

A pilot study comparing the efficacy of the Medi-Shower silver impregnated showerhead and hose to fixed and adjustable showerheads in a healthcare environment

Introduction

Showers are a necessity in many healthcare premises for patient and staff welfare. However, they present a foreseeable risk of nosocomial waterborne infection from the inhalation of *Legionella* and other bacteria, and fungal spores such as those produced by *Aspergillus fumigatus*. The direct contact of water contaminated with *Pseudomonas aeruginosa*, *Stenotrophomonas maltophilia* and other commonly occurring waterborne bacteria discharged from shower outlets onto open wounds and burns can result in morbidity and mortality.

Healthcare showers can remain unused for long periods of time notably where patients have limited mobility, or may choose not to shower. Showers can also be misused and contaminated by patients and staff. Concern has been raised about the role of showers in supporting and transmitting multi-antibiotic resistant bacteria such as carbapenemase producing enterobacteriaceae (CPE) which is now a widespread problem throughout Europe according to the European Centre for Disease Prevention and Control's `EuSCAPE project 2013

Maintenance of showerheads

Showers can be difficult to maintain, particularly in clinical areas, where they may not always be accessible to maintenance staff. Furthermore, showerheads and associated flexible hoses hold water at ambient temperatures, there are low flow areas within the showerhead, and showers commonly contain materials which support the growth of microorganisms, including waterborne pathogens such as *Legionella* and *Pseudomonas* species.

The traditional procedure of removing showerheads quarterly and submerging them in a hypochlorite and descaling solutions for several minutes is difficult to audit retrospectively. It is also a costly process involving many hours of maintenance staff activity and it also presents additional logistical and health and safety issues, e.g. accidental mixing of sodium hypochlorite and an acid de-scalant can result in the release of noxious chlorine gas.

Additionally, many showerheads currently found in healthcare premises cannot be readily dismantled for cleaning as recommended in HTM04-01, so while cleaning may be taking place, bacteria in air pockets and inaccessible parts of a showerhead are not affected and recolonisation of the head and hose reoccurs within days.

HTM04-01 indicates that the rate at which showers become colonised with bacteria is subjective, and so the adopted frequency of quarterly cleaning may not be sufficient. The frequency of cleaning showers in healthcare settings should now be determined by risk assessment, which should consider available evidence on the rate of visual biofouling and results of microbiological testing.

However, these efforts may be in vain, for even if the frequency of cleaning and disinfection were to be increased, this does not provide any residual antimicrobial activity.

Heavy metals such as copper and silver are known to have antimicrobial properties and this has been utilised for the control of waterborne pathogens by the direct dosing of copper and silver ions into water. More recently, silver has also been encapsulated into rigid polymer showerheads which manufacturers claim also has antimicrobial properties and may inhibit the accretion and development of biofilms containing opportunistic waterborne pathogens.

Trial

As part of a multifaceted approach to reduce recurrent colonisation and infection of patients with CPE in two wards of a large NHS teaching hospital, anti-microbial silver impregnated shower heads and hoses manufactured by Medi-Shower were installed with the approval of the Trust Water Safety Group at six shower outlets chosen at random from across the two acute medical wards where CPE positive patients were received.

The existing showers that were chosen to be replaced with Medi-Showers were fitted with a mixture of fixed and adjustable showerheads. The latter are still commonly found in NHS hospital Trusts, despite being contraindicated in HTM04-01 due to difficulties in cleaning them, and their increased propensity for retaining biofilm.

A procedure was agreed for sampling of the existing and replacement shower heads and hoses to ensure a consistent and reproducible approach to the evaluation. This included first catch (pre-flush) water samples collected aseptically from the six showerheads weekly for two weeks before being replaced with Medi-Shower silver impregnated heads and hoses.

The original showers were placed in sterile bags and taken to UKAS accredited laboratory Cheshire Scientific where they were dismantled. Swab samples were collected from the inner surfaces and outer shower rose to identify the range of microorganisms present in conventional fixed and adjustable showerheads.

Medi-Shower silver impregnated showerheads and hoses were fitted to the six shower outlets and tested weekly for nine weeks. Three of the Medi-Shower outlets were then cleaned, descaled, disinfected and the silver impregnated and colour coded removable shower rose was replaced. The remaining three Medi-Showers had only the coloured rose inserts changed. Cleaning and disinfection was not carried out on these three showers.

The showers were then tested for a further four weeks to assess the effectiveness of the clean and disinfection compared to when just the shower rose insert was changed.



All results are displayed as follows:

Legionella = CFU/L, Pseudomonas = CFU/100ml, TVC = CFU/100ml

Trial

Two of the original six showerheads (Ward 1 - Shower 1 - Near” & “Ward 2 – Shower 3 – far) were adjustable showerheads of different construction. The remaining four showerheads were standard Trust approved showers with non-adjustable showerheads. Water samples were collected weekly for two weeks from each of the showers and tested for general heterotrophic organisms (TVC) at 22 and 37°C, Legionella and *Pseudomonas aeruginosa*.

Legionella bacteria were found in three of the shower outlets, two of these tested positive for the bacteria on two consecutive weeks. *Pseudomonas aeruginosa* was also detected at two different shower outlets on two consecutive weeks. TVC counts ranged from 50 to 12,960 cfu/100ml at 37°C and 100 to 6,640 cfu/100ml at 22°C.

Sample Location	Standard showerheads wk1				Standard showerheads wk2			
	01/02/2016				06/02/2016			
	TVC 22	TVC 37	Legionella	Pseudomonas	TVC 22	TVC 37	Legionella	Pseudomonas
Ward 1 - Shower 1 - Near 	1130	2450	<1	104	1730	1500	88	>150
Ward 1 - Shower 2 - Mid	4840	12960	140	<1	6640	9680	10	<1
Ward 1 - Shower 3 - Far	2140	3180	<1	<1	3210	2100	0	<1
Ward 2 - Shower 1 - Near	100	50	<1	<1	130	50	0	<1
Ward 2 - Shower 2 - Mid	2130	1100	<1	22	1820	800	0	>150
Ward 2 - Shower 3 - Far 	1260	800	40	<1	1760	1020	120	<1

 = Adjustable spray showerheads

Following the initial two weeks of baseline sample collection, the showers were removed aseptically, sealed in sterile bags and transported to Cheshire Scientific laboratory where they were dismantled and swabbed.



Adjustable showerhead



Dismantled adjustable showerhead with areas of low flow and EPDM rubber components. There was a distinct smell of stagnation when disassembled



Biofilm recovered from swab of adjustable showerhead



Visible biofilm on internal surface of shower rose

The following bacteria were recovered from swabbing of the existing showerheads. The majority of bacterial species recovered from these showerheads have been associated with infection. Notable amongst those recovered were *Stenotrophomonas maltophilia*, *Pseudomonas aeruginosa*,

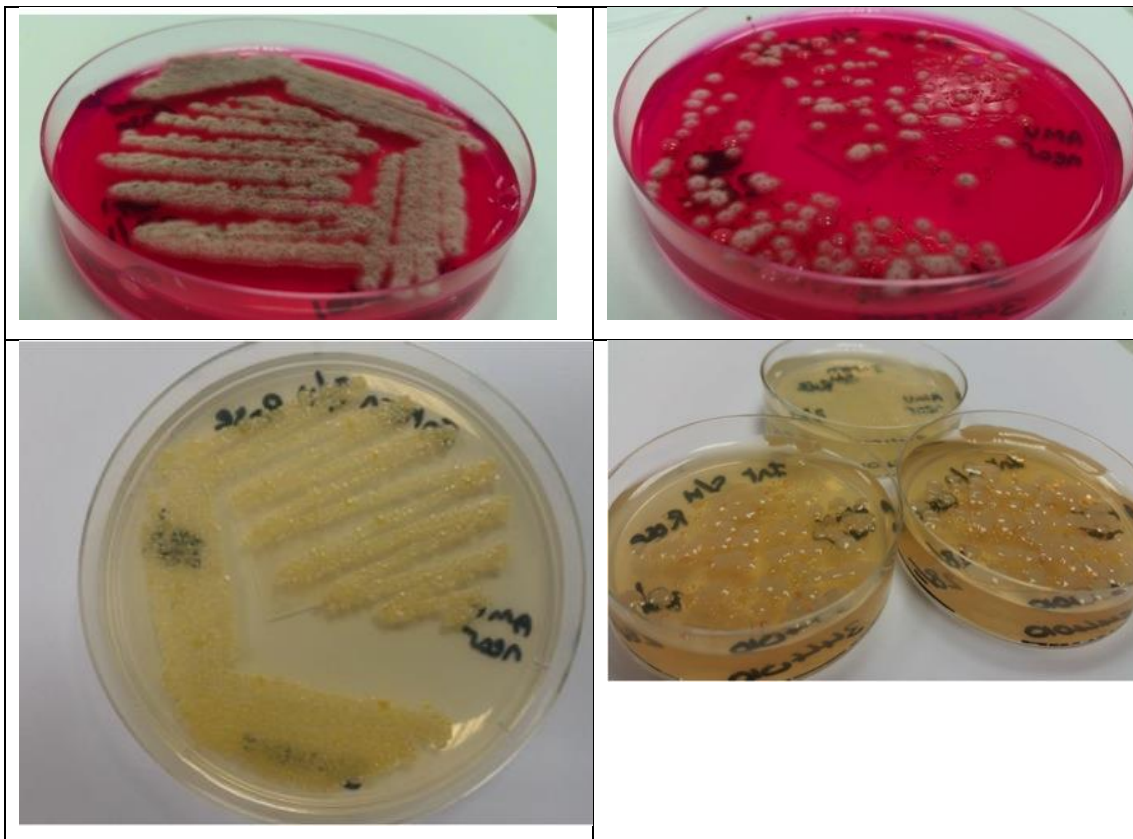
Legionella pneumophila, *Aeromonas hydrophila*, and *E. coli* which is an indicator of faecal pollution.

Bacteria recovered from standard and adjustable showerheads

Sample Location	Showerheads removed, dismantled and swabbed
Ward 1 - Shower 1 - Near +	<i>Stenotrophomonas maltophilia</i> , <i>Pseudomonas aeruginosa</i> , <i>Aeromonas hydrophila/caviae</i> , <i>Achromobacter xylosoxidans</i>
Ward 1 - Shower 2 - Mid	<i>Pseudomonas aeruginosa</i> , <i>Pseudomonas luteola</i> , <i>Legionella Pn</i> , <i>Stenotrophomonas maltophilia</i>
Ward 1 - Shower 3 - Far	<i>Aeromonas hydrophila/caviae</i> , <i>Stenotrophomonas maltophilia</i>
Ward 2 - Shower 1 - Near	<i>Kocuria varians/rose</i> , <i>Pseudomonas fluorescens</i> , <i>Pseudomonas luteola</i>
Ward 2 - Shower 2 - Mid	<i>E. coli</i> , <i>Coliforms</i> , <i>Aeromonas salmonicida masoucida/achromogenes</i> , <i>Pseudomonas luteola</i> , <i>Achromobacter xylosoxidans</i>
Ward 2 - Shower 3 - Far +	<i>Aeromonas salmonicida masoucida/achromogenes</i> , <i>Pseudomonas luteola</i> , <i>Legionella bacteria (not pn)</i>

+ = Adjustable spray showerheads

Agar plates showing bacteria recovered from existing standard and adjustable showerheads



The existing showers were removed and replaced with Medi-Shower silver impregnated showerheads and hoses immediately after the second week of baseline testing. Water samples were collected weekly for a further nine weeks.

Ward 1 - shower 3 – far, was discovered to have been damaged on week 4 (08/03/16) and was replaced with a conventional fixed showerhead (non Medi-Shower). The broken shower had been repaired by clinical staff by tying latex gloves around the showerhead.

The Estates team had not been informed of the damaged shower head by ward staff or the temporary repair, which is against Trust policy. It was also noted that the shower hose was excessively long and the showerhead was able to reach the floor of the shower cubicle, which contravenes Water Quality Regulations, and may facilitate contamination of the showerhead. A shorter silver impregnated hose was fitted shortly after this observation.

A pre flush (first catch) sample was collected from the damaged shower before it was removed and transported to the laboratory for analysis. A shorter Medi-Shower hose and standard non-adjustable shower outlet were fitted at this outlet.



The damaged Medi-Shower outlet repaired by ward staff.

Internal structure of the showerheads

The existing showerheads (standard and adjustable) allow water to pass into the entire body of the showerhead before passing through the shower rose. The water also comes into contact with rubber seals, O rings, and washers. There were areas of potential low flow in the non-adjustable showerheads and in sections of the adjustable showerheads where water could become trapped and stagnate.

Several of the adjustable and fixed showers could not be opened and had to be placed in a sterile bag and broken open with a hammer. It was evident that these showerheads had never been dismantled and cleaned as recommended in HTM 04-01.

The Medi-Shower colour coded rose is connected by a luer lock fitting and it was easily removed for cleaning/replacement. It contained no obvious areas that would accumulate debris or stagnant water. Water entering the showerhead passes through a smooth bore fixed internal tube which is silver impregnated. This helps prevent creating areas of low flow within the showerhead where biofilm can accumulate, which would also be deterred by the antibacterial silver impregnated in the plastic showerhead.



Internal tube structure within the Medi-Shower head through which water is channeled

Results

Pseudomonas aeruginosa

Following the installation of Medi-Shower silver impregnated showerheads and hoses, *Pseudomonas* was only detected in 5 of 71 (7%) water samples, compared with a positivity of 9/18 (50%) in water samples collected from the original non- silver impregnated showerheads.

Two of the standard showerheads tested positive for *Pseudomonas* on two consecutive weeks. Silver impregnated showerheads, which tested positive for *Pseudomonas*, were negative when retested the following week without the intervention of remedial works.

Legionella

Legionella bacteria were detected in 5/18 (27%) of the water samples collected from original showerheads, and in only 2/71 (2.8%) of samples collected from the Medi-Showers.

Legionella was recovered on two consecutive weeks from the original showerheads. Consecutive Legionella positive samples did not occur with the silver impregnated Medi-Shower.

TVC

TVC results fluctuated throughout the trial as expected in operational healthcare showers. However, TVC counts were notably higher in the water samples collected from the existing standard showerheads than those collected from the Medi-Shower showerheads.

On average, water samples collected from standard showerheads and incubated at 22°C contained around four times the number of heterotrophic organisms (TVC) than samples recovered from Medi-Showers. When incubated at 37°C, the mean TVC in the standard showerheads was more than seven times higher than TVCs from Medi-Showers.

Mean TVC results from Medi-Shower and the original showers

	Standard Shower TVC @ 22°C	Medi-Shower TVC @ 22°C	Standard Shower TVC @ 37°C	Medi-Shower TVC @ 37°C
No. of samples	18	73	18	73
Mean count	5353 cfu/ml	727 cfu/ml	2692 cfu/ml	646 cfu/ml

Ecoli and Coliforms

E. coli was not detected in any of the samples. Coliforms were detected in three samples from Medi-Showers (Ward 1 shower 1, and Ward 2 showers 2 and 3).

No additional samples were collected following these results due to the scheduled conclusion of this trial and it is not known if the contamination was localised or present in the incoming mains supply at the time of sample collection.

Clean and disinfection of the showerhead and hose, and changing of the shower rose

Ward 1 – Medi-showers 1 and 2 were cleaned and disinfected using the Tristel Legion disinfecting and descaling foam, and the rose inserts changed in Week 9 (23/05/16) while Ward 2 - Showers 1,2, and 3 had the rose inserts changed only and were not disinfected as above. A new Medi-Shower silver impregnated shower head was fitted to Ward 1 – Shower 3 at the same time.

The Legion disinfecting and descaling foam was applied to all wetted surfaces of the showerhead and left for a period of five minutes.

TVC results indicate that the installation of a new Medi-Shower head, and replacement of the rose insert combined with cleaning and disinfection, were the most effective antibacterial measures.

Where cleaning and disinfection was not carried out and only the shower rose inserts were changed, the TVC results remained similar to those samples collected before this intervention.

Results following disinfection, and replacement of rose inserts in Medi-showers

Sample Location	23/05/2016	Medishower wk 9 Post-disinfection and rose insert change 23/05/2016				Medishower wk 10 06/06/2016				Medishower wk 11 13/06/2016			
		TVC 22	TVC 37	Legionella	Pseudomonas	TVC 22	TVC 37	Legionella	Pseudomonas	TVC 22	TVC 37	Legionella	Pseudomonas
Ward 1 - Shower 1 - Near	Disinfected and roses changed	<10	<10	0	<1	<10	270	0	<1	10	40	0	<1
Ward 1 - Shower 2 - Mid		<10	<10	0	<1	<10	<10	0	<1	2400	3300	0	<1
Ward 1 - Shower 3 - Far	New Medishower installed	<10	<10	0	<1	<10	<10	0	<1	430	530	0	<1
Ward 2 - Shower 1 - Near	Roses changed only (no disinfection)	<10	560	0	36	740	3040	0	<1	120	110	120	<1
Ward 2 - Shower 2 - Mid		560	800	0	<1	220	2520	0	<1	550	1300	0	<1
Ward 2 - Shower 3 - Far		<10	140	0	<1	10	130	0	<1	540	860	0	<1

Pseudomonas bacteria were detected at 36cfu/100ml in Ward 2 - Shower 1 after the rose insert was changed, but this outlet tested negative in the next samples collected (week 10).

The standard showerhead on ward 1 (Shower 3) was disinfected on the 27/03/16 following two consecutive Pseudomonas positive water samples collected in Week 5 (14/03/16) and Week 6 (21/03/16).

While Pseudomonas was not detected in the sample collected in Week 7, TVC counts at 22°C increased more than three fold from 8,160cfu/ml to 28,320 cfu/ml, and at 37°C there was almost a twenty fold increase from 430 cfu/ml to 8,480 cfu/ml.

The standard shower outlet tested positive for pseudomonas again in Week 8

Results following clean and disinfection of standard showerhead

Sample Location	29/03/2016	Medishower wk 7 29/03/2016				Medishower wk 8 04/04/2016				Medishower wk 9 Pre-disinfection and rose insert change 23/05/2016			
		TVC 22	TVC 37	Legionella	Pseudomonas	TVC 22	TVC 37	Legionella	Pseudomonas	TVC 22	TVC 37	Legionella	Pseudomonas
Ward 1 - Shower 1 - Near		250	170	0	<1	50	250	0	<1	<10	<10	0	<1
Ward 1 - Shower 2 - Mid		<10	<10	0	<1	5440	6640	0	<1	<10	<10	0	<1
Ward 1 - Shower 3 - Far	Remedial action carried out (C&D)	28320	8480	0	<1	24010	1460	0	38	<10	<10	0	<1
Ward 2 - Shower 1 - Near		10	10	0	<1	440	10	0	<1	<10	30	0	<1
Ward 2 - Shower 2 - Mid		No access - sample not collected				210	680	0	<1	700	980	0	<1
Ward 2 - Shower 3 - Far		<10	10	100	<1	50	250	0	<1	<10	10	0	<1

⊕ = Standard showerhead cleaned and disinfected

Conclusion

Water samples collected from the silver impregnated Medi-shower were much less likely to test positive for *Pseudomonas aeruginosa* and Legionella than the standard showerheads. TVC's at 22 and 37°C were significantly lower in water samples collected from the Medi-shower silver impregnated showerheads and hoses than from the standard fixed and adjustable showerheads.

The results suggest that cleaning and disinfection (C&D) of standard showers may actually increase total bacterial counts (TVCs) A combination of C&D and changing rose inserts in the Medi-shower outlets reduced TVC counts to undetectable levels for several weeks before recolonisation occurred.

The results suggest that the silver impregnated Medi-shower showerheads and hoses are less likely to become colonised with Legionella and Pseudomonas and they reduce levels of general heterotrophic bacteria detected in shower water.

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Raw trial data

Sample Location	Medishower heads and hoses fitted	Medishower wk 1 12/02/2016				Medishower wk 2 22/02/2016				Medishower wk 3 29/02/2016			
		TVC 22	TVC 37	Legionella	Pseudomonas	TVC 22	TVC 37	Legionella	Pseudomonas	TVC 22	TVC 37	Legionella	Pseudomonas
		Ward 1 - Shower 1 - Near	60	180	0	58	590	130	0	<1	210	180	0
Ward 1 - Shower 2 - Mid	<10	<10	0	<1	<10	<10	0	<1	950	1120	0	>150	
Ward 1 - Shower 3 - Far	80	120	0	<1	300	480	0	<1	120	80	0	<1	
Ward 2 - Shower 1 - Near	<10	<10	0	<1	200	10	0	<1	10	40	0	<1	
Ward 2 - Shower 2 - Mid	1880	1940	0	<1	330	420	0	<1	10	<10	0	<1	
Ward 2 - Shower 3 - Far	820	560	0	<1	40	<10	0	<1	20	20	0	<1	

Sample Location	Medishower wk 4 08/03/2016				Medishower wk 5 14/03/2016				Medishower wk 6 21/03/2016			
	TVC 22	TVC 37	Legionella	Pseudomonas	TVC 22	TVC 37	Legionella	Pseudomonas	TVC 22	TVC 37	Legionella	Pseudomonas
	Ward 1 - Shower 1 - Near	1680	1080	0	<1	12560	7360	0	<1	2800	820	0
Ward 1 - Shower 2 - Mid	570	600	0	<1	240	60	0	<1	10	10	0	<1
Ward 1 - Shower 3 - Far	10	200	0	<1	8960	2200	0	86	8160	430	0	>150
Ward 2 - Shower 1 - Near	80	200	0	<1	2440	520	0	<1	20	10	0	<1
Ward 2 - Shower 2 - Mid	20	10	0	<1	5640	2400	0	<1	2280	1080	0	<1
Ward 2 - Shower 3 - Far	2800	2520	0	<1	10	10	0	<1	60	80	0	<1

Sample Location	Medishower wk 7 29/03/2016				Medishower wk 8 04/04/2016				Medishower wk 9 Pre-disinfection and rose insert change 23/05/2016			
	TVC 22	TVC 37	Legionella	Pseudomonas	TVC 22	TVC 37	Legionella	Pseudomonas	TVC 22	TVC 37	Legionella	Pseudomonas
	Ward 1 - Shower 1 - Near	250	170	0	<1	50	250	0	<1	<10	<10	0
Ward 1 - Shower 2 - Mid	<10	<10	0	<1	5440	6640	0	<1	<10	<10	0	<1
Ward 1 - Shower 3 - Far	28320	8480	0	<1	24010	1460	0	38	<10	<10	0	<1
Ward 2 - Shower 1 - Near	10	10	0	<1	440	10	0	<1	<10	30	0	<1
Ward 2 - Shower 2 - Mid	No access - sample not collected				210	680	0	<1	700	980	0	<1
Ward 2 - Shower 3 - Far	<10	10	100	<1	50	250	0	<1	<10	10	0	<1

Sample Location	Medishower wk 9 Post-disinfection and rose insert change 23/05/2016				Medishower wk 10 06/06/2016				Medishower wk 11 13/06/2016			
	TVC 22	TVC 37	Legionella	Pseudomonas	TVC 22	TVC 37	Legionella	Pseudomonas	TVC 22	TVC 37	Legionella	Pseudomonas
	Ward 1 - Shower 1 - Near	<10	<10	0	<1	<10	270	0	<1	10	40	0
Ward 1 - Shower 2 - Mid	<10	<10	0	<1	<10	<10	0	<1	2400	3300	0	<1
Ward 1 - Shower 3 - Far	<10	<10	0	<1	<10	<10	0	<1	430	530	0	<1
Ward 2 - Shower 1 - Near	<10	560	0	36	740	3040	0	<1	120	110	120	<1
Ward 2 - Shower 2 - Mid	560	800	0	<1	220	2520	0	<1	550	1300	0	<1
Ward 2 - Shower 3 - Far	<10	140	0	<1	10	130	0	<1	540	860	0	<1

Sample Location	Medishower wk 12 21/06/2016					
	TVC 22	TVC 37	Legionella	Pseudomonas	Ecoli	Coliforms
	Ward 1 - Shower 1 - Near	10	180	0	<1	0
Ward 1 - Shower 2 - Mid	170	190	0	>150	Positive	Positive
Ward 1 - Shower 3 - Far	<10	70	0	<1	0	0
Ward 2 - Shower 1 - Near	<10	<10	0	<1	0	0
Ward 2 - Shower 2 - Mid	700	490	0	<1	0	Positive
Ward 2 - Shower 3 - Far	2440	1460	0	<1	0	Positive