



Improving Indoor Air Quality in Dental Offices

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How minimizing airborne bioburden can reduce the risk of infection.

Dental environments are frequently exposed to high levels of contaminated indoor air. Aerosol generating procedures conducted daily in dental offices like ultrasonic scaling, tooth extractions, implant surgery and root canals generate pathogenic fusions of saliva, blood, plaque, tooth debris, and gum secretions, carrying risk of contamination and infection. An increase in a variety of bacteria, viruses, and fungi has been detected on surfaces and in the air following these procedures.¹ Dental professionals are also at risk for infections transmitted from patients who may be carriers of viruses.

When Business Insider ranked the “47 jobs that are most damaging to your health,” 6 of the top 7 spots were occupied by dental professions, including dentist, dental hygienist, and dental lab technician.² The rankings were based on a U.S. Department of Labor database of occupational health risks, such as exposure to airborne contaminants and infectious pathogens. Chemical plant operator, vet tech, embalmer, oil derrick operator — all were rated less hazardous than

dental occupations.

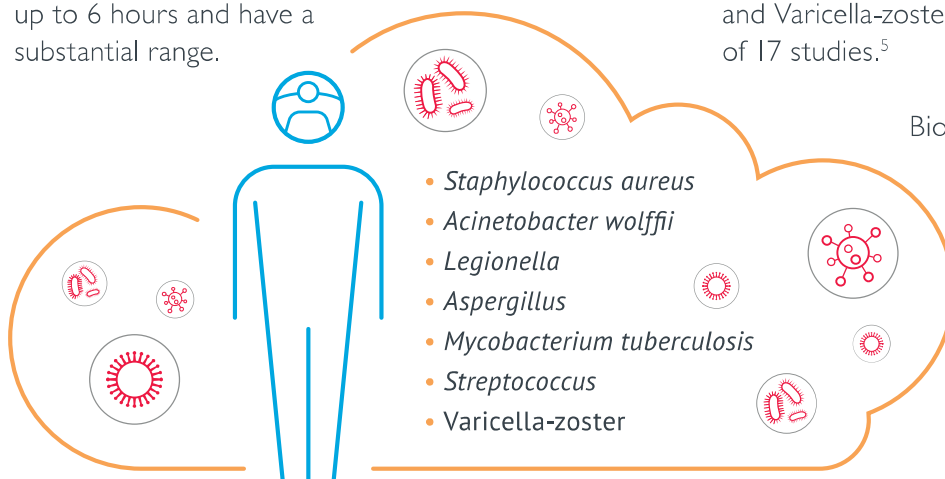
Of course, it's not just staff who are exposed to pathogens in dental clinics. Patients have contracted Legionnaire's disease, *Aspergillosis*, tuberculosis, and Methicillin-resistant *Staphylococcus aureus* (MRSA) infections directly from dental appointments, case studies document. And influenza and rhinovirus are easily spread in the dental environment.

As a report³ from the European Oral Microbiology Workshop noted, the oral cavity is a “natural habitat” and “reservoir” for pathogenic microorganisms.

While personal protective equipment (PPE) is often used for staff safety, less emphasis has been placed on improving and managing the ongoing air quality in dental offices. Evidence now suggests that proactive management of Indoor Air Quality (IAQ) in dental workspaces should be a vital component of minimizing airborne bioburden and subsequently, infection risk.

A “Toxic Cloud” of Bio-Aerosols

One of the most worrisome sources of airborne contamination in dentistry are bio-aerosols, mixtures of air from a handpiece, water from the dental-unit waterline, and debris from the patient's mouth. These microscopic droplets can hover in the air for up to 6 hours and have a substantial range.



As one American dentist described it, “a toxic cloud spans from the floor to a height of six feet.”⁴ Among the pathogens commonly found in this “cloud”: *Staphylococcus aureus*, *Acinetobacter wolffii*, *Legionella*, *Aspergillus*, *Mycobacterium tuberculosis*, *Streptococcus*, and *Varicella-zoster* virus, according to Dutch analysis of 17 studies.⁵

Bio-aerosol concentrations skyrocket during and immediately after dental treatments.

At a Saudi university dental clinic, for example, the concentration of bacterial aerosols was 5 times higher during the workday than before the clinic opened.⁶ In a Polish

dental office, the concentration of bio-aerosols generated by dental grinding was 16 times higher than concentrations in the dental office background.⁷

Bio-aerosols pose significant risks because they're small enough to penetrate the lungs. Splatter droplets, while often too large for respiratory penetration, create their own hazards.

"They have sufficient mass and kinetic energy to move ballistically and quickly settle on objects," notes Jolanta Szymańska, DMD, of Poland's Medical University of Lublin.

Splatter particles often reach the practitioner's nostrils, mouth, eyes, and skin and are deposited on hair, clothing, and surfaces within 15 to 120 cm of a patient's oral cavity. "Splatter can easily reach a doctor and an assistant," Dr Szymańska observes.

The surfaces most contaminated by splatter and aerosol droplets are the dentist's and assistant's masks, unit lamps, mobile instrument-material tables, and surfaces close to spittoons. *Streptococcus* and *Staphylococcus* strains are the most commonly detected bacteria, with Gram-negative bacteria a distant third.

Studies by Szymanska⁸ and others have indicated that the microflora of air in a dental surgery unit contained opportunistic infectious agents such as *Staphylococcus epidermidis* (37.1%), non-diphtherial corynebacteria (28.2%) and *Pseudomonas* spp. (~1%), in addition to other microorganisms.

According to Rautemaa et al., there is evidence⁹ that the spread of this airborne bioburden is not

limited to a small restricted area, but in fact can easily find its way across the larger office area. In a study involving the use of modern high-speed rotating dental instruments, bacterial colony-forming units (CFUs) were found to increase at distances beyond five feet from the site of the procedure, more than three hours after the procedure.

Laheij and co-workers have demonstrated¹⁰ that the risk of cross-contamination and infection of viruses and bacteria are of particular concern in the dental environment. Specifically, Hepatitis B is a particular threat for cross-infection. The pathogens present as biofilms in dental unit water lines (DUWL) can also be aerosolized during the use of high-speed dental handpieces.

In 2015, pediatric *Mycobacterium abscessus* infection outbreaks were reported in the U.S. states California and Georgia, resulting in the hospitalization of dozens of children that had undergone a pulpotomy procedure in dental practice¹¹. The source of the bacterial contamination was traced to biofilms in the DUWL.

An inefficient ventilation (HVAC) system can exacerbate the problem by withholding or recycling contaminants. As HEPA filtration is not a commonly deployed HVAC feature in dental offices, both bacterial and viral airborne bioburden can easily contribute to cross-contamination.

A number of preventive measures have been adopted to minimize the risk of contamination, such as hand hygiene, PPE, instrument sterilization, surface disinfection and cleaning of DUWL. However, none of these methods adequately address the source of the risk, which is aerosolized viral and bacterial particles.

The Risk of Infection

For dental patients and staff, the infection risk is not just theoretical. It's real. In Rome, an 82-year-old woman died of septic shock two days after contracting Legionnaire's disease from a dental-unit waterline.¹² *Legionella* bacteria — commonly found in aerosol-producing water systems such as showers, fountains,

and water-cooling towers — have been detected in numerous dental-unit waterlines, the flexible plastic tubes that carry water to hoses for mouth rinsing. The start-and-stop nature of dental treatment makes the waterlines breeding grounds for bacteria.

“They only use the water sometimes,” explains Nuala Porteous, D.D.S. of the University of Texas, an expert on infection control in dentistry. “They work and then they rinse, so there’s a lot of stagnant water.”¹³

While Legionnaire’s disease is on the rise in the United States and elsewhere, a more prevalent bacterial threat to dental clinics is MRSA, a superbug wreaking havoc worldwide.

In the *British Dental Journal*, Scottish dentists reported on a 49-year-old man who developed persistent facial swelling after a dentist extracted one of his molars. Tests found a “profuse growth of MRSA” resistant to several antibiotics. The dentists urged “increasing awareness of the probability of MRSA infection in dental-related infections.”¹⁴

In another British case, a dentist who’d contracted MRSA during emergency surgery at a hospital transferred the same MRSA strain to two patients, likely because of a lapse in hand hygiene.¹⁵

MRSA spreads when airborne particles settle on

surfaces touched by vulnerable patients or by healthy, colonized staff who touch high-risk patients. The bacteria are so infectious, hospital studies show, that a patient can become infected when the MRSA-contaminated sleeve of a doctor’s lab coat brushes against a wound.

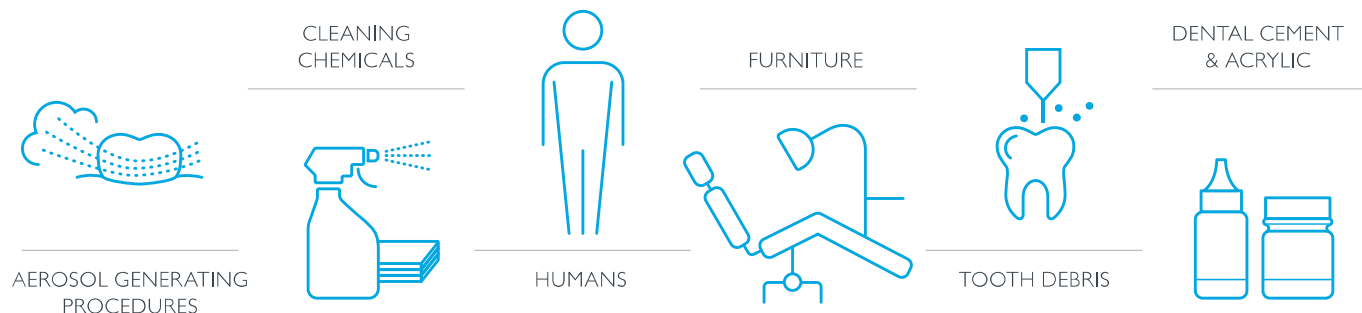
“Both dental clinic surfaces and dental staff may be “reservoirs for MRSA,”

American researchers concluded in a study of 7 dental clinics.¹⁶

Among 61 dental students tested, 21% carried MRSA, a rate 10 times higher than the general public. MRSA-positive surfaces were detected at 4 of the 7 clinics tested.

At Japan’s Shinshu University School of Medicine, researchers in the dentistry department found MRSA on the air-water syringes and reclining chairs. Among 140 consecutive patients who were MRSA-free at admission, eight became colonized or infected with the same strain detected at the clinic.¹⁷

Air Pollution at the Dentist’s Office



In just about any indoor environment — schools, offices, laboratories — toxic chemical gases are emitted by furniture, flooring, cabinetry, and cleaning products. But dental clinics are at greater risk for indoor air pollution because of the materials used in treatments.

Among the most toxic may be methyl methacrylate, a monomer of acrylic resin used in dentures and cement

and known, according to Taiwanese researchers, for its “strong acid smell and volatile character.”¹⁸

Other toxic gases and vapors are released by metal casting, grinding and polishing acrylic materials, removing amalgam fillings, and creating crowns, bridges, and dental prostheses.

When the Taiwanese team recorded total VOC

concentrations at a university dental clinic, all six areas tested exceeded the indoor air-quality standards of the Taiwan Environmental Protection Agency.

“The dental departments of the hospital had serious total VOC pollution,” the authors concluded.

VOCs were particularly high in the periodontal department, which the authors attributed to bleaching

solvent used to disinfect the boxes used for collecting surgery devices.

Similarly, in a study at Athens University dental school, researchers found total VOC concentrations “far exceeded the [recommended] limit for the indoor environment.” Indoor particulate-matter concentrations were 12 times higher than nearby outdoor concentrations.¹⁹

Cleaning the Air in Dental Clinics

Warning that bacterial and viral infections are under-reported in dentistry, Dutch researchers offered this guiding principle for dental clinics:

“Every patient should be treated as potentially infectious.”²⁰

The same might be said of every dental-unit waterline, patient chair, sink, and instrument.

That’s why clinics must take every precaution to prevent the spread of infectious bioaerosols, as well as the emission of toxic gases and vapors. It is becoming increasingly clear that traditional prevention methods, while important, are wholly inadequate.

For example, dental personnel are urged to wear face masks, though masks are not designed to eliminate air leakage around the edges and don’t filter out submicron particles.²¹

“Surgical masks offer some protection for the mucous membranes of the nose and mouth of the wearer from large droplets and splashes but will not protect against the inhalation of aerosols,” American researchers concluded.

Similarly, dental practices must follow strict protocols for cleaning dental-unit waterlines, though diligent disinfection, draining, and water testing won’t eliminate risk.

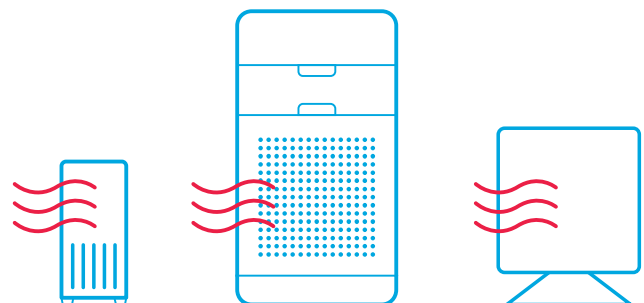
As French researchers found, even when dental-unit waterlines were submitted to stringent disinfection, “results clearly suggested that patients and dental staff remained exposed to potential infectious risk.”²²

The limits of hand hygiene and surface cleaning have long been documented, which makes one important precaution all the more critical: air disinfection, via ultra-low-energy plasma technology by Novaerus.

Novaerus: 24/7 Air Dis-infection

Commonly installed in hospital emergency rooms, waiting areas, ICUs, and operating theaters, Novaerus technology has recently become more prevalent in dental clinics.

The technology is proven to eradicate airborne pathogens highly contagious viruses, such as influenza, norovirus, and measles, dangerous bacteria and fungi,



such as MRSA, *Clostridium difficile*, and *Aspergillus niger* as well as VOCs and particulate matter.

Infectious aerosols can be extremely small (<5 µm) and remain suspended and viable in the air stream over long periods of time, resulting in a high risk of airborne infection. Larger infectious particles drop from the air to contaminate surfaces and hands.

Independent laboratory testing has proven Novaerus technology highly effective against MS2 Bacteriophage, a surrogate for SARS-CoV-2, the virus causing COVID-19, reducing the airborne load by 99.99%.²³

In the dental setting, ultra-low-energy plasma technology is a critical complement to ventilation and filtration.

As a Greek study concluded, typical dentistry ventilation systems are insufficient, causing the “accumulation and trapping of air pollutants in certain areas of the room.”²⁴ And whereas conventional HVAC filters capture only large particles, Novaerus units destroy the smaller and more dangerous ones.

The efficacy of Novaerus dis-infection technology was evaluated in the dental practice of Dr. Gary Walton, DDS, located in Indianapolis, IN. Air and surface samples of bacterial and fungal counts were taken from five different locations in the dental practice including patient, sterilization, laboratory, hygiene, and reception areas. One Novaerus NV800/NV900 unit was deployed in each of these pre-selected areas across the dental practice. Sampling was conducted from each of these areas before the units were deployed and three weeks (21 days) after deployment in order

to evaluate their impact on airborne and surface bacterial and fungal counts.

Airborne bacterial sampling was conducted using a standard Anderson-type air sampler (air IDEAL® 3P Air Sampler, bioMérieux, Inc.). Bacterial culture plates from the air sampling were submitted to EMSL Analytical, Inc. in Indianapolis, IN for the identification and enumeration of culturable bacteria using EMSL Method M009.

Figure 1. shows the reduction in airborne bacterial counts before and after the deployment of the Novaerus NV800/NV900 units. The most prevalent bacteria found in the pre-selected environments were *Bacillus sp.*, *Micrococcus sp.*, and *Staphylococcus sp.* In addition, the Sterilization area showed a prevalence of *Actinomyces sp.*, while the Laboratory area showed a prevalence of *Corynebacterium sp.*

Overall bacterial Colony Forming Units (CFU/ m³) in each of the sampled areas were reduced by more than 95% as a result of the deployment of the Novaerus dis-infection unit.

Figure 2. shows the reduction in surface fungal counts before and after the deployment of the Novaerus NV800/NV900 units. The most prevalent fungal specimens found in the pre-selected environments were *Aspergillus sp.*, and *Cladosporium sp.*

During this evaluation, by continually cleaning the air at the point of care, Novaerus technology not only reduced the amount of bioburden in the air but showed a reduction in surface contamination as well.

Airborne Bacterial Counts (CFU/m³)

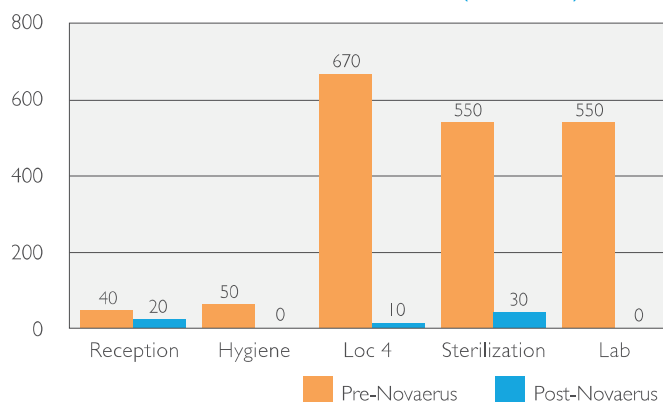


Figure 1: Reduction in airborne bacterial counts following use of Novaerus

Surface Fungal Counts (CFU/m³)

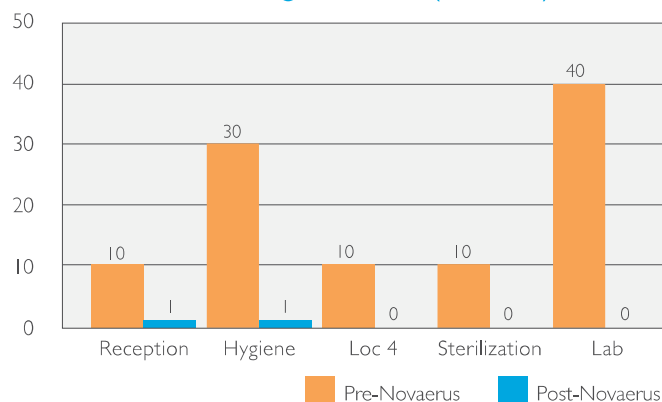


Figure 2: Reduction in surface fungal counts following use of Novaerus

Novaerus technology is safe for continuous use around vulnerable patients, and as a welcome bonus, the units eliminate even the most noxious odors.

And it's one reason Wassan Specialty Dental Centre in Muscat, Oman, has been so pleased with Novaerus technology.

Shortly after installing Novaerus technology, the dental staff noticed a reduction in odours that had originated from within the clinic and from nearby restaurants.

Patients, too, noted a fresh quality to the air inside the clinic.

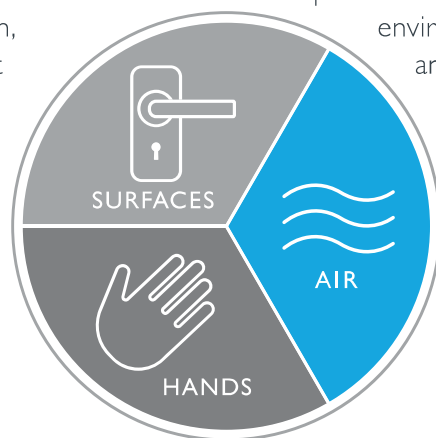
Of course, staff were also reassured to know that Novaerus technology was operating continuously in the background to eliminate airborne pathogens and pollutants.

“We know we are providing a safer practice to our patients and safer workspace to our staff,”.

Closing the Loop in Infection Control

In healthcare environments, air quality is perhaps the most easily forgotten component of microbial burden. The constant traffic of patients, visitors, and staff combined with the effect of ongoing procedures using high-speed mechanical tools ensures consistently high levels of airborne microbial contamination. Chemicals used in cleaning, sterilization, and paints can contribute to significant

levels of VOCs in the air. Traditional protocols to clean hands and surfaces do not adequately address the contribution of airborne bioburden and the risk it presents for cross-infection. Implementing air disinfection technology that is constantly working at the point of care results in increased safety of the environment and the wellbeing of patients and staff alike.



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