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# Who's at The Door? – Surface Contamination of Door Frames in a Single-Bedded In-Patient Adult Cystic Fibrosis (CF) Unit

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## ABSTRACT

The Gram-negative bacterium, *Pseudomonas aeruginosa*, is a major respiratory pathogen in patients with cystic fibrosis (CF), with an associated increase in morbidity and mortality. Consequently, infection prevention and control (IPC) plays an important role within health care in order to minimize the risk of cross-infection of this organism amongst patients and the hospital environment. It was the aim of this study to examine bacterial contamination of the health estate of CF in-patients' single-bedded rooms and related environments (n=40). Twelve bacterial genera were identified, six being Gram-positive (*Brevibacterium*, *Dermaococcus*, *Micrococcus*, *Rothia*, *Staphylococcus* and *Streptococcus*), and six being Gram-negative (*Acinetobacter*, *Citrobacter*, *Klebsiella*, *Moraxella*, *Pantoea* and *Pseudoxanthomonas*). None of the organisms identified were considered of particular clinical significance to CF patients. The CF lung and associated sputa may be important reservoirs of *Pseudomonas aeruginosa*, with potential for spill-over into the health care estate. In the aftermath of the *Pseudomonas* neonatal outbreak at Altnagelvin and the Royal Jubilee Maternity Hospitals, where there was heightened IPC awareness regarding the presence of this bacterium, it is encouraging to note its absence from the CF-health care estate examined.

## INTRODUCTION

In late December 2011 and early 2012, there were outbreaks of *Pseudomonas aeruginosa* infection at the neonatal unit at Altnagelvin Hospital, Londonderry, as well as at the Royal Jubilee Maternity Service, Belfast, which tragically led to the death of four babies.<sup>1</sup> The subsequent Independent Review examined the fabric and design of neonatal units throughout Northern Ireland and made several recommendations relating to the fabric and design of estate to support good principles of infection prevention and control.<sup>2</sup>

Whilst *Pseudomonas aeruginosa* is an uncommon cause of bacteraemia in babies, around one or two cases have been reported each year in Northern Ireland for babies under 1 year old, it is however a commonly isolated pathogen from patients with cystic fibrosis (CF).<sup>2</sup> CF is the most common lethal genetic disease affecting mainly Caucasian populations, with an approximate frequency of 1 in 2500 live births and a genetic carriage rate of approximately 1 in 25 persons. The pathophysiology of the disease stems from a genetic defect of the CFTR protein, which transports chloride ions through ion channels in the cell membrane. Absence or limited functionality of these ion channels results in the accumulation of sticky sputum/mucus, which traps a variety of different micro-organisms. Failure to be able to expel trapped bacteria leads to their accumulation in the airways of the lungs of CF patients, resulting in chronic

infections, which are largely responsible for high morbidity and mortality in these patients.<sup>3</sup>

*Pseudomonas aeruginosa* (*P. aeruginosa*) and *Burkholderia cenocepacia* (*B. cenocepacia*) are two important bacterial pathogens in patients with cystic fibrosis (CF), resulting in chronic lung infections with significant morbidity and mortality.<sup>4</sup> Both of these bacteria have been isolated from a wide variety of environmental sources, including waters.<sup>4</sup>

The importance of these bacteria has driven the implementation of stringent cross-infection strategies,

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particularly in the in-patient setting. The development of and adherence to robust infection prevention and control (IPC) guidelines for cystic fibrosis (CF) has helped minimize the transmission of respiratory pathogens within this patient population.<sup>5,6</sup> One key component of such IPC guidelines is the in-patient management of CF patients in well-ventilated single rooms of adequate size, each with their own ensuite facilities. People with CF understand the infection risks from physical interaction. Yet, on occasion adults with CF may speak to other patients but position themselves in the open doorway of an inpatient room in an attempt to reduce this risk. Fomite surfaces therefore have the potential to become contaminated, as their positioning breaches the “3 foot rule”.<sup>7</sup> Given the importance of the need to prevent cross-infection between CF in-patients, whilst they are treated in their single bedded ensuite rooms with i.v. antibiotics, building design strategies targeting and promoting such infection prevention need to be developed and adopted into new builds. To date, there has been limited interaction between building design teams and cystic fibrosis clinical teams, in setting out what organisms are of key clinical importance. Given the clinical importance of this organism, the tragic historical legacy of its association with neonatal deaths in Northern Ireland, coupled with the heightened awareness of *Pseudomonas aeruginosa* within infection control and prevention, we wished to examine the hospital environment, where this organism is prevalent with in-patients. To date, there is no data to tell if door frames or other CF in-patient fixtures and fittings of similar height may become contaminated with CF respiratory pathogens during such events, through direct contamination at head level, from patients’ saliva, respiratory secretions or from handling doors.

## METHODS

A study was performed, whereby pre-moistened swabs (Sterilin Ltd, UK) were collected from door frames, as well as from three other locations within an adult CF Unit (n=40), as detailed in Table 1. All doors frames were located in single bedded ensuite rooms that adult CF patients occupy during their in-patient stay which normally lasts two weeks. Door frames were wooden and were sealed with a plastic veneer. After completion of swabbing an area of door frame, swabs were transferred from the Adult CF Unit on transport medium and were immediately plated onto Columbia Blood Agar (CBA; Oxoid CM, Oxoid Ltd., Basingstoke, UK), which were incubated aerobically at 37°C for 48hrs. Resulting colonies were purified and those which were phenotypically different in terms of the colonial morphology, were sub-cultured singly onto fresh CBA plates, in preparation for phenotypic identification by MALDI-TOF analysis.

## RESULTS

Microbiological results are shown in Table 1. In total, this study generated 47 bacterial isolates, of which 33 (70.2%) were able to be identified by MALDI-TOF analysis. For the remaining 14 unidentified isolates, clear spectra were obtained, but these spectra were, as yet, not available in

the MALDI-TOF database. Overall, no conventional CF bacterial flora, including *Pseudomonas aeruginosa*, *Burkholderia cepacia* complex organisms, *Staphylococcus aureus*, *Achromobacter xylosoxidans* or *Stenotrophomonas maltophilia*, were isolated from any area. Twelve bacterial genera were identified, six being Gram-positive (*Brevibacterium*, *Dermaococcus*, *Micrococcus*, *Rothia*, *Staphylococcus* and *Streptococcus*), and six being Gram-negative (*Acinetobacter*, *Citrobacter*, *Klebsiella*, *Moraxella*, *Pantoea* & *Pseudoxanthomonas*). None of the organisms identified are considered of particular clinical significance to CF patients.

## DISCUSSION

In this study, we targeted four fomite areas, as shown in Table 1, with emphasis on door frames and door handles in patients’ single-bedded rooms. Sampling purposely targeted these areas at head height to attempt recovery of CF pathogens which could be deposited from patients’ mouths, nose and hands onto such surfaces, whilst chatting at the door threshold of patients’ rooms. Results indicate that “dry” areas, including door frames and handles, predominantly yield Gram-positive organisms, whereas “wet” areas including sinks and taps, yield Gram-negative organisms. The former finding is in agreement with other studies, which have shown an exclusive predominance of Gram-positive organisms, in “dry” sites/fomites, including ATM machines<sup>8</sup> and monetary coinage.<sup>9</sup> The potential demise of Gram-negative organisms in dry fomites is of particular importance for people with cystic fibrosis. Knowledge of the biology of the processes leading to a reduction of Gram-negatives would allow for a better understanding, especially for IPC purposes. After deposition on fomite surfaces from the patient, the drying process commences for the Gram-negative organism, in the presence of the biological matrix (sputum, saliva) that it is contained in. There is a marked decrease in membrane integrity and redox activity and a concurrent increase in membrane depolarization, which is usually lethal to the bacterium.<sup>10,11</sup> Gram-positive organisms are less susceptible to drying than Gram-negatives, due to the presence of their robust cell wall structure. The work of Nocker and colleagues demonstrated that the killing effect due to desiccation in Gram-negative organisms was amplified in the presence of 150-400 mM sodium chloride.<sup>11</sup> This finding may be significant in cystic fibrosis, where nebulized hypertonic saline solution (0.6 – 0.7% w/v NaCl) is employed as a mucolytic agent to improve mucociliary clearance of sputum from the CF lung. Translating IPC guidance is necessary to keep pace with the changing microbiological environments. This knowledge indicates that where fomite surfaces remain wet or moist, this scenario may lead to greater environmental persistence of Gram-negative organisms. Maintenance of dry conditions may lead to the reduction of Gram-negative organisms but have less effect on Gram-positive organisms and spore-forming organisms, such as *Clostridium difficile*. Therefore, where pragmatic, shifting the environmental paradigm from “wet/



moist” to “dry” environments or investing resources to maintain a relative state of dryness, could add value to IPC interventions relating to cystic fibrosis and in general and further lead to reduced environmental persistence of Gram-negative organisms contaminating fomites.

It is reassuring to note the lack of recovery of pathogenic CF bacterial flora from such sites. However, recovery of a spectrum of bacteria from these sites demonstrates these areas have their own bacterial signatures despite regular cleaning. The clinical significance of these organisms remains unknown but with declining rates of *Pseudomonas aeruginosa* within CF populations there is increasing interest in the role of other Gram negative and anaerobic bacteria and their potential for pathogenicity in the CF lung. This emphasizes the need to maintain effective IPC interventions, including keeping doors closed in single-bedded rooms, as well as educating the CF patient and re-emphasizing the need for stringent IPC behavioral precautions amongst people with CF, both in and out of health care facilities, in order to minimize the burden of cross infection with known and future CF respiratory pathogens. In the context of

the present study, CF centres should be aware of the latest recommendations from the UK CF Trust<sup>12</sup>, with particular reference to the non-tuberculous *Mycobacterium* (NTM), *Mycobacterium abscessus*, including:-

- (i) Rooms must be left with the door closed, with at least an hour between patients to allow for dispersion of possible airborne contamination and then cleaned according to local infection control guidelines,
  - (ii) Gloves and aprons must be worn and hand washing with soap and water must be performed before and after contact with each patient and/or their immediate environment,
  - (iii) All other equipment and surfaces must be cleaned and dried between patients, according to local infection control guidelines.
- To date, there has been little interaction between CF clinical and building design teams.<sup>13</sup> Such early discussions are essential in new builds, namely the construction of new buildings, as well as in retrofits, namely the modification/adaptation of an existing building, which was not present during initial construction, regarding the specific needs of the CF patient environment, which present relatively unique

Area	Number of fomites from which bacteria were isolated	Identification of bacteria
Door frames in patients' single-bedded rooms (n=10)	5	<i>Acinetobacter lwoffii</i> <i>Micrococcus luteus</i> <i>Pantoea agglomerans</i> <i>Staphylococcus epidermidis</i> <i>Staphylococcus hominis</i>
Door handles entering patients' single-bedded rooms (n=13)	7	<i>Brevibacterium casei</i> <i>Dermaococcus nishinomiyaensis</i> <i>Micrococcus luteus</i> <i>Moraxella osloensis</i> <i>Staphylococcus capitis</i> <i>Staphylococcus epidermidis</i> <i>Staphylococcus hominis</i> <i>Staphylococcus simulans</i> <i>Streptococcus mitis/oralis</i> <i>Rothia dentocariosa</i> <i>Unidentified (x1)</i>
Push devices [automated door release buttons, alarm buttons, door visors, keyboard, mousemat] (n=11)	8	<i>Dermaococcus nishinomiyaensis</i> <i>Micrococcus luteus</i> <i>Moraxella osloensis</i> <i>Pantonea agglomerans</i> <i>Staphylococcus capitis</i> <i>Staphylococcus epidermidis</i> <i>Staphylococcus hominis</i> <i>Unidentified (x1)</i>
Wet areas [tap, sink drain, showerhead] (n=6)	3	<i>Citrobacter freundii</i> <i>Klebsiella oxytoca</i> <i>Pseudoxanthomonas mexicana</i>

**Table 1:**  
Identification of bacteria isolated at specific locations within the adult cystic fibrosis unit

challenges to such teams, when contemplating designs to minimize the burden of bacteria on surfaces in such units. More data on the employment of materials and architectural design is urgently required to help choose optimal designs to ensure “infection-free by design” solutions are duly implemented.

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