Dry surface biofilms: what you need to know

Environmental dry surface biofilms are a new type of biofilm found on dry surfaces, that are not visible to the human eye. Dry surface biofilms harbour multidrug-resistant organisms, are resistant to cleaning and disinfection and cannot be detected by wet or dry swabbing, so may play an important role in the persistence of pathogens in the healthcare environment.

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Introduction

The hospital environment harbours organisms that could be potentially pathogenic to staff, patients and visitors. Appropriate infection control measures, including routine cleaning, are crucial in lowering the risk of healthcare-associated infections. Worryingly, studies show that cleaning efforts in hospitals are not always effective, with pathogens surviving on surfaces despite regular environmental cleaning or more advanced terminal cleaning. These pathogens can be further transmitted to vulnerable patients directly from high-touch surfaces or indirectly via healthcare workers' hands.

It is now recognised that patients are at a higher risk of acquiring an infection with a multidrug-resistant organism from a previous room occupant, even when deep cleaning protocols are used and environmental surface wet swabbing tests are negative. Dry surface biofilm impacts on our ability to detect microorganisms by wet swabbing, a well-accepted routine method used not only in healthcare settings but also in other environments. Swabbing is known to have low sensitivity, but is still trusted to deem the surface safe.

Another concern is the efficacy of disinfectant products in practice. Such products are essential for effective infection prevention and control, and labels report efficacy against bacteria in liquid or dried on surfaces, yet still in a free-living state. However, microorganisms found on hospital surfaces are not often found in a free-living planktonic state – sessile bacteria on surfaces in biofilms are more common, and biofilms are much tougher to eradicate.

Biofilms living in a challenging environment

With detection rates above 90% on disinfected intensive care surfaces, dry surface biofilms are a relatively recent concern in healthcare settings. The term was coined with the introduction of a new dry surface biofilm model in 2015 (Vickery et al, 2012; Hu et al, 2015). The widespread presence and abundance of dry surface biofilms on environmental hospital surfaces is well documented (Ledwoch et al, 2018).

But what is a dry surface biofilm? There is not yet an official definition, but they consist of multispecies bacterial communities embedded in extracellular polymeric substances, present and growing on environmental surfaces subjected to low water availability, in a dry state. Dry surface biofilms are not planktonic cells simply dried on the surface.

Under the microscope, dry surface biofilms can be observed as scattered cellular aggregates of complex structures within thick extracellular polymeric substance (Figure 1). Dry surface biofilms tend to be thinner and more randomly scattered on surfaces than wet biofilms, but as a result of the harsh conditions they live in, low moisture and nutrients levels, their survival depends on high resistance to desiccation. It is not yet known how dry surface biofilms form on surfaces and it is unclear whether or not they follow a standard biofilm lifecycle with attachment, accumulation, maturation and dispersion steps.

A dormant danger?

Dry surface biofilms are resistant to chemical disinfection and less susceptible to physical processes than their wet biofilm equivalents (Almatroudi et al, 2016; Ledwoch et al,

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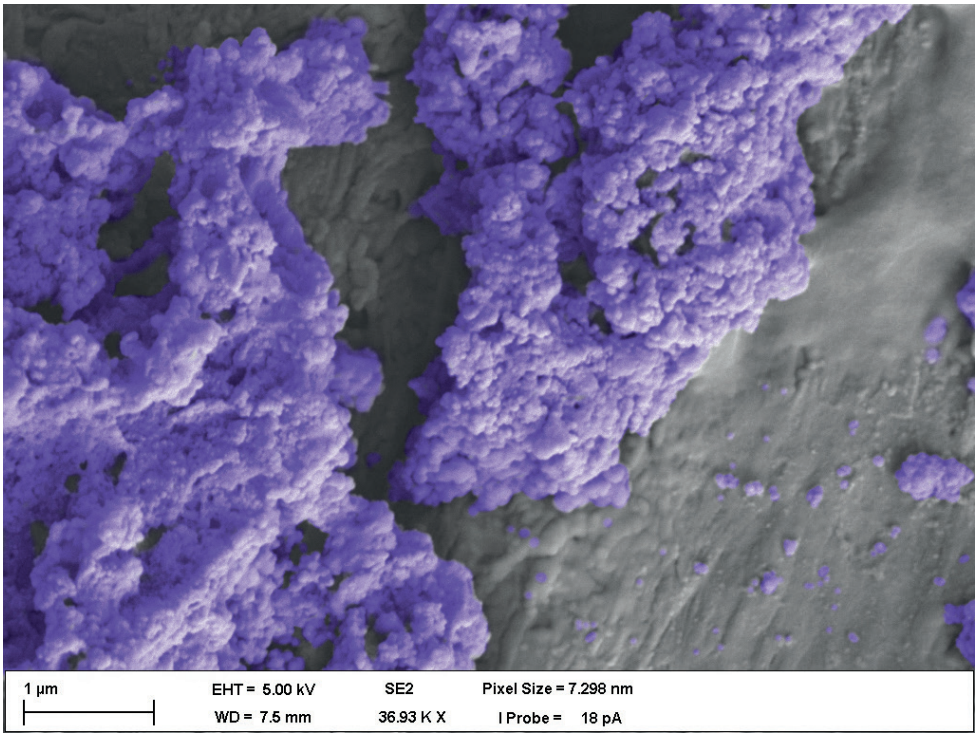

Figure 1. Scanning electron microscopy image (magnification x10 000) of an environmental dry surface biofilm recovered from a patient folder. (The biofilm is artificially coloured.)

2021b). Although the direct link between infection outbreak and pathogenic bacteria from dry surface biofilms is yet to be made, connecting the dots from various studies paints a worrying picture.

Dry surface biofilms are widespread on a range of surfaces across hospitals, from patient folders through to nurse station keyboards to high-touch areas in close proximity to patients (Ledwoch et al, 2018, 2021a; Costa et al, 2019). These include surfaces that are routinely decontaminated, so in theory should be safe.

Dry surface biofilms are composed of various environmental bacteria, including *Staphylococcus* spp. and *Bacillus* spp., and multidrug-resistant microorganisms, such as meticillin-resistant *Staphylococcus aureus*, vancomycin-resistant enterococci or multidrug-resistant *Acinetobacter* spp (Costa et al, 2019; Ledwoch et al, 2021a).

Studies have shown that bacteria from artificial dry surface biofilm can be transferred directly and indirectly, for example, via gloves (Tahir et al, 2019; Ledwoch et al, 2021a) and when disturbed following cleaning or disinfection. However, when they are dry, transfer is unlikely, explaining the failure of wet swabbing to detect dry surface biofilms on environmental surfaces. Therefore, it is possible that the gloved hands of a hospital staff member could act as a bacterial carrier when dry surface biofilms are disturbed.

Should we be worried?

Dry surface biofilms mostly consist of environmental microbes that people face in everyday life (Ledwoch et al, 2018), do not multiply rapidly and do not seem to be transferable when dry. They could just be harmless inhabitants of environmental hospital surfaces.

On the other hand, dry surface biofilms could be a ticking time bomb. They are difficult to detect, difficult to eradicate, harbour pathogens (Ledwoch et al, 2018, 2021a; Costa et al, 2019) and are transferable when disturbed (Tahir et al, 2019; Ledwoch et al, 2021a). The authors hypothesise that transmission of multidrug-resistant organisms to naïve patients from a previous room occupant could have resulted from the persistence of dry surface biofilms on environmental surfaces despite the use of appropriate infection control regimens. The use of reproducible artificial dry surface biofilms has been reported for the testing of product efficacy (Almatroudi et al, 2016; Ledwoch et al, 2021b).

Key points

- Dry surface biofilms are widespread on dry environmental surfaces in healthcare settings (as high as 95% of surfaces).
- Dry surface biofilms can harbour bacterial pathogens including multidrug-resistant organisms.
- Dry surface biofilms cannot be detected by routine wet swabbing.
- Dry surface biofilms are less susceptible to disinfection.
- Bacterial pathogens in dry surface biofilms are transferable by direct and indirect contact (gloves) following cleaning and disinfection.

Conclusions

The role that dry surface biofilms play in healthcare-associated infections is unclear at present. Additional studies need to be conducted to establish a link between pathogenic microorganisms residing on hospital surfaces in dry surface biofilms and infection outbreaks.

Nevertheless, it is important for infection control professionals to be aware of the presence of dry surface biofilms and the potential threat they pose. Dry surface biofilms cannot be overlooked in the efforts to create a safe hospital environment, with introduction of cleaning and disinfection protocols against dry surface biofilms.

To date, dry surface biofilms have only been studied in healthcare settings, but they are highly likely to be present in other environments such as food manufacturing.

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