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Legionella in Hospital Water Systems - Prevention and Control Measures Conference Report - SCIEH Seminar Day 17th March 2004

Prepared by John Mooney & Martin Donaghy

1. Introduction:

1.1 Legionaires Disease

Legionnaire's disease is a potentially fatal form of pneumonia caused by the *Legionella* bacteria which are distributed widely in both natural and artificial water systems. Although usually associated with larger water systems such as that in hospitals and factories, the bacterium can also contaminate domestic water supplies. Since it thrives particularly at temperatures of between 20 and 45°C and is most commonly acquired by aspiration of contaminated water droplets, any artificially heated water systems which generate a spray or aerosol would present a relatively high risk of becoming a *Legionella* source if not carefully maintained using organised preventative measures (1,2).

Although the disease can affect anybody, the likelihood of being infected and progressing to serious illness is dependent firstly on the type and intensity of exposure and secondly on individual susceptibility. Predictors of higher susceptibility are advanced age / late middle age, smoking, underlying chronic disease or compromised immunity through illness or drug therapy (1,3).

Otherwise healthy individuals exposed to infection may go on to develop the less serious (non-pneumonic) conditions of Pontiac fever and Lochgoilhead fever. Legionellosis is the collective name given to all three clinical manifestations.

While legionnaires' disease remains rare in Scotland, with the majority of cases being imported (from overseas travel or travel within the UK) (4) there were a number of confirmed hospital associated cases in the late 1990s (see Figure 1). Although many hospitals contain air conditioning units (the traditional suspect source), the risk of the infection to patients is much more likely to be a result of contaminated hot and cold water systems to which exposure is more likely. The control measures highlighted at Hospitals in Glasgow, Dundee and Ayrshire later in this report were all implemented over three years ago and it is those initiatives among others that have no doubt helped contribute to the absence of hospital associated cases in the last few years.

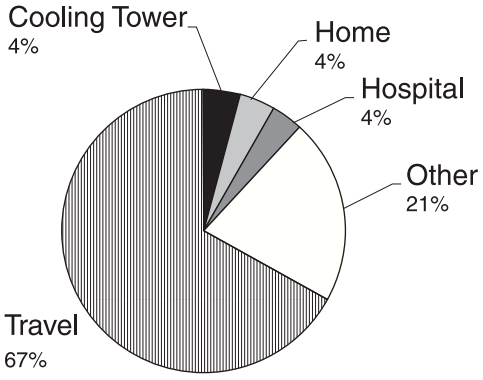

Figure 1. *Legionella* cases in Scotland by presumptive source 1995 -2003

1.2 *Legionella* in Hospitals:

Water distribution systems in hospital buildings are often dated in design and layout as well as being characterised by the presence of long pipe runs (where temperature control is difficult) and an over supply of water outlets (some of which may be used so infrequently that they effectively serve as 'functional dead-legs'). These systems present an ideal environment for *legionnella* bacteria, which have a particular tendency to colonise areas where organic material and waste products from other organisms build up into a 'bio-film' layer that adheres to the inner surface of piping (5). Such bio-films are often stubbornly resistant to disinfection measures once established. Since hospital patients by definition are already themselves not in optimal health, the combination of host vulnerability and pathogen 'support system' can combine to lethal effect. Indeed where the case fatality rate for all Legionnaires' disease is around 10%, that for hospital-acquired infection is in the range 35-40% (6,7).

Additionally, recent international surveys have shown that 12 to 75% of all hospital water systems are contaminated with *Legionella* (8). A patient's risk of acquiring *Legionella* pneumonia is related to the type and intensity of exposure, advanced age, smoking or a chronic underlying disease. Patients undergoing bone marrow or solid organ transplants and other immuno-suppressed patients are at the highest risk for infection.

1.3 Seminar overview

Following the introduction by the Health and Safety Commission of a revised code of practice for the control and prevention of *Legionella* (2), it was recognised that there is currently a diversity of practice within Scotland and the *Legionella* working group felt that the seminar would offer a timely opportunity to pool available expertise about practical prevention and control measures. Primarily aimed at hospital microbiologists, infection control specialists as well as buildings engineers and environmental health officers, the major objective of the meeting was to discuss how best to implement the new guidance in the light of the experiences of participant speakers about practical solutions which are currently working well in Scottish Hospitals. In addition to hearing about the implementation of several successful control regimes and the background to their development (see Table 2: Seminar Programme) participants also benefited from the contributions of two leading UK experts, Mike Arrowsmith, formerly of NHS Estates (who was involved in drafting the new guidance) and Dr John Lee of the UK Health Protection Agency.

2 THE LEGAL FRAMEWORK

2.1 The Legislation

The relevant sections of three major pieces of legislation in the UK come together to inform the legal framework with which those responsible for hospitals and other health care facilities should comply in order to safeguard against risks from *Legionella*:

1. Health and Safety at Work Act 1974.
2. Management of Health and Safety at Work Regulations 1999 (MHSWR)
3. Control of Substances Hazardous to Health Regulations 1999 (COSHH)

The new approved code of practice and guidance (2) is essentially a means of drawing together the different component pieces of legislation and offering the best guide to their interpretation in the light of current evidence. As the document which inspectors will now use to assess compliance, it represents an important resource for those with legal responsibilities for minimising the risk from *Legionella*. Among the important changes to previous UK guidance there is now no longer a 300 L threshold for water systems below which the risk from the infection can be discounted. In consequence, all institutions which provide residential accommodation (eg: including smaller health care facilities and institutional care homes), must now comply with the guidance. The other main changes to the guidance include (9):

- Keeping records for a minimum of five years
- Water treatment companies and consultants must show that their treatment is effective.
- Details on all aspects of risk assessment and control
- Inclusion of tables which detail the monitoring requirements for cooling towers and hot and cold water systems.

2.2 Assessing the Risk

The essential starting point in managing and minimising any risk to health that may arise in the workplace is first and foremost to undertake a full and comprehensive assessment as to the true extent of the risk involved. In conducting a risk assessment for *Legionella* the following questions need to be considered:

- Are conditions right for bacteria to multiply? eg: is the water temperature between 20°C and 45°C?
- Are there areas where stagnant water occurs (eg: "dead-legs" - an example would be pipes to an appliance that is no longer in use)
- Are there infrequently used outlets, eg: showers and taps?
- Is there debris in the system, such as rust, sludge or scale (often a problem in old metal cisterns) that could provide nutrients for bacterial growth?
- Are any employees, residents, visitors etc. particularly vulnerable to infection, eg: older people, those already ill?

Of course in the hospital health/care setting the well established increased vulnerability of the patient population means that a risk is clearly foreseeable anywhere the possibility of exposure may arise.

Table 2: Conference Programme:

09.30	*COFFEE & REGISTRATION*
09.45	Welcome and Introduction **1. Overview of the Seminar and intended aims** - **Dr Martin Donaghy**, Clinical Director, SCIEH
10.00	*Legionella* in the Hospital Environment- A front-line perspective: **2. Scottish situation** - **Dr John Hood**, Consultant Microbiologist, Glasgow Royal Infirmary **3. England & Wales** - **Dr John V Lee**, Consultant Clinical Scientist and Unit Head, Water & Environmental Microbiology Reference Unit, Health Protection Agency, Colindale.
11.00	*TEA AND COFFEE*
11.15	**4. New Guidance and Best Practice** - **Mike Arrowsmith**, Formerly Chief Engineer for Department of Health's NHS Estates Agency
12.00	*LUNCH*
12.45	Teaching/In Practice: Examples **5. Chlorine dioxide** - **Dr John Hood**, Glasgow Royal Infirmary **6. The Silver Copper Way - Dr Gabby Phillips**, Ninewells Hospital **7. The Peroxide solution** - **Drs Alan Macdonald** & **Jim Alderton**, Ayrshire & Arran NHS Board [Ailsa Hospital]. **8. Laboratory Perspective** - **Dr Giles Edwards**, Stobhill Hospital **9. PEFEx Perspective - Mr Eddie McLaughlan** **Questions & Answers: Panel Discussion**
3.30	**10. Conclusion & Recommendations**
3.45	Closing Remarks **Dr Martin Donaghy**

Where a risk has been identified there is a requirement to introduce proper controls, which could include disinfection of the system. The code of practice gives extensive guidance on the choice of appropriate control measures, although none are prescriptive reflecting that the optimal control strategy is best tailored to each unique situation.

2.3 Basic actions required

As the design, maintenance and operation of the system are crucial in controlling the growth of legionella any action taken is likely to include the following (with any additional site specific measures dependant on the results of a risk assessment as outlined above):

- Ensuring water cannot stagnate anywhere in the system eg: remove redundant pipe-work, run taps & showers in unoccupied rooms
- Keep water cisterns covered, insulated, clean and free of debris
- Insulating pipe-work (keep the hot HOT and the cold COLD)
- Maintaining the correct temperature at the calorifier (ie: the hot water cylinder)
- Advising maintenance staff working on the system about the risks and how to minimise them.
- Advising tenants about the risks, the control measures employed and the precautions they can take, such as flushing through showers following a period of non-use.
- Include consideration of other risks which chosen solutions might introduce to the workplace eg: scald risk from high temperatures; chemical risk from biocides etc.

2.4 Monitoring and follow up

Once control measures have been installed that adequately minimise the risk, they must of course be maintained and reviewed regularly by the same risk assessment approach which will take into account any changes to the patient population, the disinfection regime or prevailing environmental conditions. An audit checklist is available from HSE, which systematically covers all aspects of what needs to be considered in reviewing the control measures for both Cooling plant and for hot and cold water systems [ref no.10 Control of Legionella bacteria in water systems – HSE Audit Booklet [see footnote].

3 IMPLEMENTING THE GUIDANCE

3.1 Engineering factors

Comprehensive though they are, the Approved code of practice publication and accompanying audit booklets lack the hands on perspective that can be conveyed by experts in the field who have experience of implementing practical solutions and overcoming problems which may arise.

According to Mr Arrowsmith (former chief engineer for the department of Health's NHS Estates Agency), the main issue is how best to reconcile the requirements of the code of practice to current designs of what can often be antiquated water systems. Most guidance diagrams for example are over simplistic [see figures 2a and b] and more representative of domestic hot water systems than their hospital equivalents. Maintaining cold water below 20°C is also not very practicable when inlet temperature can exceed this in summer months (admittedly more of an issue for the south of England).

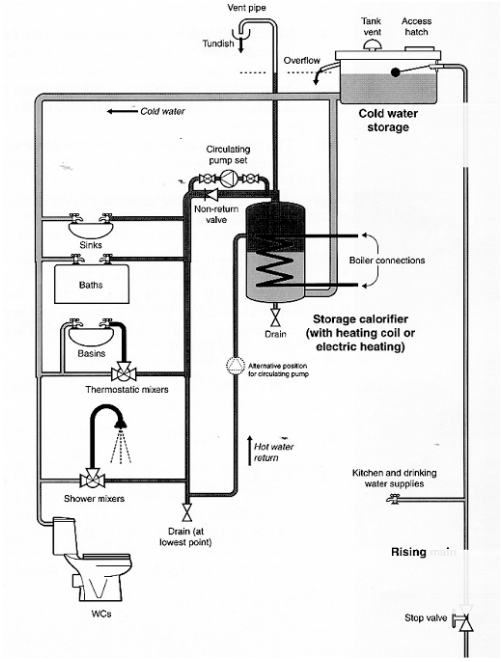

Figure 2a: Diagram from approved code of practice L8

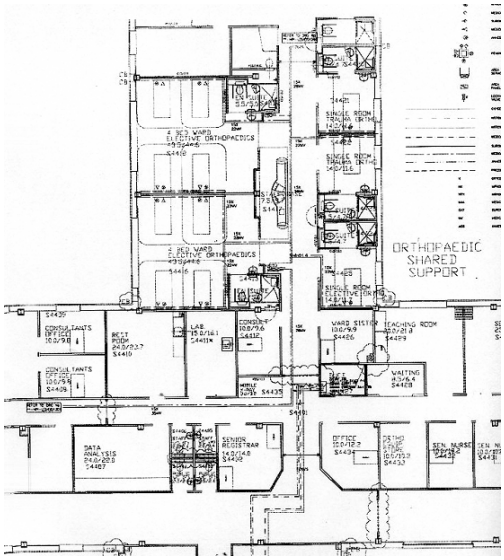

Figure 2b: The Reality!

3.2 Common shortfalls

As consultant clinical scientist and unit head of the Water and Microbiology reference unit (HPA), Dr John Lee has considerable experience of participating in investigations of *Legionella* cases with a suspected nosocomial source. While there is occasionally a Legionella policy in place, it is too often accompanied by an inappropriate sampling protocol (eg: always from the same outlet) or the absence of any form of documented risk assessment, the latter of which has already resulted in legal prosecutions. Other problems commonly encountered were too little cleaning of shower heads, baths and shower rooms used as stores (functional dead-legs if outlets not used), radiators still attached to domestic hot water supply, clinical humidifiers filled with tap water, Nebulisers washed with tap water between uses, too many hand-basins installed, overall poor design and spa pools.

3.3 Recommendations on testing

On the subject of culture testing water systems for the presence of legionella there remains a lack of any international consensus. Notoriously fastidious, *legionella* cultures are difficult to grow and interpretation of a positive result is also hazardous due to the organism's status as a widespread environmental contaminant. While CDC have argued that testing & culturing is not worthwhile (12), Yu et al recommend routine culturing of samples: negative cultures being evidence for low risk and positive ones being an indication for extended active surveillance and decontamination measures (13). Of course water-testing will always have a role to play, even if just to check on the effectiveness of control measures and as with all checks in the system there should be a judgement call depending on the circumstances at the time. Both John Lee and Mike Arowsmith outlined the likely scenarios where an infection control team would consider implementing water testing:

1. Hot water systems where temperatures have been reduced from the recommended range (eg: due to biocide treatment)
2. In systems where desired threshold parameters of the treatment regime (eg: biocide concentrations) are not are not consistently achieved
3. When an outbreak is suspected or has been identified
4. As a routine precaution in wards with patients deemed to be at particularly high risk (eg: immuno-compromised).

Table 3: Action required following *Legionella* sampling in hot and cold water systems

***Legionella* bacteria (cfu/litre) (colony forming units)**	**Action required**
More than 100 but less than 1000:	
(a) One or two positive samples only	(a) If only one or two samples are positive, system should be re-sampled. If a similar count is found again a review of control measures and risk assessment should be carried out to identify any remedial actions.
(b) Majority of samples are positive	(b) If the majority of samples are positive, the system may be colonised, albeit at a low level. Dis-infection should certainly be considered (see below) and an immediate review of control measures and risk assessment carried out to identify any other remedial action required.
More than 1000	The system should be re-sampled and an immediate review of the control measures and risk assessment carried out to identify any remedial actions, including possible disinfection of the system.

[Source: Ref 2 Guidance Notes section of Approved Code of Practice L8].

3.4 Confirmation of sources

In the event of a suspected nosocomial case of *Legionella*, environmental and water samples take on a much greater significance and are often the most important evidence in confirming or discarding a link. Dr Giles Edwards from the *Legionella* Reference Laboratory presented several key instances where environmental samples have proven either hospital water or the patient's domestic water supply as the most likely source. Of course establishing a definite link requires also that a cultured isolate be obtained from the patient and a decline in culture testing towards predominantly confirmation by urinary antigen test that has undoubtably undermined the potential for establishing such links. Where a nosocomial case is suspected therefore it is particularly important to obtain a cultured isolate from the patient for public health reasons as it may definitively highlight shortcomings, or not as the case may be, in control and prevention measures.

4. CONTROL AND PREVENTION MEASURES

4.1 Cleaning and Disinfection [Traditional Approaches and their drawbacks]:

Several of the speakers highlighted the role of disinfection as a first response measure upon initially discovering that their systems were contaminated. Guidance notes 190 and 191 in L8 outline the role of disinfection as important component in the prevention and control of exposure to *Legionella*.

Specifically (extract):

190. Hot water services and, exceptionally, cold water services, should be cleaned and disinfected in the following situations:

a) If routine inspection shows it to be necessary
b) If the system or part of it has been substantially altered or entered for maintenance purposes in a manner which may lead to contamination
c) During or following an outbreak or suspected outbreak of *legionellosis*.

191. Disinfection of the water services may be carried out in two ways:

a) By the use of suitable chemical disinfectants, eg by chlorination when it is necessary to disinfect the whole system including storage tanks.
b) By thermal disinfection, ie: by raising water temperature to a level at which *legionella* will not survive ie: to at least 60°C throughout the system for a minimum of 1 hour. Each tap or appliance also to be run continuously for at least five minutes at the full temperature.

These two traditional means of eradication given in the guidance however, are not without problems of their own. Hyper-chlorination for example has proved disappointing due to high expense, problems with corrosion and relatively poor penetration of the bio-film layer (Ref: 3 & presentation 3). As a longer term means of control at lower concentrations, additional concerns have arisen over the possible generation of carcinogenic by products when free chlorine reacts with organic material.

While the established temperature sensitivity of *Legionella* bacteria should ensure that proper temperature controls are an effective means of prevention (see Figure 3), it is often extremely difficult to maintain temperature parameters in large complex buildings such as hospitals. Additionally, using very high temperatures as an eradication measure is labour intensive, intrinsically hazardous and contamination often recurs within a month (3,13).

4.2 Newer disinfection technologies

In Common with available international evidence, mainly from the US, the presenters of the seminar case studies often reported

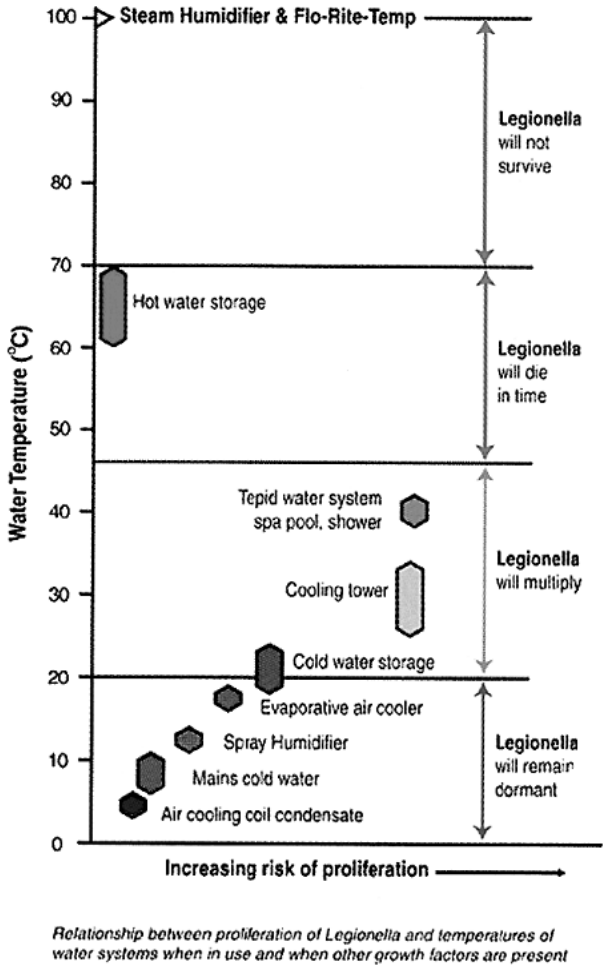

Figure 3. Temperature range for *legionella* in water systems

a history of unsatisfactory control achieved with both temperature alone and chlorination methodologies, which had prompted them to consider newer solutions.

The case-studies themselves concentrated on three possible disinfection strategies with which guest speakers had direct experience: Chlorine dioxide (Dr John Hood, Glasgow Royal Infirmary), Silver/Copper ionisation (Dr Gabby Phillips, Ninewells hospital) and Silver Catalysed Hydrogen

Peroxide (Drs Alan Macdonald and Jim Alderton). Presenters gave an overview of the decision making process that led to the introduction of their respective control methods and of the benefits and lessons learned from each system. As a guide to navigating the complexity of such decisions and rapidly comparing the benefits of different systems, Stout and Yu have proposed an evaluation framework with four sequential criteria (13):

1. Demonstrated efficacy in *Legionella* eradication in vitro using laboratory assays.
2. Anecdotal experience in preventing legionnaires disease in individual hospitals.
3. Controlled studies in individual hospitals
4. Validation in confirmatory reports from multiple hospitals during a prolonged period of time (eg: over 5 years).

Of Stout and Yu's four test criteria outlined above (5.1) both Chlorine Dioxide (CLO2) and Silver / copper ionisation (Ag/Cu) have now clearly fulfilled each test. For the third method discussed (viz: silver catalysed hydrogen peroxide or Ag/H2O2), criteria 4 is still somewhat lacking although this is mainly as a result of its limited widespread use to date). All presentations are available on the SCIEH Website [http://www.show.scot.nhs.uk/scieh/] and the main points are summarised below.

4.3 Seminar case studies

(i) Chlorine Dioxide

Experience elsewhere:

Chlorine dioxide (CLO2) is a gaseous chemical that can be generated mechanically or electrolytically from a sodium chlorite solution. A potent oxidant it kills bacteria through oxidative disruption of cellular processes. Although it has been used for many years in industrial and municipal water systems there are few reports published on its use in hospital water systems for *Legionella* control. Those which are available however (one of which is for Glasgow Royal Infirmary as highlighted below) would tend to suggest that it is certainly efficacious (Hood abstract). The other relevant study, published by Srinivasan et al (14), was provided in the conference papers and presents a 17-month evaluation of the use of Chlorine dioxide of a 154- bed building at the John Hopkins Hospital in Baltimore.

For the John Hopkins based study, at the end of a seventeen month evaluation period, there were no cases of nosocomial *Legionella* infection detected in the building with the chlorine dioxide system (although there was one definite case in the sister building which did not have water treatment). In the routinely cultured water samples, *Legionella* declined steadily from 41% of all sites tested at baseline to 4% (P = 0.001). Only *L*. anisa was recovered and it was cultured from both hot and cold water systems. After the follow up period, the only remaining test site that grew *Legionella* was on the fifth floor of the building, furthest away from the chlorine dioxide source. Chemical monitoring showed that while chlorine dioxide levels were initially higher on the lower floors of the building after 1 month of implementation, the difference was not present after 17 months. The chlorine dioxide had no deleterious effects on the buildings plumbing system, which primarily consisted of copper piping. To reduce the slight additional risk of heamolysis in those particularly vulnerable to oxidative stress, extra carbon filters were fitted to dialysis equipment which removed all chlorine dioxide and chlorite. The water for sensitive laboratory equipment was similarly filtered.

Local experience:

As acknowledged by the authors of the John Hopkins study, the most significant limitation in their evaluation was the short duration of the follow up period. In contrast, Glasgow Royal Infirmary have now had over ten years experience of the control of *Legionella* in their water supply with chlorine dioxide (15). Following 3 nosocomial cases in 1990, 2 of whom did not survive, a fatal accident enquiry led to an engineering review and improvements, a trial with hyper-chlorination (which was poorly tolerated) insertion of double check valves between hot and cold systems to prevent migration and routine water sampling for *Legionella* (but only in medical and surgical blocks). When routine surveillance was implemented in the main (or centre) block from 1992, large numbers of serogroup 1 positive samples were found immediately in several outlets (including nephrology and rheumatology) in spite of adequate levels of chlorination. In the wake of findings that chlorination had been ineffective due to an alkaline water supply and problems with biofilm, Chlorine dioxide was implemented as an alternative means of control and continuous dosing has been in place in all blocks

since February 1995. Initially heavily colonised pipe runs were treated with 50ppm CLO2 and there has been an ongoing requirement to deal with engineering problems as they arise (eg: a lack of double check valves in the surgical block). Implementing measures to run outlets in infrequently used wards was also instigated. From its implementation to the present time, chlorine dioxide at 0.5ppm has proven to be a very successful means of controlling planktonic *Legionella* pneumophila and positive culture samples have been virtually eradicated from all blocks with no cases of hospital acquired legionellosis in the hospital since 1992. Furthermore the setting has been that of a complex water system in a relatively old building where the water is soft and has a high pH. The system is well tolerated by both staff and patients and there have been no corrosion failures. The only notes of caution relate to the requirement for continued vigilance for engineering and water supply problem areas (such as temperature controls and functional dead-legs) and the finding that the full beneficial effects were not evident until up to 6 weeks after commencing continuous dosing.

Relevant guidance[2] (Note 174) For most systems routine inspection and maintenance will usually be sufficient to ensure control providing the following areas are checked at regular intervals and remedial action taken when necessary, with details of all actions being recorded:

a) The quantity of chemicals in the reservoir.
b) The rate of addition of ClO2 to the water supply.
c) On a monthly basis, the concentration of ClO2 should be measured at the sentinel taps (ie: the first and the last).
d) On an annual basis the ClO2 concentration at a representative number of outlets should be at least 0.1mg/l.

(ii) Silver/Copper ionisation

Experience elsewhere:

Although the addition to hospital water supplies of copper and silver ions (Cu/Ag) (usually generated electrolytically) has yet to be formerly sanctioned by the US CDC as a means of legionella control , it is nevertheless already the method of choice for over one hundred American hospitals. Sixteen US hospitals participated in a two-stage survey (1st stage1995; 2nd in 2000) which looked in detail at their experience of the Cu/Ag control method. No cases of hospital acquired legionnaires disease were diagnosed after the installation of the Cu/Ag ionization system in 94% (15 of 16) of the hospitals. In an overall subjective appraisal by infection control practitioners using a rating scale ranging from 'poor' to 'excellent', most rated the system as excellent, based on the results of environmental cultures and the incidence of hospital acquired legionnaires disease.

From an operation and maintenance point of view most engineering personnel rated the system as average.

Mechanism of action:

Metal ions in solution such as silver and copper are believed to exert their bactericidal effects by binding to negatively charged sites on cell wall, which when coupled with protein denaturation leads to cell lysis and death . Although both disinfecting in their own right, copper and silver appear to work synergistically their effectiveness to be maintained at significantly lower concentrations when in combination. A major advantage with regard to Legionella control is the capacity of the Cu/Ag system to efficiently penetrate bio-film layers which can be inaccessible to other commonly used disinfectants. Compared to hyper-chlorination, Cu/Ag is reported to be significantly more cost effective, easier to maintain, does not corrode piping or plumbing fixtures, and in the event of mechanical failure recontamination is delayed for weeks. In contrast if a chlorinator fails, recontamination occurs rapidly. In a review of the use of Cu/Ag in the US, copper silver ionisation systems proved effective in 75% (12 of 16) of the institutions in which thermal eradication, hyper-chlorination or both had proven unsatisfactory .

Scottish experience (Dr Gabby Phillips, Ninewells Hospital):

Ninewells hospital is a large teaching hospital based in Dundee/Tayside health-board area [no. of beds?- approx] in NE Scotland. Prompted by a single case of nosocomial legionellosis in the early 1990's, a comprehensive water testing survey discovered that 50% of all water outlets grew *Legionella* serogroup 1. A series of refurbishments and changes in use of hospital buildings had contributed to water circulation problems and a system that was less than ideal to control. Initial attempts to control the *Legionella* risk with temperature control and chlorination had proven unreliable, costly and unpopular. The current Cu/Ag system was installed in 1996/97 and has been in place for over five years. Despite some initial problems with optimizing metal ion levels in the system (acidification step required for alkaline water supply) and relatively high component costs with specialist input (maintenance about £5 - £10K per annum), the system has performed well and positive cultures there have been substantially reduced [with the hospital still experiencing the occasional positive outlet: "This would be in the order of less than 2% of outlets sampled over the year".).

There is also a regular requirement to monitor silver ion levels in the water to maintain optimal concentrations. One problem which does persist is the staining of porcelain which although harmless is unsightly and can be discomforting to patients (see Figure 4).

Figure 4. Staining as a result of Silver / Copper ionisation

One option being looked at is to switch the system on intermittently which could save on running costs but may require an increased frequency of testing. Unfortunately also in the case of Ninewells, the supplier of the original system has now gone out of business and investment will need to be made in the future on an entirely new plant at an estimated cost of £100K. These issues aside however the Cu/Ag system has been a success story at Ninewells and in common with evidence from international work (most notably in the US) it has succeeded where other methodologies have failed.

Relevant Guidance [Note 178] For most systems, routine inspection and maintenance will usually be sufficient to ensure control if the following parameters are also monitored at regular intervals and remedial action taken when necessary, with details of all actions being recorded:

a. The rate of release of copper and silver ions into the water supply
b. The silver ion concentration at sentinel outlets should be checked monthly. This should be at least 20ug per litre at outlets
c. The silver ion concentrations at representative taps, selected on a rotational basis once each year (again at least 20ug per litre at outlets).
d. The condition and cleanliness of the electrodes
e. The pH of the water supply (silver ion concentrations are difficult to maintain above pH 7.6)

(iii) Silver catalysed hydrogen peroxide

The importance of considering solutions tailored specifically to your patient population was brought home by the final practical solution presentation. Part of Ayrshire and Arran Primary Care Trust, Ailsa Hospital is a campus site housing a total of 22 buildings, the oldest of which were built some 140 years ago and have an infra-structure to match although some have recently been refurbished. More importantly from a patient vulnerability point of view, Ailsa Hospital also includes buildings designated as 'places of safety' under the Mental Health Act. There is also a significant proportion of frail elderly patients who are bedridden and cannot be moved easily. The combination of vulnerable patient groups with an absence of decant facilities makes it highly problematic to temporarily relocate any residents during refurbishments.

In 1995/6/7? pipe-work problems which came to light during a routine maintenance on the water system, prompted an extensive water sampling exercise in which *Legionella* was found to be present at very high levels (some results in excess of 25,000 cfu/L) at many points within the main block.

Research by the NHS Estates Department suggested that among possible disinfection systems, a silver catalysed hydrogen peroxide product (trade name Herlisil) might be the best option in terms of safety, effectiveness and ease of use while taking account of the site specific factors relating to the patient population and the age of the premises. Silver catalysed H2O2 is especially effective at rapidly stripping bio-film from pipework and its application at Ailsa resulted in "extremely dirty water (or sludge) running clear within about two hours of the application of Herlisil". Bottled water was provided for drinking during the initial phase of the disinfection and all showers were taken out of use during the water treatment period. Continued random sampling for *Legionella* throughout the campus on a regular three-monthly basis has only resulted in one incidence of a positive count for *Legionella* (3 positives out of an 18 point sample). Although figures were below the HSE guidance threshold (of 100 cfu/L) immediate local sterilisation was carried out using Herlisil and further samples from the three affected points have all come back negative for *Legionella*. In conclusion, the use of Herlisil has played a significant role in virtually eliminating the risk of *Legionella* from Ailsa Hospital.

In terms of lessons learned there had been a degree of complacency previously about the safety of the water system which had not been well founded and using this system when there is already considerable bio-film build up requires adequate numbers of large bore scour points to be able to clear debris effectively with aggressive flushing. Current uncertainty over DWI [?] approval for Herlisil was later clarified (personnal communication, Jim Alderton) as being the result of a change in company ownership and not a reflection of the products intrinsic safety or effectiveness.

(iv) Other control measures

The presented alternatives to chlorination and temperature covered at the seminar are by no means an exhaustive list of available interventions. The potential benefits of treating mains water supply with monochloramine (as an alternative to Chlorine) as has been carried out in parts of the United Sates was highlighted by several participant speakers and a published study was provided in the conference materials 18. More stable than free chlorine, monochloramine has been used as a residual disinfectant in mains water as long ago as 1916 and is reportedly better at bio-film penetration. If mains water supply in Scotland or the UK was to switch to mono-chloramine there could presumably be benefits for *Legionella* control in general. The remaining two options with a track record in Legionella prevention are Ozone (O3) and UV irradiation. A powerful and rapidly acting biocide which is unaffected by changes in temperature or pH, Ozone degrades to oxygen and water leaving no residual bactericidal activity under normal conditions 20. Since neither Ozone or UV irradiation lead to any residual active component which remains in the water system, they are both classified as "non-dispersive techniques" and are usually only designed to exert their effects at or very close to the point of application (eg: at point of entry to a ward with immuno-suppressed patients).

In Conclusion

While traditional methods of temperature control (ie: below 20°C for cold and above 50°C for hot water) to limit the opportunities of *Legionella* bacteria to contaminate and grow in hot and cold water systems should be sufficient if they are rigorously maintained, the nature and design limitations of hospital water systems means that temperature alone has often proved an inadequate means of controlling the risk. Traditional chemical disinfection using hyper-chlorination often leads to problems with pipe and fitting corrosion and the generation of carcinogenic by-products is also a source of concern. Since new legal guidance requires that measures which are implemented can be shown to be effective, there is considerable interest in novel chemical biocides with chlorine dioxide and silver/copper ionisation being popular alternatives to the more traditional hyper-chlorination. The newer agents have the advantages of improved bio-film penetration, less corrosion, reduced generation of toxic by-products and better acceptability for end users of the water supply. Silver catalysed hydrogen peroxide has also been shown to deal rapidly with heavily contaminated systems, although the evidence base for its long-term use is less well established.

More generally, while the seminar day highlighted the effectiveness of the newer control technologies which have been successfully applied in Scotland, the major take home message in terms of both complying with the spirit of the guidance and preventing *Legionella* infections ultimately rests with minimising the risk of *Legionella* contamination and growth in the first place with the proper design and regular maintenance of health care water systems. Hospitals and other health-care

premises will continue to treat and accommodate increasing numbers of patients who are particularly susceptible to *Legionella* infections by virtue of their advanced age or immune status. As the seminar in March has highlighted, there is now a significant body of international published evidence as well as considerable local expertise in *Legionella* prevention measures for health-care premises. As these strategies continue to be shared and further refined in the light of practical experience, combined with sound engineering principles and backed up by comprehensive risk assessments, the risk of health-care associated *Legionella* infections should continue to diminish in Scotland. Feedback from participants on the seminar itself was very positive who found it to be both timely and highly informative. There was also a recognition however that *Legionella* prevention remains a complex and developing area of health protection where decision makers and hospital planners need to be kept informed of the best evidence available from around the world.

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