

How Do Biofilms Affect Surface Cleaning in Hospitals?

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The science of biofilms is progressing rapidly. Now that there is recognition that microorganisms in dry surface biofilm might contribute towards healthcare-acquired infection (HAI), work has escalated to define, investigate and identify biofilm components on accessible surfaces in the healthcare environment. The risk of HAI comes from direct transfer of pathogens released from biofilm to patients, compromised by inadequate cleaning and decontamination. Staff, patients and visitors acquire pathogens on their hands and fingertips after touching surfaces and either inoculate a potential infection site themselves or transfer microbes to other sites including those on vulnerable recipients. This clearly raises a question over the validity of routine cleaning practices for healthcare surfaces.

What do we mean by biofilm, and how prevalent is it in our hospitals [1]? Dry surface biofilm coats most, if not all, surfaces in the indoor environment, including floors, walls, fittings, fixtures, furniture and equipment, although the coatings are not necessarily uniform [2,3]. It begins with airborne organisms settling on surfaces, along with others transferred from direct and indirect contact from a range of living things, including people, animals, birds and insects. These microbial immigrants need to protect themselves to ensure survival while facilitating their potential transfer to more habitable sites [4,5]. Thus, biofilm can be thought of as a ‘microbial village’, with an identifiable infrastructure supporting a disparate mesh of bacteria, viruses, fungi, protozoa and spores embedded in exopolymeric substances (EPS) [6].

EPS makes up 90% of the biofilm and plays an important role in maintaining its mechanical stability [7]. The microscopic community is shielded by this protective covering, while the base elements penetrate tiny surface crevices, or even ‘glue’ themselves onto underlying surfaces [6]. This level of adherence means that biofilm poses a significant physical challenge to remove, as well as presenting an almost impenetrable barrier to chemical agents such as disinfectants [8,9]. Difficulty in removal is compounded by increased resistance or tolerance of biofilm components, including viable pathogens, to disinfectants, antiseptics, heavy metals and a range of antimicrobial agents used for patients [10]. Biofilms typically present gradients of physiology and concentration for any chosen decontamination agent, which enables the less susceptible species to survive [11].

Biofilm villages periodically release free-swimming planktonic bacteria onto the surface, thus allowing them the opportunity for onward transfer. Wiping surfaces will not substantially disrupt or remove the biofilm structure, although it might dislodge newly released superficial microbes. Aggressive cleaning or use of disinfectants damages the microbial community and its supporting structure, thus releasing a larger proportion of viable planktonic microorganisms and other material [5,12,13]. These may be detected by sampling, but the real risk is contact with hands and/or fingertips and subsequent transmission to other surfaces or patients. While this risk seems obvious, few studies have so far managed to irrevocably link immured biofilm pathogens from dry healthcare surfaces with patient infections. The extensive surface area of the general indoor environment complicates sampling, making it difficult to locate potential pathogens from dry surface biofilm.

Studies on outbreaks involving microorganisms from ‘wet’ surface biofilm, as found on contaminated plumbing components and specialist healthcare equipment, serve to



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highlight the potential infection risk from dry surface biofilm [14,15]. There are clear associations between pathogens originating from sink traps, filters and drains, and invasive equipment such as endoscopes, with increasing numbers of cross-transmission incidents in healthcare environments [16]. These organisms often demonstrate tolerance to the agent(s) used for routine decontamination as well as multi-drug resistance to antimicrobial agents used for patient treatment [14,17]. The risk from dry surface biofilm can also be surmised from sampling studies targeting general surfaces. These studies have characterised known hospital pathogens using genotypic methods, which confirm their identity with the same species linked to previous cases or outbreaks occurring weeks or months before in the same hospital [18–20]. Furthermore, genomic material conferring resistance properties in biofilm components can be transferred to organisms eventually identified from patient infections [20]. These studies infer that generic dry surfaces could pose an equitable HAI risk to patients just as much as endoscopes, sinks, plumbing, filters and drains.

Microbes use biofilm to persist in the healthcare environment pending release, should they survive. Indeed, over half of the organisms immured in biofilm do survive and will be viable [6,18]. The question is, what should we do about the risk of infection posed by dry surface biofilm? Is the risk sufficient to change current operating procedures for cleaning and decontamination, or do we continue with standard practice? It is possible that frequent application of powerful disinfectants will control or even eventually eradicate surface biofilm over time, and inhibit its recovery, provided surfaces remain undamaged [13]? The type (and strength) of disinfectant used is almost certainly important although there is insufficient evidence to distinguish between multiple products [21]. It is already known that bleach will not necessarily eradicate biofilm at first application and captured organisms within the ‘village’ eventually demonstrate tolerance or frank resistance after repeated exposure [9,21].

Routine detergent cleaning in hospitals is unlikely to remove the biofilm community from general surfaces although wet wipes should pick up superficial microbes depending upon cleaning process (‘one wipe; one site; one direction’) [22]. Failure to disrupt hard surface biofilm does not necessarily have to invalidate this type of manual cleaning, however we should determine the relative risk from cleaning frequencies required for the timely removal of newly liberated pathogens while leaving the biofilm structure relatively intact. At present, optimal cleaning frequencies for all surface types and different areas of clinical risk in the healthcare environment remain unknown. Perhaps seeking complete obliteration of hard surface biofilm in our hospitals might be viewed as disproportionate, let alone time-wasting and expensive. Indeed, excessive use of disinfectants, enzymes and physical force could create additional risk, since nature abhors a vacuum and will fill it up if it can [23].

Eradicating all surface microbes, whether part of a biofilm community or not, will encourage the rapid repopulation of a newly decontaminated surface with environmental, and other, microbes. Some of these represent a bigger risk to patients than those originally present. For example, one recent study showed that disrupting wet surface biofilms following bleach exposure resulted in increased detection of multidrug resistant organisms including carbapenemase-producing Enterobacteriaceae [17]. These organisms are becoming increasingly common as healthcare pathogens can be extremely difficult to treat. It is also known that hospitals using disinfectants are more likely to encourage multidrug resistant pathogens such as vancomycin-resistant enterococci, *Acinetobacter* spp. and Gram-negative organisms such as *Stenotrophomonas* spp., simply due to the selection of linked biocidal and antimicrobial resistance characteristics [21,24–26]. Hospitals that rely upon detergent or probiotic-type products encourage the repopulation of surfaces with inert environmental organisms such as Methylobacteria, *Bacillus* spp. and other non-pathogens [27,28].

It is clear that there are many gaps in our knowledge of dry surface biofilm in the healthcare environment and we do yet not know how those gaps relate to the infection risk for patients. Managing biofilm constitutes a challenge due to its tenacious character and

the current lack of evidence. It is hoped that this supplement will go some way towards contributing useful findings from this microbial world at our fingertips.

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Stephanie J. Dancer, BSc, MB.BS, MSc, MD, FRCPath, DTM&H, FRCP(Ed), FESCMID, FISAC. Stephanie is a medical microbiologist in NHS Lanarkshire and a Professor of Microbiology at Edinburgh Napier University in Scotland. She edited the *Journal of Hospital Infection* for over 20 years, five of them as editor-in-chief, and now edits for *Infection, Disease & Health* and *International Journal of Antimicrobial Agents*. She trained at St. Bartholomew's Hospital in London followed by a period of postgraduate study at Guy's Hospital, where she gained a thesis on the epidemiology and biochemistry of toxin-producing staphylococci. She has worked and travelled all over the world, including the Canadian High Arctic, where she resuscitated 30,000-year-old organisms from glacial ice. She spent six years as Infection Control Officer for Argyll before moving to Health Protection Scotland as their inaugural microbiologist (2002–2005). There, she set up MRSA surveillance for Scotland, evaluated real-time PCR for MRSA screening and helped establish the Scottish Microbiology Forum. She has been a member of various working groups on antibiotic prescribing, MRSA and hospital cleaning, and is a current or recent member of NHS Scotland Decontamination; UK NICE (infection control & antimicrobial prescribing); UK HTA (screening and diagnostics); ESCMID groups on infection control, MRSA & multi-resistant Gram-negative bacilli; 2023 ECCMID conference committee. She advised DEFRA on surface cleaning and hygiene during the COVID-19 pandemic and has been collaborating with an international group of virologists, physicists, ventilation engineers and aerosol scientists on airborne spread of SARS-CoV-2. She has published books, book chapters and over 200 papers in peer-reviewed journals on hospital cleaning, antimicrobial management, infection control and MRSA. At present, she balances editorial duties with research and teaching, specifically antimicrobial stewardship and environmental control of hospital pathogens.