

# Re-opening hairdressing salons, barber shops and gyms following COVID-19 lockdown: reducing risks from *Legionella* species through successful domestic steam disinfection of showerheads

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## Abstract

Given the importance of disinfecting showerheads from *Legionella* species and the lack of instructions as to how to successfully achieve this, the aim of this study was to examine the ability of domestic steam disinfection to successfully disinfect showerheads from *Legionella* species. Steam disinfection of *Legionella pneumophila* [ $n=3$ ; *L. pneumophila* serogroup 2–15 (wildtype environmental water isolate); *L. pneumophila* serogroup 1 NCTC11192 (reference strain); *L. pneumophila* serogroup 1 (wildtype environmental water isolate)], *L. erythra* (wildtype environmental water isolate) and *L. bozemanii* CRM11368M (reference strain) were examined in this study. Steam disinfection employing a baby bottle steam disinfectant device eradicated all *Legionella* organisms tested. Steam disinfection, when performed properly under the manufacturer's instructions, offers a relatively inexpensive, simple, versatile and widely available technology for the elimination of *Legionella* species from contaminated showerheads. We therefore advocate the employment of such devices to regularly disinfect showerheads and shower tubing in hairdressing salons, barber shops and gyms, as a critical control in the elimination of these organisms from these sources, thereby enhancing customer/client/staff safety.

## INTRODUCTION

The Gram-negative bacterium *Legionella* is the causative organism of Legionnaire's disease (LD), which usually presents as a pneumonia and Pontiac fever (PF), which is a milder form, mimicking the symptoms of influenza [1]. Each year, there are approximately just over 500 cases of LD reported in England and Wales [2], whereas in the USA, there are approximately 10000 cases each year [3], with a case fatality rate of 10% [4]. *Legionella* are opportunistic bacterial pathogens which are predominantly associated with human-made building water systems, and infection occurs where residents or others associated with *Legionella*-positive water systems within the housing breathe in small droplets of contaminated water that contains *Legionella* organisms. Showers and showerheads provide ideal environments for *Legionella* proliferation and exposure and have often been proposed as a source of sporadic, community-acquired legionellosis [5], especially if the water has been allowed to

stagnate in the showerhead, due to periods of inactivity and lack of use.

Prior to COVID-19, a study of 160 water samples from showerheads or taps from recreational centres showed that 41/160 samples (25.6% overall; 57.1% hotels and 41.2% sports centres) were positive for *Legionella* [6].

In spring 2020, the emergence of COVID-19 disease, caused by the SARS CoV2 coronavirus, led to the closure of close contact services, including highstreet hair dressing salons, as well as barber shops, in order to help prevent the transmission of the coronavirus between clients and staff, as well as from client-to-client. This closure of premises lasted for several weeks, with the re-opening and subsequent re-closure due to emerging public health regulations. Overall, such actions has created a scenario in which water has been allowed to stagnate for long periods of time over the summer months with elevated temperatures in pipework, tubing and showerheads

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**Abbreviation:** LD, legionnaire's disease.

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in such establishments. In an attempt to prevent the potential aerosolization of *Legionella* on re-opening of these services and to protect staff and customers, various guidelines have been introduced to help protect public health. The Chartered Institute of Environmental Health (CIEH) has published guidelines [7] to mitigate the risk from *Legionella* in water systems, including: (i) run all taps for approximately 5 min, (ii) raise the temperature of hot water tanks to at least 60°C or above to ensure any *Legionella* bacteria are killed, (iii) disinfect all tap areas and sinks, and (iv) seek guidance from a competent water treatment consultant to assist with the re-opening of swimming, hydrotherapy or jacuzzi pools, which were not drained prior to closing down. Importantly, these guidelines help inform business owners, where needed, to descale and disinfect showerheads, although no advice is given as to how best to disinfect showerheads. Equally, many showerhead manufacturers do not offer such advice, but rather give instructions as to how to descale showerheads from an accumulation of limescale.

Given the importance of disinfecting showerheads from *Legionella* species and the lack of instructions as to how to successfully achieve this, the aim of this study was therefore to examine the ability of domestic steam disinfectors to successfully disinfect showerheads from *Legionella* species, thus helping to protect employee and customer safety.

## METHODS

### Description of organisms employed

*Legionella pneumophila* [ $n=3$ ; *L. pneumophila* serogroup 2–15 (wildtype environmental water isolate); *L. pneumophila* serogroup 1 NCTC11192 (reference strain); *L. pneumophila* serogroup 1 (wildtype environmental water isolate)], *L. erythra* (wildtype environmental water isolate) and *L. bozemanii* CRM11368M (reference strain) were examined in this study. All *Legionella* organisms were subcultured on *Legionella* CYE (LCYE) agar base (CM0655; Oxoid) containing: activated charcoal (2 g l<sup>-1</sup>), yeast extract (10 g l<sup>-1</sup>) and agar (13 g l<sup>-1</sup>), which was supplemented with *Legionella* BCYE Growth Supplement (Oxoid SR0110), containing buffer/potassium hydroxide (10 g l<sup>-1</sup>), ferric pyrophosphate (0.25 g l<sup>-1</sup>), L-cysteine HCl (0.4 g l<sup>-1</sup>) and  $\alpha$ -ketoglutarate (1.0 g l<sup>-1</sup>), as well as *Legionella* (GVPC) selective supplement (Oxoid SR0152) containing glycine (ammonia free; 3 g l<sup>-1</sup>), vancomycin hydrochloride (1 g l<sup>-1</sup>), polymyxin B sulphate (80000 IU l<sup>-1</sup>) and cycloheximide (80 mg l<sup>-1</sup>). Isolates were cultured in a humid atmosphere containing 2.5% (v/v) CO<sub>2</sub> at 35°C. Individual inocula of each organism were freshly prepared by adding a 48 h culture into Maximum Recovery Diluent (Oxoid CM0733) to give a mean combined inoculum of *Legionella* organisms of  $2.33 \times 10^5$  (log<sub>10</sub> 5.37) c.f.u. ml<sup>-1</sup>.

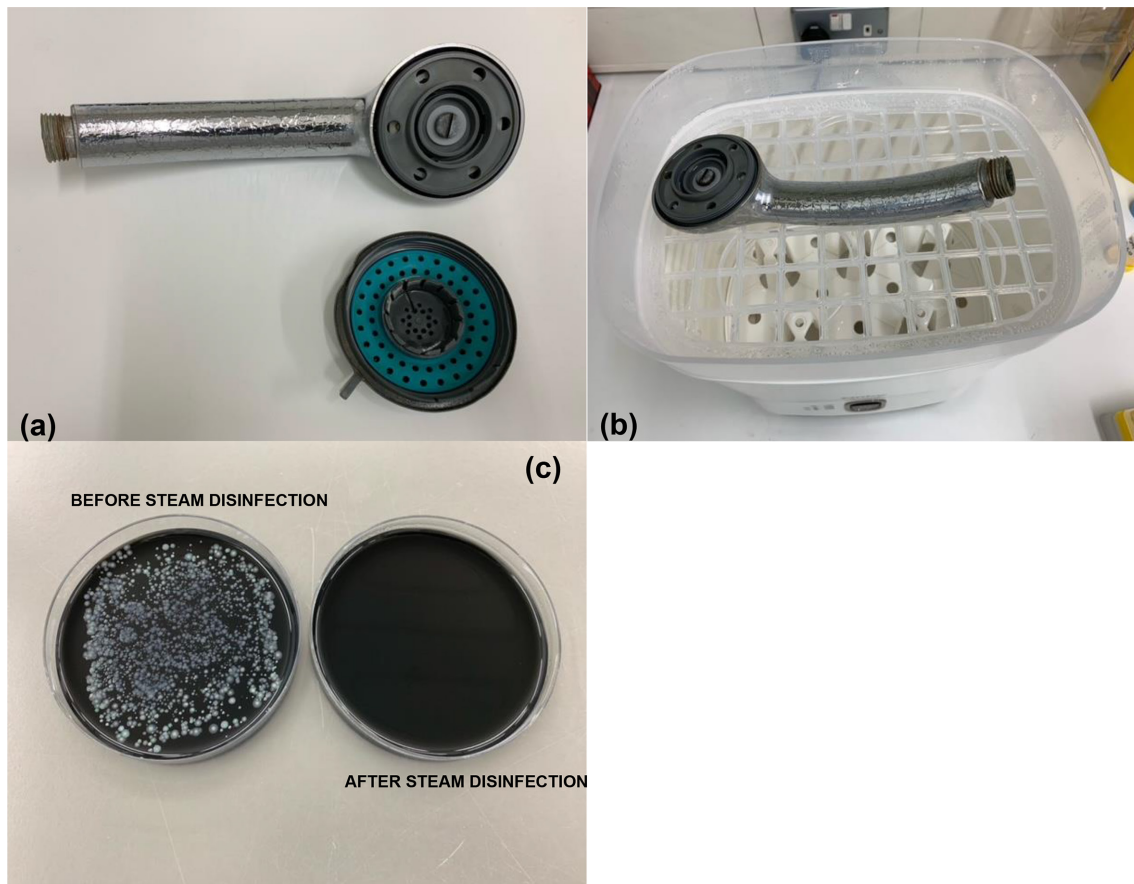
### Disinfection of showerhead employing domestic steam disinfectors

The 'Nuby Natural Touch Steriliser and Dryer' (Model number: BB1022-GS; 220–240V; 50–60 Hz; 650 W; Nuby UK) domestic steam disinfectors device was examined in this

study, as previously described [8]. Briefly, this domestic baby bottle steam disinfectors device consists of five components: base, main body, lower tray, upper tray and lid. The lower layer is designed to hold five baby bottles upside down via locators, with the top layer used for accessories (teat and screw rings). The device can be operated solely in disinfection mode, as well as in disinfection + drying mode [short drying time (15 min) or long drying time (30 min)], where in the latter mode, the fan dryer commences 2 min after the disinfection mode has ended, without any further heating. All steam disinfection studies were performed at GPS coordinates 54588699, -5.942102 (54° 35' 19.3" N 5° 56' 31.6" W) at 12 m above sea level. In brief, the device was disassembled, water (90 ml) was placed in the heating element reservoir and the device was re-assembled for immediate disinfection of the showerhead. A plastic showerhead (Mira Flex; Kohler Mira) was disassembled by unscrewing the front plate and was sterilized by autoclaving at 121°C for 15 min at 15 p.s.i. (Fig. 1a). The device was placed aseptically on the upper layer of the baby bottle steam disinfectors (Fig. 1b). A combined inoculum of *Legionella* organisms (1000  $\mu$ l), as prepared above, was added aseptically to the inner ring of the showerhead and disinfected in the device without drying. On completion of the disinfection cycle, the disinfected showerhead was allowed to stand for 3 min, after which disinfected inocula (100  $\mu$ l) were removed and plated onto BCYE or GVPC agar and incubated as described above. In addition, disinfected inocula (100  $\mu$ l) were enriched in BCYE broth (10 ml), consisting of LCYE base (without agar) + BCYE growth supplement and incubated for 48 h at 37°C. Following enrichment, inocula were subsequently plated onto BCYE or GVPC agar and incubated as described above. Plates were further incubated for 1 week. The experiment was replicated four times. In addition, two controls were set up: (i) examining the survival of all *Legionella* organisms in Maximum Recovery Diluent (Oxoid CM0733) for the same duration as in the steam disinfectors; and (ii) two reference strains, *L. pneumophila* serogroup 1 NCTC11192 and *L. bozemanii* CRM11368M, were placed on the showerhead without disinfection for the same duration. Following completion of control conditions, the organisms were tested for survival by culturing as described above.

## RESULTS

Application of disinfection using the domestic steam disinfectors device employed under the manufacturer's instructions resulted in the eradication of all legionellae, equating to a log<sub>10</sub> 5.37 reduction (Fig. 1c). Furthermore, no organisms could be recovered after disinfection and following non-selective microbiological enrichment, demonstrating the absolute eradication of all viable *Legionella* organisms. All organisms survived in the controls, both in the Maximum Recovery Diluent, as well as on the showerhead that had not been disinfected, demonstrating that all organisms remained viable throughout the experiment, as well as that the showerhead was not intrinsically antimicrobial.



**Fig. 1.** (a) Disassembly of the showerhead. (b) Positioning of the showerhead in the upper layer of a domestic steam disinfectant. (c) Culture of *Legionella* species before steam disinfection (left) and after steam disinfection (right).

## DISCUSSION

This study examined the performance of steam disinfection using a domestic steam disinfectant device for the disinfection of showerheads contaminated with *Legionella* species. Recently, our group reported on the thermal performance of baby bottle steam disinfectors in the hospital-at-home setting [8]. That study showed that such steam disinfectors can reach temperatures of 100 °C [8].

Following disinfection, we were unable to recover any organisms from disinfected showerheads, either with direct plating onto *Legionella* agar or via non-selective *Legionella*-specific enrichment techniques. In order to ensure that we did not miss any potentially surviving but sub-lethally heat-stressed organisms, we conceived and performed novel bacteriological enhancement to ensure optimal recovery. For this, we introduced a novel non-selective broth-based *Legionella*-specific enrichment (containing cysteine) to improve recovery of potentially sub-lethally heat-stressed cells. Even with such enhanced bacteriological techniques, we were unable to recover any organisms, demonstrating that the heat stress applied was lethal to all strains examined.

Previous thermal inactivation studies for *Legionella* have shown that the inactivation kinetics of the five *Legionella* strains fit a first-order model [9]. At 50 °C, *L. longbeachae* ATCC 33462 was the most sensitive strain, reaching a 5-log inactivation after a 20 min exposure. At higher temperatures, *L. pneumophila* strains reached a 4-log reduction in a range between 2–4 min at 60 °C and 1 min at 65 and 70 °C. Given these heat inactivation data, the time/temperature profiles achieved by the baby bottle steam disinfectant device [8] would exceed these requirements, and hence the device was able to eradicate all *Legionella* organisms on the contaminated showerhead in the current study.

Unlike other *Legionella* control measures, including flushing with large volumes of water or chemical disinfection, as a physical disinfection method, steam disinfection has the ability to heat up the entire device absolutely and is not compromised by biofilm and limescale that may harbour *Legionella* organisms and compromise the efficiency of the former control methods. This method of *Legionella* control in showerheads may have wider uptake than just hairdressing salons, barber shops or gyms, but may be adopted by any establishment which uses showerheads, including hotels,

student accommodation, hospitals, holiday homes and the domestic setting. Operators of commercial establishments, including hairdressing salons, barber shops and gyms, should ensure that showerheads are made of materials that are able to withstand regular steam disinfection and to avoid the use of rain showers or similar devices which are not amenable to dismantling and disinfection by steam on a regular basis. Further advice and guidance on *Legionella* control in water systems may be obtained from the Health and Safety Executive [10].

In conclusion, domestic steam disinfection employing baby bottle disinfectant devices, when performed properly under the manufacturer's instructions, offers a relatively inexpensive, simple, versatile and widely available technology for the elimination of *Legionella* species from contaminated showerheads. We therefore advocate the regular employment of such devices to disinfect showerheads and shower tubing in hairdressing salons, barber shops and gyms, as in other establishments and homes that employ showerheads, as a critical control in the elimination of these organisms from these sources, thereby enhancing customer/client/staff safety.

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#### Author contributions

B.C.M.: conceptualization; formal analysis; investigation; methodology; visualization; roles/writing - original draft; writing - review and editing. J.F.: methodology; writing - review and editing. A.M.: methodology; writing - review and editing. N.R.: methodology; writing - review and editing. J.E.M.: conceptualization; formal analysis; investigation; methodology; visualization; roles/writing - original draft; writing - review and editing.

#### Conflicts of interest

The authors declare that there are no conflicts of interest.

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