

The environment as a source of *Pseudomonas aeruginosa* and some other potential CF pathogens

We hope the information in this document will not engender excessive anxiety in parents and people with CF for in many of the situations discussed the risk of an individual acquiring Pseudomonas aeruginosa, after a relatively short exposure, would be very low.

The risk for people with cystic fibrosis (PWCF) of encountering *Pseudomonas aeruginosa* (PA) and other potentially harmful organisms in various environments is a frequent question for the CF Trust's "Ask the Expert" service. Here we review some of the evidence that is available on the subject, with emphasis on *Pseudomonas aeruginosa* as questions most frequently concern this organism.

This document does not deal in detail with the occurrence and prevention of cross infection in CF Centres and Clinics, nor at CF camps and holidays, for when recommended precautions of hygiene and segregation are in operation it is apparent that most new infections are acquired outside hospital (See "Publications" on CF Trust website www.cfftrust.org.uk where there are the following Standards Documents - ***Pseudomonas aeruginosa* infection in people with cystic fibrosis. Suggestions for prevention and infection control. 2004;** also ***Burkholderia cepacia* complex. Suggestions for prevention and control. 2004**).

So where are PWCF likely to encounter *Pseudomonas*? Advice from CF centres varies widely concerning precautions for families to take. The impression of widespread parental anxieties regarding PA infection was confirmed in a study from Germany; if precautions were exaggerated inappropriate advice could lead to non-intended side effects to the detriment of the child's quality of life¹. For example, in Germany some CF physicians are recommending that people with CF should avoid public showers and swimming pools and should drink only tap water that has been boiled².

Although eradication of early PA infection is now usually feasible and well established practice in most centres, it is certainly preferable to avoid infection rather than eradicate it as second and subsequent episodes of infection are increasingly difficult to eradicate. Also, although the proportion of people with CF who have chronic PA infection (prevalence) has steadily fallen at centres where early eradication has been practiced, the number of new infections (incidence) has remained much the same^{3, 4}. So it is timely to consider the possible environmental sources of these new infections and the reasonable precautions which could be taken to avoid infection.

General environment

People with "colds". The increase in first isolations of PA and the onset of chronic infections between October and March has been attributed to the increased likelihood of viral infections⁵. A recent, interesting and rather

surprising study of individuals, who do not have CF, shows more than a third may carry PA transitorily in their airways at times of acute viral respiratory infections during the winter months, but they clear the organism spontaneously when they recover; in contrast, the 30% of PWCF who become PA positive during “colds” often fail to clear the infection spontaneously when the viral infection settles. So otherwise healthy children with “colds” may be not only a source of viral infections but also of PA infection for people with cystic fibrosis⁶.

Households of people with CF. Pseudomonas was detected in 73 of 102 (71.6%) households of PWCF – most frequently in drains of showers (39.6%), drainpipes of kitchen hand basins (35%) and bathrooms (34.7%) and drain pipes of toilets (26.5%)⁷. However, it was not stated how many patients were chronically infected with PA and therefore the possible source of re-infection of the household environment.

Domestic showers. Showers have not been reported as a source of PA cross-infection in people with CF nor have domestic **cold-water tanks** in the roof, although the organism can be recovered from the drains.

Tropical fish tanks. Tanks with heated water are a potential source of infection if the patient is in direct contact with the water e.g. cleaning out, hands in the water etc. There are various reports of infection with various organisms from fish tanks including Salmonella, *Mycobacterium marinum* but not of Pseudomonas or in people with CF.

Greenhouses and garden centres. These are considered to be a potential risk as they have warm humid conditions. After discussion with an expert CF microbiologist we recently advised that a boy with CF did not become involved with regular holiday work in the family garden centre.

Domestic pets. Relatively little attention has been paid to household pets in the context of infection in PWCF but “companion animals” do appear to constitute a definite, but as yet unproven, risk.

A recent study from Canada reported detailed microbiological findings on 102 **apparently healthy dogs** taken to visit people in hospital. No less than 80% of the animals carried a potentially harmful infectious agent. *Clostridium difficile* was isolated from 58%, *E. coli* from 3%, Salmonella from 3%, *Pasteurella canis* from 29%, and a variety of other organisms although PA was not detected⁸.

Dogs and cats in Japan carried a variety of organisms on their paw and hair samples. *Staphylococcus aureus*, *E. coli*, *Pseudomonas aeruginosa*, Proteus and others were detected on each sampling area on dogs and cats kept outdoors⁹. Staphylococci and PA are frequently isolated from the ears of dogs¹⁰ and those with bacterial keratitis eye infection¹¹. In a 6 year study from canine skin and ear samples PA was isolated from 7.5% and 27.8% of skin and ear samples respectively¹². Dogs can carry strains of MRSA and the

organism caused an outbreak in dogs in Leeds (Dr Miles Denton, 2005, personal communication)

Pseudomonas aeruginosa is found in many natural and domestic environments including **plants, soils and surface water, especially warm moist environments containing organic material or contaminated by human or animal waste**. Although PA thrives in moist environments, it is not considered to be a marine organism because the high salt concentrations in **seawater** are considered to inhibit its growth – so sea bathing and playing on the **beach** have been considered no problem. However, there is some evidence to suggest this is not always the case as some beaches have significant contamination by sewage and there is some evidence that PA can survive in seawater¹³.

Soil samples may contain *Pseudomonas aeruginosa*. 24% of soil samples from various areas of California contained *Pseudomonas* which were of similar types to those causing illness. The soil is a reservoir for *P. aeruginosa* which will colonize plants in suitable conditions. Sprinkler watering was suggested as a contributory factor¹⁴.

Hydrotherapy pools, Jacuzzis and hot tubs are a definite risk for people with CF because the combination of water, warmth, aeration and human contamination impair adequate disinfection whilst providing ideal growth conditions for bacteria such as *P. aeruginosa*^{15, 16} variety of infections acquired from these sources have been reported including hot tub folliculitis, green nail syndrome, infective endocarditis, invasive external ear infections and puncture wound osteomyelitis¹⁷.

Swimming pools are generally safe provided the recommended programme of maintenance is carried out - but standards do vary. In a “Which” survey in 2002 no less than 35 of 61 samples from pools and spas fell outside acceptable microbiological standards – 9 posed a definite risk and 3 a serious health risk to bathers; spa pools were worse than swimming pools. *Pseudomonas* poses a particular risk in spa pools and outbreaks of infection in non-CF people have been reported. A list of pools and their standards were included in the report (Which, June 2002). If water is faecally contaminated by bathers the water will not be immediately sterilized and thus would be a risk to other bathers.

Pseudomonas skin infection has been associated with a **swimming pool inflatable**. A child with a positive skin swab for PA attended the local swimming pool and played on an inflatable and later developed folliculitis. A total of 35 further cases were identified during the outbreak. Nine of 10 (90%) of the inflatables sampled were colonized by *P. aeruginosa*. The authors suggest that attention should be given to the problem of routine decontamination of swimming pool inflatables¹⁸.

In a study from Northern Ireland 4/13 (30.8%) of **hydrotherapy pools**, 37/51(72.5%) of **Jacuzzis/spas** and 26/68 (38.2%) of **swimming pools** were positive for *P. aeruginosa* – it is important to note that private facilities were

worse than public facilities. The authors concluded that the “*water may be a potential source of P. aeruginosa infection for susceptible patient groups including patients with cystic fibrosis*”¹⁹.

In contrast, in Switzerland in 2002 none of 72 specimens from 28 **outdoor swimming pools** revealed *P. aeruginosa*. In 2003 only 3/46 (7%) grew *P. aeruginosa* – in each instance from **paddling pools**. Two of 128 (4%) specimens from 56 **indoor pools** grew *P. aeruginosa* – both positives were from private pools.²⁰ Acquisition of a PA infection by a person with CF from a swimming pool has never been documented; they do not consider tap water or swimming pools to be a significant risk. Obviously the risks vary according to the location and it is impossible to generalize.

Fresh water lakes may contain *P. aeruginosa*. In Holland external ear infections were closely associated with swimming in recreational fresh water lakes in the previous 2 weeks. The lakes met Dutch standards but PA was isolated from all of them as well as from 83% of ear swabs of affected patients. “*Even when current bathing water standards are met, swimming can be associated with a substantial risk of otitis externa because of exposure to P. aeruginosa*”²¹.

Recently we discussed visiting the **Eden Project** in Cornwall with a CF microbiologist and also with the very helpful technical staff at the Eden project itself. The humidity in the Biomes (the large domes) is high (50% to 90%) but the moist humid air is filtered and will not contain bacteria. The humidity is higher on cool days but less on hot days when the ventilation panels will be open. There is no rotting vegetation but there are ferns - however, we are not aware these are a risk. The microbiologist noted that *B. cepacia* has been found in the soil of one botanical garden and Gram negative organisms are more likely to grow in moist conditions. Our overall conclusion, taking everything into consideration, was that the risks of a person with CF visiting the Eden Project are very low and perhaps it would be better to go on a warm day when the ventilators would be open wider! It reassuring that the staff confirmed that the moisture in the air is filtered.

Foods and drinking water

There are numerous publications reporting the variable bacterial quality of assorted **bottled waters**; usually the carbonated specimens are less likely to be contaminated than the still specimens. Also **ice cubes** are a potential risk depending on the quality of the water used.

The bacteriological content of water in **large dispensers (coolers)** and from the 20 liter supply bottles had *P. aeruginosa* in 25% of samples from the large supply bottles and also in 24% of water specimens from the actual coolers. A further 21.6% of 162 specimens from the coolers yielded *P. aeruginosa*²².

Bottled water and tap water were tested using standard microbiology techniques. The bacterial count of bottled water increased dramatically from 1 colonies/ml to 38,000 colonies /ml over 48 hours at 37°C after drinking once

from the bottle but markedly reduced at cooler temperatures²³. Half the samples of drinking water from mobile food vendors in Cheshire were examined microbiologically and found to be unsatisfactory. There was a relation between the frequencies with which the containers were cleaned and the viable counts²⁴. The bacterial content of carbonated and non-carbonated commercial bottled water samples were examined and showed no growth from carbonated water but of 22 samples from non-carbonated water, 3 grew *S. maltophilia* and 8 grew *P. aeruginosa*²⁵.

None of 102 running water specimens from **water taps** were infected in winter and only 2/50 of the standing water (first specimen after turning on) were positive in summer; but none of the running water specimens were positive²³. In another study tap water resulted in only minimal growth particularly at low temperatures²⁰.

Water softeners should not be a problem. *P. aeruginosa* is not usually present in drinking water but can be present where there are repairs or alterations to the plumbing system. The water softener should remove any bacteria that enter the system; compliance with regulation DIN 19636 will apparently ensure this occurs²⁶.

Vegetables and salads. A considerable time ago a study of **food in a hospital kitchen**^{27, 28} recovered PA from 82% of tomatoes, and 27% of tomato salads. The organism was also present in 7 of 9 radishes, 4/6 celery, 3/10 carrots, 2/8 endives, 2/7 cabbages, 2/6 cucumbers, 1/5 onions, 1/9 lettuces and 30/111 tomato salads. Subsequently 44% of 116 vegetable salads prepared for patients yielded PA in addition to a variety of other Gram-negative organisms²⁹.

Pseudomonas aeruginosa multiplied in lettuce and beans when temperature and humidity were high (27°C and 80-95% humidity). Three hundred and eight **vegetable samples** from 3 German supermarkets were screened for organisms including PA which was detected in 15 (4.9%) of samples. Other *Pseudomonas* species were detected in 73.1% of the vegetable specimens – in green salad (7.4%), tomatoes (10%), and cucumber (13.8%); however, neither *Staphylococcus aureus* nor *B. cepacia* were found³⁰.

Button and open cap mushrooms purchased from several leading supermarkets from five different countries all contained *P. aeruginosa*; also the organism has been consistently isolated from **spent mushroom compost** purchased from garden centres as a soil improver. Also PA was isolated from packets of **bean sprouts** but not detected in a selection of other common supermarket fruit and vegetables. Thorough cooking should be sufficient to kill the organism but handling uncooked mushrooms or bean sprouts may constitute a risk to a person with cystic fibrosis³¹.

Equipment

Toys used by children with CF who are chronically infected with PA are a potential source of infection; the organism can exist on hands contaminated with infected sputum for up to 180 minutes.

Sponges and tooth brushes at home should not be a risk for personal use provided they are dried thoroughly after use – drying of all equipment is particularly important.

Respiratory function equipment has not proved to be a major source of infection provided there are appropriate standards of hygiene in operation. 33 of 155 samples cultured from the proximal (patients' end of the equipment) and only 2 of 155 from the distal (equipment) side of single use bacterial viral filters grew pathogenic organisms³².

The home nebulisers of 34 PWCF who had chronic PA infection did not harbor the organism, although other pathogens were identified. Drying was emphasized as an important part of the cleaning procedure³³.

Dental equipment may be a source of PA but is a relatively low risk and patients should not be deterred from visiting the dental surgeon! Three of 103 (2.9%) water samples from 25 dental sessions in an oral health care service in Denmark were positive for *P. aeruginosa*. Eighteen of 327 samples (5.5%) from 9/82 (11%) sessions from various clinics were positive for *P. aeruginosa*. One was the same strain as isolated from a CF patient³⁴. In a recent survey in a Dental Hospital 43% of suction hoses were infected with *P. aeruginosa* and corroded at their attachment to the main dental chair unit. The problem was eliminated by replacement hose connectors³⁵. Very detailed recommendations for infection control procedures for dentistry have been published by the US Centers for Disease Control and Prevention in 2003 – including references to and details for preventing water borne infection³⁶.

Washing machines in three Italian commercial launderettes were examined. Bacterial contamination was highest in the most frequently used launderette. Low temperature washing (25-30°C) did not guarantee elimination of bacteria from the inside of the machine or from the fabric. Only washing at 55°C+ with the addition of an oxygen-based bleach ensured almost total elimination of bacteria such as *P. aeruginosa*³⁷. Domestic washing machines were shown to reduce the viable count of *Staphylococcus aureus* below detectable levels from the uniforms of hospital staff even using a low temperature programme. Gram negative flora were introduced from the machine but were destroyed by tumble drying or ironing³⁸.

Gymnasiums and health clubs

A number of studies have shown apparatus in health clubs may harbor significant numbers of harmful bacteria in the residue left on gym equipment, bench-press headrests, dumbbells, dirty towels, in hot tubs, spas, whirlpools, saunas and changing rooms and even in drinking water from plastic bottles (Peta Bee, Daily Mail. July 4th 2006).

Hospital environments

Pseudomonas aeruginosa is frequently found in some hospital environments, particularly intensive care units. In one study, washbasins and sinks were found to be contaminated and identical strains were identified on the hands of staff. The contamination level of *P. aeruginosa* in aerosols from the sinks was greater in the mornings, presumably because of the opportunity for overnight bacterial growth^{39, 40}.

In a 4-week study 88% of all hospital ward washbasin drains contained *P. aeruginosa*, which correlated with the strains isolated from patients; four of 16 patients grew the organism from hand cultures. The organisms were detected for up to 180 minutes from hands experimentally contaminated with sputum. Genomic fingerprinting of the bacteria did not distinguish between contamination of the environment from secretions or cross-infection i.e. patient-to-patient transmission⁴¹.

Rates of fecal carriage of PA differ widely. In healthy individuals PA carriage rates are generally low (less than 10%) but may rise to 40% in hospitalized patients⁴².

In a study from the Danish CF Centre, where precautions are taken to avoid PA cross-infection, including segregation of patients according to their microbiological status and good hygienic practice, there was no evidence that the hospital environment was an important source of infection⁴³. This is the impression gained from experience at many large CF centres where policies to reduce the risk of cross infection are in operation. This supports the view that most new *Pseudomonas* infections in people with CF are acquired from the environment away from hospital.

So what are we to recommend for people with CF?

The CF Trust document ***“Pseudomonas aeruginosa infection in people with cystic fibrosis. Suggestions for prevention and control. 2004”*** lists simple precautions to take when away from hospital as follows:-

- Casual meetings between people with CF, including brief encounters indoors and outdoors, carry a low risk of infection and this risk is increased the longer and closer the contact.
- Avoid contact with all people who have acute viral respiratory infections including those without CF.
- Patients should discuss cross-infection issues with their physician and CF Team and be aware of what usually grows from their sputum/throat swab samples (their own “microbiological status”).

- All communal camps and holidays for groups of people with CF should be avoided.
- Spa and other forms of aerated baths should be avoided. Check the swimming pool used is serviced regularly and reliably.
- Schooling: although there is no evidence that *P. aeruginosa* infection can be transmitted between children in the school environment, it is preferable for children with CF attending the same school to be in different classes.
- Higher education: students should be aware of their microbiological status and may wish to discuss this with their CF physician, the Student Health Service (who then has legal responsibility) and their personal tutor.
- Workplace: People with CF should be aware of their microbiological status and may wish to discuss this with their CF physician and Occupational Health Services who can then take appropriate action to minimize the risk of cross-infection.
- Siblings with CF should have separate bedrooms and should do their airway clearance and other treatments separately.

To these we suggest considering the following precautions –

- Avoid swimming in rivers and fresh water lakes particularly if there is a well-maintained swimming pool as an alternative.
- Notice the hygienic precautions taken in gymnasiums and health clubs that you may visit. Take your own towel.
- Remember that some domestic pets can be a source of *Pseudomonas aeruginosa* and *Staphylococcus aureus*, particularly if they have ear or eye infections. So avoid pets who are unwell particularly with ear or eye infections and always wash your hands after handling pets
- Avoid close contact with, and becoming involved in the cleaning of, tropical fish tanks.
- Greenhouses and indoor garden centres where there are damp warm conditions may be a risk both for *Pseudomonas* and also for spores of *Aspergillus*.
- Damp straw in stables is a proven risk for *Aspergillus fumigatus* spores and if people with CF go horse riding they should avoid “mucking out” stables or being in the stables when this is in progress for the air becomes laden with fungal spores.

- Wash all fruit, vegetables and salads thoroughly including those described as ready washed in packets in and cook all mushrooms.
- Ensure all equipment and toys are cleaned regularly and dried. Allow tooth brushes to dry after use.
- Use washing machine at 55°C+ and use an oxygen based bleach.
- Ensure plastic bottles and containers used for drinking water are sterilized with boiling water before refilling. Tap water and carbonated bottled water are preferable to still bottled water. Allow tap water to run for a minute if used for the first time that day

Comment

The risk of acquiring *Pseudomonas* and other harmful organisms obviously differs according to local conditions. However, it is likely that people with CF do acquire the organism from the general environment outside the hospital and it is likely to be via water or in damp situations.

It seems reasonable, when possible, to avoid the situations described above which have proved a problem particularly warm pools, Jacuzzis and hot tubs and also to enquire as to the bacteriological supervision of any swimming pool a person with CF intends to visit on a regular basis. Even though the Swiss pools appear satisfactory, the standards in some UK pools obviously do vary considerably and some are a definite health hazard and are best avoided.

It is hoped that the information in this document will not engender excessive anxiety in parents and people with CF for in many of the situations discussed the risk of an individual acquiring *Pseudomonas aeruginosa*, after a relatively short exposure, would be very low.

Jim Littlewood Sept 2007

Many thanks to Dr Miles Denton, Consultant Microbiologist, Regional Cystic Fibrosis Centres, Leeds Teaching Hospitals for his expert advice.

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