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Major article

Field evaluation of a new point-of-use faucet filter for preventing exposure to *Legionella* and other waterborne pathogens in health care facilities

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Background: Opportunistic waterborne pathogens (eg, *Legionella*, *Pseudomonas*) may persist in water distribution systems despite municipal chlorination and secondary disinfection and can cause health care–acquired infections. Point-of-use (POU) filtration can limit exposure to pathogens; however, their short maximum lifetime and membrane clogging have limited their use.

Methods: A new faucet filter rated at 62 days was evaluated at a cancer center in Northwestern Pennsylvania. Five sinks were equipped with filters, and 5 sinks served as controls. Hot water was collected weekly for 17 weeks and cultured for *Legionella*, *Pseudomonas*, and total bacteria.

Results: *Legionella* was removed from all filtered samples for 12 weeks. One colony was recovered from 1 site at 13 weeks; however, subsequent tests were negative through 17 weeks of testing. Total bacteria were excluded for the first 2 weeks, followed by an average of 1.86 log reduction in total bacteria compared with controls. No *Pseudomonas* was recovered from filtered or control faucets.

Conclusion: This next generation faucet filter eliminated *Legionella* beyond the 62 day manufacturers' recommended maximum duration of use. These new POU filters will require fewer change-outs than standard filters and could be a cost-effective method for preventing exposure to *Legionella* and other opportunistic waterborne pathogens in hospitals with high-risk patients.

The water distribution system of hospitals is an important reservoir for waterborne pathogens, including *Legionella* spp, *Pseudomonas aeruginosa*, *Acinetobacter* spp, nontuberculous *Mycobacterium*, *Stenotrophomonas maltophilia*, and fungi (eg, *Aspergillus* spp).[1] These organisms may persist despite widespread disinfection of the water distribution system using any number of techniques and chemicals (eg, chlorine dioxide, copper silver ionization, hyperchlorination, ultraviolet light, super heating).[1-3] At even low levels, these organisms may pose a threat to certain patient populations, including those in bone marrow transplant units, hematology and oncology units, or solid organ transplant units.[1] Filters can be used in addition to or in the place of systemic disinfection.

Numerous studies have investigated the efficacy of point-of-use (POU) filters installed in high-risk areas to prevent the transmission of waterborne pathogens to their immunocompromised hosts.[1,2,4-8] Different models of filters have been shown to be efficient in removing *Legionella* spp,[1,2,8] *P aeruginosa*,[4,8] *P aeruginosa* and *S maltophilia*,[5] *Mycobacterium* spp,[6,8] and fungi.[7,8] However, in 6 of these 7 studies, the filters were only rated for 1[1] or 2 weeks of continuous use.[4-8] In addition, flow restriction has been reported to further shorten the duration of use for the filters.[7] The utility of POU filters as a tool for infection prevention would improve and be less cost prohibitive if the filters maintained efficacy and flow for longer periods of time. We evaluated a new extended-use 62-day POU faucet filter. The purpose of our study was to provide an objective

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field evaluation of this filter in eliminating *Legionella*, *Pseudomonas*, and total bacteria in water from faucets over a period that met and exceeded the manufacturer's 62 days of approved use.

MATERIALS AND METHODS

The location for the study was a cancer center in Northwestern Pennsylvania that was colonized by *L pneumophila* serogroup 1. POU filters (QPoint; Pall Medical Corp, East Hills, NY) were installed on 5 faucets. Five faucets without filters served as control sites.

Samples were collected weekly from May 8, 2013-August 28, 2013. Approximately 250 mL of water was collected after the hot water valve was turned on and flushed for 1 minute. Samples were collected in high-density polyethylene bottles with enough sodium thiosulfate (Microtech Scientific, Orange, CA) to neutralize 20 ppm of chlorine. Prior to sampling, the faucets equipped with filters were wiped with an antiseptic wipe to remove bacteria from the external surface of the filter.

Culturing for *Legionella* was done using buffered charcoal yeast extract and buffered charcoal yeast extract agar with dyes, glycine, vancomycin, and polymyxin B agar plates,[9,10] for *Pseudomonas* using MPAC agar,[11,12] and total bacteria using an R2A pour plate methodology.[13] Representative isolates of bacteria recovered from the faucets with filters were speciated by DNA sequencing (MIDI Labs, Newark, DE).

Rainfall data were analyzed from June 1, 2013-August 14, 2013. Data were obtained from the National Climatic Data Center Web site (www.ncdc.noaa.gov) and were from the nearest weather station to the cancer center.

Analysis of variance was used to compare *Legionella* and total bacterial counts between filtered and nonfiltered sites using Stata version 13.0 (Stata Corp, College Station, TX). Student *t* tests to compare *Legionella* and total bacterial counts at filtered and control sites before filter installation were performed using VassarStats (http://www.vassarstats.net; Vassar College, Poughkeepsie, NY).

RESULTS

Initial Legionella *and heterotrophic plate count results*

Faucets chosen for filter installation and control sites did not differ statistically in their concentrations of *Legionella* (control average = 10 colony-forming unit [CFU]/mL, filter average = 9 CFU/mL; $P = .74$) or heterotrophic plate count (HPC) bacteria (control average = 5,680 CFU/mL, filter average = 4,280; $P = .42$) prior to filter installation.

Legionella

No *Legionella* was recovered from water samples collected from faucets with filters over the entire 17-week period for 4 of the 5 faucets with filters (Fig 1). Water obtained from 1 faucet on week 13 was positive for *L pneumophila* serogroup 1 at 1-10 CFU/mL (1 colony on the plate) (Fig 1). *Legionella* was not recovered from this fixture in weeks 14-17. Control faucets had, on average, 292.4 CFU/mL of *L pneumophila* serogroup 1 during the study, ranging from 1-10 CFU/mL to 1,150 CFU/mL (Fig 1). This reduction in *Legionella* was statistically significant ($P < .0001$).

Other bacteria

Filters completely excluded HPC bacteria (total bacteria) from samples for the first 2 weeks (Fig 2). During these 2 weeks, the average log reduction in HPC bacteria in filtered samples was 4.35 (3.93 and 4.77 in weeks 1 and 2, respectively) compared with the controls. This was followed by an average 1.86 log reduction in filtered samples for the remainder of the study (range, 1.31-2.47). The filters significantly reduced the amount of total bacteria in these water samples ($P < .0001$). Bacteria in the filtered water were identified as *Hydrogenophaga* spp by DNA sequencing. *P aeruginosa* was not isolated from this water supply; therefore, no conclusions can be made about the efficacy of these filters with respect to this organism.

Flow restriction

Prior to the study, the total suspended solids were measured and found to contain 2.40 mg/L at 0.2 μm or larger. Despite this level and size of particulates, adequate flow was observed throughout the study and found to be unrestricted even at 17 weeks.

DISCUSSION

Legionella and other opportunistic pathogens multiply in hospital water systems and pose a threat to patients despite receiving treated water from municipal water treatment plants.[1-3] Additional secondary disinfection measures are sometimes necessary to prevent health care–acquired infections. Disinfection methods include both chemical methods (chlorine, chlorine dioxide, copper-silver ionization, monochloramine) and physical methods (ultraviolet light, POU filtration). Because systemic disinfection cannot completely eliminate *Legionella* from all fixtures, POU filters have been used to further protect high-risk patients.

Although POU filters have been successful at preventing exposure to *Legionella* and other waterborne pathogens, their use has been limited because of their relatively short recommended duration of use, flow restrictions, and cost. The purpose of this study was to provide a field evaluation of the efficacy a new POU faucet filter both in excluding waterborne pathogens from water and also evaluating the number of weeks they could maintain this exclusion. To accomplish this, we sampled 10 faucets (5 with filters installed, 5 without) in a cancer center for 17 weeks and conducted analyses for the presence of *Legionella*, *Pseudomonas*, and total bacteria.

The faucet filters removed *Legionella* from the hot water throughout the course of the study (Fig 1). There was 1 positive water sample (1-10 CFU/mL) from a filtered site recovered during week 13. There was no further breakthrough through 17 weeks of testing.

Complete bacterial exclusion was achieved for the first 2 weeks of this study (Fig 2). Thereafter, HPC bacteria were isolated on the R2A culture media. This is consistent with 3 previous studies where total bacteria were seen consistently within 14 days of use.[1,6,8] Explanations for the presence of total HPC bacteria have included external contamination of the filter housing or that growth occurred within the filter. Our data suggest an alternative explanation. External contamination is unlikely because the outside of the filter was sanitized with an antibacterial wipe prior to sample collection. The bacteria that we isolated were atypical small gram-negative rods and represented a limited number of colony types and included *Hydrogenophaga* spp. Because of its small dimensions (0.24 ± 0.01 μm wide by 2.48 ± 1.04 μm long) and flexibility, this organism has been previously shown to consistently pass through 0.2-μm filters.[14] We could not find any reference to human diseases caused by this organism; therefore, their presence may be inconsequential from an infection control perspective. The other 2 organisms isolated have similar characteristics to *Hydrogenophaga*, but we were unable to speciate them by DNA sequencing.

This study also provided an opportunity to observe changes in *Legionella* positivity over a 17-week period. The study began in May