to participate. Facilities managers provided written consent to include their building in the study. Two PCU employees entered each building to collect water and biofilm samples, once before the switch to monochloramine (January to April, 2002) and once after the switch (June to September, 2002). Characteristics of each building (e.g., size, age, water source) were collected on a standard data collection form. Operations personnel from each building were contacted by letter and telephoned to arrange a time for sample collection for the purposes of this study.

Within each building, we collected three samples from two sites. First, we collected into a sterile bottle 1 liter of water (central bulk sample) from the central hot water heater or a randomly chosen heater if there was more than one (central site). We collected from a site distant (distal site) from the hot water heater (e.g., a faucet or showerhead) a biofilm sample by inserting a cotton-tipped swab into the fixture (after removing the aerator or showerhead), rotating the swab against the inner wall, and placing it into 0.5 ml of water from the distal site. Finally, we collected another liter from the same distal site (distal bulk sample). Both 1-liter samples were collected after the water temperature had equilibrated. Monochloramine and total and free chlorine concentrations were measured (Hach 890 meter; Hach Company, Loveland, CO). They were subsequently neutralized with 0.5 ml of 0.1 N sodium thiosulfate. Temperature, pH (Oakton, Vernon Hills, IL), and conductivity (Cole Parmer, Vernon Hills, IL) were also measured at the point of collection. Calcium and magnesium were measured in distal bulk samples within approved holding times at the PCU Laboratory (Perkin-Elmer ICP Optima 3000 DV; Perkin-Elmer, Boston, MA) using EPA method 200.7 (17). All samples for *Legionella* and amoeba culture were shipped to the Legionella Laboratory at the Centers for Disease Control and Prevention (Atlanta, GA) where they were processed for the identification of *Legionella* (9) and amoeba (6) as previously described (10).

**Data management and analysis.** All data were entered into Access 2000 (Microsoft, Redmond, WA) and analyzed using SAS version 9.1 (SAS Institute, Inc., Carey, NC). We analyzed the data in two ways. First, we treated each building as an independent observation, i.e., if any sample—central bulk, distal bulk, or distal biofilm—within a building yielded one or more colonies of *Legionella*, we considered the building colonized. We examined factors that predicted colonization at the building level, including building age, number of floors, and building type (e.g., hotel versus county government building). Because cation concentrations were measured at only one site in each building during each phase, we treated these concentrations as building-level predictors of colonization.

Second, we treated each sample site (central or distal) as an independent observation, irrespective of whether they came from the same building (sample-based analysis). We assessed whether any physical parameters (e.g., temperature, conductivity) measured at individual sampling sites changed between the chlorine phase and the monochloramine phase. If either the bulk water sample or the biofilm swab from a distal site yielded one or more colonies of *Legionella*, we classified the distal site as colonized. We identified predictors of site colonization, including water temperature, pH, free and total residual chlorine concentration, and the presence of amoeba.

For each analytic approach, we identified univariate risk factors for colonization by calculating odds ratios (OR) and 95% confidence intervals (CI). The odds ratio is defined as the ratio of the odds in favor of colonization among buildings (or samples) with a particular characteristic to the odds in favor of colonization among buildings without that characteristic. We used McNemar's test for comparisons between the CL and MC phases, Fisher's exact test for comparisons of proportions, and the *t* test for comparisons of means, as appropriate. Because some exposure variables (e.g., temperature and free chlorine concentration) were likely associated with each other, we used logistic regression to control for the independent contributions of different exposures and to calculate adjusted odds ratios (aOR). *P* values of $<0.05$ were considered significant.

TABLE 1. Distribution of samples with *Legionella* and amoeba growth during the chlorine and monochloramine phases

| Building or site | No. of positive samples/no. of total samples (%) | |
|---|---|---|
| | CL phase | MC phase |
| Buildings colonized with *Legionella* | 19/96 (19.8) | 6/96 (6.2) |
| Buildings colonized with amoebae | 15/96 (15.6) | 14/96 (14.6) |
| Sites colonized with *Legionella* | | |
| Hot water heater | 9/96 (9.4) | 3/96 (3.1) |
| All distal samples combined | 15/192 (7.8) | 7/192 (3.6) |
| Distal bulk samples | 5/96 (5.7) | 4/96 (4.2) |
| Distal swab samples | 6/96 (6.2) | 3/96 (3.1) |

## RESULTS

**Change in colonization status of buildings before and after monochloramine.** Nineteen (19.8%) of 96 buildings were colonized with *Legionella* spp. during the CL phase (Table 1). Of these, 14 (74%) were identified by one positive culture, while 5 were identified by colonization in two different samples (e.g., one central positive sample and one distal positive sample or two distal positive samples). Six buildings (6.2%) were colonized in the MC phase (three with one positive sample, two with two positive samples, and one with three positive samples). Fifteen (15.6%) and 14 (14.6%) of the buildings were colonized with amoeba during the CL and MC phases, respectively. The *Legionella* colonization status of hotels and single-family homes was more likely to change from positive to negative than county government buildings, although this association was not statistically significant ($P = 0.08$) (Table 2).

The following sections summarize the results of our building-based (descriptive findings, followed by univariate and multivariable analyses in each phase) and sample-based analyses (descriptive findings, followed by univariate and multivariate analyses).

**Building-based analysis. (i) Descriptive features of buildings surveyed.** We surveyed 96 buildings, including hotels, county government buildings, and single-family homes (Table 3). More than half of the buildings used electric hot water heaters, less than a third of buildings were >3 stories tall, and less than 1 quarter used a water softener. Most distal sites sampled were showerheads that were used daily.

TABLE 2. Change in colonization status of buildings by building type between the chlorine and monochloramine phases

| *Legionella* colonization status during each study phase | | No. of buildings (%) that had the indicated colonization status during each phase[a] | | | Total |
|---|---|---|---|---|---|
| CL | MC | Hotel | County government | Single-family home | |
| Positive | Negative | 8 (19.5) | 2 (5.7) | 4 (20.0) | 14 (14.6) |
| Positive | Positive | 0 (0) | 4 (11.4) | 1 (5.0) | 5 (5.2) |
| Negative | Positive | 0 (0) | 1 (2.9) | 0 (0) | 1 (1.0) |
| Negative | Negative | 33 (80.5) | 28 (80.0) | 15 (75.0) | 76 (79.2) |
| Total | | 41 (100) | 35 (100) | 20 (100) | 96 (100) |

[a] $P = 0.08$ for association between building type and before-after colonization status by McNemar's test.

TABLE 3. Descriptive features of buildings surveyed and sites sampled

| Building or site characteristic | No. | % | Median | Range |
|---|---|---|---|---|
| Building type | | | | |
| Hotel | 41 | 42.7 | | |
| County government | 35 | 36.5 | | |
| Single-family home | 20 | 20.8 | | |
| Heat source for hot water heater | | | | |
| Electricity | 51 | 53.1 | | |
| Natural gas | 45 | 46.9 | | |
| Building with ≥3 stories | 26 | 27.1 | | |
| Source water | | | | |
| Source A | 61 | 63.5 | | |
| Source B | 28 | 29.2 | | |
| Source C | 5 | 5.2 | | |
| Source D | 1 | 1.0 | | |
| Source E | 1 | 1.0 | | |
| Water softener used | 13 | 13.5 | | |
| Continuously circulating hot water system | 36 | 37.5 | | |
| Type of distal site sampled | | | | |
| Shower | 80 | 84.4 | | |
| Faucet | 16 | 15.6 | | |
| Frequency of use of distal site | | | | |
| Daily | 82 | 84.4 | | |
| Weekly | 9 | 9.4 | | |
| Monthly | 3 | 3.1 | | |
| Rarely | 2 | 3.1 | | |
| Building age (yr) | | | 26 | 0–73 |
| Building ht (no. of stories) | | | 2 | 0–10 |
| Distance from water main (meters) | | | 30.5 | 3–1,610 |
| No. of hot water heaters | | | 2 | 1–40 |
| Total capacity of hot water heaters (gal) | | | 80 | 30–1,000 |
| Distance from hot water heater to distal sampling site (no. of stories) | | | 0 | 0–8 |

**(ii) Risk factors for *Legionella* colonization among buildings.** In the univariate analysis of the CL phase of the study, neither the type of building ($P = 0.78$), the presence of a water softener ($P = 0.72$), the type of hot water heater ($P = 0.11$), the concentration of calcium ($P = 0.19$), the concentration of magnesium ($P = 0.67$), nor the height of the building ($P = 0.10$) was associated with *Legionella* colonization. Buildings with continuously circulating hot water systems were at increased risk of colonization relative to buildings with systems that were not continuously circulating (OR, 5.1; 95% CI, 1.7 to 15). Source water was also significantly associated with colonization (OR for association between colonization and source B versus all four of the other sources combined, 6.5; 95% CI, 2.2 to 19.3). While buildings served by source B were also at increased risk of colonization with amoebae (OR, 10.6; 95% CI, 2.9 to 36.6), this association did not explain the tendency for these same buildings to be colonized with *Legionella*: when amoeba-colonized buildings were removed from the analysis, the association between source B and *Legionella* colonization remained (OR, 6.2; 95% CI, 1.5 to 26.7).

During the MC phase of the study, we identified no risk factors for infection, possibly because so few buildings were colonized. In particular, none of the buildings served by source B was colonized. The six buildings that were colonized were served by four different water sources. None of the colonized buildings was a hotel.

In the multivariable analysis of the CL phase, after adjusting for building size, building type, water source, type of hot water heater, the presence of water softeners, and the presence of a continuously circulating hot water system, only water source and the presence of a continuously circulating system remained significant risk factors (aOR for source B compared to all others, 6.7; 95% CI, 2.0 to 23; aOR for continuously circulating versus noncontinuous systems, 9.8; 95% CI, 1.9 to 51). In addition, single-family homes were more likely to be colonized than hotels (aOR, 18.6; 95% CI, 1.6 to 223), although this estimate was based on a small number of homes (5 positive of 20 sampled).

In the monochloramine phase, because three variables (building type [hotels, specifically], water source, and presence of a water softener) completely distinguished buildings that were colonized from buildings that were not colonized, we were unable to construct a multivariable model that could independently adjust for these factors.

**Sample-based analysis: descriptive features of samples taken in each phase.** We observed changes in CL and MC concentrations consistent with the conversion to MC in May 2002 (Table 4). These changes indicate that MC was successfully delivered to the point of use in nearly all buildings sampled. We did not observe significant changes in water temperature, either in central water heaters or at distal sites, after the introduction of MC. We observed small but statistically insignificant changes in pH among water heaters and in magnesium and calcium concentrations in distal sites.

In the univariate analysis of the CL phase, sites with detectable free chlorine were less likely to be colonized with *Legionella*, although this difference was not statistically significant (central sites with detectable free chlorine versus those with no detectable free chlorine, three [5.1%] colonized versus six [16.2%] not colonized, $P = 0.08$ Fisher's exact test; distal sites with detectable free chlorine versus those with no detectable free chlorine, six [10.0%] colonized versus six [17.7%] not colonized, $P = 0.34$). During the MC phase, the low prevalence of MC throughout the distribution system eliminated our ability to identify any association between MC and colonization. We did not observe an association between temperature and *Legionella* colonization at the sample level: samples with water temperature in the ideal growth range of *Legionella* (25 to 42°C) were no more likely to be colonized with *Legionella* than samples with other water temperatures. However, few samples had temperatures below 26°C, and of those with temperatures >42°C, 75% were <51°C, the minimum temperature recommended for return water (2).

The presence of amoeba predicted colonization with *Legionella* at the sample level during both phases and at both types of sampling sites. In the CL phase, 67% of central samples with amoeba and 7.5% of central samples without amoeba were colonized with *Legionella* (OR, 24.6; 95% CI, 2.0 to 306). Among distal samples, 55% with amoeba and 7.2% without amoeba were colonized with *Legionella* (OR, 15.4; 95% CI, 3.6 to 66). In the MC phase, 50% of central samples with amoeba and 2.1% of samples without amoeba were colonized with *Legionella* (OR, 46; 95% CI, 2.1 to 1,027). Among distal sam-

TABLE 4. Change in sampling site-specific parameters between the chlorine phase and the monochloramine phase

| Parameter | Value for hot water heaters | | | Value for distal sites | | |
|---|---|---|---|---|---|---|
| | CL phase | MC phase | *P* value[a] | CL phase | MC phase | *P* value |
| Total chlorine detectable, no. (%) | 72 (75.8) | 77 (81.0) | 1.0 | 70 (76.1) | 77 (81.9) | 0.21 |
| Free chlorine detectable, no. (%) | 59 (61.5) | 0 (0) | <0.0001 | 60 (63.8) | 0 (0) | <0.0001 |
| MC detectable, no. (%) | 0 (0) | 85 (88.5) | <0.0001 | 0 (0) | 87 (92.6) | <0.0001 |
| Temp category[b] | | | | | | |
| <26°C | 4 (4.2) | 2 (2.1) | 0.61[c] | 2 (2.2) | 1 (1.1) | 0.54[c] |
| 26–42°C | 35 (36.5) | 39 (40.6) | | 28 (30.8) | 35 (37.2) | |
| >42°C | 57 (59.4) | 55 (57.3) | | 61 (67.0) | 58 (61.7) | |
| Mean temp (°C) | 43.6 | 44.1 | 0.72[d] | 44.1 | 43.5 | 0.57[d] |
| Mean pH | 7.6 | 7.7 | 0.05[d] | 7.7 | 7.7 | 0.19[d] |
| Mean conductivity (μS/cm) | 533.7 | 503.8 | 0.12[d] | 518.7 | 498.7 | 0.07[d] |
| No. of sample locations with *Legionella* | 9 (9.4) | 4 (4.2) | 0.062 | 13 (13.8) | 4 (4.3) | 0.004 |
| No. of sample locations with amoebae | 2 (2.0) | 2 (2.1) | 1.0 | 11 (11.7) | 14 (14.9) | 0.25 |

[a] *P* value comparing the value for CL phase to the value for MC phase by McNemar's test unless otherwise indicated.
[b] Categories indicate temperatures favorable (26 to 42°C) and unfavorable (<26°C and >42°C) for *Legionella* growth.
[c] By Fisher's exact test.
[d] By *t* test.

ples, 21% with amoeba and 1.2% without amoeba were colonized with *Legionella* (OR, 21.5; 95% CI, 2.1 to 226).

In the multivariable analysis of the CL phase and after controlling for temperature and the presence of free chlorine, the presence of amoeba was the only independent predictor of colonization with *Legionella* at central sites (aOR, 21.2; 95% CI, 1.5 to 298) and at distal sites (aOR, 16.9; 95% CI, 3.7 to 78.5). Similar to the multivariable building-based analysis of the MC phase, there were not sufficient numbers of colonized buildings for us to construct a logistic regression model robust enough to discern independent predictors of colonization at the level of individual sampling sites.

## DISCUSSION

Our study shows that routine introduction of monochloramine into a municipal water system can reduce *Legionella* colonization of buildings served by the water system by 69% within a 1-month period. This finding represents the first demonstration of a community-wide intervention with the potential to reduce the incidence of Legionnaires' disease associated with potable water.

Colonization by *Legionella* spp. was significantly associated with the presence of amoeba in the chlorine phase of the study. This is not surprising, since *Legionella* infection of and multiplication within these protozoa are the primary means by which *Legionella* amplifies in the environment. Ours is one of few studies to document the *Legionella*-amoeba association in building environments, especially on such a large scale. The strong association between the presence of amoebae and *Legionella* during the CL phase supports the theory that protozoa represent the bacterium's primary means of multiplication and suggests that amoeba shelter the bacteria from disinfection by chlorine (6, 7a). On the other hand, monochloramine significantly decreased the presence of *Legionella*, suggesting that monochloramine was able to penetrate amoeba-laden biofilms while having no direct effect on the amoebae themselves.

Several lines of evidence support the conclusion that the observed reductions in *Legionella* colonization were actually caused by the conversion to MC. MC was detectable in 88% of water heaters and 93% of distal sites after the change, while free CL was undetectable in water heaters and at the point of use. Other factors known to impact the growth of *Legionella*, such as temperature and pH, did not change substantially between the two phases of the study. Random fluctuation in colonization status is an unlikely explanation for our observations; such changes should lead to previously culture-negative sites becoming culture positive with roughly the same frequency as culture-positive sites becoming culture negative. Instead, we observed a dramatic and statistically significant reduction in the proportion of sites colonized. Finally, these findings are supported by previous work documenting that MC reduces the risk of *Legionella* colonization in hospitals (11) and the risk of outbreaks of nosocomial Legionnnaires' disease (13).

We observed differences in the effectiveness of MC in different types of buildings. *Legionella* colonization was more likely to be eliminated from hotels and single-family homes than from county government buildings, independent of other factors. One possible explanation for these differences is that hotels and single-family homes might have more consistent water usage, which could facilitate the delivery of residual monochloramine to all parts of the building water system. These differences could also be explained by unmeasured factors, such as the complexity of the building water systems, the pervasiveness of biofilm, or differences in maintenance. These factors could be important in predicting the impact of community-wide introduction of monochloramine.

We also observed an important association between water source and building colonization. Buildings served by water source B were almost seven times more likely, after adjusting for other factors, to be colonized with *Legionella* during the chlorine phase than buildings served by other water sources. To our knowledge, an association between a particular water source and colonization with *Legionella* has not been previously described. Furthermore, during the MC phase, none of the colonized buildings received their water from source B. One possible explanation for this observation is that the main difference between source B and the other water sources is that source B water passes through a hydrogen sulfide removal

TABLE 5. *Legionella* species isolated from hot water heaters and distal sites

| *Legionella* species | No. of times *Legionella* isolated from: | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | Hot water heaters | | | Distal sites | | | | |
| | CL phase | MC phase | Total | CL phase | | MC phase | | Total |
| | | | | Bulk | Biofilm | Bulk | Biofilm | |
| *L. rubrilucens* | 2[a] | 0 | 2 | 3[a] | 2 | 1 | 1 | 7 |
| *L. pneumophila* serogroup 1 | 3 | 1 | 4 | 1 | 1 | 2 | 0 | 4 |
| *L. pneumophila* serogroup 3 | 0 | 1 | 1 | 1 | 1 | 1 | 1 | 4 |
| *L. gormanii* | 2 | 0 | 2 | 1 | 1 | 0 | 0 | 2 |
| *L. bozemanii* serogroup 2 | 1 | 0 | 1 | 0 | 1 | 0 | 1 | 2 |
| *L. feeleii* serogroup 1 | 0 | 1 | 1 | 0 | 1 | 0 | 0 | 1 |
| *L. maceachernii* | 1 | 0 | 1 | 1 | 0 | 0 | 0 | 1 |
| *L. pneumophila* serogroup 10 | 1 | 0 | 1 | 1 | 0 | 0 | 0 | 1 |
| *L. feeleii* serogroup 2 | 0 | 0 | 0 | 0 | 1 | 0 | 0 | 1 |
| Total | 10 | 3 | 13 | 8 | 8 | 4 | 3 | 23 |

[a] Isolated as a second species from one sample.

plant and is treated with a corrosion inhibitor. Higher turbidities observed in the plant effluent suggest that biofilm grown in the hydrogen sulfide removal towers sloughs off and enters the distribution system, thereby releasing larger quantities of *Legionella* downstream. Regardless of the precise nature of this association, it implies that there might be source-specific factors that predict colonization of buildings by *Legionella* and that these factors can be overcome by MC.

Despite the positive findings of our study, Pinellas County Utilities, in cooperation with other investigators, observed several negative and potentially detrimental outcomes following the conversion to MC (16). The proportion of buildings that were colonized by mycobacteria increased from 19.1% during the CL phase to 42.2% during the MC phase. In the PCU distribution system, the number of samples that contained detectable levels of coliforms also increased from two samples during the CL phase to 20 samples during the MC phase. The long-term health effects of these changes are unknown. However, in light of these findings, PCU now recognizes that implementation of chloramination may have negative as well as positive impacts.

In 2002, nine cases of legionellosis among persons residing in Pinellas County, Florida, were reported to the CDC (CDC, unpublished data), a number too small to determine whether the change to MC had an impact on human disease. There are several explanations for the low incidence of disease. First, Legionnaires' disease, like other causes of community-acquired pneumonia, is underdiagnosed, largely because diagnostic testing is done infrequently in favor of empirical therapy (3). Also, in recent years, cultures for *Legionella* have become less common as *Legionella* urinary antigen testing (4), which detects only *Legionella pneumophila* serogroup 1 (Lp1), has become more common. Of note, 28 (78%) of 36 *Legionella* strains isolated from buildings in our study were species and serogroups other than Lp1 (Table 5). Third, some cases of legionellosis could have occurred among travelers who left Pinellas County to return home before they were diagnosed.

We sampled buildings served by a water utility in one county in southwestern Florida, which might differ from other counties in terms of its water distribution system, baseline water quality, patterns of water use, or other factors. Therefore, our results might not be generalizable to utilities in other counties in Florida or in other areas of the country. In addition, due to a planned change in PCU's source water 4 months after the conversion to MC, we conducted our survey over a short period of time, so long-term consequences on water quality, *Legionella* colonization, or colonization by other pathogens are unknown. We sampled a relatively small number of buildings, and therefore, we were unable to detect statistically significant changes in particular species of *Legionella*, including *Legionella pneumophila* serogroup 1, the most common species and serogroup that causes Legionnaires' disease.

Our study is the first to document a positive impact of conversion to MC on *Legionella* colonization in potable water systems of public and private buildings. As other municipalities consider which residual disinfectant might bring their trihalomethane levels in line with the Stage 1 Disinfectants and Disinfection Byproducts Rule, these data offer some insights into the potential effect of MC on colonization of buildings with *Legionella*. While these findings imply that MC might hold promise as a tool for the community-wide prevention of legionellosis, they must be interpreted in light of the overall impact on water quality. Additional larger-scale studies in other parts of the country are needed to document positive and negative aspects of routine, community-wide implementation of MC disinfection.

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