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Dental Infection Control Overview

PREPARED BY:

John A. Molinari, Ph.D. and
Peri Nelson, B.S.

Healthcare professionals (HCP) are routinely at risk of occupational cross-infection when providing patient treatment. With specific regard to dental medicine, there are three general routes of microbial transmission:

1. **Direct contact** with infectious saliva, blood, or lesions;
2. **Indirect contact** resulting from transfer of microorganisms via a contaminated intermediate object; and
3. **Airborne transmission** (aerosolization) of microorganisms.

In 1986, the CDC published the first set of comprehensive dental infection control guidelines based on the concept that all blood and body fluids that might be contaminated should be treated as infectious. As a result, recommended Universal Precautions for dentistry mandated the use of the *same* appropriate infection control precautions and procedures in the care of *all* patients. In 1996, in an effort to prevent any potential confusion that might result between universal precautions (directed at bloodborne pathogens) and body substance isolation precautions (directed at other moist body substances), the CDC published guidelines that incorporated the major features of universal precautions and body substance isolation precautions; these are classified as Standard Precautions. A second tier of precautions (Transmission-Based Precautions) is designed only for the care of specified patients. There are three types of Transmission-Based Precautions: Airborne, Droplet, and Contact Precautions. These additional precautions are sometimes needed in dental settings to interrupt transmission of highly transmissible or epidemiologically important pathogens (tuberculosis, influenza, and chicken pox).

While the fundamental principles and rationale for infection control remain the same, the information contained in infection control practices and protocols is not static, and is modified as new scientific and clinical-based evidence continues to emerge. The goal of the following discussion is to provide an overview and update of representative components of a practical dental infection control program.

Guidelines and Regulations

The Occupational Safety and Health Administration (OSHA) and the Centers for Disease Control and Prevention (CDC) have been at the forefront of developing infection control regulations and recommendations to protect HCP. It is important to realize that the OSHA and the CDC are two completely different governmental agencies with different mandates (**Table 1**). The CDC develops guidelines designed to protect both the patient and the HCP, while OSHA regulations apply only to the latter. Guidelines published by the CDC or other advisory agencies do not carry the weight of law possessed by a regulatory agency such as OSHA. OSHA has the authority to require and enforce compliance with recommended infection control practices and procedures. OSHA relies upon appropriate authorities, including the CDC, to provide background information when they formulate their standards. It is important that dental providers be aware of updates or changes to recommended infection control practices to provide the safest environment possible for their patients and employees. The most recent CDC update in this area was published in March 2016, and "reaffirms Standard Precautions as the foundation for preventing transmission of infectious agents during patient care in all dental health care settings."[1]

Table 1: OSHA and CDC Governmental Agencies

OSHA	CDC
• Regulatory agency • Set and enforce standards • Investigates and inspects • Blood-borne Pathogen Standard 29 CFR 1910.1030 and CPL 2-2.69 • Employee protection	• Non-regulatory agency • Guidelines/Recommendations • Morbidity and Mortality Weekly Report Recommendations and Reports • Often enforced by state

Hand Hygiene

Hand hygiene (formerly termed hand washing) is the single most important infection control procedure clinicians perform to minimize cross-contamination and cross-infection in patient care settings. Its primary purpose is the mechanical removal of transient microorganisms from the skin. The most frequently used classes of currently available antimicrobial antiseptics for hand washing are chlorhexidine gluconate, parachlorometaxylenol, and triclosan. Each is capable of providing substantivity (residual antimicrobial effect) following each hand wash procedure.[2,3]

The CDC expanded its hand hygiene recommendations in 2002[4] to include alcohol-based hand antiseptics as an option, and not just when soap and water aren't available. Accumulated

Table 2: Pros and Cons of Handwashing* vs Alcohol-Based (Antiseptic) Hand Rubs†

Technique	Pros (+)	Cons (-)
Handwashing	+ Can use plain or antimicrobial soaps + Effective antimicrobial activity with antimicrobial soaps + Effectiveness only minimally affected by organic matter + Sinks readily available and accessible in most dental settings + Familiar technique + Allergic reactions to antimicrobial active ingredients are rare + Irritation dermatitis related to handwashing may be solved by relatively simple techniques / changes	- Frequent handwashing may cause skin dryness, chapping and irritation - Compliance with recommended handwashing protocol is traditionally low - Takes more time than antiseptic hand rubs - Requires sink and water and paper towels or air dryers - Personal habits and preferred products such as hand lotions may undermine professional training - Strong fragrances and other ingredients may be poorly tolerated by sensitive people - Water alone may be a skin irritant - Time and technique are critical
Alcohol-Based (Antiseptic) Hand Rub	+ Provides more effective antiseptic action on visibly clean hands than handwashing with plain or antimicrobial soaps + Faster protocol than handwashing + Reduced skin irritation and dryness compared to handwashing + May be used in absence of sinks and water, and during boil-water notices + Allergic reactions to alcohol or additives are rare + Reduces use of paper towels, waste	- Not indicated for use when hands are visibly dirty or contaminated - Dispensing proper amount is critical - Hands must be dry before agent is applied - Frequent use may cause skin dryness or irritation if product lacks effective emollients / skin conditioners - Agent may temporarily sting compromised skin - Strong fragrances and other ingredients may be poorly tolerated by sensitive people - Alcohol products are flammable – should be stored away from flames - Residual powder may interfere with effectiveness or comfort of antiseptic rub - Handwashing stations must still be accessible for times where waterless sanitizers are inappropriate

* Handwashing performed according to recommended protocol, as outlined in this chapter

† Antiseptic Hand Rubs meet recommended product selection criteria as defined in this chapter

(Adapted with permission from Organization for Safety and Asepsis Procedures. From policy to practice: OSAP's guide to the guidelines. 2004:23.)

evidence has demonstrated that alcohol-based hand gels, foams, and sprays can significantly reduce the number of microorganisms on skin, are fast acting, cause less skin irritation, and may increase use compliance. While both antimicrobial antiseptics and alcohol-based hand rubs provide an appropriate alternative for the HCP, it is important that positive and negative features of are considered before use (**Table 2** above).[5]

Healthy, intact skin is the primary barrier against infection. Skin damage changes the microflora, resulting in more frequent colonization by transient bacteria that can cause dermal infections. The physical act of washing hands can remove surface lipids, fatty acids, and other skin components that lubricate epithelium. Frequent repeated use of hand hygiene agents, especially soaps and detergents, has been associated with irritant dermatitis among HCPs, most frequently those reporting a history of skin problems (**Figure 1**).

The extent of skin irritation can vary considerably among individuals and can be substantially reduced by 1) choosing hand hygiene products with emollients; and 2) using appropriate water-based lotions designed for health professional use that reduce skin dryness.

Figure 1. Factors Associated with Dermatitis in Home Care Settings

Hand Hygiene Considerations

1. Skin sensitivities and personnel allergies
2. Initial thorough hand wash at beginning of workday
3. Always wash and rinse when hands are visibly soiled or dirty
4. Wash and rinse or use waterless alcohol rub when hands are not visibly soiled
5. Subsequent hand hygiene procedures should last at least 15 seconds or time recommended for the specific preparation
6. Do not wear jewelry, long nails, or artificial nails
7. Maintain epithelial integrity with frequent hand hygiene procedures

Personal Protective Equipment

Personal protective equipment (PPE) can be defined as specialized clothing or equipment worn by an employee for protection against a hazard. The routine use of PPE is important in reducing the tissue contact with potentially infectious pathogens and materials, ultimately reducing cross-contamination and cross-infection between the HCP and their patients. Treatment providers must wear protective attire such as disposable gloves, eyewear and protective clothing when performing treatment procedures capable of causing splash, spatter, contact with body fluids or mucous membranes, or touching items or surfaces that may be contaminated with body fluids (**Table 3**).

Table 3. Personal Protective Equipment

Face Mask	Gloves	Protective Eyewear
1. It must fit the face well to minimize open spaces on the side of the face. 2. It should be able to prevent penetration of aerosolized particles generated during the procedure for which the mask is worn. 3. It should not rest against the mouth, as the wearer's breath can condense and wet the fabric.	1. Single-use. 2. Must be able to prevent microbial penetration through epithelial tissue barriers. 3. Non-sterile disposable gloves appropriate for examinations and other non-surgical procedures. 4. Alternative glove materials should be available for latex-allergic persons. 5. Chemical- and puncture-resistant utility gloves should be available for instrument reprocessing and clean up.	1. It should have solid sideshields to afford peripheral protection. 2. It must meet the American National Standards Institute occupational and Educational Eye and Face Protection Standard for impact resistance. 3. It should be able to withstand cleaning and disinfection between patient procedures. 4. It should not distort the operator's vision. 5. A faceshield worn with a mask can be worn when great protection is desired.

Gloves

Properly fitting gloves protect dental professionals from direct exposure through visually undetected cuts and abrasions on the hands. Gloves used during the provision of patient care are single-use items and must not be used when providing care for another patient or be washed for reuse. Glove types worn during patient treatment can be comprised of latex, nitrile, vinyl, or chloroprene. The most frequently worn gloves during patient treatment are non-sterile, disposable patient examination gloves. Non-sterile examination gloves provide an effective barrier during the time interval of most routine procedure appointments, as well as comfortable fit and tactility for most users. The American Dental Association (ADA) initially approached the issue of practitioners wearing disposable gloves in an important 1976 publication[6] aimed at protecting dental clinicians from occupational HBV infection. This recommendation has been re-enforced and expanded in later ADA and CDC publications.[7-13] The conversion of treatment providers from "wet fingered dentistry" to routine use of disposable gloves in patient care is widely considered the most important aspect of personal protective protection.

Traditionally, the most common type of glove worn during patient treatment has been comprised of latex. This material can be manufactured in a number of sizes and specifications (ambidextrous, right or left hand, low powder, powder-free, low protein), affords a comfortable fit and tactility for most users, and provides an effective barrier during the time interval needed to provide most dental procedures. As a consequence of the development and manifestations of latex allergies in HCP and the population at large, a large percentage of HCP are now wearing nitrile gloves. The use of sterile latex or similar treatment glove materials is indicated when surgical procedures are performed. These are found as right- and left-handed fitted items, and offer clinicians excellent tactility, comfort and dexterity. Puncture and chemical resistant reusable utility gloves are a type of non-treatment glove routinely worn when the cleaning contaminated instruments, the operatory area, or completing surface cleaning and disinfection procedures. These gloves are puncture-resistant, resistant to chemical toxicity, and are able to withstand multiple cleaning and disinfection exposures. They are usually comprised of nitrile or neoprene. Some types can withstand repeated heat sterilization.

Masks

The dental HCP are routinely exposed to high concentrations of aerosols, sprays, spatter and/or splashes during various treatment procedures. These involve the use of a dental handpiece, ultrasonic scaler, air/water spray, while grinding items contaminated with oral secretions, or even while cleaning contaminated instruments. Airborne microorganisms that can be infectious via this route of exposure include staphylococci, streptococci, tubercle bacilli, herpesviruses, and influenza viruses.[14] The routine use of an FDA-approved mask will protect the HCP from microbe-laden droplets. Many masks are now able to filter out particles ranging in size from 0.1 – 1.0 mm. Routine mask use, however, is not sufficient protection against the tubercle bacillus. Patients with active tuberculosis should not receive treatment in most dental offices until their sputum is free of *Mycobacterium tuberculosis*. Masks used during provision of care should be carefully adjusted to mold to the face, and changed between patients, more frequently when exposed to heavy spatter and/or aerosols during treatment, or when they become moist or wet. This latter recommendation is an important consideration as wet fabric may serve as a vehicle for microbial passage through the mask.

Protective Eyewear

The eyes and other surrounding tissues of the HCP can be exposed to: 1) a variety of macroscopic and microscopic particles (tooth fragments, amalgam, surgical tissue debris) which can cause mechanical trauma; 2) chemical injury from splashing; 3) or infection (conjunctivitis caused by staphylococci, gonococci, or herpes simplex viruses). Protective eyewear such as goggles, glasses with side-shields, or chin-length face

shields should be used during procedures in which aerosol generation or splash/spatter is anticipated. One should choose an appropriate device based on the level of protection indicated. A mask should be used in conjunction with an eye protection device, even if the device is a face shield, to reduce contamination through the nasal and oral portals of bacterial entry. The use of eyewear that is too small to protect the eyes from airborne debris is potentially dangerous, and can increase the risk of ocular injury from macroscopic or microscopic particles. As an example, a person's personal eyewear is not designed or sized for use during provision of dental treatment. It does not provide sufficient protection from airborne macroscopic or microscopic trauma to the eyes. This is contrasted with eyewear that is large enough and has side shields to protect this most vulnerable exposed part of the body (**Figure 2**).

Figure 2. Representative eyewear that provides sufficient protection for the dental health care professional.

Instrument Processing and Recirculation

Instrument processing and recirculation is a complex series of events that requires specialized equipment, adequate space, and qualified personnel. Appropriate cleaning, packaging, sterilization, and storage practices are essential to ensure that instruments and other contaminated items are appropriately processed and safe for re-use. Reusable instruments, supplies, and equipment should be cleaned and decontaminated in a specific processing area. If at all possible contaminated and clean areas should be separated. Whether the practice has a large or small area available for this process, the basic premise

Table 4. Considerations for Instrument Processing

1. Contaminated instruments handled as little as possible and carefully to prevent sharps exposure accidents.
2. Use of heat recognized as the most efficient, reliable method of sterilization in dental settings. These include steam under pressure (autoclave), dry heat, or unsaturated chemical vapor.
3. "Cold sterilization," is no longer considered necessary or appropriate, since most reusable instruments devices used in dentistry can withstand heat sterilization.
4. Single-use disposables should be considered for certain devices and items that cannot withstand heat sterilization.
5. Cleaned instruments packaged in pouches or wraps before placement in a heat sterilizer.
6. Chemical indicator recommended for each package to evaluate attainment of sterilization conditions.

Table 5. Characteristics of Commonly Used Heat Sterilization Methods in Dentistry

METHOD	PROCESS OVERVIEW	CYCLE TIME & TEMPERATURE	ADVANTAGES	DISADVANTAGES
Steam				
Gravity displacement	Moist heat at higher temperatures in the form of saturated steam under pressure	15–30 min at 250°F/121°C	• Time efficient • Good penetration • Can be used with packaged items • Ability to process wide range of materials without destruction	• Corrosion of non-stainless steel metal items • Do not use closed containers • Possible deposits from using hard water • May leave instruments wet at end of cycle • May damage heat-sensitive plastics & rubber items • May dull certain sharp items
Pre-vacuum		3.5–10 min at 270°F/132°C		
Dry Heat				
Static Air	Hot air rises inside the chamber through natural convection	60–120 min at 320°F/160°C	• No corrosion or rust • Does not dull cutting edges • Items dry after cycle • Closed containers may be used if a spore test is used to confirm appropriate kill	• May damage heat-sensitive plastic and rubber items • Items must be thoroughly dried before processing • Long cycle time • May not be appropriate for handpieces
Forced Air	Heated air is circulated throughout the chamber at a high velocity	12 min at 375°F/190°C	• Time efficient • No corrosion or rust • Does not dull cutting edges • Items dry after cycle	• May damage plastic and rubber items • Items must be thoroughly dried before processing • May damage heat-sensitive items • May not be appropriate for handpieces
Unsaturated Chemical Vapor	Hot formaldehyde vapors under pressure	20 min at 270°F/132°C	• Time efficient • No corrosion or rust • Items dry after cycle	• Special solutions required • Ventilation must be adequate • Items must be thoroughly dried before processing • May damage heat-sensitive plastics • Do not used closed containers • Do not use thick wrapping materials • May not be appropriate for handpieces

for instrument processing remains the same: *do not disinfect when you can sterilize*. In addition, other representative issues to consider are presented in **Table 4** on page 4.

Sterilization equipment with claims of effectiveness and safety must be cleared by the Food and Drug Administration (FDA). Heat-tolerant instruments can be routinely sterilized by steam under pressure (autoclaving), dry heat, or unsaturated chemical vapor. Major characteristics of each of these modalities are summarized in **Table 5** on page 4. The method chosen must be compatible with the items to be sterilized and the sterilization wrapping materials or containers, such as cassettes.

Sterilization cycles are routinely monitored using a combination of mechanical, chemical, and biological indicators. These are able to evaluate sterilization conditions and the procedure's effectiveness. Mechanical monitors of sterilization cycles evaluate gauges, displays, or computer printouts for correct temperature, pressure, and exposure time. While incorrect reading of these indicators serves as a first indication of problems with the cycle, they do not assess conditions within the packages being processed. In contrast, chemical indicators and integrators can use time, temperature and pressure during the cycle, and also have varying degrees of sensitivity. Their characteristics are summarized in **Table 6** below.

Table 6. Classification of Chemical Indicators/Integrators

Class I (Process Indicators) - tapes or strips used only as external indicators to distinguish processed from unprocessed items (e.g. autoclave tape)

Class II (Bowie-Dick Indicators) – used as quality control indicators for vacuum steam (Class B) sterilizers to assess air removal during cycle

Class III (Temperature Specific Indicators) – indicate attainment of specific minimum temperature within sterilization chamber during a cycle; not sensitive to other parameters (i.e. time)

Class IV (Multi-Parameter Integrators) – provide integrated color change to the temperature, pressure, time sterilization parameters

Class V (Integrating Indicators) – strips that contain a chemical ink which reacts to all 3 sterilization parameters during the sterilization cycle; when the final color change is in the card "SAFE" zone provides immediate notification to the user of sterilization cycle success or failure.

Adapted from: Hughes CA. Sterilization Quality Assurance Process. http://www.spsmedical.com/education/articles/sterilizationquality.html

Even when sterilizer gauges display correct readings for unit conditions and chemical indicators show that appropriate chamber conditions have been attained to achieve sterilization, the use of calibrated biological indicators is considered the main guarantee of sterilization. The CDC updated earlier dental infection control recommendations in 1993[15], stating "proper functioning of sterilization cycles should be verified by the periodic use (at least weekly) of biologic indicators (spore tests). Biologic indicators containing heat-resistant spores provide the best challenge for sterilization cycles. Two species are used, *Geobacillus stearothermophilus* and *Bacillus atrophaeus* (formerly *Bacillus stearothermophilus* and *Bacillus subtilis*). Calibrated *G. stearothermophilus* spore-impregnated paper strips or glass vials are appropriate biological monitors for autoclaves and unsaturated chemical vapor sterilizers, while *B. atrophaeus* preparations provide effective challenge for conditions in dry heat sterilizers. Placement and location of biological indicators in the sterilizer, as well as appropriate incubation times and temperatures are to be done according to manufacturer's instructions. Destruction of the heat-resistant resistant spores is used as a measure that all microorganisms exposed to the same conditions have been destroyed. Biological indicators are considered the "gold standard," and represent the most sensitive check of sterilizer efficiency.

Dental Water Quality

CDC and ADA recommendations maintains that the quality of water used for non-surgical dental procedures meets the EPA standard for drinking (potable) water, <500 cfu/mL. Unfortunately, dental unit waterlines are particularly prone to contamination with microorganisms due to design, low water flow, and long periods of stagnation. Each of these help to create an environment optimal for biofilm colonization. When a mature biofilm is present, potable quality water (<500 cfu/mL of bacteria and <1 coliform) entering the unit may become contaminated, leading to up to 1 million cfu/mL once it is dispensed from high-speed handpieces, air/water syringes, ultrasonic scalers, and cuspidors.[16-21] Multiple types of organisms have been identified in dental unit water samples including: *Corynebacterium* species; gram-negative bacilli and cocci; *Klebsiella* species; *Pseudomonas* species, including *P. aeruginosa, P. pyogenes, and P. capacia, Staphylococcus epidermidis; Streptococcus mutans, S. salivarius, and S. mitis; Actinomyces species; Enterococcus species; a-hemolytic streptococci; Staphylococcus aureus; B. subtilis; Escherichia coli; Legionella pneumophilia; Mycobacterium species; Aspergillus niger*; and *Alkaligenes fecalis.*

Until recently, there was no published evidence of serious health problems for either a patient or HCP's from contact with water from a dental unit. However, in the past few years we have had two documented cases in the United States and Europe. The first occurred in early 2012, an article published in The Lancet[22] described the first documented case of a dental patient contracting Legionnaires' disease (*Legionella pnuemophila*) from water used during treatment. A second case involving 20 children (ages 3-11 years) at a pediatric dental practice was reported in March 2016.[23] Pediatric pulpotomy patients were infected with *Mycobacterium abscessus* resulting in severe illness, and for most, surgical excisions. In this case, the practice's seven dental units had an average bacterial load of 91,333 cfu/mL in treatment water. These tragic cases reinforce the premise that exposing dental patients to water of poor microbiological quality is inconsistent with both universally accepted infection control principles and the high level of asepsis standards routinely exhibited in most dental offices.

Treatment options vary depending on the type of dental unit, self-contained (bottle) system or an open (municipally supplied) system, and most of the time it will require more than one type of treatment (**Table 7** on page 6). To ensure the

quality of water that meets CDC and ADA recommendations, two things typically need to happen: 1) the source water should meet the microbial levels for potable water, and 2) dental waterlines should be treated to minimize biofilm accumulation.

Table 7. Types of Water Treatments

These include:

1. Filtration involving in-line filters to remove bacteria immediately before dental unit water enters instrument attachment.
2. Chemical disinfection involving periodic shocking of lines with a disinfectant followed by appropriate rinsing of lines with water, or a continuous release chemical disinfectant system.
3. Thermal inactivation of facility water at a centralized source.
4. Reverse osmosis or ozonation using units designed for either single chair or entire practice water lines.
5. Ultraviolet irradiation of water prior to entrance into individual unit waterlines.

When a procedure involves surgery or exposes bone, sterile water or saline must be used to reduce the chance of postoperative infection. It is important that the water delivery system be sterile to avoid contaminating the sterile water/saline. The clinician should also remember that conventional dental units cannot be reliably sterilized. Sterile water systems for surgery procedures must bypass the dental unit and employ sterile disposable or autoclavable tubing. In addition, handpieces or ultrasonic scalers used during surgical procedures must deliver sterile water or other solutions using sterilizable or single-use disposable tubing.

Summary

Infection control is a critical component of quality dental care. Fundamental principles to prevent disease transmission provide the foundation for infection prevention guidelines. Today, infection control recommendations are developed using evidence based approaches that integrate scientific and clinical information; governmental and professional recommendations; federal state and local regulations; and practice specific considerations. At a minimum, a dental facility should review and revise its infection control policies and procedures, and update its exposure control plan (ECP). An ECP must be updated annually and any time there is a significant change in knowledge, practices, or policy. These new guidelines present a unique opportunity for all staff members to review the manner in which they deliver dental services and to implement recommended measures that can minimize further the already low risk of disease transmission in dental settings. ■

Author Biographies

John A. Molinari, Ph.D. – *Dr. Molinari is Director of Infection Control for THE DENTAL ADVISOR. He is also Professor Emeritus at the University of Detroit Mercy School of Dentistry, He has published over 450 scientific articles, text chapters, and abstracts in microbiology/immunology, and lectures nationally and internationally on topics dealing with infectious diseases and infection control.*

Peri Nelson, B.S. - *Peri Nelson graduated from the University of Michigan in 2003 with a Bachelor of Science in Neuroscience and Biology. Her research experience is in the fields of microbiology, genetics, neuroscience and biomaterials. She currently works as Assistant Director in the Infection Control Laboratory.*

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