Contaminated dental unit waterlines July 2000

Feature articles in newspapers and broadcast media in the United States critical of the dental profession's management of dental unit waterlines (DUWs) have reached the UK. This Fact File critically examines the available evidence as to whether bacteria from contaminated DUWs pose any risk to the health of patients or dental team members.

What evidence do we have?

Prospective case-controlled studies on infection risks from DUWs are non-existent and would probably be deemed unethical, so available data is based on surveillance studies. Infection, if it does occur, is very unlikely to be traced back to the dental surgery, unless one of two situations arises: either the index case is a dentist; or there is a clustering (or outbreak) of cases. The authorities would then mount an investigation to trace and establish the source of the infection. Much of the available data has relied on extrapolation from hospital outbreaks. The picture is further complicated as most of these organisms are found not only in DUWs but also in domestic water supplies, drinking fountains and mineral waters. So determining the potential contribution that contaminated DUWs make to the incidence of respiratory infections is difficult.

Where are the bacteria coming from?

DUWs are colonised by bacteria derived from incoming mains water and, to a lesser extent, from patients' mouths. Counts of 10^{4-6} colony-forming units (cfu)/ml are common. The American Dental Association recommends that no more than 200 cfu/ml of bacteria should be present in waterlines, which is equivalent to the level permitted for drinking water. More than 25 different species of bacteria have been isolated from DUWs. Predominant among these are the environmental Gram negative bacteria. DUWs may also harbour opportunistic pathogens which are responsible for respiratory disease – namely *Pseudomonas aeruginosa, Legionella spp.* and non-tuberculous *Mycobacterium spp*.

Modern dental handpieces normally incorporate an antiretraction valve, which prevents suck-back of oral microbes. If the valve is not fitted or is malfunctioning it is estimated that approximately 1ml containing 25,000 oral bacteria could contaminate the handpiece each time the air turbine is stopped.

Bacterial contamination can also occur with the use of independent bottled-water systems. These systems are not user-friendly. If they are not used with sterile water, or the bottles and lines are not disinfected on a daily basis and then stored dry, the interior of the bottle becomes colonised. The microbes in the bottle proliferate in the stagnant, room-temperature water and contaminate the waterline. The major advantage of bottled-water systems is that they are unlikely to be contaminated by potential respiratory pathogens, such as *Legionella spp.*, found in mains water.

Is there an infection risk from environmental microbes?

For our immune systems to develop normally, we require exposure to environmental bacteria. Recent evidence suggests that such exposure prevents asthma and other diseases with an immunological basis. The environmental aerobic Gram negative bacteria that comprise the bulk of the organisms found in the DUW biofilm are non-pathogenic. Currently, there are no clinical cases of environmental bacterial infections associated with dental procedures, whereas in medical equipment prone to biofilm build-up, such as humidifiers, a condition known as 'humidifier lung' is recognised. This is considered to be a hypersensitivity pneumonitis, a reaction possibly to endotoxins released by colonising bacteria. So the profession cannot afford to be complacent about these environmental organisms, even

though no concrete evidence is available at the present time.

What is the route of infection in respect of respiratory pathogens?
For an infection to be transmitted, a source is necessary, in this case the DUW biofilm. Amplification has to occur in order to reach a potentially infective dose, a process that occurs rapidly in stagnant waterlines. A route of transmission also has to be present, in this case aerosolisation. Dental handpieces generate particles which are 5 µm across; these are large enough to transport microbes, and small enough to bypass the nasal baffle and pass into the alveoli of the lungs. The numbers of microbes in aerosols generated by air turbines are considerably higher than those from conventional speed handpieces. Finally, the host has to be susceptible. Dentists are now treating a more susceptible population than in the past. Increasing numbers of people are medically compromised by age, steroids (inhaled and systemic), diabetes, gastrectomy, antibiotics, smoking, cancer and chronic diseases.

Is there an infection risk from Pseudomonas aeruginosa?
Pseudomonas aeruginosa is highly resistant and can grow in dilute disinfectants such as chlorhexidine and iodophors. It is able to thrive in low-nutrient environments such as distilled water, which is often used by dentists in bottled-water systems.

Unfortunately, risk assessment data on waterborne opportunistic pathogens in DUWs is not yet available and data has to be extrapolated from that on drinking water. In *P. aeruginosa* infection colonisation of the gut is the initial step. The infective dose for colonisation in healthy human volunteers is $>1.5 \times 10^6$ cfu/ml. Such high concentrations are rarely encountered in DUWs. Antibiotic treatment makes patients more susceptible to opportunistic pathogens and markedly lowers the required infectious dose. The estimated risk of colonisation by daily exposure to water with low levels of *Pseudomonas aeruginosa* is 1.7×10^{-8}. Therefore, the risk of a healthy person becoming colonised is vanishingly low.

The only proven evidence for DUW-associated infection during dental treatment is due to *P. aeruginosa* and was published in 1987. It graphically illustrates just how susceptible medically-compromised patients are. Two patients with solid tumours were unwittingly exposed to DUWs contaminated with *P. aeruginosa*. Both patients subsequently developed gingival abscesses which typing confirmed were caused by the same strain of *P. aeruginosa* as that isolated from the turbine waterlines. In a prospective study, 78 other non-compromised patients treated in one of six *P. aeruginosa*-contaminated dental units, were transiently colonised for three to five weeks with *P. aeruginosa*, but no infection ensued. (It should be noted that transient colonisation commonly occurs – for instance, after eating a salad – without any adverse health consequences.)

Do Non-tuberculous Mycobacteria in DUWs pose a health risk?
Non-tuberculous *Mycobacterium spp.* (NTM) is an opportunistic pathogen causing pneumonia, and cutaneous and disseminated disease. AIDS patients are highly susceptible to opportunistic NTM. Worldwide, there is an increasing incidence of infection in non-compromised patients, which is thought to be acquired from environmental sources such as drinking water. NTM can be isolated from up to 50% of municipal water supplies, in low numbers. In hospital outbreaks of NTM infection, the source of the organism was traced back to contaminated taps and showerheads. Fortunately, most NTM infection is asymptomatic; studies suggest that approximately 12% of the population in the USA has been infected by the NTM, *M. avium*. Priming of the immune system by exposure to environmental NTM is thought to be beneficial as it helps to maintain the BCG vaccine (anti-tuberculin) immune response.

There are very few studies evaluating NTM in DUWs. It is commonly isolated from DUWs and has been shown to proliferate in the biofilm. Significantly, the numbers of NTM in DUWs exceeded that in drinking water by a factor of 400. It is worth noting that in one of the prevalence studies in which many of the dental units were fitted with decontamination systems that continuously dosed the waterlines with hydrogen peroxide, the growth of NTM was not inhibited.

The obvious concern is that high numbers of NTM may be swallowed, inhaled or alternatively be inoculated into oral wounds during dental treatment with potential for colonisation and infection. Gargling with water containing NTM resulted in respiratory colonisation. A small number of cases of NTM infection have been associated directly with dental treatment. One report described a prosthetic heart valve infection with *M. gordonae* and another two cases of NTM cervical lymphadenitis following dental extractions. The true extent of the risk posed to the immunocompromised patient by NTM in DUWs has yet to be fully clarified.

Legionnaire's Disease

Legionella are ubiquitous in the environment and are found in all types of water, including marine water. Transmission is via inhalation of contaminated aerosols; there is no case-to-case transmission. Large outbreaks of infection have been associated with aquaria, cooling towers, showers, taps and humidifiers. 6–30% of domestic hot-water systems harbour *Legionella*, in the majority of cases without causing disease. Clinical infection presents as pneumonia or as a milder self-limiting flu-like illness, Pontiac fever. In the UK, *Legionella* infection accounts for 5–15% of cases of pneumonia. Most are due to *Legionella pneumophila* type 1, though other species in the genus can also cause pulmonary illness. There are geographical 'hot spots' for pneumonia; dental practices in these areas are, presumably, more likely to have contaminated waterlines.

People at particular risk are males aged over 45 who smoke. The infective dose for *Legionella* in humans is not known, but infection is usually associated with counts $>10^5$ cfu/ml and concentrations of *Legionella pneumophila* type 1 of 10^3 cfu/ml are considered significant. Recovery rates for *Legionella* in DUWs are in the range of 10^2–10^5 cfu/ml. Data on the prevalence of *Legionella* species in DUWs varies widely from 0% to 60%, with a prevalence of *Legionella pneumophila* type 1 of approximately 8%. Once contaminated, colonisation may persist for years in the waterlines, even if treated.

There is no evidence that any patient has ever caught Legionnaire's Disease in a dental chair. A nation-wide survey performed by the Legionella Reference Laboratory looking at risk factors in notified cases of Legionnaire's Disease, failed to find any association with prior dental treatment.

However, the possibility still remains that DUW-associated infections have gone unrecognised or unreported because of the failure to associate exposure to DUW aerosols with the development of specific infections. Sporadic infections not requiring hospital admission, such as Pontiac fever, are less likely to be investigated or notified to health authorities.

Occupational exposure to Legionella

Logically, the person at the greatest risk from a contaminated DUW is the dentist. An abnormal type of nasal flora in dental personnel has been linked to exposure to contaminated waterlines.

Studies looking for evidence of exposure to *Legionella* in the dental surgery found higher titres of *Legionella* antibodies amongst dental personnel than amongst the general population. The magnitude of *Legionella* antibody titres correlated directly with the length of time spent in clinical dentistry. Dentists had a higher incidence of antibodies than other members of the dental team. However, two of the London Dental Schools reported *Legionella* in the waterlines but found no correlation with respiratory illness in their staff.

A single fatal case of *Legionella* pneumonia in a dentist, caused by *L. dumoffi*, has been reported. The evidence linking the disease to a DUW is only circumstantial. *L. dumoffi* and other *Legionella* species were recovered from the dentist's surgery waterlines, although not from his domestic water supply. Unfortunately, the isolates were not available for molecular typing, which would have definitively confirmed the link to the source. Epidemiological surveillance data has uncovered a small number of dentists who contracted *Legionella* pneumonia but investigation of their DUWs was not performed. All had other known risk factors for *Legionella* infection and no causal occupational association could be made. The Department of Health is currently funding research into the occupational risks of respiratory pathogens in DUWs.

Risk factors identified in domestic acquisition of Legionnaire's Disease are of relevance in

preventing infection in the dental surgery. Multivariate analysis showed an increased risk of infection following recent plumbing repairs, the use of an electric rather than a gas water heater, smoking, and working more than 40 hours per week. *Legionella* can tolerate a wide range of temperatures.

Summary

There is a case for saying that manufacturers of DUWs ought to redesign equipment to prevent biofilms accumulating in units. But it is also up to dentists to minimise the – already negligible – risks as far as possible.

As a precaution to protect those who are not medically compromised, dentists should run water through the relevant equipment for at least two minutes each morning to help reduce any overnight microbial accumulation – and for 20–30 seconds after the treatment of each patient. They are also advised to use a bottled-water system to help control contamination. In the case of immunocompromised patients, special precautions should be taken and sterile water supplies used.

The average temperature of most DUWs is 23ºC, which supports *Legionella* growth. To prevent colonisation of cold-water systems, water in a DUW should be kept below 20ºC. Contamination of surgery hand basins with *Legionella* can be avoided by heating hot water to 60ºC (*Legionella* are normally killed at this temperature).

A proportion of dentists are experiencing occupational exposure to *Legionella*, although in the vast majority of cases there is no evidence of it leading to pulmonary infection. Legislation is ahead of the technology at the moment and is risk-led, being based on the small number of verified cases of DUW-associated infections. New guidelines on maintenance of water supplies in commercial premises will probably require testing of water supplies and evidence of implementation of guidelines. Monitoring of water supplies is going to be an essential part of improving the safety of DUWs, driving research on occupational illness as well as the development of new designs for the delivery of irrigant water.

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