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ALLEGHENY COUNTY HEALTH DEPARTMENT

APPROACHES TO PREVENTION AND CONTROL OF LEGIONELLA INFECTION IN ALLEGHENY COUNTY HEALTH CARE FACILITIES

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1993

Allegheny County Health Department Legionella Task Force

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INTRODUCTION

In the course of investigating several local outbreaks of Legionellosis in health care institutions, it became apparent that there was no uniformity in the evaluation and monitoring of Legionella in hospital water systems and that several institutions were asking for appropriate suggestions for practices to institute in their own facility. A Task Force composed of outstanding members of the medical, public health, plumbing, and drinking water regulatory agencies was convened in June, 1992 for the purpose of developing practical guidelines for use in health care institutions, if they should so choose. A Task Force of Allegheny County experts devoted many hours to reviewing the literature and critically evaluating data available to them. Several of the members of the Task Force are, themselves, acknowledged leaders in their respective fields and have published extensively on this problem. The report in draft form was also circulated among several other experts for their input and suggestions.

The following report consists of their consensus opinion of recommendations for use in health care institutions to minimize the occurrence of Legionella in their water systems and reduce the incidence of Legionellosis among patients.

The Task Force fully recognized that there is no uniformity of opinion, and so, has provided several alternatives which might be of use to a variety of health care institutions.

The committee has not extensively addressed the issue of Legionella in water cooling towers because of even less data supporting its relevance to the development of human disease.

Legionellosis is a reportable disease under the statutes of the Commonwealth of Pennsylvania and all health care institutions are encouraged to report cases of Legionella occurring in hospitalized patients or its detection in their water supplies. By further examining the occurrence of this ubiquitous organism and the illness it produces, we can, hopefully, refine the recommendations hereinwith presented.

The Special Pathogens Laboratory of the Pittsburgh VA Medical Center can provide Legionella testing (patient and environmental cultures, urinary antigen, DFA, and Serology) for those institutions who do not have the technical capability for these tests or the demand for frequent culturing. Additionally, the Special Pathogens Laboratory provides training (gratis) to personnel from laboratories desirous of developing their own in-house capability for Legionella testing.

It is our intent to ask the Subcommittee to meet at periodic intervals to update these recommendations as new knowledge becomes available, both in the literature and from our local experiences. Users of these guidelines are encouraged to communicate their experiences and any problems so that these may be addressed in future editions. It is the intent of the Task Force that these be used as recommendations rather than mandated requirements and that they will prove useful to a large segment of health care facilities ranging from those providing low-level, chronic domiciliary care to those providing tertiary, referral care with critically-ill, immuno-compromised patients.

TABLE OF CONTENTS

I. DIAGNOSIS OF LEGIONNAIRES' DISEASE

Legionnaires' disease is pneumonia caused by a bacterium in the family Legionellaceae. The most common species involved in human infection is Legionella pneumophila, although 20 other species (e.g., Legionella micdadei) have also caused pneumonia. There are many serogroups of L. pneumophila, although serogroups 1,4,6 are the most pathogenic.

The clinical manifestations of Legionnaires' disease are that of bacterial pneumonia. There can be a diverse clinical presentation ranging from mild cough and slight fever to stupor with widespread pulmonary infiltrates and multisystem failure. In the early stage of illness, symptoms are non-specific including fever (often exceeding 104°F), malaise, myalgias, and headache. Cough is initially mild and slightly productive. Chest pain, occasionally pleuritic, may be present. Gastro-intestinal symptoms (nausea, vomiting, and abdominal pain) are often prominent; diarrhea is seen in 25-50 percent of cases.

The chest x-ray shows pneumonia. Laboratory findings may include abnormal liver function tests, hypophosphatemia, hematuria, and thrombocytopenia. Hyponatremia (sodium less than 130 mEq/liter) is very common. Sputum gram stain shows many neutrophils but few, if any, bacteria. Failure to respond to beta-lactam antibiotics (penicillins or cephalosporins) should raise the possibility of Legionnaires' disease.

The newer macrolides (azithromycin) and quinolones (ciprofloxacin, levofloxacin) have displaced erythromycin as the drug of choice. Azithromycin and levofloxacin have been FDA approved for therapy. Other alternatives include doxycycline, minocycline, olfloxacin, clarithromycin, and trimethoprim-sulfamethoxazole. Rifampin is often used in combination with another active agent for confirmed cases who are seriously ill.

Specialized laboratory tests are the key feature for diagnosing this infection since the clinical presentation is non-specific.

Culture on selective media: The single most important test for Legionnaires' disease is culture of the organism on selective media. In order to achieve a high yield from sputum, use of multiple media are required. There are at least 3 useful media: buffered charcoal yeast

extract agar (BCYE); BCYE with dyes, polymyxin, anisomycin and vancomycin (PAV); BCYE with polymyxin, cefamandole, anisomycin (PAC). All of these media are commercially available (PAC, Remel catalog #01-339, BBL #97879; PAV, Remel #01-333, BBL #97880).

Pretreatment of the sputum specimens with an acid wash (HCL-KC1) reduces competing flora and can improve the sensitivity by 10-20% (Vickers 87). Specimens obtained by bronchoscopy can be useful, but do not provide any higher yield than a good sputum specimen.

Urinary antigen: The urinary antigen test (Binax, South Portland, ME) can detect serogroup 1, L. pneumophila only. But since this serogroup causes 80-90% of L. pneumophila infections, this shortcoming is relatively minor. Two testing formats are available: radioimmunoassay and enzyme immunoassay. Both formats provide results in less than 3 hours and are highly specific (99%). The radioimmunoassay appears to be slightly more sensitive than the enzyme immunoassay (>90% vs approxamately 80% respectively). Test positivity will persist for days even during administration of antibiotic therapy.

Direct fluorescent antibody: The reported sensitivity of the direct fluorescent antibody test has ranged from 25% to 80%. It is highly specific. Expertise is required for confident interpretation. The monoclonal antibody test (Genetic Systems, Seattle, WA) for detection of all serogroups has eliminated the rare occurrence of cross-reactivity with other gram-negative bacilli and is easier to read than the polyclonal reagent.

Serology: Maximal sensitivity requires both IgG and IgM tests. Since fourfold seroconversion is the definitive criteria, a repeat serology is required 4-6 weeks after convalescence.

Laboratories should consider making available both a rapid test with at least moderate sensitivity (>80%) for detection of L. pneumophila serogroup 1 and culture for the isolation of all species of Legionella. The urinary antigen test is generally considered as the choice rapid test because of its high sensitivity for detection of serogroup 1, L. pneumophila. Athough the direct fluorescent antibody test is less sensitive than the urinary antigen test, it can detect other serogroups of L. pneumophila and may be used as an alternative or supplementary rapid test.

Tissue from lung and other sites are processed to provide 10% (wt/vol) suspensions. The suspensions should be diluted 1 to 10 in either sterile broth (e.g. trypticase soy broth) or water. The undiluted and diluted suspensions are then inoculated onto BCYE.

II. RECOMMENDATION FOR CONSIDERATION IN ENVIRONMENTAL SURVEILLANCE OF LEGIONELLA IN ALLEGHENY COUNTY HEALTH CARE FACILITIES

All hospitals should perform an environmental survey yearly. If transplants are performed, then a survey should be performed more often. An environmental survey should consist of: a) all hot water tanks, b) distal sites (faucets or showerheads).

If hospital beds are less than 500, a minimum of 10 distal sites should be surveyed. If bed size is greater than 500, 2 distal sites per 100 beds are recommended. The distal sites should be taken from units housing patients at higher risk for acquiring Legionnaires' disease (COPD, immunosuppression, transplant).

A sampling protocol (See III) and two algorithms (Figures 1 and 2) are presented. The two algorithms take into account the following principles: 1) Environmental cultures provide the basis for rational action, 2) Small numbers of Legionella species in a limited number of distal sites will not pose unusual danger for hospitalized patients if a strong infection control program utilizing in-house laboratory capability is present.

If any single water tank or site is positive for a Legionella species, then specialized laboratory testing for Legionella should be available, either in-house or through a reference laboratory, for patients with nosocomial pneumonia. In-house laboratory capability is worthwhile, especially if transplant patients are part of the hospital population. If the organism isolated from the water distribution system is L. pneumophila, serogroup 1, the adoption of the urinary antigen test (Binax, S. Portland, ME) is a consideration. Empiric anti-Legionella therapy should be considered for patients with nosocomial pneumonia of uncertain etiology. In addition, the medical staff should be alerted and informed about the implications of this finding.

If the percent of positive cultures at the distal sites is equal to or greater than 30% of the total number sampled, then disinfection of the water distribution system is appropriate. The Task Force recognizes the arbitrariness of the 30% figure, although there is some data to support its use as a cutpoint for decision making (Best, Lancet, 83); this figure may be modified in the future with continuing research. Environmental cultures confirming efficacy should be performed after disinfection.

If the percent of positive cultures is less than 30%, disinfection measures need not be initiated until definition of the problem is clarified. However, prospective surveillance by Legionella laboratory testing for all patients with nosocomial pneumonia becomes important. The infection control practitioner, with a physician, should take responsibility for ensuring that such patients have the appropriate tests ordered. Culture of respiratory tract specimens on selective media, direct fluorescent antibody stain, urinary antigen, and acute and convalescent serology are appropriate. If there exists a significant number of COPD patients, immunosuppressed hosts, and transplant recipients, then in-house capability for the Legionella laboratory tests is appropriate.

III. CULTURE PROTOCOL FOR ENVIRONMENTAL SAMPLING FOR LEGIONELLA

Faucets: Moisten the outlet by allowing water to trickle through the opening. A sterile, dacron swab is inserted and rotated four times around the inner circumference and moving up the faucet as far as the swab will reach. Replace the swab into the container. If the swab system does not contain a transport medium, then allow 0.5 ml of water to flow from the faucet into the container to keep the swab moist. The culturette II system (Becton Dickinson) has a self contained transport medium, and it is not necessary to add outlet water to the swabs.

Showerhead: Moisten the showerhead by allowing water to trickle through the opening. Rotate the swab over the entire surface of the showerhead 4 times. Place swab into the container. If the swab system does not contain a transport medium, then allow 0.5 ml of water to flow from the showerhead into the container to keep the swab moist.

Hot water tank: Open the drain valve at the base of the tank. Collect 10 to 50 cc immediately into a sterile specimen container. Then let the water drain out of the pipe for 15-30 seconds to flush out residual water within the drain pipe and then collect another 10 to 50 cc into a second specimen container. This procedure ensures that both residual water in the drain pipe and water from the tank are sampled.

Scale and sediment often harbor Legionella, so it is worthwhile to obtain scale or sediment from tanks or distal sites. Heavy "syrupy" specimens from the bottom of hot water tanks, however, often will not yield the organism.

Samples should be refrigerated at 2-8°C until processing.

Media: Selective/differential BCYE medium containing glycine, vancomycin, polymyxin B, alpha-ketoglutarate, bromothymol blue and bromocresol purple dyes (DGVP). Remel, Catalog #01-338, BBL, Catalog #99648.

Direct Processing: Swabs are inoculated down the center of a DGVP agar plate and streaked perpendicularly with an inoculating loop. A 0.1 ml aliquot of each water sample is spread onto the surface of a DGVP plate. Samples are stored at 2-8°C. The plates are incubated in a humidified atmosphere at 35°C to 37°C in air and read after 3 to 5 days. If the sample is overgrown with non-Legionella organisms on direct culture, the samples have to be treated with an acid buffer and the culture repeated. Plates demonstrating no growth are discarded after 7 days' incubation.

Acid Buffer Treatment: 2.0 ml of HCl-KCl acid buffer should be added to 1.0 ml sediment of the centrifuged water specimens and 0.1 ml spread onto BCYE and DGVP media. Swab samples are placed in 2.0 ml of the acid buffer and processed as described by Vickers.

Fig. 1 An Approach To Disinfection

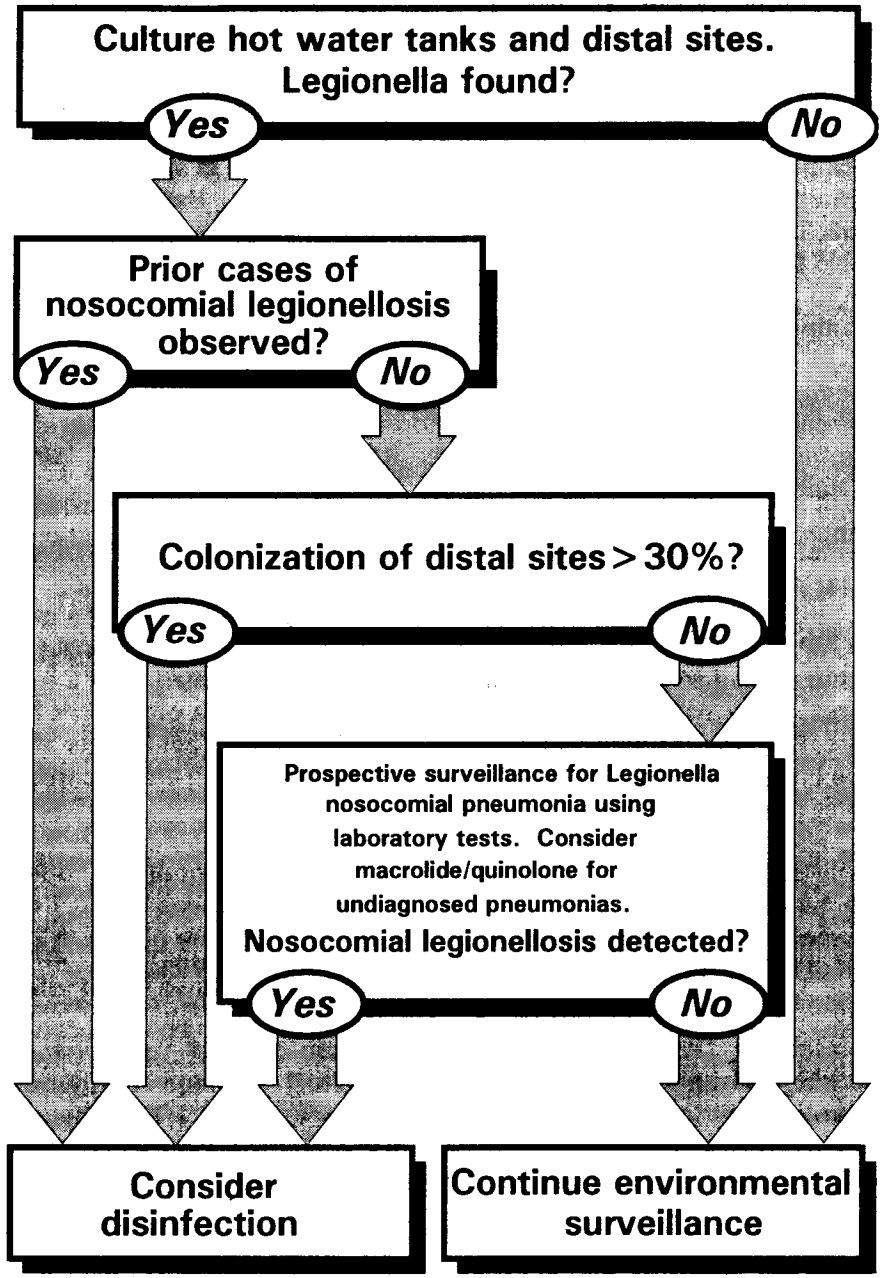
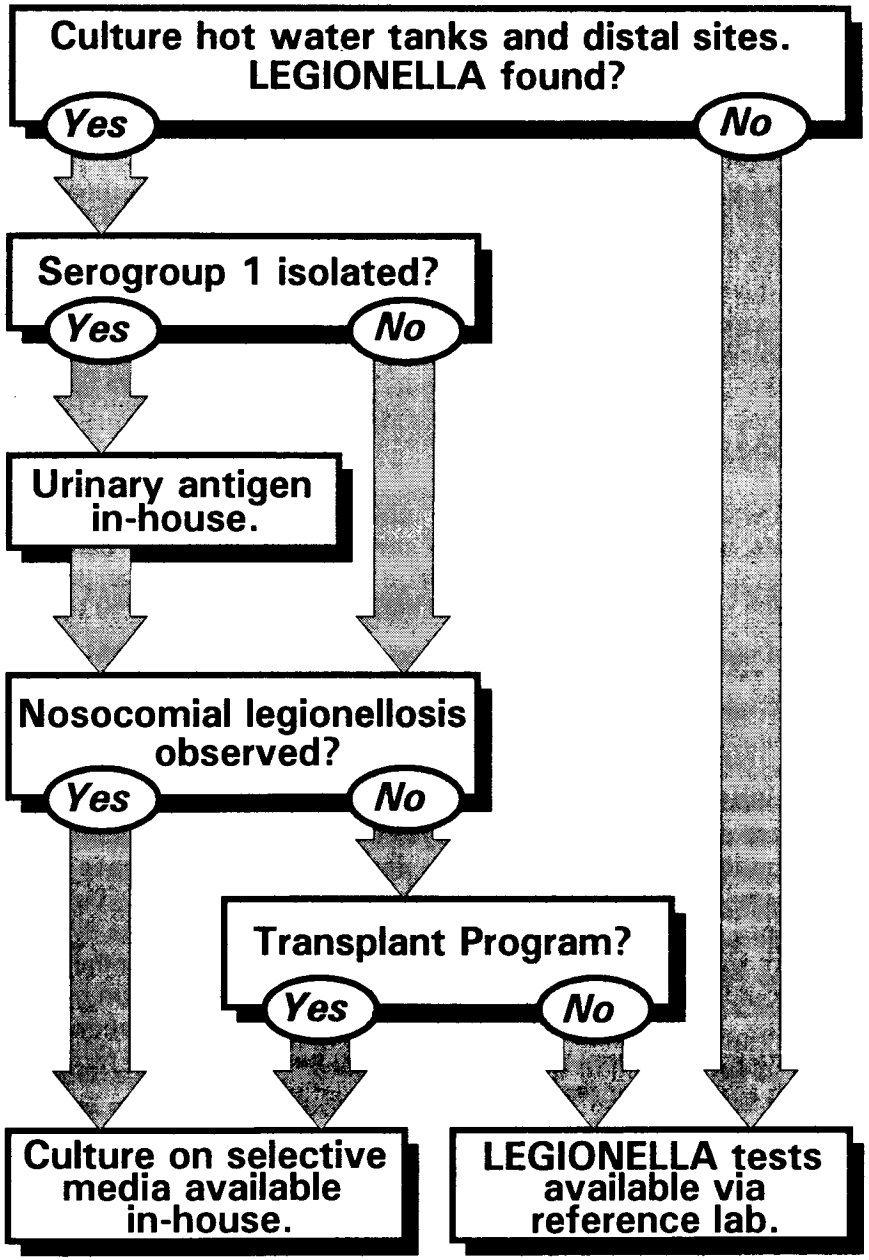


Fig. 2 Approach To Laboratory Capability For Hospitals.



IV. OPTIONS FOR CONTROL OF LEGIONELLA IN WATER DISTRIBUTION SYSTEMS OF ALLEGHENY COUNTY HEALTH CARE FACILITIES

The Task Force is issuing these formal guidelines for potable water systems in health care facilities. The Task Force has decided not to issue formal guidelines for cooling tower maintenance and disinfection for three reasons: 1) Although hospital-acquired outbreaks have been convincingly linked to potable water distribution systems in numerous instances in Allegheny County hospitals, known outbreaks linked to cooling towers have not occurred. 2) Reports of cooling-tower-associated outbreaks have declined precipitously so that numerous investigators have suggested that with more precise epidemiologic methods, cooling towers may not even be a vector for outbreaks of Legionnaires' disease. 3) Unlike potable water distribution systems, methods for disinfection of cooling towers have been notably unsuccessful.

Potable water systems include all building plumbing systems that distribute water for direct human contact (e.g. drinking, bathing, showering). Likely avenues of infection may include the inhalation of Legionella-contaminated aerosols or aspiration of contaminated water.

Control measures of potable water systems are divided into two approaches (Active Disinfection Measures; Design, Operation, and Maintenance Measures). Active Disinfection Measures include devices and procedures not normally present in the health care facility, which are installed specifically to control colonization by Legionella species. These are particularly useful for systems that are already seriously contaminated and for which the decision has been made that immediate control of legionellae colonization is required. Design, Operation, and Maintenance Measures are changes in the typical structure and utilization of potable water systems, which over the long run, should minimize the potential for extensive colonization by the bacterium. It is highly worthwhile to review the Design, Operation, and Maintenance Measures when constructing new health care facilities or when adding to or replacing parts of existing systems.

Numerous recommendations from various authorities have been published; while some of them are reasonable, many have little relevance to minimizing Legionella in water distribution systems. We have critically reviewed these published recommendations on the basis of ease of application, cost-efficacy, and scientific validity in control of Legionella. We discourage extensive or expensive modifications to the water distribution that have not been scientifically validated in decreasing Legionella colonization.

Legionella may colonize storage tanks, hot water heaters, pipes, water softeners and filters, and outlets including taps, showerheads, and other appliances. Proliferation can occur whenever conditions are ideal for growth. Factors that promote Legionella colonization in potable water systems include: temperature (<50°C or 122°F); scale and sediment accumulation; stagnation; and presence of commensal microflora (free-living protozoa and other bacteria). The Design, Operation, and Maintenance Measures described below are aimed at controlling these Legionella promoting factors, while the Active Disinfection Measures are designed to attack the Legionella species directly.

The health care facility should select its approach to Legionella control based on the results of environmental culturing epidemiology, and susceptibility of its population. It is the responsibility of the health care facility to select the control measure that best suits the facility's needs and plumbing system layout, and results in the desired level of control.

A. ACTIVE DISINFECTION MEASURES

These control measures should be used by health care facilities with susceptible populations or which have found Legionella present in the facility through environmental monitoring. Evaluate and use one or a combination of disinfection approaches. More than one of these methods can be used simultaneously in the same building, and redundancy may be desirable if nosocomial Legionellosis has been a demostrated problem. Mere disinfection of individual distal water fixtures alone (e.g. by boiling or chemicals) is ineffective without system-wide measures because once the fixtures are reinserted on-line, the fixtures will colonize with Legionella.

Several modalities for disinfection have been tried at numerous hospitals throughout the world, but only two have emerged as cost effective: 1) copper-silver ionization and 2) thermal erradication. Other methods including chlorination, installation of instantaneous heating systems, and ultraviolet light irradiation might be considered in special cirumstances. The advantages and disadvantages for each modality are discussed below.

1) Copper-Silver Ionization: Positively-charged metal ions kill bacteria by bonding with negatively-charged sites on the microorganism denaturing cellular protein and distorting cellular permeability. An ionization unit is installed at the hot water recirculating line. Copper and silver ions are released into plumbing system hot water passing within a flow-through ionization chamber when electrical current is applied to copper/silver electrodes. The typical levels used are 0.2 - 0.8 ppm copper and 0.02 - 0.08 ppm silver.

Copper/silver ionization systems have proven to be quite effective and their use in hospitals is becoming widespread. While this approach usually does not completely eradicate legionellae from the plumbing system, it keeps their numbers at acceptably low levels. Experience has shown that it is important to maintain the units and periodically monitor for metal concentrations and legionellae occurrence. Ion levels can be best determined by atomic absorption spectroscopy: low levels will be ineffective while high levels may cause discoloration of water. Hot water samples should be collected from a distal site and the hot water recirculating line. It is important to note that ionization systems only control legionellae in showerheads, taps, and other parts of the plumbing system that are regularly in use.

2) Thermal Eradication: This is the Heat-and-Flush method in which hot water tank temperatures are elevated to greater than 70°C (158°F) followed by a flushing of all faucets and showerheads with hot water to kill Legionella colonizing these distal sites. All outlets are flushed for a period of 20 to 30 minutes, depending upon the temperature of the water when it reaches the outlets. At 60°C (140°F), each outlet must be flushed for a least 30 minutes. For the technique to be effective, the water at distal outlets should reach at least 60°C (140°F).

This procedure may need to be repeated periodically based on the results of routine culturing of the plumbing. Re-colonization can be minimized by maintaining the tank temperature at 60°C (140°F).

An advantage of this method is that no special equipment is required so the procedure can be initiated expeditiously -- an advantage in outbreak situations. However, the technique is time consuming and labor intensive, and therefore costly. Each heating/flushing event is likely to cost thousands of dollars in overtime pay, etc. Scalding is a potential hazard.

3. Chlorination: Chlorination was one of the first modalities used for legionellae disinfection. With long-term experience, some logistic disadvantages have emerged so that this approach should be reserved as an alternative option, should other methods prove unsatisfactory. The possibility that it can be used in concert with copper-silver ionization remains to be explored since chlorine interacts synergistically with copper and silver ions against Legionella. The disadvantage of chlorination include high expense, the necessity for unusually stringent monitoring of Legionella and chlorine levels, and corrosion with development of pinhole leaks in the piping.

3) Instantaneous Steam Heating Systems: These systems operate by "flash heating" water to a temperature > 88°C (190°F) and then blending the hot water with a proportionate volume of cold water to achieve the desired temperature.

Instantaneous heating systems are most effective when installed in the original heating system of a new building that has not previously been colonized with Legionella. The system eliminates the need for hot water storage tanks which are well documented breeding sites for Legionella. This system cannot be used as the sole disinfection modality in a hospital already colonized with Legionella.

4) Ultraviolet Irradiation: A UV sterilizer is a flow-through device installed on a water line to kill Legionella as water flows through the unit. UV light is most effective if disinfection can be localized to a specific area within the building (e.g. a transplant unit or intensive care unit).

Since UV lamps are housed in quartz sleeves, the sleeves need to be kept clean to allow adequate light penetration. If the water is hard or dirty, either a manual wipe system or an automatic motorized wiper system will be helpful. A pre-filtration unit can also assist in preventing scale buildup. Additionally, a sensor should be utilized to ensure adequate intensity of UV radiation.

Advantages of UV systems are that UV is an effective bactericide which produces no disinfectant byproducts and does not damage the plumbing system. Disadvantages include the fact that UV light, unlike chlorine or copper-silver ionization, provides the water with no residual disinfectant and, therefore, will not eliminate legionellae colonizing portions of the plumbing system downstream of the unit. Thus, it cannot be used as a sole modality for disinfection for an entire building. Additionally, high water temperatures and scale buildups reduce disinfection efficacy and increase the maintenance requirement.

B. DESIGN, OPERATION, AND MAINTENANCE MEASURES

Evaluate and implement one or more of the following design, operation, and maintenance measures considering the results of environmental monitoring and case epidemiology:

1). Faucet Aerators: The use of aerators on faucets should be avoided since legionellae grow well in the sediment that accumulates there.

2). Drains: Hot water storage vessels and hot water service boilers should be fitted with a drain valve located in an accessible position at the lowest point so that accumulated sludge may be removed.

Horizontal vessels should be slanted to enable the vessel to be emptied completely. The drain in heating vessels should be located preferably at the heating coil end.

3). Distribution System Design: The distribution system should be designed to minimize the length of any dead-legs (i.e. laterals that are capped-off or infrequently used). Legionellae can grow in these stagnant sections of the distribution system and subsequently contaminate the rest of the system.

4) Storage and Distribution Temperatures: The temperature of water as it leaves the hot water heater or hot water storage vessel should be 60°C ± 2.5°C. Ideally, this temperature should be maintained for at least five minutes prior to discharge into the hot water distribution system. At this temperature, Legionella survive for only approximately 2 minutes. Therefore, it is unlikely that the organism will be distributed into the hot water distribution system in sufficient numbers to be harmful to patients.

Temperatures greater than 60°C are undesirable because the risk of accidental scalding increases considerably above 60°C, and dramatically above 65°C (149°C).

The minimum temperature in the water returning to the hot water heater should be 50°C. Hot water at sinks and baths should reach a steady static temperature of between 50°C and 60°C within 1 minute at full flow. Cold water at sinks and baths should ideally reach less than 20°C within 2 minutes. Legionella growth increases at temperatures > 20°C.

4) Stagnation in Hot Water Heaters: Stagnation can occur in a hot water heater if the cold feed and/or return water connections are incorrectly sited. These can be modified by relocating the tapping or by sparge pipes. A degree of stagnation also occurs in concave-base vertical calorifiers. This can only be eliminated by replacement or by addition of pumps.

5) Routine Cleaning and Maintenance: All cold water storage and feed tanks should be regularly examined, cleaned, and disinfected annually. Hot water heaters should be drained quarterly to minimize the accumulation of sludge. This frequency can be increased or decreased based on the amount of debris detected during inspection.

6) Interruption of Service: If a hot water tank or substantial part of the hot water system is out of use for a week or longer for maintenance or other purposes, water should be raised to the operating temperature of 60°C throughout for at least one day before being brought back into use.

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